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25 March 2018

Mr and Mrs Steel
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Dear Stephanie and Andy

Hydrogeological Assessment: Site 5 Glebe Farm, Wasperton

Further to our meeting of 9 March I have reviewed the information you have provided in addition to the Warwickshire Minerals Plan. I set out below my assessment of that data.

Background Reports

The DK Symes report, 1987, assesses the mineral reserves in Site 5 by a series of boreholes. The following are key observations:

1. There is approximately 1.5m of topsoil and clayey overburden material lying above the mineral reserve.
2. The mineral reserve is described as a sandy gravel and is up to 2.5m in thickness.
3. The mineral is underlain by marl, which is of much lower permeability.
4. The rest water level following investigations was generally found to lie at the overburden/mineral interface, ie approximately 1.5m below ground level. The site investigations were undertaken in September, when groundwater levels can be expected to be at their lowest.
5. An area in the southeastern corner of site is described as uneconomic to work due to reduced thickness relative to overburden.

Radius of Influence – Quarry Dewatering

During quarry dewatering operations it is possible to estimate the radius of influence of the dewatering. Such information can be used to determine the distance of standoff from any particular water feature, if adverse impacts are to be avoided. However, these estimates generally require a knowledge of the quarry pumping rate and preferably the use of an observation borehole between the quarry and the water feature.

In the absence of such data approximations can be made for unconfined aquifers using the Sichardt formula as follows:

$$R_o = C \times h \times k^{0.5}$$

Where R_o is the radius of influence (m)
C is a factor of 3000 for radial flow
h is the drawdown achieved by the dewatering operation (m)
and k is the permeability of the aquifer (m/s).

Based on groundwater observations by DK Symes, it is likely that the full thickness of the mineral reserve will contain water and therefore the drawdown required to keep the quarry dry would be 2.5m. In wetter times of year, if the groundwater levels were higher, this drawdown could be larger.

The permeability of the mineral reserve is unknown but estimates can be made from the sand content. The range of permeabilities that can be expected for different grades of sand are presented in Table 1. If the deposits were found to contain significant gravel content larger permeabilities would result, therefore this is a conservative approach.

Table 1: Sand permeabilities

Sand grain size	Min. (m/s)	Max. (m/s)	Mid value (m/s)
course	9×10^{-7}	6×10^{-3}	7.5×10^{-5}
medium	9×10^{-7}	5×10^{-4}	2×10^{-5}
fine	2×10^{-7}	2×10^{-4}	2×10^{-6}

Domenico and Schwarz, 1990

Table 2 indicates how the permeability would affect the radius of influence. Estimates of the radius are calculated for the full range of permeabilities and include the mid values for each grade of sand.

Table 2: Radius of influence estimates

R_o	C	h	k
3	3000	2.5	2×10^{-7}
11	3000	2.5	2×10^{-6}
34	3000	2.5	2×10^{-5}
65	3000	2.5	7.5×10^{-5}
581	3000	2.5	6×10^{-3}

The DK Symes investigation describes more clay content in the central southern half of site 5 (borehole 6). It is unlikely that the mineral reserve in this area would have an average permeability at the higher end of the ranges presented: 6 x 10-3m/s. However, it would be reasonable to find that the mineral had permeabilities in the range of 2×10^{-5} m/s, giving a radius of influence of 34m, or potentially permeabilities of 7.5×10^{-5} m/s, giving a larger radius of influence of 65m.

Other Considerations

1 Breakthrough of the brook to the quarry

The Environment Agency (EA) in their letter to you of 18 January 2018, refers to standoffs from water courses of 30 – 45m. This is earlier referred to by Martin Ross, also EA, in response to the Minerals Publication, 15 February 2017, based on his experience of a quarry break through at Catton, Staffordshire. These standoffs are of a similar magnitude to those calculated for the potential zone of influence of quarry dewatering.

However, the EA have also indicated that the scale of the standoff might be lower for a smaller water course. Reference has been made to a typical standoff of 10 m.

A standoff from the Thelsford Brook is required for two reasons:

1. To avoid breakthrough of waters flowing through the brook bed in to the quarry and the associated instability that might result.
2. To ensure the quantity of water flowing in the brook is not reduced by quarry dewatering operations.

A general standoff of 10 m is often required for works close to water courses. This includes activities such as standard rules environmental permits where there is no intention to carry out dewatering activities. The 10 m standoff is to minimise the chance of disturbing the water course both physically and by contamination.

When making an application to the Environment Agency for a permit to abstract water from the ground a more site specific assessment must be made to ensure that water features within the vicinity of the abstraction are not affected by the dewatering. Some water features are fed by the aquifer below and dewatering of the aquifer could lead to the drying up of the water features.

Given the depth of the Thelsford Brook in relation to the depth to groundwater level in the sands and gravels, there is a likelihood that the brook is fed in part by groundwater. Hence there is a need to calculate the required zone of influence of any dewatering to ensure the baseflow to the brook is not prevented. The calculations above, although indicative only, suggest a standoff of at least 35m might reasonably be required.

2 Adjacent Abstractions

It is understood there is an abstraction from the brook adjacent to site 5, although records have not been seen. Any quarry activities will need to maintain the quantity and quality of flow to adjacent abstractions. If the proposed location was dewatered, the quarry water would need to be returned to the brook without affecting its quality.

3 Flood Risk

The proposed site 5 is in low lying land and flood zone 3. A key issue in determining whether the site is viable is the need for a flood risk assessment. The EA's letter of response to consultation of 7 January 2016 sets out the aspects which should be addressed in a flood risk assessment for the site.

Summary

To give more accurate estimates of the radius of influence of proposed quarry workings more detailed site specific data would be required. However, based on a preliminary review of available data the indication is that a standoff of at least 35m would be appropriate to maintain groundwater levels below the Thelsford Brook and minimise the chance of the flow in the brook being reduced by quarry dewatering.

Assessment of flood risk to the site should consider not only the probability of the site flooding in the abstraction and in the infilling stages, but the practicalities of removing the flood waters at a suitable quality to return to the brook, or other controlled waters.

Please let me know if you would like to discuss any of the above further.

Yours sincerely,

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