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Leeds, 14/02/2023

## **Land at Hollins Cross – Groundwater flood risk review**

Dear Liz

### **1 Introduction**

Burnley Council have requested an independent review of potential groundwater flood risk associated to the proposed development at Hollins Cross Farm, Burnley (planning application FUL/2022/0149). We understand that this review is required as the planning application has been deferred twice from committee on the basis there might be groundwater issues which might impact on flood risk at the site and its surroundings.

This report is a review of the site from a groundwater flood risk perspective only. The study is based on a high-level review of the third-party information available and is current at the time of drafting. No consultation or a site visit has been undertaken.

Although this report was prepared using the degree of skill and care ordinarily exercised by engineers practicing under similar circumstances, please note that Sweco has had to rely on the accuracy of the third-party data and, therefore, will not be held responsible for the conclusions and findings of the report if the third-party data is determined to be inaccurate at a later date.

The following data sources have been reviewed as part of this assessment:

- SurveyEng Ltd (23 April 2021) Glen View Road, Burnley Topographical Land Survey. For Prospect GB. PRO.TS.13
- REFA Consulting Engineers (2 December 2022) Proposed Residential Development Hollins Cross Farm, Burnley. For Prospect Homes. Final Issue 01. Geo-environmental investigation Report 21061/GEIR/01
- REFA Consulting Engineers (27 July 21) Hollins Cross Farm Burnley, Drainage Strategy Drawings 1 – 3. Reference 21061/100/1-3 Rev A/B. For Prospect Homes

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- REFA Consulting Engineers (30 November 2022) Supplementary Site Investigation at Hollins Cross Farm, Burnley letter report for Prospect Homes
- RSK (December 2021) Hollins Cross Farm, Burnley Flood Risk Assessment 680259-R1(02)-FRA (Draft). For Prospect (GB) Ltd
- Savills (December 2022) Supplementary planning statement, Erection of 200 dwelling – addressing reasons for application deferral at Planning Committee on 8<sup>th</sup> December 2022. For Prospect Homes REFA (9 February 2023) Letter report to Prospect Homes on supplementary site investigation at Hollins Cross Farm, Burnley.

Comments made in the letter reports from Aegaea (18 January 2023) and LDE (2 February 2023) have also been taken into consideration.

This letter report discusses the ground and groundwater conditions across the site based on the information available and focusing on the area immediately surrounding the proposed attenuation basin. Regrading of the site has also been qualitatively considered, from a groundwater flood risk perspective only.

## 1.1 Residents' concerns

We understand that concerns about the proposed scheme were raised to the council from a local group of residents as discussed in the Aegaea report dated 18 January 2023. The report takes into account the findings of the FRA (RSK, December 2021) and GEIR (REFA, December 2022) as well as the drainage design, drainage queries and LLFA responses. The key conclusions of the report in relation to groundwater are summarised below:

- The risk of groundwater flooding and its impact on surface water flows needs to be considered in greater detail to not increase flood risk elsewhere.
- The proposed surface water drainage strategy has not considered groundwater levels. There are concerns that the attenuation pond as an artificial feature will not allow groundwater to ingress, and that existing groundwater could be displaced post-development.
- Groundwater monitoring is required across the site to inform the foundation design of the properties, buoyancy calculations for SuDS such as tanks and the performance of swales if they are not lined.
- There is no consideration of the regrading of the site in the drainage strategy, or the impact on overland flows of surface water, interaction / impact of groundwater as a result of the regrading.

## 2 Groundwater assessment

### 2.1 Ground Conditions

The ground conditions are understood based on rotary boreholes, window samples and trial pits installed as part of the site investigation works undertaken in May – June 2021 (REFA, December 2022) and additional windowless sample boreholes installed in September – October 2022 (REFA November 2022), plus comments on site conditions made during the topographic survey of April 2021

(SurveyEng, April 2021) and the May-June 2021 site investigation (REFA, December 2022).

Comments on the wider conditions, as presented in the Flood Risk Assessment (RSK, 2022) are also included for context.

## 2.2 Topography and drainage

The site as a whole slopes towards low ground along the northern boundary, with the lowest ground elevations in the north-eastern corner of the site. Ground elevations along the northern boundary are around 234 to 239m AOD. OS mapping indicates that ground continues to fall to the north of the site.

The April 2021 topographic survey identified water ponding towards the northern end of the site where ground elevations were around 238 to 239.6m AOD. This ponded area was connected to, and downstream of dry ditches running from southeast to northwest across the site. A further southwest to northeast ditch runs from the area of pooled water towards the north-eastern corner. Further pooled water was reported along the side of this ditch. The ponded area and drainage ditches qualitatively match areas identified in the Flood Risk Assessment (RSK, December 2021) as having low to medium risk of surface water flooding.

## 2.3 Geology

The ground investigation undertaken to inform the GEIR (REFA, December 2022) indicates that the area immediately surrounding the proposed attenuation basin is generally underlain by around 0.2m topsoil, underlain by 0.6 to 1.6m of firm to stiff grey and brown clays of Devensian Diamicton (glacial till), and subsequently weathered shaley mudstone of the Pennine Lower Coal Measures Formation, as demonstrated by trial pits TP02 – 06 and rotary boreholes RBH01 and 03.

The clays are variable across the site, and are described to include cobbles, pockets of sands and silts and mudstone laminations in various locations. The western-most trial pit (TP02) also recorded soft clayey peat between 0.2 and 1.2mbgl (237.4maOD).

The mudstone is described as weak and shaley, and in one location is described as a siltstone. Sands and sandstone were generally absent at shallow depths, although small pockets of sands were identified at the western boundary (WS04) and in the centre of the site (TP16 and WS08 – 09). Rotary drilled boreholes RBH01 and RBH03 identified a band of weathered sandstone at the top of the bedrock (3.7m - 4.50mbgl and 4.5 – 5.3mbgl respectively). The bedrock encountered in these boreholes was described as mudstone with interbedded sandstone. The weathered sandstone was not encountered in RBH02, further to the south.

As the central depression was not accessible due to very wet ground conditions during the original phase of ground investigation works, four further windowless sample boreholes were subsequently installed, focussing on this central depression (REFA, November 2022). These identified a 1m thick horizon peat either directly below clayey topsoil or at ground surface to depths of between 1.0 and 1.4mbgl (236.6 – 237.2maOD) beneath the western half of the proposed attenuation basin location (WS101 – 103). This peat was found to be underlain by soft becoming firm, slightly sandy slightly silty clay with occasional cobbles of sandstone and mudstone. The peat was absent in the eastern half of the proposed attenuation basin location (WS104), with almost 5m of grey

slightly sandy gravely and silty clays underlying the topsoil. The weathered bedrock was not encountered in these four boreholes.

## 2.4 Groundwater

The Flood Risk Assessment (FRA; RSK, November 2021) highlights that the Devensian Diamicton is classified by the Environment Agency (EA) as a secondary (undifferentiated) aquifer, and sandstones within the Pennine Lower Coal Measures Formation as a secondary (A) aquifer. This also identified two 5m deep boreholes and a spring source to the south of the site. The borehole logs (accessible on the BGS website<sup>1</sup>) both identify groundwater within a sandstone horizon close to surface. This is interpreted as sandstones of the Pennine Lower Coal Measures.

Groundwater seepages were observed during the site investigation at locations TP02 (May 2021), WS102, WS103 and WS104 (September 2022), in the area around the attenuation basin (REFA, December 2022 and November 2022). A groundwater seepage was also observed during construction of WS04 in May 2021, further southwest and along the western boundary of the site. The table below summarises groundwater seepages encountered during each of the site investigations. This shows that these were primarily associated with peat in the area surrounding the proposed attenuation basin., with the exception of WS04 that was associated with a sandstone gravel horizon.

RBH01 and RBH03 were not completed for groundwater monitoring and so it is not possible to confirm groundwater levels in the weathered sandstone horizon at the base of the clayey superficial deposits. No water strikes are recorded on the borehole logs but the overlying clays are described as “very wet”, so it seems likely that the weathered sandstone was saturated at the time of drilling.

Most other site investigation locations across the wider site area, and including those immediately to the south (i.e. upgradient) of the attenuation pond were found to be dry. Groundwater seepages across the wider area are limited to that associated with a sand horizon in the west at WS04 (REFA, December 2022) and trial pitting undertaken in February 2023 (REFA, February 2023), which identified three instances of groundwater. These were all reported to be either slow ingress or accumulations within the base of the trial pit, however, and were primarily associated with weathered bedrock overlying the more competent mudstone bedrock.

Reference	Estimated ground elevation (m AOD)	Groundwater strike or seepage (mbgl / m AOD)	Horizon
TP02	~238.6	Seepage at 0.8mbgl (~237.8m AOD)	peat
WS102	~238.5	Water ingress at 0.8mbgl (~237.7m AOD)	peat
WS103	~238.1	Water ingress at 0.3mbgl (~237.8m AOD)	peat
WS104	~238.0	Water ingress at 0.5mbgl (~237.5m AOD)	clay

<sup>1</sup> [http://scans.bgs.ac.uk/sobi\\_scans/boreholes/32105/images/13383117.html](http://scans.bgs.ac.uk/sobi_scans/boreholes/32105/images/13383117.html),  
[http://scans.bgs.ac.uk/sobi\\_scans/boreholes/20240941/images/20238366.html](http://scans.bgs.ac.uk/sobi_scans/boreholes/20240941/images/20238366.html),  
[http://scans.bgs.ac.uk/sobi\\_scans/boreholes/20240940/images/20238365.html](http://scans.bgs.ac.uk/sobi_scans/boreholes/20240940/images/20238365.html)

WS04	~242.75	Seepage at 1.2mbgl (~241.55m AOD)	Sandstone gravel inclusions within clay
TP101	~243	Slow water ingress at 0.6mbgl (~242.4m AOD)	Base of silty clays, overlying weathered coal bedrock.
TP104	n/k	Accumulation of groundwater in base of trial pit at 1.7mbgl	weathered mudstone
TP106	n/k	Accumulation of groundwater in base of trial pit at 1.8mbgl	weathered mudstone

Limited groundwater monitoring was undertaken between 12 June and 23 August 2021 following the first round of site investigation (REFA, December 2022), and between 12 and 27 October 2022 following the supplementary site investigation (REFA, November 2022).

WS04 was reported to be “flooded” during the site visits between 12 June and 23 August 2021. this does not necessarily confirm groundwater levels to be at surface, and it is in fact likely that this merely reflects the ingress of standing water around the monitoring installation.

Groundwater monitoring following the supplementary ground investigation was only possible at WS101, where groundwater levels were recorded between 0.25 and 0.6mbGL (around 238.2 – 238.55maOD) between 12 and 27 October 2022. These groundwater levels coincide with the top of the peat layer. WS103 and 104 were both reported to be flooded. As gas taps and bungs were installed in the top of the monitoring installations, it is expected that this flooding is a reflection of standing water inundating the monitoring installations rather than groundwater.

## 2.5 Assessment of ground and groundwater conditions

Based on the available information groundwater seepages appear to be primarily associated with peat deposits, which are limited in extent to the depression along the northern boundary, in the vicinity of the proposed attenuation basin. Although peat can hold reasonable quantities of groundwater, it is limited in extent and therefore groundwater storage and release will also be limited. The peat is underlain by stiff to firm clays, which are likely to hydraulically isolate the peat from the underlying bedrock.

The weathered sandstone horizon identified in boreholes RBH01 and RBH03 at the top of the bedrock is likely to contain groundwater but as these boreholes were not completed for monitoring, it is not possible to comment on groundwater levels or whether there is any upwards leakage between this and the peat. It is also not possible to confirm the extent of this weathered sandstone horizon along the northern boundary of the site. However, the weathered sandstone was not encountered in RBH02, further to the south.

Similarly, it is not possible to comment on groundwater flow directions within the uppermost bedrock. However, the hydraulic gradient is likely to reflect topography, from south to north.

Given that the weathered sandstone is at a depth of at least 3.7mbgl, it appears likely that the poor drainage of the site is primarily due to the presence of the low permeability clays, preventing surface water from infiltrating rather than groundwater seepages or springs from the underlying bedrock. This would also account for the reports of flooded monitoring installations, and the presence of drainage channels across the site.

Wet ground would also naturally be associated with peat present at or near-surface. Whilst peat can hold significant quantities of water, it is actually poorly permeable with flow primarily through “pipes” and via underdrainage. In this case, it is also limited in extent, which means groundwater storage will also be limited.

Groundwater monitoring is limited and monitoring over a winter period is limited to the observations made in the February 2023 trial pitting, and which excludes the area containing peat. The site observations of standing water were made during the wetter than average late winter/spring 2021, however, and are likely to reflect surface water flooding rather than groundwater seepage or springs, especially considering the limited extents of the groundwater-bearing peat deposits and depth to the weathered sandstone horizon.

### 3 Proposed development

The proposed attenuation basin is located along the northern boundary, in an area where ground elevations are in the region of 238 to 239m AOD. We understand that the design bed level is at 236.8maOD and is up to 1.6mbgl. The drainage strategy drawings (REFA, July 2021) state that “infiltration has been discounted as a suitable means of surface water disposal due to ground conditions”, although there are no details as to whether the pond is due to be lined.

The eastern third of the attenuation basin will be designed to permanently hold around 0.3m of water to create a wetland nature feature, whilst the remaining two thirds will be designed to only hold water temporarily following rainfall events (Savills, December 2022).

The proposed development also includes regrading of the remaining site.

#### 3.1 Impact of the proposed attenuation basin

The excavation works to construct the attenuation basin is likely to remove the majority of the groundwater-bearing peat deposits, which are found to depths of up to 1.4mbgl (236.6m AOD). This was recommended by REFA (November 2022) in order to avoid differential settlement or movement risks. The northern extents of the peat are not understood and deposits may extend beyond the site’s northern boundary. Without further ground works, therefore, there may be some peat remaining along the site boundary and beneath the western end of the attenuation pond. Notwithstanding this, removal of the peat within the site should have the effect of reducing groundwater storage and any associated flow to the north (for example by underdrainage), rather than increasing the risk of groundwater flooding.

From the available ground investigation information, it appears that the weathered sandstone bedrock along the northern boundary of the site is below the base of the attenuation basin and therefore groundwater flow within the bedrock will not be impacted.

Elsewhere, the site is primarily underlain by low permeability clay. Although there are some local pockets of more permeable deposits within the clay, these are very limited in lateral and vertical extent and perched groundwater stored within them will similarly be very limited.

In summary, based on the available information construction of the attenuation is very unlikely to increase the risk of groundwater flooding. Rather, the removal

of much of the peat deposit within the site boundary will reduce groundwater storage and flow. Similarly, groundwater inflows into the attenuation basin (assuming it is unlined) will be very limited such that there is not likely to be any significant impact on the storage capacity of the attenuation basin.

The proposed development includes some regrading of the site's ground elevations. If shallow sandy horizons are exposed during the regrading, there may be some limited groundwater seepages issuing from ground. Moreover, these may only likely to temporary as the groundwater storage is so limited.

### 3.2 Limitations and data gaps

- Topographic survey and site investigations do not extend beyond the northern boundary of the site and therefore site conditions are not known beyond the site boundary. TP02 is situated within the corner of the site and recorded peat, and therefore it is considered likely that the peat does extend further north.
- Similarly, the lateral and vertical extent of the weathered sandstone bedrock horizon beyond the site boundary is not known.
- Groundwater monitoring has not been undertaken over a whole winter period. Winter observations of groundwater levels is limited to trial pitting undertaken in February 2023 and which does not cover the area of peat. Groundwater monitoring within the peat is limited to October 2021 and may not have captured winter maximum groundwater levels, as these can occur at any time between around November and March.
- There has been no groundwater monitoring of the weathered sandstone bedrock and therefore there is no information on groundwater levels or the degree of leakage between the sandstone and overlying peat or ground surface.
- Our comments on the likely permeability are qualitative based on observations from trial pitting and lithological descriptions on borehole logs.

## 4 Conclusions

Based on the high-level review of the reports and information listed in Section 1 our assessment concludes that groundwater and any associated potential flood risk is not expected to be a significant constraint to the development.

Based on the information available, any flooding appears to be primarily associated with surface run-off due to the presence of low permeability clayey glacial till underlying most of the site.

Groundwater is present within the peat, which would be naturally associated with wet ground. Groundwater is also within small, localised pockets of more permeable deposits within the clayey glacial till.

Much of the peat deposit within the site boundary will be removed during construction of the attenuation pond, reducing groundwater storage. Any perched groundwater within more permeable horizons within the till will be isolated and of very limited extent. It may be encountered during regrading or excavation activities, but flows are likely to be minimal in terms of volume and duration.

Weathered sandstone at the top of the bedrock is likely to contain groundwater but will not be intercepted by the attenuation basin.

Further monitoring of winter groundwater levels (between November and March) within peat and sand horizons would be beneficial to inform the detailed design and temporary works.

Best regards

**Caroline Ball**

Technical Manager – hydrogeology

Reviewed by Harriet Carlyle and approved by Enrico Isnenghi



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