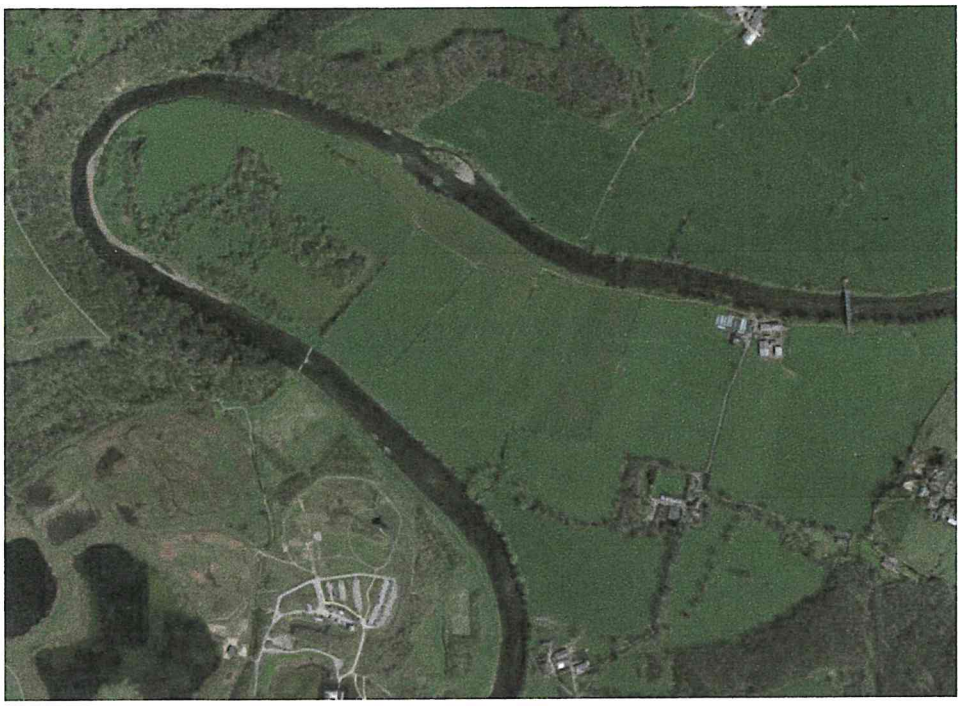
HARLEYFORD AGGGREGATES LTD
SAMLESBURY ESTATE

Hydrogeological & Flood Risk Assessment of the Proposed Mineral Extraction



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Ref: P:\Samlesbury FRA (1998)\40 - Reporting\2 - 2016 Update\Samlesbury HRA_2016 r3.2.docx
June 2016

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Revision	Details	Completed by	Date	Checked by	Date
REV01	1st Draft	PJ/JS	31/05/2016	PH	03/06/2016
REV02	Final	PJ	16/06/2016	PH	17/06/2016

SAMLESBURY ESTATE
HYDROGEOLOGICAL & FLOOD RISK ASSESSMENT

NON TECHNICAL SUMMARY

Harleyford Aggregates proposes to extract sand and gravel at the Samlesbury Estate near Preston, Lanacashire. The site is bounded to the north and east by the River Ribble and the Bezza Brook, and is located within the associated floodplain.

The site will be worked to the base of the sand and gravel deposit, which varies in thickness from approximately 3 to 7m (base of deposit at 6 - 12mAOD). It is intended that the unsaturated deposit will be worked dry and the remaining saturated deposit will be worked wet as far as possible. No dewatering is planned. There will also be 25m standoff from the River Ribble and Bezza Brook.

Envireau Water has been commissioned by Harleyford Aggregates Ltd to assess the hydrogeology and risk of flooding at a site. The hydrological and hydrogeological settings of the proposed workings have been described by reference to:

- British Geological Survey mapping and documentation
- Ordnance Survey maps at various scales
- Environment Agency database searches, published documentation and guidance
- Review of Natural England database and SSSI designation
- Site investigation drilling and data from piezometers constructed at the site
- Discussions with Harleyford Aggregates and their consultants

Various water features have been identified in the area, including licensed and unlicensed surface and ground water abstractions, however none are considered to be as risk from the proposed development.

The site lies within the natural flood plain of the River Ribble, and is at risk of flooding from a 1 in 100 year storm event (zone 3b). In accordance with the National Planning Policy Framework and Planning Practice Guidance, sand and gravel extraction would be permitted in zones at risk of flooding but mitigation measures will need to be developed to protect the safety of the quarry personnel, plant and local environment.

The development will provide additional floodplain storage and there is a net benefit during working and following restoration from a flood risk perspective. Subject to discussions and an agreement with the Environment Agency, the restored site could be utilised as an unmanned flood alleviation feature, providing additional floodplain storage for flood flows associated with the River Ribble.

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SAMLESBURY ESTATE
HYDROGEOLOGICAL & FLOOD RISK ASSESSMENT

1 INTRODUCTION

Envireau Water has been commissioned by Harleyford Aggregates Ltd to assess the hydrogeology and risk of flooding at a site proposed for mineral extraction at Samlesbury, Preston.

Harleyford Aggregates proposes to extract sand and gravel at the site. The site will be worked to the base of the sand and gravel deposit, which varies in thickness from approximately 3 to 7m (base of deposit at 6 - 12mAOD).

It is intended that the unsaturated deposit will be worked dry and the remaining saturated deposit will be worked wet as far as possible. No dewatering is planned.

1.1 Report Objective

This report has been prepared by Envireau Water and presents a hydrological and hydrogeological assessment for the proposed development at the site, and considers the issues of flood risk during the proposed mineral extraction.

The report been prepared to support an Environmental Statement (ES), being prepared by others, in support of the planning application.

1.2 Report Context

The report combines published regional data and the results of intrusive site investigations and includes the following:

1. A review of the baseline hydrology, geology and hydrogeology
2. Identification of surface water and groundwater features in close proximity to the site
3. A conceptual hydrogeological model
4. The proposed outline development plan and proposals for how water will be managed during development
5. A Flood Risk Assessment (FRA) written in accordance with the National Planning Policy Framework (NPPF) [Ref. 1] and the accompanying online resource, Planning Practice Guidance: Flood Risk and Coastal Change [Ref. 2].

2 SITE SETTING

2.1 Location

The site occupies an area of land known as Lower Hall Farm, which forms part of the Samlesbury Estate and covers an area of approximately 140 acres (57Ha). The site is located approximately 5.5km northeast of Preston city centre near the village of Samlesbury at national grid reference SD 5880 3166 (approximate centre of site).

The site location is shown on Figure 1. Images of the site obtained during construction of piezometers in December 2008 are presented on Figure 2. The site has remained essentially unchanged since that time.

2.2 Topography

The topography of the land is gently undulating and, based on the results of a land survey and a digital terrain model provided by Harleyford Aggregates Ltd., the majority of land varies between around 11mAOD to 15.5mAOD as shown schematically on Figure 3.

2.3 Land Use

The site is located in a rural setting, with the site and surrounding land predominantly used for agriculture. The area is also interspersed with woodland and farms.

2.4 Soils

The soil type at the site (taken from the LandIS Soilscapes website, developed by Cranfield University accessed on 22/04/2016 [Ref. 3]) is classified as 'freely draining floodplain soils'. Drainage is described as being to local groundwater feeding into rivers.

3 HYDROLOGY

3.1 Hydrological Characterisation

The closest hydrological feature to the site is the River Ribble, which bounds the site to the north, south and west. The river banks are at an elevation of around 12 - 15mAOD. The river flows in a north-westerly direction to the north of the site and a south-easterly direction to the south of the site.

The Bezza Brook is a small tributary of the River Ribble located in the south-eastern part of the site, the banks of which are at an elevation of approximately 15mAOD.

There are a number of small unnamed streams and field drains at or in the vicinity of the site. All of these contribute to flows in the Bezza Brook and/or River Ribble. There are also a number of lakes associated with Brockholes Quarry/Nature Reserve to the southwest of the site.

There are no springs identified in the vicinity of the site on the 1:25,000 scale Ordnance Survey map of the area.

The hydrological catchment descriptors relating to the site, surrounding area and associated hydrological catchment have been derived from the Flood Estimation Handbook (FEH) CD-ROM 3 [Ref. 4] and are provided in Table 1.

Table 1 Hydrological Catchment Descriptors

Descriptor	Abbreviation	Value
Catchment Area	AREA	9.9km^2
Mean Altitude	ALTBAR	86m
Mean direction of all drainage path slopes	ASPBAR	302 degrees
Base Flow Index associated with each HOST soil class	BFIHOST	37%
Standard Percentage Runoff associated with each HOST soil class	SPRHOST	42%
Proportion of time when soil moisture deficit was equal to, or below, 6mm during 1961-90	PROPWET	0.51 (i.e. 51% of the time)
Standard Average Annual Rainfall (1961 – 1990)	SAAR	1050mm
Extent of urban and suburban land within catchment	URBEXT$_{2000}$	0.03

The standard average annual rainfall (SAAR) value is 1050mm/annum, which is consistent with the region. The SPRHOST value indicates that the proportion of runoff within the catchment is 42%, which is a moderate value. The BFIHOST value is 37%, which indicates that there is a moderate groundwater component in the river discharge. The urban extent registered in the year 2000 (URBEXT2000) is 0.03, reflecting the very rural nature of the catchment. These descriptors are consistent with the site setting and known hydrogeological setting presented in Section 5.

3.2 Surface Water Features

Surface water features within 2km of the site have been identified from 1:25,000 Ordnance Survey mapping. The locations of the surface water features are presented on Figure 3 and their details are summarised in Table 2.

Table 2 Surface Water Features

Reference on Figure 3	Feature	Description	Distance from Site
A	River Ribble	River flowing in a north-westerly direction to the north of the site and a south-easterly direction to the south of the site.	Adjacent
B	Bezza Brook	Small tributary of the River Ribble located in the south-eastern part of the site.	Within Site Boundary
C	Unnamed streams/field drains	Small unnamed streams and field drains at or in the vicinity of the site. All of these contribute to flows in the Bezza Brook and/or River Ribble.	Within Site Boundary
D	Pit lakes at Brockholes Quarry	Pit lakes associated with Brockholes Quarry to the southwest of the site.	0.4 – 0.6km

3.3 Flood Zones

The majority of the site is located within Flood Zone 3 and Flood Zone 2, as defined by the Environment Agency flood zone map. However, the north-eastern most section of the site is located within Flood Zone 1. A Flood Risk Assessment (FRA) is presented in Sections 8 to 11 of this report.

4 GEOLOGY

The geological setting of the area has been characterised using information from the British Geological Survey (BGS) 1:50,000 scale map sheet 75 (Preston) and geological data obtained during site investigations and the construction of piezometers at the site. The geological setting is presented on Figure 4.

4.1 Regional Geology

4.1.1 Superficial Deposits

The geological map shows Quaternary age River Terrace Deposits overlying Glacial Till. The River Terrace Deposits forms the economic resource at the site and are described as predominantly sand and gravel, locally with lenses of silt or clay, whilst Glacial Till is described as a red-brown stiff to sandy clay with pebbles and boulders.

4.1.2 Bedrock Geology

The superficial deposits are underlain by the Permo-Triassic age Sherwood Sandstone Group, which outcrops to the northwest of the site. The Sherwood Sandstone Group is comprised of red, yellow and brown sandstones with subordinate red mudstones and siltstones and is in excess of 100m in thickness.

4.1.3 Structural Geology

In terms of geological structure, there are two mapped faults located within 2km of the site (Figure 4). The closest is located 750m to the southeast of the site, trends in a northwest-southeast direction and downthrows the strata to the southwest. The second fault is located 1.5km to the northeast of the site, trends in a northwest-southeast direction and downthrows the strata to the southwest. The solid strata in the vicinity of the site are relatively flat lying.

4.2 Site Specific Geology

Prior to this study, two site investigations had been undertaken with 15 site investigation boreholes drilled by Blue Diamond Drilling Ltd in 2004 and 21 boreholes drilled by A J Goff Ltd in March 2008. The boreholes were drilled to a maximum depth of 7.5m. Bulk samples were taken from 9 of the boreholes drilled in March 2008 and grading analyses were carried out.

The results are presented by Goff [Ref. 5] and have been reviewed as part of this study to provide a more detailed description of the superficial geology at the site.

4.2.1 Sand and Gravel Deposits

Samples were logged during the site investigation in March 2008 and the deposit described as generally clean, well graded pale coloured flint sand and rounded gravel (mainly flint derived with some sandstone)

overlain by varying thicknesses of clayey silty fine brown sand, and with either a base of firm brown clay or very compacted friable red sandstone [Ref. 5].

The sand and gravel deposit forms the economic resource and varies in thickness between 3 – 7m across the majority of the site (Figure 5). The deposit is thickest in the north-western part of the site and thins out towards the southeast. The elevation of the base of the deposit is variable although it occurs between 6 – 12mAOD across the majority of the site (Figure 6). Based on all intrusive investigations, the geometric mean deposit thickness across the site is estimated to be approximately 6.1m.

4.2.2 Glacial Till

The site investigations in March 2008 indicate that Glacial Till is not present beneath the River Terrace Deposits at all locations across the site. In fact, Glacial Till was only encountered across the centre of the site and is absent to the northwest and east (Figure 7). This was further confirmed during the installation of piezometers in December 2008 (see Section 5.2)

4.2.3 Sandstone

The focus of previous investigations was on the thickness and nature of the sand and gravel deposits and not the nature of the underlying sandstone. Therefore no site specific information was obtained.

5 HYDROGEOLOGY

5.1 Aquifer Potential

The aquifer potential at the site has been assessed using literature published by the BGS in the Principal and Secondary aquifers database [Ref. 6 and 7]. There are two aquifer systems of interest at the site; the River Terrace Deposits and the Sherwood Sandstone Group.

River Terrace Deposits

The River Terrace Deposits form a locally important unconfined, shallow minor aquifer [Ref. 6]. Groundwater movement through the sands and gravels will be predominantly intergranular. Locally, lenses of silt and clay will impede groundwater movement, resulting in complex flow paths and possibly perched water systems. The overall level of saturation in the superficial deposits is likely to be seasonally variable and dependent on the rate of recharge and hydraulic connectivity with the River Ribble.

Glacial Till generally has a low permeability and where present is likely to impede movement of water between the underlying sandstone and overlying gravel. Where absent, there is likely to be hydraulic continuity between the Sand and Gravel aquifer and the underlying sandstone.

Sherwood Sandstone Group

The Sherwood Sandstone Group is classified as a major aquifer of regional importance. In this region, the Sherwood Sandstone Group has a low intergranular hydraulic conductivity and porosity [Ref. 7]. The majority of groundwater flow therefore occurs where the sandstone is well fractured, with a lower contribution from the rock matrix.

5.2 Piezometer Installation

In December 2008, 8 piezometers were installed at the site by Allied Exploration Geotechnics Ltd as shown on Figure 3. The installation was supervised by Envireau Water; the location of the piezometers was chosen taking into account the expected geology at the site.

The piezometers were constructed using a combination of cable percussion and rotary drilling methods. All boreholes were drilled at 150mm diameter. 75mm uPVC standpipe was installed to the appropriate depth and the piezometers completed as shown in Appendix A. Six of the piezometers were completed in the sand and gravel deposits whilst two piezometers were completed to a depth of 6m into the underlying sandstone. The basic details of the construction are summarised in Table 3.

Table 3 Summary of Piezometer Construction

Piezometer	PZ1	PZ2 Deep	PZ2 Shallow	PZ3	PZ4 Deep	PZ4 Shallow	PZ5	PZ6
Ground Elevation (mAOD)	12.72	13.79	13.63	12.52	13.95	13.9	16.02	15.19
Completion Depth (mbgl)	5.95	13.07	6.36	6.25	13.61	7.29	4.46	2.51
Screened Aquifer Unit	Sand and Gravel	Sandstone	Sand and Gravel		Sandstone	Sand and Gravel		
Screened Section (mAOD)	8.22 – 7.22	2.29 – 0.29	8.13 – 7.13	7.22 – 6.22	0.95 – -1.05	7.40 – 6.40	13.02 – 11.52	13.69 – 12.69
Groundwater Level on completion (mAOD)	9.08	8.93	9.02	8.84	9.76	9.60	13.20	dry

Logging of sample returns by Envireau Water during the construction of the piezometers provided additional geological information to supplement the results of the previous site investigations. The completion depth of the piezometers constructed in the sand and gravel deposits is indicative of the thickness of mineral deposit at those locations and is consistent with the expected thickness based on the previous site investigation carried out in March 2008.

The primary purpose of the piezometers was to provide groundwater level data, which has been interpreted (see Section 5.3 below) to better understand the hydrogeology at the site. Of particular interest are the groundwater flow directions, interaction between the river and the sand and gravel deposits, and potential for connection with the deeper sandstone aquifer.

The piezometers provide permanent groundwater monitoring locations and could be utilised during the future development of the site. The piezometers have been constructed such that they can also be used to obtain groundwater samples for water quality analysis in the future, should this be required.

5.3 Groundwater Levels

Automatic water level monitoring equipment was installed in all the piezometers in September 2009 to collect water level data at a frequency of 6 times per day and groundwater level data has been collected and reviewed on quarterly year intervals since that time.

The groundwater level data is reproduced as a series of hydrographs for the entire monitoring period (August 2009 to March 2016) on Figure 8 together with rainfall data recorded at two nearby gauging stations (Haighton, approximately 4km north east of the site; Moor Park, approximately 5.5km west of the site).

Figure 9 presents the hydrographs and the river stage data from the River Ribble at Samlesbury gauging station, located between PZ2 and PZ3. This shows that with the exception of periods of very high flow and peak stage, the river level is at least 1-2m below the groundwater level.

Summary statistics based on the entire monitoring period are presented in Table 4. The approximate distance of the piezometers from the river has been derived by Envireau Water based on OS mapping data.

Table 4 Summary of Groundwater Level Statistics

Piezometer	PZ1	PZ2 Deep	PZ2 Shallow	PZ3	PZ4 Deep	PZ4 Shallow	PZ5	PZ6
Approx. distance from river (m)	40	50	50	55	19	19	220	260
Screened Aquifer Unit	Sand and Gravel	Sandstone	Sand and Gravel		Sandstone	Sand and Gravel		
Site Location	N bank	W bank	W bank	W bank	NE bank	NE bank	East field	West field
Water Levels (m) below ground level								
Maximum	4.49	5.70	5.60	4.65	4.80	4.60	3.74	N/A dry
Minimum	1.61	3.99	3.83	2.96	2.44	1.38	2.00	
Average	3.77	5.04	4.95	4.05	4.36	4.22	3.10	
Range (m)	2.9	1.7	1.8	1.7	2.4	3.2	1.7	
Water Levels (mAOD)								
Maximum	11.1	9.8	9.8	9.6	11.5	12.5	14.0	N/A dry
Minimum	8.2	8.1	8.0	7.9	9.1	9.3	12.3	
Average	8.9	8.7	8.7	8.5	9.6	9.7	12.9	

Groundwater levels in both the sand and gravel aquifer and the sandstone aquifer vary between 1.4 – 5.7m below ground level across the site.

The average water level in the piezometers on the north and west river banks is approximately 8.5mAOD, whereas the water level upstream at PZ4 is approximately 1m higher.

PZ5, located away from the river towards the eastern perimeter of the site, has the highest average water level at approximately 13mAOD, which is more than 3m higher than the average water levels at the other piezometers. PZ6 has remained dry since it was constructed.

5.4 Recharge & River Interaction

With the exception of PZ6 (which is dry), groundwater levels observed in all the piezometers show a similar trend and suggest they are responding quickly to recharge type events either from direct infiltration (Figure 8) or interaction with the river (Figure 9).

The hydrographs for PZ4 shallow and deep (Figure 9) show that groundwater rises sharply with recharge and recedes quickly following recharge. This 'flashy' response during recharge and recession correlates with the river flow data and is attributed to interaction with the river. PZ4 is located 19m from the river bank and is the closest of the piezometers to the river.

PZ5 is located the furthest from the river (220m) and is screened at 13.02 – 11.52mAOD. The S_{50} stage in the River Ribble is 8.5mAOD. Thus, the borehole is screened in the region of 2 – 4.5m higher than the normal stage in the closest part of the river. This difference in elevation means it is not possible for the river to be impacting groundwater levels at PZ5. The response observed at PZ5 is therefore attributed to recharge from surface; not interaction with the river.

The remaining piezometers (1, 2 & 3) show responses similar to both the flashy response of PZ4 and the smoother response of PZ5.

The hydrographs for PZ2 (shallow and deep) and PZ3 show similar response shapes to PZ5, which suggests these piezometers are also responding principally to recharge from surface and not interaction with the river. This would suggest that the influence from the river is limited to ~50m, i.e. the distance of PZ2 from the river.

PZ1 is 40m from the river and shows an intermediate response between PZ3 (55m), and PZ4 (19m). As would be expected in this environment, the data demonstrates that the interaction with the river decreases with distance and water levels are controlled more by recharge from surface.

The hydrographs for river stage and groundwater in Figure 9 show that both are responding with to the same rainfall events. There is also direct interaction between the river and groundwater within 50m of the river which increases the response to recharge close to the river.

During periods of recession (drier periods) the groundwater levels gradually decrease but always remain at least 1-2m above river level. This observation is consistent with groundwater providing baseflow to the river.

The groundwater level data demonstrates that the River Ribble is the local hydrological base for the site and local groundwater system but direct interaction between the river and the sands and gravels is likely to be limited to within ~50m of the river bank. The interaction is a function of distance and permeability of the sand and gravel deposit.

5.5 Hydraulic Conductivity of the Sand and Gravel Deposits

The results from grading analyses carried out on soil samples obtained during site investigations in March 2008 have been analysed using the Hazen method [Ref. 8] to derive values of hydraulic conductivity for the sand and gravel deposits at the site. The results of the full analysis are presented in Appendix B and summarised in Table 5.

Two samples demonstrated d_{10} values outside the valid limits of Hazen (S/01/2 & S/05/1 - 0.06mm and 0.5mm respectively) and were omitted from the statistical analysis.

Table 5 Hydraulic Conductivity of Sand and Gravel Deposits

Site Investigation Hole	Grain Size d_{10} (mm)	Hydraulic Conductivity (m/day)
S/01/1	0.200	41.5
S/01/2	0.060	3.7
S/02/1	0.180	33.6
S/03/1	0.250	64.8
S/03/2	0.250	64.8
S/04/1	0.300	93.3
S/04/2	0.125	16.2
S/04/3	0.200	41.5
S/05/1	0.5	259.2
S/05/2	0.3	93.3
S/08/2	0.180	33.6
S/09/2	0.150	23.3
Geometric Mean (excluding invalid data)		40.4

The spatial variation in hydraulic conductivity of the sand and gravel deposits at the site is illustrated on Figure 10. The analysis shows that the hydraulic conductivity of the sand and gravel ranges from 16 – 93m/day, with a geometric mean of 52m/day. This is consistent with available baseline information for shallow sand and gravel aquifers [Ref. 6] although it should be noted that the permeability of glacial sediments is highly variable and no baseline information is available for the sand and gravel deposits at the specific site in question.

There are likely to be areas of lower and higher hydraulic conductivity in the deposit. In particular, it is the areas of higher hydraulic conductivity which is likely to be of interest as these have the potential to transmit water at a higher than average rates.

5.6 Hydraulic Continuity with the Sherwood Sandstone Group

There is only a small difference in water levels observed in the sand and gravel piezometers to those recorded in the deeper piezometers completed within the sandstone. Given the geological setting, this suggests that overall there is likely to be hydraulic connection between these two aquifer units, particularly at the regional scale. However, at a local scale, the degree of hydraulic continuity is influenced by the presence (and thickness) of Glacial Till which separates the two aquifers in some places at the site.

Figure 11 shows the groundwater hydrographs for PZ2 (shallow and deep), where sand and gravel deposits directly overly the sandstone. The observed water levels for the deep and shallow installation are considered to be the same with the minor variation (in the order of a few centimetres) probably attributed to the piezometer construction and being within an acceptable range for field measurement error. The data therefore suggests that there is direct continuity and little hydraulic resistance between the sands and gravels and the sandstone where the Glacial Till is absent. The sandstone is therefore effectively unconfined.

Figure 12 shows the groundwater hydrographs for PZ4 (shallow and deep), where a ~2m layer of Glacial Till separates the sand and gravel deposits from the underlying sandstone. The trend in the two hydrographs is very similar, suggesting that there is some regional connection between the two formations.

Unlike the data from PZ2, there is a significant difference in groundwater levels recorded in the shallow and deep installations at PZ4. These hydrographs show that following the winter recharge period, groundwater levels in the sandstone (PZ4 Deep) are up to 10cm higher than in the sands and gravels (PZ4 Shallow), suggesting an upward hydraulic gradient. Conversely, following the summer recession, for example July 2010, groundwater levels in the sands and gravels are up to 20cm higher than in the underlying sandstone, suggesting a downwards hydraulic gradient.

The clay layer therefore provides vertical separation and reduces the magnitude of the response in the sandstone to river interaction events. At the peak of the winter recharge period, groundwater levels in both the shallow and deep formations are very similar. Following the period of recharge, recession is observed more strongly in the sands and gravels, leading to the upward gradient which is then reversed during the summer recession period.

5.7 Conceptual Hydrogeological Model

A conceptual model for the site is presented as Figure 13. The superficial sand and gravel deposit varies in thickness between 3 – 7m across the majority of the site and thins out towards the south-eastern part of the site. Recharge occurs by direct infiltration of rainfall and indirectly by runoff from the higher ground to the east.

The underlying Sherwood Sandstone Group is composed predominantly of sandstone with bands of mudstones and siltstones and is in hydraulic continuity with the overlying sands and gravels. However, the central part of the site has up to 2m of Glacial Till separating the sand and gravel deposit from the sandstone aquifer (Figure 7), which provides vertical separation and acts as a local confining layer. The clay layer reduces the magnitude of the response in the sandstone and there can be either an upward or downwards vertical gradient between the two formations depending on the season.

The River Ribble is the local hydrological base but interaction between the river and the sands and gravels is likely to be limited to within ~50m of the river bank. The interaction is a function of distance and permeability of the deposit.

Hydraulic conductivities of the sand and gravel across the area have been calculated using the Hazen method (Appendix B), indicating a typical range of hydraulic conductivities between 16 – 93m/day, with a geometric mean of 52m/day. Locally however, hydraulic conductivities could be one or two orders of magnitude lower/higher and where this is the case there is a possibility that the rate of groundwater migration could be much lower/higher than generally expected.

6 ENVIRONMENTAL SETTING

As part of this assessment, a review of the environmental setting within a 2km radius of the centre of the site has been undertaken. The Environment Agency and local councils have been contacted and a search of the Natural England online database undertaken.

6.1 Licensed Abstractions

Details of licensed abstractions within a 2km radius of the site have been obtained from the Environment Agency (Appendix C). There are four licensed abstractions in the search radius, the locations of which are shown on Figure 14 and summary details provided in Table 6.

Table 6 Licensed Abstractions

Map Ref	Licence No.	Abstraction Point	Source	Licence Holder	National Grid Reference	Distance from Site Centre (m)	Annual Licensed Quantity (m^3)
1	26/71/33/ 9010	Lagoon at Brockholes Quarry	Groundwater	Lancashire Wildlife Trust	SD 585 313	500	1,685,000
2	26/71/33/ 8030	Borehole at Elston Old Hall Farm	Groundwater	J & L Eccleston	SD 599 324	1300	7,955.5
3	26/71/33/ 9006	Boreholes (4) at Samlesbury	Groundwater	Interbrew UK Ltd	SD 584 300	1700	3,273,000
4	NW/071/ 0339/002	River Ribble at Lower Brockholes Quarry	Surface Water	Hargreaves Ltd	SD 579 301 & SD 578 301	1700 - 1800	437,583

Of the licensed abstractions, there are three groundwater abstractions from the Sherwood Sandstone and one surface water abstraction from the River Ribble, downstream of the site. The Lancashire Wildlife Trust licence at Brockholes Quarry is the closest to the site and is located on the opposite side of the river to the site.

6.2 Deregulated Abstractions

Details of deregulated abstractions within a 2km radius of the site have been obtained from the Environment Agency (Appendix C). There is one deregulated abstraction (< $20m^3$/day) in the search radius. The location of the deregulated abstraction is shown in Figure 14 and summary details are provided in Table 7.

Table 7 Deregulated Abstractions

Map Ref	Licence No.	Abstraction Point	Source	Licence Holder	National Grid Reference	Distance from Site Centre (m)	Annual Licensed Quantity (m^3)
5	26/71/33/ 9008	Borehole at Lower Brockholes Farm	Groundwater	L Redmayne	SD 575 303	1900	4,977.87

The deregulated abstraction is a groundwater abstraction from a borehole located at Lower Brockholes Farm; on the opposite side of the river to the site. The water is used for general agriculture and water supply.

6.3 Private Water Supplies

A search of the registers of Private Water Supplies (PWS) at Preston City Council, Ribble Valley Borough Council, and South Ribble Borough Council has been undertaken. Four private water supplies were identified within a 2km radius of the site as shown on Figure 14; three within the Preston City Council district, and one within the South Ribble Borough Council district. The summary details provided by the Councils are presented in Table 8.

Table 8 Private Water Supplies

Map Ref	Abstraction Point	Source	National Grid Reference	Distance from Site Centre (m)
6	Borehole at Brockholes Nature Reserve (Visitor Centre)	Groundwater	SD 58769 30904	625
7	Borehole at Elston Old Hall Farm	Groundwater	SD 60023 32426	1450
8	Borehole at Lower Brockholes Farm	Groundwater	SD 57575 30288	1800
9	InBev Brewery	Unknown	SD 594 297	2050

Of the recorded PWS, three are groundwater abstractions that are likely to target the Sherwood Sandstone and one is classed as 'unknown' although it is also expected to be a groundwater abstraction from Sherwood Sandstone. The PWS at Brockholes Nature Reserve is the closest PWS to the site and is located on the opposite side of the river.

It is recognised that the PWS registers may be incomplete and that unrecorded supplies may also exist at outlying properties. The potential for any unrecorded PWS in close proximity to the site should be checked prior to development.

6.4 BGS Water Wells Database

A search of the BGS boreholes and wells online database has been undertaken, which has identified 32 borehole records within the 2km radius.

Of the boreholes, 25 are described as targeting the Sherwood Sandstone Group, 2 target the Superficial Deposits and 5 boreholes are unknown, although based on their locations and the geology of the area they are expected to be targeting the Sherwood Sandstone Group or Superficial Deposits. The closest of the borehole records are located at Red Scar Wood approximately 0.45km southwest of the centre of the site.

The borehole records are summarised in Appendix D and their locations are presented on Figure 14.

6.5 Source Protection Zones

Source Protection Zones (SPZs) are used as a general level of protection for all drinking water sources, identifying those areas where the risk associated with groundwater contamination is greatest.

Data obtained from the Environment Agency shows that the site lies within a SPZ 3 (Total Catchment) associated with the licensed abstraction at Interbrew UK Ltd (Map Ref. 3 on Figure 14). The location of the Environment Agency defined SPZs in the vicinity of the site are presented on Figure 15.

A default circular SPZ with a radius of 50m is applied to all other groundwater abstractions intended for human consumption. However, there are no recorded abstractions within 50m of the site.

6.6 Natural England Designated Sites

A search of Natural England's MAgiC database identifies three protected areas within 2km of the site as shown on Figure 14.

The Red Scar and Tun Brook Woods SSSI borders the north-western boundary of the site, Pope Land Open Space LNR is approximately 100m to the west and Grange Valley LNR is approximately 750m to the west of the site.

The SSSI and LNRs are not groundwater dependent features. The River Ribble separates the site from the protected areas, therefore they are hydraulically separated and there is no threat to any of the protected areas as a result of the proposed development.

There are no Ramsar Sites, Special Protection Areas (SPA), Biosphere Reserves or other designated areas within the 2km radius.

7 PROPOSED DEVELOPMENT

7.1 Mineral Extraction

Harleyford Aggregates proposes to extract sand and gravel at the site. The site will be worked to the base of the sand and gravel deposit, which varies in thickness from approximately 3 to 7m (base of deposit at 6 - 12mAOD).

It is intended that the unsaturated deposit will be worked dry and the remaining saturated deposit will be worked wet, as far as practicably possible. No dewatering is planned to take place.

A phasing plan will be prepared prior to commencement of the development. A draft plan showing the restoration scheme is presented in Appendix E and shows the extent of the proposed mineral extraction.

The mineral will be worked in cells, extracting dry above the water table and then extracting wet below the water table. Extraction is likely to commence in the southeast corner of the site and the excavation will continue northwest in a clockwise direction to the bend in the River Ribble and then returning to the eastern limit of the site. Once a cell has been worked the 'wall' between that and the previous cell will be removed to make a continuous water body as shown on the restoration plan in Appendix E. A 25m standoff zone will be maintained between working cells and the River Ribble.

The development will require the construction of a new access road to the A59 and a new private access road from that access road to the mineral extraction and processing area; the proposed route of which is presented on the plan in Appendix F. A central haul road to transport mineral from excavation cells to the processing plant will be constructed through the site and removed as final operations retreat towards the east. The residual route of the haul road will be used to create the islands shown on the plan in Appendix E.

7.2 Surface Water Management

A surface water management plan will be developed based on the final phasing plan and will be prepared prior to commencement of the development. The key principles of surface water management during mineral extraction will be:

- There will be no dewatering.
- Surface water generated on site will be contained within the working area (the excavation cells).
- There will be no active discharge (pumping) of water from the working area to the adjacent surface waters.

During normal operations, the above principles will prevent surface water associated with the proposed development coming into direct contact with the identified surface water features in close proximity to the site.

It is already recognised that workings could become inundated and it may not be possible to contain all surface water during storm (flood) events, on which basis:

- Plant and fuel/chemical stores will be mobile so they can be relocated off site in the event of a flood event.
- Working areas will provide flood water attenuation and promote conveyance of flood waters across the flood plain.

The above principles will be embedded into the surface water management plan for the site.

7.3 Restoration

On completion of mineral extraction, the excavation will be restored to a lake with islands and reed beds. The site could be utilised as an unmanned flood alleviation feature, with an inlet on the River Ribble towards the northeast corner of the site and an outlet towards the southwest. However, this concept would need to be discussed and agreed with the Environment Agency.

8 FLOOD RISK ASSESSMENT

This Flood Risk Assessment (FRA) has been written in accordance with the National Planning Policy Framework (NPPF) [Ref. 1] and the accompanying online resource, Planning Practice Guidance: Flood Risk and Coastal Change [Ref. 2].

The principal objectives of this assessment are to demonstrate that the proposed sand and gravel extraction development will:

- Result in no net loss of floodplain storage;
- Not impede water flows; and
- Not increase the risk of flooding at the site or elsewhere.

8.1 Flood Zones and Levels

The Environment Agency Rivers and Sea flood map shows the extent of a fluvial flood without defences with a 1% annual probability (1 in 100 year flood – Flood Zone 3) and additional extent of an extreme fluvial flood with up to a 0.1% annual probability (1 in 1,000 year flood – Flood Zone 2) for a given location. Flood Zone 3 is split into Zone 3a (1% annual probability) and Zone 3b, the functional floodplain (5% annual probability or a 1 in 20 year flood event). The Environment Agency Rivers and Sea flood map does not delineate between Zones 3a and 3b.

The Environment Agency Rivers and Sea flood map for the site and surrounding area is presented as Figure 16 and shows that the majority of the site is located within Flood Zone 3 and Flood Zone 2. However, the north-eastern most section of the site is shown to be within Flood Zone 1 (<0.1% annual probability). In line with the requirements of the NPPF, sites situated within Flood Zone 2 and 3 should be assessed on the basis of the 1 in 100 year fluvial flood, including a climate change allowance. In line with the recent update to climate change allowances to support NPPF by the Environment Agency on 19th February 2016 [Ref. 9] a peak river flow allowance factor of 15% has been deemed appropriate. This reflects the flood risk vulnerability classification of the proposed development (see Section 8.2) and expected lifespan (up to the year 2039).

The majority of the proposed private access road to the A59 will be situated in Flood Zone 1. However, a small section from the processing plant south-east to Potters Lane will be situated i(n part) within Flood Zone 3 and Flood Zone 2. This section of the private access road will be designed and constructed unfenced and level with the adjacent agricultural land to allow agricultural operations to continue.

Comparing stage data of the River Ribble to topographical elevations at the site indicates the vast majority of the site is outside the functional floodplain of the River Ribble and fluvial flooding would be expected at an annual probability of less than 5%.

There is anecdotal evidence to suggest that flooding has occurred at the site in the past and it is understood that this was limited to the southern boundary of the site, which is consistent with the highest recorded stage data measurements and the site topography. For example, the stage data shows that the maximum average daily stage recorded was approximately 11.65m in October 2000, which would result in minor flooding along the southern boundary at the northwest corner of the site and the area of the site between PZ2 and PZ3. The flooding would result from overtopping. While not definitive or statistically valid, the anecdotal evidence provides some reassurance on the flood levels shown on the Environment Agency Rivers and Sea flood map.

The Flood Zone 3a flood level has been estimated from the Environment Agency Rivers and Sea flood map at approximately 15mAOD. Thus, the site could be flooded by up to a depth of approximately 2m in the case of a 1 in 100 year fluvial flood event (1% probability flood event).

8.2 Flood Risk Vulnerability Classification

The site currently comprises agricultural and grazing land. The flood risk vulnerability classification of this land use type as defined in the NPPF [Ref. 9] is 'less vulnerable'. The operational site would be classified as 'water compatible'. This is the least flood-vulnerable of all categories and as such a high degree of flood resilience is expected throughout the extraction operations.

Mobile plant (excavators, dump trucks, etc.), including machinery and fuel/oil/lubricant and chemical stores associated with the site workings will be located within areas at risk of fluvial flooding at the site during normal operating conditions. These land use types would therefore classify as 'less vulnerable'. However, mobile plant will be relocated off site in the event of notification of possible inundation. Fuel, lubricants and other stores will be contained in mobile containers and similarly will be relocated off site in the event of notification of possible inundation. The off site location is that length of the private access road which lies within Flood Zone 1. The site offices will be located on a raised framework at a minimum of 300 mm above the 1 in 100 year fluvial flood level.

The restoration plan for the site indicates that land use will be restored to a series of reedbeds, areas of grassland and a lake. The restored site will therefore remain as 'water compatible'. The lake and surrounding grassland could be utilised as an unmanned flood alleviation feature, providing additional floodplain storage for flood flows associated with the River Ribble.

The development stages and corresponding flood risk vulnerability classification are summarised in Table 9.

Table 9 Flood Risk Vulnerability Classifications

Development Stage	Land Use Type	Flood Risk Vulnerability Classification
Current Application Site (Pre-Development Area)	Agriculture/Grazing	Less vulnerable
Operational	Sand and Gravel Extraction	Water compatible
	Mobile Plant Inc. Machinery and Stores	Less vulnerable
	Site Offices	Less vulnerable
Post-Operational / Restored landform	Grassland/Reedbeds/Flood Alleviation	Water compatible

8.3 Strategic Flood Risk Assessment

District-wide information on flood risk has been obtained from the Ribble Valley Borough Council (RVBC) Strategic Flood Risk Assessment (SFRA) May 2010 [Ref. 10]. The SFRA provides a detailed and comprehensive assessment of the extent and nature of the risk of flooding and its implications for land use in the district.

The primary source of fluvial flooding in the district is the River Ribble. Major historical floods have occurred in years such as 1995, 2000, 2002 and very recently in 2015. The worst hit areas were the villages of Ribchester and Whalley which are situated approximately 7.3km and 15.3km northeast of the site, respectively. No evidence of groundwater flooding within the district was identified during the strategic assessment.

9 POTENTIAL SOURCES OF FLOOD RISK

9.1 Risk of flooding from the sea (Tidal)

The site is substantially inland and not at risk of flooding from the sea.

The normal tidal limit of the River Ribble is approximately 3km downstream of the site at Fishwick Bottoms which is situated between the villages of Samlesbury and Walton-le-Dale.

9.2 Risk of flooding from groundwater

Groundwater levels within the sand and gravel aquifer are likely to be controlled by the water level within the adjacent River Ribble (Section 5.4). Groundwater level data collected since 2009 demonstrates that groundwater levels vary by around 2m seasonally and therefore flooding could occur under normal base-flow conditions in much of the proposed workings.

9.3 Risk of flooding surface water (Pluvial)

Figure 17 shows an extract of the Environment Agency Surface Water Flood Map for the site and surrounding area. The Environment Agency categorise the risk from surface water flooding using the following four categories:

- **High** – Greater than a 3.3% probability of occurrence in any given year;
- **Medium** – Between a 1%-3.3% probability of occurrence in any given year;
- **Low** – Between a 0.1%-1% probability of occurrence in any given year; and
- **Very Low** – Less than a 0.1% probability of occurrence in any given year.

The overall risk of surface water flooding on land at the site is considered to be very low and confined to natural hollow areas.

The low topographic gradients at the site and in the surrounding area result in there being a very low risk of surface water flooding from areas up gradient. In the event that surface water overland flows are generated up gradient it is considered that these would be captured and conveyed to the Bezza Brook/River Ribble or captured within the quarry void.

9.4 Risk of flooding to / from public sewers

The site is in a rural location away from built up areas and as such it is not expected that there would be public sewer systems in the vicinity.

The proposed development and associated infrastructure will not require a connection to a public sewer system. Based on the above, there is no risk of flooding to and from public sewers.

9.5 Risk of flooding from artificial waterbodies

There are no canals or lakes at the site or in the vicinity. Therefore there is no risk of flooding from these sources. However, the site and surrounding area is within the predicted reservoir flood extent of an uncontrolled release of water from a service reservoir owned by United Utilities Water plc.

Reservoir flooding is extremely unlikely to happen. There has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers. As the enforcement authority for the Reservoirs Act 1975 in England, the Environment Agency ensure that reservoirs are inspected regularly and essential safety work is carried out.

Based on the above, it is considered that the risk of flooding to the site from reservoirs is very low.

9.6 Risk of flooding to / from roads

Surface water runoff generated over the proposed private access road will be captured and conveyed by formalised, permanent open drainage ditches and attenuation ponds and basins situated alongside the road.

Based on the above, the risk of flooding to and from roads is therefore considered to be very low.

9.7 Flood Risk Summary

A summary of the potential sources of existing flood risk detailed in Sections 9.1 – 9.6 is highlighted in Table10.

Table 10 Summary of Potential Flood Risk

Flood Source	Potential Risk				
	None	Very Low	Low	Medium	High
Tidal	X				
Fluvial					X
Pluvial		X			
Groundwater			X		
Public Sewers	X				
Artificial Waterbodies		X			
Roads		X			

10 IMPACT OF DEVELOPMENT ON FLOOD RISK

10.1 Floodplain Storage

Subject to discussions with the Environment Agency, the proposed development could be utilised to provide additional floodplain storage for flood flows associated with the River Ribble. This would act to reduce the risk of flooding downstream and provide betterment in areas at high risk of flooding such as the villages of Ribchester and Whalley.

10.2 Conveyance of Flood Waters

It is assumed that when flood waters associated with the River Ribble flow onto the floodplain, they will be able to flow into the excavations. Necessary bunds will be constructed in a form to allow conveyance of flood waters across the floodplain. Any residual soil or overburden arising from the mineral working will be stored and retained in the excavation.

The small section of the proposed private access road from the processing plant south-east to Potters Lane will be situated (in part) within Flood Zone 3 and Flood Zone 2. This section of the private access road is designed and constructed unfenced and level with the adjacent agricultural land to allow agricultural operations to continue. This will also therefore ensure that this section will not negatively alter or impact upon the conveyance of flood waters at the site.

The capture and attenuation of flood water within the excavation cells and working areas during the operational phase of the development would also constitute significant betterment to the current flood risk situation.

11 PREVENTATIVE FLOOD SAFETY MEASURES

The Environment Agency Rivers and Sea flood map for the site and surrounding area shows that the majority of the site is located within Flood Zone 3 and Flood Zone 2. However, the north-eastern corner of the site is shown to lie within Flood Zone 1 (<0.1% annual probability). The site will therefore inundate in a less than 5% annual probability fluvial flood event. This poses a risk to people working at the quarry, site offices, plant and machinery.

It is recognised that a risk of fluvial flooding exists at the site. However, the proposed development also provides floodplain storage by virtue of a void being created, thereby reducing the risk of fluvial flooding downstream of the site.

Preventative flood safety measures for the proposed development and associated infrastructure are discussed in the following sections (Section 11.1 – 11.3). These measures should be adhered to for the longevity of the proposed sand and gravel workings and restoration at the site.

11.1 Flood Warning and Evacuation

The site and immediate surrounding area adjacent to the waterway corridor of the River Ribble is registered with the Environment Agency flood warning area system. This system provides real time, early flood warning information.

In the event that emergency evacuation is required, then that section of the proposed private access road east of Potters Lane and to the A59 will act as a dry access and egress route, and storage area.

11.2 Protection of Offices and Mobile Plant

All manned site offices should either be constructed outside the 1 in 100 year (+15% climate change allowance) fluvial flood extent where possible or so that finished floor levels are set at a minimum of 300mm above the 1 in 100 year fluvial flood level (+15% climate change allowance).

During evacuation procedures at the site mobile plant and machinery should be moved in the first instance to the private access road east of Potters Lane. Early flood warning information provided by the Environment Agency would allow for this before conditions at the site become hazardous.

11.3 Protection of Fuels/Oils/Lubricants and Chemical Stores

Fuel, oil, lubricant and chemical stores will be enclosed and mounted such that, in the event of notification of possible inundation at the site, these stores can be removed from the flood risk area onto the private access road.

12 IMPACT ASSESSMENT

The site is bounded on three sides by the River Ribble and Bezza Brook (a tributary of the River Ribble). A number of water features have been identified in the area, including licensed and unlicensed surface water and groundwater abstractions.

There is no dewatering proposed as part of the development. The mineral will be worked dry above the water table and wet below it. There will also be a sufficient standoff (25m) from the River Ribble and Bezza Brook.

The lakes, streams and drains to the north, south and west of the site are considered not to be at risk from the proposed workings as the River Ribble hydraulically separates them from the site.

There are no surface water features or licensed or unlicensed water abstractions from either ground or surface water that will be affected by the proposed development.

The site is at risk of flooding when the river is high and there is also a risk of groundwater flooding.

The development will provide additional floodplain storage and there is a net benefit during working and following restoration from a flood risk perspective.

13 CONCLUSIONS

The site geology consists of sand and gravel, which forms a Secondary aquifer with a bulk average permeability of 52m^2/day. The groundwater level is between 2 to 5mbgl and the workable deposit is between 3 to 7m in thickness. The River Ribble forms the hydrological base.

There is no dewatering proposed as part of the development. The mineral will be worked dry above the water table and wet below it. There will also be a sufficient standoff (25m) from the River Ribble and Bezza Brook.

The lakes, streams and drains to the north, south and west of the site are considered not to be at risk from the proposed workings as the River Ribble hydraulically separates them from the site.

There are no surface water features or licensed or unlicensed water abstractions from either ground or surface water that will be affected by the proposed development.

The site lies within the natural flood plain of the River Ribble, and is at risk of flooding from a 1 in 100 year storm event (zone 3b). In accordance with PPS25, sand and gravel extraction would be permitted in zones at risk of flooding but mitigation measures will need to be developed to protect the safety of the quarry personnel, plant and local environment.

The development will provide additional floodplain storage and there is a net benefit during working and following restoration from a flood risk perspective. Subject to discussions and an agreement with the Environment Agency, the restored site could be utilised as an unmanned flood alleviation feature, providing additional floodplain storage for flood flows associated with the River Ribble.

Envireau Water
16/06/2016

14 REFERENCES

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