RICK BRASSINGTON
Consultant Hydrogeologist

Proof of Evidence for
Professor Frederick Charles Brassington

On behalf of Stop Bengeo Quarry

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Contents

1. Introduction

1.1 This document has been prepared as an Expert Report by Professor Frederick Charles Brassington on behalf of Stop Bengeo Quarry ("**SBQ**"), a local group opposed to the granting of permission to RJD Ltd and Gowling WLG Trust Corporation Ltd ("**the Applicants**") to quarry sand and gravel at Bengeo Field, also known as Ware Park in Hertford (**"Bengeo Field"**).

FREDERICK CHARLES BRASSINGTON will say:

1.2 The evidence which I have prepared and provide for this appeal (reference APP:M1900/W/17/3178839) in this proof of evidence is true and I confirm that the opinions expressed therein are true and professional opinions.

Qualifications and Experience

1.2 I hold the degrees of BSc in geology from Liverpool University and MSc in civil engineering from Birmingham University. I am a Chartered Geologist and a Fellow of the Geological Society of London; a Chartered Civil Engineer and a Member of the Institution of Civil Engineers; a Chartered Water and Environmental Manger and a Fellow of the Chartered Institution of Water and Environmental Management; and hold the European qualifications of European Geologist and European Engineer. I was appointed to the honorary position of the Visiting Professor of Hydrogeology in the School of Civil Engineering and Geosciences at Newcastle University in 2007.

1.3 I am a hydrogeologist and water resources engineer with more than 50 years of professional experience. I was employed in a number of posts in the public sector from 1967 to 1991 when I moved into consultancy. I held posts at Director level in three major companies until I established my own independent consultancy practice in 1998. Full details of my Curriculum Vitae are contained in Appendix 2 to this Expert Report.

1.4 I am the author of more than 30 scientific papers and technical articles and have written two textbooks, one on the design construction and maintenance of private water supplies and the second on field methods in hydrogeology.

1.5 I have had experience in both environmental regulation and as a consultant assessing the potential impact from mining and quarrying on surface and groundwater systems. During my employment with the Severn River Authority, the North West Water Authority and the National Rivers Authority I made routine assessments of such proposals or managed those who did. I represented the North West Water Authority at two public inquires of sandstone quarrying and as a consultant I have acted as an expert witness at several public inquires including the major limestone quarry at Whatley in Somerset and two proposed opencast coal mines in the Manchester area.

1.6 Since I started my independent consultancy in 1998 I have provided advice to clients on the potential impacts of several large limestone quarries in south and west Cumbria and in Derbyshire; sandstone quarries in Derbyshire and North Yorkshire; opencast coal mines in County Durham and south Wales; and sand and gravel quarries in North Yorkshire, Shropshire and Essex. I recently acted as an expert witness on a claim for damages relating to alleged water supply interruptions alleged to be caused by opencast coal mining near Durham. I worked on the hydrogeology and gave evidence at a public inquiry on a proposed opencast coal mine in the Castleford area. I worked on the assessment of the hydrogeological impact of a long-established sandstone quarry in Greater Manchester. I have also worked with TerraConsult Ltd advising on the hydrogeological aspects of quarries the company is working on for clients located in different geologies across northern England, the Midlands, the southwest and in North Wales. In addition to Stop Bengeo Quarry, my clients since 1998 include Aggregate Industries Ltd, Armstrongs Aggregates Ltd, the Banks Group, Celtic Energy Ltd, Land Securities Group plc, Long Rake Spar Co Ltd, James Associates, Marshals plc, SRC Ltd, Skipton Properties Ltd, Stancliffe Stone Company Ltd, Tarmac (Northern) Ltd, TerraConsult Ltd and Tudor Griffiths Ltd.

Instruction

1.7 My instruction is to provide an expert review of the proposed quarry at Bengeo Field, in particular its potential impact on a nearby local groundwater source that is used for public water supplies.

1.8 My instruction is also to consider mitigation systems proposed by the Applicants that are designed to prevent the contamination of that water source at Wadesmill Road pumping station owned and operated by Affinity Water and make appropriate comments.

Information used to prepare this report

1.9 This report is based on information in documents supplied to me by SBQ and other publicly available information that are listed in Appendix 1 of this report.

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2. Executive Summary

2.1 The two reports prepared on the site by Hafren Water Ltd (**"Hafren"**) has made on behalf of the Applicants[1] have been reviewed and the geological and hydrogeological aspects are accepted, except for the aspects that refer to the proposed measures to be taken to prevent the pollution of the nearby Wadesmill Road pumping station by the disturbance of fine-grained materials and/or the spillage of fuel oils, lubricants or domestic sewage from the site offices, including those aspects that refer to the elevation of the Chalk rockhead.

2.2 In particular, the way that the buried Chalk surface has been defined is not considered to be in sufficient detail to define local peaks and troughs that are expected to occur across the site and impact on the thickness of the layer of sand and gravel that is proposed to be left in situ to act as a filter for the fine-grained materials.

[1] Hydrogeological Impact Assessment in support of gravel extraction at Ware Park, Hertford, Hertfordshire. Report ref: 1701/HIA-01 Final. Dated July 2014 (the **"Hafren 2014 report"**); and, (2) Addendum to Hydrogeological Impact Assessment Ware Park, Hertford. Dated July 2017 (the **"Hafren 2017 report"**). The Hafren 2014 report covers the area of the original proposal and the Hafren 2017 report refers to the reduced area of the modified proposal as shown in Figure 3.1 below.

3. Geological and hydrogeological background

3.1 The Applicants, proposed mitigation measures rely on Hafren's assessment of the local geological and hydrogeological conditions. This section is included as background to the specific arguments set out in later sections of this proof of evidence.

3.2 The site lies some 2.5 km to the north of Hertford town centre, in an area known locally as Bengeo Field. The Applicants' original proposal covers the whole area inside the red hatched line (marked in red as "Approximate area of the original site") and the modified proposal covers the reduced area in the western half of the site (marked in black as "Approximate revised area") as shown at Figure 3.1 below.

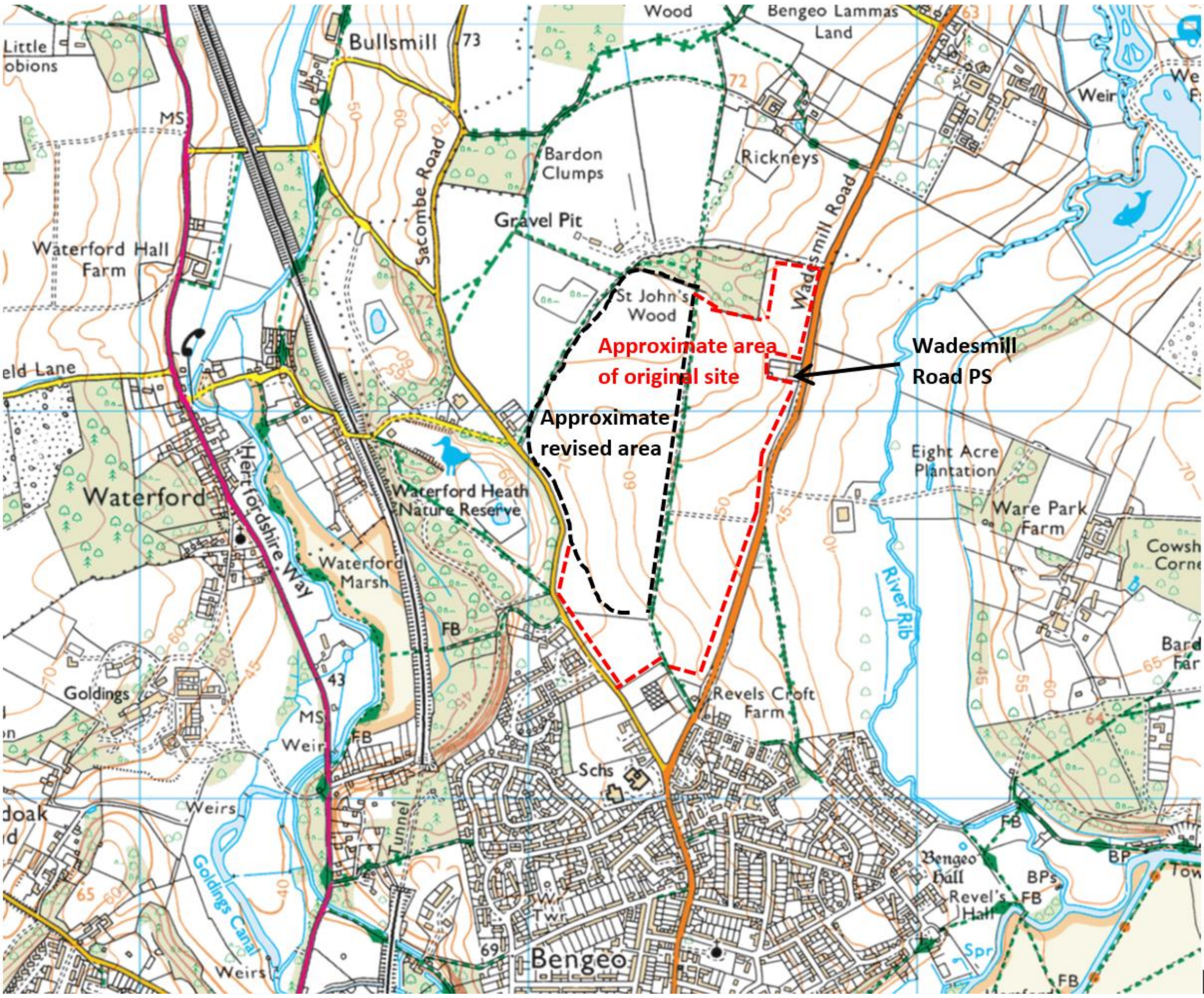

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Figure 3.1 – Location map

3.3 The site lies on the divide between the River Beane to the west and the River Rib to the east, both tributaries of the River Lee with the confluences being in Hertford to the south. The land slopes to the east across the entire site which has an elevation of just under 70 metres above Ordnance Datum (**"mOD"**) in the west to below 50 mOD in the east. A shallow dry valley feature runs west to east across the site.

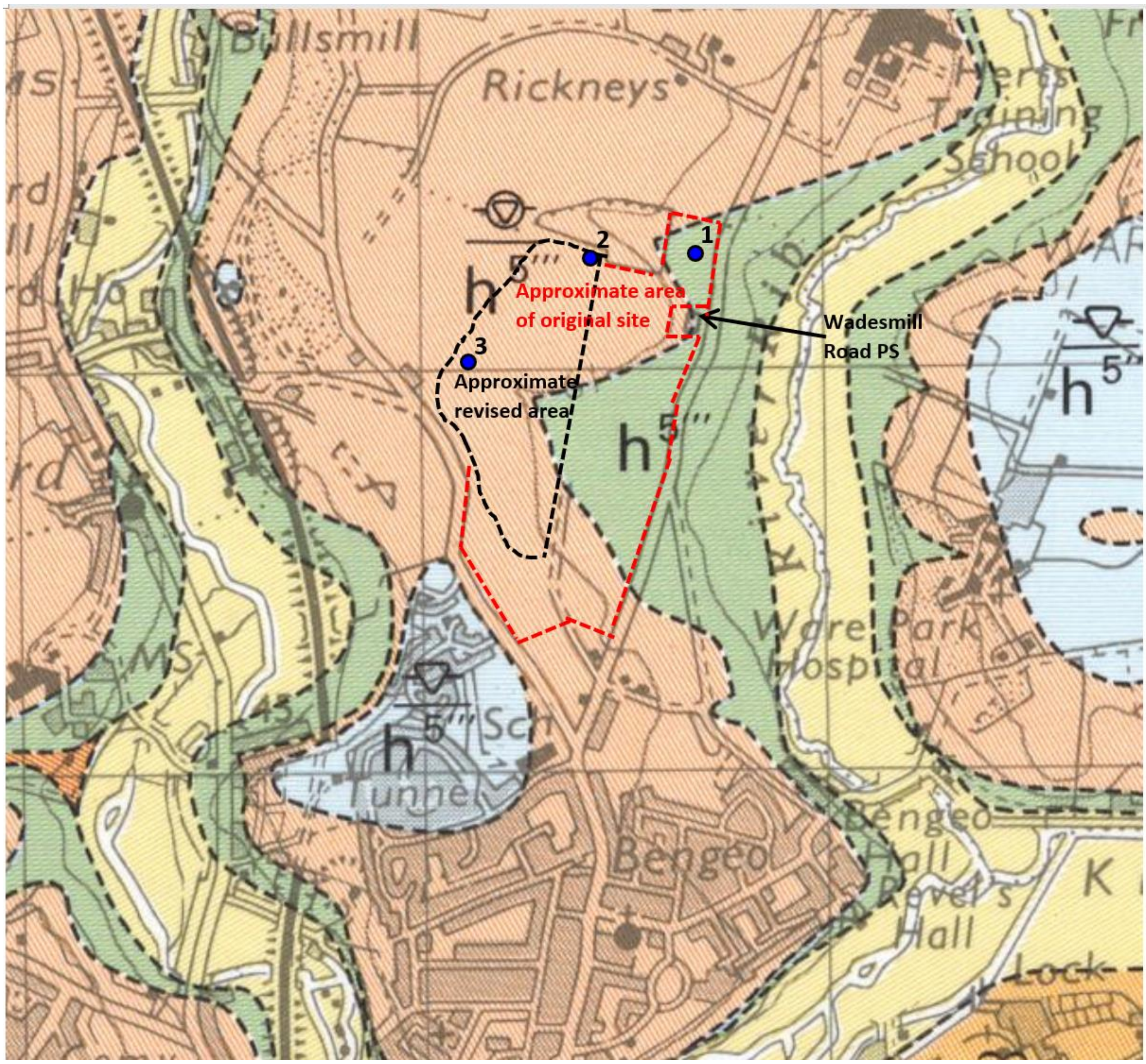

Figure 3.2 – Geological map

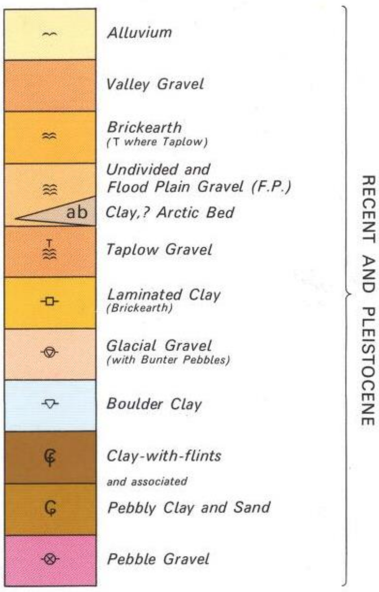

Figure 3.3 – Key to Geological map

Note: The solid rocks are all Upper Chalk and are coloured green with symbol h$^{5'''}$

3.4 The geology of the area is shown at Figure 3.2 above, which is based on the 1:50 000 scale British Geological Survey (**"BGS"**) map. Again, the approximate site boundaries of the original and modified proposals are shown along with the Wadesmill Road Pumping Station. Three observation boreholes used to monitor groundwater levels and possible pollution from the nearby Rickneys Quarry are also indicated (as blue dots) and marked 1, 2 and 3. The key to this map is shown at Figure 3.3.

3.5 It can be seen that the whole area covered by the map is underlain by Upper Chalk and that the site is underlain by Glacial Gravel. The lower part of the eastern slopes is shown as Upper Chalk at outcrop. The Glacial Gravel has since been reclassified as the Kesgrave Catchment Subgroup that comprise mainly river terrace sand and gravel, brickearth silt and alluvial floodplain silt, silty clay and sand that were deposited by the proto-Thames. Boreholes drilled for the Applicants in 2013 and by Pioneer Aggregates in the 1980's show that the area of Chalk shown on the map as being at outcrop to be overlain by up to 9 m of clay.

The Chalk aquifer

3.6 The Chalk is the most significant principal aquifer (i.e. water-bearing rock) in the United Kingdom and provides significant public and private water supplies. It was mentioned earlier in this proof of evidence as the source of water for the Wadesmill Road pumping station. Chalk is a type of limestone and has its own peculiar characteristics.

3.7 The Chalk is said to have *dual porosity* (or *double porosity*) as it has a relatively small porosity in the matrix of the rock and a much larger porosity that results from fractures that are associated with the earth movements that have affected the rock. As a result of the relatively large porosity of the fractures in the Chalk the aquifer is said to have a *dual permeability*.

3.8 In addition, as a limestone the Chalk rock is soluble in percolating waters and consequently has developed karst features that are developed (enlarged) fractures that can carry groundwater flows at relatively high velocities; in addition to features such as swallow holes. Karstic development in the Chalk aquifer increases its permeability in many places, increasing the flow of water to boreholes. However, the process of dissolution decreases with depth and the effective thickness of the Chalk is commonly held by hydrogeologists to be limited to some 30 – 60 m below the surface.

3.9 The Kesgrave Catchment Subgroup sand and gravel deposits mentioned above are dry with the water table in the Upper Chalk being at a depth of some 30 m in the boreholes 2 and 3 on the map in Figure 3.2 and some 12 m depth in borehole 1 on the east.

3.10 The groundwater elevations in the Chalk aquifer are strongly influenced by the abstraction from the nearby Wadesmill Road pumping station. The abstraction started in 1936 and would have lowered the natural groundwater levels in the area. I interpret the natural levels to be within the sand and gravel deposits. The groundwater flow would have been towards the River Rib and to have formed small streams that can still be seen on the satellite images for the area as shown at Figure 3.4 below.

Figure 3.4 – Dry stream channels seen on satellite imagery

Pollution concerns in the Chalk aquifer

3.11 The Environment Agency (**"EA"**) has evaluated the source catchment areas for all public water supply sources derived from groundwater. The EA defines a source catchment area in terms of the time it takes for the groundwater to travel to the borehole from all points in the borehole catchment. A source catchment area includes Source Protection Zones (**"SPZs"**). The Inner Zone (**"Zone 1"**) is where the groundwater arrives at the borehole in no more than 50 days. The Outer Zone (**"Zone 2"**) is where the groundwater arrives in less than 400 days. Groundwater in the Total Catchment (**"Zone 3"**) may take much longer to arrive at the borehole although all the recharge that takes place in this area will eventually arrive at the borehole source.

3.12 The EA has set different levels of protection for each SPZ and its policy guidance states that it will normally object in principle to any planning application for a development in Zone 1 that may physically disturb an aquifer. In this case, the Applicants propose to physically disturb the aquifer by removing part of the overlying materials that provide protection, in the process disturbing fine-grained particles that if washed into the groundwater makes it turbid. [Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye. The measurement of turbidity is a key test of water quality with the maximum acceptable concentration at consumers' taps being 4 NTU (Nephelometric Turbidity Units)].

3.13 The fact that most of the site - both in its original and modified form - lies inside the Zone 1 (as shown over the page at Figure 3.5) for the public water source means that the percolating water could quickly reach the water table and flow into the local boreholes with the fine-grained material still in suspension. The fact that the proposed quarry operation would also use fuel oil and lubricants and would generate sewage also poses a threat to the local groundwater resources. The presence of such fractures or swallow holes beneath the sand and gravel cover could result in a rapid contamination of the public supply boreholes from turbidity, spilled fuel oils or leaked domestic sewage.

3.14 Fractures and joints (including faults) in the Chalk matrix have been formed by tectonic disturbances or resulting from stress release upon uplift and sub aerial exposure. The fractures typically occur in three orthogonal joint sets of small aperture (≤ 5 mm with the majority being ≤ 1 mm) and account for only a very small fraction of the total porosity of the rock (typically ≤ 0.01%). As a result of their low porosity, fractures possess low storage capacity compared to the Chalk matrix but where fractures are open by dissolution, they are extremely transmissive and account for nearly all of the effective measured permeability of the aquifer (typically between 10^{-1} m/day and 102 m/day). This characteristic of the Chalk aquifer makes it a highly valuable water resource but also means that it is particularly vulnerable to pollution. Fractures dominate flow and transport and are the principal pore space through which any dissolved contaminant phase will migrate. Owing to dual porosity processes, contamination events in Chalk are highly persistent. Temporary storage in the matrix acts to retard the transport of dissolved species through the Chalk and the slow rate of diffusion means that contamination can persist in the aquifer mass for long periods of time (10s - 100s of years).

3.15 There are examples of groundwater pollution occurring that have impacted on public water supply sources. Significant bromate pollution was discovered in 2001 at two public water supply boreholes abstracting water from the Chalk aquifer at Hatfield Hertfordshire and owned by Affinity Water. This was shown to be from a former chemical works at Sandridge, Hertfordshire. Further investigations showed additional public water supply boreholes to be at risk that lie as far away as the Hertford area. The result has been significant expense in investigating and treating the water and modifying the local sewer system to take the effluent. The investigations showed that karstic groundwater flow has been a significant factor in the spreading of the bromate pollution from the former chemical site.

Figure 3.5 – Source protection zones for the Wadesmill Road PS

3.16 This case has also been the subject of a EngD study by Dr Simon Cook at University College London (The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Incorporating Karst in Predictive Models). In his findings, he says that karst and solution enhancement of the aquifer is more common in the Hertfordshire Chalk than had been established previously.

3.17 There are other examples of pollution incidents such as a a plume of chloride originating from former mine workings at Tilmanstone in Kent that is of similar extent and magnitude to the bromate contamination in the Hertfordshire Chalk aquifer. Another local example is of fuel oil (unleaded petrol) leaking from a site in Luton discovered during December 2001 that affected the Crescent Road public water supply pumping station.

4. Reports by Hafren Water and proposed mitigation measures

Hafren 2014 report

4.1 Hafren provide a detailed report on the hydrogeology of the site and the following sections of the Hafren 2014 report are accepted in their entirety:

- Section 1 – Introduction
- Section 2 – Site setting
- Section 3 – Baseline conditions
- Section 5 – Assessment of impacts

4.2 The report identifies the risks to the groundwater alluded to in paragraph 3.12 above, namely: the mobilization of fine-grained materials mentioned above by the excavation of the sand and gravel deposit that may cause turbidity; the accidental spillage of fuel oils and lubricants from the machines used to work the deposit; fuel stored on site; and domestic sewage from the site office.

4.3 The suggested mitigation measures are set out in sections 4 and 6 in the Hafren 2014 report. However, as the Hafren 2017 report makes several changes to the perceived risks these will be discussed together below.

4.4 The most significant aspect of the Hafren 2014 report is contained in paragraph 3.6.2 and headed "Aquifer characteristics". The report says:

"***The aquifer is very vulnerable to contamination due to the presence of the fracture network**. Very rapid flows can occur through the fracture system in both the unsaturated and saturated zones. Tracer tests in the Chilterns have recorded transport times of several metres per day (Allen et al, 1997). In addition, once contamination enters the Chalk matrix it is very difficult to remove".* (emphasis added)

Further, the report states, at paragraph 3.6.7, headed "*Conceptual hydrogeology*", that:

"*...any polluted material that reaches the chalk has the potential to be rapidly transported in the direction of flow. In the case of Ware Park**, this could mean contamination reaching the Wadesmill Road PWS in a very short period***." (emphasis added)

4.5 I agree with these observations and it is my view that the proposed quarrying threatens the local groundwater quality for the reasons set out above (i.e. turbidity, fuel and domestic sewage leakage etc) and if this occurs it will impact on the Wadesmill Road pumping station.

The Hafren 2017 report

4.6 Hafren comments on a proposed reduction in the area of the original site and changes to the location of the wheel wash, welfare and office units. The report states that:

"*Due to the revised positioning of the wheelwash and welfare and office units, there are additional risks from hydrocarbons washed off vehicles in the wheelwash and foul drainage from the offices and mess facilities. Again, without mitigation measures, there are potential 'medium' to 'high' to groundwater with a significance of 'major'*."

Proposed Mitigation Measures

4.7 The mitigation proposed in the Hafren reports involve not removing all the sand and gravel down to the rockhead. Instead a thickness of some 5 m will be left unworked to a distance of some 300 m from the Wadesmill Road source; that will reduce to 3 m up to 500 m from the source; and then it will reduce further to 1 m for the remainder of the site.

4.8 The Applicants propose in paragraph 6.1.2 of the Hafren 2014 report that the following mitigation measures will also be implemented:

Fuel storage & re-fuelling

Storage tanks to comply with the relevant storage regulations; fuel bowsers to be double-skinned and with limited capacity; refuelling only in designated prepared areas and drip trays used; designated persons be trained and no refuelling except by them; refuelling only by manually operated systems; spill kits provided at refuelling stations.

Screening plant

Fuel tank to be double-skinned, and protection included to contain any leak; spill pan installed for refuelling.

Vehicles

Regular vehicle checks to ensure fuel storage and engine condition are satisfactory and that no fuel release will occur during site operations; spill kits provided on all mobile plant.

Procedures and reporting

All spills to be reported; impacted soils removed; a protocol will be developed to cover the refuelling and spill response; the Environment Agency and Affinity Water will be informed at the earliest opportunity and appropriate course of action agreed.

Additional proposed mitigation

All the water used by the wheel washer will be recycled; the foul drainage from the office and welfare blocks will be collected in tanks and emptied periodically.

4.9 Hafren suggest that the above mitigation measures change the risk to the groundwater system from ‘high’ to ‘negligible’. I do not agree with this dramatic change in risk category because of the high likelihood of there being karstic features in the underlying Chalk aquifer that will provide rapid transport of any leaking or spilled fuel oil or domestic sewage from the site office and mess facilities. It perhaps reduces the risk to ‘medium’ at the most.

5. The Chalk rockhead

5.1 The mitigation for the mobilization of fine-grained materials is to leave untouched an unworked layer of sand and gravel that varies in thickness across the site from 5 m in the east to 1 m in the southwest and west. Essentially, the thickness of the sand and gravel materials that are to be left undisturbed would be reduced as the workings move away from the public water supply source.

5.2 However, even if a 5 m thick layer is thought sufficient to filter out any disturbed fine-grained materials in a range up to 300 m from the source, there is no reason to believe that lesser thicknesses will be adequate to perform the same task at greater distances. The potential flow paths from the Chalk rockhead beneath the sand and gravel will be through fractures some of which may be large, and these could exist across the whole of the quarry area. The flow rates along such fractures may be so rapid that any pollution would take only a day or two to reach the public supply borehole. On that basis the thickness of sand and gravel left in place should be 5 m across the whole area.

5.3 The main difficulty, however, with any proposal to leave a specified thickness of sand and gravel in place is in the understanding of the surface on which it rests. With their reports, Hafren have supplied drawings of contours on the base of the excavation: drawing number 1701/HAI-01/13 in July 2014 modified to drawing number 1701/HAI-AD/02 in July 2017 as listed in Appendix 1 of this proof of evidence.

5.4 The contours are based on information from a series of boreholes that have been drilled across the site during the 1980's and in 2013. Figure 5.1 below shows the rockhead contours and the boreholes on which they are based.

5.5 The drawings appear to have been created using a smoothing program to determine the elevations between the data points. Such programs use the 'least squares method', a form of mathematical regression analysis that finds the line of best fit for a dataset, and provides a visual demonstration of the relationship between the data points, which in this case are the contour lines.

5.6 In my view the Chalk rockhead is unlikely to be smooth and instead there are expected to be local changes on the scale of the proposed site that will result in the thickness of the residual sand and gravel being less than that proposed, i.e. 5 m. The thickness could be significantly different in some cases.

5.7 The deposits known as the Kesgrave Catchment Subgroup which locally comprise mainly sands and gravels with some silts were deposited on an eroded rockhead in the Lower Pleistocene (about 2 million years ago). These materials have been identified as having been deposited by river erosion and the presence of gravels suggests that the river would have been a high energy environment that is likely to have caused a different shaped rockhead to that shown in the Hafren documents. It is likely that there will be irregularities a few metres high in locations across the site.

5.8 This conclusion is backed up by a statement by George Sandell formally chairman of a campaign group opposed to quarrying in the area to the north of the present proposed site. He said: *On one occasion early in the 1990s we received a report that the chalk aquifer had been breached. To ensure that the matter was dealt with by County Planning I took a photograph - accompanied by Rev Gerard Booker to witness the event - from the edge of Bardon Clumps. The photograph clearly showed an area of Chalk covering an area of over 60 square metres and this was sent to the County Planning Officer. Pioneer* [the site operator] *did cover the area with gravel very quickly and while I am not aware of any actual contamination of the aquifer it did show that the aquifer did have peaks and was not level or even.*

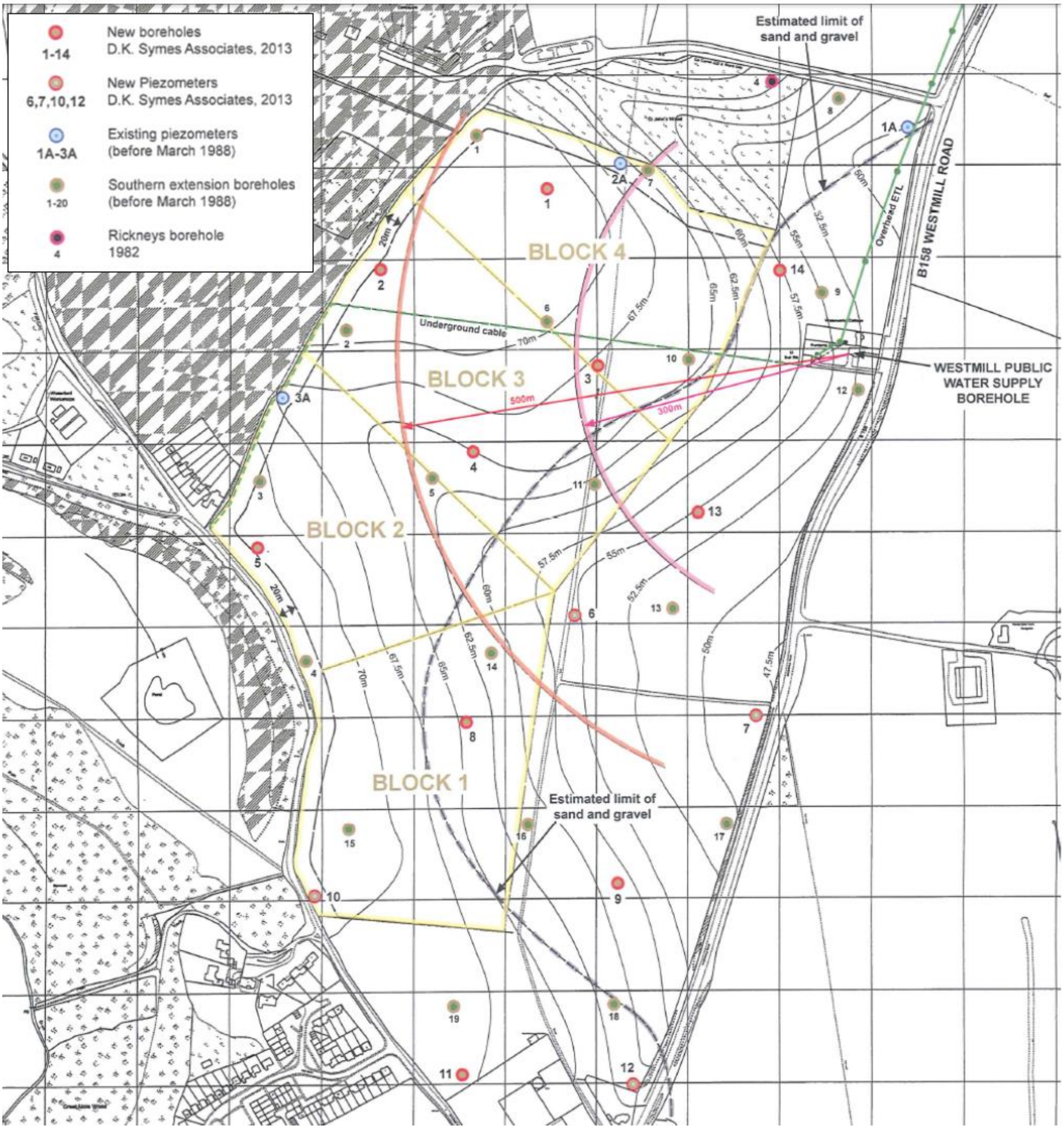

Figure 5.1 – Chalk rockhead map

5.9 The present information that has been used by Hafren to show the contours on the base of the proposed quarry is not sufficient to be sure that the thickness of sand and gravel left in situ will be 5 m. An appropriate geophysical survey could provide more detailed information although the available techniques are likely to miss significant features on the rockhead such as large fractures and swallow holes because these are difficult to detect. Even with a detailed survey, fissures that exist beneath the sand and gravel cover may well not be located.

5.10 Due to these technical problems with the available methods to detect fractures and swallow holes on the buried Chalk rockhead, it is recommended that the precautionary principle is applied, and the application be refused. At the very least, it is suggested that before any permission to quarry can be given, a detailed survey using appropriate geophysical methods should be used to identify the Chalk rockhead across the whole of the site.

6. Fuel oil, lubricants and foul drainage

6.1 The proposals to deal with these potential contaminants is to contain the liquids in safe tanks and collect any spillage when the machines are being refuelled.

6.2 While these proposed mitigation measures seem adequate the location of the proposed quarry and its proximity to the Wadesmill Road pumping station should not be ignored especially as the site lies within a SPZ 1 where the travel times for groundwater to reach the borehole would be less than 50 days. If karst features such as enlarged fractures or swallow holes exist beneath the Kesgrave Catchment Subgroup layer, then travel times to the borehole could be one or two days or even less for spilled fuel oils, lubricants or domestic sewage from the office block.

6.3 In such circumstances, any planning conditions for any future application that are concerned with the proposed mitigation measures for dealing with the potential spillage of contaminating liquids on the site need to be more prescriptive than those proposed by the Applicants. It is suggested that the conditions should stipulate that immediately following any spillage of these contaminating liquids the affected sand and gravel or other materials should be excavated, stored in a safe location and then removed from site as soon as possible. This is likely to be the only effective method of dealing with such a leakage.

6.4 It is also requested that the sand and gravel layer to be left in situ is increased to 5 m across the whole site rather than be a decreasing thickness away from the Wadesmill Road public water supply source.

7. Discussion and conclusions

7.1 The description of the hydrogeology of the area around the proposed quarry site by Hafren is considered to be accurate. In addition, the potential threats to the groundwater beneath the site and consequential pollution of the nearby Wadesmill Road pumping station as identified by Hafren are considered to be exhaustive.

7.2 However, the mitigation measures proposed - to leave a thickness of sand and gravel in place to act as a filter to remove the fine-grained materials that inevitably will be mobilized during the digging operations, and for the contaminating liquids that will be brought to site and could potentially reach the groundwater body to be contained in tanks and the like – are insufficient to reduce the risk level to the groundwater source from high to negligible as concluded by Hafren for the reasons set out above.

7.3 It might be argued that the permission to quarry can be granted now, on condition that the Applicants conducts adequate surveys of the Chalk aquifer, as described above. It is entirely possible that these surveys would identify features of the Chalk aquifer that preclude safe quarrying in this location on the scale proposed by the Applicants. It should be incumbent on those making any future application to quarry on this site to produce convincing evidence that it is safe to do so. That evidence is not currently available.

7.4 The proposed quarrying of sand and gravel in a site that lies within a SPZ 1 threatens the quality of the groundwater being abstracted from the Wadesmill Road boreholes. If this occurs the contaminants cannot be removed from the aquifer for all practical purposes and the source will have to be abandoned. Such action will not just be the loss of this infrastructure but will also extend to the pipes and reservoirs where the water is pumped and represents a very large loss to the water company as well as the inconvenience suffered by those that are served by the source at the moment.

7.5 The Wadesmill Road public water supply source is threatened by this proposal and if it is polluted the contaminated water could be distributed to homes across the Hertford area before anyone realizes that it has happened such as if leakage of fuel oil or sewage occurs for some time before it is noticed. In any event, pollution of the Chalk aquifer will mean that the pollutants will remain in the aquifer and it could result in the source being abandoned. The logical conclusion of the Chalk rockhead and fracture issue when combined with the high risks to the groundwater source posed by the proposed development within a SPZ 1 for a public water supply source is that the precautionary principle should be used, and the application should be refused.

Appendix 1 – Information used in this report

The report uses information from the following documents:

Reports from Hafren Water Ltd

Hafren Water July 2014 Hydrogeological Impact Assessment in support of gravel extraction at Ware Park, Hertford, Hertfordshire including drawings Numbered 1701/HIA-01/01 – 14.

Hafren Water July 2017 Addendum to Hydrogeological Impact Assessment Ware Park, Hertford including drawings Numbered 1701/HIA-AD/01 – 03.

DK Symes Associates. Drilling for Sand and Gravel. Drawing No 1217/DS/1. Dated 20th May 2013.

DK Symes Associates Borehole logs by from 2013 and earlier.

Hydrogeological and geological information

Information has also been obtained from these publications:

Cook, S.J. 2010 The Hydrogeology of Bromate Contamination in the Hertfordshire Chalk: Incorporating Karst in Predictive Models. Unpublished EngD thesis University College London

Cook, S. J., Fitzpatrick, C. M., Burgess, W. G., Lytton, L., Bishop, P. and Sage, R. 2012 Modelling the influence of solution-enhanced conduits on catchment-scale contaminant transport in the Hertfordshire Chalk aquifer Geological Society, London, Special Publications **364** (1):205

Downing, R.A., Price, M. and Jones, G.P. 1993 *The Hydrogeology of the Chalk of North-West Europe*. Clarenden Press Oxford. 300pp

Headworth, H., Puri, S. and Rampling, B. 1980 Contamination of a Chalk aquifer by mine drainage at Tilmanstone, East-Kent, UK *Quarterly Journal of Engineering Geology* **13**(2), 105-117.

McMillan, A.A, Hamblin, R.J.O. & Merritt, J.W. 2011 *A lithostratigraphical framework for onshore Quaternary and Neogene (Tertiary) superficial deposits of Great Britain and the Isle of Man*. British Geological Survey Research Report, RR/10/03. 343pp.

Maurice, L. 2008 *Investigations of rapid groundwater flow and karst in the Chalk* PhD thesis, University College London.

Maurice, L., Atkinson, T., Barker, J., Bloomfield, J., Farrant, A. and Williams, A. 2006 Karstic behaviour of groundwater in the English Chalk *Journal of Hydrology* **330**, 63-70.

Sumbler, M.G. 1996 *British Regional Geology: London and the Thames Valley* (Fourth Edition). British Geological Survey, Nottingham 173 pp.

Watson, S. (2004), Solute transport and hydrodynamic characteristics in the Chalk aquifer at Tilmanstone, Kent. PhD thesis, University College London.

British Geological Survey maps and publications

Sherlock, R.L. & Pocock, R.W. 1924. *Geology of the country around Hertford*. Explanation of geological sheet 239. Memoirs of the Geological Survey of Great Britain, England and Wales (New Series) HMSO, London

Geological Sheet 239 Hertford. 1:50 000 Series Solid and Drift Edition Published 1978

Borehole records from the BGS website: http://www.bgs.ac.uk/data/boreholescans/

Ordnance Survey maps

Ordnance Survey Sheet 194 Hertford & Bishop's Stortford 1:25 000 scale published 2015

Environment Agency information

What's in your backyard online map-based information on various matters

Policy statements

The Environment Agency's approach to groundwater protection November 2017 Version 1.1

Information on source protection zones; and abstraction licences

http://apps.environment-agency.gov.uk/wiyby/37833.aspx

Appendix 2 – Curriculum Vitae of Prof Rick Brassington

PERSONAL DETAILS

FULL NAME: Professor Frederick (Rick) Charles BRASSINGTON

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BORN: 22 May 1946 at Skegness, Lincolnshire NATIONALITY: British

EDUCATION & PROFESSIONAL QUALIFICATIONS

BSc Geology, University of Liverpool, 1967
MSc Civil Engineering, University of Birmingham, 1974
Fellow of the Geological Society, 1968; Chartered Geologist, 1990; *(Member of Council, 1991 - 94, & 2015 - 18; Vice-President 1993/4 & 1994/95)*
Fellow of the Institution of Geologists, 1985 *(Member, 1978; Member of Council, 1978 - 83; Honorary Secretary, 1980 - 83) (Founding Fellow, 1985: Aberconway Medallist, 1987)*
Chartered Civil Engineer, 1990; Member of the Institution of Civil Engineers, 1990
Fellow of the Chartered Institution of Water and Environmental Management, 1989 *(Member, 1975); (Member of Editorial Panel 1987 -1997; Chairman, 1992 - 94) (Publication Award, 1989)*
Chartered Water and Environmental Manger (2002)
European Engineer (Eur Ing), 1992 European Geologist (Eur Geol), 1996
Visiting Senior Fellow University of Liverpool 1989 - 2002
Visiting Professor of Hydrogeology, Newcastle University from 2007

EMPLOYMENT RECORD

1998 to date: Principal, Rick Brassington - *Consultant Hydrogeologist*, Warrington
See (http://www.brassingtonhydrogeology.co.uk/) & (http://www.ncl.ac.uk/ceg/staff/profile/rick.brassington)

An independent consultancy in all aspects of hydrogeology, water resources management and training. Expert witness. Clients include the Environment Agency, local authorities, multinational companies in soft drinks and mineral waters, brewing, chemical manufacture etc, engineering consultancies, water well drillers, farmers and private individuals (see client list).

1997- 1998: Technical Director and Head of Hydrogeology, Stanger Science & Environment, Manchester
Responsible for the development of hydrogeological and water management consultancy services across the UK. Senior consultant in hydrogeology, water resources management and water well design and construction. Expert witness.

1993 - 1997: Northern Regional Manager, Southern Science Ltd, Manchester.
Established and developed the company's first regional office and was part of company management team. Senior consultant in hydrogeology and water well design and construction. Expert witness.

1991 - 1992: Managing Director, Hydrotechnica Ltd, Shrewsbury
In charge of all aspects of the company's management and business development in the UK and overseas. Senior consultant and expert witness in water resources management and specialist aspects of hydrogeology and water well construction.

1988 - 1991: Regional Water Resources Manager, National Rivers Authority - North West Region, Warrington
Established the regional department concerned with all aspects of surface and groundwater resources assessment, management and control; solid waste management and data processing. Member of the Regional Management Team and regional committees: at national level, member of R&D Committee (Commissioner for Water Resources R&D), and member of Water Resources Group.

1986 - 1988: Hydrogeological Services Manager, North West Water, Warrington
Responsible for providing hydrogeological support for all North West Water's regulatory and operational activities by managing a multi-disciplinary team of hydrogeologists and chemists. Developed an internal consultancy service for improving the efficiency of groundwater source operation and groundwater control in civil engineering construction.

1976 - 1986: Principal Engineer (Hydrogeology), North West Water, Warrington
Set up, developed and managed a section of hydrogeologists to provide groundwater assessment, management and protection. Established groundwater data collection networks and procedures for assessing abstraction licence applications and evaluating landfill sites. Managed and co-ordinated large multi-disciplinary hydrogeological investigations.

1974 - 1976: Senior Hydrogeologist/Site Engineer, Waste Disposal Department, Tyne and West County Council, Newcastle-upon-Tyne
Dual role in providing a hydrogeological service for the Waste Disposal Department and for the day-to-day operation of county landfill sites. Introduced procedures to assess and monitor privately operated landfills. Conducted numerous investigations into the groundwater aspects of landfills.

1968 - 1974: Hydrogeologist, Severn River Authority, Malvern, Worcestershire
Provided the hydrogeological input to water resources management and planning. Completed the first comprehensive assessment of groundwater resources in the Severn catchment. Designed and initiated the observation borehole network. Undertook hydrogeological investigations of landfill sites following the 'cyanide scares' of the early 1970's.

1967 - 1968: Assistant Hydrologist, Lothians Rivers Purification Board, Edinburgh
Carried out field measurements of rainfall and river flows, monitored gauging station calibration and data processing and validation.

PUBLICATIONS

1. Journal Papers (Peer reviewed):

Rushton K.R. & Brassington, F.C. (2016) Pumping from unconfined aquifers of limited saturated thickness with reference to well points and horizontal wells. *Hydrogeology Journal*, **24(2)**, 335–348

Rushton, K.R. & Brassington, F.C. (2013) Hydraulic behaviour and regional impact of a horizontal well in a shallow aquifer: example from the Sefton Coast, northwest England (UK). *Hydrogeology Journal* **21(5)**, 1117-1128.

Brassington, R. (2013) Lessons Learned About the Nature of Groundwater Contamination by PAHs: A Case History-Based Discussion. *Remediation* **23(1)**, 103-121.

Rushton, K.R. & Brassington, F.C. (2013) Significance of hydraulic head gradients within horizontal wells in unconfined aquifers of limited saturated thickness. *Journal of Hydrology*, **492**, 281-289.

Brassington, F.C. & Taylor, R. (2012) A comparison of field methods used to define saline/fresh groundwater interfaces. *QJEGH*, **45,** 173- 181

Brassington. F.C. & Younger, P.L. (2010) A proposed framework for hydrogeological conceptual modelling. *Water and Environment Journal* **24**, 261–273

Brassington, F.C., Whitter, J.P., Macdonald, R.A. & Dixon, J. (2009) The potential use of hydrogen peroxide in water well rehabilitation. *Water and Environment Journal* **23** 69–74

Brassington, F.C. (2007) A proposed conceptual model for the genesis of the Derbyshire thermal waters. *QJEGH*, **40**, 35 – 46

Brassington, F.C. & Preene, M. (2004) A horizontal wellpoint as a low impact water source in a dune sands aquifer. *Water & Environmental Management*, **18**, 102-106

Brassington F.C. (2003) A note on aspects of the Harrogate mineral waters. *QJEGH*. **36**, 75-83.

Preene, M. and Brassington, F.C. (2003) Potential groundwater impacts from civil engineering works. *Water & Environmental Management* **17** pp 59-64

Brassington, F.C. & Preene, M. (2003) The design, construction and testing of a horizontal well-point as a water source in a dune sands aquifer. *QJEGH*, **36**, 355-366

Preene, M. and Brassington, F.C. (2001) Environmental regulation of groundwater abstraction for dewatering works. *Geotechnical Engineering* 149 pp 75-76

Brassington F.C. (1992) Measurements of head variations within observation boreholes and their implications for groundwater monitoring. *JIWEM* **6**, pp 91-100

Brassington F.C., Lucey P.A. and Peacock A.J. (1992) The use of down-hole focused electric logs to investigate saline groundwaters. *QJEG* **25**, pp 343-50

Brassington F.C. (1992) Present and future use of groundwater resources. *Modern Geology* **16**, pp 363-374

Brassington F.C. (1990) A review of rising groundwater levels in the United Kingdom. *Proc Inst Civ Eng, Part 1,* **88** Dec, pp 1037-1057

Walsh P.D. and Brassington F.C. (1990) Application of weather forecasts and meteorological products for river management. *Weather*, Nov 1990, pp 408-413

Howsam P., Brassington F.C. and Lucey P.A. (1989) The examination of encrustations in an unlined borehole using the sidewall sampling technique *QJEG* **22**, pp 139-44

Rushton K.R., Kawecki M.W., Brassington F.C. (1988) Groundwater model conditions in Liverpool sandstone aquifer *JIWEM* **2** pp 67-85

Brassington F.C. and Rushton K.R. (1987) A rising water table in central Liverpool *QJEG* **20** 151-58

Brassington F.C. and Walthall S. (1985) Field techniques using borehole packers in hydrogeological investigations *QJEG* **18** pp 181-93

Brassington F.C. (1982) Hydrogeological problems caused by Quarrying. *Trans Inst Min & Metal Applied Earth Science* **91** pp B21-25

Ireland R.J. and Brassington F.C. (1981) An investigation of complex saline groundwater problems in the Permo-Triassic Sandstones of North West England. *The Science of the Total Environment* **121** pp 261-66

2. Contributions to edited works (Peer reviewed):

Brassington, F.C. (2014) Interpretation of groundwater data in the vicinity of a long-established sandstone quarry. pp. 108-117 in Hunger, E., Brown, T. J. and Lucas, G. (Eds) *Proceedings of the 17th Extractive Industry Geology Conference*, EIG Conferences Ltd. 202 pp.

Brassington F.C. (2004) Developments since 1974 – bringing the story up to date. In *200 Years of British Hydrogeology*, Geological Society of London Special Publication 225, 363-385. Mather J.D. (ed.)

Brassington F.C. (1998) Contributions on "Hydrogeology" and "Water Divining" for *The Encyclopaedia of Hydrology and Water Resources*. Edited by R.W. Hershey and R.W. Fairbridge. Kluwer Academic Publishers.

Gallagher N.J. and Brassington F.C. (1994) Merseyside Groundwater - Regional overview and specific example. Paper 15 in *Groundwater Problems in Urban Areas* - Proceedings of the International Conference organised by the Institution of Civil Engineers (London 1993). Edited by W.B. Wilkinson Institution of Civil Engineers, London, pp 310-329

Jones G.P. and Brassington F.C. (1992) Data collection storage, retrieval and interpretation. Chapter 7 in *Applied Groundwater Hydrology*, Downing R.A. and Wilkinson W.B. (Eds) Clarendon Press, pp 96-113

Wilkinson W.B. and Brassington F.C. (1992) Rising groundwater levels - an international problem. Chapter 4 in *Applied Groundwater Hydrology,* Downing R.A. and Wilkinson W.B. (Eds) Clarendon Press, pp 35-53

3. Authored Books

Brassington F.C. (2017) Field Hydrogeology. Fourth edition. John Wiley and Sons, Chichester. 294pp

Brassington F.C. (2006) *Field Hydrogeology.* Third edition. John Wiley and Sons, Chichester. 264pp

Brassington F.C. (1998) *Field Hydrogeology.* Second edition. John Wiley and Sons, Chichester. 248 pp

Brassington F.C. (1998) *Alumbramiento de Aguas – guía para le construcción y mantenimiento de suministros de agua privados.* Editorial Acribia, S.A., Zaragoza. 242 pp (Spanish Language edition of *Finding Water* second edition)

Brassington F.C. (1995) *Finding Water - a guide to the construction and maintenance of private water supplies.* Second edition. John Wiley and Sons, Chichester. 280 pp

Brassington F.C. (1988) *Field Hydrogeology*. Geological Society of London Professional Handbook Open University Press 176 pp

Brassington F.C. (1983) *Finding Water - a guide to the construction and maintenance of private water supplies.* Pelham Books Ltd 184pp

4. Edited Books

Atkinson K., & Brassington F.C. (editors) (1983) *Prospecting and Evaluation of Non-Metallic Rocks and Minerals*. Papers given at the *Extractive Industry Geology Conference 1983.* Institution of Geologists 264 pp

Brassington F.C. (edit) (1982) *The Geologist's Directory*. Second Edition. Institution of Geologists 180pp

Brassington F.C. (edit) (1980) *The Geologist's Directory*. First Edition. Institution of Geologists 128pp

5. Conference Presentations (other than listed above)

Brassington, F.C. (2017) Practical fieldwork in hydrogeology. *Presentation to the Early Career Hydrogeologists at Strathclyde University.*

Brassington, F.C. (2013) Interpretation of groundwater data in the vicinity of a long-established sandstone quarry. *17th Extractive Industry Geology Conference. Extractive Industry Geology Conferences Ltd.*

Brassington F.C. (2002) Water Resources. *Presentation to the Conference on The Maritime World 2025- Future Challenges and Opportunities, Greenwich Forum, London*

Preene, M. and Brassington, F.C. (2001) The inter-relationship between civil engineering works and groundwater protection. *Environment Agency Conference on Protecting Groundwater*

Gallagher N.J. and Brassington F.C. (1994) Merseyside Groundwater - Regional overview and specific example. *Presentation to the International Conference on Groundwater Problems in Urban Areas. Institution of Civil Engineers, London*

Brassington F.C. (1992) Groundwater sampling and monitoring. *Presentation to the Conference on Groundwater Quality, Cafe Royale, London*

Brassington F.C. (1992) Investing in excellence to produce the ultimate landfill. *Presentation to the 94th Annual Conference. Institute of Wastes Management*

Brassington F.C. (1990) Recent water supply experiences of climatic extremes in England and Wales. *Presentation to 10th Annual Seminar. International Association of Hydrogeologists, Irish Group, Dublin, Ireland.*

Brassington F.C. (1980) Controlled and uncontrolled groundwater development. *Paper presented to British Assoc Advancement of Science: Salford.*

6. Other articles:

Brassington F.C. 2011. *The use of Hydrogen Peroxide for the remediation of water wells.* Online publication Newcastle University. See: http://research.ncl.ac.uk/geometry/assets/pdf/Summary%20of%20Hydrogen%20Peroxide%20experiments%20at%20the%20Geometry%20borehole%20array%202011.pdf

Brassington F.C. (2002) A brief history of the Institution of Geologists. *Geological Society Web Page.*

Brassington, F.C. & Preene M. (2002) A new type of water source for Southport and Ainsdale. *Greenkeeper International*, September 2002, pp 18 – 22

Brassington F.C. (1991) Construction causes hidden chaos. *Geoscientist* 14, pp 8-11

Brassington F.C. (1988) Errors in hydraulic conductivity and groundwater level measurements and their significance in groundwater pollution control. In *Land Disposal of Hazardous Waste.* Gronow JR, Schofield AN & Jain RK (Eds.) pp 49-58

Brassington F.C. (1986) The inter-relationship between changes in groundwater conditions and engineering construction. In: *Groundwater in Engineering Geology* Cripps, J.C., Bell, F.G. & Culshaw, M.G. (eds), Geological Society, pp 47 – 50

Brassington F.C. (1974) Description of aquifers and assessment of groundwater resources in the Severn River Authority Area. In *First Periodical Survey of Water Resources and Demands.* Severn River Authority.

Brassington F.C. (1978 – to date) Reviews of technical books - some 50 in total - mainly for the *Journal of the Chartered Institution of Water and Environmental Management* and *Geoscientist* (Geological Society) See www.brassingtonhydrogeology.co.uk for examples.

CLIENT LIST

The Rick Brassington *Consultant Hydrogeologist* practice was founded in September 1998. The following list shows the major clients for whom projects have been undertaken since that date. A large number of other projects have also been completed for private individuals not listed here.

CORPORATE CLIENTS

Aggregate Industries UK Ltd
Armstrongs Aggregates Limited
H.J. Banks Ltd
Lord Barnard, Raby Estate, County Durham
Bass Brewers Ltd
Bechtel Water Technology Limited
Jeremy Benn Associates
Blair Water Well Drilling
Blackshaw Holdings Limited
Bomford Limited
Brontë Natural Spring Water Ltd
Calderdale Metropolitan Borough Council
Carl Bro
Carrillion Facilities Management
Casella Science & Environment Ltd
Church of England Chester Diocese
Coca Cola Enterprises Limited
Coke, Turner & Co
CPL Energy Ltd
Christie Hospital NHS Trust, Manchester
Harrogate Golf Club Ltd
Harrogate Spa Water Limited
Charles Haswell and Partners Limited
Hepscott Water Systems Ltd
High Peak Borough Council
High-Point Rendel
Hillside Golf Club Ltd
James Associates
James Homes (Yorkshire) Limited
Macaw (Soft Drinks) Limited
Frank R. Marshall, Chartered Surveyors
Meller Braggins, Chartered Surveyors
Ministry of Defence (Royal Engineers)
Newcastle under Lyme Borough Council
North of England Zoological Society
NX Consulting Limited
Ove Arup & Partners
Ramswood Nurseries Limited
RoC Consulting Ltd
Royal Spring Natural Mineral Water

Dales Water Services Limited
Edge Consultants UK Ltd
Entec UK Limited
Enventure Limited
Environment Agency
Environmental Simulations International
European Demolition Services Limited
Forestry Commission
Andrew M. Green, Chartered Surveyors
Glentoal Associates Ltd
Haltermann Custom Processing
Hannan Associates
Thomas Hardy Burtonwood Limited
UK Waste Management Limited
United Utilities plc
Urban Splash Ltd
Waterman Environmental Ltd
Severn Trent Water Limited
Shepherd Gilmour Environment Ltd
Simply Fresh Foods Limited
Skipton Properties Limited
Solvay Interox Limited
Southport & Ainsdale Golf Club Ltd
Stancliffe Stone Company Limited
Stanger Science & Environment Ltd
Swinton Electroplating Ltd
TerraConsult Ltd
TGSS Limited
Time Token Limited
Water Management Consultants
Westmorland Limited
J.P. Whitter (Water Well Engineers) Ltd
Woodford Industries Ltd
Yorkshire Spring Mineral Water Company Ltd

Advice and services have been given to the following Corporate Clients through other consultancies:

Airtricity Limited
BAE Systems
Belden Communications Ltd
Blackpool Borough Council
Calderdale Council
Cambridgeshire County Council
Duke of Northumberland Estates
Dumfries and Galloway Council
Durham County Council
Elementis Chromium Limited
Eli Lilly & Company Limited
English Cities Fund Ltd
Grovehurst Energy Ltd
Hydes' Brewery Ltd
Intergen (UK) Limited
Ionics (UK) Limited
H. & R. Johnson Tiles Limited
Long Rake Spar Company Limited
MAFF
Manchester City Council
Manchester City Football Club
Manchester United Football Club
Marlow Foods Limited
Marshalls plc
Miller Pycraft Chartered Loss Adjusters
Ministry of Defence
William Morrison Supermarkets plc
Network Rail
Onyx (UK) Ltd
Paragon Hotels Limited
Renewable Energy Systems Ltd
St Helens Metropolitan Borough Council
Stockton Borough Council
Tarmac (Northern) Limited
The Trafford Centre Limited
Village Hotels & Leisure Ltd
J.D. Wetherspoon plc
Yorkshire Water Services

EXPERT WITNESS

Expert witness advice has been given through the following legal practices:

Bitterman & Wood Solicitors, North Shields
Browne Jacobson Solicitors, Nottingham
Mr Stephen Cadwalader QC, Birmingham
Dilwyn Solicitors, Llandrindod Wells
Fentons Solicitors, Manchester
Goad & Butcher Solicitors, Skipton
HBJ Gateley Wareing LLP, Birmingham
Janice Lawler, Solicitor, Southport
Mr Shay I. Lotan, Barrister
Mills & Reeve LLP
Pluck Andrews & Co, Solicitors, Hyde
Valerie Pack, Solicitor, Henley in Arden
James Richardson, Barrister, Newcastle upon Tyne
Slater & Gordon Solicitors, Manchester
Valerie Pack, Solicitor, Henley in Arden
James Richardson, Barrister, Newcastle upon Tyne
Mr Reuben Taylor, Barrister, Landmark Chambers
Ian Whalley Solicitor, Blackburn
Woodcock & Sons, Solicitors, Bury

TEACHING and TRAINING

Teaching and training courses have been carried out at undergraduate and postgraduate level and training courses for continuing professional development through the following organizations:

Newcastle University	University of Lancaster
Royal Engineers (521 STRE (WD)	University of Manchester
University of Birmingham	University of Strathclyde
University of East Anglia	WTI Training