ASSESSMENT OF THE REPORT "HYDROGEOLOGICAL AND SURFACE WATER RISK ASSESSMENT FOR LOAD TEST PILING LOCATION 2" IN THE CONTEXT OF THE SITE OF SPECIAL CONTAMINATION

A REPORT BY

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July, 2020

Executive Summary

This assessment addresses the question if there is reasonable cause to believe whether the report issued by ALIGN on behalf of HS2 for installation of piles (LTP2) has omitted consideration of the proximity of the Special Site of Contamination known as the Newyears Green Landfill Site. The fact that this remit was to consider whether an *omission* occurred that was relevant to the granting of consent of the work to be carried out makes this a slightly different question than the more standard one regarding prediction of the future environmental impact (i.e. water quality) of the Special Site of Contamination concerning the load test piling location, LTP2. To this end, systems tools have been used extensively to critique the assessment process and it is concluded is that it is desirable and should have been possible to include an initial assessment of the risk of pollution and mitigation of risk from the Special Site of Contamination without adversely affecting the delivery of the work package involved in the task. It is the personal opinion of the author that this ought have been done before consent was sought for the work.

Furthermore there are concerns in some of the assumptions given in the assessment concerning long-term structural health of the piles, particularly those of Section 5.4.3 which unless supported with considerable documented evidence might reasonably cause alarm to both expert personnel and the layperson when considering transport of pollutants over the long term. Finally a suggestion has been made as to what knowledge-based mitigation could be made to mitigate the risk of the task without affecting the work involved and with minimal cost.

1.1 Scope

This report was commissioned by Mr Shahid Khan of Advice Wise Solicitors, 24 Cameron Road, Ilford, Essex, on behalf of Mrs Sarah Green. The remit given was to assess the report "Hydrogeological and Surface Water Risk Assessment for Load Test Piling Location 2, document 1MC05-ALJ-EV-NOT-CS01_CLO1-100368". This report (called "the report" in this work) was submitted by ALIGN, working on behalf of HS2 and approved for issue on 22/01/19. The brief given by Mr Khan for this assessment was

"to consider whether there is an omission of the Special Site of Contamination which means that the presence of leachate is not being assessed……(and) consider the assessment of corrosion prediction especially in an area where there is leachate".

1.2 Source Texts

The following source texts have been used as source material for this assessment

Document for Review

"The Report"

Hydrogeological and Surface Water Risk Assessment for Load Test Piling Location 2, Author, ALIGN (for HS2), Reference 1MC05-ALJ-EV-NOT-CS01_CLO1-100368, (2019)

Water Chemistry Prediction and Hydrogeology

"Drever"

J. I. Drever, "The Geochemistry of Natural Waters; Surface and Groundwater Environments, Third Edition", Prentice-Hall Inc, New Jersey, USA. (1997)

"Snoeyink"

V. L. Snoeyink and D. Jenkins, "Water Chemistry", John Wiley and Sons, New York. (1980)

Corrosion Prediction

"Tretherway"

K. R.Tretherway and J. Chamberlain, "Corrosion for Science and Engineering, Second Edition, Longman Publishing, Harlow, UK. (1995)

"Ahmad"

Z. Ahmad, "Principles of Corrosion Engineering and Corrosion Control", Butterworth-Heinemann, Amsterdam, Netherlands. (2006)

"Fontana"

M. G. Fontana and N. D. Greene, "Corrosion Engineering", McGraw-Hill Book Company, New York, USA. (1967)

"Talbot"
D. E. J. Talbot and J. D. R. Talbot, "Corrosion Science and Technology, Third Edition", CRC Press, Boca Raton, USA. (2018)

Geology

"Bailey"
H. W. Bailey, "The Geology of the Newyears Green Area, Hillingdon, London, Commissioned Report. (March 2019)

1.3 Principles

The guiding principles of assessment of risk to water quality are laid out in the DEFRA guidelines, conveniently quoted in Section 3.8 of Appendix D of the report when referring to the use of polyacrylamide gel in the installation of the piles. These are (from "Defra, 2010, Environmental Permitting Environmental Permitting Guidance Groundwater Activities for the Environmental Permitting (England and Wales) Regulations 2010").

"4.20 A reasonable measure would be one where the necessary technical precautions to prevent inputs to groundwater are technically feasible, not disproportionately costly and are within the control of the operator. Such measures could include; source control, alteration of discharge mechanism, treatment of the discharge, interception or diversion of contaminated groundwater, and diversion of the discharge to another disposal route. For new developments this could include simply not conducting the activity in a location where valuable groundwater resources would be particularly vulnerable to inputs of hazardous substances"

"4.27 It is the clear objective of the GWDD to prevent the input of all hazardous substances into groundwater. Clearly the interpretation of "prevent" is important in this context and is to be interpreted having regard to the Common Implementation Strategy guidance issued by the European Commission… …. This recognises that, whilst the aim is to avoid the introduction of hazardous substances into groundwater, it may not be technically feasible to stop all inputs of hazardous substances. Moreover some inputs are environmentally insignificant and in such instances the exemption noted in paragraph 3(3)(b) of Schedule 22 may be applied"

"(Additional note) For example, an environmentally insignificant input into groundwater would be one that could not have any effect in (i) any of the receptors noted in the Water Framework/GWDD definition of pollution (ii) the chemical status if a groundwater body; or

(iii) could give rise to a significant and sustained rising trend in the concentrations of pollutants in groundwater as noted in those directives"

It should also be noted that the underlying principle is governed by the statement "*It is the clear objective of the GWDD to prevent the input of all hazardous substances into groundwater"* and therefore if the issue of leachate from the Special Site of Contamination as a potential pollutant is to be discounted as insignificant that this comes under the condition. "*Moreover some inputs are environmentally insignificant and in such instances the exemption noted in paragraph 3(3)(b) of Schedule 22 may be applied.*" Thus the remit of this work effectively becomes to consider whether this exemption was correctly applied to a source of leachate from the Special Site of Contamination, or whether its omission was an oversight.

For a pollutant - leachate or otherwise - to be environmentally insignificant one of three primary conditions must be satisfied and shown in an assessment beyond reasonable doubt. There is also a secondary condition in case there is a negative reinforcement between B & C, for example if containment were to cause a change in chemical composition. These conditions are given in Table 1.

It should be noted that there is a hierarchy in these conditions. Thus if condition A for a particular pollutant is satisfied then conditions B, C and D do not apply. Similarly if condition B applies, then only condition D need also be considered. Finally it should be noted that if conditions A and B do not apply then a risk assessment for condition C must be done to determinate that exemption via the application of *paragraph 3(3)(b) of Schedule 22* is justified as quoted above. It should be noted here that the position stated as laid out in section 5.4 of the report issued by ALIGN for HS2 is that transport of pollutants is not possible since there are no vertical pathways after piling. This is condition B in Table 1.

2.1. Systems Review

The process whereby it can be determined whether the potential for leachate from the Special Site of Contamination should have been considered, is to apply the constraints of Table 1 in turn.

Condition A There is no source of environmental hazard

A full overview of the hydrogeological aspects of the Newyears Green Area is given by Bailey. The locations are given by document number, 1MC05-ALJ-TP-MAP-CS01_CL01-000002. The Special Site of Contamination (the Newyears Green Landfill site) is approximately 500 meters from the test piles. The report states

"3.4.3 The NYGB…….skirts the former Newyears Green landfill site in a culvert……. The NYGB is also fed by groundwater, giving high base flows in winter……"

"4.2.9 There is the potential for the piles to introduce vertical pathways that could provide a route for contamination of the Chalk aquifer from surface/shallow sources of pollution derived from historical pollution within the wider area. Although the superficial sands and gravels may naturally be in hydraulic continuity with the Chalk, the degree of water movement may be limited by the presence of silts in the sand and gravels, in addition to the presence of putty chalk at the top of the weathered horizons. Any construction activity that could result in a preferential pathway between the sand and gravel and the chalk aquifer, particularly where the latter is well fissured, could result in greater water movement than is currently the case." This could result in the introduction of pollutants into the chalk aquifer."

The likely cause is that the Special Site of Contamination is the source of leachate pollution into the aquifer. Leachate is caused by the anaerobic digestion of organic material in buried covered-in domestic refuse sites and contains low-chain fatty acids, especially acetic acid together with mobilised toxic metals, micro-organic species and a high bioflux of anaerobic bacteria. As such it is a potential hazard to water courses and also a potential risk to corrosion of steels due to the presence of acidic material and stimulated microbially induced corrosion (MIC) of buried steel.

If an environmental pollution source is remote from the site of environmental assessment then condition A may still apply. It is noted here that the closure of Ickenham Pumphouse (approximately 1000 metres from the Special Site of Contamination) in 1997 was due to hydrogeological contamination arising from leached material attributed to the Newyears Green landfill site and this implies considerable mobility of leachate products over distance. The hydrogeological aspects are discussed in detail by Bailey. When considered alongside the potential (Section 3.4.3 in the report) for groundwater exchange of the Newyears Green Bourne (NYGB) with groundwater believed to be contaminated with leachate products, in the absence

of other evidence, this raises a possibility of faster transport of contaminants than simply by subsurface percolation. Interestingly the report also states.

"4.3.5 Indirect effects could occur if pollutants (particles or chemicals) migrate within groundwater which subsequently discharges at one of the water features listed above. This is not considered to be a significant risk due to the fact there are no major springs feeding the watercourses in this area, indicating that baseflow supporting these features is largely diffuse and from superficial deposits as much as from the Chalk and so less sensitive to any increased turbidity carried within it. In addition, the proposed works are largely to be undertaken in the chalk, with casing installed through the superficial deposits. As most interaction with surface water features will be via the superficial deposits, primarily the sand and gravel, no significant adverse effects via the diffuse flow pathway to surface water are anticipated."

This specifically does not mention the Site of Special Contamination and might be an oversight.

Provisional Assessment: Condition A does not apply

Condition B There is no transport process available

The report states

"5.4.3 Literature review of the degradation (rusting) of steel pipes below the water table indicated a loss of steel thickness of the order of 1mm from both the inside and outside of the steel tubes over a 100 year period. Generation of rust would serve to reduce the rate of loss beyond that as the rust forms a protective layer that seals off the steel from the environment and also expands into the already compressed natural deposit to reduce the space available to form a preferential pathway."

Since condition A (from above) is not satisfied, the assessment regarding the impact of leachate products and the effect of LTP2 relies entirely on the assumed permanent structural integrity of installations preventing vertical transport (Section 5.4) of the report. Section 5.4.3 raises considerable concerns. Namely

(a) no record of the evidence (the literature relied upon is not quoted and thus cannot be independently reviewed)

(b) corrosion prediction is essentially a time dependent phenomenon. The layperson can appreciate that a steel pipe in the ground will not rust in five minutes but is probably

not likely to survive one million years. It is thus obvious that corrosion prediction ultimately depends on the intended lifetime of the structure. In the report no lifetime description is given and although one could be implied (100 years) from the corrosion rate quoted, it must be noted here that the pollution source (Special Site of Contamination) has an infinite life as it is impractical for it to be removed, and the piles have no stated lifetime before removal or repair.

(c) the materials specifications (grade of steel etc.) are not given at all. It is impossible to assume a rate of corrosion rate without knowing the composition and processing history of the installed materials.

(d) the corrosion rate is given in Section 5.4.3 of the report as a steady state rate (one millimetre over a 100 year period) with no attribution. The phases of the corrosion product varies with the partial pressure of carbon dioxide which can vary within an aquifer and can occur as either iron oxides (for example magnetite) or iron carbonate (siderite) (see Drever, p144-148.). Thus to quote a single steady state corrosion rate seems simplistic. The rate of corrosion and the nature of the scale formed is notoriously vulnerable to varying local surface factors; very often heterogeneity of the metal-surface condition in terms of species supply stimulates electrochemical cells to accelerate corrosion. Bailey notes that the geological strata of the aquifers underlying the Newyears Green area exhibit heterogeneity, both in terms of solution features and in lithological barriers within the chalk. Thus even if a single value for steady state corrosion were applicable, to have a uniform corrosion rate at each point of the steel is very unlikely.

(f) mechanical integrity of corrosion products to fill space cannot not be assumed. When a metal transforms into a corrosion product it replaces the metal. Since the product almost always has a different relative density to the metal it means that there are internal stresses within the corrosion product. The parameter which describes this is the *Pilling-Bedworth Ratio*, (Fontana and Greene pp 347-349) originally conceived for metals and their oxides, but can be used for other corrosion products. When the Pilling-Bedworth Ratio (PB) is 1.0, the corrosion product occupies the same volume as the metal. If it is much less than 1.0 or greater than 1.0 the product is under internal stress and likely to spall from the metal surface leaving it unprotected and prone to corrosion. This effect

is progressively more likely the thicker is the corrosion layer. For magnetite the PB ratio is 2.1, and for siderite it is 4.3.

(g) corrosion lifecycle analysis takes ino account the role of human factors - misdesign (giving rise differential aeration or local action cells), change of economic circumstances over the years (deferred maintenance, interruption of supply chain etc.), misoperation, in-service modification, and other factors over the lifetime of the product. Corrosion prediction is thus far too complicated to assume a steady state of corrosion over 100 years, even if the chemical kinetics of the system were constant. For more information on corrosion prediction and human factors the reader is referred to Chapter 11,"Corrosion Management", in Tretherway (pp 240-255) and Chapter 30, "Prediction of Corrosion Failures", in Talbot (pp 473-536). In situations where the confidence of lifecycle assessment due to corrosion is in doubt it is advisable to maintain a Masterfile with the information required (metal specifications, environmental assays and monitoring during installation, maintenance reports, modifications, change of circumstances, etc.) and review it periodically.

"5.4.5 It is therefore concluded that there is very limited potential for creation of such pathways in either the short or long term from piling activities. Mitigation is therefore not required….."

From the foregoing discussions, the statement "Mitigation is not required" cannot be justified

Provisional Assessment: Condition B for exemption cannot be not applied as it stands

Condition C The potential environmental damage is within prescribed limits

Since condition B does not apply, an assessment for the potential environmental damage of leachate in the aquifer should be done. An initial one can be carried out by modelling the chemical interactions of leachate with water chemistry using standard software designed for this (for example PHREEQC, freeware issued by the US Geological Survey). A more detailed description is given in Drever, Chapter 16 "Transport and Reaction Modelling", pp 353-378

Provisional Assessment: Task not yet done

Condition D There is no destructive synergy between B and C

Since leachate is of microbiological origin, there is always the possibility that the steel in the piles might exhibit accelerated corrosion due to stimulated Microbially Induced Corrosion (MIC). This needs to be assessed.

Provisional Assessment: Ongoing Issue to be Reviewed Regularly

3.0 Mitigation

As mentioned previously, from the regulations

"4.27 It is the clear objective of the GWDD to prevent the input of all hazardous substances into groundwater. Clearly the interpretation of "prevent" is important in this context and is to be interpreted having regard to the Common Implementation Strategy guidance issued by the European Commission… …. This recognises that, whilst the aim is to avoid the introduction of hazardous substances into groundwater, it may not be technically feasible to stop all inputs of hazardous substances. Moreover some inputs are environmentally insignificant and in such instances the exemption noted in paragraph 3(3)(b) of Schedule 22 may be applied"

Thus where the cost and disruptions to operations are minimal all reasonable steps should be taken to mitigate the risk. Deciding the optimal procedures that need to be implemented is beyond the scope of this present document. However it is sometimes prudent to deliberately construct a knowledge-based scheme to ensure that the issue is not (a) overlooked or omitted (the remit of this assessment) in the future and (b) that impact assessments are kept as up to date as possible. This type of tool is often of minimum cost as an exercise as it is largely desk-based and takes little time. A suggested example knowledge-based scheme for considering the impact of leachate ingress from the Special Site of Contamination and the effect of test piles LTP2 is given in Table 2.

Tables

Table 1. Systems Condition Hierarchy of Assessment of Environmental Hazard.

Primary

A There is no source of environmental hazard

B There is no transport process available

C The potential environmental damage is within prescribed limits according to the "additional note" quoted above in Section 1.3 of this report

Secondary

D There is no destructive synergy between B and C

Table 2. Suggested Knowledge-Based Mitigation.

	Structural Health Assessment and Prediction	*Task*
1	Corrosion	Creation of a Masterfile
2	Cementitious Material	*Add to Masterfile if required*
Geochemical Assessment		
3	Initial Modelling	Use of PHREEQC or equivalent
4	Risk Assessment	Assessment of geochemical impact of leachate from model
5	Fate Modelling and Monitoring	*As required*
Periodic Review		
6	Assignment of Risk Lifetime (example 100 years)	From risk assessment
7	Review period (example every 10 years)	Notification of stakeholders of "state of play" of risk (no change/change etc.)

The Author

Dr Talbot has published on freshwater chemistry and on corrosion science and also on water quality with an emphasis of long term prediction of complicated systems. Corrosion expertise is best illustrated by the book "Corrosion Science and Technology, Third edition, D. E. J. Talbot and J. D. R. Talbot, CRC Press (550 pages), 2018. The author synopsis from this work reads

"*James D R Talbot, PhD, graduated with a BSc ARCS from Imperial College London, and earned an MSc from Brunel University. He earned a PhD from the University of Reading for research on the physical chemistry of aqueous solutions and its application to natural waters. Dr Talbot worked at the River Laboratory of the Institute of Freshwater Ecology, Dorset, United Kingdom, where he assessed and predicted physical chemical changes occurring in river management. He has written papers on the speciation of solutes in natural waters. From 2000 to 2006 he was a lecturer in materials research chemistry at Cranfield University in the United Kingdom, where he specialized in the physicochemical aspects of corrosion, polymer science and process science. He is presently a chemist with interests in species-specific corrosion mechanisms. Dr Talbot is a current member of the Structure and Properties of Materials Committee of the Institute of Metals, Minerals and Mining. He has published in the fields of corrosion, polymer chemistry, solution chemistry and the chemistry of natural waters"*

Water quality prediction experience is best illustrated by two reports where Dr Talbot was principal author for water quality assessment whilst employed at the NERC Institute of Freshwater Ecology. These are

"The NRA Severn-Thames Transfer Project: An Assessment of the Effect of Mixing of Source Waters on the Chemical Composition", W. A. House, J. D. R. Talbot, J. T. Smith, R. Sadak and A. J. Lawlor, NERC Report RL/T0407307/1, (July 1996)

"The Severn-Thames Transfer Project: Phase II. Chemical Interactions of Transferred Sediment with the Host Water", J. D. R. Talbot, W. A. House, G. P. Irons, K. J. Clarke and A. J. Lawlor, NERC Final Report. (July 1997).

These reports were commissioned by the Environment Agency and represent multi-parameter assessment and prediction of water quality for the proposed Severn to Thames transfer pipeline.