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Deadline 7 **submission to Planning Inspectorate, National Infrastructure Planning: Ref. TR010025**

Prepared by Dr. G.M. Reeves for the **Stonehenge Alliance. Ref.2001870**

Part one: **Response to Section 11.2 "Comments on Written Representations Report"** in Highways England's document REP5-003 ("Comments on any further Information Requested by the ExA and Received at Deadline 4")

Part two: **Summary of fundamental failures in Highways England's ground characterisation** of proposed A303 Tunnel and Road Project with ref to REP5-003, Section 11.1, Oral Submissions

Part One. Comments on REP5-003, Section 11.2. concerning Flood risk, groundwater protection and land contamination

In response to the following items:

FLOOD RISK, GROUNDWATER PROTECTION AND LAND CONTAMINATION Points raised by Stonehenge Alliance in this section of their submission have already been covered by responses to comments raised in the oral submission summary submission from the ISHs – see first 5 points at the top of this table. Additional points raised are detailed below.		
11.2.55	17.3.3: Although leaching tests of the Phosphatic Chalk have been carried out for Highways England, they are rather basic and simplistic in that potential changes in groundwater and surface water chemistry (specifically with varying Ph and Dissolved Oxygen levels) have not been extensively investigated.	The leachate tests described in Chapter 10 of the ES [APP-048] and in Appendix 10.1 [APP-273] were undertaken in accordance with the British Standard BS EN 12457-2 methodology. This is a vigorous end-over-end shake test in a glass vial, on specimens sieved and / or ground to a small fraction (<4mm). The sample is then introduced to the leachant at a leachant to solids ratio of 10:1 de-ionised oxygenated water at pH 7 / kg material. The sample in its leachant is then agitated for 24.5 hours using an end-over-end tumbler or a roller table (5 -10 revolutions per minute). The method therefore maximises potential for the release of a solute from the specimen, which contrasts with the nature of the material present either in the ground or placed as fill. Thus the leach test will give a solute which is comparatively rich compared with the solute emerging from infiltration through the material when placed. Since the ES submission, a package of ground investigation referred to as Phase 6 has been undertaken which included additional Phosphatic Chalk leachate testing. Local rainwater chemistry was taken into account by using a pH 6.2 dilution for some of the specimens, which accounts for the slightly acid rain water plus some interaction with the soil substrate. Thus Highways England has been conservative, but also site specific in the adopted pH used in the test. Five pairs of duplicate samples were analysed using a standard pH 7 and a pH 6.2 dilution in accordance with the BS EN 12457-1 methodology as part of the Phase 6 investigation. This leachate preparation method uses a leachant to solids ratio of 2:1, which is more conservative as there is less dilution. The recorded orthophosphate concentrations were at or below the method of detection limit (0.5mg/l) in all samples, indicating that the solubility of phosphorus in Phosphatic Chalk does not appear to be measurably effected by varying pH levels. The oxygenated water used for the test is considered reasonably representative of the local surface waters and ground waters which are oxygenated. The results of dissolved oxygen concentrations measured in groundwater and surface water can be found in Appendix 11.4 (Groundwater Risk Assessment) [AS-017] to ES Chapter 11, these show water to be well oxygenated. In Appendix 11.4, paragraphs 3.10.8 to 3.10.14 set out Highways England's further assessment of the Phosphatic Chalk mineralogy and solubility. Dissolved phosphates in groundwater and surface water samples have been measured and the results indicate that solubility of mineral phosphate is low. Nevertheless, the method used in leachability tests completed on the soil samples imposes more rigorous conditions with higher solubility potential than in the in-situ conditions and are therefore considered to be conservative. The Factual Report containing the results of the Phase 6 leachate testing will be submitted at Deadline 6 of the Examination.
11.2.56	17.3.6: More detailed and specific designs (with alternatives) [to emergency measures involving grouting and ground stabilisation] would be expected at the Examination stage of such a major scheme. It is, as stated above, fundamentally unacceptable to put the onus and responsibility for this aspect of investigation and interpretation of Highways England data onto Tenderers and Contractors. If this is done, escalating costs through numerous claims, down-time (with attendant risk of formation collapse and subsidence and considerable delays in progress) can only be predicted and expected.	Please see the Applicant's response to the following agenda items in the Written Summary of Oral Submissions: item 5.1 from ISH4 Flood risk, Groundwater, Geology and Waste [REP4-032]; item 6 (iii) from ISH5 regarding Noise, Vibration, Health and Wellbeing [REP4-033], and the response to Written Question Fg.1.5 [REP2-031]. In developing the preliminary design provided in support of the DCO application, the Applicant has followed best practice as embodied in the Institution of Civil Engineers (ICE)/British Tunnelling Association (BTS) Joint Code of Practice for the Risk Management of Tunnel Works (ACOP) to: a) Undertake hazard identification and the management of risk to ensure their reduction to a level 'as low as reasonably practicable' as an integral consideration in the design, procurement and construction of the tunnel works.

Commentary

The short and long term stability of the weaker horizons of both the Newhaven and especially the Seaford Chalk remain problematic. In particular, the Phosphatic Chalk found in the Seaford Chalk sequence (found mostly in the western section of the proposed tunnel), shows properties of rapid degradation and disintegration (in 3 to 9 days), as shown in the Stonehenge Alliance presentation to the ExA of June 11th (Dr. GM Reeves; Slides 6,7 and 8; Borehole R501, 18.75 to 21m and 24.00 to 27.50 metres depth).

As displayed in Mortimore et al., 2017 (Figure 25, reproduced below), at various borehole locations and depths along the original proposed tunnel line (slightly to the south along the western portion of the current proposed tunnel route), weak Phosphatic Seaford Chalk was identified as a potential instability problem along the tunnel line and especially at and above the tunnel face.

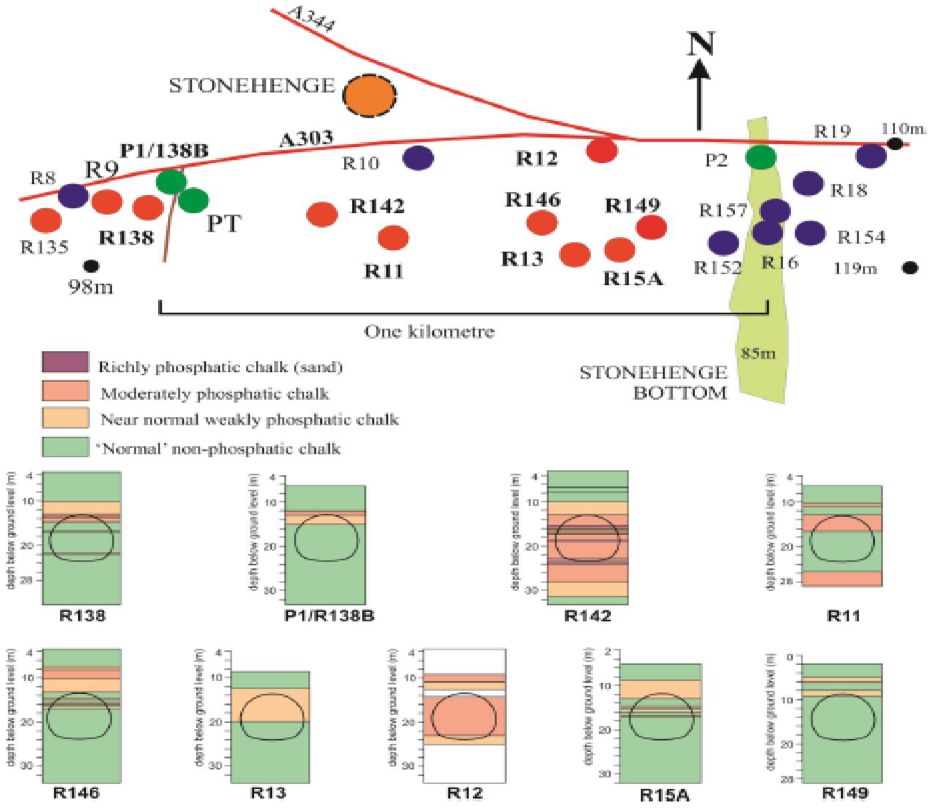
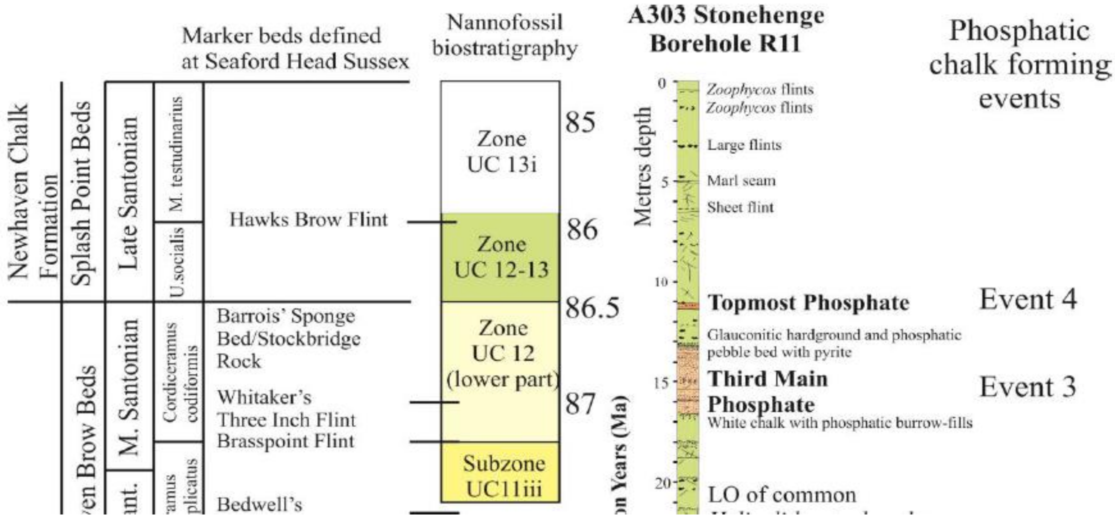


Figure 25. A303 Stonehenge proposed twin road tunnels original alignment; typical cross sections of tunnel faces showing lithological variability to expect based on borehole logs through the phosphatic-chalks. This figure illustrates the frequency of potentially unstable tunnel crown conditions with overlying phosphatic chalks, a key issue in the escalating cost of tunnelling and eventual cancellation of the project.

(Figure from Mortimore et al., 2017)

The Barrois' Sponge Bed/Stockbridge/Whitway Rock Formation level, which appears to control much horizontal groundwater flow eastwards towards Amesbury and beyond (*see* GM Reeves, comments on Blick Mead and Amesbury Abbey Springs etc. in SA Submission REP6-064, at Deadline 6, dated 25th July 2019), can be positively identified in both Borehole R501 (at approximately 20 metres depth- Zero RQD -as shown in GM Reeves Session 4 Presentation (REP4-088): Slides 6,7 and 8; Borehole R501, 18.75 to 21m) and also as an equivalent fractured bed in the earlier drilled borehole R18, at approx. 24.00 to 33.00m depth - c.66m AOD, coincident with a spike in the DTH - porosity log. The sequence containing this horizon is as shown below (Mortimore et al., 2017, Figure 7).

NB. Standing Groundwater Levels are reported at or about this horizon level, i.e., at 23.10m BGL in a zone of steeply dipping open fractures, as reported on the drill logs and shown in core box photos.

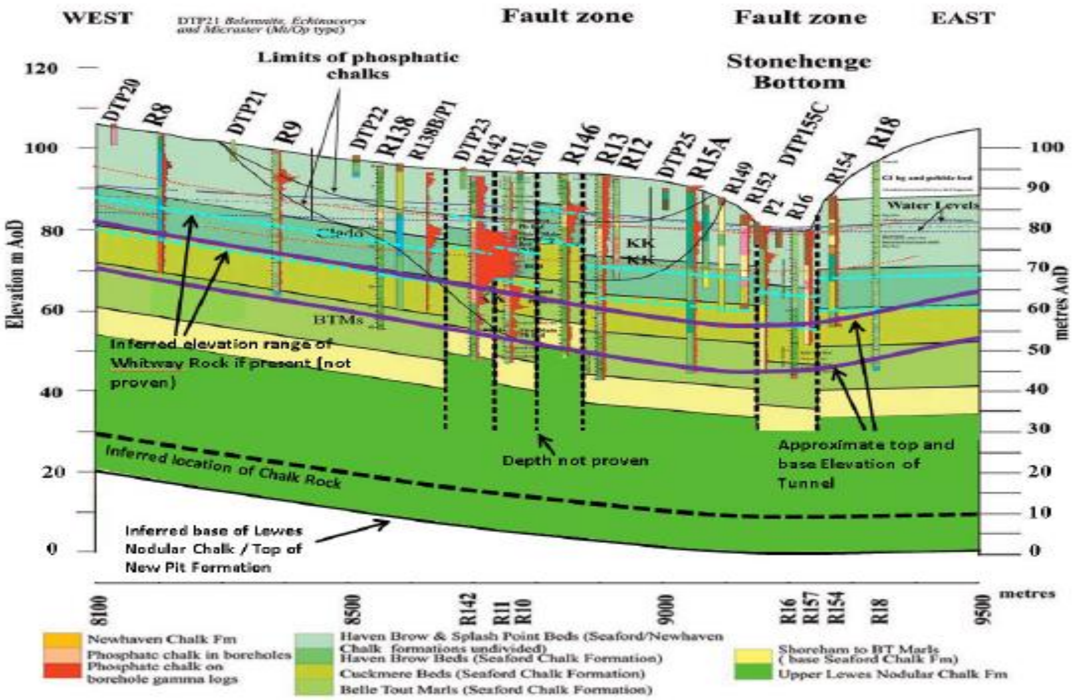


(From Mortimore et al., 2017, Figure 7 in part)

The same, horizontal groundwater flow controlling horizon (the Whitway/Stockbridge Rock) can be also observed in Boreholes R142 (at approx. 13m depth; c. 80mAOD), R13 (at approx. 9m depth; c.80m AOD), R138 (at 14.5m; c. 81m AOD) and probably also in R9, R11, R146 and R12. (See Mortimore et al., 2017; Figure 13)

Despite the AMW report for Highways England referring to the "possible" presence of the Whitway Rock along the proposed tunnel line (REP3-019; Report No. TR010025 Document 8.23 – Implications of 2018 Ground Investigations to the Groundwater Risk Assessment (republished with tracked changes, dated 31.05.19), no significance is placed on this horizon being a possible significant horizontal control on groundwater movement.

Figure 2 Chalk Stratigraphy with Tunnel and Chalk Rock Elevations (adapted from Mortimore (2012))



However, as can be seen on Figure 2, page 12 of this report (reproduced above), the Whitway Rock ("if present", and controlling lateral groundwater movement as seen further to the east, and especially in the Blick Mead/Amesbury Abbey spring system) could be a significant problematic feature during the proposed tunnel construction which has yet to be fully and thoroughly investigated by HEng.

The special significance of this "Marker Horizon", and its relevance to the control of potential "Underdrainage of the Chalk" (See Soley et al., 2012), defined as the Stockbridge/Whitway Rock (AKA the Barrois' Sponge Bed) horizon, cannot be underestimated.

Throughout the Wessex Basin Chalk Groundwater modelling work (Soley et al., 2012- upon which the groundwater model adopted by Highway's England groundwater consultants -the AMW consortium of AECOM, Mace, and WSP work has been based), the significant feature of the horizontally higher permeability, underdraining horizon formed by the Stockbridge/Whitway Rock is described as a dominant feature in these Chalk Aquifer catchments.

"A BGS structural model providing a three-dimensional interpretation of the elevations of the new stratigraphic formations . . . was an essential building block of the Wessex Basin conceptualization. . . . Figure 4 is a north–south cross-section through these formations and includes the inferred elevations of three horizons that, in different parts of the Wessex Basin, are associated with enhanced fissure flow into abstraction wells, as well as with locations of river flow loss and spring discharge. These are the Melbourn Rock and Plenus Marls at the base of the Holywell Chalk, the Chalk Rock, and the Whitway Rock (which is also called the Stockbridge Rock further east)."
(Soley et al., 2012, 133)

Elsewhere in the Wessex Basin, the Stockbridge Rock is described as controlling "*Underdrainage associated with the Stockbridge Rock in a syncline plunging westward to crop out in the Alre and Upper Itchen is associated with high transmissivities and a concentration of watercress beds and fish farm operations. This feature captures water from a large area towards the eastern scarp, which is topographically located within Thames Region, and enhances the reliability of low summer flows in the Itchen beyond that expected from its surface catchment*."
(Soley et al., 2012, 149)

This important, apparent horizontally controlling major hydrogeological feature, known as important to the Wessex Basin Groundwater Modelling Group, and especially to the Environment Agency, has not been investigated in any way by Highways England.
It is obviously an important controlling feature of groundwater movement in the context of the Stonehenge Tunnel location, the Stonehenge Bottom/Springbottom Farm areas /other local farm abstraction wells/Blick Mead-Amesbury Abbey spring occurrences, and other relevant areas.
Its relevance has apparently been ignored by Highways England, their consultants, collaborators, the Environment Agency and Wiltshire County Council.

In the context of the potential short and long-term effects on groundwater along the proposed tunnel, groundwater control and dewatering during construction, and (most significantly) local agricultural and private abstractors, this is a significant "blindspot" in Highways England's Site Investigation activities to promote and progress this project.

In summary, therefore:

1. The engineering properties, “Stand-up Time”, excavatability, rock strength (over days and weeks, unsupported) of the critical sections and depths of the Upper Seaford Phosphatic Chalk “bodies” have neither been fully investigated, nor detailed or presented in any relevant reports by Highways England (HEng).

2. HEng’s comment that “drilling techniques were to blame for the disintegrating core in the R501 core boxes”, made in Session 4, June 11th 2019, is invalid. This “Potential Instability” and poor Rock Strength had already been identified in the drilling of Borehole R11, by Soil Mechanics Ltd. (SML), again using standard triple-tube wireline core drilling techniques in March 2001. Varying drill bit selection (Geobore Cube Set in SMLs case and alternate polycrystalline and stepped tooth bits, with finally a Geocube bit used as by SML) has had therefore no effects on the demonstrable poor rock strength of the Phosphatic Chalk, in particular, and the weakness of much of the upper Seaford Chalk west of Stonehenge Bottom.

3. High groundwater levels, in anything other than high summer drought conditions, are likely to hamper tunnelling, and in the event of possible varied and adverse induced groundwater chemistries, could cause potential additional degradation of the Phosphatic Chalk in particular, with possible solution, piping conditions and migration of voids to surface.

4. The Whitway/Stockbridge Rock/Barrois Horizon zone of high horizontal elevated permeability must be specifically investigated throughout the proposed project area.

5. Dewatering and additional grouting, from surface or the tunnel levels, will threaten yields and groundwater quality in local abstraction boreholes and springs.

6. Such risks of adverse ground and tunnelling conditions should not be contemplated within the vicinity of a World Heritage Site such as Stonehenge and would not be permitted at any other World Heritage Site in Europe.

Part Two: Summary of fundamental failures in Highways England's ground characterisation of proposed A303 Tunnel and Road Project with ref to REP5-003, Section 11.1, Oral Submissions

In response to the following:

11 Kate Fielding for Stonehenge Alliance (REP4-055, REP4-056, REP4-087 and REP4-095)

11.1	Oral Submissions	
	Matter Raised	**Highways England's Response**
11.1.1	Geotechnical Properties of Chalk Bedrock along the tunnel line: Rock Strength and Stability To adequately understand the changes in rock properties (rock strength/RQD, permeability, degree of fracturing, persistence and groundwater flow potential of major fractures and faults) it is essential to adequately examine changes in all these aspects throughout the 3.3km (and possibly up to 0.5km additional distance west and east of each tunnel portal), and up to 1km or more to the north and south of the proposed tunnel line, and perhaps up to at least 100 metres in depth. There is no possibility of thoroughly examining this 4.3 x 2 x 0.1 km block of (predominantly) Chalk rock, with very variable strengths and permeability properties, without creating a 3-Dimensional Ground Model. The present situation, in the opinion of this current specialist expert (GMR) is that all this data is poorly collated, investigated and interpreted, along and around (especially to the north and south) of the proposed tunnel line.	See the Applicant's response to agenda item 5.1 in the Written Summary of Oral Submission from ISH4 regarding Flood risk, Groundwater, Geology and Waste [REP4-032]. The Applicant considers that a proportionate approach has been taken to characterise the variable nature of the geology employing experts in this field, including Professor Rory Mortimore, and does not agree that a 3D model is necessary at this stage.
11.1.2	Hydrogeological Conditions and Consequences It is especially evident to the present author that the proponents of the A303 Stonehenge tunnel project, Highways England and some of their consultants, do not have the necessary in-house expertise to fully assess and understand the potential hydrogeological data and the need for site specific groundwater modelling.	The groundwater levels provided in AS-015 support the conceptual model that the regional Chalk aquifer is maintaining the wet conditions in the Mesolithic deposits. Rainfall will also provide a mechanism for wetting of the Mesolithic deposits. (Section 2.6 of Annex Appendix 11.4 Annex 3 Blick Mead Tiered Assessment [APP-282]). The groundwater levels and rainfall at Blick Mead would not be affected by the Scheme and therefore there is no mechanism for impacts at Blick Mead. Given that no significant effects are predicted at Blick Mead [APP-282] additional investigations into the detail of Blick Mead and site specific modelling would not change the outcome of the assessment. The professional credentials and expertise of the team is provided for all parts of the ES and has been undertaken and reported by competent experts.
11.1.3	Hydrogeological Conditions and Consequences Groundwater modelling for such a specific high-profile tunnelling project needs to be carried out at an appropriate scale, using the available site-specific data, set in the regional, larger scale context of the local context of Chalk Aquifer conditions. Since much of the proposed tunnelling will now occur below the Chalk groundwater water level, a far more detailed, site specific groundwater model needs to be developed rather than the "Wessex Basin" approach currently adopted and applied by Highways England consultants and the Environment Agency. Nodes (and consequently a groundwater modelling mesh) of 20m, or at worst 50 metre spacings is more applicable and relevant to expected tunnel groundwater flow conditions than the 250 metre node spacing currently adopted.	Modelling has been carried out at an appropriate scale to simulate the effects of the Scheme on regional groundwater flow and sensitive receptors. The modelling has been reviewed by the Environment Agency and Wiltshire Council's peer reviewers. This model has been refined in the area of the tunnel with aquifer property data from pumping tests and preferential flow horizons have been considered using geological, geotechnical and geophysical data. The model with a 250m grid is conservative because if the tunnel crosses part of a 250m model cell the entire cell is set to block a proportion of flow. In a refined grid with a mesh of 50m or 20m, but less of the aquifer would be blocked and the results would be less precautionary. The precautionary approach to the modelling used is therefore robust and sound.
11.1.4	Tunnelling Methods, ground vibration, settlement and subsidence Unless ground conditions along the proposed tunnel line (especially the existence of weak unstable, often Phosphatic, Chalk), as well as the permeability and persistence of major fracture zones (as are shown on Figures 9 and 10 on attached presentation), are properly understood, no assessment of the effects of grout migration from tunnelling can be made.	See the Applicant's response to agenda item 5.1 in the Written Summary of Oral Submission from ISH4 regarding Flood risk, Groundwater, Geology and Waste [REP4-032] and the additional information provided in the Post Hearing Note. As noted there, the properties and characteristics of the grout will be carefully selected to limit grout migration, dilution and other effects from groundwater and fissures in the chalk. This would be undertaken in accordance with best practice and as part of the risk management of the tunnelling works, and will be controlled pursuant to item MW-WAT9 of the

Comments on above, and summary observations

As previously stated, a complete understanding of conditions, with adequate geoscientific ground data, sufficient for realistic, accurate and unconditional tendering for this project, is currently not available from HEng to present to any interested tunnelling contractors as part of the tendering process which HEng initiated on 1th July 2019. (See previous SA submissions and evidence given in Sessions 4 and 5; June 11th and 12th 2019.)

Contractors tendering for this work will therefore not have sufficient geological, geotechnical nor hydrogeological information upon which to base any realistic tenders.

Hence the onus for "unforeseen ground conditions" will be placed entirely upon the successful tenderer. This goes against many modern Civil Engineering protocols and procedures, as encapsulated in the NEC 3 and 4 guidelines, as well as the Civil Engineering Contractors Major Infrastructure Contracts terms and conditions.

The outcome of such a situation can therefore only be to invoke a multitude of claims, and extensions to the predicted Contract Term, which would result in inflated costs and considerable time losses for completion of the works.

Government funds, or rather the British Taxpayer, should be properly protected against such inevitable consequences of the inadequacy and incompleteness of HEng's ground investigations, rock and groundwater data interpretations and predictions of conditions and changes, and failure to provide a professional, competent and complete set of ground condition descriptions, below a significant and sensitive World Heritage Site.

Dr. GM Reeves *09-08-19*

References

Mortimore, R.N., L.T. Gallagher, J.T. Gelder, I.R. Moore, R. Brooks and A.R. Farrant "Stonehenge—a unique Late Cretaceous phosphatic Chalk geology: implications for sea-level, climate and tectonics and impact on engineering and archaeology", *Proc. Geol. Assoc.* (2017). Vol.128. Issue 4; pp.564-598.

Soley, R.W.N., T. Power, R. N. Mortimore, P. Shaw, J. Dottridge, G. Bryan and I. Colley, "Modelling the hydrogeology and managed aquifer system of the Chalk across southern England", Geological Society, London, Special Publications 2012, v.364; pp.129-154.