From: Kate Fielden <[redacted]
Sent: 23 August 2019 17:14
To: A303 Stonehenge <A303Stonehenge@planninginspectorate.gov.uk>
Cc: 'Dr. Dr George M M REEVES' [redacted]; 'Charlie Hopkins' [redacted]
Subject: Presentation by Dr Reeves at ISH 10 on 29.8.19

Dear Richard,

Thank you for your advice re Dr Reeves' presentation.

I attach the latest version of his slides (for the convenience of having them together with his notes) and the notes to which he would refer in his presentation. The notes are more full than 10 minutes would allow and would be abbreviated for the presentation. They are provided at greater length in what is hoped will be more helpful detail to the reader.

As Dr Reeves tried to explain on Wednesday, it seems that the complete picture of the geology and hydrogeology affecting the tunnel has not so far been fully explored or explained. He does have a pretty thorough knowledge of the situation, since he first became involved in A303 tunnelling proposals at Stonehenge at the 2004 Public Inquiry where he argued the (Stonehenge Alliance's) case for inadequate information and potential tunnelling problems on far less information at the time. The 2004 scheme was abandoned owing to a considerable increase in cost, primarily for the reasons Dr Reeves had put forward: the nature of the Chalk Rock and groundwater/water table problems – which had been dismissed by the Highways Agency at the Inquiry.

We did ask recently (14 August) for more information on borehole data etc. but this has, so far, not been forthcoming.

Nevertheless, from Dr Reeves' on-going analysis of what has been supplied to date, I understand that the presence of impermeable/semi-impermeable Whitway Rock has apparently not been positively identified by Highways England (perhaps because the coring was not deep enough in places to encounter it) but it does appear to be present from the lower levels of some cores. This Whitway Rock horizon could have a profound effect on groundwater movement which has crucial implications for tunnelling. As I understand it, without full knowledge of the actual situation, then it might be argued that planned provisions for certain strategies might not be appropriate.

If, in the event, it is not possible for Dr Reeves to speak to his presentation next week, I hope that his slides and notes will be accepted by the ExA as a written submission, as you indicated to me by email on Monday.

With all good wishes –

Kate

For Stonehenge Alliance

Notes to accompany Slides/Presentation on fundamental Issues of Groundwater Conditions relating to the proposed A303 Stonehenge Tunnel by Highways England. August 2019.

By Dr. GM Reeves

Slide Number Commentary

1. Introduction and purpose of contribution.
   This set of slides and accompanying presentation is intended to supplement that given to the ExA on June 11th, and results from some considerable further work done by the author on available borehole logs, wireline geophysics and core information, tied in with local and regional geological maps and data (published by BGS, Soley et al., Mortimore et al. and other sources), to explain the relevance of the Whitway Rock horizon, from its outcrop at Blick Mead/Amesbury Abbey springs (which are fed by this significant sub-horizontal hydrogeological feature), westwards along the proposed A303 Tunnel route.

2. Relevant Topics to be addressed.
   i. Groundwater Issues.
      Relevant evidence that the Amesbury Abbey/Blick Mead spring system arise at the Whitway Rock/Barrois' Sponge Bed/Stockway Rock horizon is presented.
   ii. Presentation of Data
      The likely hydrogeological conditions relevant to this major sub-horizontal marker bed are discussed and presented.
   iii. Unpublished Information.
      The importance of availability to unavailable data will be demonstrated (see Letter to ExA from Stonehenge Alliance dated 14th August 2019).
   iv. Consequences.
      The absence of adequate investigations in both depth and detail of groundwater conditions arising from the identification of a significant horizontal controlling groundwater feature, together with the combined effects of major identified significant vertical features (major faults and fractures at Stonehenge Bottom and further west, for example) will be raised.

3. Relevance of controlling horizon (Whitway Rock) to hydrogeology of entire proposed tunnel route.
   A conceptual model of the structural and hydrogeological properties of the Whitway Rock Horizon is presented, as interpreted from the borehole data available. Sub-horizontal fracture systems lying above the less permeable Whitway Rock/Barrois sponge bed horizon provide a faster conduit for southward and eastward groundwater movement below the Newhaven Chalk.
   The less permeable layer of Whitway Rock consequently gives rise to the Blick Mead/Amesbury Abbey springs. Note: The Whitway Rock is known further to the east as Stockbridge Rock. (See Slide No. 7)

4. Methods of geoscientific data presentation and interpretation and their shortcomings.
   The problems of assessing, integrating and correctly interpreting very complex

geological, geotechnical and hydrogeological information to a proposed tunnel environment are presented and summarised.

5. A representation of available site data.
   An example of "old fashioned" OS map, pen, pencil (and eraser) approach to assessing the extent, in plan and to depth of Site Investigation (SI) data is presented.

6. Publicly available relevant SI data.
   From the publicly available records (the BGS Geology of Britain online Geological Map Viewer), some borehole locations and data can be downloaded by the user.

7. The Whitway/Stockbridge Rock, representation and recognition on published BGS maps.
   Little is known of the Whitway Rock horizon west of Amesbury since adequate exploratory work has not been undertaken at sufficient depth and detail until recently. This, and the superficial Drift cover west of Countess Roundabout explains its absence on published maps.

8. The Barrois' Sponge Bed/Whitway Rock horizon, its stratigraphical position and hydrogeological relevance along the proposed tunnel route.
   The stratigraphic level of the Whitway Rock in the Upper Seaford Chalk, approximately 5 metres below the base of the overlying Newhaven Chalk can be seen in this figure from Mortimore et al. 2017. Note: Borehole R11 is a significant distance west of Stonehenge Bottom: see Section in Slide 10, from AWM report.

9. Details of evidence for the Whitway Rock horizon, it's hydrogeological relevance, importance and significance to the proposed tunnel route.
   The Whitway Rock horizon, a complex zone of contrasting permeabilities, is up to 5 metres thick and occurs in the Upper Seaford Chalk approximately 5 metres below the base of the overlying Newhaven Chalk. It is a "marker horizon" in the Upper Seaford Chalk, with greater and lesser degrees of imprint on the borehole records through the tunnel line. Some of the best features can be seen on Optical Televiewer geophysical logs (OPT), porosity (POR) and Formation Density logs (Den), as well as in some core box images and drill logging comments (e.g. "Orange staining", "sponge bed possible horizon", etc.)
   Additional, more relevant DTH/Wireline logging geophysical techniques should have been used which would undoubtedly give improved supporting logging data (e.g. DTH Resistivity/SPR logs; Gamma Spectrometer & Caliper).

10. Critical Review/Discussion on AWM figure from "Groundwater Modelling Report".
    This section (from the AWM Groundwater Modelling Report) shows that the author(s) were aware of the possible importance of the Whitway Rock horizon and associated groundwater conditions to their model, and the tunnel line.
    This again emphasises the absence of the necessary detailed groundwater investigations at appropriate depths and detail to adequately characterize these significant groundwater conditions as the "possible" horizon which controls west to east groundwater movement and is not considered in, or important to, the groundwater models.

11. Available/Unavailable Basic SI data

    This is as listed in Stonehenge Alliance's letter of 14th August to the ExA, detailing known possible additional sources of Site Investigation data which are likely to enhance the above interpretations of the important stratigraphy, and its control on hydrogeology along the proposed tunnel line: specifically,

    (i). All drill logs, drilling data, groundwater measurements and test data from all boreholes drilled for the project, subsequent to the last release of information to us in the December 2017 Final Report from Structural Soils (Report No. 731823; Vs.3).

    (ii). All original ground investigation data (drilling records, borehole logs, geophysical logs, unpublished groundwater testing data) which support the published "Groundwater Reports".

    (iii). All drilling and testing geological, geotechnical and hydrogeological data from continuing field and drilling investigations commenced in May/June this year, up to and subsequent to the announced Project Tender date of 15th July 2019.

12. Current BGS GeoIndex Database for the Stonehenge area.

    The current BGS GeoIndex Borehole Database Borehole Locations are shown on this figure. "Commercial In Confidence" borehole logs (which are numerous) and unavailable are shown in Black.

13. Whitway Rock Horizon- Boreholes: east to west- A Zone of Elevated Permeability

    This slide summarises current work by Dr. GM Reeves, (also correcting some previous depth errors e.g., in Borehole R142 (last submission to ExA) from detailed examination of Borehole Core Logs/Core photographs and Wireline Logging interpretations, identifying evidence showing possible identification of the Whitway Rock Horizon, going from east to west along the proposed tunnel line. This research work is continuing.

14. An example from Borehole R20: Corebox images.

    From about 29.00m to the suggested level of the Barrois' Sponge Bed at 32.56m, as identified on the 2001 borehole log, core box photographs and geophysical logging of Borehole R20 (to the east of Stonehenge Bottom), a zone of heavily fractured Seaford Chalk (extending from 74.68m down to 71.30m AOD) can be identified. Along this fractured zone, groundwater flow is concentrated, moving from the recharge area to the west and Stonehenge Bottom, to discharge into the River Avon via the Blick Mead area and the Amesbury Abbey Springs.

In summary, therefore, there is convincing evidence of a sub-horizontal zone of elevated permeability in the upper 10 metres of the Seaford Chalk which is likely to adversely affect groundwater inflows to the proposed tunnelling, with possible considerable chance of delays and requirements for much additional grouting and groundwater control by dewatering.

gmr 23.08.19

Dr. GM Reeves

For

The Stonehenge Alliance

On

Geology, Hydrogeology, Geotechnics &

Effects of Tunnelling on Groundwater

Additional Topics: August 2019

- 1. Groundwater Issues
- 2. Presentation of Data
- 3. Unpublished Information
- 4. Consequences

1. Groundwater Issues

- Whitway/Stockbridge Rock (Barrois' Sponge Bed Horizon)
- Amesbury Abbey/Blick Mead Springs
- Borehole Log interpretations.

2. Presentation of Data

- 2-D Plan
- 2-D Sections
- Complexities: Chalk Permeability is 3-dimensional and multi-modal
- Variations in 3 Dimensions- Space + Time (4^{th} Dimension!)

Fargo Plantation
The Cursus
Cumuli
Sewage Works
Long Barrow
Totterdown Clump
Dismantled Railway
Old King Barrows
Halfmoon Clump
Cumulus
The Avenue
The Avenue (course of)
New King Barrows
Stonehenge
Stonehenge Cottages
Countess
Countess Farm
Motel
Memorial
MS
Long Barrow
A303(T)
Stoke Group
Normanton Gorse
Henge (site of)
Luxenborough
West Amesbury
Amesbury Park
Amesbury Abbey
Fort
Coneybury Hill
Coneybury House
Coneybury Hill Plantation
Queens Falls (Weir)
Bush Barrow
Normanton Down
Wilsford Down
Moor Hatches
New Barn
Ham Hatches
Recn Gd
Cemy
Sewage Works
Aqueduct
Pit (dis)
Chalk Pit
Normanton Down House
Normanton
Springbottom Farm
Resr
Cumuli (Lake Group)
Earthwork
Southmill Plantation
AMESBURY
11
12
13
14
15
WILSFORD CUM LAKE CP
SML 2000
* 1:10 000 'DESCALED'


British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL
Geology of Britain viewer
More BGS map viewers
Surface Geology
3D Models
Borehole Scans
Earthquake Timeline
Borehole Scans
Click on a borehole to view scan.
Borehole depth
0 - 10m
10 - 30m
30m+
Unknown
Confidential or Restricted
More on boreholes
Stonehenge, Wilts
Go to Location
Switch Basemap
100%
0%
Geology Transparency
Grid Ref: 409314, 142917
Visitor Centre
A360
Longbarrow Lane
Winterbourne Stoke Barrows
Byway 12
Stonehenge Landscape
Normanton Gorse
Normanton Down Barrows
SU14SW25
SU14SW61
SU14SW78
SU14SW79
SU14SW77
SU14SW63
SU14SW58
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SU14SW97
SU14SW98
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SU14SW40
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SU14SW32
SU14SW28
SU14SW27
SU04SE84
SU04SE85
SU04SE99
SU04SE82
SU04SE106
SU04SE33
SU04SE60
SU04SE81
SU04SE83
SU04SE117
SU14SW101
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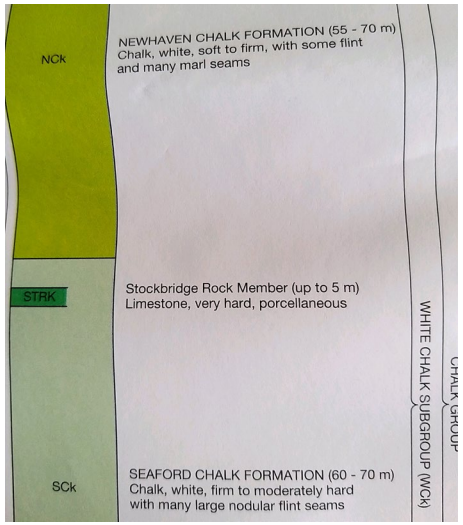
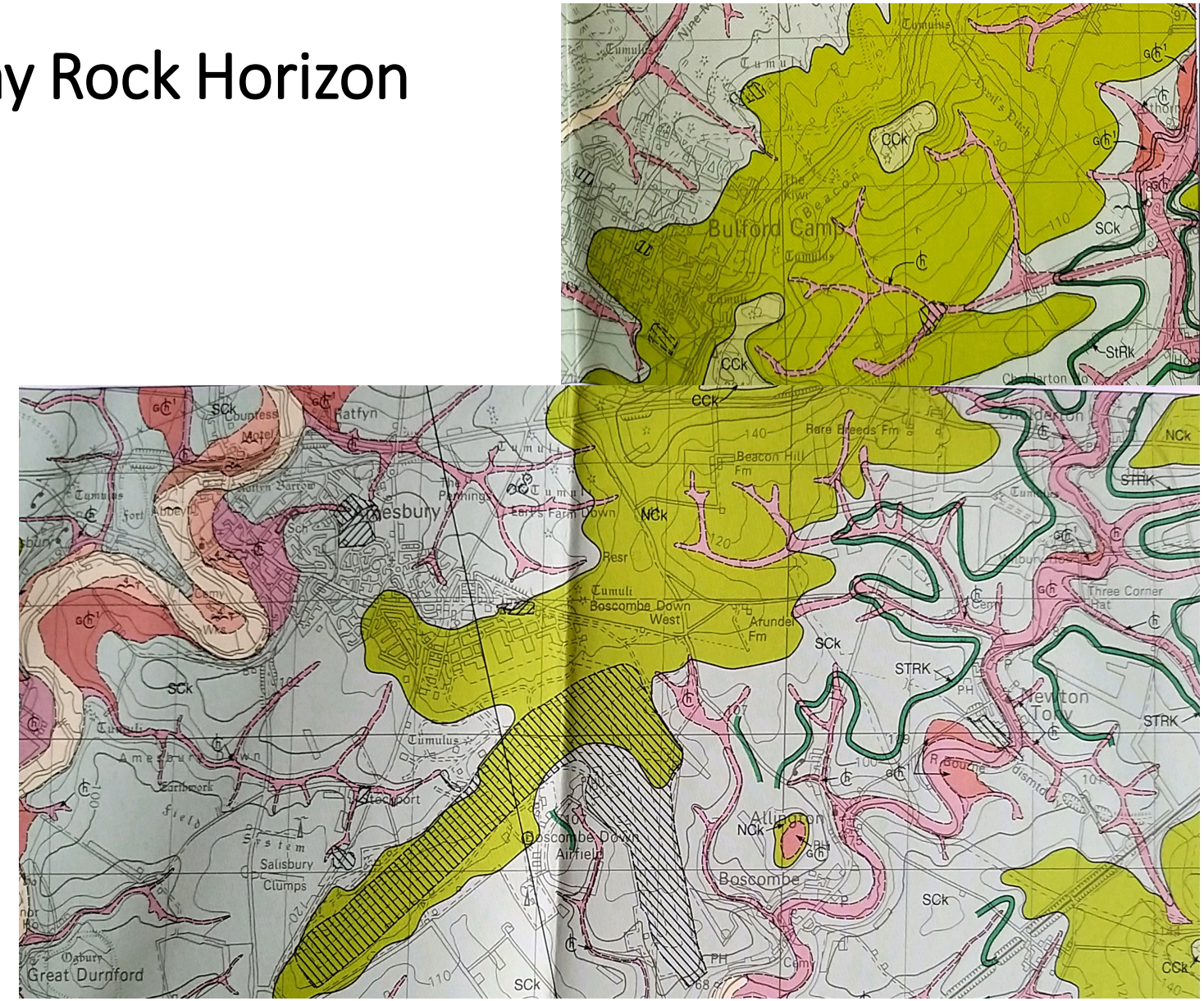
0.15
0.3km
POWERED BY esri

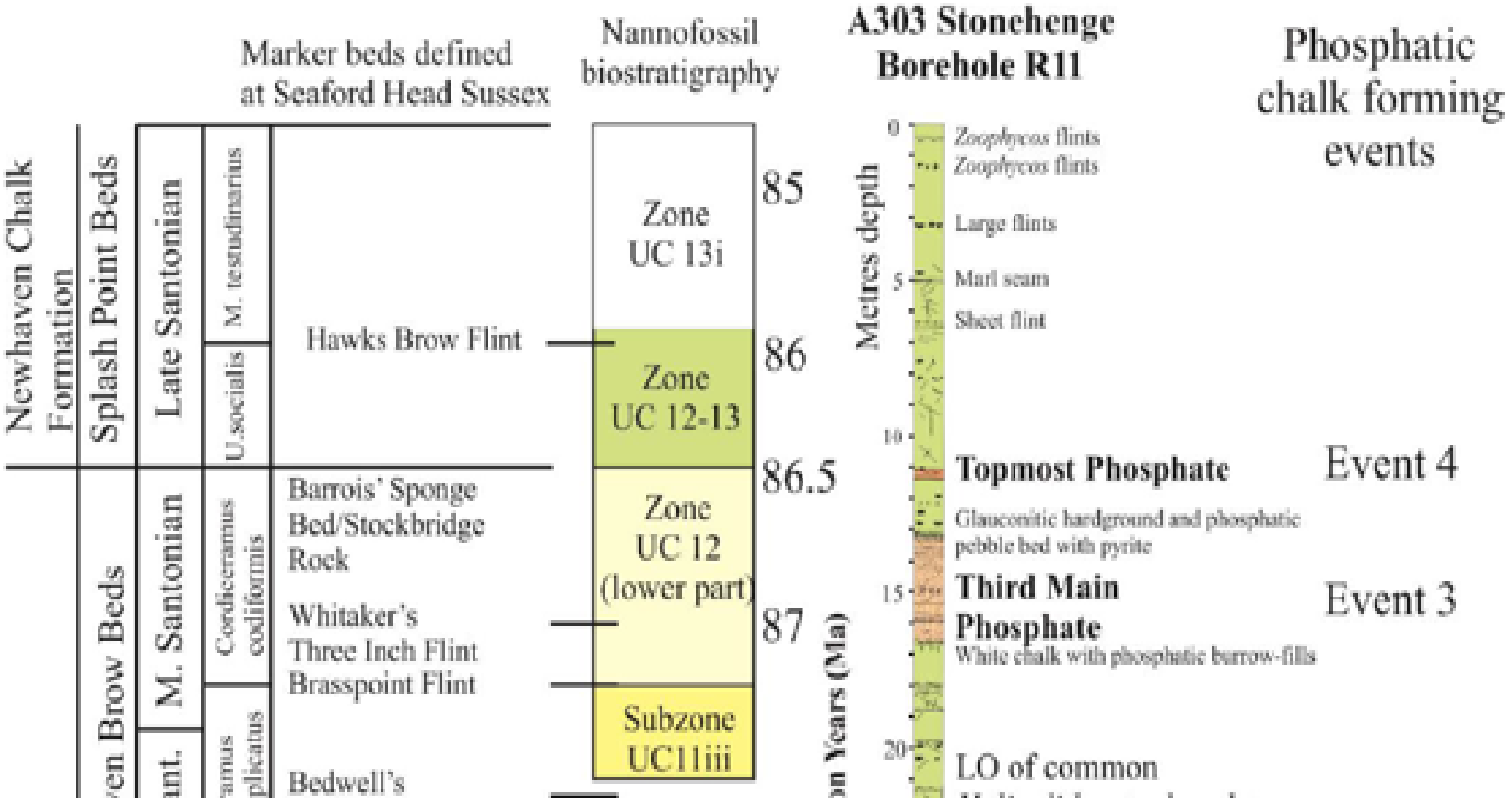
The Whitway Rock Horizon





Barrois' Sponge Bed/Whitway Rock Stratigraphic Level:

- A zone of elevated permeability (sub-horizontal fissures) controlling lateral groundwater flow- SE wards- :underlain by Seaford Chalk/"Porcellanous Limestone" of significantly lower horizontal permeability.

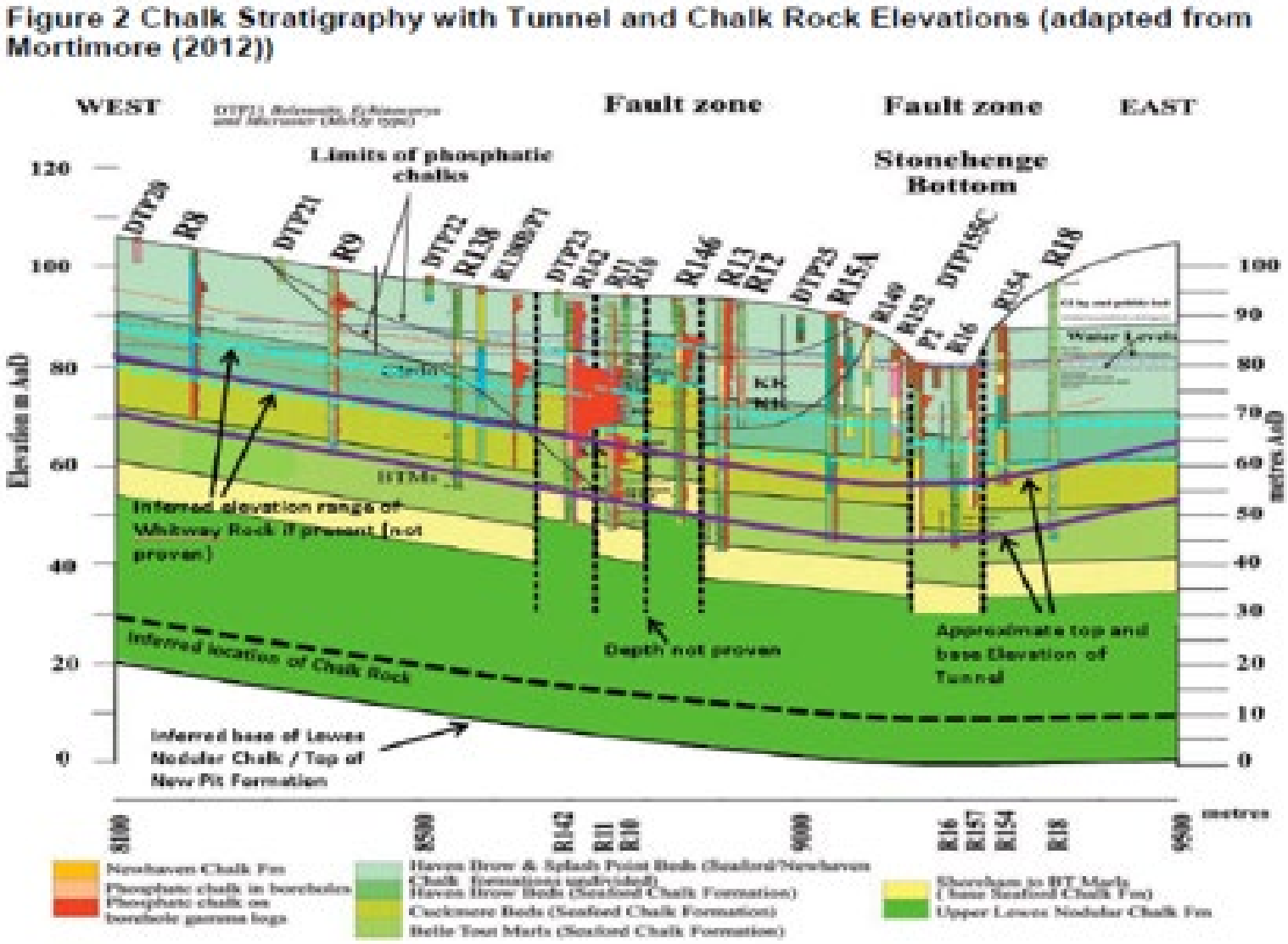


(From Mortimore et al, 2017, in part)

Details of Evidence for Whitway Rock Horizon

- From Blick Mead to Eastern Portal to Western Portal.
- **A zone of elevated permeability (sub-horizontal fissures) controlling lateral groundwater flow- SE wards- :underlain by Seaford Chalk/"Porcellanous Limestone" of significantly lower horizontal permeability.**
- **A dominant High Permeability sub-horizontal zone, above, with restricted flow below.**
- Varies from 60m AOD to 71.30m AOD at Blick Mead
- Sometimes as Stockbridge Rock Member…"a hard porcellanous limestone up to 5m thick, ……approx. 5m below Seaford/Newhaven Chalk Boundary.
- Equivalent stratigraphically with Barrois' Sponge Bed.
- Typified by high degree of fracturing (sub-horizontal to near vertical.
- Seen as weak zones in numerous core boxes
- Coincident often with orange staining, core loss and sponge fragments with rinded flints.
- Often shows on OPT, POR, Den
- For full list of evidence, see separate listing.

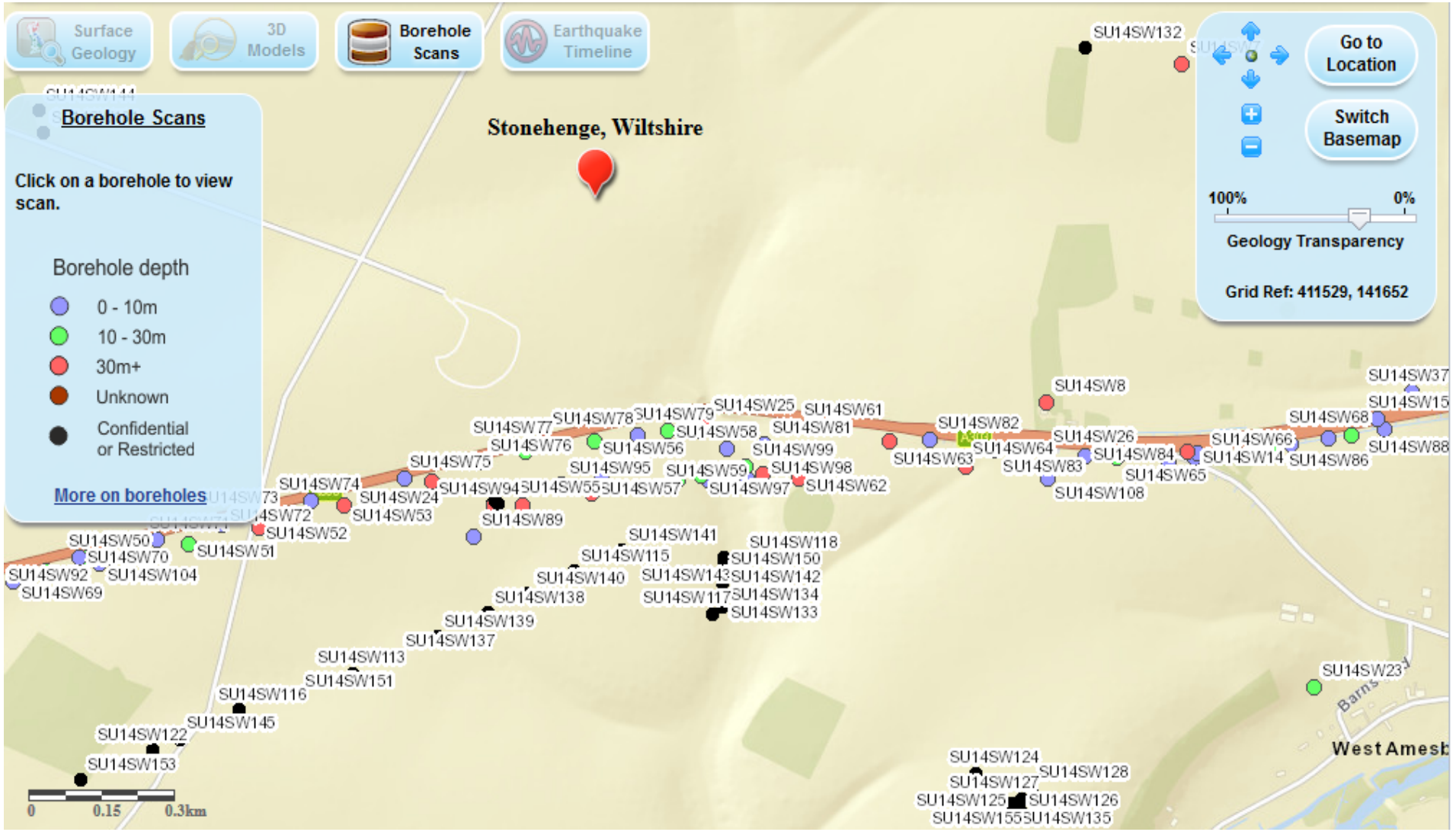
Figure 2: from AWMReport No. TR010025 Document 8.23 – Implications of 2018 Ground Investigations to the Groundwater Risk Assessment (republished with tracked changes, dated 31.05.19)- Travis et al.



3. Unpublished SI Information

- **A303 Amesbury to Berwick Down:** Factual Report on Ground Investigation
  -Project No: 731823 (Last available Download from BGS- Ref:
- Amesbury Abbey/Blick Mead Springs investigation
- Supporting SI data for Groundwater modelling and Reports.
- Borehole Log interpretations.

BGS GeoIndex Database:



Whiteway Rock Horizon- Boreholes: East to West- A Zone of Elevated Permeability

Borehole No.	GL (mAOD)	Total Depth	GWL (mAOD) (As Drilled)	WR Level (mAOD)	Evidence
P3	109.48	31.3	12	N/A	Not deep enough for WR
R20	103.9	35	N/A	c.74-68m…71.30m	"Possible Sponge Bed at 32.56-32.69m+CorePix-9+10
R19A	106.33	45	N/A	c.80.0-73.00m	26.00-Por:33.0-FDN+CorePix
R18	96.5	51	N/A	70-66m	CoreBoxes 6-9+POR:26m+FDN:29m
R16	79.5	36	N/A	c.53mAOD	26.0m-30.50m
P2	80.88	35.7	N/A		10-18m -core heavily orange stainned
R152	83.48	23	N/A		Zero RQD for whole hole.
R13	93.1	50	N/A	60.6mAOD	32.50 CoreBox 12
R11	92.9	45.7	19.5	86.5	OPT+Core+RM
R10	94.4	25.43	N/A	c.74.40m	20.50 DEPTH-Core Pix
R142	92.94	45	19.5	c.80mAOD	

The Whitway Rock Horizon- A Zone of Higher Permeability-

:underdraining the Newhaven Chalk & Upper Seaford Chalk

Borehole R20