TECHNICAL REVIEW:

Review of -

RSK Environmental Ltd (2019) Hydrogeological Risk Assessment of the Angus Energy Lower Stumble Exploration Site, London Road, Balcombe - (Report No 11467-R01(00))

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Prepared for:

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DOCUMENT CONTROL

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Review of RSK Environmental Ltd (2017) 'Hydrogeological Risk Assessment: Angus Energy Lower Stumble Exploration Site, Balcombe', Report for Freddie Holt, Angus Energy, Lower Stumble Exploration Site, London Road, Balcombe, West Sussex, RH17 6JH. Dated 20 December 2019. Report No 11467-R01(00); as submitted by Heaton Planning Ltd (Heaton) to West Sussex County Council Planning on 20 December 2019.

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01st February 2020

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(Director, Tapajós Limited).

Dated:

02nd February 2020

Contents

1. INTRODUCTION AND SCOPE OF WORKS

1.1 Tapajós Limited have been commissioned by Frack Free Balcombe Residents' Association (FFBRA) to undertake a desk study review of a hydrogeological risk assessment as submitted by Heaton Planning Ltd (Heatons) dated 20 December 2019 to West Sussex County Council (WSCC) in support of an application for a three-year extended well test by Angus Energy (WSCC/071/19) at Lower Stumble Exploration Site, London Road, Balcombe, West Sussex, RH17 6JH.

1.2 The address for which the application is being made is 'Lower Stumble Exploration Site, London Road, Balcombe, West Sussex, RH17 6JH'. The Planning Application number is WSCC/071/19.

1.3 The primary document reviewed was: 'RSK Environmental Limited (2019) Hydrogeological Risk Assessment: of the Lower Stumble Exploration Site, Balcombe. Report for Freddie Holt, Angus Energy, Lower Stumble Exploration Site, London Road, Balcombe, West Sussex, RH17 6JH. Dated 20 December 2019. Report No 11467-R01(00)' as submitted as Appendix 1 to a letter report from Liam Toland of Heatons to Chris Bartlett, Principal Planner, West Sussex County Council dated 20 December 2019 entitled "Remove drilling fluids and carry out an extended well test. this proposal is a two-stage activity: 1) Pumping out previously used drilling fluids to ascertain any oil flow (up to 4 weeks) 2) Should oil be seen to flow; an extended well test would be carried out over a period of three years. Lower Stumble Exploration Site, Off London Road, Balcombe, RH17 6JH." Heaton Planning Ltd, 9 The Square, Keyworth, Nottingham NG12 5JT. Ref ANG-001-M.

1.4 The 'Hydrogeological risk assessment' (Appendix 1) are reviewed in detail in this Technical Review Summary.

1.5 Other documents reviewed or referenced are presented in Section 0 References:

1.6 The review is desk-based using the following sources:

- Existing published literature;
- Consultancy, water company, regulatory and government reports relating to the

hydrogeology of the area, where available;

- British Geological Survey (BGS) mapping and memoir for the area;
- Well and borehole records;
- The current groundwater vulnerability map for the area;
- Local groundwater level and chemistry data, where available
- Local spring or well discharge and chemistry data, where available.

1.7 For the purposes of this review the RSK Environmental Ltd's Hydrogeological Risk Assessment of the Lower Stumble Exploration Site, Balcombe (Report No. 11467-R01(00) document (referred to in this report as RSK (2019) HRA) runs to 27 pages with additional Figures and Appendices. This will be referred to as the "RSK (2019) HRA''.

1.8 The RSK (2019) HRA was issued to WSCC by Heatons as an Appendix in a 4-page letter report dated 20 December 2019.

1.9 Regarding the structure of this Technical Review Note:

- An overview of the RSK Environmental Ltd (2019) Hydrogeological Risk Assessment (Appendix 1 of the Heatons submission to WSCC) is presented in Section 2.
- The RSK (2019) Hydrogeological Risk Assessment (Appendix 1 of the Heatons submission to WSCC) is reviewed in detail in Sections 3 and 4.
- A review and comment on the proposed mitigation measures to address the hydrogeological risk as presented in RSK (2019) HRA is presented in Section 4.

1.10 Throughout this Technical Review, text quoted *verbatim* from other documents is given in italics and quotation marks, whereas bold and underlining for emphasis are given by the author of this Technical Review Note.

1.11 Please note, for the avoidance of confusion, where page numbers from the RSK (2019) HRA document are referred to in this Technical Review, the page numbers will be referred to as the page number from the beginning of RSK Environmental Ltd document and not the page number of the Heatons submission.

2. LOWER STUMBLE EXPLORATION SITE BACKGROUND

2.1. Review of RSK Environmental Ltd Scope of Works

2.1 This section focuses on the background information presented in the RSK Environmental Ltd revised Hydrogeological Risk Assessment of Angus Energy Lower Stumble Exploration Site; Balcombe dated 20 December 2019 (RSK (2019) HRA).

2.2 Section 1.1 RSK (2019) HRA states that RSK Environmental Ltd were "commissioned by Angus Energy to provide a Hydrogeological Risk Assessment (HRA) to support a planning application (WSCC/071/19) seeking consent to undertake development at the Lower Stumble Exploration Site".

2.3 Section 1.1 of the RSK (2019) HRA establishes that the RSK (2019) HRA "forms an update to a previously issued Environmental Statement (ES), dated 11 November 2019 (HA/2019/121694/121674/01-L01)."

2.4 Section 1.2 RSK (2019) HRA explains the background to Angus Energy's application. This includes that the seven day well test on Balcombe 2Z well carried out in Autumn 2018 was unsuccessful such that "sustained oil flows from the formation were not achieved" because "leftover drilling fluids [were] in the well".

2.5 RSK (2019) HRA explain in Section 1.2 that Angus Energy "attempted to return to the well" in February 2019 "to pump out the remaining drilling fluids" in order to prepare the well for an Extended Well Test (EWT). However, WSCC deemed that the planning permission granted at the beginning of Autumn 2018 had expired due to notification to WSCC that "the original work had finished." Consequently, "the operation was therefore cancelled."

2.6 The context of the RSK (2019) HRA is to support the application by Angus Energy to undertake the EWT of the well under a proposed two-staged approach [RSK (2019]:

- "Stage 1 – removal of previously used drilling fluids to ascertain presence of dry oil in the well"
- "Stage 2 – should oil be seen to be present, undertake an EWT over a period of up to three years".

2.2. *Review of Environment Agency's Response*

In Section 1.3, RSK (2019) HRA sets out their scope of works. This includes a review of the environmental setting; groundwater sampling data review for the period 2015 to 2019; the Environment Agency's environmental permit; the site layout including infrastructure and ground conditions in Stage 1 and Stage 2; site operations including chemical use and storage; review design embedded mitigation measures and propose mitigation measures that are "considered necessary".

2.7 The Environment Agency had "no objection in principle" to the proposed site development (Section 1.5 of the RSK (2019) HRA citing the Environment Agency's letter date 11 November 2019 Ref HA/2019/121694/01-L01). However, the Environment Agency objected to the site development planning application WSCC/071/19 on basis that there was "insufficient information" made available to support the proposed development. In particular, the Environment Agency objected as the proposal did not include a Hydrogeological Risk Assessment (HRA) thereby making no assessment of the risk to the groundwater environment and of the risks to actual or potential future receptors including impacts on secondary aquifers.

2.8 Specifically, in their letter of response dated 11 November 2019, the Environment Agency cited Section 10.5.6 of the Planning Statement that "concluded that there should be no risk to groundwater from the proposed works." Commencing that "this statement alone is not sufficient" and as such the Environment Agency would "require a fully justified assessment of the risks."

2.9 In their response letter dated 11 November 2019, the Environment Agency made reference to a previous risk assessment by RSK Environmental Lrd (RSK/MA/P66130-04-rev02, dated October 2017) submitted in support of a previous planning application (WSCC/040/17/BA) and cited that a more thorough and updated risk assessment is required as the period of testing in the current application is over a notably longer period of time.

2.10 With respect to potential risks to the groundwater environment, including secondary aquifers, the Environment Agency concluded in their letter to WSCC in response to planning application WSCC/071/19 that "until a HRA, which reflects all aspects of the current application is provided we are not able to verify that the proposal is acceptable from a groundwater protection standpoint."

3. REVIEW OF LOWER STUMBLE EXPLORATION SITE GEOLOGICAL AND HYDROGEOLOGICAL UNDERSTANDING IN RSK (2019) HRA

3.1. Overview of the Geological and Hydrogeological Content

3.1 This section focuses on the geological and hydrogeological information presented in RSK (2019) HRA and considers whether the information considered by RSK (2019) is sufficient to build a robust and thorough understanding of hydrogeological risk and assessment of appropriate mitigation measures for the Angus Energy Lower Stumble Exploration Site in Balcombe.

3.2 A general comment on the content and style of the RSK (2019) HRA report, it is noted that there is considerable cross over in the report between the sections describing geology (Section 3.3.1) and hydrogeology (Section 3.3.2). Notably, there are comments about groundwater movement in the geological section and new details about the geological formation and lithology presented in the hydrogeology section not first noted in the geology section. This point is raised in the context of this review as there has been a need to jump between these two sections to draw out many of the points made.

3.3 RSK (2019) HRA report that there is substantive thickness of Wadhurst Clay – 50 metres – beneath the Lower Stumble Exploration Site. Beneath the Wadhurst Clay is 200 metres of Ashdown Beds; above the Purbeck Beds. For the purposes of this review, the active groundwater system that naturally interacts with the surface and near-surface aquatic environments is expected only in the upper geologies and their outcrops. Therefore, the principle focus of this review is on the Head Deposits, the Wadhurst Clay and the Ashdown Beds.

3.4 The inherent primary focus of this HRA review will be on the near surface geologies, aquifers and groundwater systems; unless there is evidence of hydraulic connectivity between the deep geological units and those where an active groundwater system is expected to interact with the near surface. Therefore, this HRA review inherently requires less focus on deeper geologies where the naturally occurring and generally less mobile groundwater is substantially less likely to interact with near surface aquatic environments or be developed for water abstraction purposes.

3.2. Superficial Deposits

3.5 RSK (2017) stated that there were "no superficial deposits are present at the [Lower Stumble Exploration] site." However, the RSK (2019) HRA determines that "the [Lower Stumble Exploration] site is underlain by Head deposits." Head deposits are generally classed as *superficial deposits*.

3.6 It is noted that the presence of the Head Deposits is marked on the British Geological Survey Geological Map (solid and drift) Sheet 302. However, the RSK (2019) HRA makes no further reference to the Head Deposits in their assessment of geology in their Section 3.3.1. Rather, the RSK (2019) HRA build their understanding of the Lower Stumble Exploration site geological succession using the two boreholes drilled at this site – one vertical and one directionally drilled; supported by the two publicly available borehole logs – referenced as TQ32NW6 located approximately 100 metres northwest of the Lower Stumble Exploration site; and TQ32NW7 located approximately 650 metres north of the Site. Neither of these borehole logs record the Head Deposits.

3.7 In contrast, in Section 3.3.2, RSK (2019) HRA, establish that "the head deposits beneath the Site" "are very limited in aerial extent." This again contradicts the RSK (2017) view that there were no superficial deposits beneath the Lower Stumble Exploration Site.

3.8 RSK (2019) HRA also states that the Head deposits present "beneath the Site" are "classified as a secondary (undifferentiated) aquifer" and this "is typical of units that have a variable hydraulic conductivity and where it has not been possible to fully characterise the rock."

3.9 The absence of further site-specific evaluation on the presence of Head Deposits or their extent within the area of the Lower Stumble Exploration Site may be an omission and to a degree, may shape the hydrogeological risk assessment. Due consideration of the Head Deposits and their spatial distribution may be important in understanding the site drainage and recharge of the groundwater system (including localised perched systems within more permeable horizons in the Wadhurst Clay Formation); and may affect groundwater dynamics including recharge, hydraulic gradients, whether the groundwater in the aquifers has atmospheric or non-atmospheric piezometric pressures; and to what extent the underlying geology is naturally protected by lower permeability cover.

3.10 Therefore, although the absence of further reference and evaluation of the presence and distribution of Head deposits at or nearby to the Lower Stumble Exploration Site may not be a substantive impact and the Head deposits may be thin hence not recorded in the drilling logs; the absence of detailed site-specific reference to the Head Deposits indicates that the HRA may not be as thorough or complete as it should be and, therefore, undermines some confidence in the assessment of risk.

3.11 RSK (2019) HRA also make reference to the “thin ribbon of alluvium associated with the tributary to the River Ouse” nearby to the Lower Stumble Exploration Site and recognise that this superficial deposit “is classified as a secondary A aquifer, which is capable of providing localised base flow to surface water and local groundwater abstraction.”

3.3. Tunbridge Wells Sands *and Wealden Clay*

3.12 The RSK (2019) HRA set out that there is no Tunbridge Wells Sands present at or beneath the Lower Stumble Exploration site. Further, there is no reference to the Wealden Clay that underlies the Tunbridge Wells Sands apart from one reference to the Wealden Clay within Section 3.3.6 Surface Water. For the purposes of this review, it understood that neither the Tunbridge Wells Sands nor the Wealden Clay are impacted by the proposed activities at the Lower Stumble Exploration Site. However, an inclusion of reference to both the Tunbridge Wells Sands and the Wealden Clay is considered appropriate for the geological and hydrogeological setting as it is noted that springs emitting from the Tunbridge Wells Sands at the outcrop with the Wealden Clay contribute to the source of the stream that flow 100 metres south west from the Lower Stumble Exploration Site that forms a tributary of the River Ouse. An evaluation of the overlying deposits beyond the site boundary would help inform the HRA, notably in the context of helping to inform the recharge mechanisms and areas and nearby springs and surface water drainage.

3.4. Wadhurst Clay

3.13 RSK (2019) HRA report a substantive thickness – 50 metres – of Wadhurst Clay.

3.14 RSK (2019) HRA describe the Wadhurst Clay as "comprising soft, dark grey thinly bedded mudstones (shales) and mudstones with subordinate beds of pale grey siltstone, fine grained sandstone, shelly limestone, clay ironstone and rare pebble beds."

3.15 In both descriptions of the Wadhurst Clay and the Ashdown Beds, there is minimal reference to the lithostratigraphy and notable absence to referencing the lateral extent or continuity of beds, the degree of heterogeneity, lenses, clay layers connectivity or otherwise of more permeable medium and coarse sand layers.

3.16 The RSK (2019) HRA identifies notable lithological variability of the Wadhurst Clay, as described above, such that there are significant permeable and transmissive medium and coarse-grained sand layers, some which are connected and allow groundwater to pass through and between layers. However, RSK (2019) HRA simplify the hydrogeology of the Wadhurst Clay by stating "the Wadstone Clay is understood to act as an aquiclude, confining groundwater within the underlying Ashdown Formation, which is classified as a secondary aquifer at a regional scale."

3.17 [presumably "the Wadstone Clay" is a misspelling and this should read "the Wadhurst Clay" in RSK (2019) HRA Section 3.3.2].

3.18 This characterisation of the Wadhurst Clay as a homogenous impermeable continuous clay shapes RSK (2019) HRA attitude to risk for the groundwater within the more transmissive Wadhurst Clay sand layers; and influences the groundwater monitoring strategy as described by RSK (2019) HRA. Notably, there is no targeted groundwater monitoring of the Wadhurst Clay; and as such the background groundwater quality information as obtained by Ground Gas Solution Ltd from 2013 from monitoring wells into "the Ashdown Beds (secondary A aquifer), which is confined by the overlying Wadhurst Clay (unproductive strata)." Although this may be a common characterisation of the Wadhurst Clay as an thick continuous aquiclude; this lack of detailed characterisation has resulted in no monitoring boreholes within the Wadhurst Clay and no attempt for targeted monitoring of the connected medium and coarse sand layers understood from RSK (2019) HRA's geological description to be present within the Wadhurst Clay. This is a significant absence, as the RSK (2019) HRA does not inform an understanding of whether or not there are potential groundwater pathways within and through the Wadhurst Clay. Therefore, no meaningful assessment of hydrogeological risk within the transmissive horizons of the Wadhurst Clay have been demonstrated to have been established.

3.5. Ashdown Beds

3.19 The brief description as presented by RSK (2019) HRA Section 3.3.1 is that the Ashdown Beds "comprises siltstones and silty fine-grained sandstones with subordinate amounts of finely-bedded mudstone. "

3.20 In Section 3.3.2, RSK (2019) HRA establishes that the Ashdown Beds "strata comprise alternating sands and mudstones frequently forming multi aquifer systems although the layers are not always laterally extensive", which "adds further to the complexity of the aquifer system." The disruption of the strata and, therefore, groundwater flow through this disturbed sequence is deemed by RSK (2019) HRA as "very complicated." This is notably emphasised in Section 3.3.2 where RSK (2019) HRA state that "The hydrogeology of the Ashdown Formation is complex and not well understood." However, it is the view of this review that the RSK (2019) HRA sets out to simplify and characterise the groundwater dynamics within these geologies and effectively substantively simplifies the stated very complicated disruption of strata and groundwater flow through these disturbed geological sequences.

3.21 Specifically, the RSK (2019) HRA identifies the highly variable heterogeneity of the Ashdown Beds such that "the lack of correlation of water levels even between closely situated boreholes is a further indication of a patchy, multi-layered aquifer, without a single water table." This description is consistent with the characteristic hydrogeology of the Ashdown Formation where boreholes drilled at very short distances from one another may yield substantially different abstraction yields. Layered groundwater within multiple perched groundwater systems makes it very hard to determine whether the driller encounters perched groundwater or the main water table for that aquifer unit. Several water-strikes when drilling through the Ashdown Beds are not uncommon.

3.22 Furthermore, the perched groundwater units may affect the recharge mechanism and result in localised ephemeral springs – locally referred to as chalybeates. The presence of multiple perched systems and complex recharge areas and ephemeral and perennial springs makes understanding the hydrogeology of the Ashdown Beds very challenging. Without robust and detailed assessment of the layering, lenses and multiple perched systems across a range of seasonal and annual rainfall conditions, a thorough determination of the hydrogeology is very difficult to attain. Any understanding of risk is conditional on the information used to inform the risk assessment. If the hydrogeological system is characterised in an over simplified manner, then the understanding of both the hydrogeology and associated risk assessment will, too, become over simplified. The complexity of the hydrogeology of notably the Ashdown Beds and also the Wadhurst Clay means that a detailed field-based assessment of hydrogeology is required to sufficiently and thoroughly determine the risks to the groundwater environment; from which appropriate mitigation measures can be properly determined.

3.6. Groundwater Quality within the *Ashdown Beds Aquifer Units*

3.23 Section 3.3.2, RSK (2019) HRA references the groundwater quality sampling undertaken by Ground Gas Solutions Ltd. (GGS) in 2013. This review identities several shortfalls in the RSK (2019) analysis of this GGS data. Notably, the groundwater samples referenced by RSK (2019) HRA to emphasise their initial assertions were taken “on four separate occasions” over the period from July 2013 to August 2013 – two months in the height of one summer. The inference of their analysis, therefore, does not account of the possible seasonal variability of groundwater conditions; such that the samples referenced would have been from a receding groundwater table, heading towards the lowest groundwater levels in the late summer. Many of the ephemeral springs and perched groundwater units characteristic of the Ashdown Formation and possible present in the Wadhurst Clay also during the late autumn to early Spring would have dried up and/or ceased groundwater and spring flows. This may also have an impact on the oxygen levels in the groundwater, thereby affecting the extent of dissolved or precipitated metals such as iron and manganese.

3.24 However, notwithstanding the Summer 2013 groundwater sample data, RSK (2019) HRA obtained from GGS up to quarterly groundwater quality sample analysis results for the period 2015 to 2019 – with groundwater "monitoring comprised two rounds in 2015, one round in 2016, three rounds in 2017, four rounds in 2018 and three rounds in 2019."

3.25 The extent of the artesian conditions reported by RSK (2019) HRA during the monitoring visits are expected to be suppressed compared with the artesian head during and following the winter recharge season. These factors may have had an influence on the groundwater quality.

3.26 RSK (2019) HRA cite GGS' (2013) conclusion that "their data set that the majority of analytes are below the relevant quality criteria although for some determinants, particularly metals and sodium these criteria were exceeded." However, rather than emphasise that these groundwater conditions are natural for groundwater in parts of the Ashdown Beds, RSK (2019) HRA attribute this "poor" water quality to "low yield and the lack of local connection to surface recharge mechanisms."

3.27 The discussion presented by RSK (2019) HRA Section 3.3 relates observed concentrations of aluminium, zinc and iron relative to environmental quality standards (EQS) and drinking water standards (DWS). The reference of these standards reads as though exceedance of DWS or EQS are problematic, a result of a potential third-party pollution or unnatural anthropogenic influence. However, the text does not emphasise that these concentrations are reasonably likely to reflect natural groundwater quality within the Ashdown Beds. More so, the Water Framework

Directive emphasises the importance of understanding the baseline groundwater quality conditions and then ensuring there is no deterioration against the known or observed baseline.

3.28 It is the view of this review that RSK (2019) HRA make a poor assertion by establishing groundwater has deteriorated quality, is immobile and unconnected to recharge; as the quality of the groundwater in the Ashdown Beds is characteristic of groundwater moving through the iron rich geological formation and build up concentration of dissolved metals in the groundwater as a result. The presence of iron rich springs and streams emitting from the Ashdown Beds is characteristic of much of the High Weald. High dissolved and total metal concentrations above environmental quality standards are natural in the perennial and ephemeral springs (or Chalybeates) of the Ashdown Beds; with specific and some cases rare ecological communities developed associated with this natural groundwater quality - notably within the nearby Ashdown Forest Special Area of Conservation (SAC) (located approximately 10 miles east of Balcombe on part of the Ashdown Beds outcrop).

3.29 Furthermore and in contrast, later in Section 3.3.2, RSK (2019) HRA refer to "short lived" peaks in dissolved zinc and dissolved iron in October 2016 and a "short lived" peak in Aluminium in April 2018. This infers an active and mobile groundwater system may be present in the Ashdown Beds locally and contradicts the earlier assertion that there is a "lack of local connection to surface recharge mechanisms." However, with fairly infrequent groundwater monitoring (such as only one sample round taken in 2016), it would be inappropriate to dismiss such observed concentrations as "short lived" peaks. A more frequent and, therefore, more thorough sampling programme would be required to draw any robust assertions about the groundwater quality, its variability, trends, seasonality and connectivity between deep groundwater units, perched groundwater systems and the surface and near surface recharge and aquatic environments. Without this substantive baseline detail and informed understanding of site-specific and local hydrogeology, a thorough and robust appraisal of the hydrogeology and, therefore, hydrogeological risks cannot be completed.

3.30 RSK (2019) HRA also highlight the presence of dissolved carbon dioxide, methane and ethane in the GGS samples; and then set out to compare with the methane and ethane results in the Ashdown Beds as reported by Conoco (1986).

3.31 For the record, the concentration of methane as reported by Conoco (1987) slightly differ from that presented by RSK (2019) HRA – such that Conoco (1987, p 2.2) reported precisely 54,910 ppm CH_4 (Methane) and 1,335ppm C_2 H_6 (ethane); whereas RSK (2019) HRA appear to approximate the methane (CH_4) to 54,000ppm. Nevertheless, it is not of dispute that these concentrations were encountered by Conoco (1986, 1987).

3.32 RSK (2019) HRA infer that Conoco (1986, 1987) reported that the whole of the aquifer has the same level of gas as the pocket found at 54.3 metres (178 ft) (expresses as 280 units of gas). Whereas Conoco (1986) report for Section 2 in the Lower Cretaceous Ashdown Beds from 47.2 metres (154 ft) to 259 metres (850 ft) the "Background gas averaged 1.25 units and consisted of C1 and C2 down to 540 ft below where only C1 was present. At [54.3 metres] 178 ft the well flowed 150 bbls of formation water and associated with this was a gas peak of 280 units consisting of 54910 ppm C1 and 1335 ppm C2". That is, average for the aquifer was 1.25 units; whereas RSK (2019 HRA report appears to infer that Conoco Well Report (1986) found whole of the aquifer has 54,000 ppm of methane (C1) and 1,335 ppm of ethane (C2). In this respect, there appears to be a contradiction between the findings of Conoco (1986, 1987) that stated that these gas concentrations referred to a short peak of gas at 54.3 metres (178 ft) and the inference of RSK (2019) HRA on the gas concentrations within the Ashdown Beds aquifer as a whole. The background gas concentrations as reported by Conoco (1986) in the groundwater in the Ashdown Beds aquifer were on average 224 times less than stated in the RSK Risk Assessment. Furthermore, from 164.6 metres (540 ft) to 253 metres (830 ft) the concentration of ethane (C2) was reported as zero. RSK (2019) HRA misrepresentation or misreporting of these gas concentrations within the Ashdown Beds aquifer as a whole as applied within the hydrogeological risk assessment is of notable concern and may, therefore, undermine the understanding of the hydrogeology and thereby the stated appreciation of hydrogeological risk.

3.33 However, there is a concern about the inference made in the RSK (2019) HRA that as occasional outliers of methane and ethane were found at depth within the Ashdown Beds when drilled – including that reported by Conoco (1986, 1987). Nonetheless, the substantive record of the Ashdown Beds aquifer is not one of elevated methane and ethane; and such gases are not commonly encountered where the Ashdown Beds aquifer is developed for water supply purposes, for instance. Therefore, to suppose that the outlier concentrations as observed by Conoco (1986, 1987) are representative of the baseline groundwater conditions would be inappropriate. Using very limited data set, the RSK (2019) HRA sets out to compare observed dissolved carbon dioxide, methane and ethane concentrations in the Ashdown Beds monitoring wells with the Conoco outlier data. Furthermore, the baseline monitoring of the aquifer set up from 2015 to 2019 only analysed samples for these dissolved gases at two sample rounds – one in April 2019 and the other in July 2019. With only two samples for each dissolved gas, there is insufficient data to draw conclusions from the 'range' of concentrations and insufficient to effectively describe the baseline conditions. This review considers it important that a much longer data set is obtained and then assessed before drawing conclusions about the baseline conditions. To help determine effect of seasonality and range of piezometric conditions on these concentrations, a minimum of 1 years sampling is required and highly recommended that the monitoring period exceeds at least two years of monthly (or at least 6 weekly) sampling to help determine baseline conditions. Sampling should be from a minimum of three groundwater monitoring points within the Ashdown Beds aquifer to help determine hydraulic and concentration gradients and direction of movement through triangulation of the data observed.

3.34 It is the view of this review that the limited groundwater quality monitoring data and analysis and the poor assertions drawn from a very limited data set unduly shape the evaluation of risk as presented by RSK (2019) in their HRA. Substantially more data is required to confidently assess baseline conditions.

3.7. Structural Geological Controls on Hydrogeology of the Lower Stumble Exploration Site and surrounding area

3.35 From the summary of the site details in Section 2 of RSK (2019) HRA, it is noted that the Lower Stumble Exploration Site is central to the Weald Basin on the downthrown side of the Borde Hill Fault. The Well Balcombe 2 and its associated side-track Balcombe 2Z is also understood to be located on the downthrown side of the Borde Hill Fault; with drilling completed in September 2013 to a vertical depth of 670.5 metres and some 522.4m horizontally through the Kimmeridge upper limestone.

3.36 The presence and effect of structural features such as faults and folds are considered by RSK (2019) HRA in terms of their impact on the Weald and the geological sequence as a whole. However, the RSK (2019) HRA report is light on detail in terms of the impact of these structural controls especially on the near surface Wadhurst Clay and Ashdown Beds sequence. The extent of the evaluation of geological structure on groundwater is stated in RSK (2019) HRA Section 3.3.1 that "the Wealden strata are affected by valley bulge and cambering (particularly in the central Weald) and this process can locally cause great disruption of strata and groundwater flow through these disturbed sequences is very complicated."

3.37 This acknowledgement of the complexity caused by structural disturbance is emphasised in Section 3.3.2 where RSK (2019) HRA state "The structural geology of the Weald has a significant influence on groundwater flow. Groundwater tends to flow down dip towards the axis of synclines and away from the axis of anticlines. The presence of faulting in the area causes large variations in water level, which have not been well studied or documented. For example, where faulting inhibits groundwater flow, rest water levels in boreholes either side of faults may be very different. Consequently, it is often difficult to predict the potentiometric levels in boreholes."

3.38 Therefore, the stated complexity and acknowledged lack of detailed understanding of the effects of structural disturbance on the hydrogeology – particularly at the local scale – requires considerable detailed and site based assessment to better understand how this affects the hydrogeology of the Lower Stumble Exploration Site and surrounding area and therefore an understanding of hydrogeological risk. This degree of assessment, supported by field evidence, is not presented by RSK (2019) and therefore their HRA is considered inadequate in terms of robustly and thoroughly assessing the risk to the groundwater environment and its possible interactions with the surface and near-surface aquatic environments.

3.8. Surface Water Drainage associated with the Lower Stumble Exploration Site and surrounding area

3.39 RSK (2019) HRA reports that a tributary of the River Ouse passes approximately 100 metres southwest from the Lower Stumble Exploration Site; noting that this tributary reaches the confluence of the River Ouse approximately 950 metres to the southwest. However, there is no further evaluation of other springs and drainage in the area. Particularly, RSK (2019) HRA makes no reference to the location of springs emitting from the Ashdown Beds outcrop associated with the Ashdown Beds identified beneath the site.

3.40 Also, there is not discussion about the empirical and perennial springs associated with the Ashdown Beds, Tunbridge Wells Sands and possibly more permeable medium to coarse sand horizons within the Wadhurst Clay. For example, the presence of chalybeates or ephemeral springs are reported in this vicinity and whether these are present at or near to the Lower Stumble Exploration Site or not, this should be explicitly stated.

3.41 A [seasonal] spring survey would, therefore, be an appropriate field measure to inform this assessment and is absent from the HRA presented by RSK (2019).

3.42 RSK (2019) HRA makes reference to the Lower Stumble Exploration Site "is within a surface water safeguard zone (SWSGZ4008), which is designated on the basis of risks from pesticides (Metaldehyde) and turbidity." Under these circumstances, further assessment of the impacts on the surface water environment to better inform the hydrogeological risks would be considered appropriate to include as part of the RSK (2019) HRA.

3.9. Potential Receptors *and* Groundwater Pathways associated with *the Lower Stumble Exploration Site and surrounding area*

3.43 RSK (2019) HRA notes that "There are no licensed groundwater abstractions within 1km of the Site and the Site is not within a groundwater source protection zone (SPZ)."

3.44 As stated by RSK (2019) HRA, there are no licence abstraction and the groundwater beneath Balcombe has no present value for public water supply purposes. It is also reasonable to assert that there no specific or published plans by water utility companies to develop groundwater resources in the area of the Lower Stumble Exploration Site.

3.45 However, the RSK (2019) HRA make no reference to unlicensed abstractions in this area. These may include abstractions less than 20 cubic metres per day that do not require an abstraction licence from the Environment Agency. Based on information presented in RSK (2019) HRA, it is unknown and unstated as to whether there are such unlicensed abstractions within the vicinity of the Lower Stumble Exploration Site. A thorough HRA should state whether such abstractions are present and what steps have been taken to determine whether or not they are present; and where present, the purpose of abstraction should be stated (be that for irrigation, private water supply, industrial, agricultural or domestic processes or unknown).

3.46 Furthermore, a hydrogeological risk assessment should not only consider the present-day abstractions but also potential future use of the groundwater resource. As established in Section 3.6 above, RSK (2019) HRA infer that as the natural groundwater has elevated iron, zinc and aluminium, it is considered as poor value. In this context, RSK (2019) HRA takes a view on the potential future resource use solely based on groundwater quality with respect to drinking water and environmental quality standards (DWS and EQS, respectively) without due consideration of the natural water chemistry that naturally feeds the springs and baseflow within the streams locally and the natural ecosystems that have developed as a result; and may have some potential value for localised irrigation or flow augmentation purposes. It would be inappropriate to infer that the groundwater in the Balcombe area has no value to the natural environment or potential future use. Therefore, it is the view of this review that the future resource value of the groundwater in the area of the Lower Stumble Exploration Site and the natural water quality that sustains local aquatic ecosystems should not be disregarded.

3.47 The RSK (2019) HRA makes reference to the Lower Stumble Exploration Site "is within a surface water safeguard zone (SWSGZ4008), which is designated on the basis of risks from pesticides (Metaldehyde) and turbidity." The delineation of the site within this surface water safeguard zone infers a connectivity or pathway between the site and the surface water drainage, with a particular focus on near-surface interactions with the surface water drainage notably in respect to turbidity and potential agricultural applications. An understanding of the basis of this delineation is important to informing the HRA of the risk to the surface water drainage to inform appropriate mitigation. It is the view of this review that the RSK (2019) HRA provides insufficient information about the surface water safeguard zone to inform the risk to the surface water from the proposed development.

4. REVIEW OF RSK'S PROPOSED HRA MITIGATION MEASURES FOR LOWER STUMBLE EXPLORATION SITE

4.1. Overview of the Proposed Development and Mitigation Measures

4.1 This section focuses on the geological and hydrogeological information presented in RSK (2019) HRA and evaluates whether the information considered is sufficient to build a robust and thorough hydrogeological risk assessment of the Angus Energy Lower Stumble Exploration Site in Balcombe.

4.2 RSK (2019) HRA summarises the proposed two-stage site development as presented in the planning statement (Angus Energy, Planning Statement. Lower Stumble Exploration Site, London Road. September 2019). In summary, Stage 1 set out comprise pumping operations, which are anticipated to take up to four weeks. Should Stage 1 prove successful, Angus Energy propose to move on to Stage 2, which includes an Extended Well Test (EWT) of an approximate duration of three years.

4.2. Stage 1 Summary of the Proposed Method

4.3 The proposal Stage 1 development is to set up and undertake pumping operations from Well Balcombe 2.

4.4 The proposed method for Stage 1 as described by RSK (2019) HRA sets out a 4 weeks programme of works including mobilisation, site setup and demobilisation either side of a seven days fluid pumping operation. The expressed stated intention is that Angus Energy intend to "carry out the Stage 1 operation with the minimum equipment in order to minimise environmental impacts and reduce any disruption to the local environment. "(RSK (2019) HRA).

4.5 The equipment planned for Stage 1 is understood from RSK (2019) HRA to "include a pump, a surge tank, a storage tank for brine and a slops tank for any contaminated brine. A pressurised tank will also be on site for fluid export and vapour recovery. All the equipment will be located in a small bunded area adjacent to the well head and will comply with industry best practice guidelines." "Ancillary equipment for Stage 1 will include a generator and a small welfare unit."

4.6 All equipment proposed within Stage 1 will be bunded consistent with CIRIA guidelines. Good site practice and monitoring of bunds is considered an essential aspect of this form of pollution prevention; particularly following heavy rainfall; such the design capacity of all bunds is maintained throughout the works. This is not explicitly stated and should be as part of the proposed mitigation measures presented in the HRA.

4.3. Stage 2 Summary of the Proposed Method

4.7 From RSK (2019) HRA, it is understood that the aim of the proposed Extended Well Test (EWT) is to determine whether commercial hydrocarbon rates can be achieved. The proposed EWT will involve several flowing and shut-in periods to enable full analysis of the reservoir; and understood to have a proposed duration of up to three years.

4.8 The proposed equipment planned for Stage 2 to enable the proposed EWT is, according to ESK (2019) HRA "the well test spread and storage tanks." According to RSK (2019) HRA, this comprises of the following: "test separator unit, MAWP 1440 psig; on board data acquisition and reporting system; associated pipework and manifold package; surface ESD system; choke manifold; surge tank - second stage separator; oil and waste storage tanks; linear rod pump; vapour recovery tank (as per Environment Agency specifications); and Shrouded Flare Stack."

4.9 However, to enable the proposed contingency options, the proposed equipment required to "aid the flow of the well" comprise of either a "Nitrogen Lift" or a "coiled tubing unit" to be mobilised. This Nitrogen Lift comprises of the following: coiled tubing (CT) unit including injector head and reel; nitrogen convertor; 2 to 4 nitrogen tanks. "If Nitrogen is not to be used via Coiled Tubing, the nitrogen will be discharged down the well via lines from commercially available racks"

4.10 The proposed contingency 2 is Acid Wash with Coiled Tubing. RSK (2019) HRA set out that "if an acid wash is required, this will be done with the CT equipment as above" "with HCl acid truck (on site only for the day)" as an additional measure. The proposed Contingency 3 requires an inflatable bridge plug with Coiled Tubing, that will be "run on the CT equipment as per Contingency 1 if required.

4.4. Review of Environment Mitigation Measures

4.11 The construct of the conceptual understanding of the complicated geology and hydrogeology beneath and in the area of the Lower Stumble Exploration Site is discussed in Section 3 of this review. The mitigation measures as presented in Section 4.2.1 of RSK (2019) HRA initially recognise the complexity of the geology and, therefore, potential complex hydraulic connectivity between the geological horizons and perched and deep aquifer units. However, the generic assumption that the Wadhurst Clay is a uniform aquiclude is not consistent with the detailed appraisal of the Wadhurst Clay discussed in Section 3 above. The presence of more permeable and, therefore, potentially transmissive medium to coarse grained sand layers is not referenced in the RSK (2019) HRA characterisation of the Wadhurst Clay. Consequently, there are no mitigation measures presented to address the potential pathway to small scale perched aquifer units that may - particularly on a seasonal basis – emit groundwater to the environment via ephemeral or perennial springs from parts of the Wadhurst Clay.

4.12 The assertion in Section 4.2.1 of RSK (2019) HRA that because there is an artesian head within the Ashdown Beds aquifer at depth means that there is a natural upward gradient to counter pollution risk is wholly inappropriate and not validated by field evidence. This poor assertion is then applied in Section 4.2.3 of the RSK (2019) HRA to help justify less robust mitigation measures with regards to the impermeable sub-base or bund for Stage 1 of the proposed pumping trials; and in Section 4.3 to counter the movement of contaminant into the Wadhurst Clay (despite many statements in RSK (2019) HRA that the Wadhurst Clay is effectively a thick continuous impermeable layer).

4.13 To suggest that the Ashdown Beds aquifer "may be saline" without baseline groundwater quality evidence to substantiate this can be considered as poor science, not evidence based and contrary to an general understanding the Ashdown Beds aquifer in the High Weald part of Sussex (where groundwater is abstracted from the Ashdown Beds elsewhere for public water supply). The groundwater yields may be low in terms of suitability for sizeable groundwater purposes. However, this should not preclude local scale resource development for potential agricultural use and should not devalue the groundwater where is it known to supply natural perennial and/or ephemeral groundwater fed springs (locally known as chalybeates) that may support natural aquatic ecosystems in the area.

4.14 RSK (2019) HRA in Section 4.2.1 state that "Groundwater within the vicinity of the site is not used for domestic or industrial water supplies and according to the EA the shallow soils are not considered sensitive to surface contamination." This statement would appear to dismiss the present and future value of the natural groundwater beneath the proposed exploration site. Furthermore, this construct in this statement seeks to devalue the groundwater that flows to the natural aquatic environments that are spring fed and rely on groundwater for their baseflow. As a consequence, the proposed mitigation measures to protect the natural resource are not sufficiently considered and as such, both the understanding of risk to the groundwater systems and the proposed mitigation to protect these perched and deeper groundwater systems is wholly inadequate.

4.5. Review of Well Integrity Mitigation Measures

4.15 The RSK (2019) HRA sets out that the liner of the well comprises steel casing strings are run and cemented into place as each section of the well was drilled. The cement, therefore, should form an impermeable barrier between the rock and the steel casing and should seal up "any conduit, which may connect different aquifer units or the ground surface that would normally be isolated by layers of lower permeable clay (e.g. Wadhurst Clay)."

4.16 However, the complexity of the lithology and structure of the Ashdown Beds and Wadhurst Clay may mean that sealing interconnected units via conduits may not be practicable throughout whole length of the well. For instance, the structural deformation of the Ashdown Beds may result in extensive fissures and void spaces with depth. Establishing a robust cement seal through all such conduits may not always be viable. Furthermore, the assertion that the Wadhurst Clay is a uniform impermeable layer is misjudged and, therefore, to rely on this generalised characteristic as inferred would also be a poor approach.

4.17 RSK (2019) HRA stated that "The quality of the cement in the well has been verified by a CBL (Cement Bond Log) tool to ensure that all casing strings are cemented properly and provide sufficient isolation to the surrounding formations."

4.18 The interpretation of the cement bond log report by Weatherford (dated 31 August 2013) described much of the cement bonding along the length of the well as "moderate to poor". This indicated that there are possible breaches in the cement seal and cavities along part of the outside of the casing and as such some of the potentially connected conduits are also not fully sealed. This poses a concern and increases risk to groundwater quality should there be any leak within the well column.

4.19 Notably, the drilling logs show that the Ashdown Beds aquifer lies between 46.6 metres (135 ft) and 253 metres (830 ft). Page 9 of Weatherford (2013) Cement Bond Log report finds that the cement bond through the depths corresponding with the depth of the Ashdown Beds aquifer is rated as mostly "moderate to poor casing to cement bond and cement to formation"; and furthermore, through the section between 182.9 metres (600 ft) and 215.8 m (708 ft) depth, the cement bond is rated in the Weatherford (2013) as "poor casing to cement bond and cement to formation."

4.20 To support their conclusions that "risks to groundwater from failed well integrity are considered to be very low," and that "all casing strings are cemented properly and provide sufficient isolation to the surrounding formations," RSK (2019) HRA refer to the findings of the Cement Bond Logs (CBL) as reported by Weatherford in Summer 2013. However, as stated above, Weatherford (2013) established that the cement bonding along the length of the well was "moderate to poor" in 2013. Therefore, for

RSK (2019) HRA to state "due to the mitigation from the well design (steel casing and cement sheaths), which have been proven to have good integrity from the results of CBL testing" is considered misleading and grossly inadequate as RSK (2019) HRA ignores the principal finding from Weatherford (2013) notably through the Ashdown Beds aquifer section. Consequently, it is the view of this review that the RSK (2019) HRA is subjective and selective in this respect and, therefore, cannot be considered wholly objective and robust in their representation of the observed data.

4.21 It is the objective opinion of this review that RSK (2019) HRA builds on this subjective construct that the well construction with regard to the CBL is robust; such that RSK (2019) HRA then asserts in Section 4.3 that "The construction method and proven well integrity from the CBL shows that acid release into non-targeted formations is unlikely."

4.22 However, it is noted that the RSK (2019) HRA Section 2.1 reports that the "once" the Well Balcombe 2 "died", it filled in water. This was established some five years after the CBL was undertaken during a short flow test of the well in 2018 which had to be stopped unexpectedly due to water ingress. According to RSK (2019) HRA, it was the view of Angus Energy that water present in the well was "not formation water but drilling fluid that had remained in the well". This review of the HRA does not set out evaluate this, although it would be reasonable to assert that Angus Energy should be able to provide mass balance, water quality and borehole survey information to substantiate this view and confirm that the water present in the well is drilling fluids and not water from the formation at depth or groundwater or surface water drainage from the near-surface aquifers or drainage entering the static fluid column in the well. The method to demonstrate this would need to be proposed by the developer with the intention to confirm the integrity of the well and confirm or otherwise that there is no breach with the near surface aquifer units – notably the artesian groundwater head within the Ashdown Formation aquifer. Robust and thorough evidence-based evaluation of this possible risk is considered as fundamental to protecting the aquifer ahead of progressing any planned pumping trials of the well, particularly with regards to introduction of hydrochloric acid (HCl) or movement of hydrocarbons or other fluids under pressure through the well column. Any doubts about the integrity of the well should be fully addressed, evaluated and evidenced ahead of any plans to pump the well in order to protect the groundwater in the deep and perched aquifer units beneath the site and along the length of the exploration well.

4.6. Review of Chemical Fluids Mitigation Measures

4.23 The use of maximum dilution of up to 15% hydrochloric acid (HCl) should only proceed once there is confidence that there is no risk of breach to the casing and cement bond. Use of HCl if there is a weakness in the casing and breach in the cement bond, there is a heightened risk that the HCl might exacerbate such a weakness. Hence, the significance and importance of undertaking robust tests to confirm that there are no breaches to the well construction and, therefore, no risks from fluids within the well column to the natural groundwater in deep and perched aquifer units along the well column length.

4.24 It is not appropriate to state that HCl is a non-hazardous substance to groundwater. It may be helpful at depth when diluted with groundwater. However, should the HCl enter a transmissive aquifer unit that are connected with a spring or baseflow in a stream, it can cause environmental damage including affecting ecology and inducing elevated turbidity. Furthermore, HCl has been used to clean encrustation and iron bacterial sludge from water well screens in the Ashdown Beds in the High Weald region. Should the HCl enter the iron-rich Ashdown Beds aquifer, it is reasonable to expect discoloration and release of iron precipitates. This may affect flow paths within the groundwater system and where springs emit from these aquifer units, may result in elevated iron concentrations, elevated turbidity and discolouration within groundwater fed springs and streams. Other metals – such as aluminium, manganese and zinc – may also be released into the groundwater from the formation with the addition of HCl.

4.7. Review of Membrane Bund and Basal Liner Mitigation Measures

4.25 Although the thoroughness of the membrane bund and basal layer are considered essential mitigation measures throughout all stages works; the justification that the upward gradient from the artesian head in the Ashdown Beds aquifer and the continuous impermeable nature of the Wadhurst Clay may infer that there is a degree of leniency in the quality of the bund because of the natural protection afforded by these factors. However, as established in this review, the Wadhurst Clay has medium to coarse grained sand layers that act as perched aquifer systems, some of which are interconnected. If the Wadhurst Clay was a continuous impermeable aquiclude unit some 50 metres thick, the then upward gradient in the Ashdown Formation at depth could not be a mitigating factor as suggested by RSK (2019) HRA. It is the view of this review that RSK (2019) HRA contradicts itself by sometimes asserting the Wadhurst Clay forms an robust barrier to groundwater movement because it is effectively continuously impermeable clay; whilst also establishing that there are lithological and structural reason why groundwater may be present and may locally flow though the Wadhurst Clay and can provide a conduit for upward groundwater movement from the artesian head in the Ashdown Beds. This is a clear contradiction and undermines the assessment of hydrogeological risk of the proposed development on the Ashdown Formation aquifer and its interaction with the near aquatic environments.

4.8. Review of Chemical Storage and Emergency Response Measures

4.26 Robust bunded and procedures to manage rainfall within bunds is an essential part of pollution prevention. Good site practice and monitoring of bunds is considered an essential aspect of this form of pollution prevention; particularly following heavy rainfall; such that the design capacity of all bunds is maintained throughout the works. This is not explicitly stated and should be as part of the proposed mitigation measures presented in the RSK (2019) HRA. All the equipment proposed within both the proposed Stage 1 and Stage 2 works are to be bunded consistent with CIRIA guidelines; and the storage of diesel and other fuels (that may be required to power site equipment) are to be undertaken in accordance with the *Control of Pollution (Oil Storage) Regulations (2001).*

4.27 One of the weaker aspects on pollution risk from site-based plant are fuel lines and pipes or hoses where chemicals and fuel flow. Fittings are to be robust; all pipelines and hoses are to be within bunds and checked routinely and frequently. Any on-site refuelling should be kept to a minimum and entirely within bunded areas. Spill kits must be sufficient to enable rapid clean-up of any spill, leak or incident. These points are not stated within the RSK (2019) HRA.

4.28 Good site practices are essential as sometimes the method and equipment are not necessarily the weakest link, rather an understanding of the methods and specific site-based risks by all working on site. This human interaction with this risk can be the most pertinent mitigation yet this is not explicitly stated in the RSK (2019) HRA.

4.29 Good communication in the event of a spill, leak or incident is considered one of the most effective forms of mitigation. This is not presented as a mitigation measure by RSK (2019) HRA.

4.9. Review of Groundwater Monitoring Mitigation Measures

4.30 The description of the proposed groundwater monitoring as presented by RSK (2019) HRA Section 4.2.7 looks to be inadequate and vague. There is a reliance on the GGS monitoring borehole that is some seven years old. The condition of this monitoring borehole may need to be confirmed. Due consideration should be given as to whether at least two new monitoring boreholes to strengthen the existing monitoring borehole should also be made both to increase confidence in the groundwater quality, determine whether and to what extent there is local variability in groundwater conditions; and to set out to triangulate piezometric level and groundwater quality concentrations to establish flow direction and gradients across the site.

4.31 Furthermore, analysis of frequent water level monitoring data using a transducer logger can provided information about whether there are hydraulic signals in the aquifer units associated with the fluid movement within the well and help determine whether there may be a leak or breach in the construction of the well.

4.32 The water quality parameters are listed in Section 4.2.7 of RSK (2019) HRA as dissolved carbon dioxide, heavy metals, strontium, earth metals, dissolved ethane, dissolved methane, dissolved propane, dissolved butane, ammoniacal nitrogen, nitrite and nitrate, BOD, COD, pH, salinity, total dissolved solids, total petroleum hydrocarbons, and total suspended solids; there are few inclusions of parameter that could help determine and inform the baseline quality of the natural groundwater and potential changes from the baseline condition. For example, it would be appropriate to consider including metals – notably dissolved and total iron, zinc, manganese and aluminium together with other indicators, such as dissolved oxygen, pH, turbidity and electrical conductivity – in the groundwater quality monitoring suite.

4.33 Although the parameters are considered, the frequency of monitoring during Stage 1 and Stage 2 are not stated by RSK (2019) HRA. The inference in Section 4.2.7 is that monitoring will be on quarterly – that is three monthly – basis. This seems rather infrequent and it would be prudent to increase this to at least monthly or every six weeks and undertake a period of baseline monitoring ahead of any proposed works to gain confidence in the baseline groundwater quality and piezometric level. Analysis of the baseline quality and piezometric level information ahead of any proposed well testing is advisable to then be in a position to interpret changes resulting from the testing works and quantify an assessment of its impacts on the groundwater environments.

4.34 The importance of seasonal monitoring in the context of the multiple perched groundwater systems and perennial and ephemeral springs and groundwater fed baseflow streams cannot be understated when evaluating the impact on the deep and perched groundwater systems and dependent aquatic habitats in the Balcombe area.

5. SUMMARY AND CONCLUSIONS

5.1 This review has identified several significant shortfalls and concerns about the thoroughness and robustness of the Hydrogeological Risk Assessment (HRA) as presented in by RSK Environmental Ltd, dated 20 December 2019. (RSK (2019) HRA). Furthermore, there are several *constructs* established within the RSK (2019) HRA report concerning the hydrogeology beneath Balcombe that lead to potentially spurious and subjective opinion rather than wholly evidence based objective assessment of the risks to groundwater and near surface aquatic environments.

5.2 This review understands that the RSK (2019) HRA was developed within limited information about the underlying geology and hydrogeology; and in this regard, RSK (2019) HRA has undertaken a reasonable assessment of the geology and hydrogeology. However, the shortfalls in robust site based geological and hydrogeological information and known uncertainties have not been explicitly applied as uncertainties in the assessment of risk. For instance, RSK (2019) HRA clearly establish that the geology and hydrogeology of the Ashdown Beds and Wadhurst Clay is complicated by structural controls; thereby complicating the interpretation of what is determined to be a limited dataset. RSK (2019) HRA further determine that "The structural geology of the Weald has a significant influence on groundwater flow." However, rather than apply a level of confidence or uncertainty within the hydrogeological risk assessment, reflecting this stated complexity and uncertainty of the lithology, structure and hydrogeology; RSK (2019) HRA apply a more certain opinion of the hydrogeological risk than the level of supporting data could support. In this manner, the outcomes of the RSK (2019) HRA lead to a degree of subjective opinion rather than a wholly objective evidence-based assessment of risk. The assessment of the mitigation measures builds on these constructs and as a result, may not be sufficiently robust to thoroughly mitigate the actual risks.

5.3 Furthermore, the RSK (2019) HRA dismisses the Wadhurst Clay on the grounds that it is essentially a 50 metres thick impermeable clay aquiclude even though it is recognised that there are potentially interconnected medium and coarse grained sand layers within the Wadhurst Clay that may facilitate groundwater storage a movement. These transmissive horizons may be associated with perched groundwater systems and local perennial and ephemeral springs. However, this is not sufficiently considered by RSK (2019) HRA. Without field-based validation, this applied assumption concerning the localised hydrogeology of the Wadhurst Clay may be an oversight. Further assessment to determine whether groundwater stored in the more permeable horizons of the Wadhurst Clay and whether these contribute to connectivity within the groundwater system and/or perennial or ephemeral spring and stream flows is recommended to inform the hydrogeological risk assessment.

5.4 RSK (2019) HRA also presents a somewhat dismissive view about the value of the groundwater within the Ashdown Beds aquifer. This is broadly on the basis that the aquifer is not presently developed locally for licenced abstractions for water supply and has elevated dissolved metals and other water quality parameters.

5.5 However, RSK (2019) HRA does not include an assessment as to whether there might be smaller unlicensed abstraction (for instance abstractions less than 20m^3 per day that do not require an abstraction licence) and should these be present, what purpose these unlicensed smaller abstractions are used for (such as whether there are any private waters supplies, abstraction for irrigation or other purposes). A statement regarding the presence of such abstraction is expected within an HRA for this area. Furthermore, the current use of the aquifer should not preclude or exclude the potential future use of the groundwater resources. The RSK (2019) HRA makes no reference to potential future development of groundwater resources. A reference to future resource development or view to the contrary should be included as part of the HRA.

5.6 RSK (2019) HRA view on the groundwater quality is based on a fairly limited and infrequent groundwater monitoring and sampling from the Ashdown Beds aquifer. The limited sampling is considered insufficient to robustly assess the seasonal variation and consider trends in the water quality data. Furthermore, by solely comparing with drinking water standards (DWS) and environmental quality standards (EQS), RSK (2019) HRA dismisses the value of the groundwater held in the Ashdown Beds as poor quality. However, this is not entirely consistent with the application of the Water Framework Directive and does not seem to acknowledge the value of the naturally elevated metals - such as iron, zinc and aluminium – in the groundwater of the Ashdown Beds aquifer. Such that, the springs and base flow of local streams are reliant on the natural groundwater emitting from these iron rich geologies and the ecosystems of the aquatic environments of the these ephemeral springs (such as chalybeates) and perennial springs and stream flows are dependent on the natural water chemistry. It is, therefore, inappropriate to dismiss the value of the groundwater beneath Balcombe and infer the risks to groundwater are low and therefore less rigorous mitigation measures can be applied.

5.7 There findings from the cement bond log (CBL) report by Weatherford (2013) are poorly represented in the RSK (2019) HRA to the extent that the HRA does not represent that much of the cement bond log for the length through the Ashdown Beds aquifer is “poor casing to cement bond and cement to formation.” (Weatherford, 2013). It is the view of this review that by not accurately and thoroughly conveying the findings of the CBL report for section through the Ashdown Beds aquifer, RSK (2019) HRA have not wholly represented the known facts and therefore not thoroughly accounted for the hydrogeological risk the aquatic environments associated with the Ashdown Beds aquifer. In this regard, expected sufficiency of the evaluation of the hydrogeological risks has not been sufficiently robustly met by the RSK (2019) HRA.

5.8 The RSK (2019) HRA neglects to detail some of the site-based mitigation measures that could minimise risks to the groundwater environment. These incudes good site practices and the bunding of all fuel and chemical lines and connections; and routine frequent checks and maintenance of bunds, notable following rainfall.

5.9 The construct and conceptualisation within the RSK (2019) HRA in terms of detailed understanding of the specific geology of the Balcombe area and the structure and lithological controls on the hydrogeology is inadequate to fully establish a robust understanding of hydrogeological risk. As a consequence of the shortfalls in the hydrogeological risk and data that supports this understanding, the proposed mitigation measures are considered either inadequate or require more information to inform them. Before this development progresses, there is a need for robust monitoring data to inform the baseline conditions throughout the year and thorough field data to confirm the interactions between perched and deep groundwater systems and the surface and near-surface aquatic environments. An understanding of site-specific hydrogeological risk has, therefore, not been sufficiently demonstrated by the RSK (2019) HRA and the confidence as to whether the mitigation measures are sufficient and appropriate has not been demonstrated as a result.

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