



NYMNPA

26 FEB 2015

Technical Note: Eberston to Knapton Planning Application Review

1. Introduction

Amec Foster Wheeler was commissioned by the North York Moors National Park Authority (from hereon referred to as 'the Authority') on 24 November 2014 to undertake a targeted desk review of the potential for pollution of groundwater and land stability issues in respect of the current planning application NYM/2014/0587/EIA¹.

The planning application has been submitted by planning agents Barton Willmore on behalf of Third Energy Limited and Moorland Energy Limited ('the Applicants'), and is for the following (Environmental Statement (ES), paragraph 1.1):

"Natural gas production and water re-injection at the existing borehole at Eberston Moor South Well Site, the drilling of a second borehole for water production and re-injection, the construction of a 13.9 km long 12" diameter underground pipeline from the Eberston Moor South Well to the Knapton Generating Station at East Knapton, Malton and the construction of ancillary works at the Generating Station."

The primary purpose of the Amec Foster Wheeler independent review is to advise the Authority (in its role as the Local Planning Authority) whether the Applicants and their consultants have identified and assessed all the known likely groundwater pollution and land stability environmental effects; have applied appropriate mitigation; and have demonstrated that the effects have been reduced to an acceptable level. Consideration of most other potential environmental effects are outwith the remit of the review, although Amec Foster Wheeler does make comment on potential effects on the surface water environment, particularly where there are linkages with the underlying groundwater environment, by way of leakage to, or baseflow from, groundwater. The main focus of the review is on those parts of the proposed development of most interest to the Authority, i.e. those within the North York Moors National Park; the southern boundary of the Park being located immediately to the south and just under 1 km to the west of the Eberston Moor South (EMS) Well Site, a key component of the proposed development.

This technical note summarises the findings of Amec Foster Wheeler's review. The following initial section (Section 2) documents the sources of information used to inform the review, whilst the remainder of the document closely follows the order of a typical ES. Section 3 describes the proposed development, whilst the assessment area and methodology are reviewed in Sections 4 and 5 respectively. The baseline (current) water environment is reviewed in Section 6, whilst the core of the Environmental Impact Assessment (EIA) is reviewed in Sections 7-11 i.e. with reference to potential receptors, potential effects, mitigation, residual effects and cumulative effects respectively. Consultee comments are considered in Section 12, and the Amec Foster Wheeler review conclusions are finally summarised in Section 13.

As some of the review is of necessity quite technical in nature, to help the reader non-technical summaries of the Amec Foster Wheeler review are provided in bold at the end of each section.

¹ <http://planning.northyorkmoors.org.uk/Northgate/PlanningExplorer/ApplicationSearch.aspx>



2. Sources of Information

The review has focussed on ES Chapters 11 (Flood Risk, Hydrology and Drainage, in other words the EMS Well Site surface works and the pipeline) and 12 (Produced Water Disposal), but with reference to other ES Chapters as necessary e.g. Chapter 2, EIA Methodology; Chapter 3, Site and Development Description; Chapter 6, Ecology and Nature Conservation; Chapter 15, Ground Conditions and Contamination.

The review has also been informed by a number of other documents. Shortly after commencing its review, Amec Foster Wheeler submitted a request for further information from the Applicants (see Amec Foster Wheeler letter to the Authority dated 9 December 2014). Barton Willmore responded on behalf of the Applicants on 28 January 2015, and the Barton Willmore Response Table, together with its supporting appendices, have been taken into account in the review, namely with respect to the following:

- ▶ Disposal of Produced Water at Ebberston South Well Site (Envireau Water Technical Report, August 2014), a report designed to support an application to discharge to groundwater under the Environmental Permitting Regulations 2010;
- ▶ Disposal of Produced Water at Ebberston South Well Site (Envireau Water Technical Addendum, December 2014), submitted in response to an Environment Agency request for further information to support the application to discharge to groundwater;
- ▶ Catchment area boundaries and abstraction points map (R Elliott Associates Limited, undated);
- ▶ WFD status of the River Derwent from Troutdale Beck to River Rye (uncredited and undated, but presumed to be from R Elliott Associates Limited); and
- ▶ Response to issues raised by third parties (Barton Willmore letter and appendix to the Authority dated 14 November 2014).

A meeting was held between the Applicants and its consultants, the Authority and Amec Foster Wheeler at Knapton Generation Station (KGS) on 12 February 2015 to discuss the proposed development and the requirements of the review. During the course of the meeting a copy of a report entitled '*Ebberston South Water Injection: Seismic Event Risk Assessment*' (Rockflow Resources, July 2014, on behalf of Third Energy) was released by the Applicants for consideration by the review.

Amec Foster Wheeler made a request at the February 2015 meeting for other further information. The response to this request was received by the Authority from Barton Willmore on 16 and 17 February 2015, and comprised the following:

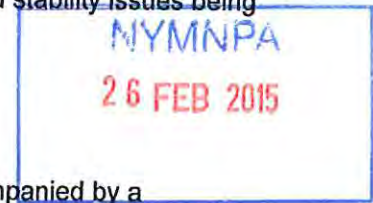
- ▶ Produced water disposal '*area of influence*' calculations (Envireau Water);
- ▶ Detail of the bentonite membrane (bentomat) that extends beneath the EMS Well Site (R Elliott Associates Limited)
- ▶ Technical report relating to the Ebberston 'A' Well Site (Envireau Water, December 2013);
- ▶ Revised EIA table and an area map relating to the EMS Well Site surface works and the pipeline (R Elliott Associates Limited);
- ▶ Groundwater WFD status (R Elliott Associates Limited);
- ▶ Detailed surface water and hydrogeological conceptual models (R Elliott Associates Limited and Envireau Water respectively); and
- ▶ Monitoring '*Statement of Intent*' (Envireau Water).

Apart from the WFD information, no response was received in connection with one of Amec Foster Wheeler's meeting requests, namely surface and groundwater quality monitoring results.



Finally, for the purposes of the review the Authority provided Amec Foster Wheeler with consultee responses to the proposed development, of most relevance with respect to the water and land stability issues being those of the following consultees:

- ▶ Environment Agency (22 September 2014);
- ▶ Yorkshire Water (13 October 2014); and
- ▶ Frack Free Ryedale and Frack Free North Yorkshire (undated), accompanied by a hydrogeological review report produced by H Fraser Consulting (23 October 2014).



Amec Foster Wheeler is reliant on the information provided in the documents supplied to it to inform its review. It is beyond the scope of its commission for Amec Foster Wheeler to undertake its own data collection, either desk- or field-based.

3. Nature of the Proposed Development

3.1 Overview

The proposed development envisaged in the ES comprises the following activities, based largely on the scheme summary presented in ES paragraphs 3.17 and 5.50:

- ▶ Natural gas production and water re-injection at the existing borehole at the EMS Well Site;
- ▶ The drilling of a second borehole for water production and re-injection;
- ▶ The construction of a 13.9 km long 300 mm diameter steel underground pipeline from the EMS Well Site to the KGS;
- ▶ Construction of ancillary works at the KGS; and
- ▶ Decommissioning and restoration.

It is understood that the planning application seeks to effectively combine two extant planning permissions that have already been granted i.e. the so-called 'Ryedale Gas Project' (RGP) and the 'Eberston Moor-Knaption Gas Pipeline' (EMKGP) project (ES paragraph 3.16). The ES (paragraph 3.18) anticipated planning and field development approval in 2014, with construction commencing in 2015 and transfer of gas between the EMS Well Site and KGS commencing in 2016, with up to a 15 year production life.

For the purposes of its review, Amec Foster Wheeler is most concerned with the residual (post-mitigation) effects of the construction and operation activities at the EMS Well Site and along the proposed pipeline route with respect to the water environment and land stability. Amec Foster Wheeler's understanding of these two elements of the proposed development, based on its reading and interpretation of the documentation listed in Section 2 earlier, is summarised below.

3.2 EMS Well Site

The ES anticipates (paragraph 3.21) that the volume of gas to be produced at the EMS Well Site would be up to 15 million standard cubic feet per day (mmscf/d). The ES reports (paragraph 3.30) that the existing borehole would be used for both gas production and re-injection of water. Modification of the existing borehole would be required to facilitate gas and water extraction from the deep Permian Kirkham Abbey Formation (KAF), and produced water disposal to the overlying Triassic Sherwood Sandstone (paragraph 12.45). As Envireau Water notes in its Non-Technical Summary to its Technical Report, by avoiding the 'watering off' of the gas production well, this method of water disposal would help ensure a higher rate of gas recovery and improve the commercial viability of the scheme.

The ES (paragraph 3.30) notes that a new water production and re-injection borehole is also proposed. There is brief reference (paragraph 12.46) to this new borehole taking its water from the KAF, but no explanation of the purpose of this abstraction. However, the ES (paragraph 3.32) implies that the majority of the water abstracted from the two boreholes would be disposed of via the new borehole. The produced water injection would be achieved by low pressure injection from the surface with the hydrostatic pressure of



the water column assisting the water injection process, with injection at the existing borehole at a rate of approximately 556 m³/d, and at the new borehole at a rate of 1344 m³/d i.e. a combined rate of 1900 m³/d, which Amec Foster Wheeler understands is equivalent to the Ebberston 'A' permission.

The description of the gas production and water re-injection presented in the ES raises the possibility that the new borehole could itself become a gas production borehole, given that its source of water is the KAF. However, the subsequent Envireau Water Technical Report only makes reference to the deployment of the existing borehole (Section 5.1 and Figure 13). The refurbishment of the existing borehole would first involve the removal of the existing borehole completion, followed by the installation of a packer to separate the KAF and Sherwood Sandstone strata, and then the perforation of the cemented liner along the proposed injection zone opposite the Sherwood Sandstone, possibly for the full thickness of the formation. Abstracted water, together with any produced water separated from the gas at the surface, would be injected back into the borehole above the packer. According to the Envireau Water Technical Report, the proposed maximum daily injection rates remain at the EMS rate of 556 m³/d (Section 5.3), but the disposal water would contain small quantities (2 l/d) of chemical additives (Sections 4.3 and 5.4, also Appendix E).

The focus on the existing borehole is retained in the Envireau Water Technical Addendum, with more detailed information regarding the existing borehole (Section 2.2, Figure 1 and Appendix A) and the modifications required (Section 2.3 and Figure 2), including barriers for the purpose of borehole integrity, and borehole monitoring and maintenance protocols (Section 2.4). Justification for modifying the existing borehole rather than constructing a new borehole is presented in Section 2.5.

There is therefore some 'disconnect' between the ES and the subsequent Technical Report and Addendum as to whether or not a new borehole would be constructed and operated on the EMS Well Site. However, by way of clarification, the February 2015 meeting was informed that only in the event of the modifications of the existing borehole proving unsuccessful would the Applicants resort to a new borehole. This point is reiterated in the Barton Willmore Response Table. This new borehole would be a combined gas production and water disposal borehole, broadly equivalent to the proposed existing borehole, with the same target injection rate i.e. 556 m³/d.

Notwithstanding these assurances, Amec Foster Wheeler considers that the Applicants intentions with respect to the possible new borehole need to be more clearly and publicly stated, and needs to be aligned with the planning application and EIA. Whether or not the new borehole is constructed and operated is very relevant to the EIA. For example, its construction would imply that the refurbishment of the existing borehole has failed, with possible consequences in terms of environmental effects. Furthermore, any injection rate in excess of 556 m³/d that a new borehole could potentially provide would change the 'area of influence' quoted in the Envireau Water Technical Report (Section 5.3) and potentially increase the risk of induced seismicity.

Activities related to the EMS Well Site that may impact the water environment and land stability, and therefore are of concern to the Amec Foster Wheeler review, include the following:

- ▶ The refurbishment (and possible restoration, following refurbishment failure) of the existing borehole, and in particular its potential to create new vertical flow and contaminant pathways between strata at depth and near-surface aquifers and associated receptors, such as groundwater abstractions and baseflow-fed watercourses;
- ▶ The drilling and completion of any new borehole, primarily with respect to the contamination of near-surface aquifers and associated receptors, and the creation of new vertical flow and contaminant pathways;
- ▶ The storage and use of potentially polluting chemicals and fuels at surface, and in particular the potential to contaminate near-surface aquifers and associated receptors;
- ▶ The storage of abstracted and separated water at surface, again primarily with respect to the potential for surface and near-surface contamination; and
- ▶ The disposal of abstracted water to the Sherwood Sandstone, and in particular the potential to contaminate any usable resources within this aquifer and/or to activate seismic activity.



3.3 Pipeline

The ES (paragraph 3.8) states that the pipeline working width corridor is up to 30 m wide and 13.9 km in length, and indicative cross-sections are provided in Figures 3.6a and 3.6b. It extends west from the EMS Well Site and then south, parallel to the route of the RGP pipelines south of Givendale Head Farm and Warren House (granted planning permission in June 2012). It crosses beneath the A170 carriageway (paragraph 3.9) and continues south through the Vale of Pickering and beneath a number of watercourses and field drains, including the River Derwent, until it reaches the KGS, following the route of the EMKGP (granted planning permission in December 2013 (the Authority) and April 2014 (North Yorkshire County Council)). At larger crossings such as that for the River Derwent, auger boring, directional drilling or other techniques that minimise surface disturbance would be employed (paragraph 5.21).

Activities related to the EMS that may impact the water environment, and therefore of concern to the Amec Foster Wheeler review, include the following:

- ▶ Construction of the pipeline at the EMS Well Site, and in particular its potential to create new vertical flow and contaminant pathways between the ground surface and near-surface aquifers and associated receptors;
- ▶ Construction of the pipeline in the vicinity of watercourses and drains, including the River Derwent, and in particular its potential to disturb surface flows and to result in increased sediment-loading and contamination of these surface water bodies; and
- ▶ Operation and potential leakage of the pipeline in the vicinity of surface water and groundwater receptors.

Amec Foster Wheeler is of the view that the proposed development is adequately described in the ES, except with respect to the possible new borehole. The Applicants intentions with respect to the possible new borehole need to be more clearly and publicly stated, and need to be aligned with the planning application and EIA.

4. Assessment Area

Amec Foster Wheeler is concerned that the assessment area for the purposes of the EIA is not clearly stated in the ES, either with respect to the EMS Well Site or the pipeline. However, the Envireau Water Technical Report (August 2014) makes reference to a 70 km radius search radius for licensed and deregulated abstractions and a 10 km radius for private water supplies (Section 3). On the basis that the Envireau Water calculations (Section 5.3) for a 556 m³/d injection imply an 'area of influence' of 4.2 km away from the EMS Well Site, these radii are considered adequate by Amec Foster Wheeler for the EIA of the reduced (i.e. not the ES 1900 m³/d re-injection rate, Table 12.7) water disposal element, notwithstanding that the calculations are very sensitive to the elastic storage of the Sherwood Sandstone, and the origin of the assumed value ($1 \times 10^{-5} \text{ m}^3/\text{m}^3$) is not stated.

Furthermore, Amec Foster Wheeler agrees with the Barton Willmore Response Table that the surface catchment area boundaries and abstraction points map subsequently provided by R Elliott Associates Limited serve as the basis for delineating an acceptable 'area of influence' for the purposes of EIA, at least for the more southerly elements of the pipeline. The revised EIA table and map of R Elliott Associates Limited does take account of the relevant surface catchments. The EIA 'area of influence' for the EMS Well Site surface works and the initial (i.e. more northerly) stretch of pipeline, should be the Environment Agency Source Protection Zone (SPZ) underlying the site.

Although the assessment areas should have been more clearly identified and justified in the ES, Amec Foster Wheeler is now satisfied that appropriate assessment areas have been employed in the Applicants EIA, assuming that the planning application is for a scheme requiring a 556 m³/d produced water re-injection rate.



5. Assessment Methodology

The EIA methodology template is introduced in paragraphs 2.14-2.18 and Tables 2.2-2.4 of the ES, adopting what initially looks to be a standard sensitivity-magnitude of change-significance of change approach. Following standard convention, individual technical disciplines are expected to take account of this guidance, but are permitted to modify the approach as appropriate. What can be termed the hydrology assessment (ES Chapter 11, relating to the EMS Well Site surface site works and the pipeline) has followed the generic guidance quite closely (Tables 11.4-11.6), whilst the hydrogeological assessment (ES Chapter 12, relating to the produced water disposal element) has modified it (Table 12.1) by 'offsetting' some of the significance scores e.g. a 'Major' change in magnitude on a 'Low' sensitivity receptor becomes of 'Moderate' significance, rather than 'Moderate-Minor'.

However, Amec Foster Wheeler has concerns that the sensitivity guidance provided in Chapter 2 and adopted by both of the water chapters is open to incorrect interpretation. Table 2.3 should simply make reference to examples of receptor importance or value, but instead it also discusses the ability of the receptor to respond to change, which is more appropriately a consideration in relation to the magnitude of change assessment. Amec Foster Wheeler has been mindful of this confusion when auditing the later EIA.

Amec Foster Wheeler also considers that the generic guidance is not sufficiently clear as to when an effect is considered 'Significant' or 'Not Significant' in EIA terms, which is the requirement of the extant EIA Regulations. It has been inferred, based on comments in the later assessment chapters (paragraph 11.49 and 12.28), that it is only when the significance is described as 'Negligible' in either of the ES chapters that the effect is considered 'Not Significant', and this seems to only occur when the magnitude of change is itself 'Negligible'. This is an unusually prescriptive approach, as some magnitude of change is normally tolerated in EIA, and in fact should prevent the ES assessor of the produced water disposal impacts from ever assessing the effects on a 'High' sensitivity receptor as anything other than 'Significant' unless the significance rating jumps from the assumed 'Moderate' (for 'Low' magnitude of change) to 'Negligible' (for 'Negligible' magnitude of change). Amec Foster Wheeler has therefore taken a more conventional and pragmatic approach in its audit, and assumed that it is possible to identify 'Not Significant' effects on 'High' sensitivity receptors.

Very different criteria are provided in the EIA tables (Tables 9-11) within the Envireau Water Technical Report. However, similar problems of significance definition persist, and Amec Foster Wheeler is also presented with the problem as to where to look within the EIA with respect to the water disposal element of the proposed development i.e. in Chapter 12 of the ES or the Technical Report. The conclusions of the residual assessments are very similar, and in the circumstances Amec Foster Wheeler has taken the approach of auditing the Technical Report assessment, whilst still being mindful of its ES Chapter 12 equivalent.

Although the ES assessment methodology is flawed in a number of respects, the problems are not sufficient to prevent Amec Foster Wheeler coming to reasonable and defensible conclusions regarding residual effects.

6. Baseline

The description of the existing baseline environmental conditions relating to the water environment is mainly presented in ES paragraphs 11.50-11.86. Key features of particular relevance to the EIA within this description include the following (in order of reference):

- ▶ The EMS Well Site is close to the headwaters of Troutsdale Beck, a tributary of the River Derwent (paragraph 11.51);
- ▶ A west-east geological fault (the Helmsley-Filey Fault) is located just to the north of the A170 carriageway, marking the boundary between the Corallian sandstones and limestones to the north and the lacustrine and glacial deposits that overlie the Kimmeridge Clay in the south (paragraph 11.59 and Figure 11.7);
- ▶ There are a number of springs close to the geological fault, most notably that at Allerston, which is associated with an Environment Agency SPZ (paragraph 11.65);



- ▶ The southern area is extensively drained to a number of large dikes, such as Friar Dike, which then flow into the River Derwent or its tributaries (paragraph 11.66);
- ▶ The EMS Well Site and the north area of the pipeline are located on permeable sandy soil overlying the Corallian Group, which is used for public water supply and also supports baseflow into Troutsdale Beck and other watercourses (paragraph 11.72);
- ▶ The aquifer is confirmed as a Major (now Principal) Aquifer (paragraph 11.74), and the EMS Well Site and northern length of pipeline lie within an SPZ (Zone 2) (paragraph 11.75);
- ▶ Sixteen licensed abstraction boreholes for an unspecified search area are noted on the Environment Agency database, three being surface water abstractions and thirteen being groundwater abstractions (paragraph 11.78). No further details are provided, other than the nearest is approximately 500 m away at Givendale Head Farm; and
- ▶ The EMS Well Site is underlain by a bentonite membrane (paragraph 11.82), extending under the boundary ditches and bunds of the site (paragraph 11.83). The site is drained to a sump at the south-east corner of the site, where it is pumped to onsite storage tanks and eventually removed by a licensed waste carrier (paragraph 11.84).

Engineering drawings, released by R Elliot Associates Limited in response to the February 2015 meeting request of Amec Foster Wheeler, illustrate the layout of the site and the placement of the bentomat in cross section, whilst an accompanying surface conceptual model indicates the approximate position of the underlying Corallian Group aquifer water table (i.e. 12 metres below ground level, although based on limited field data), and a potential flow path to the nearby Troutsdale Beck springs.

It is presumed that the geological and hydrogeological elements of the Chapter 11 baseline have been used to help inform the hydrogeological conceptual model that is presented in paragraphs 12.20 and 12.21, and Figure 12.1. The model recognises the near-surface Corallian aquifer and the abstractions and surface watercourses that it supports, but implies that low hydraulic conductivities and considerable thicknesses associated with the underlying thick Oxford Clay and Mercia Mudstone strata and the absence of faulting local to the EMS Well Site prevent a vertical hydraulic connection between this aquifer and the Sherwood Sandstone at depth, whilst vertical connectivity is also poor between the Sherwood Sandstone and the underlying KAF, because of intervening low hydraulic conductivity mudstones at the top of the Permian sequence. Natural recharge to the Sherwood Sandstone is limited to the outcrop and subcrop areas in the distant Vale of York/Mowbray, whilst recharge to the Corallian Group and underlying secondary aquifers (Ravenscar Group) is limited to their North York Moors outcrop.

The only other baseline description provided in Chapter 12 of the ES relates to water quality in the KAF (paragraphs 12.33-12.36 and Tables 12.2 and 12.3) and the Sherwood Sandstone (paragraphs 12.37-12.39 and Tables 12.4 and 12.5), the source and receiving waters for the proposed development respectively, with a comparison between the chemistry of the two waters and that of the North Sea in paragraphs 12.42 and 12.43 and Table 12.6. The KAF water has had to be characterised with reference to laboratory analysis of waters from an existing gas production well site in the Vale of Pickering, and the analysis indicates the presence of high salinity and hydrocarbons. The Sherwood Sandstone samples from the nearby Ebberston 'B' Well Site also indicate salinity and some hydrocarbons. The KAF appears to be double the salinity of the Sherwood Sandstone, but these waters are themselves ten and five times more saline than the North Sea. The high salinity of the Sherwood Sandstone is reported to be mineral- rather than sea water-based (Bottrell, 2006), and hints at long residence times, consistent with the hydrogeological conceptual model.

On the basis of above summary, Amec Foster Wheeler considers that the ES baseline description has a number of errors and omissions, including the following:

- ▶ The absence of a comprehensive description of the regional and local geology and geological structure;
- ▶ The lack of any hydrogeological parameter values, groundwater levels (most importantly, for the Corallian Group and Sherwood Sandstone) or near-surface water quality;
- ▶ Erroneous interpretation of the SPZ and groundwater vulnerability maps (paragraph 11.75, Figures 11.2 and 11.3 respectively) and aquifer status (paragraphs 11.73 and 11.77, Figure 11.1);



- ▶ Failure to locate the licensed abstractions (paragraph 11.78) or consider any private water supplies or Water Framework Directive (WFD) water bodies;
- ▶ The lack of information regarding the presence (or otherwise) of springs in the area, other than those at the head of Troutdale Beck and at Allerston;
- ▶ The absence of any information in the water chapters regarding groundwater dependent terrestrial ecosystems (GWDTEs, conservation sites) in the area, most notably Troutdale and Rosekirk Dale Fens Site of Special Scientific Interest (SSSI) and Nature Conservation Site (NCS), a rare spring and flush fen habitat north of the site (paragraph 15.55);
- ▶ The hydrogeological conceptual model is not as informative as it should be, lacking key details (even opinion) regarding such features as local geology and faulting, hydraulic properties and groundwater levels and flow directions; and
- ▶ The Chapter 11 figures are also not of a good quality, for instance commonly lacking a scale or eastings/northings.

Some of the issues related to the ES baseline have been addressed, at least in part, by subsequent submissions, most notably the Envireau Water Technical Report. This includes the following baseline information:

- ▶ A more comprehensive description of the regional and local geology and geological structure in the (Sections 2.3.1-2.3.3, Table 1, Figures 3-5 and Appendix B);
- ▶ A more up-to-date and informative description of aquifer potential (Sections 2.4.2-2.4.4), acknowledging the major resource value of the Corallian Group, but making the case for the Sherwood Sandstone not being considered a groundwater body or having any resource value. Also included is some limited information regarding Sherwood Sandstone permeability (hydraulic conductivity, Section 2.4.4.1), and the results of a literature review with respect to the water quality in the Sherwood Sandstone (Section 2.4.4.2);
- ▶ A more extensive and better reported licensed abstraction search, with 24 abstractions (ten surface water/springs, fourteen groundwater) located within the 10 km search radius, with all of the nearby groundwater abstractions from the superficial deposits or Corallian (Section 3.1 and Figures 6 and 7). The 70 km radius search identified that licensed abstractions from the Sherwood Sandstone are located at or very close to its outcrop, some 33 km to the south-west of the EMS Well Site;
- ▶ Completion of a private water supply search with 10 km of the EMS Well Site (Section 3.3 and Figure 9). There are 90 registered private water supplies in the area (57 surface water/springs, 31 groundwater, two unknown). The closest groundwater abstraction is approximately 2 km to the south-west;
- ▶ Considerably more information regarding SPZs in the area (Section 3.5). There are three SPZs within 10 km of the EMS Well Site. The SPZ2 it resides in relates to four licences abstracting from the Corallian Group south of Scarborough, namely three for public water supply and one for a McCain factory. The drinking water supply for Scarborough is obtained solely from the Corallian Group, which has a high resource value, and is associated with very high groundwater flow velocities. The other two SPZs are for Pickering and Allerston, approximately 12 km and 5 km south of the EMS Well Site respectively.

The water quality and hydrogeological conceptual model sections of the Envireau Water Technical Report (Sections 4 and 6 respectively) are little different from their ES Chapter 12 equivalents, although the use of small quantities of separation and injection additives in the proposed development is acknowledged (Section 4.3). However, the latest conceptual model, produced in response to the February 2015 meeting request of Amec Foster Wheeler, is an advance on the previous version, with a better depiction of local geology, faulting and groundwater flow, although still lacking indicative groundwater levels.

Finally with respect to baseline, the Barton Willmore Response Table, provided in response to the Amec Foster Wheeler first data request, gives some spot groundwater and spring elevations, but not sufficient to derive an understanding of groundwater flow directions and gradients for the Corallian Group aquifer in the



vicinity of the EMS Well Site. It also identifies High Scramridge Farm and Little Hill Green as other abstractions in the area. The accompanying River Derwent WFD status confirms that the River Derwent down from its confluence with Troutdale Beck to the River Rye (Water Body GB104027067930) is of 'Moderate' potential and 'Good' status with respect to current and 2015 predicted ecological and chemical quality respectively. The further WFD information provided by R Elliot Associates Limited indicates 'Poor' status (primarily due to fish) with respect to current and 2015 predicted ecological quality for Troutdale Beck ((Water Body GB104027067910), and also 'Poor' status (primarily due to saline intrusion and Drinking Water Protected Area Status) with respect to current and 2015 predicted quantitative and chemical quality for the Derwent Vale of Pickering Corallian Limestone (Water Body GB40401G7001200).

With respect to the baseline, Amec Foster Wheeler is of the opinion that the issues with the original ES should not have arisen, and that the absence of adequate information regarding potential receptors would have hindered the auditing of the EIA. However, the subsequent documents have helped address some of the deficiencies of the ES, such that the baseline is now sufficient for the purposes of the EIA, and the hydrogeological conceptualisation and the water quality (KAF and Sherwood Sandstone) characterisation are considered plausible, although not definitive.

7. Potential Receptors

Amec Foster Wheeler is very concerned that no definitive list of receptors or their sensitivity appears to be present in ES Chapters 11 and 12. Even the tables of significance at the end of the chapters (Table 11.3 for flood risk, hydrology and drainage (i.e. the EMS Well Site surface works and the pipeline), and Table 12.7 for produced water disposal) are activity-led, rather than receptor-led, and this makes the ES EIA very difficult to audit. This problem is particularly acute with respect to that part of the assessment presented in ES Chapter 11, because of the greater number of potential receptors with respect to the EMW Well Site surface site works and the pipeline.

It is partly for this reason that Amec Foster Wheeler requested at the February 2015 meeting that the EIA table pertaining to the EMS Well Site surface works and the pipeline elements of the proposed development (Table 11.3) was reviewed and reissued, and accompanied by a map showing the location of all considered receptors. To supplement the ES, as mentioned earlier, Amec Foster Wheeler also had to make reference to the EIA within the Envireau Water Technical Report relating to the produced water disposal (Table 12.7).

Amec Foster Wheeler interpretation of these two post-ES documents has enabled it to identify lists of receptors and sensitivities that appear to underlie the Applicants EIA (see later Amec Foster Wheeler Tables 1 and 2). The receptor listings look adequate other than some secondary aquifers and abstractions (public water supplies and private water supplies) and human health and infrastructure (related to the induced seismicity risk) are not specifically mentioned. The sensitivity scores also look reasonable, although Amec Foster Wheeler would normally regard smaller licensed abstractions and private water supplies to be of 'Low', not 'High', sensitivity. The sensitivity scores of the other receptors not specifically identified can reasonably be inferred from those of other receptor groups e.g. public water supplies can be regarded of 'High' sensitivity.

Amec Foster Wheeler again queries the quality of the ES, but following the submission of further information the lists of receptors and sensitivities look reasonable. In particular, because Amec Foster Wheeler is accepting of the baseline hydrogeological model, it also agrees that the Sherwood Sandstone in the area is not a viable groundwater resource and therefore should be 'scoped out' of the EIA. The distant Sherwood Sandstone outcrop should also have been 'scoped out', given its distance from the proposed development.

8. Potential Effects

The ES discusses the potential (before additional mitigation) effects of the proposed development with respect to the water environment in ES paragraphs 11.93-11.133 (EMS Well Site surface site works and the pipeline) and 12.44-12.64 (produced water disposal). All four stages of the proposed development, namely construction, operation, decommissioning and restoration, are considered, although only the significance of any effect is identified, with no indication of sensitivity or magnitude of change to determine significance.

The problem of an activity- rather than receptor-based approach mentioned is continued into the assessment of potential effects. Indeed, Amec Foster Wheeler has found it difficult even to map the activity-focused assessment through to the later Table 11.3 table of significance. Furthermore, the ES assessor, presumably R Elliott Associates Limited, makes the following important assertions regarding effect significance related to activity:

- ▶ What is regarded as the 'impermeable' bentomat and the oil interceptors on the EMS Well Site would prevent any surface drainage (paragraphs 11.103 and 11.119) or contaminants infiltrating to ground (paragraph 11.110);
- ▶ The installation of the pipeline and its connection to the EMS Well Site would cause a temporary localised breach in the ditch surrounding the Well Site, giving rise to a temporary increase in the risk of surface drainage (paragraph 11.104) and contaminants (paragraph 11.110) entering the ground, both constituting 'Minor' significance effects;
- ▶ In the event of a surface spillage at the time when the perimeter ditch is breached during construction, contaminants could enter the aquifer and emerge first at the Troutsdale Beck springs, thereby reducing surface and groundwater quality and potentially having 'Major/Moderate' significance effects on the flora and fauna at the SSSI and on Scarborough's water supply (paragraph 11.111). 'Moderate/Minor' significance effects are associated with similar activities during decommissioning (paragraph 11.122);
- ▶ The extension of the pipeline through the SPZ2 immediately to the west of the site and close to the Givendale Head Farm and Warren House abstractions would present 'Moderate' significance effects in the event of a fuel and oil spillage (paragraph 11.112); and
- ▶ Further to the south, construction of the pipeline would encounter land drains, resulting in 'Moderate' significance effects on the land drainage system (paragraph 11.107), whilst the occurrence of a spillage during the pipeline construction could have 'Major/Moderate' significance effects on the underlying superficial aquifers (paragraph 11.116).

Based on the interpretation of the further information provided subsequent to the 12 February 2015 meeting, Amec Foster Wheeler has formulated a potential effects table with respect to the Applicants EIA of the EMW Well Site surface works and the pipeline (Table 1). As indicated in the table footnotes, some small changes to the significance scores have been necessary due to misinterpretation of the assessment criteria tables by the ES assessor, and there are other instances where Amec Foster Wheeler questions the validity of the sensitivity scoring (see earlier) or believes it contradicts (usually underplaying) the findings of the activity-led assessment with respect to magnitude of change. However, most importantly, Amec Foster Wheeler agrees with the ES assessment that most receptors identified would be in receipt of 'non-Negligible' effects, which using the methodology adopted in the ES would represent 'Significant' adverse effects in the absence of additional mitigation, and by inference this would extend to the other secondary aquifers and public and private water supplies in the assessment areas.

Table 1 Summary of Applicants Assessment of Potential Water Effects³, EMS Well Site Surface Works and Pipeline

Ref Number	Receptor	Sensitivity/ Value	Magnitude	Level
GW01	Corallian Aquifer at EMS	High	Moderate	Major/Moderate
GW02	Corallian Aquifer along pipeline route near EMS	High	Moderate/Minor	Major/Moderate to Moderate/Minor ¹
GW03	Corallian Aquifer along pipeline route outside SPZ	High	Minor/Negligible	Moderate-Minor to Negligible ¹
GW04	Superficial deposits near KGS	Moderate	Minor	Minor
GA01	High Scamridge Farm	High ²	Minor	Moderate-Minor ^{1,2}
GA02	Allerston	High ²	Minor	Moderate-Minor ^{1,2}

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Ref Number	Receptor	Sensitivity/ Value	Magnitude	Level
SP01	Troutsdale	High	Moderate	Major/Moderate
SP02	Near A170	Moderate	Minor	Minor
WC01	Troutsdale Beck	High	Moderate	Major/Moderate
WC02	Friar Dike	Moderate	Minor	Minor
WC03	River Derwent	High	Major	Major
CS01	Weas Dale marshy grassland	Moderate	Negligible	Negligible

Table Note:

¹ Correction to Applicants assessment score applied by Amec Foster Wheeler, in accordance with Applicants assessment criteria tables

² Applicants assessment score challenged by Amec Foster Wheeler

³ Some potential receptor groups missed by Applicants e.g. some secondary aquifers, public water supplies, private water supplies

With respect to the produced water disposal potential effects (Section 12), the ES assessor, presumed to be Envireau Water, makes the following important assertions:

- ▶ With respect to aquifer contamination, modification of the existing borehole and possible construction of a new borehole would be controlled by the Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 and via a notice to the Environment Agency under Section 199 of the Water Resources Act 1991 (paragraph 12.47), both types of embedded (design) mitigation, and the effect during both construction and subsequent operation is considered 'Minor' significance (paragraphs 12.49 and 12.58 respectively);
- ▶ During operation, the considerable (700 m) thickness of overlying low permeability formations and the distance to outcrop (~35 km) (paragraph 12.56) is considered to ensure that the disposal of produced water would have no discernible effects on the water environment by way of lateral and vertical flows away from the injection zone (paragraph 12.57); and
- ▶ Regarding the important matter of induced seismicity, emphasis is placed on the low injection rates (paragraph 12.52) and the moderate hydraulic conductivity of the Sherwood Sandstone (paragraph 12.53), such that the effect is 'Minor' significance (paragraph 12.54).

Given that only effects identified as 'Negligible' are regarded as 'Not Significant' in the ES, then the ES assessor appears to be identifying that both the borehole-related aquifer contamination and induced seismicity potential (before additional mitigation) effects would be 'Significant' in EIA terms.

Even though the EIA methodology is different, the 'Significant' conclusion with respect to aquifer contamination due to the borehole construction is repeated in the Envireau Water Technical Report (Table 13), albeit based on a very much higher significance rating (e.g. 'Major' for the Corallian Group aquifer, and 'Moderate' for the underlying Ravenscar Group and other secondary aquifers). Indeed, in this later assessment there appears to be an acceptance that potentially the produced water could migrate up into the Corallian Group aquifer, and even to the Sherwood Sandstone outcrop area, where it could result in a rating of 'Major' significance.

Table 2 is Amec Foster Wheeler's summary of the Applicants potential effects assessment with respect to the produced water disposal, giving priority to the Envireau Water Technical Report assessment over that of the ES Chapter 12, and therefore using different terminology to that of Table 1. A table footnote indicates that Amec Foster Wheeler considers the magnitude of change to be at least one grade too high for the overlying aquifers, and therefore the significance scores are also too high, although they would still be 'Significant' in EIA terms. However, as stated earlier and mentioned in another table footnote, Amec Foster Wheeler believes that the effects on the distant Sherwood Sandstone aquifer should have been 'scoped out'.

Table 2 Summary of Applicants Assessment of Potential Water Effects², Produced Water Disposal

Receptor	Sensitivity/ Value	Magnitude	Level
Corallan Aquifer	Very High	High ¹	Major ¹
Secondary Aquifers	High	Medium ¹	Moderate ¹
Sandstone Aquifer ³	Very High	High	Major

Table Note:

¹ Applicants assessment score challenged by Amec Foster Wheeler

² Some potential receptor groups missed by Applicants e.g. public water supplies, private water supplies, watercourses, human health and infrastructure (induced seismicity)

³ Amec Foster Wheeler considers receptor should have been 'scoped out' of the assessment

The induced seismicity potential effect is not assessed by Envireau Water in its Technical Report, although it is considered '*Minor*', and therefore '*Significant*', in Table 12.3 of the ES, using the assessor's methodology. In undertaking its review Amec Foster Wheeler has made reference to the more authoritative assessment of induced seismicity risk by Rockflow Resources, as referred to in the Envireau Water Technical Addendum (Section 6). The Rockflow Resources work is quite detailed and technical, as befits the '*Very High*' sensitivity that has been attributed to human health and infrastructure receptors, and Amec Foster Wheeler therefore presents a summary of the work, before considering its adequacy and implications with respect to the EIA.

Water injection into a reservoir like the Sherwood Sandstone raises the formation fluid pressure, and if that fluid pressure reaches the local so-called fracture gradient, then the rocks can fail, potentially leading to fracturing or fault movement and hence generating a seismic event. The Rockflow Resources study assesses the risk that water injection may cause fault reactivation in a manner similar to the Cuadrilla Preese Hall-1 event (De Pater and Raisch, 2011; Green et al, 2012), or via a mechanism linked to fluid pressure increase within a fault compartment.

The stress system in the local Cleveland Basin has previously been assessed (Geoscience Limited, 2013), and stress-depth relationships for the minimum and maximum horizontal stresses as well as the fluid pore pressure have been generated. The assessment is presented in Rockflow Resource's Figure 4-9, together with the results of relevant site-specific tests. The lowest trap integrity (the difference between the minimum rock stress and the fluid pressure) is expected to be at the top of the Sherwood Sandstone. At the EMS Well Site, the expected pore pressure at the top of the Sherwood Sandstone is ~1200 pounds per square inch absolute (psia), based on extrapolation from limited measurements in the nearby Eberston Moor 2. From Figure 4-9, the maximum principal stress (resulting from the overburden) is ~3100 psia, whilst the minimum horizontal stress is no lower than 2385 psia. Assuming a conservative lowermost fracture point of 2200 psia provides a drilling margin (trap integrity) of ~1000 psia (2200-1200). Therefore, to avoid the risk of breaching the fracture gradient and potentially causing a seismic event, water should be injected into the existing EMS borehole (or indeed a new replacement) at a bottom-hole pressure (BHP) no more than 1000 psia above the initial formation pressure.

Modelling has been undertaken by Rockflow Resources using what it considers to be a conservative set of parameter assumptions to assess the impact of injecting water into the Sherwood Formation (Figures 4-10 to 4-12). The current working scheme design uses an electric submersible pump (ESP) across the KAF that delivers water to the Sherwood Sandstone via the well annulus, at an equivalent tubing-head pressure (THP) of 20-30 absolute pressure (bara; 290-435 psia). On this basis, the maximum injection rate is likely to be 3000-3500 barrels per day (bpd, 1 bpd = 0.16 m³/d, Figure 4-10). Figure 4-12 shows that as long as the average permeability of the formation is greater than 5 mD (1 darcy (D) = 0.831 m/d; 1 mD = 0.000831 m/d), it should be possible to inject 3500 bpd at the EMS Well Site without risking breaching the fracture gradient and inducing seismicity i.e. the BHP exceeding the initial formation pressure by > 1000 psia. If the average permeability is less than 5 mD, the injection rate would have to be limited. This is considered unlikely, as available data indicates that average permeability is at least 10 mD, and probably 25-80 mD.

The Rockflow Resources Figure 4-13 shows how the fluid pressure drops with distance from the well for different permeabilities, in a scenario where a flow rate of 3500 bpd is achieved. This is indicative of the maximum distance for fractures or faults to be activated due to the direct transient pressure increase related

to fluid injection, and can be translated into an effective area and maximum seismic event that could result e.g. 1mD = radius of 30ft = 250 m² area affected.

Based on the Preese Hall-1 event, an earthquake of 0.5 on the Richter scale (the Department of Energy and Climate Change (DECC, 2014) 'Red' threshold) requires fault movement over an area of approximately 20 m², while a 0 earthquake could be generated by a fault slipping over 4 m². Thus, with the set of assumptions presented above, it is theoretically possible that if the average permeability in the Sherwood Sandstone is <2-3 mD, then injection into the existing EMS borehole at a rate of 3500 bpd has the potential to cause fault movement in the immediate vicinity of the borehole that would trigger DECC 'Amber' or 'Red' actions.

Rockflow Resources recognises that it is also theoretically possible to raise the formation pressure within a small compartment to the fracture pressure, hence triggering rock failure and potentially fault movement. However, no identified faults or mapped fault compartments are in the near vicinity of the EMS Well Site, and there is no evidence that any sand-on-sand faults are sealing or compartmentalising the reservoir. Consequently, Rockflow Resources consider that it is extremely unlikely that the proposed injection scheme would increase the fluid pressure within a reservoir compartment to a level sufficient to cause rock failure. Furthermore, this mechanism is not instantaneous, and a monitoring programme would be able to measure any pressure increase, allowing compartment size to be extrapolated and injection policy adjusted accordingly. Also, as the BHP rises, injection rates would progressively decline.

In summary, Rockflow Resources concludes that the proposed scheme would inject relatively small volumes of water at low rates into a permeable sandstone. The pressure required to enable this injection is low compared to the pressure that would be required to fracture the Sherwood Sandstone. Consequently, the probability of the scheme causing a seismic event is extremely low.

In reviewing the induced seismicity effects Amec Foster Wheeler is not in a position to validate the Rockflow Resources calculations or conclusions. Notwithstanding it having some queries regarding residual effects (see later), Amec Foster Wheeler observes that the work appears to be well documented and reasoned. It also considers that, if correct, the potential (e.g. without additional mitigation) magnitude of induced seismicity effect on the 'High' sensitivity human health and infrastructure could be considered 'Low' i.e. still 'Significant'.

Amec Foster Wheeler is of the opinion that the original ES EIA is not of a particularly good quality. Being activity-led meant it is difficult to audit and relate to receptors, and this is compounded by the lack of a receptor location plan. Even to map the activity-focused assessment through to the ES Table 11.3 is difficult. However, these problems have been lessened by the subsequent provision of further information. Although the methodology and some of the scoring can be questioned, Amec Foster Wheeler agrees that with the EIA criteria used by the Applicants that the potential effects on most receptors, including human health and infrastructure (induced seismicity), would be 'Significant' in EIA terms. However, it believes that the effect of the produced water disposal on the distant Sherwood Sandstone aquifer should have been 'scoped out' from further consideration.

9. Mitigation

Mitigation related to flood risk, hydrology and drainage (the EMS Well Site surface works and the pipeline) is identified in paragraphs 11.134-11.153, with the mitigation focussed on the implementation of the Construction Environmental Management Plan (CEMP) and best practice as described in the Environment Agency's Prevention of Pollution Guidelines (PPGs) (paragraph 11.135). Key measures include the following:

- ▶ Modification of surface water management on the EMS Well Site so that incident rainfall is either used on site or discharged through an oil interceptor and soakaway into the ground, at the south-east corner of the site and on the outer edge of the SPZ2 (paragraph 11.143);
- ▶ Implementation of a land drainage scheme to divert water in the land drains further south. Repairs to damaged land drains would be undertaken where practicable (paragraph 11.144);

- ▶ A wide range of pollution prevention procedures would be adopted on the EMS Well Site, including protection of the perimeter ditch lining and the placement of temporary retention structures (paragraph 11.147); and
- ▶ Regular monitoring of the pipeline, and the establishment of a spill response plan (paragraph 11.150).

Further mitigation related to hydrology and drainage is also implied by the responses of the Environment Agency and Yorkshire Water (see Section 4 later).

Mitigation in relation to the proposed produced water disposal is described in paragraphs 12.65-12.69 of the ES. The focus is on the requirements of The Offshore Installations and Wells (Design and Construction etc) Regulations 1996 with respect to the borehole design, construction, commission, operation and abandonment (paragraph 12.67), together with the continuous monitoring of low injection pressures to avoid induced seismicity (paragraphs 12.68 and 12.69).

The 1996 Regulations and injection pressure mitigation is further discussed in Sections 7.5.1 and 7.5.2 respectively of the Envireau Water Technical Report. Section 2.4 of the Envireau Water Technical Addendum identifies the rigorous testing regime required to ensure compliance with the 1996 Regulations, and a commitment to establishing baseline groundwater quality and an ongoing monitoring regime is presented in Section 4 of the same report.

With respect to the risk of induced seismicity, Rockflow Resources (July 2014) recommends that the ESP is not be supplemented by a booster pump. Furthermore, whilst continued water injection would gradually increase formation pressures, a monitoring scheme would track formation pressures over the initial test period, providing data that can guide future injection strategy decisions.

Amec Foster Wheeler considers that the mitigation related to the proposed development is generally satisfactory, and is supportive of the proposed CEMP and the rigour to be imposed on the proposed development (including the potential abandonment on the existing borehole should the refurbishments fail, an event not specifically identified in the ES mitigation) by way of The Offshore Installations and Wells (Design and Construction etc) Regulations 1996. However, given the 'High' sensitivity of a number of receptors in the close vicinity of the EMS Well Site (Corallian aquifer, Scarborough public water supplies, Troutdale Beck and River Derwent, Troutdale and Rosekirk Dale Fens SSSI), Amec Foster Wheeler strongly advises that the integrity of the existing bentomat underlying the EMS Well Site, especially in the drains, is tested, and the proposal to utilise an oil interceptor and soakaway system on the site should be reconsidered, and that these actions should be pre-commencement conditions within any planning permission.

The monitoring of water quality and injection performance in the vicinity of the EMS Well Site prior and during the proposed development, and the establishment of trigger levels and an emergency remedial action plan, is also particularly important. Amec Foster Wheeler considers that an acceptable monitoring scheme design and emergency remedial action plan should be a further pre-commencement condition. The Envireau Water 'Statement of Intent', produced in response to the February 2015 meeting request of Amec Foster Wheeler, acknowledges the importance of the monitoring, and it is encouraging that it commits the Applicants to provide data on the key receptors identified in the ES, including shallow groundwater, springs and watercourses. Amec Foster Wheeler considers that the monitoring and comparison of shallow and deep water levels should form part of the monitoring regime, so as to avoid the occurrence of upward vertical hydraulic gradients and groundwater flow, especially in the circumstances where the existing borehole has had to be abandoned and restored.

Amec Foster Wheeler considers that the embedded and additional mitigation proposed by the Applicants is appropriate, provided it is implemented rigorously and that certain EMS Well Site pre-commencement conditions are applied with respect to confirmation of the integrity of the bentomat, reconsideration of the proposed use of an oil interceptor and soakaway system, and the agreement of a suitable monitoring scheme design and emergency remedial action plan.

10. Residual Effects

The ES briefly states the residual (after additional mitigation) effects of the proposed development with respect to the water environment in ES paragraphs 11.154-11.157 and Table 11.3 (the EMW Well Site surface site works and the pipeline) and paragraph 12.70 and Table 12.7 (produced water disposal). All four stages of the proposed development, namely construction, operation, decommissioning and restoration, are again considered, although again only the significance of any effect is identified, with no indication of receptor sensitivity or magnitude of change and once again the assessment is activity- rather than receptor-focused.

With respect to both parts of the assessment, the ES assessors consider that the identified additional mitigation is sufficient for all effects to become 'Negligible' i.e. 'Not Significant', although no further explanation for each activity assessment is provided. Even though the EIA methodology is different, the 'Negligible' and 'Not Significant' conclusion with respect to aquifer contamination due to the borehole construction and migration of produced water is repeated in the Envireau Water Technical Report (August 2014, Table 13), again with little further explanation.

Amec Foster Wheeler summaries of the Applicants residual water effects are presented in Tables 3 and 4. Using the Applicants EIA criteria, 'Negligible', 'Not Significant' scores imply post-mitigation magnitudes of change of 'Negligible'. Based on its assessment of the adequacy of the additional mitigation (with pre-commencement conditions), and its recognition that the potential effects related to the produced water disposal has been 'over-scored' during the pre-mitigation assessment by the Applicants, Amec Foster Wheeler considers that the final conclusion regarding significance is reasonable and defensible, including with regard to any potential upward movement of the re-injected water (with low concentrations of additives).

Table 3 Summary of Applicants Assessment of Residual Water Effects², EMS Well Site Surface Works and Pipeline

Ref Number	Receptor	Sensitivity/ Value	Magnitude	Level
GW01	Corallian Aquifer at EMS	High	Negligible	Negligible
GW02	Corallian Aquifer along pipeline route near EMS	High	Negligible	Negligible
GW03	Corallian Aquifer along pipeline route outside SPZ	High	Negligible	Negligible
GW04	Superficial deposits near KGS	Moderate	Negligible	Negligible
GA01	High Scamridge Farm	High ¹	Negligible	Negligible
GA02	Allerston	High ¹	Negligible	Negligible
SP01	Troutsdale	High	Negligible	Negligible
SP02	Near A170	Moderate	Negligible	Negligible
WC01	Troutsdale Beck	High	Negligible	Negligible
WC02	Friar Dike	Moderate	Negligible	Negligible
WC03	River Derwent	High	Negligible	Negligible



Ref Number	Receptor	Sensitivity/ Value	Magnitude	Level
CS01	Weas Dale marshy grassland	Moderate	Negligible	Negligible

Table Note:

¹ Applicants assessment score challenged by Amec Foster Wheeler

² Some residual receptor groups missed by Applicants e.g. some secondary aquifers, public water supplies, private water supplies

Table 4 Summary of Applicants Assessment of Residual Water Effects¹, Produced Water Disposal

Receptor	Sensitivity/ Value	Magnitude	Level
Corallian Aquifer	Very High	Negligible	Negligible
Secondary Aquifers	High	Negligible	Negligible
Sandstone Aquifer ²	Very High	Negligible	Negligible

Table Note:

¹ Some potential receptor groups missed by Applicants e.g. public water supplies, private water supplies, watercourses, human health and infrastructure (induced seismicity)

² Amec Foster Wheeler considers receptor should have been 'scoped out' of the assessment

The induced seismicity residual effect is not assessed by Envireau Water in its Technical Report, although it is considered to have a 'Negligible' magnitude and therefore be 'Not Significant', in Table 12.3 of the ES. Rockflow Resources has estimated the likelihood that with the additional mitigation, the injection scheme would cause a seismic event with a magnitude greater than 0.0 at less than 1 in 100000 (Table 4.2), and depending on the responses to its earlier queries regarding induced seismicity, Amec Foster Wheeler considers that if reliable, this assessment could be equated to a 'Negligible', and 'Not Significant' effects. However, to help support its assessment, the Applicants are invited to clarify the implications of the Rockflow Resources work with respect to re-injection rates of any proposed new borehole at the EMS Well Site, and also how its assessment of residual effects is reconciled with the Envireau Water 'area of influence' calculations (Technical Report, Section 5.3) that imply that the water disposal pressure effects would propagate to the Helmsley-Filey Fault, 4 km to the south of the EMS Well Site.

Amec Foster Wheeler considers that on the basis of the mitigation proposed, an assessment of 'Negligible', i.e. 'Not Significant', effect with respect to the water environment is a reasonable one, although clarification from the Applicants regarding the implications of the Rockflow Resources work with respect to re-injection rates of any proposed new borehole at the EMS Well Site and in regard to the Helmsley-Filey Fault is required to help support their assessment of a 'Not Significant' effect with respect to induced seismicity. The Applicants are reminded that it is the effective delivery of the mitigation as described that prevents the potential 'Significant' effects from possibly being realised, including contamination of watercourses and aquifers that support public water supply and industrial abstractions, and induced seismicity.

11. Cumulative Effects

The ES Chapter 11 considers the cumulative (combined) effects of Ebberston 'A' and the proposed development with respect to flood risk, drainage or hydrology (paragraph 11.159) as 'Negligible', i.e. 'Not Significant', arguing that they appear to reside in different surface water catchments. However, Amec Foster Wheeler is concerned that both Ebberston 'A' (Envireau Water, December 2013) and the EMS Well Site reside over the same Corallian Group aquifer and SPZ, and therefore the cumulative effects of surface site works and pipelines on the aquifer and other dependent groundwater receptors such as Troutsdale Beck still need to be considered, unless or until the Applicants rescind their existing Ebberston 'A' permit.

ES Chapter 12 takes a different approach to the issue with respect to the produced disposal water, arguing (paragraph 12.72) that the Applicants would not seek to inject more than the Ebberston 'A' permitted rate of 1900 m³/d at the two locations, and therefore a cumulative assessment is not required. However, Amec Foster Wheeler is of the view that until the Ebberston 'A' permit is rescinded or modified, a cumulative impact assessment based on the assumption of 1900 m³/d injected at Ebberston 'A' and at least 556 m³/d at the

EMS Well Site (assuming operation of a refurbished existing well) should be undertaken, including for induced seismic risk. There may also be a case for the cumulative assessment to take account of the more distant York Potash proposed development, given that it also includes water disposal into the Sherwood Sandstone.

Amec Foster Wheeler considers that the cumulative impact assessment requires more consideration by the Applicants, both with respect to the EMS Well Site surface works and the pipeline, and the produced water disposal.

12. Consultee Comments

12.1 Introduction

As stated earlier, for the purposes of the review the Authority provided Amec Foster Wheeler with consultee responses to the proposed development. Amec Foster Wheeler's review of each of the three key responses is provided below.

12.2 Environment Agency Response

Amec Foster Wheeler notes the following with respect to the Environment Agency response:

- ▶ The Environment Agency has corrected the aquifer status declarations within the ES with respect to the Corallian Limestone (principal aquifer) and the Amphill Clay Formation and Kimmeridge Clay Formation (unproductive aquifers);
- ▶ The Applicants would need to provide a justification as to why the pipeline has to pass through a SPZ2;
- ▶ A series of planning conditions are recommended, including the provision for approval for pipeline trench lining throughout the SPZ2 (Condition 1), and no placement of pipes below the water table in any principal or secondary aquifers (part of Condition 2); and
- ▶ A series of informatives are recommended, including no potential contaminating substances should be allowed to enter groundwater in strata shallower than, and including, the Corallian Group aquifer; any boreholes should be constructed in such a way so as to cause no contamination between and including any overlying drift deposits and the Corallian Group aquifer, and between the aquifer and any underlying deposits.

Whilst the errors in baseline are regrettable and avoidable, Amec Foster Wheeler considers that compliance with the Environment Agency planning conditions and informatives would further bolster the Applicants proposed mitigation.

12.3 Yorkshire Water Response

Amec Foster Wheeler notes that there are three public water supply pipelines present within the proposed development boundary, and protection works would need to be incorporated within the Applicants proposed mitigation.

12.4 Frack Free/Fraser Consulting

Frack Free Ryedale and Frack Free North Yorkshire have submitted a joint objection to the proposed development. The response comprises a main response covering a wide range of aspects but, in terms of its hydrogeological review, Amec Foster Wheeler had particular interest in the H Fraser Consulting Review Report. A number of the reports concerns are relevant to, and reflected in, the Amec Foster Wheeler review, including the following:

- ▶ The EMS Well Site is within a SPZ, and indeed within 250 m of a SPZ1 (Section 2.1);

- ▶ The produced water quality exceeds Environmental Quality Standards (EQSs) and Drinking Water Standards (DWSs) (Table 2.1) and so is a potentially polluting water (Section 2.2). There is no current baseline for groundwater quality in the shallow aquifers;
- ▶ There is little in the way of water level information for the various strata, and this is of particular concern with respect to the potential, or otherwise, for upward flow from the Sherwood Sandstone (Section 2.2.1);
- ▶ The proposed use of oil interceptors and a soakaway at the EMS Well Site (Section 2.2.4), and the reliance on the integrity of the existing bentonite mat (Section 2.2.5), are a cause for concern with respect to pollution potential;
- ▶ Clarity is sought regarding proposed injection rates at both the Ebberston 'A' and EMS Well Site (Section 2.3.1); and
- ▶ The proximity of the EMS Well Site to the Vale of Pickering fault zone may mean that seismicity could be induced under low injection pressures (Section 2.3.2).

Amec Foster Wheeler has taken account of all the consultee responses in its main review.

13. Conclusions

Amec Foster Wheeler has completed its review on behalf of the Authority of the potential for pollution of groundwater and land stability issues in respect of the current planning application ref NYM/2014/0587/EIA.

The review has focussed on ES Chapters 11 (Flood Risk, Hydrology and Drainage, in other words the EMS Well Site surface works and the pipeline) and 12 (Produced Water Disposal). However, it has also taken account of additional documentation submitted in response to two subsequent data requests by Amec Foster Wheeler, as well as consultee comments. Indeed, some of this further information has proved critical to the review, in particular the revised EIA table and map from R Elliott Associates Limited, the Envireau Water Technical Report (August 2014), and the Rockflow Resources Seismic Event Risk Assessment (July 2014). Consultee comments regarding the proposed development have also been taken account of in the review, most notably those by the Environment Agency, Yorkshire Water and Frack Free Ryedale and North Yorkshire.

The key findings of the review are as follows:

- ▶ The proposed development is adequately described in the ES, except with respect to the possible new borehole. The Applicants intentions with respect to the possible new borehole need to be more clearly and publicly stated, and need to be aligned with the planning application and EIA.
- ▶ Although the assessment areas should have been more clearly identified and justified in the ES, appropriate assessment areas have been employed within the Applicants EIA, assuming that the planning application is for a scheme requiring a 556 m³/d produced water re-injection rate.
- ▶ Although the ES assessment methodology is flawed in a number of respects, the problems are not sufficient to prevent the derivation of reasonable and defensible conclusions regarding residual effects.
- ▶ Issues with the original ES baseline should not have arisen, and the absence of adequate information regarding potential receptors have hindered the auditing of the EIA. However, the subsequent documents have helped address some of the deficiencies of the ES, such that the baseline is now sufficient for the purposes of the EIA, and the hydrogeological conceptualisation and the water quality (KAF and Sherwood Sandstone) characterisation are considered plausible, although not definitive.
- ▶ The quality of the ES is also unsatisfactory with respect to the identification of receptors and sensitivities, but following the submission of further information the lists of receptors and sensitivities look reasonable. In particular, based on the accepted hydrogeological conceptual model, the Sherwood Sandstone in the area is considered not a viable groundwater resource

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and therefore is correctly 'scoped out' of the EIA. The distant Sherwood Sandstone outcrop should also have been 'scoped out', given its distance from the proposed development.

- ▶ The hydrogeological and hydrological assessments within the original ES are not of a particularly good quality. Being activity-led meant it has been difficult to audit and relate to receptors, and this was compounded by the lack of a receptor location plan. However, these problems have been lessened by the subsequent provision of further information. Although the methodology and some of the scoring can be questioned, adopting the EIA criteria used by the Applicants means that the potential effects on most receptors, including human health and infrastructure (induced seismicity), would potentially be 'Significant' in EIA terms prior to the incorporation of appropriate mitigation.
- ▶ The embedded and additional mitigation proposed by the Applicants is appropriate, provided it is implemented rigorously and that certain pre-commencement conditions are applied with respect to confirmation of the integrity of the bentomat, reconsideration of the proposed use of an oil interceptor and soakaway system, and the agreement of a suitable monitoring scheme design and emergency remedial action plan.
- ▶ On the basis of the mitigation proposed, an assessment of 'Negligible', i.e. 'Not Significant' effects with respect to the water environment is a reasonable one, although clarification from the Applicants regarding the implications of the Rockflow Resources work with respect to re-injection rates of any proposed new borehole at the EMS Well Site and in regard to the Helmsley-Filey Fault is required to help support their assessment of a 'Not Significant' effect with respect to induced seismicity. The Applicants are reminded that it is the effective delivery of the mitigation as described that prevents the potential 'Significant' effects from possibly being realised, including contamination of watercourses and aquifers that support public water supply and industrial abstractions, and induced seismicity.
- ▶ The cumulative impact assessment requires more consideration by the Applicants, both with respect to the EMS Well Site surface works and the pipeline, and the produced water disposal.

Subject to clarifications regarding the residual induced seismicity assessment and the findings of a revised cumulative impact assessment, Amec Foster Wheeler considers that the Applicants have identified and assessed all the known likely groundwater pollution and land stability environmental effects, have applied appropriate mitigation, and have demonstrated that the effects of a revised (556 m³/d produced water re-injection) scheme have been reduced to an acceptable level.

Author

Reviewer

Dr Shaun Salmon

Trevor Parkin

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