Royal HaskoningDHV
Enhancing Society Together

VATTENFALL

Norfolk Boreas Offshore Wind Farm

Clarification Note Trenchless Crossings and Potential Effects of Breakout on the River Wensum

Applicant: Norfolk Boreas Limited
Document Reference: ExA.AS-3.D1.V1
Deadline 1

Date: November 2019
Revision: Version 1
Author: Royal HaskoningDHV

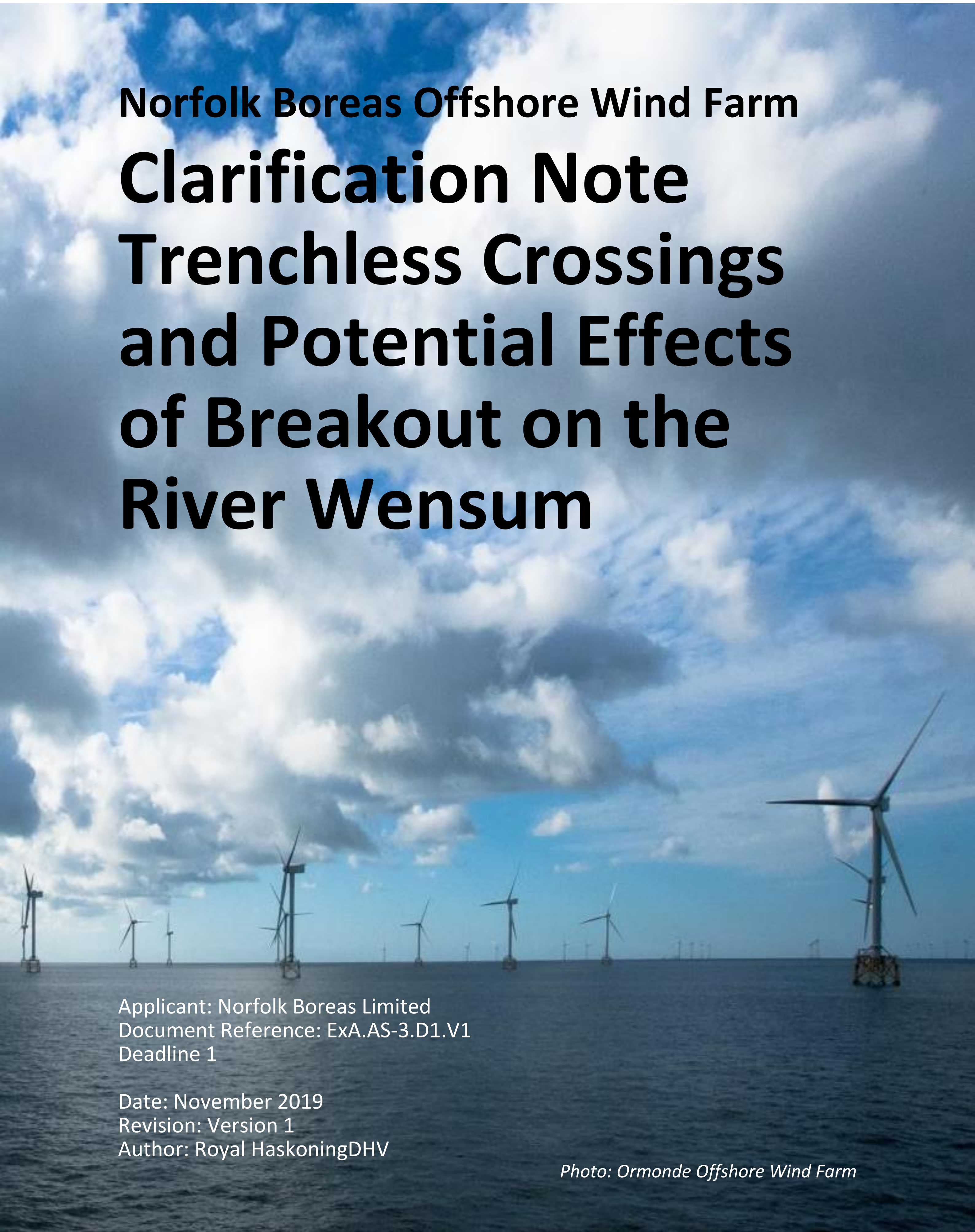


Photo: Ormonde Offshore Wind Farm

Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
22/11/19	01D	First draft for Examination Deadline 1.	CD/AH/ID/GC	JL/VR	JL

Table of Contents

1 Introduction

1. Within their Relevant Representation (REP-009) to the Norfolk Boreas Offshore Wind Farm Development Consent Order (DCO) application, Natural England stated:

"Given the recent HDD drilling mud breakouts experienced on a number of other OWFs, Natural England advises that a commitment to use best available techniques and a precautionary methodology be included and that the worst case scenario impacts of potential bentonite breakout are assessed.
There is currently insufficient information provided in the documents provided on HDD tolerance monitoring, how quickly bentonite release can be stopped, or an assessment of a worst case scenario bentonite breakout considering extent, timings and environmental impacts."

2. The Environment Agency also raised within their Relevant Representation (REP-005):

"We are pleased the Outline Code of Construction Practice (OCoCP) commits to developing a Bentonite Breakout Plan. However, there is insufficient detail to assess either the risk of, likelihood or the extent of any breakout. We stress that there should be an emphasis on prevention of breakouts."

3. This clarification note provides further information on the proposed trenchless crossing technique and the potential for drilling fluid breakout. It also examines the potential effects of such breakout on the River Wensum Special Area of Conservation (SAC) and Site of Special Scientific interest (SSSI).

2 Trenchless Crossing Technique

4. Trenchless crossing techniques have been embedded within the scheme design, informed by stakeholder consultation, to avoid direct impacts on the larger and most sensitive features, including the main channel of the River Wensum. This is in comparison to trenched crossing techniques which would require direct intrusive works to the watercourse.

5. The trenchless crossings are secured in Requirement 16(13) of the dDCO and trenchless installation techniques are defined in the dDCO as *"techniques for installing an underground duct between two points, without excavating and back-filling a trench".*

6. At trenchless crossing locations identified within the dDCO, trenchless installation techniques will be employed. Section 5.7.2.4 of Environmental Statement (ES) Chapter 5 (document 6.1.5, APP-218) outlines the different trenchless installation techniques that can be considered including horizontal directional drilling (HDD), microtunnelling or auger boring. The design envelope, including temporary land requirements, is sufficient to accommodate any of these methods. The method to be employed will be determined during detailed design following the selection of the

onshore cable and based on the most appropriate method for the feature being crossed.

7. As an example, the benefit of HDD is that it is a surface to surface drilling method, however microtunnelling and auger boring require the excavation of vertical shafts to a depth of approximately 1m below the depth of the crossing. Therefore for the crossing of the River Wensum, it is likely that HDD will be the most appropriate method in order to mitigate shaft construction in the flood plain.

3 Potential for Drilling Fluid Breakout

8. Trenchless crossing techniques such as HDD have been embedded within the scheme design to avoid direct impacts associated with trenched crossing methods at the larger and more sensitive watercourse crossings. However, during the drilling process there is the potential for the release / breakout of inert drilling fluids which may impact the watercourse. The sections below provide information on:

- Mitigating risk of breakout by design and method;
- Drilling fluid purpose and properties;
- Loss of drilling fluid and controls; and
- Breakout contingency plans.

9. The following information is based on a ‘typical HDD’ using the most commonly employed method and controls. Specific details on the HDD method and controls will be provided following detailed design and appointment of a contractor.

10. It should be noted that other trenchless techniques such as auger boring and microtunnelling also require the use of drilling fluids to maintain drill head pressures, lubricate the drill head and remove excavated materials. There is therefore a risk for drilling fluid breakout with these methods also, although the volumes of fluid are generally less than those required for HDD. Therefore, in keeping with the worst case approach to assessment the focus of this note is on the HDD method.

3.1 Mitigating Risk by Design and Method

11. A robust HDD design for the ground conditions is the most effective tool to reduce the risk of drilling fluid breakout. Using ground investigation data and design requirements of the drill (cross-section, length, number, etc.) hydro-fracturing calculations will be conducted to derive a suitable alignment and profile of the drill to minimise breakout risk by design where possible. Norfolk Boreas has committed to a minimum cover of 2m below the bed level of watercourses at trenchless crossings, including the River Wensum and a deeper installation may be suggested during detailed design to minimise risk.

12. The use of industry best practice methods during construction will help to minimise breakout likelihood. This will include ensuring effective removal of the cuttings from the borehole which is a key component of avoiding breakout. If cuttings are not removed they form cutting beds on the base of the borehole, decreasing the cross-sectional area of the borehole. This causes an increase in annular pressure and therefore increases the risk of breakout. A competent HDD contractor employing best practice measures, such as measuring sand content on both sides of the drilling fluid stream, will be proactive in ensuring that cuttings are effectively removed and look to reduce the risk of breakout.

13. It is in the interests of all parties to mitigate the risk of breakout through good design and the employment of a competent contractor. For instance, should a breakout occur, this will slow the progress of the trenchless crossing installation whilst mitigation and rectification measures are put in place.

3.2 Drilling Fluid Purpose and Properties

14. The drilling fluid serves a number of purposes including:

- Suspends the soil and rock cuttings and carry them to the entry pit for removal;
- Provides support to the drilled hole to prevent collapse of the created underground excavation;
- Hydraulically excavates soil in soft ground;
- Powers the downhole motor in hard ground;
- Cools the drilling equipment;
- Clears debris from the drilling bit and face;
- Seals the perimeter of the borehole in porous ground and;
- Lubricates the borehole to reduce friction on the drilling equipment.

15. The drilling fluid predominantly used in HDD is a mix of water and a naturally occurring swelling clay, bentonite. The bentonite (supplied in powder form) is mixed with water and the bentonite drilling fluid is circulated through the drilling system. The drilling fluid is typically >95% water and <5% bentonite powder which is suspended into the water to make a clay gel.

16. Bentonite has a neutral pH level (8-9) and grain size less than 60 microns.

3.3 Loss of Drilling Fluid and Controls

17. Despite measures taken to mitigate the risk of surface breakout by design, vigilance is required during construction, particularly within the first 30m from entry and the last 30m from exit. The HDD contractor will have a person walking the drill alignment checking for breakout throughout the operation. If detected the drilling is stopped immediately and the spill contained by creating a small excavation or sump along with proper erosion control devices and removed as necessary.

18. The operator of the fluid system will keep records of drilling fluid parameters at regular intervals and monitor drilling fluid volumes so that any losses to the formation are identified. The driller will monitor and record downhole fluid pressures and returns to the entry pit to also ensure losses are recognised quickly. Breakouts that do occur are usually constrained to an area 3m x 3m and fluid depth of 0.2m giving an approximate fluid volume of 1.8 m^3.

19. Sandbags and/or other erosion control devices can be an effective method of containing any fluid by creating a bunded area. An electric submersible pump can then be placed at the lowest point in the sandbag bunded area to pump away the fluid to a suitable location such as mobile settling tank, tanker truck, or if close enough, to the entry or exit pits. In accordance with good practice a stock of ready filled sandbags will be available on site to contain a breakout if it occurs, along with a small pump.

20. However, the appropriate site specific measures to contain the breakout will be detailed in the drilling fluid contingency plan once the specific design of the HDD is known and a contractor engaged, which will be included in the final Code of Construction Practice (CoCP), developed in consultation with Natural England and the Environment Agency.

21. There is also the potential of loss of fluids to surrounding ground, however this does not normally occur in HDD because the drilling fluid is a thixotropic fluid of high viscosity (an analogy is that it has a viscosity similar to mayonnaise) and seals the wall of the drill. The design of the drill profile will look to minimise the risk of loss to the ground through consideration of the ground conditions.

22. If fluid is lost to the ground the operator of the fluid system will quickly identify the losses because of the falling fluid levels within their mud tanks and changes in down hole pressure. Generally, the operator will identify any losses greater than $2m^3$ in volume. Pumping will then be stopped for a measured period of time (typically a few hours) to allow the drilling fluid to heal the fracture point (due to its thixotropic properties). Additional action can be taken to further seal the area of loss if required; usually with stoploss environmentally friendly additives such as coconut husk.

3.4 Breakout Contingency Planning

23. As detailed in the OCoCP (APP-698), a drilling fluid breakout contingency plan will be developed which will define the approach for responding to breakouts. The exact specification for the contingency plan will be informed by the specific design of the trenchless crossing and the contractors equipment, method and requirements. However, the steps of the contingency plan will include:

- Minimum measures to monitor and identify breakouts;
- Establishment of lines of communication and necessary reporting protocol;
- Measures to ensure drilling stops once a breakout is identified;
- Minimum level of emergency equipment that must be on-site at all times which allows response to all areas of the site;
- Measures to contain the breakout, for example sand bags, to minimise the extent of any drilling fluid dispersal;
- Measures to remove the released drilling fluid material once contained – for example pumped back to the entry/exit pit within the trenchless crossing compound, or pumped to mobile settling tanks that may be used for managing sediment traps;
- Owner and Owners representation involvement; and
- Required event documentation and reporting.

4 Baseline Information River Wensum SAC / SSSI

4.1 Baseline Information on Qualifying Habitats

4.1.1 River Wensum SAC

24. The River Wensum SAC supports the following qualifying features:

- Annex I habitats:
  - Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation;
- Annex II species:
  - White-clawed (or Atlantic stream) crayfish *Austropotamobius pallipes*;
  - Desmoulin’s whorl snail *Vertigo moulinsiana*;
  - Brook lamprey *Lampetra planeri*; and
  - Bullhead *Cottus gobio*.

25. A summary of the extent of these features within the vicinity of the onshore project area is provided below. Further details can be found in Information to Support Habitats Regulations Assessment (document 5.3, APP-201) and summarised in ES Chapter 22 Onshore Ecology (document 6.1.22, APP-235).

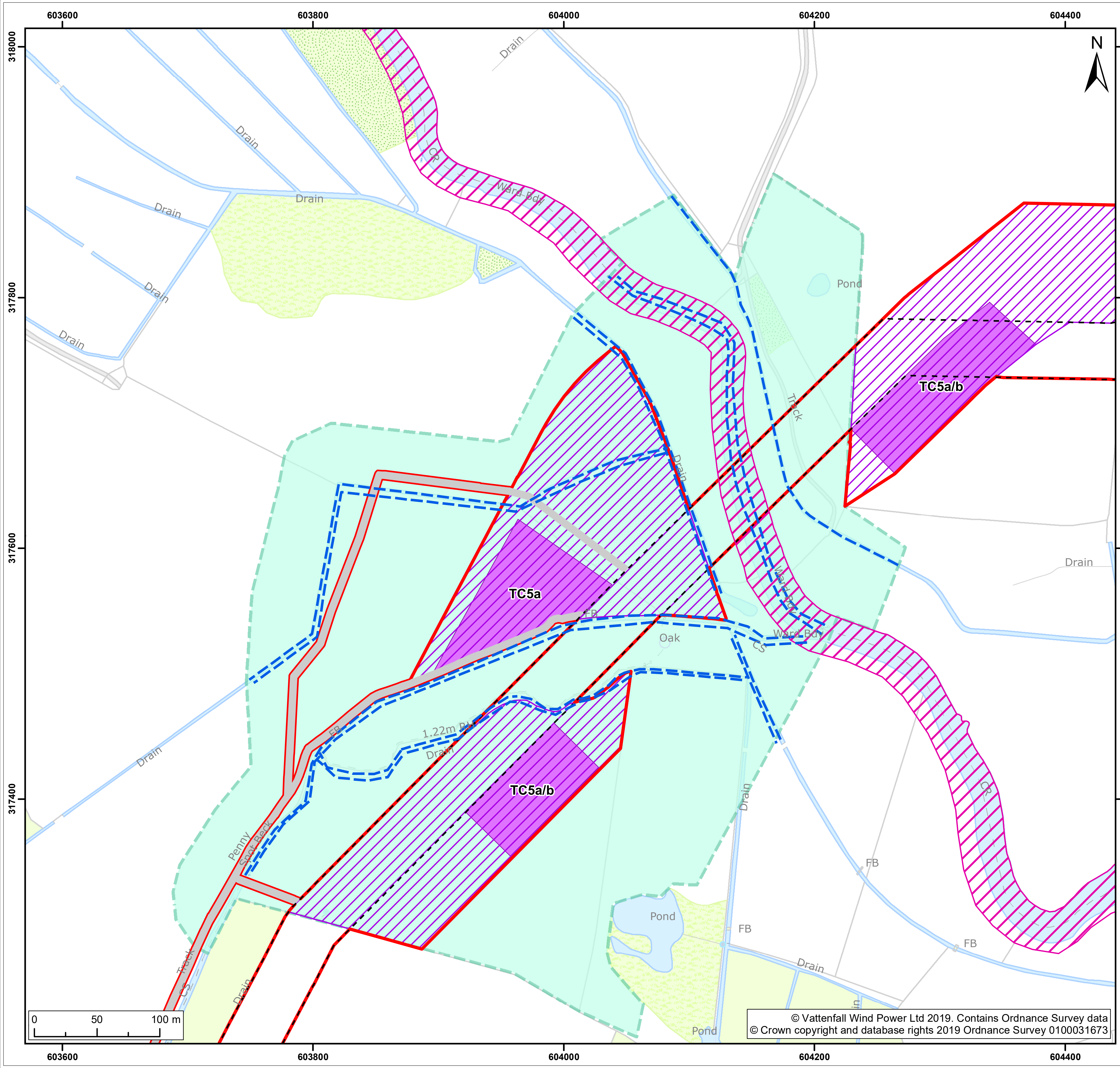
26. A botanical survey of the River Wensum and all hydrologically connected ditches and drains was undertaken in July 2017 and August – September 2018 (ES Appendix 22.7 Botanical Survey Reports (document 6.3.22.7, APP-605)). This survey included the River Wensum channel up to 110m downstream and 200m upstream of the onshore project area, and surrounding ditches located within the onshore project area. The extent of this survey is shown on Figure 1. The botanical survey recorded no

evidence of key species of *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation (pond water-crowfoot *Ranunculus peltatus*; stream water-crowfoot *Ranunculus penicillatus ssp. pseudofluitans*; river water-crowfoot *Ranunculus fluitans*) within the River Wensum and its surrounding ditches. The NVC communities recorded within the River Wensum were A8a-*Nuphar lutea* community, species-poor sub community and S5-*Glycerietum maximae* swamp, *Alisma plantago-aquatica-Sparganium erectum* sub community.

27. A Desmoulin's whorl snail survey of the margins of the River Wensum and all hydrologically connected ditches and drains was undertaken in August 2017 and August 2018 (ES Appendix 22.6 Desmoulin's Whorl Snail Survey Reports (document 6.3.22.6, APP-604)). This survey included the River Wensum channel up to 100m downstream and 150m upstream of the onshore project area, and surrounding ditches located within the onshore project area. The extent of this survey is shown on Figure 1. The botanical survey recorded no evidence of Desmoulin's whorl snail anywhere within the River Wensum or its associated ditches.

28. Advice received from the Environment Agency as part of the Norfolk Vanguard Evidence Plan Process indicated that white-clawed crayfish are not known to be present in any reaches located within the study area (Environment Agency, pers. comm. 24th March 2017).

29. The National Fish Population Database (Environment Agency, 2016) indicates that bullhead and brook lamprey are not present within the reach of the River Wensum within the onshore project area. Records of both species do exist along the River Wensum both upstream and downstream of the onshore project area.



Legend:

- Norfolk Boreas Order Limits

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable route
- Construction access

Norfolk Boreas Onshore Project Infrastructure (Scenario 2)

- Trenchless crossing zone (e.g. HDD)
- Indicative trenchless crossing compound

Environmental Designations[1]

- River Wensum Special Area of Conservation (SAC) / Site of Special Scientific Interest (SSSI)

Survey Area

- Botanical survey area
- Desmoulin's whorl snail survey extent

[1] Natural England, 2019.

Project:	Report:
Norfolk Boreas	Clarification Note Trenchless Crossings and Potential Effects of Breakout on the River Wensum

Title:

River Wensum SAC/SSSI qualifying features and survey extents

Figure: 1 Drawing No: PB5640-008-007-001

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
03	22/11/2019	JT	GC	A3	1:3,000
02	20/11/2019	LB	GC	A3	1:3,000

Co-ordinate system: British National Grid **EPSG:** 27700

VATTENFALL

Royal HaskoningDHV
Enhancing Society Together

4.1.2 River Wensum SSSI

30. The River Wensum was designated as a SSSI because it provides an exceptional example of an enriched, calcareous lowland river, supporting a diverse assemblage of plants and invertebrates. In addition to the features described for the SAC above, the following features are also featured on the River Wensum SSSI citation:

- over 100 species of plants; and
- a rich invertebrate fauna.

31. In particular, the flora, dominated by lesser water-parsnip *Berula erecta* and the brook water-crowfoot, also support a range of other aquatic and semi-aquatic species. The invertebrate fauna in particular includes diverse mollusc, water beetle and mayfly fauna.

4.2 Baseline Water and Physical Habitat Quality

4.2.1 Water Quality

32. According to Natural England's most recent condition assessment (Natural England, 2010[1]), the River Wensum SSSI is currently in unfavourable condition due to hydrological pressures, high phosphate concentrations, high turbidity and siltation-related issues.

33. However, more recent information presented on the Environment Agency's Catchment Data Explorer (Environment Agency, 2019[2]) demonstrates that chemical water quality in the River Wensum water body that would be crossed by the proposed development (Wensum upstream of Norwich, GB105034055881) is sufficiently good to meet the requirements of Good Chemical Status under the Water Framework Directive (WFD), with low concentrations of substances that could present a significant risk to the aquatic environment, such as metals and pesticides (e.g. priority substances and priority hazardous substances, as defined under Annex II of Directive 2008/105/EC).

34. Furthermore, the Catchment Data Explorer (Environment Agency, 2019[2]) also demonstrates that physico-chemistry of the water body is also good, with concentrations of pollutants such as ammonia, phosphate, arsenic, copper, iron and zinc sufficiently low to meet the requirements of Good or High Ecological Potential. Dissolved oxygen, biological oxygen demand, temperature and pH are also at High Potential.

[1] https://designatedsites.naturalengland.org.uk/SiteDetail.aspx?SiteCode=S1006328
[2] https://environment.data.gov.uk/catchment-planning/WaterBody/GB105034055881

35. This means that water quality in the River Wensum is not considered by the Environment Agency to be a barrier to achieving Good Ecological Potential under the WFD. However, the River Wensum water body is currently at Moderate Ecological Potential due to modifications to the hydrological regime resulting from surface and groundwater abstraction, a lack of mitigation measures to address physical modifications for flood protection, and pressures on macrophytes and phytobenthos (Environment Agency, 2019). The latter are attributed by the Environment Agency to phosphates from sewage discharges and agricultural runoff (noting that the apparent discrepancy between the biological data and the physico-chemical data described in the previous paragraph may reflect a lag in biological response to a reduction in phosphate concentrations, or a particular sensitivity amongst the biological communities that is not reflected in the WFD standards for phosphate).

4.2.2 Geomorphology and Physical Habitat Conditions

36. A geomorphological walkover survey undertaken in 2017 to inform the Environmental Impact Assessment (ES Appendix 20.3, document 6.3.20.3, APP-588) found that the River Wensum is a gently meandering chalk river, with a wide, deep channel and very shallow banks. Flows are dominated by uniform, low energy glides, and the water had a much higher turbidity than would normally be expected in a chalk river. Furthermore, the coarse-grained (gravel) bed that is characteristic of chalk rivers was not visible in this reach at the time of the survey. Instead, the substrate was dominated by silts, with extensive accumulations in the channel margins extending across the channel bed.

37. Overall, this means that the geomorphology and hydrological characteristics of the reach do not represent a good quality chalk river. As a result, the river does not currently support suitable physical habitat conditions for the in-channel communities that are described in section 4.1.

5 Assessment of potential impacts of breakout on River Wensum SAC /SSSI

5.1 Potential impacts on physical habitat conditions

38. Because the drilling fluid would be comprised of >95% water and <5% inert bentonite clay with a broadly neutral pH (cf. section 3.2), the release of this material into the river is unlikely to result in a degradation in the chemical quality of the receiving waters. However, a breakout of drilling fluids, either on the floodplain or within the river channel itself, could potentially result in changes to the geomorphology of the river that could be sufficient to temporarily impact upon the quality of the physical habitats supported by the river.

39. Due to the grain size characteristics of the bentonite (<60µm), the majority of the material released into the River Wensum through a breakout of drilling fluid would

be transported in suspension. This increase in the suspended sediment load could potentially result in an increase in the turbidity of the water column; and increases would be most pronounced in the immediate vicinity of the breakout and would decrease as the plume spreads out and is diluted further downstream.

40. Depending upon flow conditions, clays could remain in suspension for a considerable distance downstream. However, it is likely that a proportion of the material would be deposited on the bed of the channel downstream of the breakout location, particularly in parts of the channel with lower flow velocities and a predominantly depositional environment (e.g. in the channel margins and in areas with vigorous in-channel vegetation growth). This could smother the coarse gravel substrates (i.e. infill interstitial pore spaces) that are characteristic of chalk rivers such as the River Wensum.

41. However, as explained in section 3.3, the volume of drilling fluid release would typically be confined to a maximum of $1.8m^3$, of which less than 5% would consist of sediment (i.e. a maximum of $0.09m^3$ bentonite would be expected to be released in the event of a breakout). Although the suspended sediment load of the River Wensum is reported to be relatively low when compared to other chalk rivers (e.g. Acornley and Sear, 1999; Collins et al., 2013), this volume of material is not considered to be sufficient to result in any significant geomorphological changes. The bulk of the material would be expected to be transported downstream in suspension, and deposition would therefore only occur in small volumes in any given location. Because the volume of material supplied by a breakout would be a one-off event rather than a new regular supply, natural sediment transport processes during periods of higher flow are expected to remobilise any fresh deposits and transport them further downstream. Any changes to suspended sediment load would therefore be temporary, and reversible following a period of higher flow.

42. This means that a bentonite breakout is unlikely to result in any permanent or significant changes in geomorphological conditions in the River Wensum, and as such would not result in any deterioration in the hydromorphological and physico-chemical quality elements of the water body described in section 4.2. However, an increase in turbidity could reduce the amount of light penetrating the water column and adversely affect physical habitat conditions for the biological communities supported in the river. Furthermore, an increase in the proportion of fine sediments on the channel bed could reduce the quality of the substrate as a habitat for plants and other aquatic organisms. Further information on the potential biological effects of a breakout are therefore discussed in section 5.2.

5.2 Qualifying features of the SAC and SSSI

5.2.1 Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation

43. Increased suspended sediment load can give rise to negative effects upon *Ranunculus spp*. An increase in suspended sediment load can reduce the quality and quantity of available light (i.e. by increasing turbidity), and, because suspended sediments are likely to contain high levels of nitrogen and phosphorus, create ideal conditions for the growth of benthic algae (Mainstone et al., 2000). Furthermore, the seeds of *Ranunculus spp*. do not survive in the anoxic conditions that develop within organic sediments, and can be lost when the silt is flushed out during high energy flows (Mainstone, 1999). *Ranunculus spp*. are therefore particularly susceptible to long term and catchment scale effects of sediment increases (Hatton-Ellis, 2003). Localised sediment increases are more likely to result in a short term (i.e. seasonal) effects on plant species, until sediment is distributed downstream through the river's natural sediment transport processes.

44. As detailed in section 3, it is estimated that in the event of a breakout, the likely volume of drilling fluid released into the channel would be limited, for example $2m^3$. This represents a small, and localised release of non-toxic material. With the successful implementation of the measures set out in the OCoCP (document 8.1, APP-698), much of this volume of material is likely to be contained and pumped out of the system. As shown in Figure 1, the qualifying *Ranunculus spp*. of the River Wensum SAC are not located within at least 110m of the closest possible breakout location. If sediment is not contained before it reaches 100m downstream, it will already have distributed across the channel, reducing the volume of material deposited more than 110m downstream. In summary, the risk of a drilling fluid breakout is low, and should one occur the monitoring measures and contingency plan outlined within the OCoCP (APP-698) would reduce the volume of material released downstream to a negligible level. As such, no likely significant effects upon Water courses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation are anticipated.

5.2.2 Desmoulin's whorl snail

45. As a semi-aquatic species, increased sediment load is not a key threat to the survival of the Desmoulin's whorl snail. This species spends the majority of its lifecycle above the water level on the stems of living or dead plants on the river margin (Cameron et al., 2003). The key threats to the species are long-terms changes in water levels, or modifications to bankside habitats (Cameron et al., 2003). The species may suffer from indirect effects upon bankside habitat composition from released sediment, should it give rise to changes in bankside composition.

46. As detailed in section 2, it is estimated that in the event of a breakout, the likely volume of drilling fluid released into the channel would be limited, for example $2m^3$. This represents a small, and localised release of non-toxic material. With the successful implementation of the measures set out in the OCoCP (APP-698), much of this volume of material is likely to be contained and pumped out of the system. As shown in Figure 1, Desmoulin's whorl snail are not located within at least 100m from the closest possible breakout location. If sediment is not contained before it reaches 100m downstream, it will already have distributed across the channel, reducing the volume of material deposited more than 100m downstream. As noted in the section above, at this point it is unlikely to have any notable effect upon marginal plant communities which have the potential to support Desmoulin's whorl snail. In summary, the risk of a drilling fluid breakout is low, and should one occur the monitoring and contingency plan as outlined OCoCP (APP-698) would reduce the volume of material released downstream to a negligible level. As such, no likely significant effects upon Desmoulin's whorl snail are anticipated.

5.2.3 White-clawed (or Atlantic stream) crayfish, brook lamprey and bullhead

47. White-clawed crayfish, brook lamprey and bullhead have not been recorded within the reaches of the River Wensum where a drilling fluid breakout may occur. As such, no likely significant effects upon White-clawed (or Atlantic stream) crayfish are anticipated.

5.2.4 River Wensum SSSI features

48. The flora and invertebrate features listed on the River Wensum SSSI citation are considered to be subject to a similar impact pathway to that described under sections 5.2.1 and 5.2.2. As such, effects upon these features of the River Wensum SSSI are not anticipated.

6 Conclusions

49. The following controls will be in place to minimise the risk of drilling fluid breakout, limit fluid loss to small volumes if a breakout does occur and ensure appropriate mitigation measures are employed. These measures will be included in an updated OCoCP, submitted at Deadline 1, which is secured under dDCO Requirement 20.

6.1 Pre-construction

- Develop a trenchless crossing design and profile using ground condition information, hydro-fracturing modelling and associated calculations. This will include consideration for the trenchless crossing design to have sufficient depth below the surface to ensure adequate ground pressures to minimise risk of breakout occurring.

- Development of breakout contingency plan based on the site specific trenchless crossing design.
- Select experienced and competent contractors for all works and draw on experience from other similar wind farm projects.

6.2 Construction

- Derive, maintain and monitor drilling fluid viscosity and properties for the required ground conditions though appropriate contractor mud management techniques to minimise the risk of breakout.
- Monitor drilling fluid returns, pressures and volumes to quickly identify and limit any losses should a breakout occur.
- Have appropriate containment measures and equipment available onsite such as sandbags; excavators, pumps, etc.
- Have lost circulation environmentally friendly additive materials to be on site to seal any breakout.

6.3 River Wensum habitats and species

50. In the worst case scenario of a breakout occurring, drilling fluid would be released into the river channel. However, the volume of fine sediment released would be small, and although it could result in a temporary and localised increase in turbidity, it would not result in any permanent changes to the physical habitat characteristics (i.e. geomorphology) or water quality of the River Wensum. Any changes would be insufficient to affect the status of the water body under the WFD.

51. Given the absence of qualifying habitats and species of the River Wensum SAC from an area up to 100m downstream of the onshore project area, and the small volume of material which is likely to escape downstream should a breakout occur, no likely significant effects upon habitats of the River Wensum SAC are anticipated.

7 References

Acornley, R.M., Sear, D.A., 1999. Sediment-transport and siltation of brown trout (Salmo trutta L.) spawning gravels in chalk streams. Hydrological Processes 13, 447-458
Cameron, R.A.D., Colville, B., Falkner, G., Holyoak, G.A., Hornung, E., Killeen, I.J., Moorkens, E.A., Pokryszko, B.M., von Proschwitz, T., Tattersfield, P. and Valovirta, I. (2003) Species Accounts for snails of the genus Vertigo listed in Annex II of the Habitats Directive: *V. angustior, V. genesii, V. geyeri* and *V. moulinsiana*. Heldia, Vol. 5, Sonderheft 7, pp. 151-170, München.
Collins, A. L., Zhang, Y. S., Hickinbotham, R., Bailey, G., Darlington, S., Grenfell, S. E., Evans, R., and Blackwell, M., (2013). Contemporary fine-grained bed sediment sources across the River Wensum Demonstration Test Catchment, UK. Hydrological Processes, 27, 857–884.
Environment Agency (2016) The National Fish Population Database (NFPD): Freshwater Fish Counts for all Species for all Areas and all years.
Hatton-Ellis T.W., Grieve N. and Newman J. (2003) Ecology of Watercourses Characterised by *Ranunculion fluitantis* and *Callitricho-Batrachion* Vegetation. Conserving Natura 2000 Rivers. Ecology Series No. 11. English Nature, Peterborough.
Mainstone C.P. (1999) Chalk rivers – nature conservation and management. Water Research Centre. English Nature, Peterborough.
Mainstone C.P., Parr, W. and Day M. (2000). Phosphorus and River Ecology – tackling sewage inputs. English Nature/Environment Agency, Peterborough.