Appendix 6.1

Further Eco-hydrological Assessment

LINHAY HILL QUARRY

ENVIRONMENTAL STATEMENT - REGULATION 22 FURTHER INFORMATION

FURTHER ECO-HYDROLOGICAL ASSESSMENT

On behalf of E & JW Glendinning Ltd.

February 2019

1.0 INTRODUCTION

1.1 OVERVIEW AND PURPOSE

1.1.1 The objective of this summary document is to address item 18 in table 2.1 raised in a Request for Further Information under Regulation 22 of the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 2011 (The EIA Regulations) issued by the Dartmoor National Park Authority on 22 December 2016 (referred to as the Regulation 22 Request 2016):

> *'Provide additional ecological and hydrological assessment on subterranean water bodies and associated ecology'*

1.1.2 This document draws on information provided in the *Linhay Hill Quarry: Hydrogeological Impact Assessment (HIA) 2018* (Atkins, 2018) and an updated water resources chapter as part of the Linhay Hill Quarry Environmental Statement.

1.1.3 For completeness, this present document also confirms the ecological impact assessments that had been made on the basis of the previous Hydrogeological Impact Assessment (*Linhay Hill Quarry: HIA [*Atkins 2016]).

2.0 SCOPE OF THE ASSESSMENT

2.1.1 This supplementary assessment is limited to considering the effect of hydrogeological changes identified in the 2018 HIA on those important ecological features identified in Table 1 below.

Table 1: Important Ecological Features considered.

Type of Feature	Important Ecological Feature
Internationally Designated Sites	Rivers Ashburn and Dart as tributaries to the Dartmoor Special Area for Conservation (SAC)
	South Hams SAC
Local Sites	Mead Cross Unconfirmed Wildlife Site (UWS)
	Little Barton Fields UWS
Habitats (Running Water)	Kestor Brook, Lemonford Stream and River Lemon
	Balland Stream
Species	Subterranean fauna, including the British Cave Shrimp *Niphargus glenniei*

2.1.2 The characterisation of impacts and ecological significance follows the methods set out in *Linhay Hill Quarry Environmental Statement Chapter 10: Ecology* (Atkins 2016).

3.0 EXISTING HYDROGEOLOGICAL CONDITIONS

3.1 INTRODUCTION

3.1.1 This section provides an outline summary of the findings of surface and ground water studies undertaken in relation to the proposed quarry extension. Please refer to the updated HIA (2018) and updated water resources chapter provided as part of this Regulation 22 Response.

3.2 GROUND WATER

3.2.1 Linhay Hill Quarry is located within the Chercombe Bridge Limestone Formation (CBLF). The CBLF is a karst limestone, classified as a Principle Aquifer. The surrounding strata are the Tavy Formation and St Mellion Formation to the north (higher in the geological series) and the Gurrington Slate and Foxley Tuff Formations to the south (lower in the geological series), all of which are classified as 'Secondary A' aquifers.

3.2.2 Ground water flow in karst limestone is controlled by a network of fractures and conduits. Based on observation, the fracture network in the CBLF appears to have a low overall permeability: the existing quarry face does not display a network of open fractures and during low rainfall, a seepage face across the face of the pit walls have not been observed. In addition, during drilling operations at the existing quarry, drill cuttings were dry for up to 50m below the piezometric[1] surface, indicating the lack of a network of permeable fissures.

3.2.3 Four main groundwater inflows to the existing quarry are present:

- A calcite fracture feature on the north east face of the quarry which is believed to extend to the north east. This feature was exposed during quarrying, and may have originally been infilled with sediment. Flow from this feature appears to be largely determined by rainfall with only low conduit storage;
- two smaller inflows are located on the south eastern face, which only occasionally have detectable flows;
- some minor seepage has been detected in the lower quarry levels; and
- a conduit was encountered at Level 7 which drains to the sump.

3.2.4 Several sediment infilled conduits have been exposed by the quarrying in other parts of the pit, which are predominantly located on the southeast face of the quarry. The frequency of the infilled conduits decreases with depth.

[1] The piezometric surface is the imaginary level to which water in a confined aquifer would rise under hydrostatic pressure within a well or bore hole.

3.2.5 Thrust faults located between the Tavy Formation and CBLF, and the Foxley Tuff and CBLF may be an area of recharge to the limestone. Groundwater may be flowing across the faults from the Tavy and Crackington Formations and the Foxley Tuff to the limestone.

3.2.6 Borehole data has indicated that the deep and shallow parts of the limestone are not well connected hydraulically, and a conceptual model of a two-zone flow system is set out in the HIA. The available data also indicate that groundwater from the deep zone dominates inflows to the quarry, with a substantially smaller component coming from the shallow zone.

3.2.7 Groundwater flow from the Tavy Formation to the CBLF is limited. Borehole signal testing identified no response by boreholes in the Tavy Formation, and the persistent artesian groundwater levels in one of the boreholes in the Tavy Formation also provides further evidence that dewatering from the quarry has not affected groundwater resources in the low permeability formations to the north of the CBLF.

3.3 SURFACE WATER

3.3.1 Linhay Hill quarry lies within the catchment of the River Ashburn, a tributary of the River Dart (part of the Dart WFD Operational Catchment). The Balland Stream (a tributary of the River Ashburn) runs within the application site.

3.3.2 Seasonal springs discharge on land to the north-west above the existing quarry at the interface between the St Mellion and Tavy formations due to the different permeability of these formations.

3.3.3 The Balland Stream catchment is to the north and west of the quarry and is fed by a number of springs (to the north of the quarry), surface run off and pumped discharge from the quarry. Lower sections of the Balland Stream are dry during extended periods of low rainfall.

3.3.4 Any water entering the quarry (surface and ground water) is stored within the Balland Pit which provides attenuation and acts a settlement pond before the water is recycled in the quarry for manufacturing, washing and dust suppression. Excess water is pumped to the Balland Stream.

3.3.5 The proposed extension would expand into the catchment of the Kestor Brook, a tributary of the River Lemon (part of the Teign WFD Operational Catchment).

3.3.6 The main input to the Kestor Brook is the Goodstone Spring which lies on the boundary between the CBLF and the Foxley Tuff. The origin of the spring is considered likely to be upwelling groundwater at the contact between these formations. The Kestor Brook follows the path of alluvial deposits which extend from the western part of the CBLF to where it joins the River Lemon, c. 3km to the east.

3.3.7 Seasonal springs and adits, also on the interface between the St Mellion and Tavy formations within Alston Wood (much of which is within the Little Barton Fields Unconfirmed Wildlife Site [UWS]) flow south overland past Alston Farm and form the Alston stream. The Alston stream flows to a sinkhole to the southwest of Alston Farm (where it provides recharge to the CBLF). At times of high flow, the stream flows past the sinkhole to a small culvert under the A38 which discharges to the Mead Cross UWS. If flows are unusually high (drainage within Mead Cross UWS are typically dry even in winter) it may reach the upper reach of the Kestor Brook.

3.3.8 Further springs are present to the east of the proposed quarry extension area; flow from one of which forms what is locally known as Caton stream and the other flows to the south east. When flows are high, the Caton stream flows through a farm underpass below the A38 and forms a seasonal pond to the south of the A38. When flows are especially high, water can flow overland from here to Kiln Road to the junction with Yale Road and eventually join the Kestor Brook. Further to the north east, a spring at Higher Lemonford flows to the Lemonford stream which discharges to the River Lemon at Bickington.

3.3.9 To the south of the A38, the Mead Farm stream flows north towards the CBLF and into a small swallow hole. The swallow hole has been observed to be susceptible to blockage, at which times the Mead Farm Stream flows to the north east and into the Kestor Brook. When the swallow hole is open, flows within the Kestor Brook are reduced.

4.0 POTENTIAL IMPACTS

4.1.1 The proposed extension to Linhay Hill Quarry and associated infrastructure works will result in modifications to the existing surface water drainage within the application area including through the provision of new surface water drainage systems and an increase in attenuation storage. Dewatering of the quarry will extend the existing area of influence on groundwater. In the absence of mitigation these have potential to result in effects on watercourses and other nearby features such as valued habitats and species.

4.1.2 The Linhay Hill Quarry Environmental Statement Updated Water Resources Chapter (Atkins 2018) identifies a number of potential hydrogeological impacts, which in the absence of mitigation include:

- Changes to flow in surface water courses arising from interception of the shallow groundwater system by quarrying;
- Interception of base-flow and runoff to the Balland Stream; and
- Dewatering of the deep zone of ground from inflows to the quarry as the floor is deepened and deep zone conduits are encountered.

5.0 IMPACT ASSESSMENT

5.1 INTERNATIONAL SITES

DARTMOOR SAC

Potential Impacts

5.1.1 The Proposed Development includes minor works to Balland Stream, and construction activities in the stream catchment and in close proximity to the watercourse. Balland Stream is a tributary of the River Ashburn, which in turn is a tributary of the River Dart (a total distance of 5.4km from the Proposed Development). Further upstream (and within the Dartmoor SAC) the two main tributaries of the River Dart (the West and East Dart Rivers) originate from moorland. The River Dart therefore forms a part of the salmon migration route to and from spawning / nursery grounds within the upper reaches found within Dartmoor SAC. Otters resident within the Dartmoor SAC may also use the River Dart and its tributaries for dispersal routes and as part of extended home ranges.

5.1.2 There is therefore a hydrological pathway connecting the Proposed Development to the SAC, and river and stream sections between the SAC and the Proposed Development could potentially be used as supporting habitat by mobile qualifying interests of the SAC (salmon and otter).

5.1.3 The proposed Extension Area is partly within the catchment of the Kestor Brook and River Lemon. Once ground levels within the Extension Area are lowered through quarrying, any surface water entering the quarry would drain into the Balland Pit and from there be pumped into the Balland stream, effectively increasing the size of the Balland stream catchment.

5.1.4 Consideration has therefore been given as to whether quarry dewatering could potentially result in changes to the volume of water entering the Balland Stream, either by reducing groundwater flows directly entering the Balland stream or by an increase in groundwater (from intercepted deep-zone conduit flow as the quarry floor is lowered) pumped to the Balland stream from the quarry.

Significance of effects

5.1.5 In terms of increasing the size of the Balland Stream catchment, the proposed extension would increase the catchment by 7.74% (see Linhay Hill Quarry Updated Water Resources Chapter, Table 12.5 [Atkins, 2018]). As the portion of the Balland Stream catchment affected by the quarry is 0.63% of the total catchment of the River Dart to Austins Bridge, this represents a change of less than 0.05% of the River Dart catchment to this point, which is considered too small to be detectable against background variation.

5.1.6 In terms of the risk of decreasing flows in Balland stream and consequently rivers downstream, the pumping of surface and groundwater that enters the quarry and proposed extension back into the Balland Stream would minimise the potential for any reduction in normal flows to this watercourse to occur.

5.1.7 With regards to the risk of increasing flows to the Balland Stream, the estimated increase of deep-zone groundwater flow to the quarry arising from the proposed deepening and extension would be an annual increase in groundwater flows of 238ML compared to the existing volumes pumped to the Balland stream of 742ML (between June 2017 and May 2018). Given the relatively small size of the Balland Stream in the context of the Ashburn catchment and much larger Dart catchment, and the attenuation provided by temporary storage in the Balland Pit, even if all of the annual increase in groundwater was pumped to the Balland Stream, the change in flow would be too small to be detectable against background variation.

5.1.8 It is therefore considered that there would be no measurable effect on the Dartmoor SAC arising from changes to water flow, and no significant effects are anticipated.

SOUTH HAMS SAC

Potential Impacts

5.1.9 Surveys of the four adits within and near to Little Barton Fields UWS found that low numbers of greater horseshoe bats frequently use Adit 1 as a day and night roost during the active period and as a hibernation roost, with Adit 3 is also used very occasionally as a day and night roost. Refer to *Environmental Statement - Regulation 22 Further Information, Adit Bat Survey Report,* Woodfield Ecology (2017) for full details.

5.1.10 Consideration has been given to whether changes to groundwater levels caused by quarry dewatering could potentially change water levels within the adits resulting in changes to internal microclimates and humidity affecting their use by hibernating greater horseshoe bats outside of the South Hams SAC designated site.

Significance of effects

5.1.11 No hydrological changes to the adits are predicted to arise from operational dewatering. This is primarily due to the adits being located within the Tavy Formation, which is above the CBLF to be quarried, and separated by relatively impermeable strata. This is supported by the results of borehole monitoring undertaken in 2017-2018 (refer to the *HIA* (Atkins, 2018) and *Updated Water Resources Chapter* (Atkins, 2018) which confirmed groundwater flow between the Tavy Formation and the CBLF to be very limited and that dewatering from the existing quarry has not affected groundwater in the formations to the north of the CBLF.

5.1.12 In the very unlikely event of unpredicted changes (lowering) of water levels within these adits, this is not considered likely to result in a reduction in the overall suitability of the adits for roosting bats. Greater horseshoe bats and other bat species regularly hibernate in underground features which lack springs and streams as the high humidity and stable temperatures they require are not dependant on the presence of such features. It is considered more likely that a lowered water table would result in the adits becoming more suitable for roosting bats through increasing the available roosting space. This is evidenced by the fact that those adits that had the highest water levels and smallest air-filled voids (A2 & A3) were also found to be the least well used by bats.

5.1.13 No hydrological changes to adits are anticipated, and hence no effects on the South Hams SAC are predicted through this pathway.

5.2 LOCAL SITES

MEAD CROSS UWS

Potential Impacts

5.2.1 Changes to flows in surface water courses have the potential to result in changes to the flow through the culvert under the A38 which discharges into Mead Cross UWS. During periods of high flows, the Alston Stream flows via a culvert under the A38 to where it discharges into the Mead Cross UWS. The proposals would potentially result in some changes to flow through the culvert to the UWS, and consideration has been given as to whether this could result in desiccation or settlement of land as a result of a reduction in ground water levels, and / or changes in vegetation composition.

Significance of Effects

5.2.2 The potential effects are considered to be limited for a number of reasons:

- The flow through the culvert currently only occurs during periods of high rainfall, and the surface water channels within the woodland are predominantly dry even in winter;
- The drainage proposals enable the Alston stream watercourse at Alston Farm and surface water runoff from the bunds around the proposed extension to discharge to the pipe under the A38, hence surface flow through the Mead Cross UWS, will be maintained;
- An NVC survey of the Mead Cross woodland confirmed it to be W8 *Fraxinus excelsior – Acer campestre – Mercurialis perennis* woodland NVC community type, which is a community most abundant in the relatively warm, dry, lowlands of southern and eastern Britain. It occurs on various types of free-draining calcareous soils and is not dependent upon groundwater.

5.2.3 On the basis of the above, no significant effects from hydrological changes are anticipated to Mead Cross UWS.

LITTLE BARTON FIELDS UWS

Potential Impacts

5.2.4 Little Barton Fields UWS is situated on the St Mellion and Tavy Formations to the north of the CBLF within the proposed quarry extension area. Several springs emerge within the UWS including a number of adits. Consideration has therefore been given as to whether the changes to groundwater levels caused by dewatering associated with the proposed quarry extension could cause hydrological changes within the UWS, resulting in desiccation and settlement of land and vegetation changes.

Significance of Effects

5.2.5 Little Barton Fields UWS (which also includes much of Alston Wood) is situated on the St Mellion and Tavy formations which lie above and to the north of the Chercombe Bridge Limestone Formation within the proposed quarry Extension Area. Several springs discharge at the contact between these formations as the Tavy Formation is less permeable than the St Mellion formation above it. Springs also emerge directly from the St Mellion Formation aquifer. These springs are seasonal in nature, and do not flow during periods of dry weather. The aquifer they drain is charged by rainfall on higher land to the north. Ground water levels within the Tavy formation borehole have been found to be artesian, suggesting that current dewatering from the quarry does not significantly affect ground water within the Tavy formation.

5.2.6 As described above in relation to the adits within Little Barton UWS, no hydrological changes to the UWS are predicted to arise from operational dewatering. This is primarily due to the St Mellion and Tavy formations being above the CBLF to be quarried, and separated by relatively impermeable strata. This is supported by the results of borehole monitoring undertaken in 2017-2018 (refer to the *HIA* (Atkins 2018) and *Updated Water Resources Chapter* (Atkins 2018) which confirmed groundwater flow between the Tavy Formation and the CBLF to be very limited and that dewatering from the existing quarry has not affected groundwater in the formations to the north of the CBLF.

5.2.7 Accordingly, no significant effects from hydrological changes are predicted to Little Barton Fields UWS.

5.3 HABITATS – RUNNING WATER

Potential Impacts

5.3.1 Potential impacts to the Balland Stream are set out in section 5.1 above.

5.3.2 Existing groundwater flows to the quarry are considered likely to come from a broadly easterly direction. Some of this water is therefore likely to come from the catchment of the Kestor Brook. It is anticipated that additional flow into the quarry from the proposed deepening and extending eastward would also come from the Kestor Brook catchment.

5.3.3 The proposed extension would also result in a slight reduction in the Kestor Brook catchment by approximately 30 hectares (3.66% of its total area).

5.3.4 Changes to groundwater flows could potentially also affect other water courses to a lesser extent, including the Lemonford Stream and the River Lemon.

Significance of effects

5.3.5 Changes to flows (increase or decrease) within Balland Stream are considered unlikely to result in detectable changes to vegetation communities and riverine habitats, as set out in paragraphs 5.1.6 and 5.1.7 above.

5.3.6 In the absence of mitigation, reduction of flows to the Kestor Brook could feasibly result in increased frequency of seasonal drying out of the watercourse (which was observed to occur in 2016 and 2018) which could potentially have an adverse effect on aquatic / marginal vegetation, invertebrates and fish. The Lemonford stream could also experience reduction in flows which may result in detectable changes to vegetation communities and riverine habitats. Given the relative sizes of the water courses, any changes to flows are considered unlikely to be detectable within the River Lemon.

5.3.7 The Balland Stream is considered to have ecological value at the Local scale. On a precautionary basis and on account of their naturalistic characters, the Kestor Brook and Lemonford stream are considered to have an ecological value at a greater geographical scale than the Balland Stream, and are accordingly considered to be of ecological importance at the Local (District) scale. The River Lemon, is considered to have importance at a larger scale, potentially up to County.

5.3.8 Overall, in the absence of mitigation, adverse effects on running water are considered likely to occur at up to the Local (District) scale (as impacts to the River Lemon are considered unlikely to be significant), and accordingly it is considered that there would be a permanent direct significant adverse impact at up to Local (District) scale, which equates to an effect of **Moderate adverse** significance.

Mitigation

5.3.9 A network of monitoring points is proposed on water courses and boreholes around the existing quarry and proposed extension (refer to the *Updated Water Resources Chapter* [Atkins 2018]). Given the extended period over which the proposed extension would be excavated, regular analysis of data from these monitoring points would allow a responsive approach to maintaining water course flows. If monitoring identified that the Kestor Brook (or any other watercourses including the Lemonford stream and Balland Stream)

would require augmentation of flow, pumped discharge either directly to the brook or its tributaries would be undertaken. If a reduction in flow was indicated as beneficial, pumped discharges would be delayed, reduced or diverted to an alternative watercourse.

Residual effects

5.3.10 The *Updated Water Resources Chapter* (Atkins, 2018) considers that with controlled pumped augmentation, the residual effect on flows in water courses would be limited. Accordingly, **no significant residual effects** are anticipated.

5.4 SPECIES

SUBTERRANEAN FAUNA (INCLUDING THE CAVE SHRIMP *NIPHARGUS GLENNIEI*)

Potential Impacts

5.4.1 The *Regulation 22 Response #1 Appendix 6.1: Linhay Hill Quarry, Subterranean Fauna Survey Report* (Atkins June 2017) made a precautionary estimate that the proposed extension would result in the loss of less than 4% of the total amount of locally occurring limestone habitat within the CBLF. The updated HIA (Atkins 2018) identified very little hydraulic connection between a shallow ground water zone and a deeper zone, indicating that a body of limestone with no or very few suitable cracks and fissures is present between the two. This figure of 4% is therefore considered to represent a sizable overestimate.

5.4.2 Consideration has been given as to whether dewatering from the quarry could result in the lowering of ground-water tables arising from the proposed quarry extension that could further reduce the area of suitable habitat for subterranean fauna over a wider area than the direct habitat loss. This potential effect is considered likely to be limited by a number of factors:

- The deep and shallow parts of the limestone are not well connected hydraulically.
- The shallow zone (from which the calcite feature on the north east face of the quarry where *N. glenniei* was detected) responds rapidly to rainfall, indicating that ground water levels within the shallow zone will be determined more by rainfall than by dewatering.
- Flow from springs charge the limestone aquifer to the north-west of the quarry and proposed extension, further limiting the potential extent of any dewatering effect on the north-western side of the proposed extension.
- Observation of flows into the existing quarry from the seepages along the south-eastern face suggest that groundwater flow in this direction is also limited – these seepages have highly variable (but always low) flow rates which can be dry even during winter. This suggests that the extent of suitable subterranean aquatic habitat is limited immediately to the south east of the quarry.

5.4.3 The HIA states that effects from dewatering of the deeper zone near the base of the quarry are likely to be diffuse, but that further understanding of this would only be determined by additional monitoring. It is also not currently known whether the deeper zone supports a subterranean fauna assemblage.

Significance of effects

5.4.4 The precautionary estimate of below 4% direct habitat loss is considered unlikely to result in a significant adverse effect on the subterranean fauna of the limestone formation, considered as a whole to be a feature of ecological importance at the Local (District) scale. Dewatering within the shallow ground water zone is not considered to result in a significant reduction in habitat quality outside of the area of direct habitat loss. The status of subterranean fauna, and the extent to which dewatering would impact on habitat quality within the deeper zone is unknown. On a precautionary basis the presence of a similar assemblage as found within the shallow zone is assumed, and the volume of suitable habitat affected considered to be equivalent to that lost directly.

5.4.5 Overall, adverse effects are considered likely to occur but not at the Local (District) scale, and accordingly it is considered that there would be a permanent direct significant adverse impact at the Local scale, which equates to an effect of **Slight adverse** significance.

Mitigation

5.4.6 The mitigation previously proposed within the *Regulation 22 Response #1 Appendix 6.1: Linhay Hill Quarry, Subterranean Fauna Survey Report* (Atkins June 2017) is:

1. Funding of further studies that would contribute to the Biodiversity Action Plan (BAP) Action: *further research into the distribution of the species*. This would include a commitment from E&JW Glendinning Ltd. to fund studies to target information gaps on the species' regional distribution.
2. Ongoing monitoring of subterranean fauna throughout the quarry extension process that would contribute to the BAP Action: *further research into its ecology and habitat requirements'.* In the context of the proposed extension, this could allow assessment of different types of habitat features, seasonal changes and sampling from different geological depths.

5.4.7 No further mitigation is considered necessary as a result of the findings of the HIA (2018).

5.4.8 It is anticipated that the scope and methodologies for survey and monitoring would be agreed through planning condition.

Residual effects

The proposed commitment to undertaking surveys that would contribute towards the 2007 BAP actions (over the life of the quarry extension) is considered to be beneficial through furthering the understanding of the ecology of *N. glennii* in particular through

long-term study with the overall objective of increasing understanding of the ecology of this species in order to aid future conservation efforts.

The benefits of this are considered to compensate to an extent for the adverse effects of habitat loss, but on a precautionary basis, the residual overall effect of **Slight adverse** significance is retained.

6.0 CONCLUSIONS

6.1.1 The additional hydrological assessments set out in the 2018 HIA have allowed further assessment of the potential ecological effects of hydrological changes that may be associated with the proposed quarry extension.

6.1.2 With the exception of off-site running water, for all other Important Ecological Features considered within the assessment, no additional ecologically significant effects are anticipated, and no changes to ecological assessments as previously reported are made. No significant effects from hydrological changes on any of the identified statutory and non-statutory designated sites or their qualifying interest features are predicted. Subterranean fauna, including the British Cave Shrimp *Niphargus glenniei* effects are considered likely to occur at the Local scale only, which equate to an effect of Slight adverse significance. A commitment has been made by E&JW Glendinning to fund research which will further the understanding of the ecology and distribution of this species to aid future conservation efforts.

6.1.3 In the absence of mitigation, the potential for adverse effects on off-site running water (Balland Stream, Kestor Brook, Lemonford stream and River Lemon) has been identified in the form of reduction of flows. Accordingly, a network of monitoring stations is proposed which will inform reactive mitigation through augmentation of flow (pumping of water to affected water courses), with no significant residual effects anticipated.

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