Your Ref:

Our Ref: Fossil Forest – Cliff Stability Assessment

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CONFIDENTIAL

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Dear Sally

Subject: Fossil Forest Cliff Stability Assessment

PROJECT OUTLINE

On October 29th 2015 a substantial rock fall damaged the steps leading down from the Coast Path onto the rock shelf area containing the Fossil Forest. As a result access down to the fossilised trees is currently closed, although some of the trees can still be viewed from the Coast Path along the cliff top.

In light of the rock fall Dorset County Council requested that a site walkover be undertaken to investigate options to ascertain how access to the fossilised trees can be re-opened. The site walkover was undertaken by WSP | Parsons Brinckerhoff in the afternoon of Friday 18th November 2016 in the presence of Sally King and Guy Chapman, with access being authorised by the Ministry of Defence from their Lulworth Camp. This note provides a summary of the observed conditions and an options matrix that presents options for improving the current location or providing new access. A Geotechnical Risk Register is also included.

COASTAL SETTING

The Fossil Forest ledge is situated on a coastal cliff; however its exposure to erosive processes has little bearing on decisions about access. Although the lower cliff is clearly weathering and being worked by relatively energetic wave action, recession is understood to progress at a very low rate because the basal cliff is composed of resistant Portland stone. Standard mapping of coastal cliff recession is not particularly informative; the Environment Agency's National Erosion Risk Maps do not extend over this area, whilst the mapping provided by the local Shoreline Management Plan (Durlston Head to Rame Head Shoreline Management Plan 2, Halcrow, 2011) only shows the potential for small scale recession. Ultimately the main hazard at the site arises from the softness of the Purbeck beds above the ledge.

SITE NOTES

The site walkover was undertaken in the afternoon of Friday 18th November 2016 with weather conditions generally being sunny, cold and windy; although the ledge was secluded from the wind so slightly warmer. It was dry underfoot which made access to the cliff relatively easy. Firstly the entire area was looked at to ascertain if there were signs of movement to the cliff as a whole. Indicators would normally include some or all of the following:

- leaning trees
- tension cracks at the crest of the cliff
- bulging at the toe of the cliff

As none of the above were observed it has been assumed that global stability is not an issue and the matter of concern is local stability failures within the rock mass. However, it must be recognised that the absence of any of the normal indicators of global stability does not by itself mean that the cliff is stable and sudden failures can never be discounted. Based on an assumption of local instability a closer inspection of the rock face was undertaken.

The area of concern was identified, which is located approximately half way down on the landward side of the access stairs. An obvious section of overhanging rock was observed, where it is thought the rock fall material originated from. An insight to the geology will provide an answer as to why there is a section of hanging rock here that isn't observed elsewhere.

The geology of the Jurassic Coast is well known and is perhaps best described by Dr. Ian West of Southampton University (http://www.southampton.ac.uk/~imw/Fossil-Forest.htm). Essentially the fossilised trees are found on top of the Portland Stone, with the Purbeck Formation overlying this. The area of concern is located within the basal layers of the Purbeck Formation, with the access stairs passing through different layers of this Formation. The overhanging rocks are there as they weather at a slower rate to the layer beneath it. This layer, known as the Cypris Freestones, is not seen throughout the entire area as the thickness seemed to pinch out towards the west so there was less chance for differential weathering and as a result fewer overhanging rocks.

The overhanging rocks present a risk of further rock falls. This risk is realised by weathering of the rock, and exacerbated by the rock mass itself. Discussing the latter point, the rock mass had three obvious intersecting joint sets; one sub-horizontal and two sub-vertical. Precise measurements of the joints' orientation couldn't be taken as only one section of rock could be measured due to access constraints. Essentially the joints intersected one another such that rectangular blocks were identifiable in the rock mass. There was generally no infill material to the joints and the joint aperture was approximately 10 to 40mm. With the aperture fairly wide and not containing any material it becomes a potential conduit for water increases the potential for weathering in the form of freeze-thaw for example, and ultimately increase the risk of failure.

OPTIONS

Options were discussed on site and essentially there are two:

1. Carry out remedial works to the current stairs and rock face, or
2. Construct a new access location to the fossilised trees.

The two options are evaluated in the following table. Six items are discussed and these are generally in line with the stages a construction project would follow. For a point of clarity, it is generally thought that Dorset County Council would act as technical reviewers, but Stakeholders such as English Heritage and Natural England would be involved in any decision that affects the appearance of the cliff.

ITEM	OPTION 1 CURRENT LOCATION	OPTION 2 NEW LOCATION
Feasibility	The stairs are already in place so this option is feasible.	A potential area has been identified, approximately 100m west of the current location. In theory this would be feasible, but a more detailed study would need to be undertaken to confirm.
Planning	The stairs are already in place so this option already has planning agreed. Included with this report is a Technical Note that comments on the likely planning requirements for each option.	Planning documents would need to be prepared and submitted for approval.
Design	Discussions on site centred on making safe (so far as is reasonably practicable) the overhanging rocks and updating the barriers to the stairs. Options for this could be using high tensile steel wire to direct any potential future rock falls over the stairs onto the ledge below. Scaling of the rock face would remove loose boulders and take the rock mass back to fresh material. Note that no design can remove the risk of further falls completely.t The site is coastal, ultimately subject to a variety of external conditions. Unless a meshing system is adopted (and this is believed not to be an option), the risk of future rock falls cannot be eliminated.	Discussions between designer and approving authority would need to be undertaken before design commenced to agree what format the design process would take. For example, what documentation would need to be submitted to gain design approval. The form of construction would also need to be agreed before detailed design. This would likely involve various groups such as English Heritage and Natural England. There are systems that can be pinned to the slopes but these are generally where they align perpendicular to the slope, which would not be the case in this instance.

ITEM	OPTION 1 CURRENT LOCATION	OPTION 2 NEW LOCATION
Construction	Scaling of the rock would require a specialist contractor using rope access techniques. Installing the new mesh could be undertaken by the same contractor. WSP | Parsons Brinckerhoff have good links with a variety of companies in this field.	Similar to option 1 in regards the work will require rope access. Cutting into the slope may also be required to install new stairs as there didn't appear to be a preferential route the stairs could take.
Monitoring	It is believed that construction would not begin until late Q1 / early Q2 of 2017. This gives rise to an opportunity to monitor the current situation by way of monthly site walkovers. This would enable a geologist to monitor and report on the site conditions. If this option is taken forward this information could be used to provide confidence (or otherwise) that this is a viable solution.	Monitoring of the new stairs could be undertaking by way of 3D survey from a fixed point of origin. This would allow any potential movement to be recorded and actioned upon depending on the scale of movement. Obviously this is reactive measure and would not inhibit the movement in the first place.
	Monitoring that applies to both options could be to undertake regular LIDAR surveys to assess potential movements. These could then be interrogated to assess if any changes have occurred in the landscape. A second option could be to install web based movement indicators so that real time information could be relayed to mobile phones / tablets and actioned in a relatively short space of time. If gated access was installed as part of the construction, this action could be to shut the stairs when movement was identified so that the public were not allowed into a potentially unsafe area. The gates could also be shut after an intense or long period of rainfall. Any trigger levels would need to be agreed during the design phase.	
Maintenance	Yearly monitoring of the condition of the rock face and mesh/stairs should be undertaken to record the condition of both. This would enable any potential worsening of the rock mass or degradation of the mesh/stairs to be identified in good time to allow remedial measure to be actioned.	Similar to option 1, but would likely need to seek maintenance schedule from the manufacturer of the stair system that is implemented.
Cost and Liability	Included with this report is a Technical Note that outlines the scale of costs for each option. If option 1 was taken forward a clear agreement would need to be in place that defined where the liability for further falls and potential injury and/or loss of life sits. Clear signage that placed the risk of entry on individuals choosing to enter the area would need to be in place.	

GEOTECHNICAL RISK REGISTER

GENERAL

The geotechnical risks associated with this project have been identified and relevant health and safety issues have also been considered. The register highlights the risks and consequence of those risks.

BASIS OF THE ASSESSMENT OF RISKS

The geotechnical risk register identifies geotechnical hazards/ risks associated with the project and the risks have been assessed in accordance with the general methods described in Highways England document HD22/08 ‘Managing Geotechnical Risk.’ The register is enclosed within this report.

Yours sincerely,

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2017.02.17 07:50:42 Z

Paul Conie
Associate – Geotechnical Engineer

cc: Mark Wheeler, Mike Walkden, project file
Encl.:
Geotechnical Risk Register
Technical Note – Fossil Forest Cliff Access Options

FOSSIL FOREST – GEOTECHNICAL RISK REGISTER

NO.	TOPIC / SUBTOPIC	RISK ASSESSMENT ISSUE	CONSEQUENCE	CONTROL MEASURES
1	Loose rocks on the cliff face.	Risk to construction workers and members of the public when the access to the fossilised trees is re-opened.	Falling rocks could ultimately hit people resulting in injury and possible fatalities.	Construction workers to prepare appropriate RAMS for approval. Access to be prohibited beneath works occurring on the cliff. Members of the public to assess route and keep an eye out for loose rocks. Access to the cliff face is prohibited and entry is at an individual's own risk – signs to this effect should be installed as part of the works. Note that loose rocks cannot be totally eliminated and as such a residual risk remains.
2	Rope access to the cliff face.	Risk to construction workers if a competent contractor is not procured to undertake the works.	Potential risk to life.	Ensure a competent contractor is procured to undertake the works. Ensure RAMS are prepared for approval and check they contain workers with the appropriate rope access certification.
3	Unexpected adverse ground conditions (e.g. suitable founding strata for stairs deeper than anticipated).	Need to adjust the design if problem identified. If not recognised, possibility of underperformance of structure.	Cost and delays during redesign. Possible increase in excavation depths for foundation for new stairs.	Reduce likelihood with appropriate ground investigation, interpretation and design. Reduce consequences by identifying any remaining gaps in data and adopting conservative solutions.

NO.	TOPIC / SUBTOPIC	RISK ASSESSMENT ISSUE	CONSEQUENCE	CONTROL MEASURES
4	Unidentified contamination encountered on site	Need to impose additional control measures to continue sites work. Health and safety impact if encountered but not identified. More material processing or import/export of material required.	Delays and additional costs while contaminant is identified. Possible health issues for site staff if not identified.	Reduce consequences by making provision for possible remediation. Site health and safety plans to make provision for detection of contamination and additional control measures if encountered.
5	Geotechnical design recommendations are not taken through to construction.	Need to adjust the design if problems identified during construction. If not recognised, possibility of underperformance of structure (e.g. increased settlements)	Delays to programme and possible additional costs for re-design or remediation works.	Appoint a suitably qualified Geotechnical Engineer to attend site during construction and to validate the works.
6	Instability of temporary excavations.	Possible instability of temporary works during construction of foundations	Delay and cost of additional temporary works.	Ground investigation data to be used to inform temporary works design.
7	Morning mist rolling over the cliffs as captured by a Dorset photographer. http://www.bbc.co.uk/news/uk-england-hampshire-37787754	Risk to construction workers and site visitors.	Visibility is dramatically reduced resulting difficult and potentially dangerous working conditions.	Weather conditions to be assess prior to work commencing. Work not to start until the morning mist has passed.

TECHNICAL NOTE

FOSSIL FOREST CLIFF ACCESS OPTIONS

GENERAL

This note outlines an indicative scale of costs and comments on the likely planning requirements for each access option to the Fossil Forest. It should be read as a guide rather than absolute information as there are currently unknowns that will influence both the cost and planning requirements.

INDICATIVE SCALE OF COSTS

The following table illustrates the potential scale of costs associated with each option.

COST	OPTION 1 CURRENT LOCATION	OPTION 2 NEW LOCATION
Ground Investigation	Assumed that no ground investigation will be required as there is already a foundation in place that could potentially be modified to construct a new barrier. However this requires confirmation once the form of barrier proposed is known. Ground 'truthing' (site walkover) is recommended to confirm ground risk assumptions and it is recommended this is undertaken with a contractor.	A ground investigation would likely be required to ascertain founding conditions. A contractor with experience of working on slopes has indicated that investigatory costs may be **c. £30k**, subject to specific access constraints and foundation requirements.
Design	An estimate of geotechnical design fees will be **c. £10k**. Note this is purely for the geotechnical design associated with either design and other departments' input would be extra.	
Construction	No warranty was attached to this cost, but one contractor indicated a fee of **c. £50k** to install a new form of barrier at the existing location. Note that this is an indicative cost and subject to change because the form of construction is not known.	An idea of the form of access required will be needed to better define this cost, but a contractor has indicated that a fee of **c. £30k to £50k** would be sufficient to *provide* a new set of access steps. No warranty has been given to this value and it assumes the steps would not traverse the slope and the gradient is no more than 45 degrees. A rock access team would be required to install the steps and it is thought this would be **c. £15k to 25k**. It is very much dependant on the requirements of the planning conditions/ constraints.

LIKELY PLANNING REQUIREMENTS

The Planning Authority should be consulted to confirm that planning is not required; it is considered that this is unlikely due to the scale of the works. As the works are within a geological SSSI it is likely that they would require Assent under the Section 28 of the Wildlife and Countryside Act (this is only required as a stand-alone application if Planning is not required). For projects of this scale this is usually best dealt with using Natural England discretionary advice service (which may cost **c. £500 to £1,000**).

Without first knowing the planning requirements it is not possible to attribute a planning cost for either option. It is thought however that planning would be more readily gained at the existing location due to there already being man made works there; indeed planning may not be required here for this very reason.

CAVEATS

The information given in the table above does not include cost/programme fees/risks associated with the following areas of work. Please note this list is not exhaustive and is presented to give an idea of what may be required over and above what has already been discussed.

- Public consultation.
- Visual impact assessment.
- Environmental impacts such as ecology.
- Other internal disciplines such as structural or drainage.
- Ground investigation – third party contractor fees.
- Re-designs after any sort of consultation.
- Stability assessment of the whole cliff mass.

SUMMARY

There are currently two options to re-open public access to the Fossil Forest – make safe the existing location or provide a new access at a location to the east. In broad terms it is thought that making safe and improving the existing access will be more cost effective and have less planning restrictions than providing a new access. Ground investigation costs will be more for a new access route and although not specifically known, planning costs are also thought to be higher. There are uncertainties associated with the project at the current time, mainly the planning requirements and the constraints these requirements may have on the project.

Paul Conie
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17/02/2017