Appendix 21-1:
Coastal Erosion Assessment Report

ORIEL WINDFARM
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ORIEL WIND FARM PROJECT

Environmental Impact Assessment Report
Appendix 21-1: Coastal Erosion Assessment Report

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1 INTRODUCTION

RPS was commissioned by Oriel Windfarm Limited (OWL) in August 2023 to provide a coastal erosion assessment of the proposed Oriel Wind Farm Project at the proposed landfall at Dunany, Co. Louth.

The Oriel Wind Farm Project (hereafter referred to as 'the Project') is located in the Irish Sea. It will comprise of 25 wind turbines. The offshore wind farm area is located in the Irish Sea, off the coast of County Louth (approximately 22 km east of Dundalk town centre and 18 km east of Blackrock). The closest wind turbine will be approximately 6 km from the closest shore on the Cooley Peninsula. The offshore cable corridor extends approximately 11 km southwest from the wind farm area to the landfall south of Dunany Point.

This report includes an assessment of the Project on coastal erosion at the proposed landfall. The report is structured as follows:

1. Site description. Comprises a review of general ground conditions from published information;
2. Desk study review of published information on coastal erosion at the landfall location. The review included coastal erosion reports based on a comparison of cliff retreat using historical Ordnance Survey Ireland (OSI) mapping to determine annual rate of cliff regression;
3. Site inspection. An inspection of the landfall location was carried out to determine ground conditions, key contributory causes of coastline slope failures (landslips), and salient geomorphological features including evidence of coastal erosion;
4. Identification of key contributory causes of coastline slope failures. An assessment of the likely causes of slope failures at the landfall location were carried out to identify key contributory causes;
5. Stability and impact of proposed works. A review of the proposed landfall options (two options for the location of the Transition Joint Bay (TJB) are proposed by OWL) on the short and long-term stability of the landfall location. A review of the likely stability of the current slope conditions and the impact of both landfall options are assessed; and
6. Conclusions (findings and recommendations). The findings of the above are provided and recommendations produced. Where it is recommended that measures are required then indicative measures are provided.

In February 2023, the Geological Survey of Ireland responded to a correspondence regarding the Project and works within the Dunany Point County Geological Site (CGS). The GSI requested that the potential for the works to impact on the CGS be examined and appropriate mitigation measures be implemented to mitigate any impacts. The GSI also requested that they be kept notified of the works and allowed access to the CGS during the works.

The findings of this report support the assessment on soils, geology and hydrogeology included in chapter 21, volume 2C of the EIAR.

2 SITE DESCRIPTION

2.1 Topography

The proposed landfall location is located about 0.7 km to the southwest of Dunany Point, in County Louth (Figure 2-1). The coastline in the area of the landfall comprises a cliff slope formed of soil about 6 to 7 m high fronted by a shingle beach. To the north the cliff line increases gradually in height towards Dunany Point where the cliffs are in excess of an estimated 15 m high. Dunany Point forms the eastern end of an east-west glacial till ridge.

At the landfall location the topography behind the cliff slope is relatively flat and is used for arable agriculture. The fields are separated by hedgerows with a few minor public roads present. A minor public road accesses the beach immediately to the south of the landfall.

Figure 2-1: Site location.

2.2 Ground conditions

2.2.1 Superficial deposits

Superficial deposits in the area of the landfall comprise glacial till derived from sandstone and shale with a matrix of Irish Sea Basin origin as defined by the Geological Survey Ireland (GSI, 2023), see Figure 2-2. The glacial till encountered in boreholes (Causeway Geotech, 2021) were described as dominantly stiff to very stiff brown slightly sandy slightly gravelly silty CLAY. This description of glacial till is typical of lodgement till.

The glacial till in the area of Dunany Point forms a ridge (Dunany Ridge) which is a designated GSI County Geological Site (CGS Site Code: LH017). The CGS is designated as the cliff section exposes sediments important to an understanding of relative sea levels in this part of Ireland during the end of the last Ice Age. The Dunany Ridge is one of the highest and most continuous moraines in Ireland that has been interpreted

by the GSI to have been deposited in glaciomarine conditions (i.e. by a glacier into the sea). The GSI also note that it is the southernmost section showing definitively glaciomarine sediments along the east coast of Ireland.

The landfall location lies within the southern limit of the footprint of the CGS Site Code: LH017 (Figure 2-3).

To the south of the landfall the glacial till is overlain by marine sands and gravels. These marine deposits also form the beach area in front of the cliff line.

Figure 2-2: Superficial geology (EPA, 2023).

2.2.2 Bedrock

The 1:100k bedrock geology map for the area (GSI, 2023) shows black mudstone and quartzose greywacke of the Glaspistol Formation underlying the site at depth (Figure 2-3). Ground investigation in the area comprising essentially boreholes (Causeway Geotech, 2021) and geophysical survey (Apex Geophysics, 2021) indicated bedrock at a depth of about 35 m below ground level (bgl), that is approximately at an elevation of -30 m ordnance datum (OD).

Site inspection at the landfall location showed no evidence of bedrock exposed in the cliff face. Further north towards Dunany Point there is an increasing number of boulders exposed on the foreshore, which possibly suggests bedrock is at shallower depth to the north.

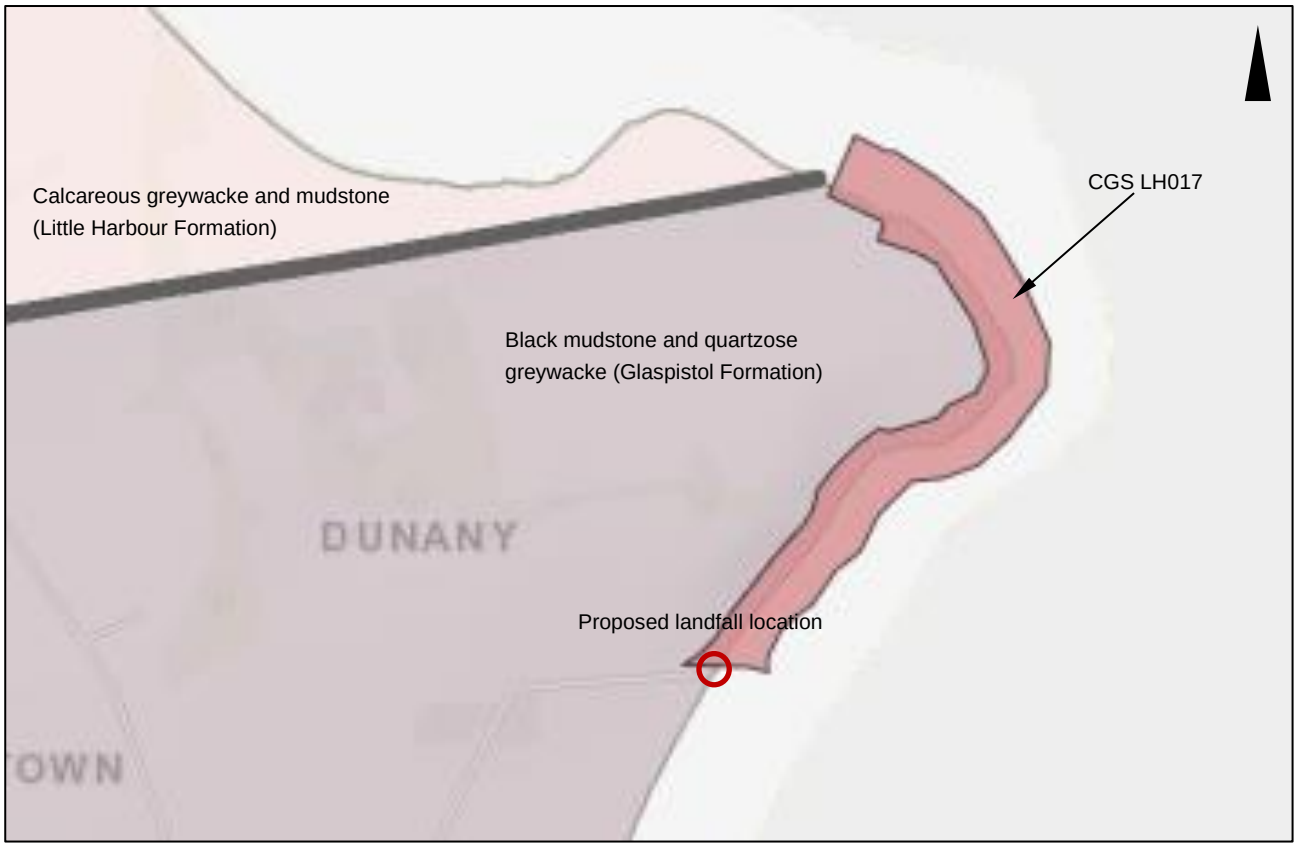


Figure 2-3: Bedrock geology (GSI, 2023).

3 DESK STUDY

A desk study review of published information on coastal erosion at the landfall location was carried out. The findings of the review are included below.

As part of a strategic assessment of coastal flooding and erosion, the Office of Public Works commissioned coastal study reports along the Irish coastline. The report covering Dalkey Island to Omeath (RPS, 2010) includes the landfall location. The coastal study reports compared the best available current and historical mapping and aerial photography data to estimate the annual rate of change in the coastline position. Using this data, a prediction of the likely future position of the coastline in the years 2030 and 2050 was obtained. The coastal study report predictions are indicative and as such are used for guidance only.

At the landfall location the predictions are considered to have a medium degree of confidence that is between 55 and 70%. The coastal study report at the landfall location indicates some future retreat of the coastline (Figure 3-1) from its current location but the magnitude of that retreat is marginal and considered beyond the of level accuracy of the study to provide an actual measurement. For the purpose of this report, it is assumed that coastal retreat may be in the range of 5 to 10 m by 2050.

Based on site inspection, see following section, RPS identified signs of coastal retreat at the landfall location.

GSI Coastal Vulnerability Index (CVI) information is currently being produced for coastal areas in Co. Dublin. No data is currently available for the landfall location.

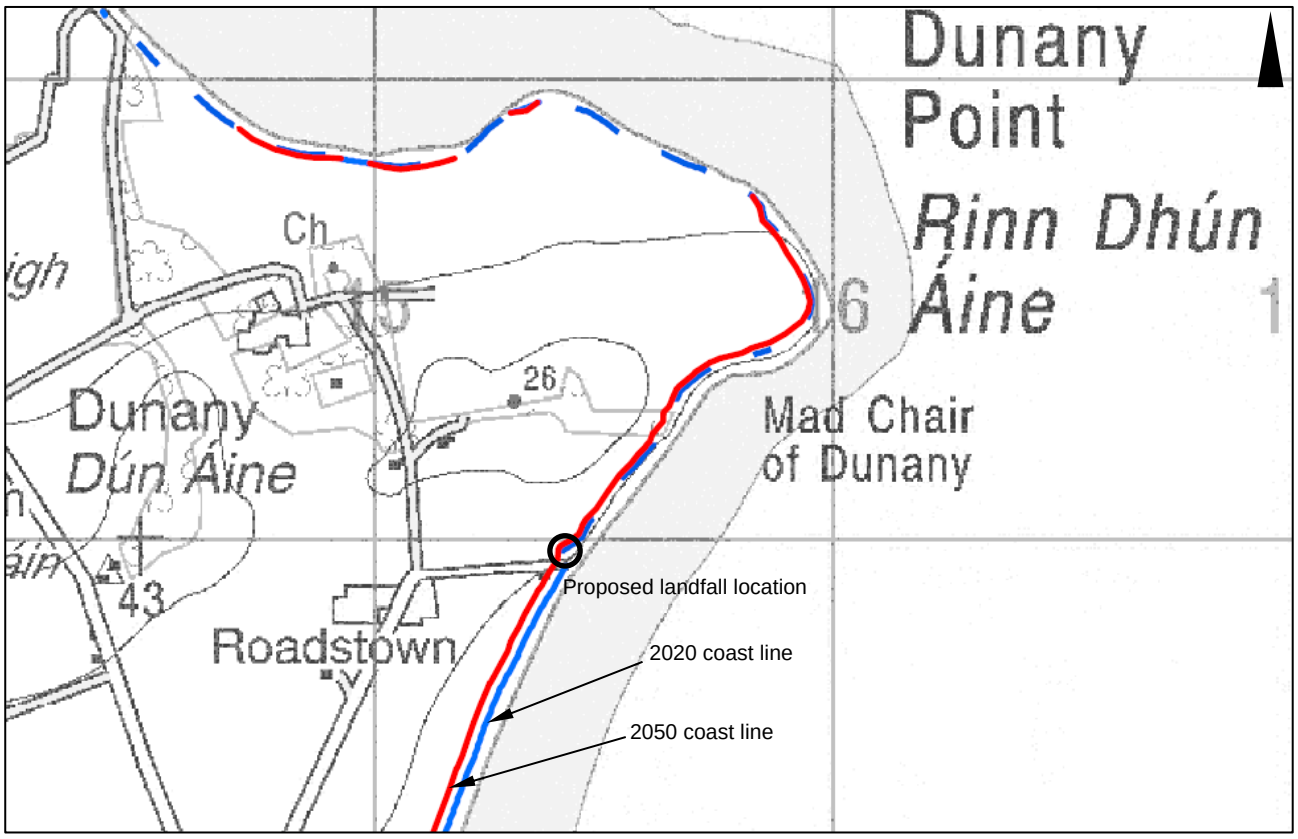


Figure 3-1: Prediction of likely coastline in 2050 (RPS, 2010).

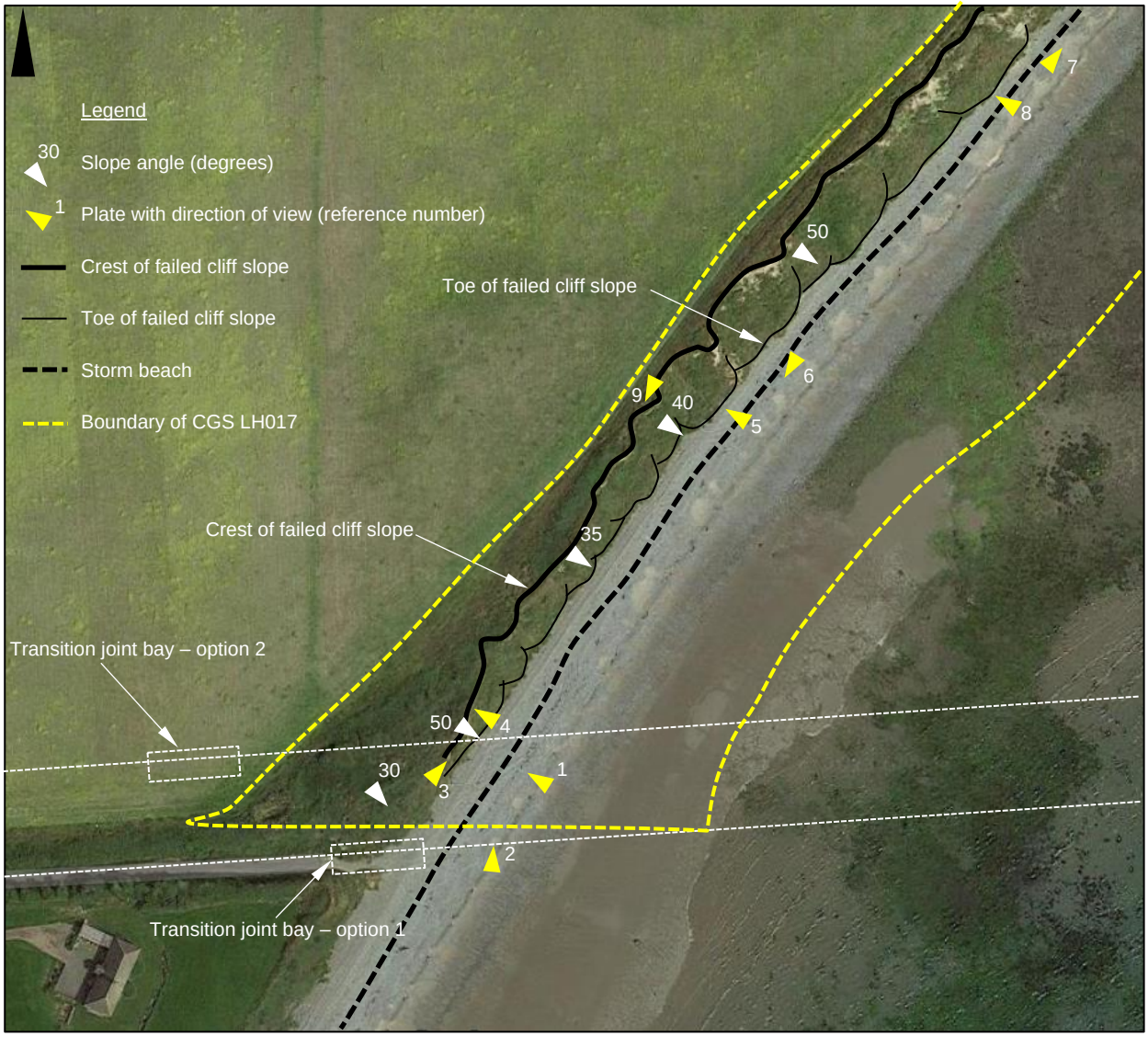
4 SITE INSPECTION

A site inspection of the landfall location was carried out in September 2023 by RPS in the company of OWL. The inspection comprised visual examination of the exposed ground conditions, particularly at the cliff face at the location of the landfall. The inspection recorded ground conditions and salient geomorphological conditions within the area.

Findings of the site inspection are as follows (see also Figure 4-1 and Appendix A for plates):

1. At the landfall a TJB is required to connect the offshore cable with the onshore cable. Two TJB options are proposed (Option 1 and Option 2), both of which would require works within the footprint of the Dunany Point CGS LH017. The CGS comprises the exposed coastal cliff and part of the foreshore;
2. The cliff slopes in the area of the landfall and heading north comprises glacial soil which has essentially failed as multiple landslips along the entire length of the coast to Dunany Point (Plate 1 and Plate 2);
3. The coastal cliff at the landfall location comprises a 6 to 7 m high cliff with an overall slope inclination of about 30º to 50º. The upper part of the cliff is locally steep and approaches about 70º, which corresponds to the back-scarp of a coastal landslip (Plate 3);
4. Examination of the cliff at the landfall shows that it is composed of dominantly stiff to very stiff brown slightly sandy slightly gravelly silty CLAY with sub-angular to angular gravel and occasional cobbles of mixed lithology. The glacial till (Plate 4) within the cliff is the same material as identified in the boreholes;
5. The landslips along the cliff comprise essentially circular shear failures within the glacial soil. Failed landslip material mantles the lower part of the cliff slope. Wave and scour erosion of the landslip material has occurred to varying amounts along the cliff face (Plate 5), with notably more erosion towards Dunany Point;
6. The wave and scour erosion at the toe of the cliff slope has caused loss of soil material (under-cutting) and loss of strength due to wetting of the lower slope which over time has continued to destabilise the cliff slope;
7. Inspection of the beach morphology shows a storm beach (berm) about 3 to 8 m from the cliff toe at the landfall location (Plate 6). The storm beach comprises beach material piled up by wave action during high water (storms). The berm divides the beach into backshore (upslope of berm) and a foreshore (downslope of the berm). The backshore and foreshore beach sections are inclined at about 5º with the separating berm inclined at about 25º;
8. It is noted that the storm beach is at a greater distance from the cliff toe at the landfall location but gradually reduces to meet the cliff toe towards Dunany Point, where cliff instability is notable greater and more active (Plate 7 and Plate 8) as a result of exposure to increased wave and scour action at the toe of the slope;
9. The crest of the cliff slopes comprise multiple arcuate scars which represent successive and multiple sequence of landslipping of the cliff slope (Plate 9); and
10. Continued wave and scour erosion at the toe of the slope with associated landslipping has resulted in coastal erosion with retreat of the coastline. The rate of retreat appears to be less at the landfall location with the rate of retreat greater towards to the north at Dunany Point, where cliff instability is notably greater and more active.

A schematic showing the details of landslipping along the cliff slope is given in Figure 4-2.



Notes

(1) For explanation refer to main text.

(2) Location of TJB options and cable route are shown approximately.

(3) Boundary of CGS LH017 is shown approximately.

Figure 4-1: Details of landfall location (image from Google Maps).

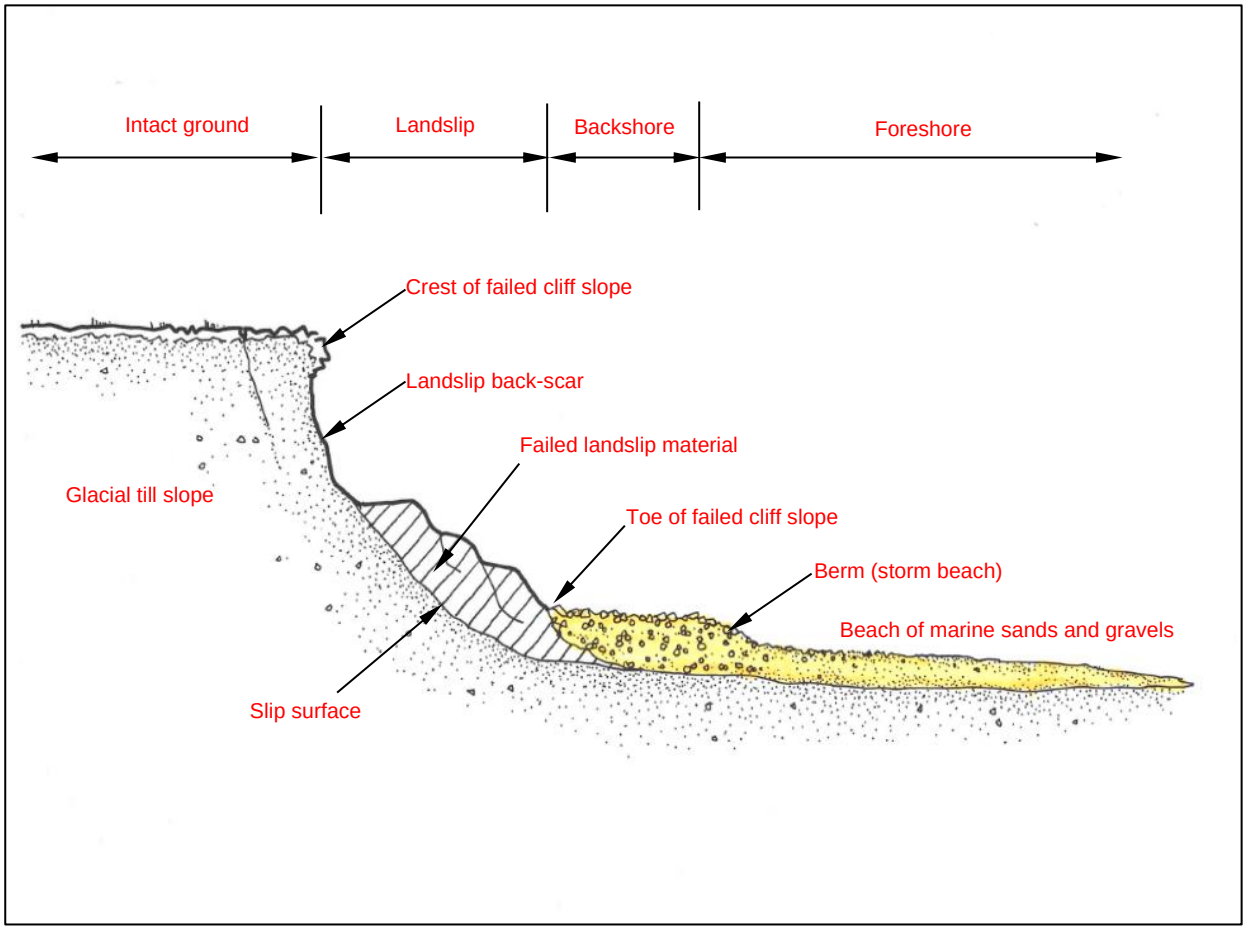


Figure 4-2: Schematic section through cliff slope showing details of landslipping.

5 IDENTIFICATION OF KEY CONTRIBUTORY CAUSES

An assessment of the likely causes of slope failures at the landfall location was carried out to identify key contributory causes. The key causes are a combination of the following:

1. Steepened coastline cliff in soil. The cliff is composed of soil which is steepened and as such is prone to long-term instability. Typically, where the slope inclination exceeds about 45º then there is an elevated risk of instability, due to for example weathering (such as salt weathering and drying), stress relief, strain-softening;
2. Wave and scour erosion at cliff toe. As the coastline cliff is formed of soil then wave and scour erosion at the toe has caused loss of previously failed landslip material (under-cutting) and loss of strength due to wetting of the lower slope which in time has continued to destabilise the cliff slope. This is considered a key destabilising factor;
3. Elevated groundwater in slope. Whilst there is no direct evidence of groundwater in the cliff slope, it is likely that raised groundwater levels within the slope occur which will result in a reduction of effective strength within the soil. Raised groundwater levels within the slope likely result from infiltration of surface water into the relatively level ground behind the slope; and
4. Erosion of beach material at toe. During periods of intense storms there is likely erosion of beach material that provides protection to the cliff slopes. Where this material is eroded this exposes the cliff slope to erosion and scour and unloads the toe of the slope. This appears to be evident toward Dunany Point and is not readily apparent at the landfall location.

6 STABILITY AND IMPACT OF PROPOSED WORKS

6.1 Review of impact

The proposed works at the landfall will comprise the construction of a TJB which is required to connect the offshore with the onshore cable. Two TJB options are proposed (Option 1 and Option 2), which are shown in outline in Figure 4-1. General details of the options (RPS, 2022) showing the extent of the footprint are provided in Appendix B.

A review of both TJB options is provided in Table 6-1 with respect to stability and impact of the works.

Table 6-1: Review of stability and impact of TJB options.

Option	Option description	Advantages	Disadvantages
1	TJB constructed at toe of the cliff slope	• Limits having to form cable trench through higher cliff slope of CGS; • Temporary piling to minimise impact on cliff slope and area of the CGS.	• Likely future ingress of seawater around TJB; • Will require construction in tidal zone which will require temporary measures to protect construction works; • Impact of future retreat of cliff slope could result in the TJB being eventually located within the beach, and at risk of exposure to greater tidal action.
2	TJB constructed behind crest of cliff slope	• TJB excavation is remote from any tidal effects; • Minimal impact due to any future retreat of cliff slope.	• Will require construction and disturbance CGS cliff slope; • Backfilling of CGS cliff slope will require additional support or local regrading to match existing slope inclination

6.2 Discussion of impact

6.2.1 Option 1

Option 1 avoids placing a cable trench through the higher cliff slope and will use temporary sheet pile support to limit disturbance of the CGS slope. The location of the TJB works is effectively outside the CGS slope.

The location of the TJB within the upper part of the beach and within the tidal zone will result in future ingress of seawater around TJB.

The burial depth of the TJB will be such as to avoid the TBJ being exposed in the event of future retreat of the cliff slope. Notwithstanding the above, the likelihood of future retreat of the cliff slope could result in the TJB being eventually located within the beach, and at greater risk of exposure to tidal action. This would however have minimal impact on the CGS.

6.2.2 Option 2

Option 2 requires a cable trench to be formed through the higher cliff slope which will use temporary sheet pile support to limit disturbance of the CGS slope to the width of the cable trench. Option 2 will result in more disturbance of the CGS slope than Option 1.

Following the works, the cliff slope would need to be re-instated to best replicate the existing slope topography. As the existing cliff slope inclinations are considered over-steep and prone to failure then placement of excavated in situ material to form a similar slope inclination will not provide a long-term stable slope. A typical stable slope inclination for the in situ material is in the range 1V:2H to 3H, which if constructed would result in a notably flatter slope at the location of the cable trench.

Typical re-instatement solutions, which could be used in combination, to re-instate the cliff slope at the cable trench include but are not limited to:

(a) Provide geosynthetic supported slope within cable trench with suitable growing medium placed within front face.

(b) Place excavated in situ material at a stable slope inclination within the cable trench and locally re-grade adjacent existing slopes to match. This solution would have the benefit of limiting further instability of the adjacent cliff slopes.

(c) Place boulders/large stone plug (long-stop) near the front face of the cable trench to limit erosion of excavated in situ material within re-instated trench. This solution would likely be used in combination with the solutions above.

As the TJB is located at its nearest point about 20 m behind the crest of the cliff slope, this places the TJB beyond the range of cliff retreat estimated at say 5 to 10 m by 2050.

7 CONCLUSIONS

7.1 Findings

The findings are provided below:

1. As part of the Project it is proposed to locate the landfall about 0.7 km to the southwest of Dunany Point, in County Louth. At the landfall the offshore cable connects with the onshore cable within a TJB;
2. The landfall location comprises a cliff slope formed of soil about 6 to 7 m high fronted by a shingle beach. To the north the cliff line increases gradually in height towards Dunany Point. The soil in the cliff slope is glacial till;
3. The landfall location is located within the southern limit of the footprint of a designated CGS, Site Code: LH017 (Figure 2-3);
4. A desk study review of published information on coastal erosion at the landfall location predicts some retreat of the coastline from its 2020 location (Figure 3-1). For the purpose of this report, it is assumed that coastal retreat may be in the range of 5 to 10 m by 2050. Site inspection confirms that there are signs of coastal retreat at the landfall location;
5. The cliff slope at the landfall location and heading north comprises glacial soil which has essentially failed as multiple landslips along the entire length of the coast to Dunany Point;
6. Several key contributory factors are associated with the landslipping in this coastal area. A key contributory factor is wave and scour erosion at the toe of the cliff slope which has caused loss of soil material and loss of strength due to wetting of the lower slope which over time has destabilised the cliff slope;
7. A review of TJB Option 1 and Option 2 shows with respect to stability and impact of the works:
    a. The works associated with Option 1 are effectively outside the CGS slope and as such have minimal impact on the CSG slope.
    b. Option 2 requires a cable trench to be formed through the higher cliff slope which will use temporary sheet pile support to limit disturbance of the CGS slope to the width of the cable trench.
    c. The in-situ slope material in the CGS slope is a cohesive deposit and is naturally prone to erosion from wave and scour action, which would result in instability of the cliff slope.
    d. For Option 1 the location of the TJB at the toe of the slope with temporary sheet pile support will limit any disturbance of the CGS slope.
    e. For Option 2 the cable trench is to be formed through the higher cliff slope which will use temporary sheet pile support to limit disturbance of the CGS slope to the width of the cable trench. Re-statement of the slope face within the cable trench will be required.
8. From the above, both Option 1 and Option 2 are feasible with respect to limiting the impact of slope instability and coastal protection.

7.2 Recommendations

The recommendations are provided below:

1. The footprint of any works will be minimised using temporary support measures such as sheet piled excavations to limit impact on the cliff slope and CGS;
2. All re-instated slopes shall be formed at a stable inclination (typically 1V:2H to 3H) or will include suitable support, such as the use of geosynthetic, with a naturalistic undulating profile with appropriate re-planting by allowing natural revegetation. Note the current slope inclination of the cliff slope at the site is about 1V:0.84H (50 degs), which is not stable; and
3. In addition to the above, the following GSI recommendations (GSI, 2023a) are also to be included within the proposed works:
    a. Access to the site is to be provided for GSI staff during construction to record the exposures of glacial till within the works;

b. GSI are to be provided sufficient notification of the commencement of works to allow GSI staff the opportunity to schedule resources to inspect the site; and

c. OWL to discuss options with GSI to provide explanation of the significance of the CGS in the local community.

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APPENDIX A

Plates

Plate 1: General view of cliff slope at landfall location.

Plate 2: General view of landfall location and cliff slopes to north of landfall location.

Plate 3: Back-scarp of landslip in cliff slope at landfall location.

Plate 4: Close-up view of exposed glacial till within back-scarp of landslip at landfall location.

Plate 5: Minor erosion of toe of landslip material at landfall location.

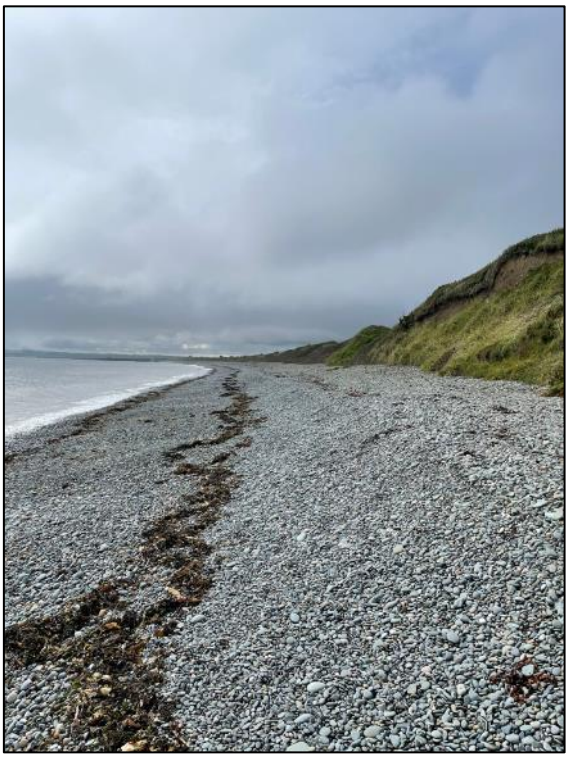


Plate 6: View south showing storm beach.

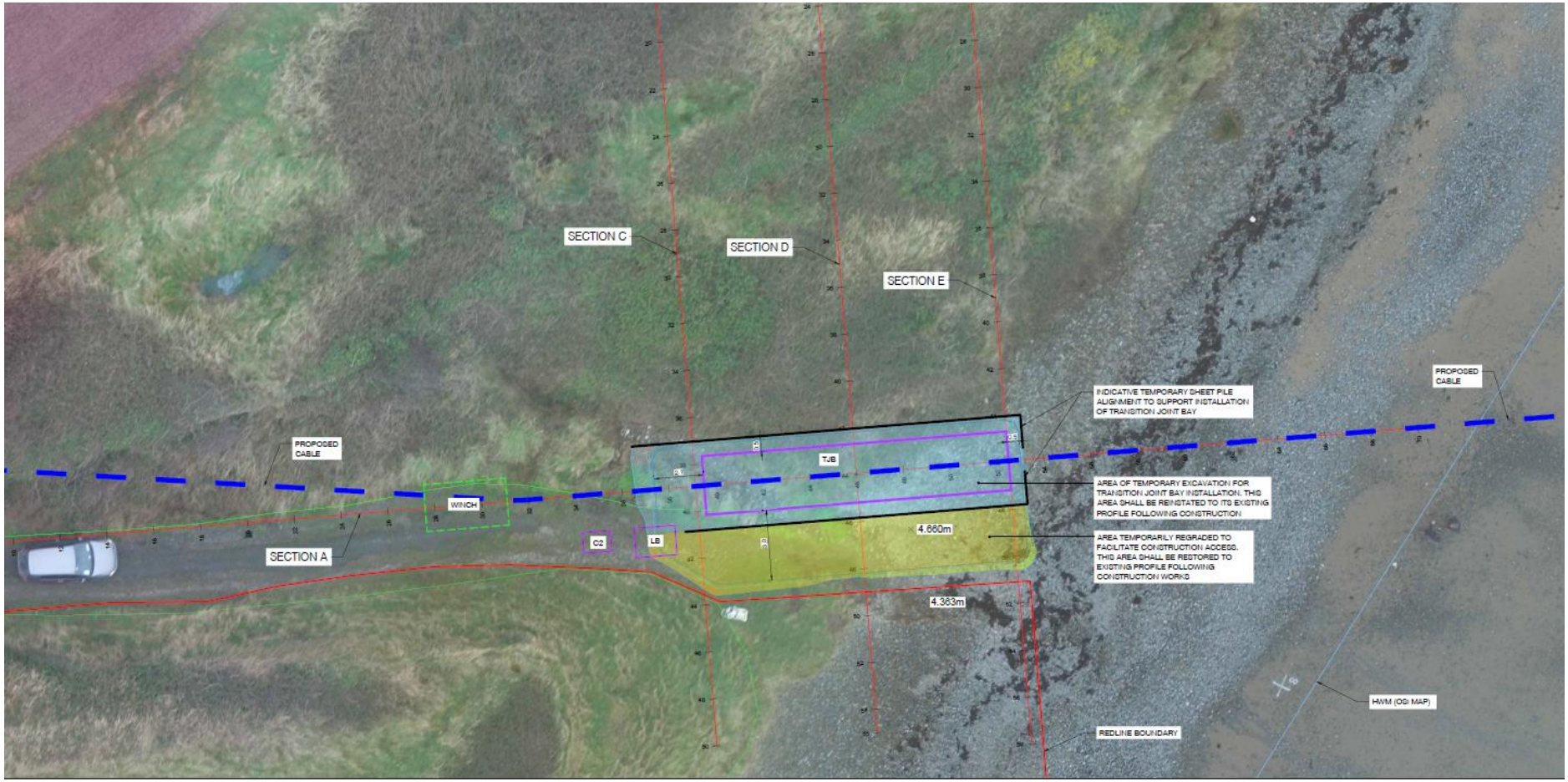
Plate 7: Increase in extent of active landslip in cliff slopes about 0.5 km north of landfall location.

Plate 8: Notable toe erosion in landslip material in cliff slope about 0.5 km north of landfall location.

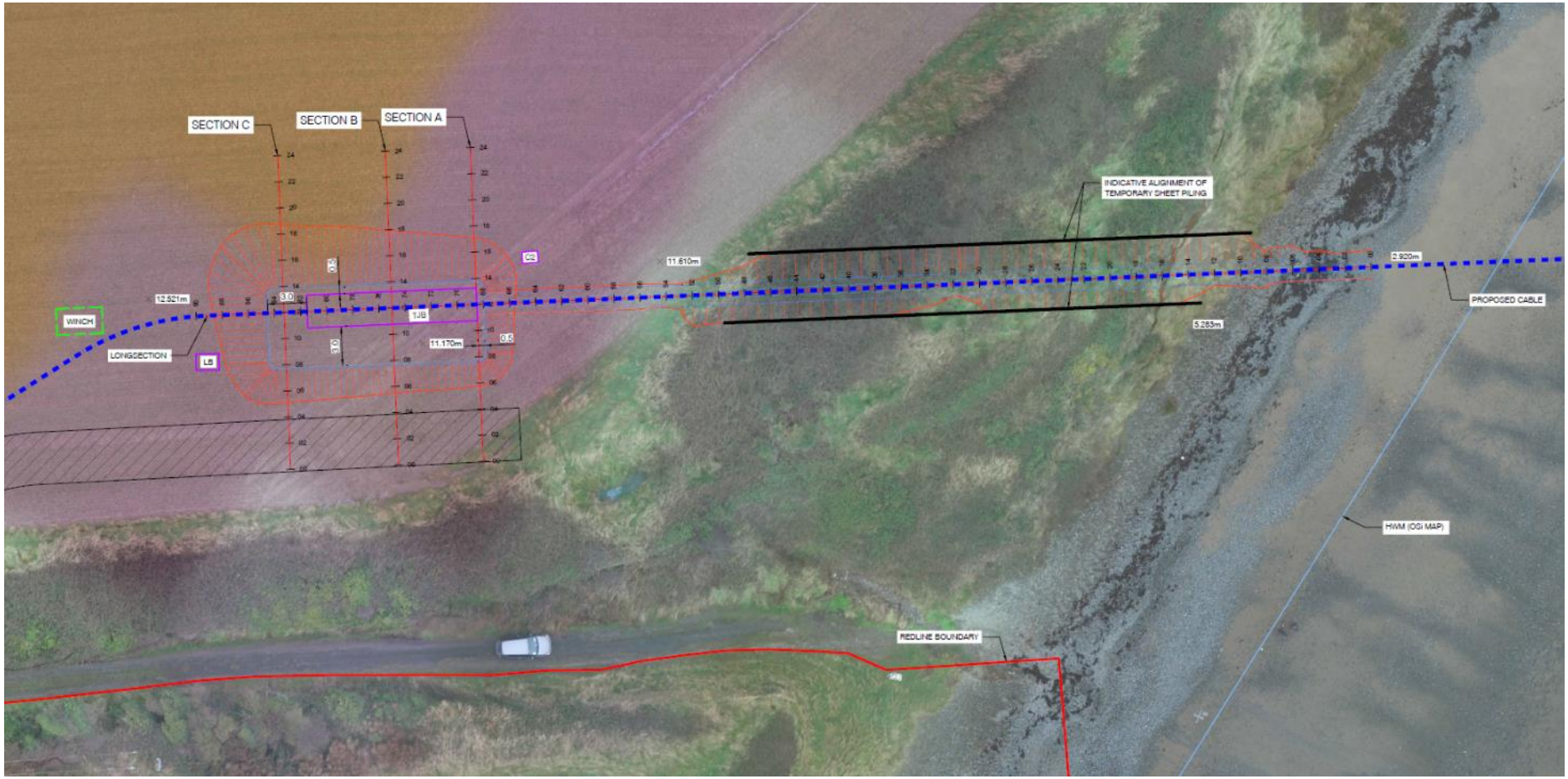
Plate 9: View south along crest of landslips in cliff slope.

APPENDIX B

Transition joint bay - options



Transition Joint Bay - Option 1



Transition Joint Bay - Option 2