1 Introduction

1.1 My name is Turlough Johnston and I am the Managing Director of Applied Ground Engineering Consultants (AGEC) Limited, an independent geotechnical engineering consultancy. I am a Chartered Engineering Geologist and have been working in these technical disciplines for more than twenty years both in Ireland and internationally. My experience includes major infrastructure projects and private development projects over challenging ground conditions both in Ireland and overseas.

1.2 This Brief of Evidence (BoE) pertains to the geotechnical issues of the ground stability assessment report including peat stability and stone road construction for the proposed Corrib Onshore Pipeline.

1.3 AGEC was commissioned by Shell E&P Ireland Limited (SEPIL) to undertake a ground stability assessment report in order to determine the potential for ground movement along the proposed pipeline route and also to provide geotechnical advice. AGEC also provided specialist geotechnical advice to Mayo County Council on the impact that the landslides that occurred on Dún Cheartáin (Dooncarton) Mountain in 2003.

1.4 The relevant geotechnical documents are included in the 2010 Environmental Impact Statement (EIS) Volume 2 Book 4 of 6 (Appendices M1A and M1B) and Book 5 of 6 (Appendices M2 to M4). The Geotechnical Risk Register (Appendix M4 of the 2010 EIS) and the proposed geotechnical supervision and monitoring as part of the Integrated Construction Programme were addressed in my 2009 BoE.

2 Qualifications and Experience

2.1 My qualifications and professional affiliations are;

MSc. Engineering Geology, Imperial College London
Diploma in Construction Law, Trinity College, Dublin
Chartered Engineering Geologist
Member of the Geotechnical Society of Ireland / Engineers Ireland
Member of the British Geotechnical Association
Member of the Society of Construction Law
Fellow of the Geological Society of London
Fellow of the Institution of Civil Engineering Surveyors

3 Knowledge of the Site and Related Activities

3.1 I have been involved in the Corrib Onshore Gas project since 2002. My involvement has included the design of ground investigations, the interpretation of the ground conditions, the geotechnical assessment and design with respect to peat areas for the Bellanaboy Bridge Gas Terminal site and the Onshore Pipeline.

3.2 AGEC has been involved continuously from the geotechnical investigations through to the establishment and recording of geotechnical monitoring for the Terminal construction. I have been a frequent visitor to the Terminal during its construction and have received continuous detailed reports throughout the ground investigations and construction activities.

3.3 In 2004, AGEC was instructed by SEPIL to carry out a site investigation for the onshore pipeline from the Corrib Gas Terminal Site to the Glenamoy River Estuary (EIS Volume 2, Book 4 of 6, Appendix M1-B). The purpose of the 2004 site investigation was to determine the ground conditions of the pipeline route for the construction of the pipeline, particularly the peat condition, and to assess the depth and strength of the peat for assessment of peat stability. The site investigation work was carried out between May and July 2004.

3.4 Further ground investigations were carried out along the route since 2004, these included Geotechnical & Environmental Services (2007), Irish Drilling Limited (2008), RPS (2008), AGEC (2009) RPS (2010) and AGEC (2010). Further ground investigations will also be carried out along the route of the pipeline.

3.5 I had oversight of the following AGEC reporting (see EIS Book 5 of 6, Appendix M2):

(1) ***Peat Stability Assessment***. This comprised a peat stability assessment for the proposed onshore pipeline route from the landfall at Glengad Headland to the Bellanaboy terminal site. This involved the assessment of the stability of natural peat slopes along the proposed pipeline route. The assessment was based on a walkover survey, review and interpretation of the ground investigation (GI) data, and stability analysis.

(2) ***Geotechnical Assessment of Stone Road Construction in Peat Areas***. This geotechnical assessment examined the proposed use of stone road construction in areas of peat for the proposed Corrib onshore pipeline. This involved a comparison of alternative road construction methods in peat, an assessment of ground investigation, an interpretation of ground conditions, and stability analysis of the stone road.

(3) ***Assessment of Landslide Impact on Stone Road in Peat****.* An assessment of landslide impact on the stone road within peat was carried out using an applied lateral load to simulate the impact of a hypothetical landslide to determine the stability. The assessment assumes that the stone road is founded on a hypothetical layer of weak sensitive clay.

(4) ***Qualitative Risk Assessment of the Relative Potential for Peat Failure****.* A qualitative assessment of the relative potential for peat failure was carried out along the proposed pipeline route in peat areas. This used a basket of environmental factors to determine the relative potential for peat failure with respect to sections of the proposed pipeline route.

(5) ***Ground Stability Risk Associated with Site of Landfall Valve Installation (LVI)****.* This geotechnical assessment examined the stability of the cliff at the proposed site of the Landfall Valve Installation (LVI) for the proposed onshore gas pipeline.

(6) ***Ground Stability Risk Associated with Landsliding in Peat Areas***. This addresses the likely risk of ground movement as a result of landsliding within the peat areas along the route of the onshore pipeline.

(7) ***Ground Stability Risk Associated with Landslides Originating on Dooncarton Mountain***. The onshore pipeline crosses the Glengad Headland about 1km north of Dooncarton Mountain where in 2003 a number of shallow landslides occurred. The potential impact on the onshore pipeline and landfall valve installation (LVI) in the unlikely event of further landslides from Dooncarton Mountain is addressed.

(8) ***Ground Stability Risk Associated with Settlement of Pipeline and Associated Services in Peat Areas***. An assessment of the settlement of the stone road with the pipe and associated umbilical pipeline and service

ducts buried in the stone road was carried out. This includes a sensitivity analysis of the stone road settlement for predicted and worst case.

(9) ***Ground Stability Risk associated with Ruptured Water Pipe in Stone Road**.* An assessment of the effect on the stone road and the surrounding peat has been carried out in the event of an unlikely rupture of the water carrying outfall and umbilical pipes. This includes a qualitative assessment of the likely effect on the surrounding ground during initial rupture of the water pipe and the effects immediately post-rupture.

4 Scope of Evidence

4.1 This evidence considers the following:

(1) The geotechnical investigations undertaken and the sources of geotechnical information referenced.

(2) A geotechnical overview of the proposed pipeline route from the landfall at Glengad Headland to the Terminal including the Sruwaddacon Bay tunnel.

(3) Findings of ground stability assessment for the proposed pipeline route from the landfall at Glengad Headland to Terminal site.

4.2 This evidence draws from geotechnical mapping and reports compiled by various authors and contributors employed by AGEC and employed by RPS.

5 Geotechnical Investigations & Sources of Geotechnical Information

5.1 As detailed in my 2009 Witness Statement, the proposed route has been the subject of significant geotechnical investigations annotated on the relevant drawings included in EIS Volume 2, Book 4 of 6, Appendix M1-A. The geotechnical investigations were listed in my 2009 Brief of Evidence but in addition two further investigations were undertaken namely;

- RPS, 2010. Peat Probing (EIS Volume 2, Book 4 of 6, Appendix M1-A)
- AGEC, 2010. Peat Probing (EIS Volume 2, Book 4 of 6, Appendix M1-A)

Other sources referenced from publicly available data were also listed in my 2009 Brief of Evidence.

6 Geotechnical Overview of the Proposed Pipeline Route

6.1 Most of the proposed pipeline land route will be within peat or inorganic soils. Within Sruwaddacon Bay there are fluvial sediments of mainly sands and gravels with occasional cobbles and boulders to depths of about 25m over bedrock. Bedrock will only be encountered during construction of the landfall valve installation (LVI) at Glengad and in the construction of the proposed pipeline tunnel in Sruwaddacon Bay, where part of the tunnel will pass through bedrock.

6.2 Where the proposed pipeline on land is to be constructed in inorganic soils, it will be founded within medium dense to dense sand or gravel. A detailed geotechnical assessment of the sections of the route in inorganic soils is included in Volume 2, Book 4 of 6, Appendix M1 of the EIS. Where the proposed pipeline is to be constructed in peat, it will be founded within a stone road construction bearing on the underlying mineral soil with typically 0.5m of peat left in situ where appropriate. A detailed geotechnical assessment of the sections of the route in peat is included in Volume 2, Book 5 of 6, Appendices M2 and M3 of the EIS.

6.3 Ground conditions at Glengad between chainage ch. 83.4 and ch. 83.9 are recorded as made ground/topsoil underlain by loose to dense sands and medium to very dense gravels to depths of between about 3.85 and 5.0m below ground level (bgl). Weak to strong moderately weathered psammite bedrock with locally highly weathered zones were recorded below the overburden material.

6.4 Ground conditions within Sruwaddacon Bay comprise dominantly fluvial sediments of varying thickness underlain by bedrock. A detailed Sruwaddacon Bay geological long-section is annotated in three parts on AGEC Drawings 1045_002, 003 and 004 titled ‘Plan and Section showing Sruwaddacon Bay Geology’ (included in Addendum Report titled “Interim Summary Geotechnical Interpretative Report – Foreshore Ground Investigation – Sruwaddacon Bay”. Sediments range from coarse gravels to silts and very occasional thin organic rich bands. Most of the deposits are fluvial in origin. Sediment thicknesses vary from about 2m up to 25m at the mouth of the bay.

The recent site investigation fieldwork has revealed ground conditions in Sruwaddacon Bay as follows (as annotated on the Ground Profile table below): Fine to medium sand (estuarine deposit), organic silt and very localised peat, sand and gravel (possible glacial soil) and bedrock.

Ground Profile of Sruwaddacon Bay (Interim)

Strata	**Depth to Top of Strata (m bsl)** (Note 1)	**Maximum Thickness of Strata (m)** (Note 2)
Fine to medium sand (estuarine deposit)	Seabed level	20.2
Organic silt and very localised peat	12 to 14	2
Sand and gravel (possible glacial soil)	3.8 to 20.2	1.2 to 10.2
Bedrock	5.2 to 24.8	-

Notes
(1) Depth given as metres below seabed level (m bsl)
(2) Maximum recorded strata thickness based on the current ground investigation data.

Bedrock within Sruwaddacon Bay comprises psammite rock with bands of semi pelite, quartz muscovite schist, semi-pelitic schist and psammitic schist. Rockhead was encountered between 5.2m and 24.8m below seabed level in boreholes. The recovered rock cores were generally highly fractured. Rock strength from Point Load and Unconfined Compressive Strength (UCS) testing varied from very weak to extremely strong.

6.5 Peat is present along the section of the pipeline route south of Sruwaddacon Bay i.e. from Aghoos to the terminal site. Ground conditions from Aghoos to the L-1202 road (ch. 88.65 to ch. 90.15) comprised grassland over peat (ch. 88.65 and ch. 89.55); and as forestry over peat (between ch. 89.55 and ch. 90.15). Peat depths are recorded between 0.4m to 4.2mbgl overlying granular and cohesive soils which in turn overlie bedrock between 8.8m and 25.4mbgl. Peat is recorded as very soft and fibrous; the cohesive mineral soil is recorded as locally very soft to soft sandy gravelly clay and as stiff slightly sandy gravelly clay. Bedrock is recorded as moderately weak to moderately strong psammite. Groundwater was struck in exploratory holes between ground level and 2.3mbgl.

6.6 Ground conditions between ch. 90.15 to ch. 91.72 (L-1202 to Terminal Site) are recorded as peat over mineral soil with peat depths ranging from about 2.1m up to 5.0m, with an average depth of 3.3m. Peat is recorded as very soft to soft and the mineral soil is recorded as grey/brown slightly silty gravelly sand with occasional cobbles (Upper Till) overlying blue grey clayey gravelly fine sand with occasional cobbles (Lower Till). A section of stone road has been safely completed between ch. 90.73 to ch. 91.69.

7 Findings of Ground Stability Assessments

The findings of the ground stability assessments along the line of the proposed onshore pipeline route are provided below. It is noteworthy that the slope stability analyses included in this report have been carried out using Eurocode 7 (NSAI 2005 and 2007). Using Eurocode 7 (EC7), a computed factor of safety (fos) for a slope of unity (=1) or greater satisfies the requirements of EC7 and provides an acceptable margin of safety against failure. This EC7 fos is annotated as FoS_{EC7} and is equivalent to the traditional (BS 6031) global fos for slopes of 1.3 or greater. Where appropriate the equivalent (traditional) global fos is also included in the reporting.

The slope instability is considered negligible or unlikely to occur in all assessments, giving the failure frequency in the range of 0 to (9×10^{-5}) in accordance with PD 8010-3:2009 Table B.15.

7.1 Peat Stability Assessment

(1) The walkover survey of the pipeline route was carried out to identify salient ground conditions, in particular evidence of peat instability. The survey identified no evidence of peat failure that would pose a risk to the pipeline route.

(2) Results of a stability analysis showed that the natural peat slopes along the proposed pipeline route have an acceptable and relatively high Factor

of Safety. The high calculated Factors of Safety for the route correspond to the findings of the walkover survey of the route which identified no evidence of peat failure.

(3) Several localised areas of weaker peat were identified along the route. These areas are not considered to represent a risk to the pipeline construction, particularly taking into account the use of a stone road construction method in peat.

(4) Taking into account the findings of the walkover survey, the results of the stability analysis and the proposed stone road construction method, it is considered that the pipeline can be safely constructed along the proposed pipeline route.

(5) The results of the peat stability assessment have been included in the pipeline design, as appropriate, and as noted in An Bord Pleanála letter to SEPIL of November 2nd 2009, *page 2 item (c)*.

(6) The results of the peat stability assessment for the area between the proposed Aghoos compound and the shoreline indicate undrained shear strengths in the range 21 to 125kPa, with an average value of about 44kPa. Slope angles recorded for the site range from 1 degree at the proposed compound to 3 degrees closer to the foreshore and peat depth across the site ranges from 0.2 to 3.25m with an average depth of 1.7m based on probe data.

For the undrained condition for the peat, the calculated FoS_{EC7} for all load conditions are in excess of 1.0 for each location analysed with a range of FoS_{EC7} of 8.54 to in excess of 10.

For the drained condition for the peat, the calculated FoS for all load conditions is in excess of 1.0 for each location analysed with a range of FoS_{EC7} of 1.74 to in excess of 10. The load conditions analysed included (1) without surcharge and (2) with the equivalent of 1m peat surcharge.

In summary, the stability analysis results show that the FoS_{EC7} for the Aghoos site are acceptable

7.2 Assessment of Stone Road in Peat Areas

(1) As stated in my 2009 BoE, stone road construction in peat areas is a proven method.

(2) As stated in my 2009 BoE the stone road provides a robust working platform to install the pipeline and is an extremely low risk construction method in peat.

(3) Analyses were carried out to assess the stability of the stone road under various load cases (load conditions (1) and (2)). The results clearly show that the stone road has an acceptable and high Factor of Safety and provides a robust and stable platform for construction and long term stability, as would be expected from such a large gravity fill structure.

(4) The long-term stability of the stone road in the peat was examined, i.e. the drained condition. The installation of the stone road into the peat provides an acceptable and high long term Factor of Safety and also enhances the stability of the natural peat slope. This is as a result of the inherent greater shear resistance to sliding provided by the stone fill forming the road. The risk of instability of the stone road during the operation of the pipeline is considered to be extremely unlikely.

7.3 Assessment of Landslide Impact on Stone Road in Peat

(1) This assessment was requested in June 2009 by the Inspector chairing the An Bord Pleanála (ABP) Oral Hearing of the Corrib Onshore Pipeline and was originally included as additional information at the time. This assessment supersedes that previously submitted as the slope stability analyses included in this EIS (2010) have been carried out using Eurocode 7 (NSAI 2005 and 2007) as appropriate.

(2) Assuming a failure along a fictitious weak sensitive clay layer (as requested by ABP in June 2009) under the road the lateral resistance of the road to a hypothetical landslide impact was determined. The results show the road could resist approximately 50kN per m run.

(3) The calculation was repeated using actual ground conditions. The actual ground conditions below the peat comprise essentially clayey and gravelly sand. An acceptable FoS_{EC7} of 1.56 is obtained for lateral loads

up to 75kN, which approximates to a hypothetical landslide impact loading.

(4) It is noted that the presence of a weak sensitive soil layer is identified as a risk to the works and included in the Geotechnical Risk Register included in the EIS, Volume 2, Book 5 of 6, Appendix M4, no.14. The Geotechnical Risk Register provides control measures where sensitive soil is encountered.

7.4 Qualitative Risk Assessment of the Relative Potential for Peat Failure

(1) This assessment was requested in June 2009 by the Inspector chairing the An Bord Pleanála (ABP) Oral Hearing of the Corrib Onshore Pipeline and was originally included as additional information at that time. An Bord Pleanála letter to SEPIL of November 2nd 2009, *page 3 items (l) and (m)*, also requested this information. This assessment supersedes that previously submitted.

(2) The qualitative risk assessment provides a score of the relative peat failure potential based on a number of environmental factors. The results of the assessment can be used to inform any confirmatory investigation and to indicate to supervising geotechnical engineers during construction of possible stability issues.

(3) The highest scores, representing greater relative failure potential, were determined for sections of the pipeline route located directly downslope of the terminal. The stone road has already been safely constructed through these sections.

(4) Based on the results of the qualitative risk assessment, mitigation measures have been produced for the sections of the pipeline route in peat.

7.5 Ground Stability Risk Associated with Site of Landfall Valve Installation (LVI)

(1) Details of the geotechnical assessment and its findings were provided in my 2009 BoE. Visual inspection showed that the natural shoreline cliff was slowly retreating inland as a result of repeated minor failure and erosion of soil. The annual rate of soil cliff regression estimated from the

historical review is estimated at 0.03m per year. As stated in my 2009 BoE; locally less frequent but greater rates of regression up to 2m would be expected due to localised minor slumping or erosion of fill slope.

(2) Given the low rate of cliff regression, the distance of the LVI building from the cliff and the proposed set-back distances for works it is considered that there is negligible risk to the LVI as a result of ground movement due to cliff regression for the design life of the project.

7.6 Ground Stability Risk Associated with Landsliding in Peat Areas

(1) Local susceptibility to landsliding has been assessed along the onshore pipeline route using site specific data. Results show that the natural peat slopes along the proposed pipeline route have an acceptable and relatively high Factor of Safety.

(2) Notwithstanding the above, the onshore pipeline route design in peat areas includes for the use of a stone road, which is up to 12m wide, into which the gas pipeline is buried. The stone road is an integral mitigation measure for the onshore pipeline route in peat and provides a secure platform in which to install the pipeline.

(3) Stability results clearly show that the stone road has an acceptable and high Factor of Safety and provides a robust and stable platform for construction and long term stability.

(4) The installation of the stone road into the peat provides an acceptable and high long term Factor of Safety, and notably increases the stability of the natural peat slope. The risk of instability of the stone road during the operation of the pipeline is considered to be extremely unlikely.

7.7 Ground Stability Risk Associated with Landslides Originating on Dooncarton Mountain

(1) The onshore pipeline route crosses the Glengad Headland about 1km north of Dooncarton Mountain where in 2003 a number of shallow landslides occurred. An assessment was carried out of the potential impact on the onshore pipeline and landfall valve installation in the unlikely event of further landslides from Dooncarton Mountain.

(2) Given the decreasing slope inclinations away from Dooncarton Mountain and the various obstructions to debris flows such as earthen ditches, fences, roads, buildings it is considered that a debris flow on an open slope would not reach the pipeline route or landfall valve installation.

(3) Debris flows on open slopes are considered to have no impact on the pipeline route and LVI. Debris flows that move down-slope however could enter existing watercourses. Once channelised within the watercourse, the debris flows would travel a greater distance compared to a debris flow on an open slope.

(4) Where watercourses cross the route the pipeline is protected being buried at depth (1.6m below the cleaned base of the watercourse) with a concrete slab placed over the top of the pipeline, see EIS, Book of Drawings, Drawing DG702.

(5) At Glengad, where the pipeline route is closest to the failures on Dooncarton Mountain, the pipeline is buried at a depth of about 5m within an infilled concrete lined tunnel and as such there is considered to be no risk to the pipeline. Several channels which were eroded during the 2003 landslide enter the bay at this location. A walkover assessment of the 2003 failure scars on Dooncarton Mountain was carried out in July 2010 to assess the current stability of the scars. Detailed inspection of the scars showed that in general the basal surface of the scars was re-vegetating and that detached peat/soil debris in the scars was eroding in situ, indicating that slope movement had effectively ceased. Inspection of the upper end of the scars showed no apparent signs of further cracking or detachment (retrogression) of soil upslope. There was little sign of debris downslope of the scars which indicated that most debris was either washed from the slope or has since re-vegetated in situ. Overall, the scars do not show signs of re-activation and continue to stabilise since the failures in 2003.

(6) An assessment of vibrations induced by the tunnel within Sruwaddacon Bay was carried out and is presented in Appendix H2 and H3 of the EIS. In Appendix H2, section 4.1.1 the vibration at 240m distance from the tunnel, which is the location of the nearest residential house, ranges from 0.01 to 0.02mm/s. The distance from the tunnel to the location of the critical upper slopes of Dooncarton Mountain, where failures occurred in

2003, is 800m or greater. At this distance the vibrations would be notably significantly less than those given above and the effect on the slopes is considered negligible.

With respect to ground vibrations produced by road traffic, these are unlikely to cause perceptible vibrations in properties located near well-maintained and smooth road surfaces. Road traffic vibration levels can therefore be largely avoided by maintenance of the road surface (refer Appendix H1, section 6.2). The distance from the main road to the location of the critical upper slopes of Dooncarton Mountain, where failures occurred in 2003, is 320m or greater; at these distances the effects of road traffic vibrations are considered to be negligible.

The cumulative effect of traffic and tunnel vibration on the critical upper slopes of Dooncarton Mountain is considered also to be negligible.

7.8 Ground Stability Risk Associated with Settlement of Pipeline and Associated Services in Peat Areas

(1) This assessment was requested in June 2009 by the Inspector chairing the An Bord Pleanála Oral Hearing of the Corrib Onshore Pipeline and was originally included as additional information at the time. An Bord Pleanála letter to SEPIL of November 2nd 2009, item (n), also requested this information. This assessment supersedes that previously submitted.

(2) The settlement of the pipeline within the stone road has been determined for several cases. Based on calculations by the pipeline designers it is concluded that the onshore pipeline routed through areas of peat and installed in the proposed stone road would not be subject to failure due to the predicted worst case settlement of the stone road. The risk of pipeline rupture due to settlement is considered to be negligible to extremely unlikely.

(3) As stone will penetrate into any peat underlying the stone road the theoretical settlement of the underlying peat will be notably reduced. Furthermore, a substantial proportion of settlement is likely to occur prior to laying of the pipeline and associated umbilical and service ducts due to traffic loading and the time that the stone road loading has been in place.

(4) Monitoring of ground movements will be carried out along the stone road during and following completion of stone road construction to ensure that settlement is within acceptable tolerances.

(5) Monitoring instrumentation shall include survey markers installed at regular intervals along the length of the stone road to monitor movement. In areas of deeper peat, inclinometers will be installed in peat adjacent to the stone road to monitor any possible lateral movement of the peat. Groundwater levels will be monitored from drive-in piezometers installed in deeper peat areas in advance of stone road construction. Information on monitoring movement of the pipeline, particularly in deep peat areas, was requested in An Bord Pleanála letter to SEPIL of November 2nd 2009, item (c).

(6) Construction staff will be made fully aware of the ground conditions expected along the route of the pipeline. A dedicated geotechnical engineer will be employed to oversee construction monitoring with respect to ground movements.

7.9 **Ground Stability Risk associated with Ruptured Water Pipe in Stone Road**

(1) In the unlikely event of a sudden and complete rupture of water bearing services associated with the pipeline, the extent of any structural instability to the stone road would be localised and would not affect the ability of the stone road to safely support the pipeline and services.

(2) As peat is essentially saturated and has a very low permeability, no further water is likely to be readily taken into the peat adjacent the stone road as a result of a rupture. As such, escaped water entering the peat mass is not considered a stability risk.

(3) Escaped water from a rupture is likely in part to be contained within the stone road fill, with an amount of escaped water draining into existing surface drainage.

(4) In summary, the likely effect of a rupture of the water-bearing services in the stone road is localised seepage and possible loosening of stone within the road above the rupture. Larger scale ground movement of the stone road peat mass is not considered a stability risk. Escape of water

from a rupture of water-bearing services is considered a negligible to extremely unlikely stability risk.

8 Indirect, Cumulative Impacts and Impact Interactions

8.1 The specific background to this section of my BoE is detailed in EIS Volume 1, Chapter 17, Section 17.3.5.4 'Soils and Geology'.

8.2 In the short term, it is noted that for the Onshore Corrib Gas Pipeline, there will be a slight impact due to the localised loss and/or compaction of peaty soils during construction. A stone road will remain permanently in place for the section of the pipeline route in peatland and the surface will be reinstated with peat excavated and stored on site during construction. A 4.9km grouted tunnel will also be in place. The Landfall Valve Installation (LVI) will be constructed within an excavated dished area in Gleann an Ghad (Glengad).

8.3 Once construction has been completed and after the full implementation of the mitigation measures, there will be an imperceptible impact on soils and geology.

8.4 A number of the individual elements of the project have the potential to result in localised impacts on geology and soils. Any cumulative impacts would not be synergistic, i.e. the combination of these impacts will not result in a more significant impact on soils and geology. Therefore the cumulative impact is considered to be slight.

9 Issues Raised in Third Party Submissions 2010.

9.1 Peat Landslip on L-1202 Road, Aughoos, Erris, May 2008.

(1) This issue was addressed in my 2009 BoE but for ease of reference is reiterated as follows:

(2) In comparison to the events at Dooncarton in September 2003, the peat landslip on L-1202 road, Aughoos, Erris in May 2008 was relatively minor in nature. The incident was located adjacent to a minor public road (L-1202), approximately 1.25 km from the junction with the R314 in Aughoos. The incident occurred during widening works for the road by Mayo County Council on 8 May 2008.

(3) The L-1202 incident comprised movement of peat over a length of over 40m along the north side of the road. The movement appeared to extend some 15 to 20m distance away from the road and affected an area possibly up to $800m^2$ with peat depth estimated at 2 to 3m. Total affected volume was estimated at up to $2400m^3$.

(4) The upper section of the failed peat (about 1m thick) appeared to be fibrous and was underlain by more amorphous peat. The incident area was vegetated by coarse grass, reeds with occasional bushes, trees and tree stumps with forestry some 30 to 50m from edge of the road. The lateral extent of the landslip was possibly controlled by the presence of drainage ditches that run perpendicular to the road.

(5) It is noteworthy that the existing road is a floating road and appeared to be essentially undamaged by the incident.

(6) The reasons for the incident are not known in detail but based on descriptions of the event and a cursory inspection of the site the possible cause of the landslip was bearing failure of the in situ peat due to excessive loading. The loading was likely as a result of placement of excavated peat and quarry stone being placed during the road widening. This loading likely caused a bearing failure within the in situ peat that would have initially failed as a rotational movement resulting in heave followed by limited translational movement.

(7) The inadvertent loading of weak peat has been identified in a number of peat failures. For the construction of the pipeline it is proposed to limit placing of load onto the peat surface by the construction of a stone road through the peat areas and consequently the risk of peat failure to construction is minimal.

(8) Stone road construction within peat areas is a recognised construction method for access in particularly deep peat areas and has been used for example on the Mayo-Galway gas pipeline. The constructed stone road provides a stable platform for subsequent construction work, so reducing construction impact on the surrounding peat, and provides secure ground in which to install the pipeline.

9.2 Sruwaddacon Bay Ground Investigation.

(1) SEPIL has engaged the services of a site investigation contractor to carry out ground investigation works within Sruwaddacon Bay. The works commenced in July 2010 and have included cable percussion (CP) and rotary drilling (CD) together with static cone penetration testing (CPT). The ground investigation works are being carried out from two jack-up rig barges within the bay. It should be noted that this work was ongoing at the time of compiling this BoE.

(2) The currently completed ground investigation **(AGEC Drawings 1045_002, 1045_003 and 1045_004)** has a typical spacing of about 100m. This coverage satisfies the spacing requirements of 20m to 200m for pipelines as set out in IS EN 1997-2: 1997 (Eurocode 7), Annex B.

(3) The findings of the current ground investigation confirm the ground conditions in Sruwaddacon Bay from previous geotechnical works.

(4) Within the current ground investigation the following field works have been completed to date:

(a) There have been eleven cable percussion (CP) boreholes completed. These exploratory holes have been sunk between depths of 5.3m (CP62) and 15m (CP40) and include: CP08, CP09, CP15, CP16, CP17, CP18, CP26, CP40, CP42, CP49, and CP62

(b) There have been thirteen rotary drill holes completed. These exploratory holes have been drilled between depths of 22.4m (CD12) and 41.7m (CD42). These exploratory holes are as follows; CD08, CD09, CD12, CD15, CD16, CD17, CD18, CD26, CD40, CD42, CD49, CD62 and CD63.

(c) There have been thirty one CPTs completed. These tests have been taken to depths between 5.3m (CPT62) and 21.4m (CPT08). The completed CPT tests are as follows; CPT08, CPT08A, CPT09, CPT10, CPT10A, CPT14, CPT16, CPT17, CPT17A, CPT17B, CPT17C, CPT17D, CPT18, CPT18A, CPT19, CPT20, CPT22, CPT24, CPT26, CPT28, CPT30, CPT31, CPT32, CPT34, CPT40, CPT49, CPT53, CPT57, CPT59, CPT62 and CPT63.

(5) The laboratory soils tests that have been carried out to date include Natural Moisture Content (NMC), Atterberg Limits, Particle Size Distribution (PSD), Sedimentation, Compaction, Chemical (pH, Sulphate and Chloride), Organic Content, Triaxial, Bulk Density, Permeability and Specific Gravity.

(6) The laboratory rock tests that have been carried out to date include Point Load Test (PLT), Uniaxial Compressive Strength (UCS), Cerchar, Porosity, Brazilian Tensile Strength, and Petrographic Analyses.

(7) The laboratory tests on water samples that have been carried out to date include Total Dissolved Solids, Chemical (pH, Sulphate and Chloride), Iron Content and Total Soluble Salts.

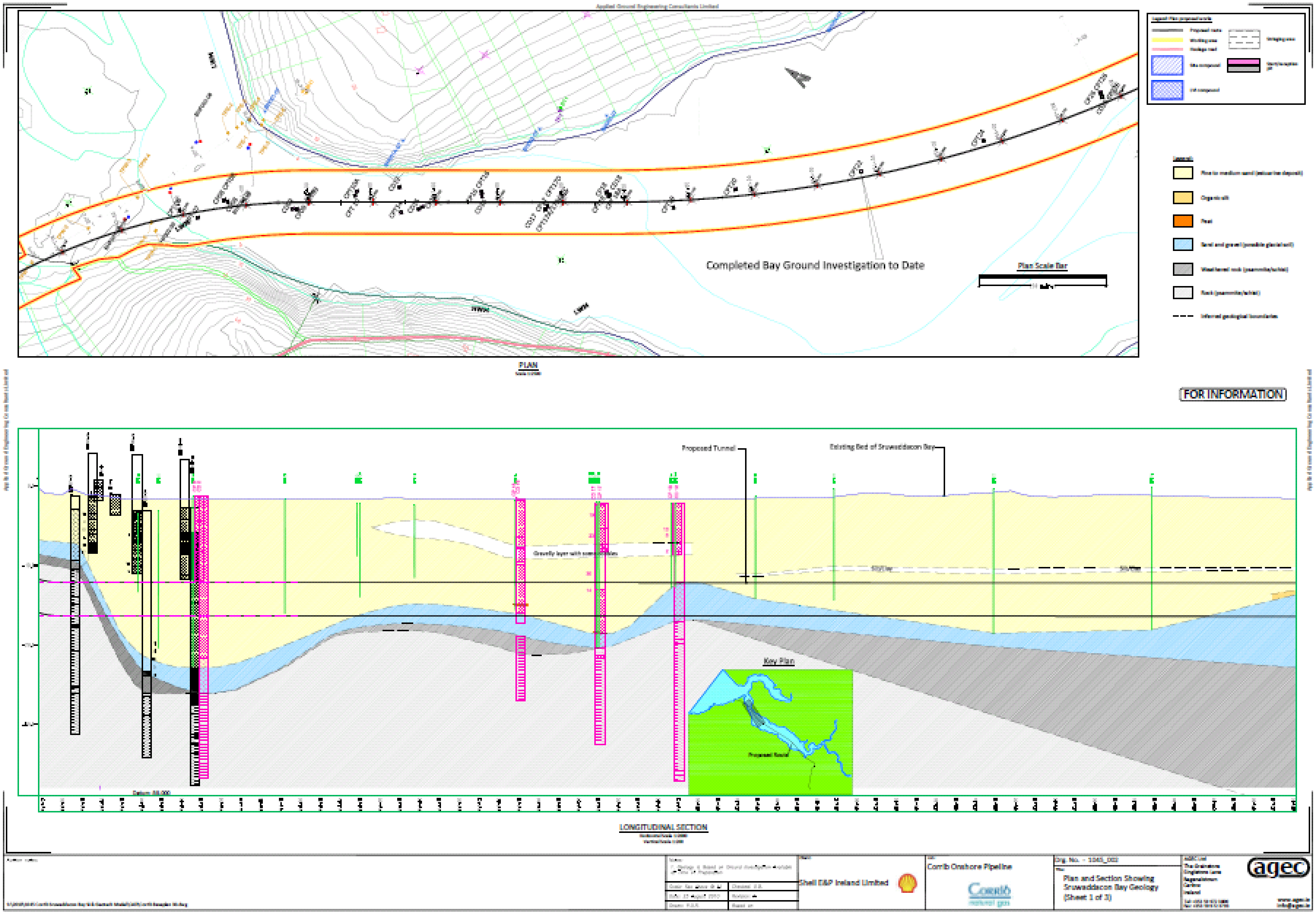
(8) Engineering classification of Sruwaddacon Bay sediments has been undertaken on samples recovered from the CP boreholes. The estuarine material has been classified in accordance with the National Roads Authority's Specification for Road Works (NRA SRW), Volume 1. From the results of grading tests the material is typically classified as a Class 1A (well graded granular material) and Class 1B (uniformly graded granular material). There are localised zones of Class 6A and Class 6C (selected well graded granular material) as recorded in borehole CP18.

Corrib Onshore Pipeline

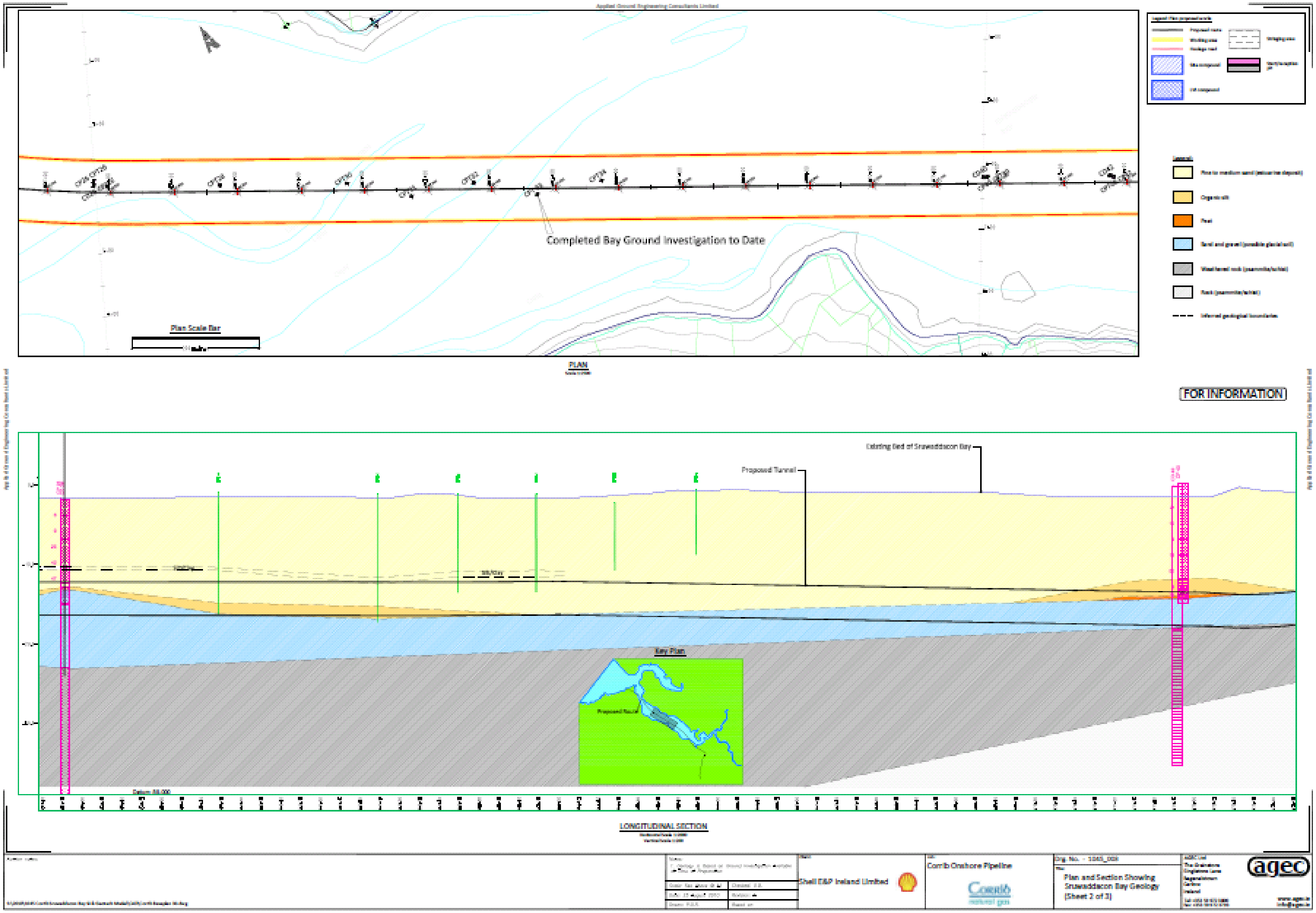
Geotechnical Issues

Turlough Johnston

(An Bord Pleanála Application Reference No.: GA0004)



Corrib natural gas



Completed Bay Ground Investigation to Date
Plan Scale Bar
PLAN
FOR INFORMATION
Existing Bed of Sruwaddacon Bay
Proposed Tunnel
Key Plan
Proposed Route
LONGITUDINAL SECTION
Shell E&P Ireland Limited
Corrib Onshore Pipeline
Plan and Section Showing
Sruwaddacon Bay Geology
(Sheet 2 of 3)
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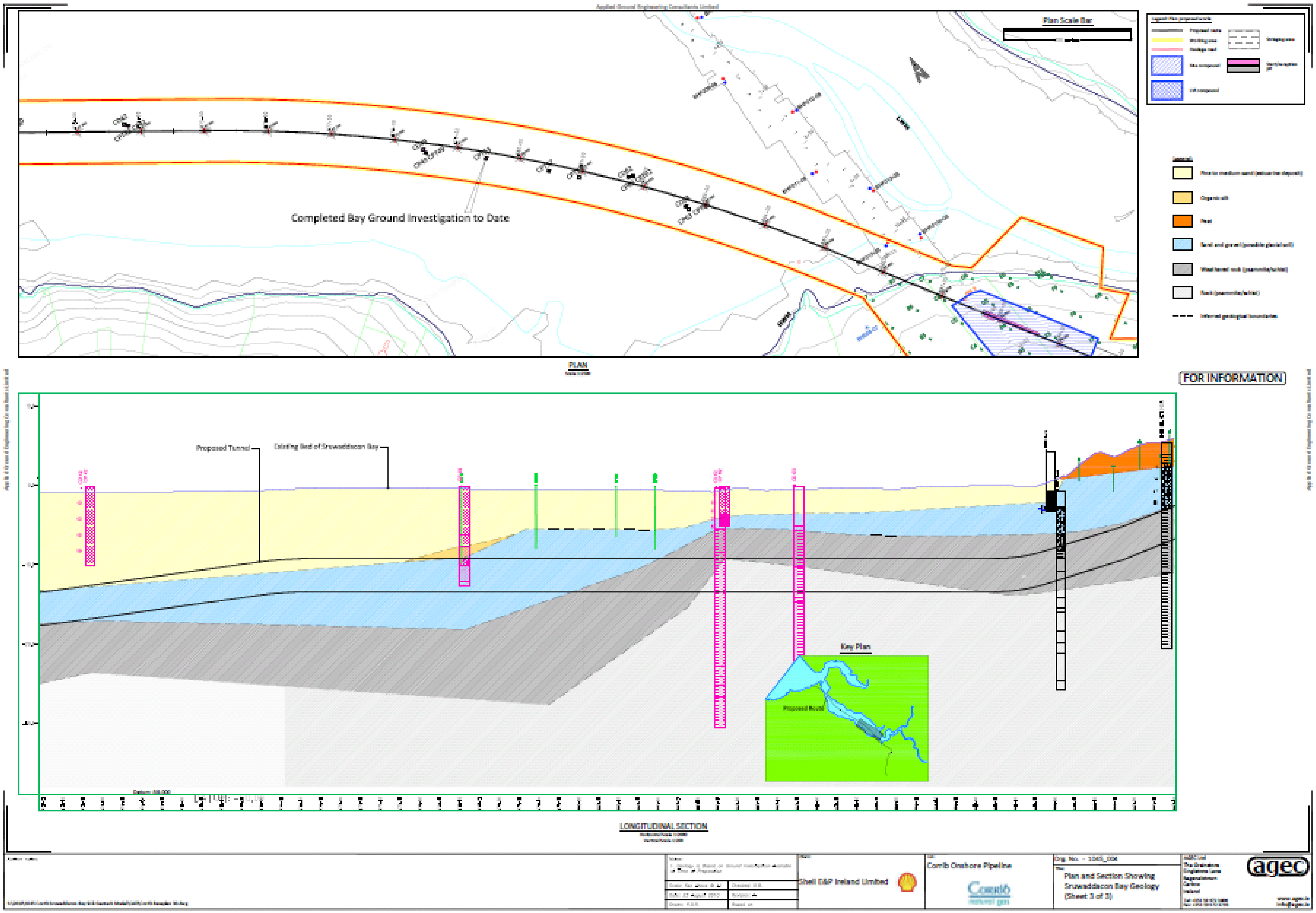
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