Appendix A.7.4

BD02 Menlough Viaduct

A.7.4

Galway County Council
N6 Galway City Ring Road
Menlough Viaduct

GCOB-4.04-020-010

Issue 4 | 23 October 2017

Job number 233985

Ove Arup & Partners Ireland Ltd

Arup
Arup Corporate House
City East Business Park
Ballybrit
Galway
Ireland
www.arup.com

ARUP

Document Verification

ARUP

Job title		N6 Galway City Ring Road		**Job number** 233985	
Document title		Menlough Viaduct		**File reference**	
Document ref		GCOB-4.04-020-010			
Revision	**Date**	**Filename**			
Draft 1		**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Reamonn MacReamoinn	Pat Moore	Eileen McCarthy
		Signature			
Issue	16 Dec 2016	**Filename**	GCOB-4.04-020-010_Issue.docx		
		Description	Issue		
			Prepared by	Checked by	Approved by
		Name	Reamonn MacReamoinn	Pat Moore	Eileen McCarthy
		Signature			
Issue 2	17 May 2017	**Filename**	GCOB-4.04-020-010_Menlough Viaduct PDR Issue 2.docx		
		Description	Issue 2		
			Prepared by	Checked by	Approved by
		Name	Yalda Acar	Pat Moore	Eileen McCarthy
		Signature			
Issue 3	31 Jul 2017	**Filename**	GCOB-4.04-020-010_Menlough Viaduct PDR Issue 3.docx		
		Description	Issue 3		
			Prepared by	Checked by	Approved by
		Name	Yalda Acar	Pat Moore	Eileen McCarthy
		Signature			

Issue Document Verification with Document ✓

Document Verification

Job title	N6 Galway City Ring Road	Job number 233985
Document title	Menlough Viaduct	**File reference**
Document ref	GCOB-4.04-020-010	

Revision	Date	Filename	GCOB-4.04-020-010_Menlough Viaduct PDR I4.docx		
Issue 4	23 Oct 2017	**Description**	Issue 4		
			Prepared by	Checked by	Approved by
		Name	Yalda Acar	Pat Moore	Eileen McCarthy
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

Appendix A

Drawings

Appendix B

Geotechnical Factual Report

Appendix C

Constructability Report

1 Introduction

1.1 Design Brief

Galway County Council, Galway City Council, Transport Infrastructure Ireland (TII) (formerly NRA)[1] and the National Transport Authority are collaborating to develop a solution to the existing transportation issues in Galway City and its environs. The solution will include a smart mobility component, public transport component and a road component. The N6 Galway City Ring Road (N6 GCRR) is the road component.

As part of the N6 GCRR there are a number of structures envisaged. This report presents the preliminary design for the Menlough Viaduct (Structure S10/01) in accordance with the guidelines detailed within TII DN-STR-03001 (formally NRA BD02).

1.2 Project Background information

The N6 Galway City Outer Bypass, an earlier scheme, was previously developed and submitted to An Bord Pleanála (ABP) for approval on 1 December 2006. A brief summary of its history is outlined below.

On 28 November 2008, ABP delivered its decision in respect of the 2006 GCOB. ABP considered that the need for an outer bypass of Galway City connecting the existing N6 on the east to the R336 Coast Road on the west as an essential part of the strategic transport network of the Galway area had been established.

ABP granted approval for the eastern part of the scheme, the section from the N59 Moycullen Road east to the existing N6, inclusive of both junctions at the N59 Moycullen Road and the existing N6. In its decision, ABP noted its consideration of all data presented and granted approval as it considered that the part of the road development being approved would be an appropriate solution to the identified traffic needs of the city and surrounding area. ABP noted that there would be a localised severe impact on the Lough Corrib candidate Special Area of Conservation (cSAC) [2].

However, ABP was not satisfied with the western section of scheme between the N59 Moycullen Road and R336 Coast Road which passed through Tonabrocky Bog. Tonabrocky Bog is:

- part of the Moycullen Bogs Natural Heritage Area (NHA)
- an active Blanket bog listed as an priority habitat in Annex I of the EU Habitats Directive

---

[1] The Minister for Transport, Tourism and Sport signed the order for the merger of the National Roads Authority (NRA) with the Railway Procurement Agency (RPA) to establish a single new entity called Transport Infrastructure Ireland (TII). The National Roads Authority is known as Transport Infrastructure Ireland (TII) since 1 August 2015.

[2] Reference ABP decision 07.ER.2056

- the site of a population of Slender cotton grass which is a legally protected and vulnerable species

ABP refused permission for the western section of the scheme between the N59 Moycullen Road and R336 Coast Road on the basis that this part of the road development would not be in accordance with the preservation of the Tonabrocky Bog habitat given the potential for significant adverse effects on the environment and that less damaging alternatives may be available[3].

An application was made by a third party to the High Court seeking leave to issue judicial review proceedings against the ABP decision which granted approval of the eastern section of the 2006 GCOB under Article 6(3) of the Habitats Directive (92/43/EEC), as amended. The basis for the request for a review was that ABP had erred in its interpretation of Article 6 of the Habitats Directive (92/43/EEC), as amended, in arriving at the conclusion that the effect of the 2006 GCOB road scheme on the Lough Corrib cSAC designated site would not constitute an adverse effect on the integrity of the site.

The High Court undertook a judicial review of the ABP decision. The High Court decision of 9 October 2009 upheld ABPs decision to approve the eastern part of the scheme. On 6 November 2009, the third party was granted leave to appeal to the Supreme Court against the High Court decision of 9 October 2009. The Supreme Court sought the opinion of the Court of Justice of the European Union (CJEU) on an interpretation of the Habitats Directive.

The opinion of the CJEU was delivered on the 11 April 2013 (Case C-258/11). The opinion concluded on two significant points:

- The 2006 GCOB would have an adverse effect on the integrity of the Lough Corrib cSAC due to the removal of 1.47ha of Limestone pavement (a habitat type for which the cSAC was selected)
- Given that the 2006 GCOB would have an adverse effect on the integrity of the cSAC, the proposed scheme could not be authorised under Article 6(3) of the Habitats Directive. It could only be authorised under Article 6(4) of the Habitats Directive

The CJEU opinion (i.e. Case C-258/11) established that the loss of a relatively small area of Priority Annex I habitat, where it is a habitat for which the Lough Corrib cSAC is selected, would adversely affect the integrity of the Lough Corrib cSAC and that the provisions of Article 6(4) must apply in granting consent for the project i.e.

6(4) "If, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected. It shall inform the Commission of the compensatory measures adopted".

Following receipt of the CJEU opinion, the Supreme Court quashed the earlier ABP decision to grant approval of the eastern section of the 2006 GCOB under Article 6(3) of the Habitats Directive, as amended.

As the decision of the Supreme Court was that the original 2006 GCOB scheme could not be granted approval per Article 6(3) of the Habitats Directive, the next recourse to secure planning was to advance the scheme under Article 6(4) of the Habitats Directive. Having reviewed the requirements of Article 6(4), it was decided to reassess the work to date to ensure that all possible alternatives were investigated in advance of proceeding under Article 6(4). Therefore, the process of developing a transportation solution for Galway City and its environs had to recommence from the start at Phase 1, feasibility and concept stage, to ensure that all possible alternatives were fully investigated.

1.3 Previous Studies and their Recommendations

Following on from the initial feasibility studies, a suitable scheme study area was determined. Thereafter the constraints study and route selection process commenced.

Key constraints were identified and examined. These included:

- The physical form of the city with the limited space available between Lough Corrib and Galway Bay
- Established communities, commercial and educational facilities
- Natura 2000 designated sites and Natural Heritage Areas
- Sites of significant architectural and cultural heritage

Taking cognisance of the judgement of the 2006 GCOB scheme, the Lough Corrib candidate Special Area of Conservation and the key constraints including those listed above, Route Options were developed for further assessment. These options comprised on-line options including an upgrade of existing infrastructure, partial on-line/off-line options and new construction off-line. These options were developed and agreed with TII and refined following public consultation and further studies.

A systematic assessment of these options was undertaken which led to the selection of the Emerging Preferred Route Corridor (EPRC) for the road component and this was published in May 2015. Full details of the route option selection process are outlined in the Route Selection Report for the N6 Galway City Transport Project.

Previous studies and documents relevant to this Preliminary Design Report are listed below.

- Galway County Council. Project Brief. Phase 1, Scheme Concept and Feasibility Studies (REF/14/11222, 2 May 2015).
- Galway County Council. Project Brief. Phase 2, Route Selection (REF/14/11222, 6 November 2015).
- GCOB-4.04-009 Route Selection Report, Issue 1, March 2016
- Galway Transport Strategy, An Integrated Transport Management Programme for Galway City and environs, Technical Report, September 2016

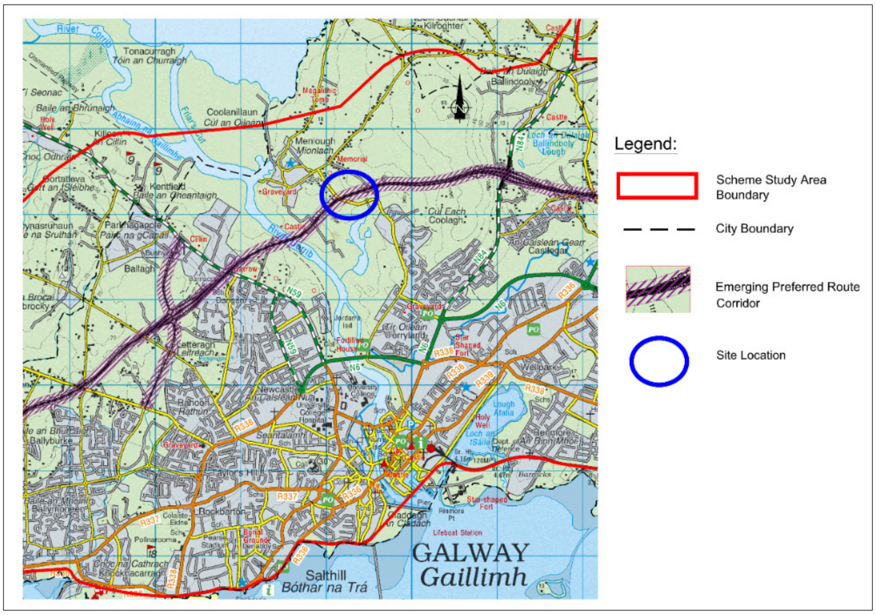
- GCOB-4.04-020-006, Menlough Viaduct Options Report, Issue 1, 11/10/2016

2 Site and Function

2.1 Site Location

The Menlough Viaduct (Figure 2.1) is located in the townland of Menlough, to the north of Galway City, on the EPRC for the N6 GCRR, between the River Corrib crossing to the west and Lackagh Tunnel to the east.

Figure 2.1: Menlough Viaduct Site Location



2.2 Function of the Structure and Obstacles Crossed

The purpose of the Menlough Viaduct is as follows:

- Elevate the proposed N6 GCRR above Limestone pavement, which is contiguous with and of similar quality to the Limestone pavement within the defined boundary of the Lough Corrib cSAC
- Cross over and maintain a Turlough feature
- Minimise the impact of the proposed road development on the area of priority Annex I habitat and Turlough feature during the construction and operational phases
- Facilitate wildlife movements (birds, bats (including the Lesser horseshoe bat) and mammals) by providing appropriate clearance and permeability
- Maintain adequate vehicular headroom over the local road in accordance with DN-GEO-03036 (Cross Sections and Headroom)

2.3 Choice of Location

An extensive constrains and route selection study was carried out for the proposed road development and its findings are presented in the Route Selection Report (GCOB-4.04-009). The EPRC was identified through a systematic assessment of the various route options with respect to the different constraints. The design of the N6 GCRR within the EPRC requires a crossing of the Limestone pavement and Turlough feature at the proposed location.

2.4 Site Description and Topography

It is located in a rural environment (**Figure 2.2**) and the terrain is undulating with rocky outcrops, local depressions and adjacent to the Lough Corrib candidate Special Area of Conservation (cSAC) to the south. In addition, the proposed road development is in the vicinity of a Turlough feature.

Given the exposed location, protection to wind susceptible vehicles may be necessary. An assessment of the wind climate at the Menlough Viaduct Bridge and an estimation of benefit to traffic from protection measures (windshields) is recommended at the next stage of design development

Figure 2.2: Menlough Viaduct Site Terrain

2.5 Vertical and Horizontal Alignments

At the viaduct location the mainline has a horizontal curvature, with a radius of 1020m in the western part and transitioning to a radius of 1440m in the eastern portion of the bridge. Due to the curvature, widening of the bridge is necessary to allow positioning of parapets outside the forward sightline stopping distance envelope. The additional widening needed results in a width of approximately 25.3m from back of verge on the northern side to back of verge on the southern side. The alignment also has a super-elevation of between 3.5% and 2.5% along the length of the bridge. This results in a bridge structure which is relatively wide for a standard dual carriageway. The vertical and horizontal alignments of the N6 GCRR and Bóthar Nua are given in **Table 2.1**.

Table 2.1: Vertical and horizontal alignments.

Name of Structure	N6 GCRR		Bóthar Nua	
	Vertical Alignment	Horizontal Alignment	Vertical Alignment	Horizontal Alignment
Menlough Viaduct	Crest Curve R=10000m	R=1020m transition for R=1440m	Crest Curve R=2000m	R=180m

2.6 Cross-Sectional Dimensions

The proposed cross section of the bridge deck is given in drawing **GCOB-D-ST-S10-01-002** and summarised in **Table 2.2** below.

Table 2.2: Dimensions on Bridge Deck (all Dimensions Measured Perpendicular to the Mainline)

Name of Structure	Carriageway Width [3] (m)	Verge [1] Width (m) - Left [2]	Verge [1] Width (m) - Right [2]	Parapet width (m) [Left]	Parapet width (m) [Right]
Menlough Viaduct	19.3 – 21.1	0.6	3.6	0.5	0.5

[1] The width of the verge includes any additional requirements due to sightline visibility.

[2] When considered in the direction of increasing chainage.

[3] Carriageway width measures from outer edge of hardshoulders (includes central reserve)

Due to the overall length of the bridge, (circa 320m), a reduced hard shoulder, from 2.5m to 0.5m is applied along the length of the structure, excluding any over widening necessary for forward stopping distances.

2.7 Existing Underground and Overground Services

All the utility providers have been consulted during the preliminary design process. The existing services in the vicinity of the proposed structures are outlined in **Table 2.3** below.

Table 2.3: Existing Services

Name of Structure	Existing Services
Menlough Viaduct	ESB MV/LV Overhead line (will be diverted and existing line decommissioned as part of the design proposals), SSE, Aircricity, Eir Overhead line (will be diverted underground and existing line decommissioned as part of the design proposals)

2.8 Geotechnical Summary

Based on available information, the ground conditions at the structure consist of shallow or outcropping rock in the form of Limestone pavement.

Isolated areas of soft to firm cohesive glacial till are also present. The underlying limestone rock is medium strong to very strong with frequent discontinuities.

The assessment of the geology, ground conditions and geotechnical aspects of the design and construction of the proposed road development at Menlough Viaduct is based on the following information:

- The proposed development boundary
- The proposed vertical and horizontal alignment
- The available ground investigation information

The ground conditions along the proposed road development were determined using various sources of information including historic data, photographic evidence, observations from site walkovers, intrusive and non-intrusive site investigations, laboratory testing and on site investigation monitoring.

A conservative geotechnical design approach has been adopted for this assessment. In the event that supplementary information is made available the information will be assessed and the results of the assessment may lead to a more efficient design solution.

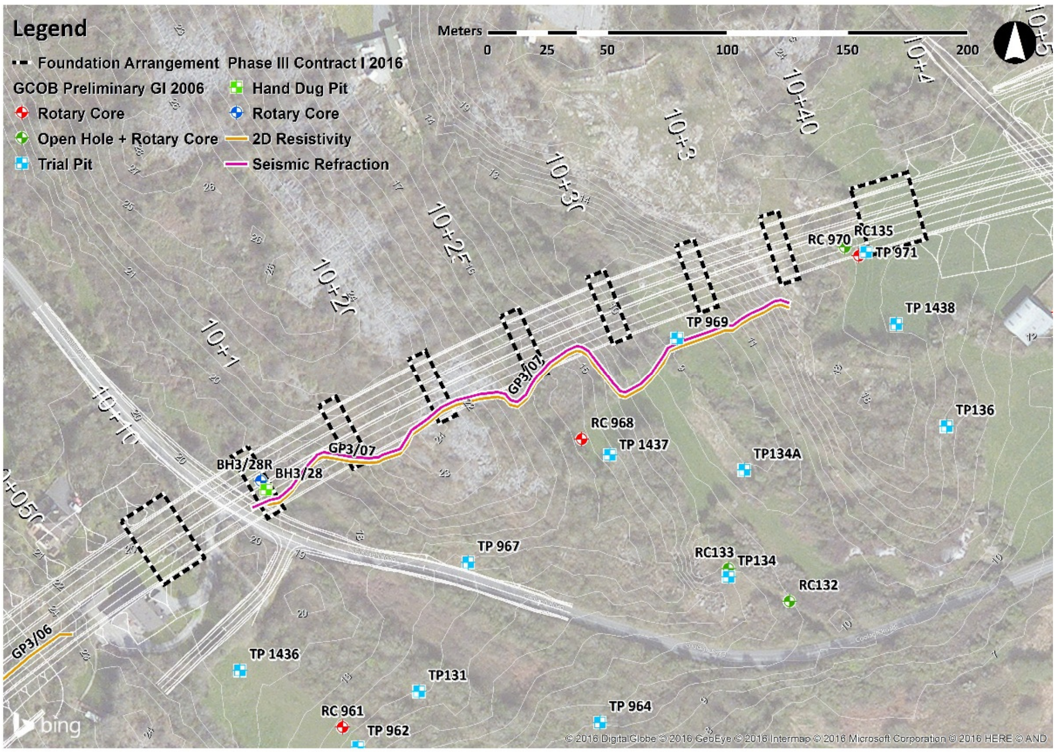
2.8.1 Ground Investigations

Ground investigations were conducted at the viaduct location and in the immediate vicinity as part of the 2006 Galway City Outer Bypass (2006, GCOB) preliminary investigation in 2006 and the N6 Galway City Transport Project (GCTP) Phase III ground investigation in 2016. These ground investigations included both intrusive and non-intrusive investigations, which consisted of:

- Four rotary coreholes
- One open holed corehole
- One cable percussive borehole
- Four trial pits
- One 2D resistivity profile
- One seismic refraction profile

Ground investigation within 50m of the structure extents were only considered for establishing the ground conditions. The plan location of the ground investigation in the vicinity of the structure is provided in **Figure 2.3**.

Figure 2.3: Plan View of Ground Investigation in the Vicinity of the Viaduct



2.8.2 Topography

The topography at the viaduct footprint consists of undulating terrain, ranging from +24mOD in the centre of the structure location to as low as +9mOD towards the west of the structure footprint.

2.8.3 Superficial Deposits

Across the footprint of the structure, the overburden thickness, to the top of weathered rock, ranges from outcropping at the surface (0.0mBGL) to 3.0m below ground level (BGL). Where superficial deposits are encountered the material is a cohesive glacial till derived from limestone.

The exploratory logs classify the overburden material as a sandy slightly gravelly silt. However, an evaluation of the atterberg limits indicates that the cohesive till behaves as a clay. The particle size distributions results show that the material tested ranges from a well graded till to a very fine till.

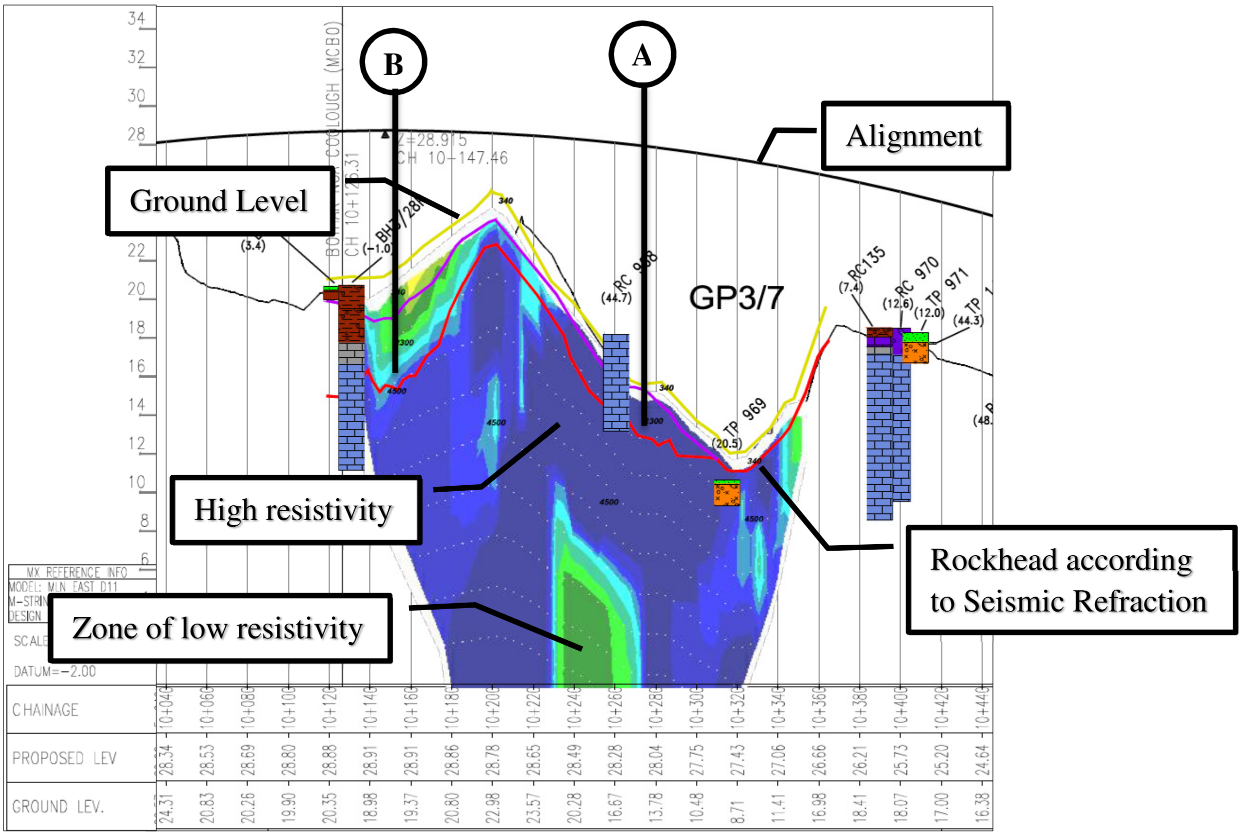
Where superficial deposits are encountered in intrusive investigation the material is described as soft to stiff, with the softer deposits typically present within the upper 1.0m to 1.5m of overburden.

2.8.4 Solid Geology

The bedrock formation at the structure location is undifferentiated Visean Limestone of the Lower Carboniferous Age.

Weathered zones between the superficial deposits and the bedrock, range in thickness up to a maximum of 1.1m, as observed in the exploratory logs. Figure 2.4 shows the variation of the rockhead as per the non-intrusive investigation.

Figure 2.4: Profile of Ground Information Along the Centreline



The rockhead is found to be either outcropping in some areas, as an Annex I habitat consisting of Limestone pavement, or typically up to 4.1m below ground level, in accordance with available intrusive investigation (see line A in the above figure). The geophysical investigation indicates that rockhead could drop to 6.1m below ground level in some isolated areas (see line B in the above figure). The rock is described as medium strong to very strong, thick to thinly bedded, locally fossiliferous, slightly weathered with widely to medium spaced discontinuities and clay filled fractures.

Non intact zones were encountered in some of the exploratory coreholes, beginning at rockhead and occurring throughout the core logs, sometimes every 1.0m. They are typically 0.1 to 0.2m in thickness. The apertures are described as tight to partly open, with very thin brown clay smearing. Other fractures are described as clay filled and dissolution features are described as common. Dips are typically described as 20 degrees to locally 40 to 80 degrees.

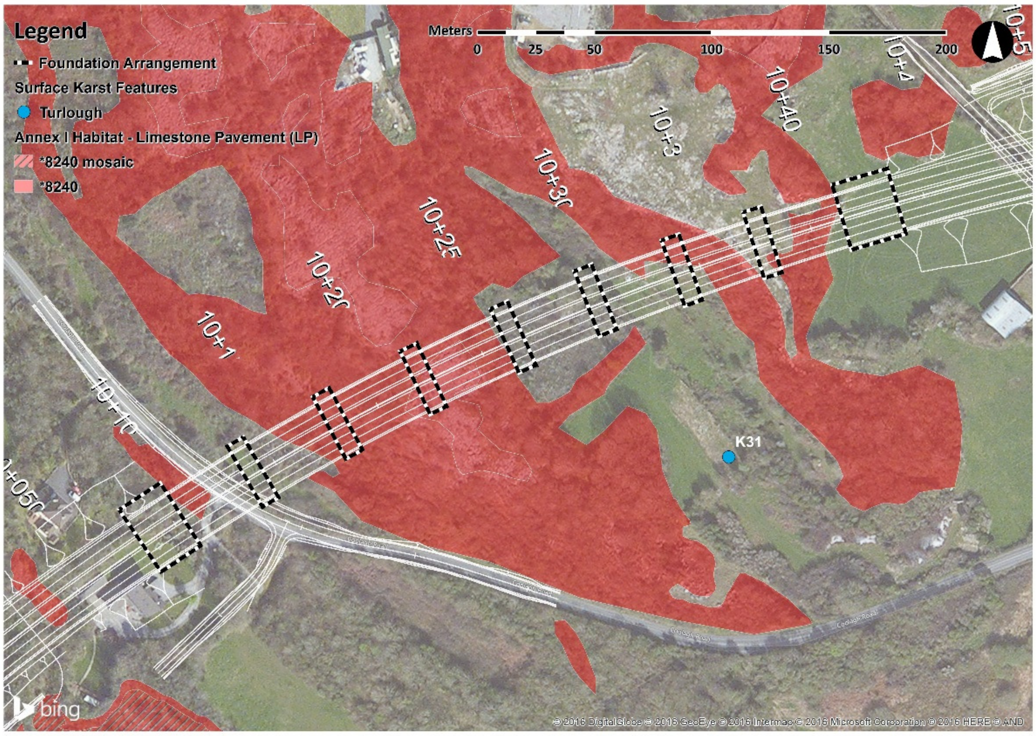
Rock strength testing was assessed from the available coreholes. In accordance with Franklin et al (1971), the rock was found to be weak to strong and will require blasting to loosen or fracture.

2.8.5 Karst

The limestone is susceptible to karstification. A combination of surface features and sub-surface geophysical anomalies were encountered within the structure footprint.

A Turlough has been identified within the footprint of the structure, north of Bóthar Nua, at Ch. 10+330. The Turlough forms a northwest to southeast elongated basin, which floods with groundwater each winter. Resistivity surveys undertaken show that the base of the Turlough has low resistivity, indicating a zone of potential karst. The Turlough forms part of the groundwater catchment that drains to Coolagh Lakes. For more information, refer to **Section 2.9**. Both the extent of the Annex I habitat and the Turlough are presented in **Figure 2.5**.

Figure 2.5: Plan of Annex I Habitat and Turlough



On the western extent of the Annex I habitat, from Ch. 10+150 to 10+200, a zone of low resistivity is observed in the geophysical survey. The drop in resistivity suggests the possibility of karst activity in the underlying limestone.

East of the Annex I habitat, from approximately Ch. 10+240 to 10+280, an anomaly was observed in the geophysical survey. A section of indicative clean limestone exists for approximately 10m between the ground surface and the anomaly. However, the geophysical survey provides only a limited understanding of the vertical and horizontal extent of the anomaly.

Due to the range of karst related features and anomalies encountered, coupled with the existence of calcite veining, non-intact zones and solution weathering, the karst activity is indicated to be high throughout the structure area.

2.9 Hydrogeology Summary

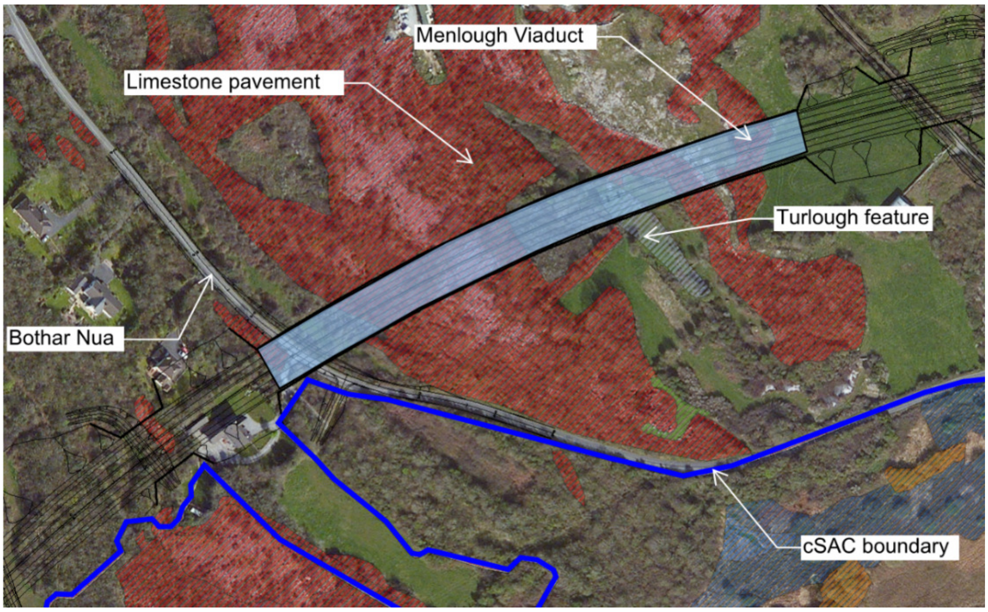
The Turlough feature (karst reference K31) crossed by the Menlough viaduct is considered a groundwater receptor as the seasonal fluctuation in the pond level is a consequence of groundwater levels in the surrounding aquifer. The Turlough is a depression in the topography and the base of the feature lies below the peak groundwater level but above the low groundwater level, so that characteristically the Turlough floods during winter and is dry during summer. Peak flood levels vary annually depending on the quantity or rainfall and groundwater level fluctuations.

The turlough is spanned by the Menlough viaduct. However, there is potential for groundwater flow paths, at or near the proposed bridge foundations, to be impacted during construction by reducing the capacity of flow paths to or from the Turlough, which could have an impact on the Turlough but also Coolagh Lakes (part of the Lough Corrib cSAC), which are fed from the Turlough catchment. In order to mitigate any potential negative impacts during the construction or in the long term, constraints will be imposed with respect to the construction of the foundations, as described in **Section 3.4**.

2.10 Ecology Summary

Due to the presence of priority Annex I habitats (Limestone pavement and Turlough) the design and construction of the Menlough Viaduct seeks to minimise the impact both during the construction and operational phase of the proposed road development. As such an elevated structure with an overall length of approximately 320m is proposed (Figure 2.6). To the west of the viaduct, small areas of Limestone pavement will be preserved using a culvert type structure within the embankment for the proposed road development.

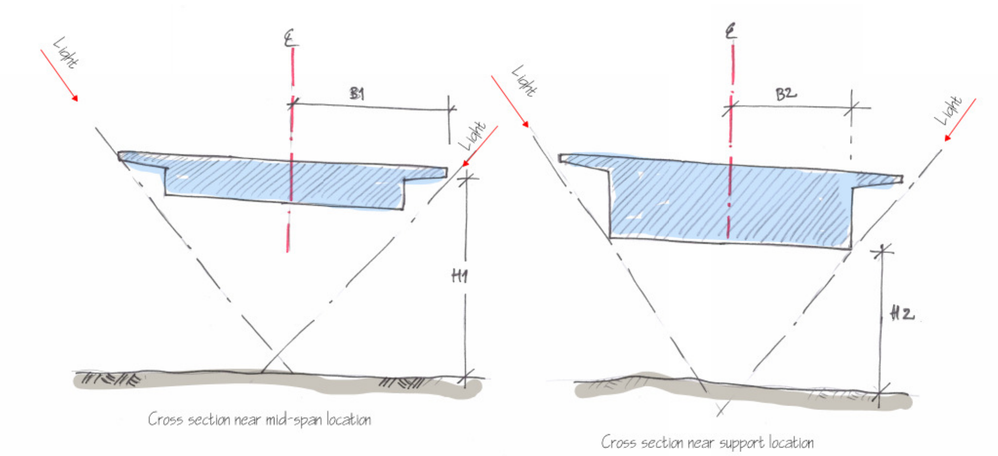
Figure 2.6: Location of Menlough Viaduct and surrounding ecological habitats



Consideration was given to the position and extent of the support locations for the viaduct, in order to reduce the amount of permanent removal of the priority Annex I habitat. The proposed viaduct will result in shading, both of light and of water, to the local environment beneath the structure as illustrated in **Figure 2.7** below. These potential impacts are assessed in the Environmental Impact Statement for the proposed road development.

Below the bridge, movements of the bats including the Lesser horseshoe bat is facilitated. A minimum clearance of 2.5m is desired with greater clearance being preferred. A Limestone pavement protection system will be put in place for the construction of the viaduct be in accordance with the Menlough Viaduct Construction Report (GCOB-4.03-6.1.74-001 Menlough Viaduct Construction Issue 2) in Appendix C.

Figure 2.7: Shading under bridge deck



2.11 Archaeological summary

The Menlough Viaduct does not directly impact any known archaeological or cultural heritage sites. Archaeological and cultural heritage sites in the vicinity of the viaduct are listed in **Table 2.4** below.

Table 2.4: Sites of Archaeological and Cultural Heritage merit located in the vicinity of the Menlough Viaduct

CH No.	Townland:	Description:	Approx. Ch.	Dist. from proposed road development
CH 50	Mionlach	Possible circular feature (2006 EIS)	10+375	56m south
CH 51	Mionlach	Possible boulder of archaeological potential (2006 EIS)	10+500	0m

2.12 Environmental Summary

For further details on the environmental constraints in the vicinity of the Menlough Viaduct refer to the Environmental Impact Assessment Report for the proposed road development.

2.13 Sustainability

Typically concrete is selected as the primary structural material. Concrete has a high durability performance and requires little maintenance during the design life (120yrs), where the product is appropriately specified and executed. Portland cement replacements such as ground granulated blast-furnace slag (GGBS) will be used where appropriate.

The continuous concrete deck superstructure minimises the number of movement joints in the deck. This helps reduce the inspection and maintenance requirements compared to simple supported bridge deck spans.

All structures can be readily demolished at the end of the service life of the bridge, and much of the structural materials (concrete, steel etc.) can be recycled and reused.

3 Structure and Aesthetics

3.1 General Description

The total length of the bridge is governed by the area of priority Annex I habitat. The bridge has a total length of approximately 320m, and the proposed road development is on embankment on both approaches to the bridge. To the west of the bridge, retaining structures are provided on the approach embankment to prevent encroachment of the embankment into the Lough Corrib cSAC.

3.2 Aesthetic Considerations

The topography is steeply undulating, with areas of Limestone pavement, scrub-land and pockets of thick vegetation and a Turlough (Figure 3.1). Apart from the local roads (Bóthar Nua and Sean Bóthar) there is limited public access to this area.

Figure 3.1: Aerial Photograph at Proposed Menlough Viaduct Location

Due to the hilly landscape and dense vegetation, the visual impact of the bridge is relatively low. The most significant impression will be at the crossing of Bóthar Nua below the viaduct at the western most span. The bridge consists of eight spans with a similar span length of around 40m. This gives the bridge a sense of rhythm and regularity. With the exception of the high point near Ch. 10+200, the bridge provides a good depth to clearance ratio (typically around 0.4), providing good visual permeability. The bridge deck is wide, with short to medium length cantilevers, varying between 0.8m and 1.15m. The substructure elements are envisaged to be of conventional concrete construction, of standard proportions of a structure of this scale.

3.3 Proposals for the Recommended Structure

The proposed Menlough Viaduct consists of a 320m, 8-span continuous bridge deck. The superstructure will be supported on bearings at some locations and fully integral at other support locations. The distance between the soffit of the superstructure and the ground level varies. A minimum clearance of approximately 1.5m occurs at the location of the high point in the rock outcropping on the western side of the structure.

The bridge deck superstructure will consist of prefabricated precast prestressed beams with a cast in-situ concrete deck slab.

The substructure will consist of conventional reinforced concrete piers at intermediate supports while the reinforced concrete skeletal abutments within reinforced earth walls will be provided at the end supports. The position of the substructure and foundations will minimise the impact on the priority Annex I habitats. No substructure supports are proposed within the extents of the Turlough.

3.3.1 Proposed Category

The Menlough Viaduct is a Category 3 structure in accordance with DN-STR-03001 (TII BD2/09).

3.3.2 Span Arrangements

The viaduct contains 8 spans, with a typical length of approximately 40m. The proposed span lengths and configuration has been selected to reduce the impact of the substructure and foundations on the Limestone pavement.

3.3.3 Approaches Including Run-On Arrangements

The approach embankments will be constructed using a compacted acceptable material with Clause 6N material behind end walls.

3.3.4 Substructure

The reinforced concrete abutments will be founded on reinforced concrete columns on pad footings. A reinforced earth wall is proposed to mask the substructure at each of the abutments.

The precast concrete beams will be supported on a downstand beam on bearings situated on within the abutments. Abutment galleries will be provided for the inspection and maintenance of bearings and movement joints.

At the intermediate supports, the superstructure will be supported on a series of columns. At the central support locations, the superstructure will be made integral with the substructure via a concrete crosshead and diaphragm; towards the end supports, bearings will be provided at the top of the piers. To ensure safety during construction, where tall slender beams are used, permanent downstand beams on to which the beams are to be landed are to be incorporated into the design. The appropriate temporary restraint measures are to be provided at the ends of the beam to prevent any instability during construction.

The construction of the Menlough Viaduct shall take into consideration the Annex 1 habitat, namely the Limestone pavement and the Turlough. Site access, enabling works, construction of a Limestone pavement protection system, viaduct construction and completion of the works shall be in accordance with the

Menlough Viaduct Construction Report (GCOB-4.03-6.1.74-001 Menlough Viaduct Construction Issue 4) given in Appendix C.

Access to the intermediate support foundation locations will be from the local road network, with appropriate temporary access routes. Access to the abutment foundations will be available from the mainline construction site on both approaches to the viaduct.

3.3.5 Foundation Type

The bridge foundations will consists of foundation pads situated on weathered rock, competent rock or soil. Any areas of soft soil will require excavation and replacement with suitable upfill.

The size of the foundations will be kept as small as possible and the depth of the foundation should be kept close to existing ground level, in order to reduce the extent of excavation at and near the priority Annex I habitats. Alternatively pile foundations with a small pilecap footprint can be adopted.

3.3.6 Superstructure

The bridge superstructure will consist of prefabricated precast prestressed beams (SY6) and insitu concrete deck slab.

3.3.7 Articulation Arrangements, Joints and Bearings

The bridge deck superstructure will be continuous. It will be supported on bearings at the abutments and at the intermediate supports near the abutments. At support gridline 5, 6 and 7 an integral connection between the superstructure and substructure is envisaged.

At gridlines 1, 2, 3, 4, 8 and 9, a pot bearing is proposed for each pair of beams, and located above a substructure column. The all pot bearings will permit free movement in the longitudinal direction, and one pot bearing per support will be guided transversely.

Type 6 expansion joints are proposed at either end of the structure. The estimated movement range at the west abutment is approximately 230mm; and at the east abutment approximately 100mm.

3.3.8 Parapet

Parapet type will be 1250mm high H2-W4, with mesh infill. The approach and departure safety barrier and transitions will be H2 containment.

3.3.9 Waterproofing

Bridge deck waterproofing shall be spray applied, and shall be in accordance with the requirements of BD47/99 and TII DN-STR-03012.

Two coats of epoxy resin waterproofing paint shall be applied to buried concrete surfaces, in accordance with TII CC-SPW-02000.

All exposed concrete will be treated with a surface applied hydrophobic pore lining impregnating material, in accordance with TII DN-STR-03012 and TII CC-SPW-01700.

3.3.10 Inspection and Maintenance

The bridge deck superstructure is continuous. The deck will be supported on bearings at intermediate supports and abutments. Movement joints are proposed at the abutments at either end of the viaduct. Inspection galleries will be provided in the abutments for the inspection of bearings and movement joints. Access to the inspection galleries is envisaged from the N6 GCRR above. For the span between Gridline 1 and 2, access to the bridge soffit will be from the local road below and will require local diversions and a mobile elevated work platform for access purposes.

In the areas of Limestone pavement, access for inspection and maintenance of the structure below deck is expected to be undertaken using under-bridge inspection equipment, supported from the bridge deck.

Waterproofing systems, joints, parapets etc. shall be designed for Working Life Category 2 (replaceable structural parts, up to 50 years design working life).

All other elements of the structure shall be designed for Working Life Category 5 (≥120 years design working life).

3.4 Construction and Buildability

Where tall and slender precast beams are used, such as SY beams, the appropriate measures to ensure stability during lifting and concreting of the deck are necessary. This should include the use of permanent drop-heads at the support locations and the necessary temporary works to restrain the beams rotation at the ends. The temporary works are to use the permanent pier as the supporting structure, and not the ground below.

Given the environmentally sensitive location of the bridge, the rural setting and general accessibility to the site, the construction method is an important consideration in the selection of the bridge type.

At locations where there is Limestone pavement, it is expected that construction may be undertaken from ground level, with the appropriate mitigation and protection measures during the construction works. The construction of the Menlough Viaduct shall take into consideration the Annex 1 habitat, namely the Limestone pavement and the Turlough. Site access, enabling works, construction of the Limestone pavement protection system, viaduct construction and completion of the works shall be in accordance with the Menlough Viaduct Construction Report (GCOB-4.03-6.1.74-001 Menlough Viaduct Construction I2) given in Appendix C.

Due to the sensitive hydrogeological location, construction of the viaduct foundations will require specific requirements to be satisfied. Pouring of the concrete to foundations will only be undertaken when the excavation has been inspected by a qualified hydrogeologist. Inspection of the full depth and extent of the excavation will be undertaken to identify if any significant flow paths, such as the karst enhancement of the bedrock permeability, are present. If no significant flow paths are present then the pouring of concrete can commence. If significant pathways are present then impacts which may arise from flow along these pathways shall be mitigated against prior to pouring, by installing a high permeability zone to replace the pathways which would be removed by the foundations. The design of the mitigation measures shall be approved by a qualified hydrogeologist to confirm that no poured concrete will enter the aquifer.

In addition, no pumping or dewatering will be permitted to be undertaken for the construction of the Menlough Viaduct. No construction works will take place directly within the extents of the Turlough. Where in situ concrete is used for the superstructure, it is expected that a temporary bridging structure would be built over the Turlough to permit construction from below the proposed deck. For construction methods using prefabricated elements, the lifting of these elements above the Turlough will be undertaken using lifting equipment located at a suitable distance from the Turlough.

At the western end span, temporary traffic diversions / road closures are necessary to permit construction over the local road. Again, either temporary supports of lifting of prefabricated elements is expect at this location.

4 Safety

4.1 Traffic Management During Construction Including Land for Temporary Diversions

Detailed traffic management proposals will be developed at detail design stage by the appointed Contractor in consultation with their Designers and the consent for the temporary traffic diversions/road closures will be sought from the appropriate authority.

4.2 Safety During Construction

The Designer will take account of the General Principles of Prevention, as specified in the Schedule 3 of the Safety, Health and Welfare at Work Act 2005, liaise with the Project Supervisor appointed by the Client for the Design Process and the Project Supervisor appointed for the Construction Stage and carry out all other duties as required by Clause 15 of the Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013).

The Project Supervisor for the Design Process will comply with all the requirements outlined in Clauses 11, 12, 13 & 14 of the Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013).

4.3 Safety in use

Parapets and safety barriers will be provided across the length of the structure and on the approach to, and departure from, the structure.

The Menlough Viaduct will be on a motorway designated route. As a result there will be restrictions on the permitted users (no pedestrians, cyclists etc.).

The bearings will require access for inspection and maintenance. At the intermediate supports, due to the environmentally sensitive area and restricted access below the bridge, inspection and maintenance of the bearings is expected to be undertaken using specialised under-bridge inspection equipment supported from the bride deck.

At the abutments, access to the bearings and the expansion joints for inspection and maintenance is provided via the abutment gallery.

The potential operational issues associated with wind effects on high sided vehicles is to be assessed and where this is found to be an issue, the provision of wind shielding may be necessary.

4.4 Lighting

There is no road lighting proposed in the area of the Menlough Viaduct.

5 Cost

5.1 Budget Estimate in Current Year, Including Whole Life Cost

The cost estimates for the Menlough Viaduct has been prepared using typical cost per square metre rates for the envisaged bridge configuration, span arrangements, materials, construction methodology and maintenance requirements (**Table 5.1** and **Table 5.2**).

Table 5.1: Basis of Cost Estimate

Construction Options Considered	**Estimated Rate (€/m²)**	
	Lower	Upper
Precast prestressed beams lifted into place and made integral with reinforced concrete deck	1975	2150

The cost of the bridge is highly dependent on the construction methodology and the temporary works necessary to build the bridge, in addition to the form of construction.

Table 5.2: Estimated Construction Cost

Description	**Cost [Million Euros] (Excl. VAT)**
Menlough Viaduct	16.5M to 18.0M

6 Design Assessment Criteria

6.1 Normal Loading

Permanent Actions in accordance with IS EN 1991-1-1:2002 and the associated National Annex.

The structure will be designed for Load Models LM1 and LM2 in accordance with IS EN 1991-2:2003 and the associated National Annex.

6.2 Abnormal Loading

Load Model 3 up to and including SV196 (where applicable) will be considered in accordance with IS EN 1991-2:2003 and the associated National Annex.

6.3 Footway Live Loading

Where applicable, a footway loading shall be in accordance with Clause 5.3.2.1 of IS EN 1991-2:2003. A nominal qfk = 5kN/m^2 will be adopted.

6.4 Provision for Exceptional Abnormal Loads

No exceptional abnormal loads are proposed.

6.5 Any Special Loading not Covered Above

Not applicable.

6.6 Heavy or High Load Route Requirements Being Made to Preserve Route

Not applicable.

6.7 Minimum Headroom Provided

The minimum headroom clearance for underbridge structures will be 5.3m in accordance with TII DN-GEO-03036 (Cross Sections and Headroom).

6.8 Authorities Consulted and any Special Conditions Required

Consultation with relevant authorities is on-going. The following groups have been consulted as part of the development of the proposed N6 GCRR:

- Transport Infrastructure Ireland (TII)
- Galway County Council (GCoC)
- Galway City Council (GCiC)
- Land and home owners

7 Ground Conditions

The general ground conditions consist of areas of soft to stiff cohesive glacial till underlain by limestone or outcropping Limestone pavement. The rock is medium strong with medium to closely spaced discontinuities and non-intact zones. Refer to **Section 2.8** for further information.

7.1 Geotechnical Compatibility with Proposed Foundation Design

The foundation types proposed for the viaduct are presented in **Section 3.3.5.**

There are nine footing locations (including piers and abutments) for the Menlough Viaduct. The footings for the viaduct are located over areas of cohesive till and Limestone pavement. Any areas of shallow overburden will require excavation and replacement with suitable upfill, thus reducing the potential for differential settlement between footings. To reduce the extent of excavation at and near the Annex I habitats, the size of the foundations will be kept to a minimum and the depth of the foundation will be kept close to existing ground level. Alternatively pile foundations with a pilecap could be adopted.

The foundations discussed below are in areas of note:

- The foundation located at Ch. 10+180 (Pier at Gridline 3) falls on a zone of low resistivity according to the geophysical survey. The drop in resistivity suggests the possibility of softer deposits and potential karst activity.
- The foundation located at Ch. 10+260 (Pier at Gridline 5) is located over an anomaly in the resistivity. The resistivity indicates a zone of clean limestone for 10m above the anomaly which, if proven to be competent rock, will reduce the karst risk at the structure footing.
- Two foundations, at Ch. 10+300 and 10+340 (Piers at Gridlines 6 and 7), are located either side of a Turlough. The details of the Turlough are described in Section 2.9. As the footings are not located directly over the identified footprint of the Turlough, the karst risk in relation to the structure is reduced. The resistivity profile east of the identified Turlough shows a zone of low resistivity. The full eastern extent of this anomaly zone is unknown at this time. The feature may extends beneath the footing proposed at Ch. 10+380.
- The proposed footing of the eastern abutment at Ch. 10+420 (End support at Gridline 9) is located over poor ground conditions. The soft overburden extends to 1.6m and is underlain by poor quality rock to approximately 5.0m below ground level.

A methodology for the evaluation and treatment of karst features shall be conducted in accordance with the Construction Environmental Management Plan (CEMP).

8 Drawings and Documents

8.1 List of all Documents Accompanying the Submission

Document Reference	Document	Appendix
GCOB-1700-D-S10-01-001	Menlough Viaduct General Arrangement Sheet 1	Appendix A
GCOB-1700- D-S10-01-002	Menlough Viaduct General Arrangement Sheet 2	Appendix A
GCOB-SK-D-672	Menlough Viaduct Plan and Profile Alignment	Appendix A
	Geotechnical Factual Report	Appendix B
GCOB_4.03_6.74_001	Constructability Report	Appendix C

Appendix A

Drawings

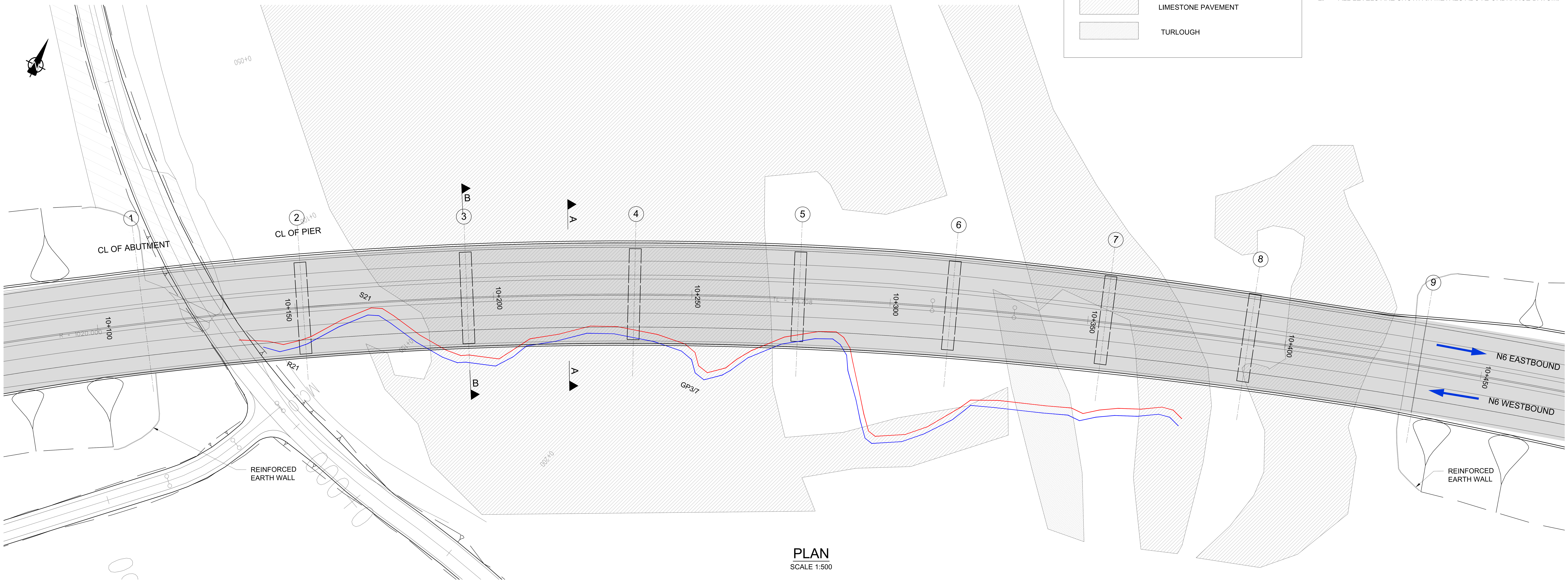
DESIGN REPORT

LEGEND: GEOPHYSICAL SURVEY LOCATIONS

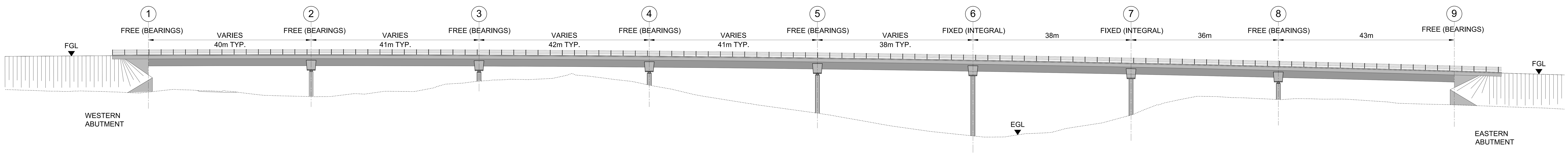
- 2D-RESISTIVITY PROFILE
- SEISMIC REFRACTION PROFILE
- LIMESTONE PAVEMENT
- TURLOUGH

NOTES:

1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE SHOWN IN METRES ABOVE ORDNANCE DATUM.



PLAN
SCALE 1:500



ELEVATION
SCALE 1:500

Clients: Comhairle Chontae na Gaillimhe Galway County Council; N6 Galway City Transport Project; An Roinn Iompair Turasóireachta agus Spóirt; TII

Consultant: ARUP
Corporate House, City East Business Park, Ballybrit, Galway, Ireland.
Tel +353 (0)91 460675, www.N6GalwayCity.ie, www.arup.ie

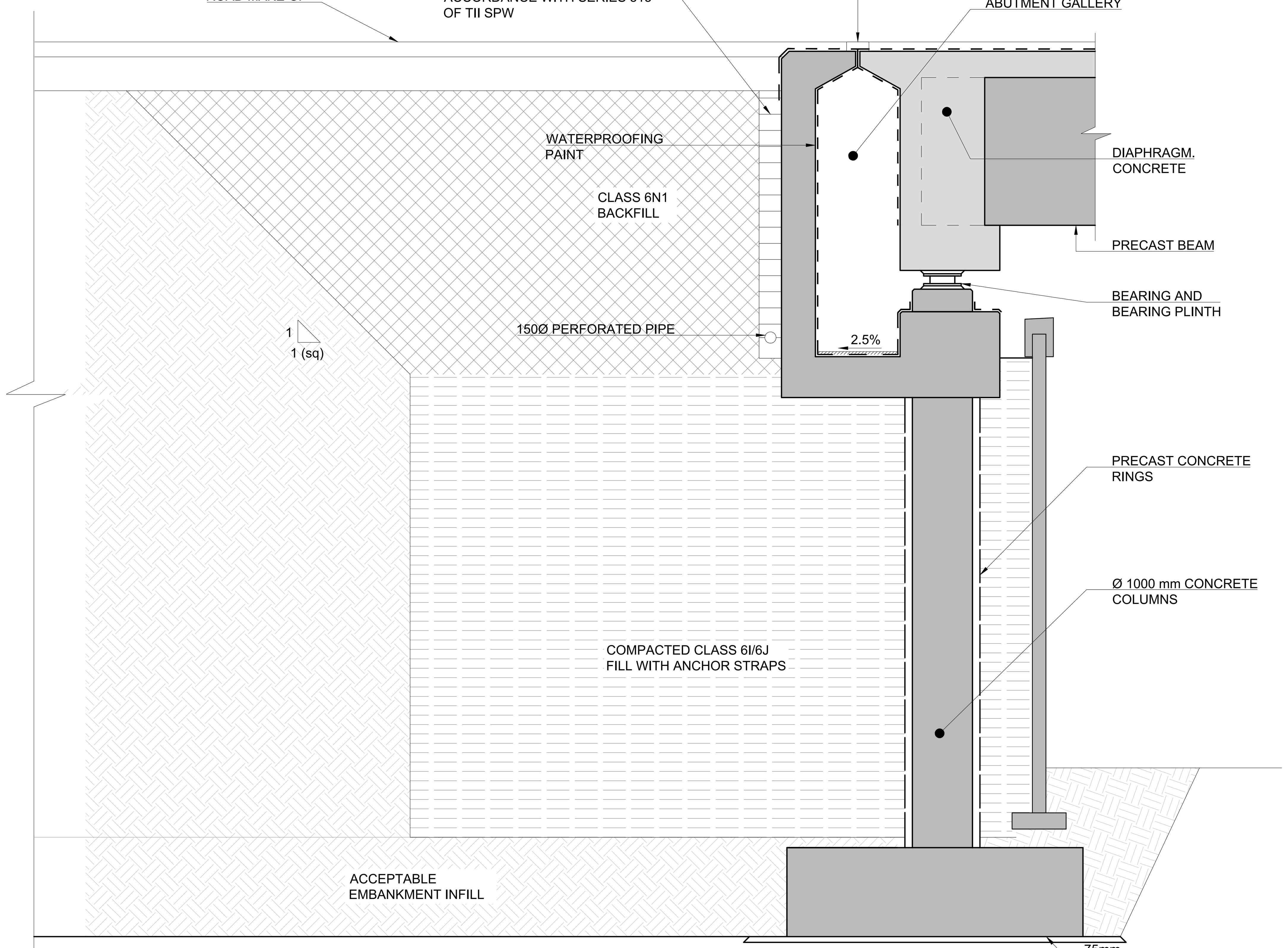
Job Title: N6 Galway City Ring Road
Scale: 1:500
Date: September 2016

Issue	Date	By	Chkd	Appd
I6	04/10/2017	TP	AP	PM
I5	18/07/2017	TP	AP	PM
I4	30/06/2017	LM	AP	PM
I3	18/06/2017	LM	AP	PM
I2	17/05/2017	LM	AP	PM
I1	24/10/2016	LM	AP	PM

Drawing Title: S10-01 Menlough Viaduct Sheet 1
Drawing Status: **For Information**
Job No: **233985** | Drawing No: **GCOB-1700-D-S10-01-001** | Issue: **I6**

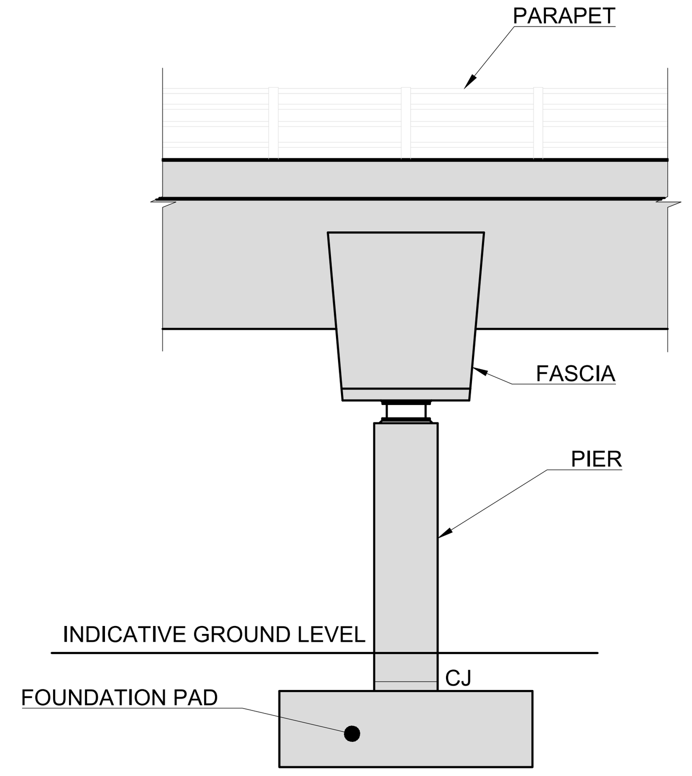
Do not scale

DESIGN REPORT



ABUTMENT CROSS-SECTION

SCALE 1:50

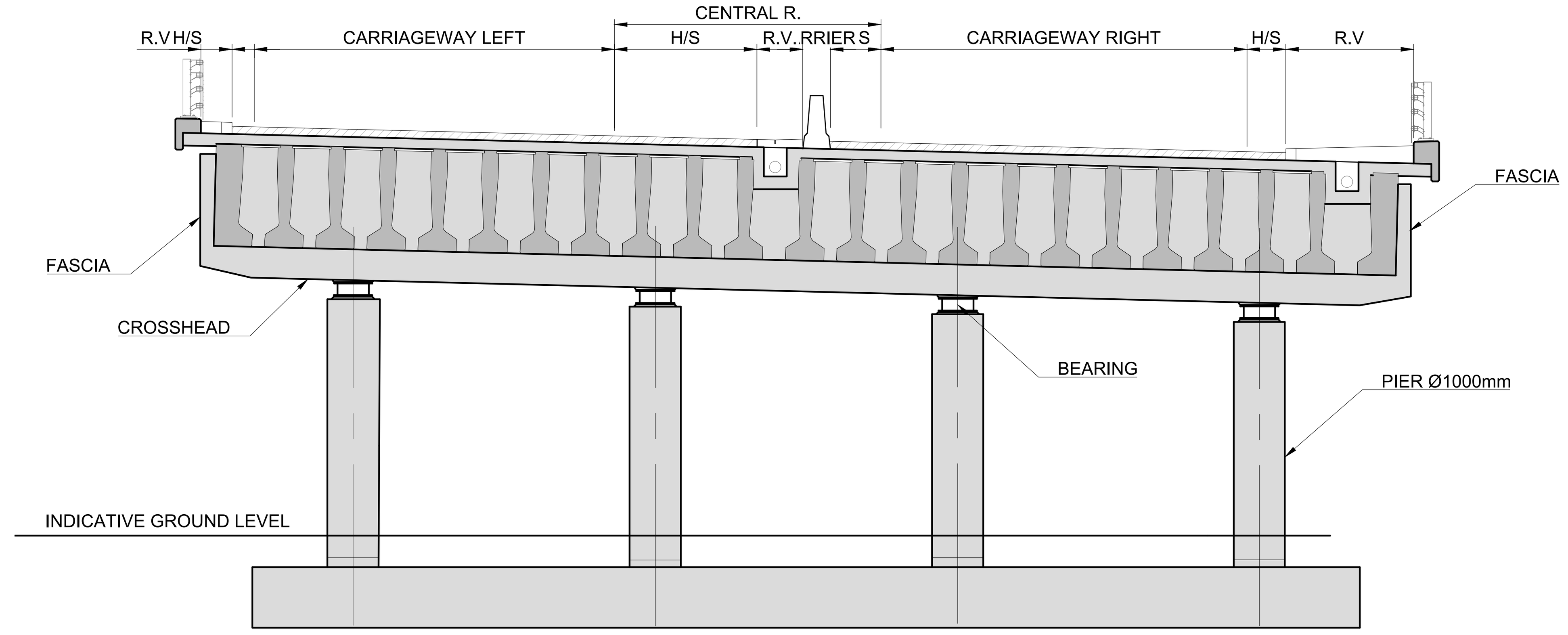


PIER ELEVATION

SCALE 1:100

NOTES:

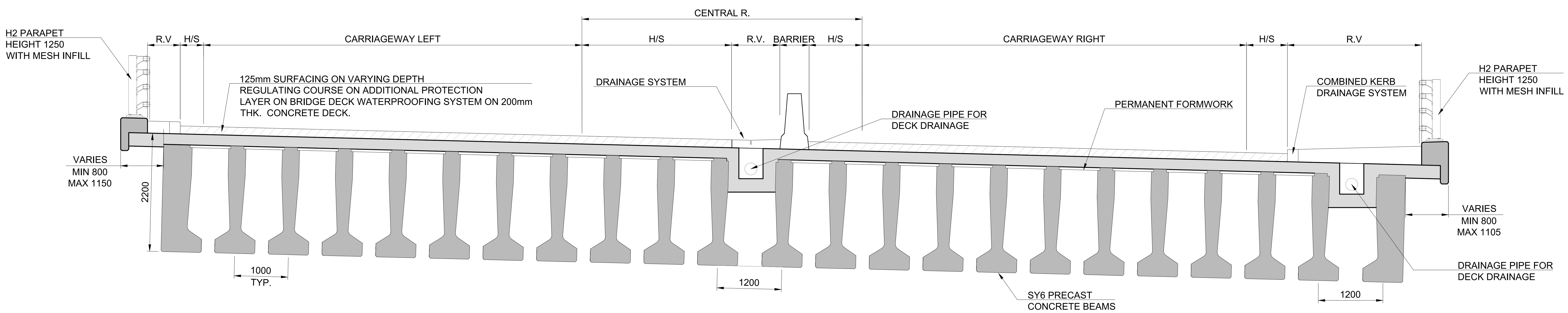
1. ALL DIMENSIONS ARE SHOWN IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE SHOWN IN METRES ABOVE ORDNANCE DATUM.



SECTION B-B

SCALE 1:100

BRIDGE DECK CROSS SECTION DIMENSIONS (ALONG INCREASING CHAINAGE) [mm]													
SECTION	PARAPET	RAISED VERGE	HARD SHOULDER (LEFT)	CARRIAGEWAY (LEFT)	HARD STRIP (LEFT)	RAISED VERGE	BARRIER	HARD STRIP (RIGHT)	CARRIAGEWAY (RIGHT)	HARD SHOULDER (RIGHT)	RAISED VERGE	PARAPET	TOTAL
WEST ABUT ch 10+097	500	600	500	7000	3500	1000	600	1000	7000	500	3600	500	26300
cH 10+200	500	600	500	7000	3500	1000	600	1000	7000	500	3600	500	26300
EAST ABUT ch 10+415	500	600	500	7000	1700	1000	600	1000	7000	500	3600	500	24500



SECTION A-A

SCALE 1:50

Clients

Comhairle Chontae na Gaillimhe
Galway County Council

N6 Galway City Transport Project

An Roinn Iompair Turasóireachta agus Spóirt
Department Transport, Tourism and Sport

TII Bonneagar Iompair Éireann Transport Infrastructure Ireland

Consultant

ARUP

Corporate House
City East Business Park
Ballybrit, Galway, Ireland.

Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title
N6 Galway City Ring Road

Scale: As Shown

Date: September 2016

Issue	Date	By	Chkd	Appd
I5	04/10/2017	TP	AP	PM
I4	18/07/2017	TP	AP	PM
I3	30/06/2017	LM	AP	PM
I2	16/05/2017	LM	AP	PM
I1	24/10/2016	LM	AP	PM

Drawing Title
S10-01 Menlough Viaduct
Sheet 2

Drawing Status
For Information

Job No: 233985

Drawing No: GCOB-1700-D-S10-01-002

Issue: I5

Do not scale

A1

P□□SE □ □DESIGN

Legend:

Plan view

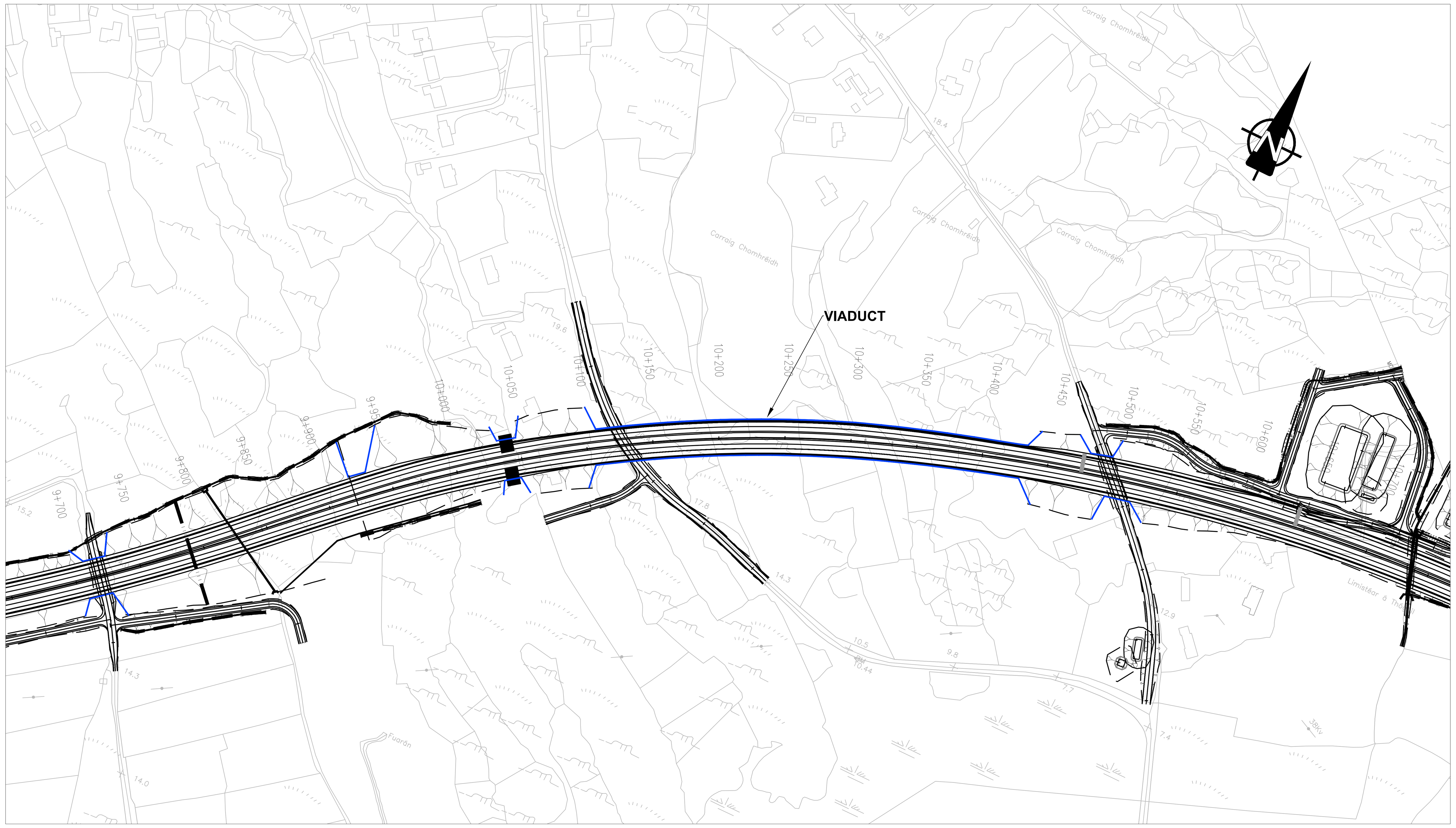
Current Design

Structure

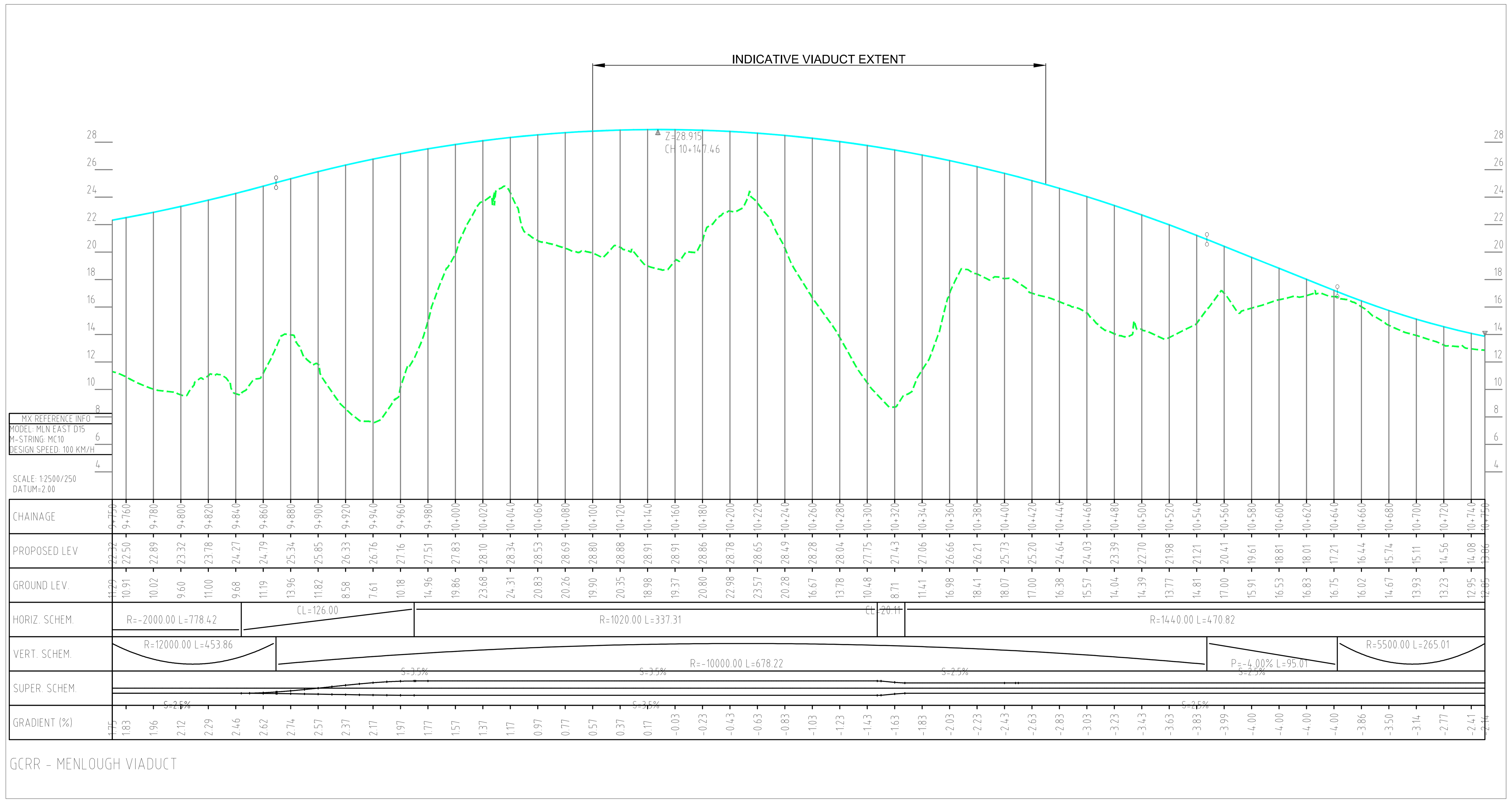
Profile view

Existing Ground Level

Proposed Road Level



PLAN: SCALE 1:2500



PROFILE: SCALE H 1:2500 / V 1:250

Disclaimer Note:
The Design shown is draft only and is subject to change. More detailed assessments, ongoing studies and the information received from the public may result in changes to parts, or all of the Design. Any changes to the Design may affect the other information.

Nóta Séanta:
Tá an Dearadh ina bhfoirm dréacht, d'fhéadfaí athraithe teacht air. Is mar toradh ar mheasúnaithe níos mionchruinne, ar staidéar leanúnach agus ar eolas ón bpobal a dhéanfaí athruithe teacht ar an Dearadh ina iomláine nó ar chuid de. D'fhéadfadh ag aon athrú ar an Dearadh tionchar a bheith aige ar an eolas eile.

Clients

Comhairle Chontae na Gaillimhe
Galway County Council
Galway City Transport Project
An Roinn Iompair Turasóireachta agus Spóirt
Department Transport, Tourism and Sport
Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Consultant

ARUP

Corporate House
City East Business Park
Ballybrit, Galway, Ireland.

Tel +353 (0)91 460675
www.N6GalwayCity.ie
www.arup.ie

Job Title
N6 Galway City Transport Project

Scale: AS SHOWN @ A1

Date: May 2017

Issue	Date	By	Chkd	Appd
I4	10/05/2017	GOD	HK	EMC
I3	21/12/2016	GOD	HK	EMC
I2	26/09/2016	GOD	HK	EMC
I1	09/05/2016	GOD	HK	EMC

Drawing Title
Current Design
Menlough Viaduct
Plan & Profile

Drawing Status
For Information

Job No	Drawing No	Issue
233985-00	GCOB-SK-D-672	I4

Do not scale

Appendix B

Geotechnical Factual Report

GEOTECHNICAL BORING RECORD

REPORT NUMBER	18963
CONTRACT	N6 Galway City Transport Project - Phase 3
BOREHOLE NO.	BH3/28
SHEET	Sheet 1 of 1
CO-ORDINATES	529,132.46 E 728,217.63 N
GROUND LEVEL (m AOD)	18.82
RIG TYPE	Hand Dug
BOREHOLE DIAMETER (mm)	
BOREHOLE DEPTH (m)	0.70
DATE COMMENCED	18/02/2016
DATE COMPLETED	18/02/2016
CLIENT	Galway County Council
ENGINEER	ARUP
SPT HAMMER REF. NO.	
ENERGY RATIO (%)	
BORED BY	JD
PROCESSED BY	JL

Description	Legend	Elevation	Depth (m)	Samples: Ref. Number	Samples: Sample Type	Samples: Depth (m)	Samples: Recovery	Field Test Results	Standpipe Details
TOPSOIL		18.62	0.20						
Firm brown slightly sandy gravelly SILT		18.52	0.30	AA39957	B	0.20-0.30			
Firm brownish grey slightly silty sandy gravelly CLAY with a medium cobble and boulder content		18.12	0.70						
Obstruction - Large BOULDER / Possible Limestone Rockhead End of Borehole at 0.70 m									

Depth scale (m): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

HARD STRATA BORING/CHISELLING

From (m)	To (m)	Time (h)	Comments

WATER STRIKE DETAILS

Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER PROGRESS

Date	Hole Depth	Casing Depth	Depth to Water	Comments

REMARKS Hand dug pit at location of BH3/28

Sample Legend
D - Small Disturbed (tub)
B - Bulk Disturbed
LB - Large Bulk Disturbed
Env - Environmental Sample (Jar + Vial + Tub)
UT - Undisturbed 100mm Diameter Sample
P - Undisturbed Piston Sample
W - Water Sample

GEOTECHNICAL CORE LOG RECORD

REPORT NUMBER: 18963

CONTRACT	N6 Galway City Transport Project - Phase 3	**DRILLHOLE NO**	**BH3/28R**
		SHEET	Sheet 1 of 1
CO-ORDINATES	529,130.20 E 728,221.35 N	**DATE DRILLED**	11/04/2016
GROUND LEVEL (mOD)	18.86	**DATE LOGGED**	12/04/2016
RIG TYPE	Casagrande		
FLUSH	Air/Mist		
CLIENT	Galway County Council	**DRILLED BY**	IGSL
ENGINEER	ARUP	**LOGGED BY**	D. O'Shea
INCLINATION (deg)	-90		
CORE DIAMETER (mm)	80		

Downhole Depth (m)	Core Run Depth (m)	T.C.R.%	S.C.R.%	R.Q.D.%	Fracture Spacing Log (mm) 0–250–500	Non-intact Zone	Legend	Description	Depth (m)	Elevation	Standpipe Details	SPT (N Value)
0								SYMMETRIX DRILLING: No recovery, observed by driller as gravelly clay	1.20	17.66		
1								SYMMETRIX DRILLING: No recovery, observed by driller as gravelly cobbly clay	3.00	15.86		
3								SYMMETRIX DRILLING: No recovery, observed by driller as weathered rock	4.10	14.76		
4	4.10–5.60	97	97	94	540			Medium strong to very strong, thick to thinly bedded, blueish dark grey, fine grained, LIMESTONE (locally fossiliferous, localized chert and stylolites), slightly weathered. Dips are 20° to locally 40° & 80°. Discontinuities are widely to medium spaced, rough to locally smooth, planar. Apertures are tight to partly open, very thin brown clay smearing. 4.64-4.78m - Clay-filled fracture				
5.60	5.60–7.20	100	100	89	1610							
7.20	7.20–8.70	100	100	100	550.0000000001 1330							
8.70	8.70–9.60	100	84	57				8.98-9.01m - Clay-filled fracture	9.60	9.26		
								End of Borehole at 9.60 m				

REMARKS

Hole cased 0.00-4.10m.

WATER STRIKE DETAILS

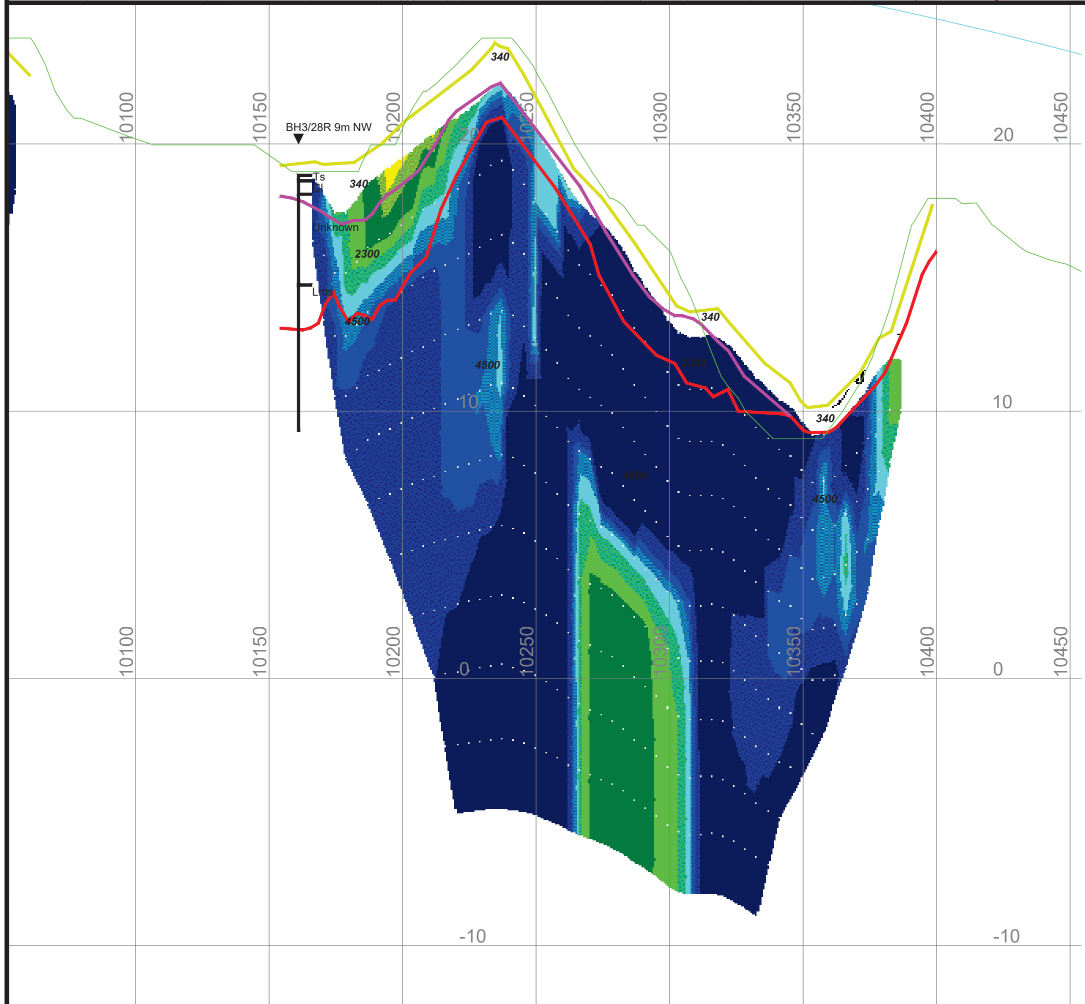
Water Strike	Casing Depth	Sealed At	Rise To	Time (min)	Comments
					No water strike recorded

INSTALLATION DETAILS

Date	Tip Depth	RZ Top	RZ Base	Type

GROUNDWATER DETAILS

Date	Hole Depth	Casing Depth	Depth to Water	Comments



Minerex Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	IGSL ARUP
PROJECT	N6 GCTP Phase 3 Geophysical Survey
TITLE	Plan 1f: Survey Locations and Models for GP3/07

SCALE:	Hor 1:1000 @ A1, Ver 1:100 @ A1, VE x 10
PROJECT:	6031
DRAWN:	RJ
DATE:	18/06/2016
MGX FILE:	6031f_Plans.dwg
STATUS:	Final

LEGEND:

Geophysical Survey Locations:

- R2 — 2D-Resistivity Profile
- S1 — Seismic Refraction Profile

Chainage based on Alignment received 12.02.2016

Locations are in Irish Transverse Mercator, Elevations are in mOD (Malin Head)

Geophysical Survey Locations:

- Ground Surface along Survey Profile
- Existing Ground Level along Centre Line
- Proposed Vertical Alignment Centre Line

2D Resistivity and Seismic Refraction results are projected onto the Centre Line

Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (200 - 340 m/s)
- Top of Layer 2 (900 - 1200 m/s)
- Top of Layer 3 (2000 - 2400 m/s)
- Top of Layer 4 (4000 - 5000 m/s)

1800 Seismic Velocity in m/s

2D-Resistivity Model Values:

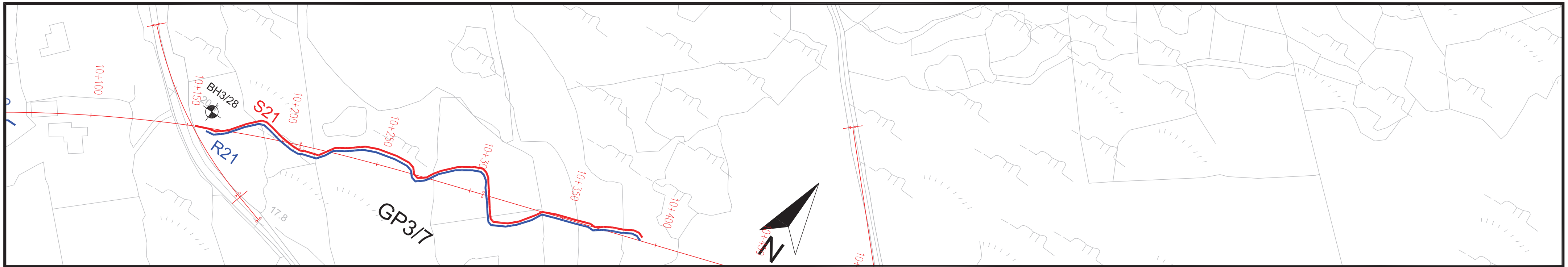
Resistivities (Ohmm) for 2D-Resistivity Model

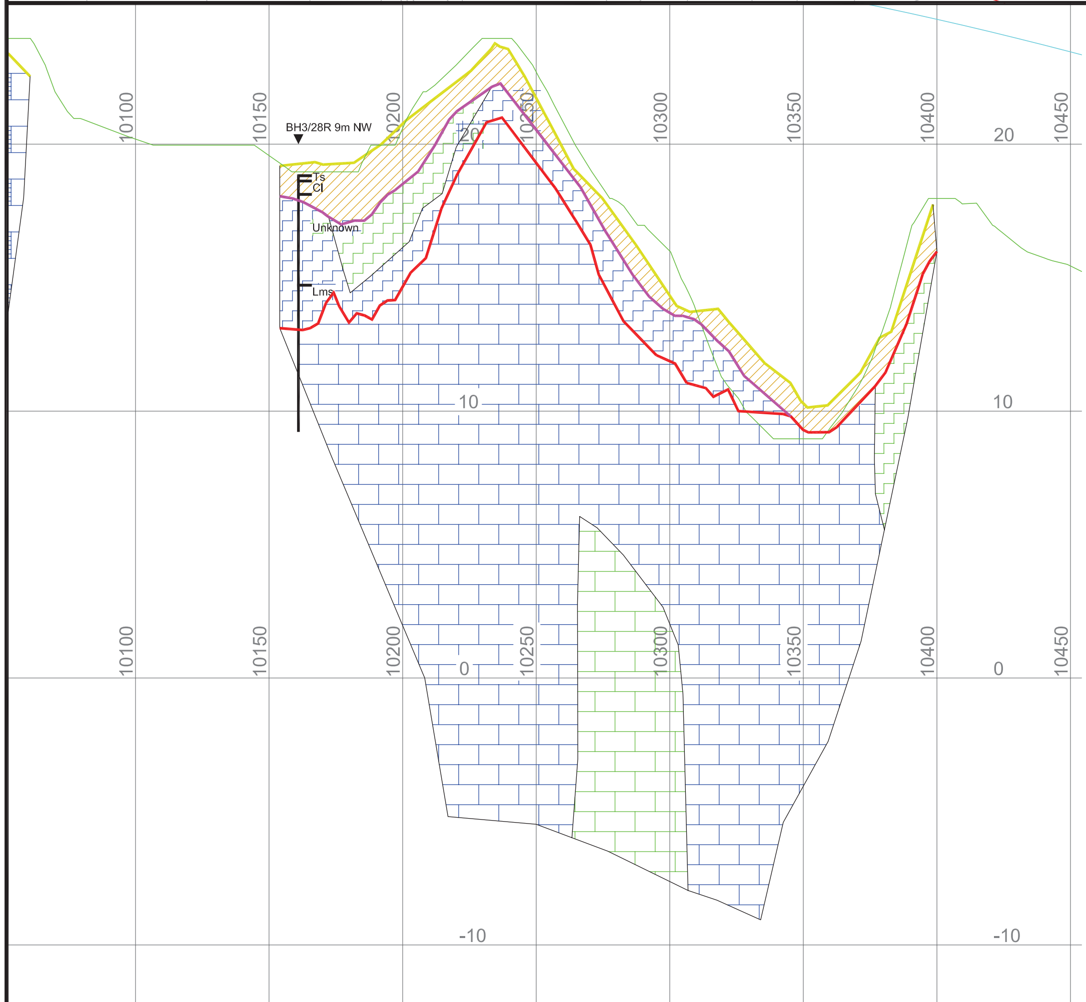
20.0 40.0 80.0 160 320 640 1280 2560

Abbreviated GI Logs:

BH3/18R Borehole Name and Location

Pt	Peat	Si	Silt
Cl	Clay	Lms	Limestone
Ts	Topsoil	WLms	Weathered Limestone
Mg	Made Ground	Gn	Granite
Gr	Gravel	WGn	Weathered Granite
Sd	Sand		





Minerex
Geophysics Limited
Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare
Tel. (01) 6510030
Fax. (01) 6510033
Email: info@mgx.ie
Web: www.mgx.ie

CLIENT	IGSL ARUP
PROJECT	N6 GCTP Phase 3 Geophysical Survey
TITLE	Plan 2f: Survey Locations and Interpretation for GP3/07

SCALE:	Hor 1:1000 @ A1, Ver 1:100 @ A1, VE x 10
PROJECT:	6031
DRAWN:	RJ
DATE:	18/06/2016
MGX FILE:	6031f_Plans.dwg
STATUS:	Final

LEGEND: Geophysical Survey Locations:

- R2 — 2D-Resistivity Profile
- S1 — Seismic Refraction Profile

Chainage based on Alignment received 12.02.2016

Locations are in Irish Transverse Mercator, Elevations are in mOD (Malin Head)

Geophysical Survey Locations:

- Ground Surface along Survey Profile
- Existing Ground Level along Centre Line
- Proposed Vertical Alignment Centre Line

2D Resistivity and Seismic Refraction results are projected onto the Centre Line

Layers from Seismic Refraction Model:

- Ground Surface/Top of Layer 1 (200 - 340 m/s)
- Top of Layer 2 (900 - 1200 m/s)
- Top of Layer 3 (2000 - 2400 m/s)
- Top of Layer 4 (4000 - 5000 m/s)

1800 Seismic Velocity in m/s

Interpretation:

- 1 Soft or loose Topsoil or Overburden
- 2a Clay or Silt Overburden
- 2b Gravelly Clay Overburden
- 2c Sand or Gravel Overburden
- 3a Clay Filled Weathered Limestone or Clay or Silt Overburden
- 3b Infilled Weathered Limestone or Gravelly Clay Overburden
- 3c Weathered Limestone or Sand or Gravel Overburden
- 4a Clay Filled Strong Limestone
- 4b Infilled Strong Limestone
- 4c Fresh Strong Limestone

Abbreviated GI Logs:

BH3/18R Borehole Name and Location

Pt	Peat	Si	Silt
Cl	Clay	Lms	Limestone
Ts	Topsoil	WLms	Weathered Limestone
Mg	Made Ground	Gn	Granite
Gr	Gravel	WGn	Weathered Granite
Sd	Sand		

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

DRILLHOLE LOG

Project				DRILLHOLE No
N6 Galway City Outer Bypass				RC 968
Job No	Date 25-10-06 25-10-06	Ground Level (m) 16.30	Co-Ordinates () E 129,297.7 N 228,210.1	
Contractor IDL				Sheet 1 of 1

RUN DETAILS / STRATA

Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thickness)	Discontinuities Detail	Main	Geology	Instrument/ Backfill
0.00	100 (95) 65	7				0.00 - 5.00 Closely spaced to 1.5m, then medium spaced, dipping 24 to 26deg's, undulating, locally irregular, rough, with a brown silt smear.	Strong fresh grey thinly bedded fine grained LIMESTONE.		
1.50	100 (74) 54	5				1.50 - 1.50 moderately strong.			
2.00	100 (99) 71	NI / 6			(5.00)	1.80 to 2.0m: Joint: subvertical, undulating, smooth, with a light greyish brown silt, wide.Non-intact-fractured rock.			
3.00	100 (93) 52	9 / 6				2.80 to 3.4m: Joint: subvertical, planar, locally irregular, smooth, with a light greenish gey silt, open.			
5.00			11.30		5.00		BH terminated at 5.0m bgl on RE's Instruction.		

Drilling Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush

From	To	Type	Returns

GENERAL REMARKS

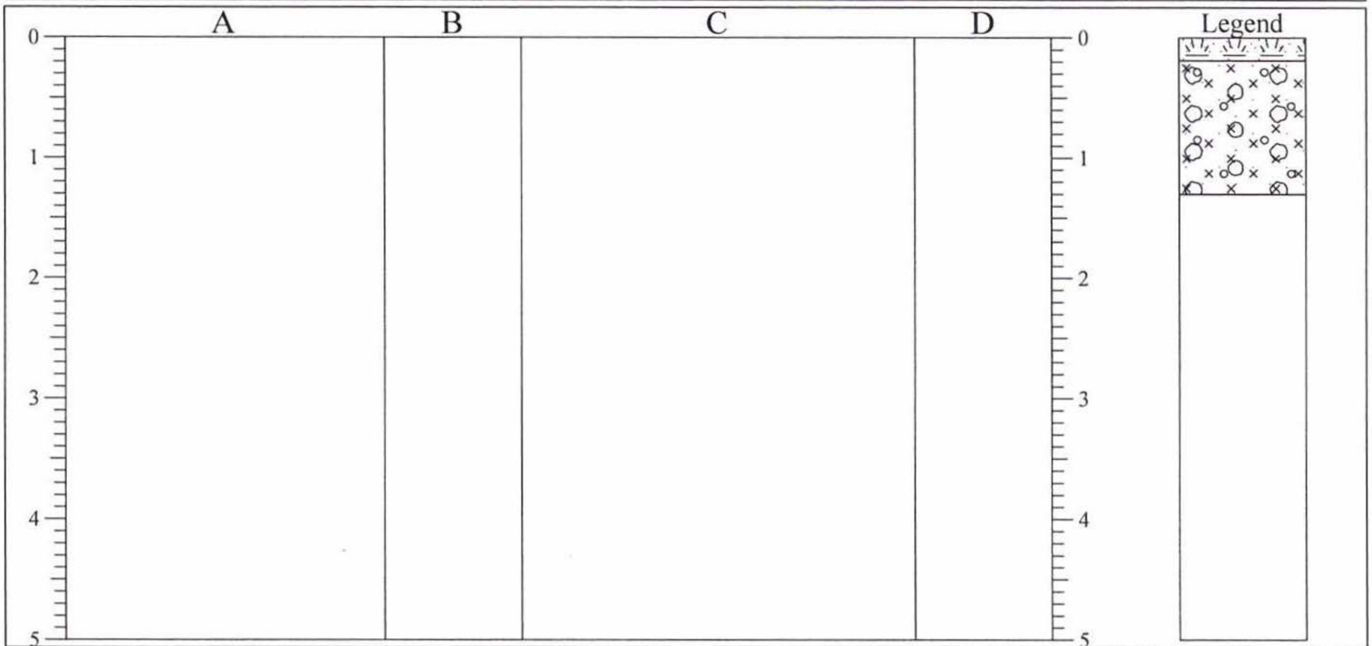
Borehole backfilled with cement bentonite grout.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used County Tractor	Bit Design HQ	Logged By EAT

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

TRIAL PIT LOG

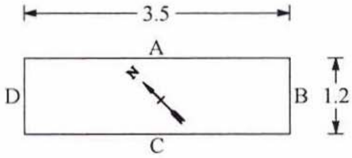
Project: N6 Galway City Outer Bypass			TRIAL PIT No: **TP 969**
Job No	Date: 24-10-06 / 24-10-06	Ground Level (m): 8.72	Co-Ordinates (): E 129,337.4 N 228,252.3
Contractor: IDL	GROUNDWATER STRIKES — Water strikes: 1st: 0.45m; Rose to (@ 20 min.): 0.10m; Sealed at:; 2nd:; 3rd:		Sheet: 1 of 1



STRATA / SAMPLES & TESTS

Depth	No	DESCRIPTION	In Situ Tests	Water	Depth (m)	No	Remarks/Tests
0.00-0.19		Soft damp brown slightly sandy gravelly SILT/CLAY with some subangular to subrounded cobbles (TOPSOIL).			0.10	J	
0.19-1.30		Stiff damp grey brown mottled orange slightly sandy slightly gravelly SILT with some subangular to subrounded cobbles and boulders.Boulders up to 1000mm long. 0.50 grey mottled brown,with many subangular to angular cobbles and boulders.Boulders up to 1000mm long.		1	0.45	W	
					0.70	B	
					0.70	J	
1.30		Refusal - possible intact rock (fractured dark grey limestone).					

Shoring/Support:
Stability:



GENERAL REMARKS

Pit unstable during excavation-spalling of sides from 1.20m.Water strike at 0.45m.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used: Hitachi ex120	Bit Design	Logged By: TS

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

DRILLHOLE LOG

Project				DRILLHOLE No
N6 Galway City Outer Bypass				RC 970
Job No	Date 24-11-06 24-11-06	Ground Level (m) 16.62	Co-Ordinates () E 129,413.2 N 228,286.6	
Contractor IDL				Sheet 1 of 1

Depth / Date	TCR (SCR) RQD	(SPT) Fracture Spacing	Red'cd Level	Legend	Depth (Thickness)	Discontinuities Detail	Main	Geology	Instrument/ Backfill
0.00	45 (14) 0	NA	15.22		(1.40) 1.40	0.00 - 1.40	Subangular limestone and granite COBBLES.		
2.00		9				1.40 - 9.00 Closely spaced to 5.0m, then medium spaced, dipping 20 to 24deg's, undulating, locally irregular, smooth, with a little brown silt.	Very strong slightly weathered grey thinly bedded fine and medium grained slightly sandy LIMESTONE.		
3.50	100 (47) 19	12				3.00 - 3.00 moderately weathered 'bleached' white.			
5.00	93 (73) 43	7 / 8				3.50 - 3.50 moderately strong.			
6.50	100 (84) 64	4			(7.60)	6.10 to 6.4m: Joint: subvertical, planar, smooth, with a little grey silt, open.			
8.00	100 (67) 56	5 / 7							
9.00	100 (99) 97	2	7.62		9.00				
							BH terminated at 9.0m bgl on RE's Instruction.		

Drilling Progress and Water Observations

Date	Time	Depth	Casing Depth	Casing Dia	Core Dia mm	Water Strike	Water Standing

Rotary Flush

From	To	Type	Returns

GENERAL REMARKS

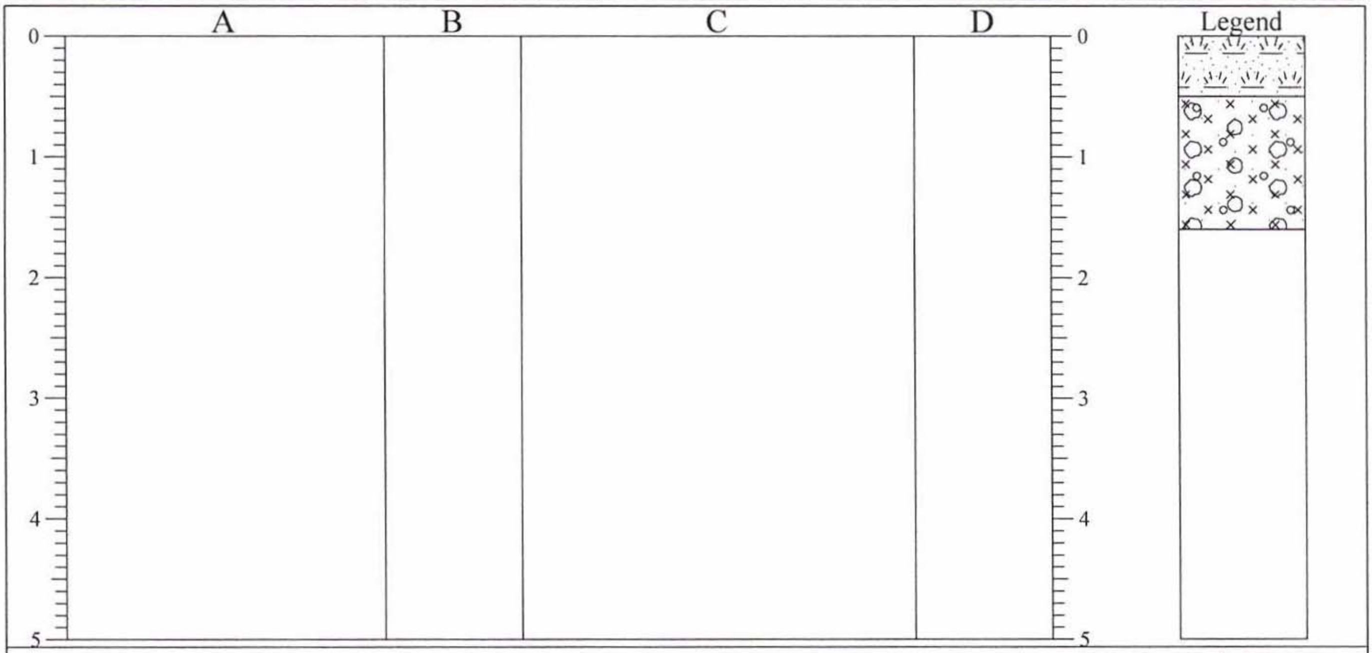
Borehole backfilled with cement bentonite grout.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used County Tractor	Bit Design HQ	Logged By EAT

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

TRIAL PIT LOG

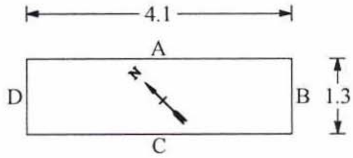
Project				TRIAL PIT No
N6 Galway City Outer Bypass				TP 971
Job No	Date 20-10-06 20-10-06	Ground Level (m) 16.41	Co-Ordinates () E 129,416.2 N 228,288.1	
Contractor IDL	GROUNDWATER STRIKES	Water strikes: 1st: dry 2nd: 3rd:	Rose to (@ 20 min.): Sealed at:	Sheet 1 of 1



STRATA / SAMPLES & TESTS

Depth	No	DESCRIPTION	In Situ Tests	Water	Depth (m)	No	Remarks/Tests
0.00-0.50		Soft damp brown grey mottled orange slightly sandy gravelly SILT/CLAY with some subangular to subrounded cobbles and boulders (TOPSOIL).Boulders up to 300mm long.			0.30	J	
0.50-1.60		Soft damp grey brown mottled slightly sandy gravelly SILT with many subangular to subrounded cobbles and subangular to angular boulders.Boulders up to 450mm long.			1.00 1.00	B J	
1.60		Refusal - possible intact rock (fractured dark grey limestone).					

Shoring/Support:
Stability:



GENERAL REMARKS

Pit dry, unstable during excavation-spalling of sides from 0.30m.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used Hitachi ex120	Bit Design	Logged By TS

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

TRIAL PIT LOG

Project				TRIAL PIT No
N6 Galway City Outer Bypass				TP 1437
Job No	Date 25-10-06 25-10-06	Ground Level (m) 15.24	Co-Ordinates () E 129,309.4 N 228,203.5	
Contractor IDL		GROUNDWATER STRIKES	Water strikes: 1st: dry 2nd: 3rd: Rose to (@ 20 min.): Sealed at:	Sheet 1 of 1

A B C D

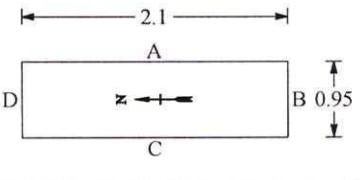
0 1 2 3 4 5

Legend

STRATA / SAMPLES & TESTS

Depth	No	DESCRIPTION	In Situ Tests	Water	Depth (m)	No	Remarks/Tests
0.00-0.10		TOPSOIL with many roots and rootlets.			0.00-0.15	J	
0.10-0.15		Soft damp dark brown slightly sandy slightly gravelly SILT/CLAY with some angular to subrounded cobbles and rare subangular to angular boulders. Boulders are up to 300mm in size.					
0.15		TP abandoned at 0.15m bgl. Obstruction - probable limestone rock.					

Shoring/Support:
Stability:



GENERAL REMARKS

Pit dry, stable during excavation.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used Hitachi ex 135	Bit Design	Logged By TS

IDL
IRISH DRILLING LTD.
LOUGHREA, CO. GALWAY
Telephone: 091 841274
Fax: 091 847687

TRIAL PIT LOG

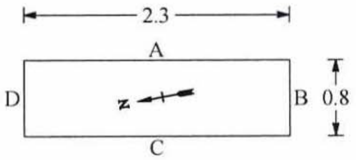
Project				TRIAL PIT No
N6 Galway City Outer Bypass				**TP 1438**
Job No	Date 26-10-06 26-10-06	Ground Level (m) 15.91	Co-Ordinates () E 129,428.7 N 228,258.2	
Contractor IDL	GROUNDWATER STRIKES	Water strikes: 1st: dry 2nd: 3rd:	Rose to (@ 20 min.): Sealed at:	Sheet 1 of 1

A B C D — Legend (depth scale 0–5)

STRATA / SAMPLES & TESTS

Depth	No	DESCRIPTION	In Situ Tests	Water	Depth (m)	No	Remarks/Tests
0.00-0.10		Broken rock at surface as light grey LIMESTONE.			0.00-0.10	J	
0.10		TP abandoned at 0.1m bgl. Obstruction - probable rock.					

Shoring/Support:
Stability:



GENERAL REMARKS

Pit dry, stable during excavation.

All dimensions in metres Scale 1:62.5	Client Galway County Council	Method/ Plant Used Hitachi ex 135	Bit Design	Logged By TS

Borehole Log

Drilled by TB Logged by JL Checked by ROR	Start 11/10/2003 End 12/10/2003	Equipment, Methods and Remarks	Depth from	to	Diameter	Casing Depth	Ground Level +16.65 mOD
		Soil Mech Rotary Open Hole 131mm diameter 0.00m to 1.00m. Rotary Core 68mm diameter 1.00m to 10.00m. Borehole examined by televiewer.	0.00m 1.00m	1.00m 10.00m	131mm 68mm		Coordinates E 129407.30 National Grid N 228290.20

Samples and Tests / Strata

Depth	Type & No (TCR/SCR/RQD)	If	Records	Date Casing	Time Water	Description	Depth, Level (Thickness)
				11/10/2003	0800	OVERBURDEN**	(0.50)
0.00-1.00	Rotary Open Hole Drilling						0.50 +16.15
						Possible LIMESTONE / COBBLES**	(0.50)
1.00-1.40	23 0 0					Possibly fractured LIMESTONE** Recovered as coarse gravel and cobbles (poor recovery) 1.00-1.82 m Non-intact. Assumed zone of core loss	1.00 +15.65 (0.40) 1.40 +15.25
1.40-2.30	100 39 11					Strong grey brown fine grained LIMESTONE with occasional heavily crenulated stylolites and rare calcite veins. 1.90-1.98 m Non-intact	
2.35			CS 1			WEATHERING: Dissolution features are common with fracture surfaces displaying chalky residue, often accompanied by orange brown discolouration. Calcite veins stained yellow 2.27-2.34 m Non-intact	
2.30-3.05	100 75 31	NI 80 140				DISCONTINUITIES: 0° -15° very closely to medium spaced, predominantly closely spaced to 4.15m then medium spaced, smooth planar to undulating fractures. 2.72-2.94 m Non-intact	
3.05-3.40	100 100 43					35° - 50° medium to widely spaced smooth undulating fractures, commonly found with chalky white residue on surface. 3.40-3.47 m Non-intact	
3.40-4.70 4.15-4.65	95 91 77		CS 2				
4.70-5.85	100 82 82					4.50-4.63 m 75 degree smooth undulating fracture 4.63-4.82 m Non-intact. Assumed zone of core loss 5.35-5.46 m Non-intact	
5.85-6.80 6.50	75 73 73		CS 3	11/10/2003 1.00	1800	5.70-5.76 m 60-70 degree smooth undulating fracture with white chalky residue and orange brown clay smear on fracture surface	(8.60)
6.72			CS 4	12/10/2003 1.00	0800	6.44-6.70 m Non-intact. Assumed zone of core loss	
6.80-8.40	91 91 91	NI 280 490					
8.40-10.00	68 43 43		Core Slipped	12/10/2003 1.00	1800	8.92-8.98 m Non-intact 8.98-9.10 m Subveritcal smooth undulating fracture 9.18-9.36 m Non-intact	
						EXPLORATORY HOLE ENDS AT 10.00 m	

Legend | Backfill/Instruments

Groundwater Entries

No. | Struck (m) | Post strike behaviour | Depth sealed (m)

None observed (see Key Sheet)

Depth Related Remarks

From to (m)

Chiselling

Depths (m) | Time | Tools used

Notes: For explanation of symbols and abbreviations see key sheet. All depths and reduced levels in metres. Stratum thickness given in brackets in depth column.

Scale 1:50

(c) MESG HBIII (298), 11/02/2004 11:34:47 AGS

Project: N6 Galway City Outer Bypass Contract 2 Ground Investigation Gortatleva to Menlough

Project No. KC3210

Carried out for: Galway County Council

Borehole **RC135**

Appendix C

Constructability Report

Galway County Council

N6 Galway City Ring Road

Menlough Viaduct Constructability

GCRR-4.03-6.1.74-001

Issue 4 | 5 October 2017

Job number 233985

Ove Arup & Partners Ireland Ltd

Arup
Corporate House
City East Business Park
Ballybrit
Galway
H91 K5YD
Ireland
www.arup.com

ARUP

Document Verification

ARUP

Job title		N6 Galway City Ring Road		**Job number** 233985	
Document title		Menlough Viaduct Constructability		**File reference**	
Document ref		GCRR-4.03-6.1.74-001			
Revision	**Date**	**Filename**	GCOB_4.03_6.1.74_001 Menlo Viaduct Construction_I1.docx		
Issue 1	14 Oct 2016	**Description**	Issue 1		
			Prepared by	Checked by	Approved by
		Name	Eimear Keane	Mary Hurley	Pat Moore
		Signature			
Issue 2	6 May 2017	**Filename**	GCOB_4.03_6.1.74_001 Menlo Viaduct Construction_I2.docx		
		Description	Issue 2		
			Prepared by	Checked by	Approved by
		Name	Eimear Keane	Mary Hurley	Pat Moore
		Signature			
Issue 3	23 June 2017	**Filename**	GCOB_4.03_6.1.74_001 Menlo Viaduct Construction_I3.docx		
		Description	Issue 3		
			Prepared by	Checked by	Approved by
		Name	Daniel Mangan	Mary Hurley	Pat Moore
		Signature			
Issue 4	5 Oct 2017	**Filename**	GCOB_4.03_6.1.74_001 Menlo Viaduct Construction_I4.docx		
		Description	Issue 4		
			Prepared by	Checked by	Approved by
		Name	Daniel Mangan	Mary Hurley	Pat Moore
		Signature			

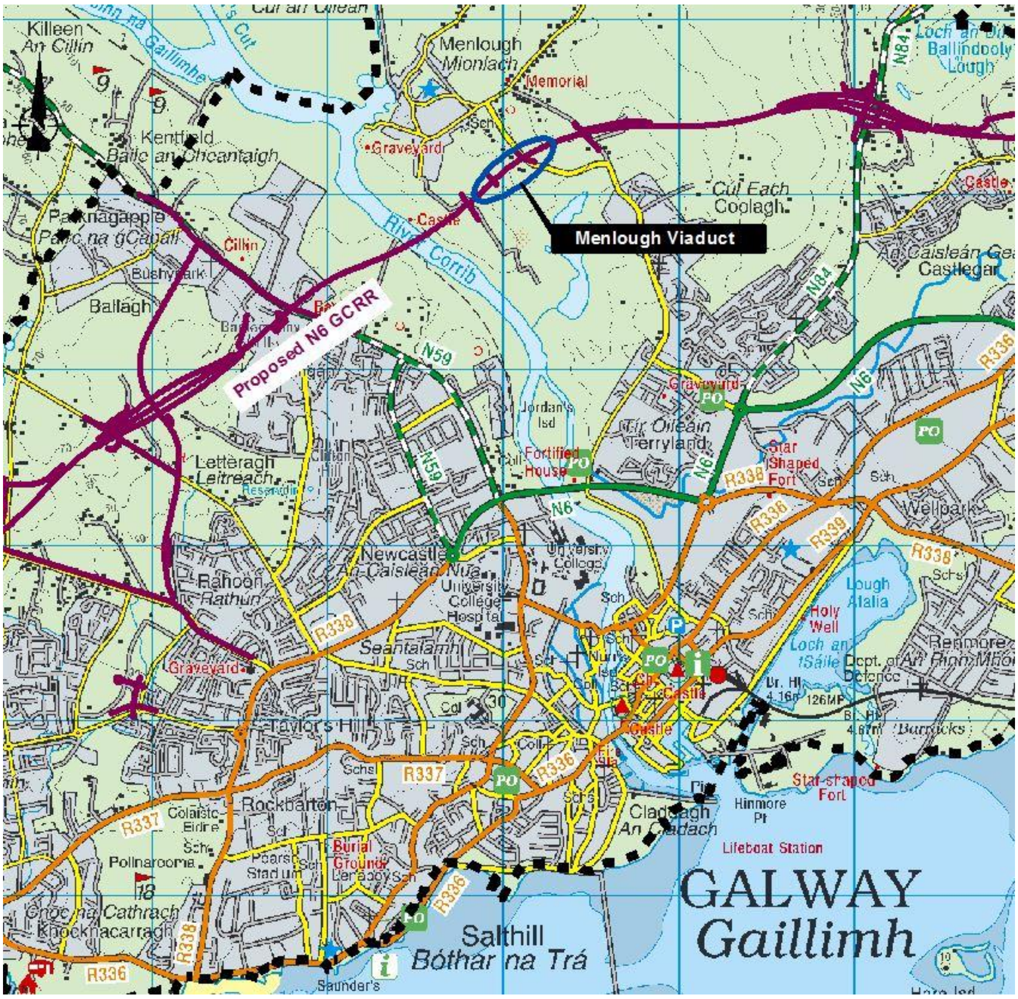
Issue Document Verification with Document ✓

Contents

1 Introduction

The N6 Galway City Transport Project, hereafter referred to as N6 Galway City Ring Road (GCRR) or proposed road development, incorporates the design of a viaduct structure, known as the Menlough Viaduct in the townland of Menlough to the north of Galway city, as shown in **Figure 1.1** below. The viaduct is situated between the River Corrib Bridge to the west and Lackagh Tunnel to the east.

Figure 1.1: Site Location – Menlough Viaduct



The proposed viaduct will be elevated over an area of Annex I habitat, namely Limestone pavement and a Turlough to reduce the environmental impacts of the proposed road development. It is located in a rural environment and the terrain is undulating with rocky outcrops and local depressions. The Menlough Viaduct is located outside of the Lough Corrib candidate Special Area of Conservation (cSAC) and between 45m and 140m to the north of the cSAC boundary.

Given the environmentally sensitive location of the viaduct, the rural setting and general accessibility to the site, the construction methods are an important aspect to be considered at this stage. This report describes the possible methods utilised to construct the Menlough Viaduct and the measures taken to minimise impacts on the Annex I habitat.

The Menlough Viaduct can be constructed using different methods, and/or a combination of these methods.

Method 1 consists of constructing from ground level using a protective layer system to protect the Limestone pavement; Method 2 consists of constructing using a cantilever type system with limited works taking place on the Limetone pavement itself.; and Method 3 consists of prefabricated construction on a span-by-span basis.

For all methods the following constructability constraints apply:

1. Construction of the viaduct foundations will require specific requirements to be satisfied to ensure that there will be no impact to the groundwater body from the construction. Pouring of the cement for foundations will only be undertaken following inspection and approval by a qualified hydrogeologist that no impact will occur. The inspection will require observation of the full depth and extent of the excavation in order to identify if any karst flow paths, such as conduits, are present.
2. If no karst pathways are evident in the excavation then the hydrogeologist will approve the construction to proceed.
3. If karst pathways are present in the excavation then there is risk that cement could leak into the aquifer, which would have negative impacts on the groundwater body and any supported groundwater dependant terrestrial ecosytems (GWDTE). The groundwater body underlying the Menlough Viaduct is the Lough Corrib Fen 1 (Menlough) GWB which supports GWDTE in the Lough Corrib cSAC European sites. Potential impacts from cement to the groundwater body include restricting or sealing groundwater flow paths or reducing the water quality due to increased turbidity. In order to prevent these potential impacts mitigation measures are detailed in the Construction Environmental Management Plan (CEMP) to ensure that karst can be managed if encountered so that no impact to the groundwater body occurs.
4. The design of the mitigation is detailed in the CEMP and comprises of backfilling the karst to ensure that the feature does not lose its connectivity or flow path within the aquifer and then secondly the feature is sealed from the excavation to ensure that cement will not enter or impact the feature.
5. Based on the regional groundwater levels measured during the ground investigation the construction and excavations are expected to remain above the groundwater table and on this basis no pumping or dewatering is included in the design. If the excavations need to be deeper than expected then the construction schedule may need to be modified in order to restrict constructing and inspecting the foundations to the groundwater low.
6. No construction works will take place directly within the extents of the Turlough.

Similiarly, the necessary headroom at the side road (5.3m) and a desired headroom for bat passage (2.5m) is provided generally over the full length of the bridge, with the exception of the central portion near chainage (Ch.) 10+200 where the headroom reduces to approximately 1.5m due to the local topography. A further localised reduction in headroom occurs in this area at the point of the peaking of the contours which is approximately 100m^2, with the absolute lowest clearance at the peak contour being 0.75m. At this location no Limestone pavement protection system will be provided as it would not be possible to safely remove the system. No construction works will take place within this zone from the ground level.

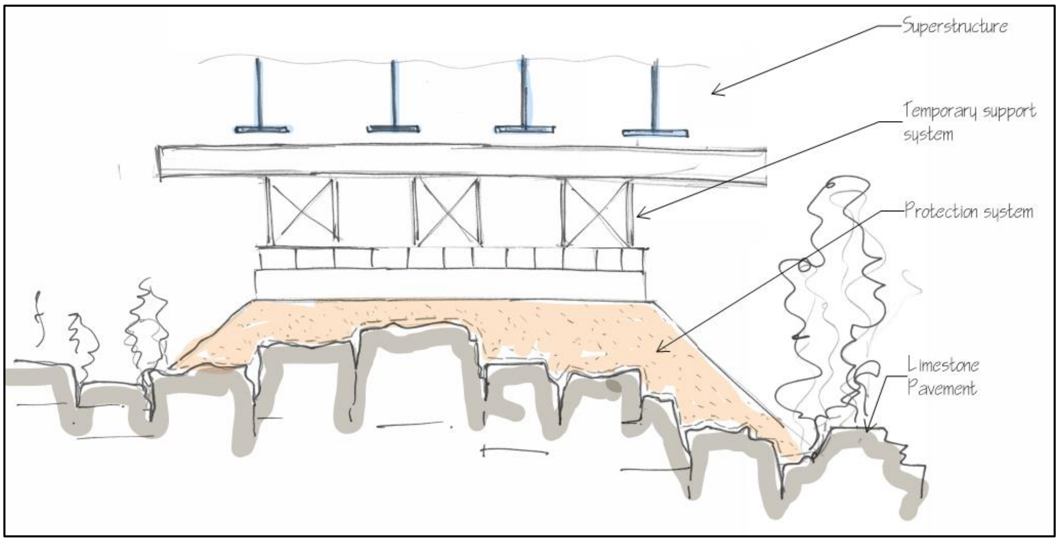
The first and third method, as presented in **Section 2** and S**ection 4,** involves protecting the Annex I habitats and then constructing the viaduct off the ground. The measures taken to protect the Limestone pavement and Turlough are also described in **Section 2**. The second methodology detailed in **Section 3** of this report is a balanced cantilever system that would allow some of the viaduct structure to be constructed primarily without any interaction with the ground below. The site preparation and reinstatement works are also outlined in **Section 2, 3** and **4** for each construction method. A summary of the findings of this report are outlined in **Section 5**.

2 Construction Method 1

2.1 Introduction

Construction Method 1, will allow construction to be undertaken from ground level, by first installing a protection system over the Limestone pavement, similar to that shown in **Figure 2.1** below, to create a working platform for construction of the viaduct that would not result in a residual impact on the Limestone pavement. In order to protect the surrounding area of Limestone pavement from spillages of sand and gravel from the protection system, the geotextile membrane will evelope the sides of the protection system to contain the various layers.

Figure 2.1: Temporary construction on Limestone pavement



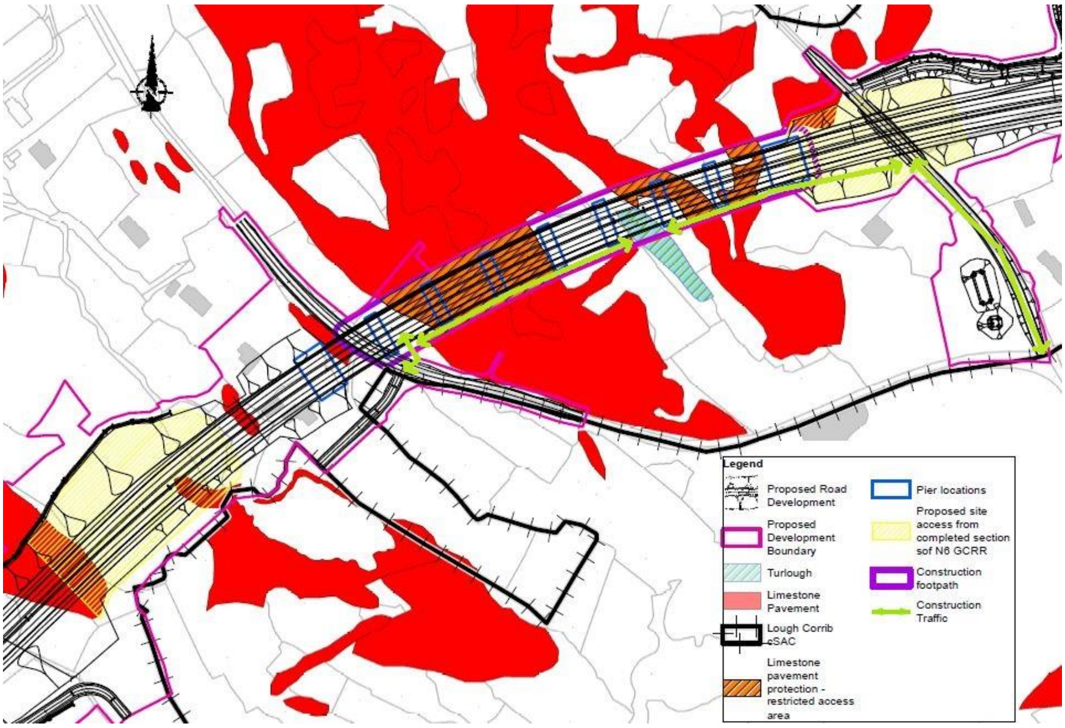
The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Construction of the Limestone pavement protection system
- Stage 3 - Viaduct construction
- Stage 4 – Completion of works

2.2 Stage 1 - Site access and enabling works

The first stage in the sequence of construction for this section of the proposed road development will be to construct the section of the proposed road development shown in blue in **Figure 2.2** below as these sections can then be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bothar as shown in green in **Figure 2.2**. The access and construction traffic paths have been designed to minimise the impact and interaction with the Annex I habitats. A construction path of approximately 3-5m either side of the bridge deck will be required.

Figure 2.2: Construction Method 1 Site Access



The proposed development boundary fencing will be erected to isolate the construction area. This fencing will be erected in a such a manner which will not impact on the structural integrity of the Limestone pavement. The vegetation assocaiated with the Limestone pavement will be removed as part of the site clearance prior to the installation of the Limestone pavement protection system detailed in **Section 2.3**. No machinery will be located on top of the Limestone pavement without the protection system in place. Any vegetation on top of the Limestone pavement will be removed using hand held equipment. Vegetation will be cut only and will not be up-rooted. The protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement.

2.3 Stage 2 - Construction of the Limetstone pavement protection system

The area of Limestone pavement to be protected is approximately 5,750m^2. The function of the Limestone pavement proection system is to safeguard the structural integrity of the Limestone pavement from loading associated with the viaduct construction that could potentially cause structural damage. In order to design the protection system required it is necessary to understand the construction loadings and duration.

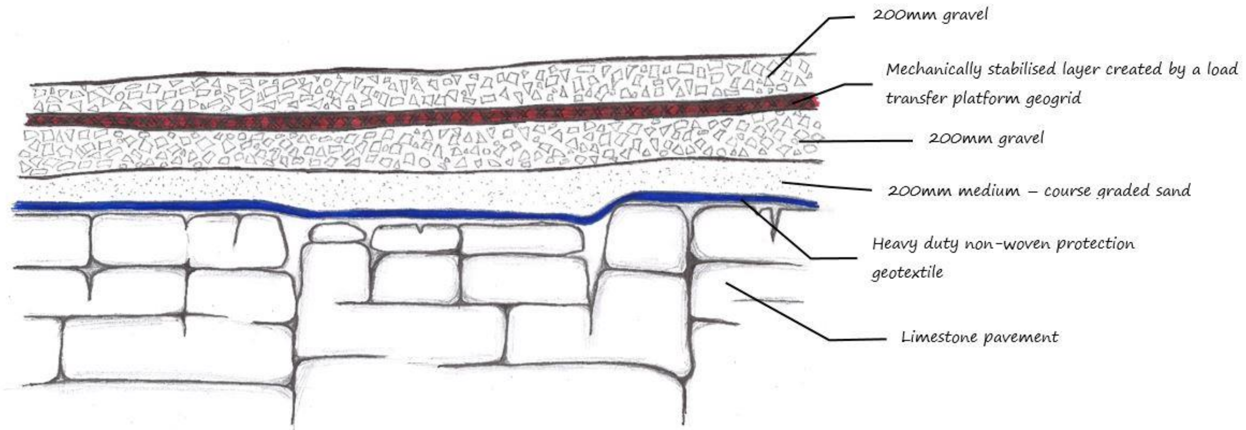
The construction of Menlough Viaduct is anticipated to take 18 to 24 months. During this time, both tracked and untracked machinery will be used depending on the terrain. A non exhaustive list of the construction machinery expected to be used during the construction period consists of excavators, cranes, dump trucks, loaders, roller trucks and concrete equipment.

The anticipated applied loading on the ground due to construction is in the range of 35-50kN/m^2. This is the total load anticipated inclusive of the wet concrete, construction machinery and falsework, where applicable. The loading will be intermittent and not confined to one single location. This is the expected loading on the area of Limestone pavement only, other loadings will apply at other locations.

The protection system will incorporate layers of materials to firstly protect the surface of the Limestone pavement but also to redistrubte the construction loadings and avoid point loads which may cause induced cracks to the surface of the Limestone pavement. Figure 2.3 below shows an indicative sketch of this protection system which is made up of the following:

1. A heavy duty non woven protection geotextile layer on the surface of the Limestone pavement
2. A layer of sand to form a level surface and protect the geotextile from tearing due to the gravels
3. A layer of gravels to provide stability and an interlocking system for the load transfer platform geogrid
4. A load transform platform geogrid to redistribute the point loadings and provide a mechanically stabilised layer and a safe working platform for construction
5. A layer of gravels to provide an interlocking system for the mechanically stabilised layer and clause 804 or similar surface for construction traffic to traverse

Figure 2.3: Limestone pavement protection system



2.3.1 Geotextile protection layer

Standard geotextile membranes are permeable nonwoven fabrics which when used in assoiciation with soil, have the ability to separate, filter, reinforce, protect or drain. The protection geotextile layer will be used to prevent the sand and granular material from seeping into grikes associated with the Limestone pavement. A heavy duty non woven protection geotextile will be used in this instance. The protection geotextile shall have a good elongation as this will help mould the layer around the clinks and grykes of the Limestone pavement and provide full protection as the geotextile is designed to deform in such a way. This layer will act as the first layer of protection to the surface of the Limestone pavement. As such it is important that this layer is of sufficient strength as to not tear or puncture, and shall have a min strength of 46 – 55 kN/m and a minimum pore sizing of approxamtely 65-75 μmm. This is to prevent any seepage of sand into the grikes of the Limestone pavement. The heavy duty non woven protection geotextile shall be crane lifted from outside the Limestone pavement to the start of the protection area. The geotextile can be rolled out and laid manually on site without the need for any heavy machinery.

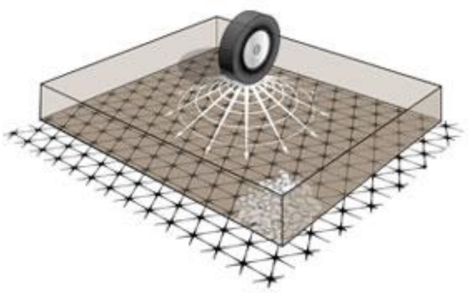
2.3.2 Sand layer

A layer of fine sand will be placed on top of the geotextile protection layer to protect the material from any tearing due to the angular gavels which will be used with the structural geotextile membrane for distributing the loading. The sand layer shall be built up and compacted to form a level surface above the Limestone pavement. The sand layer is required to be a medium to coarse graded sand in accordance with ISO EN 14688. Particle sizes in the range of 0.2mm to 2.0mm will be used which will provide enough flexibility to even out the surface while also large enough not to seep through the geotextile.

2.3.3 Geogrid load transfer platform

Geogrid load transfer platforms (LTP) are most commonly used in the construction of piled foundations on soft ground. The LTP acts to disperse the applied loading to the entire foundation and not solely to the supporting pile foundations. Similarly this can be applied to the areas of Limestone pavement. Without the LTP the applied loading would concentrate on the first contact point with the Limestone pavement, such a loading would likely cause the Limestone pavement to fracture or break. However the inclusion of the LTP, as can be seen in **Figure 2.4** below, results in the loading being diffused and applied over the entire pavement area. A material which can achieve this load dispersal, and in particular disperse loads in a multi-directional pattern, shall be utilised. This type of geogrid has near isotropic tensile properties which leads to a mechanically stabalised layer.

Figure 2.4: Radial loading dispersion of geogrid load transfer platform (Tensar International, 2010)



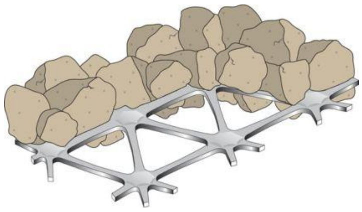
These type of geotextiles have been used in other infrastructure projects in Ireland and the UK, for example A2 Maydown to City of Derry Airport and Arecleoch

Windfarm South Aryshire. Only products which have undergone multiply rigorous tests to support the performance criteria will be used for this Limestone pavement protection system.

2.3.4 Gravel layer

A 200mm layer of 100-150mm graded stone will be placed above and below the load transfer geogrid. The stone layers will interlock with the triangular openings of the geogrid to form a stabile layer of suitable stiffness as can be seen in **Figure 2.5** below.

Figure 2.5: Interlocking of stone layer with geogrid (Tensar International, 2010)



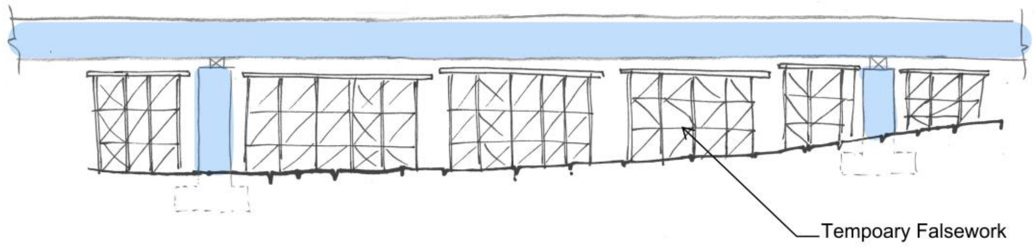
The protective system will be finished with a suitable surface such as clause 804 to enable construction traffic to traverse the area.

2.4 Stage 3 – Viaduct construction

Temporary falsework will be constructed above the Limestone pavement protection system to below the soffit of the bridge deck as shown in **Figure 2.6**. This will allow the necessary construction platform to construct the viaduct, for example for a concrete bridge the in-situ concrete could be poured and then post-tensioned or for a steel bridge, the steel sections can be lifted into place and connections fitted.

No construction works are permitted within the area of the Turlough itself. At both the local road and the Turlough a temporary spanning structure will be utilised to support the formwork for the construction activities. Where in situ concrete is used for the superstructure, it is expected that a temporary bridging structure would be built over the Turlough to permit construction from below the proposed deck. For construction methods using prefabricated elements, the lifting of these elements above the Turlough will be undertaken using lifting equipment located at a suitable distance from the Turlough to avoid any impact. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement or Turlough environment beneath.

Figure 2.6: Construction with temporary falsework



2.5 Stage 4 – Completion of works

Once the viaduct structure is complete all construction related material will be removed, including the Limestone pavemet protection system. The removal of this protection system is an important aspect of ensuring the physical structure of the Limestone pavement is intact.

The removal will be done in a similar staging as to how it was constructed. The initial layers of the gravel and geogrid will be removed followed by the sand and the protective geotextile layer. The protective geotextile layer shall be manually rolled back off the Limestone pavement and crane lifted away from the site. No machinery will be located on top of the Limestone pavement during this activity.

3 Construction Method 2

The second construction method presented is the balanced cantilever system and is less invasive on the protected habitats as the ground is not used as a platform for the construction works. The construction works will be restricted to minimise direct contact with the Limestone pavement and avoid direct contact with the Turlough. It should be noted that where balanced cantilever methods are used, it will not be for the full length of the bridge and some parts of the bridge will be constructed using Construction Method 1.

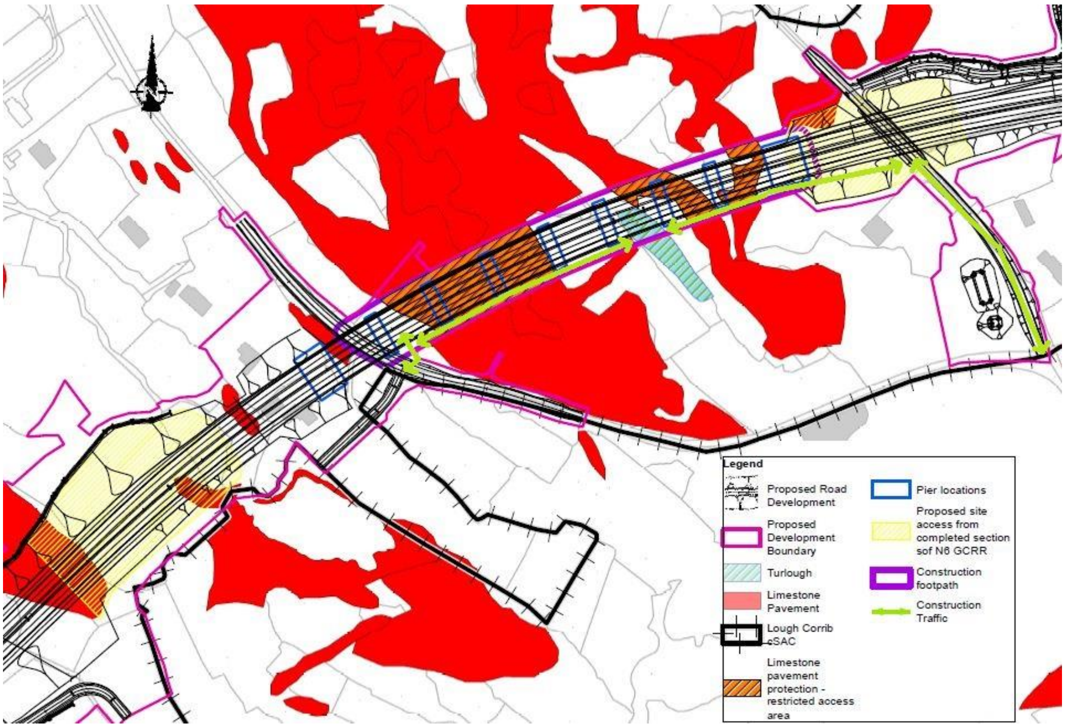
The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Viaduct construction
- Stage 3 – Completion of works

3.1 Stage 1 – Site access and enabling and works

As described in **Section 2.2**, the proposed road highlighted in blue in **Figure 3.1** will be constructed first and will be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bothar as shown in green in **Figure 3.1**. Areas of Limestone pavement will need to be protected temporarily during the construction, using the protection system described in **Section 2.3.** This protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement and under the footprint of the structure to protect the Limestone pavement in the event of any falling debris or materials during construction. Access will be restricted to the main area of Limestone pavement beneath the large span of the structure and to the Turlough.

Figure 3.1: Construction Method 2 Site Access



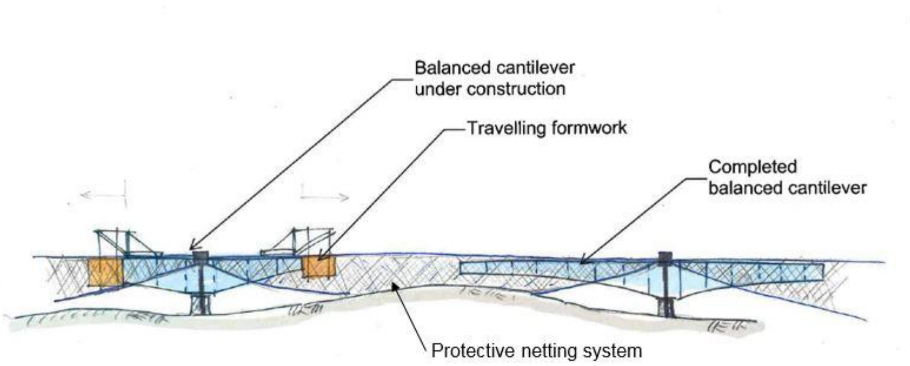
The proposed development boundary fencing will be erected to isolate the construction area as outlined in **Section 2.2** of this report.

3.2 Stage 2 – Viaduct Construction

The balanced cantilever method with travelling forms would be adopted as shown in **Figure 3.2** to construct the viaduct and avoid the need for temporary supports over the large area of Limestone pavement beneath the main span.

As described in **Section 3.1** access to the site would be gained from the proposed road development east and west of the viaduct location and construction traffic such as concrete trucks or cranes would be able to travel to the site location via these sections of the N6 GCRR. In the case of a concrete bridge the in-situ concrete can be poured from these sections of the N6 GCRR. For further mitigation details refer to Section 8 Sediment, Erosion and Pollution Control Plan, of the CEMP The concrete will be pumped as the formwork continues to progress further along the structure. For the shorter spans, particularly over the Turlough, the balanced cantilever could also be continued. Where in situ concrete is used for the superstructure, it is expected that a temporary bridging structure would be built over the Turlough to permit construction from below the proposed deck. For construction methods using prefabricated elements, the lifting of these elements above the Turlough will be undertaken using lifting equipment located at a suitable distance from the Turlough. For a steel bridge the steel girders would be lifted into place using a crane located on the constructed N6 GCRR.

Figure 3.2: Balanced cantilever construction method



This is a less invasive construction methodology as it avoids any large scale construction works off the Limestone pavement, although, some parts of the bridge will be constructed using Construction Method 1. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement environment beneath.

3.3 Stage 3 – Completion of works

As some of the works are completed from the western and eastern approaches to the structure and not off the ground itself, the removal and reistatement works are reduced with this option. All construction related material will be removed following completion of the works and the Limestone pavement protection system will be removed in the reverse to how it was installed as discussed in **Section 2.5** of this report. The protective netting will also be removed on completion of the viaduct construction.

4 Construction Method 3

The third construction method presented is a prestressed precast beam superstructure construction method. This method is similar to Method 1; the protection measures to the Limestone pavement are required for access and craning of the precast elements.

The stages of the construction under this methodology are as follows:

- Stage 1 - Site access and enabling works
- Stage 2 - Viaduct construction
- Stage 3 – Completion of works

4.1 Stage 1 – Site access and enabling and works

As described in **Section 2.2**, the proposed road highlighted in blue in **Figure 2.2** will be constructed first and will be used for site access to construct the viaduct. There will also be limited construction traffic from Bóthar Nua and Sean Bothar as shown in green in **Figure 2.2**. Areas of Limestone pavement will need to be protected temporarily during the construction, using the protection system described in **Section 2.3.** This protection system will be put in place anywhere there is the potential for interaction between construction work and the Limestone pavement and under the footprint of the structure to protect the Limestone pavement in the event of any falling debris or materials during construction.

The precast beam method will require the use of mobile cranes to lift and place the beams in position. An apporpirate temporary platform will be required at discrete locations to position the cranes for lifting of the precast beams. These temporary platforms will be provided with the protection system described above. The proposed development boundary fencing will be erected to isolate the construction area as outlined in **Section 2.2** of this report.

4.2 Stage 2 – Viaduct Construction

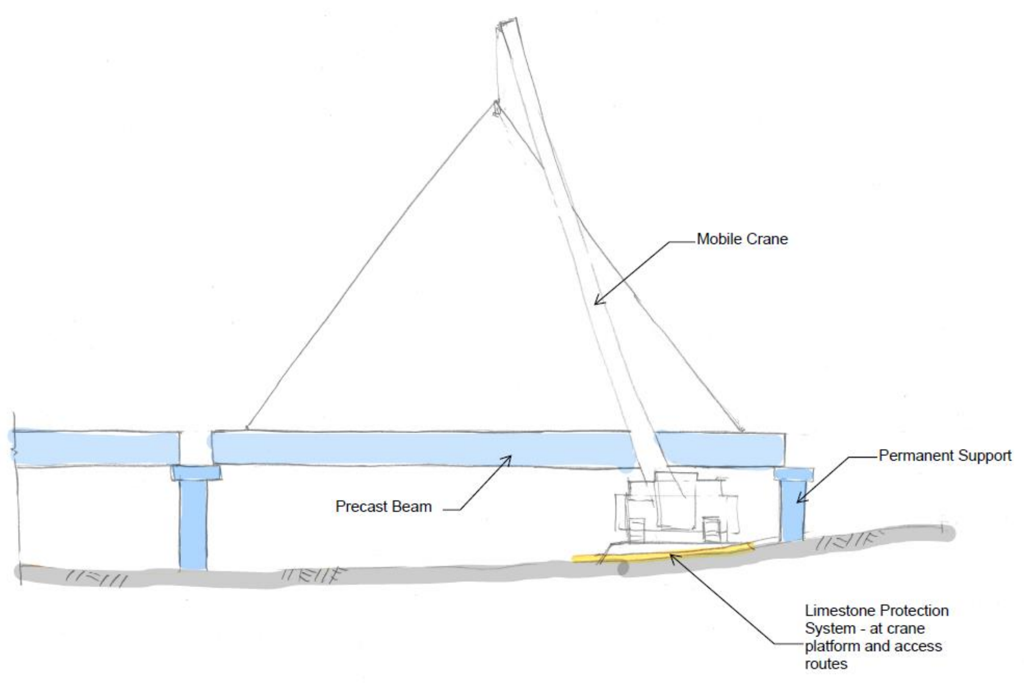
The precast beams will be lifted into position in span by span. The precast beams will be placed on the permanent supports and no temporary supports are envisaged within spans. See **Figure 4.1.** Where tall and slender precast beams are used, such as SY beams, the appropriate measures to ensure stability during lifting and concreting of the deck are necessary. This should include the use of permanent drop-heads at the support locations and the necessary temporary works to restrain the beams rotation at the ends. The temporary works are to use the permanent pier as the supporting structure, and not the ground below.

For the span over the Turlough, a tandem lift is expected, whereby two cranes are used, positioned on each side of the Turlough.

As described in **Section 4.1** access to the site would be gained from the proposed road development east and west of the viaduct location and construction traffic such as concrete trucks or cranes would be able to travel to the site location via these sections of the N6 GCRR. An insitu deck slab will be provided above the precast beams, with the concrete supply being provided by trucks adjacent to the bridge.

This construction methodology avoids any large scale construction works off the Limestone pavement. A netting system will also be used over the Limestone pavement and Turlough area to catch any falling debris or materials. This will ensure that no damage occurs to the Limestone pavement environment beneath.

Figure 4.1: Prestressed Precast Beam Superstructure Construction Method



4.3 Stage 3 – Completion of works

All construction related material will be removed following completion of the works and the Limestone pavement protection system will be removed in the reverse to how it was installed as discussed in **Section 2.5** of this report. The protective netting will also be removed on completion of the viaduct construction.

5 Summary and Conclusions

This report outlines three viable construction options for constructing Menlough Viaduct, Construction Method 1 and Method 3 includes the construction of a protection system over the Limetone pavement and using this as a construction platform and Construction Method 2 utilises the balanced cantilever system.

Although all construction methodologies will affect the vegetation associated with the Limestone pavement habitat, it is not envisaged that there will be any permanent residual impacts to the structural integrity of the Limestone pavement following the construction of the Menlough Viaduct using any of these three methods. The Limestone pavement protection system has sufficient capacity to withstand the predicted construction loading. The geotextile protective layer, as demonstrated, will act as a barrier between the Limestone pavement surface and the sand and granular layers of the protection system. The geogrid has the capability to disperse any point loading and therefore protect the Limestone pavement from cracking or any structural damage. The Turlough will be clear spanned and no construction will take place within this area to avoid any direct impacts on this habitat area.

All of the construction methodologies decribed incorporate the need to protect the structural integrity of the Limestone pavement and to ensure the Turlough is not directly affected by consruction works.

6 References

Arup. (2016). *GCOB-4.04-020-006 Menlough Viaduct Options Report.*

Tensar International. (2010, February). The properties and performance advantages of Tensar TriAx™ geogrids. Blackburn, Uniked Kingdom.

Terram. (n.d.). *Road and Highways Brochure.*