N24 CARRICK ROAD IMPROVEMENT SCHEME

PRELIMINARY DESIGN REPORT

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FOREWORD

This Preliminary Design Report has been prepared in accordance with TII in DN-GEO-03030 Guidance on Minor Improvements to National Roads and in accordance with the Project Management Guidelines.

The purpose of the Preliminary Design Report is to address and present issues relating to compliance with the relevant parts of the TII Publications and in particular the TII Design Manual for Roads and Bridges, for the proposed scheme.

The Preliminary Design Report will:

- Introduce and identify the need for the scheme;
- Identify specific objectives of the proposed scheme;
- Analysis collision data for the location;
- Identify appropriate design speed;
- Description of options considered;
- Describe constraints;
- List the main geometric features of the scheme
- Identify safety barrier requirements;
- Identify drainage requirements;
- Identify Traffic Signs and Road Marking requirements
- Comment on junction treatment;
- List Relaxations and Departures proposed by Road Authority responsible for the Scheme. (Kilkenny County Council)
- Provide details relating to Stage F Safety Audit
- Provide Preliminary Design Drawing Layouts.

During Stage 1 Appropriate Assessment Screening undertaken by Ecofact Ltd., it was determined that The N24 Carrick Road Improvement Scheme should proceed to Stage 2 Appropriate Assessment as the screening concluded that, "*there is a possibility of effects on the qualifying interests of the Lower River Suir SAC and mitigation measures will be required.*"
Subsequent to this conclusion, Kilkenny County Council engaged the services of Barry Transportation Ltd. to prepare a Natura Impact Statement (NIS) carry out screening for an Environmental Impact Assessment and prepare a Section 177ae Application. The NIS identifies the mitigation measures required and these are taken into account within the existing design and the required land-take.

1 IDENTIFICATION OF NEED FOR THE WORKS

1.1 Existing Layout

The section of N24 that is being considered is rural in nature and located immediately North West of the village of Mooncoin in County Kilkenny. The scheme is approximately 2km in length and has a specific need to address issues with substandard geometric alignment, cross section and visibility issues from a high number of accesses along the existing N24 national primary route. It is noted that this section of the N24 lies within N24 Waterford to Cahir Scheme, which is within the early stages of development and maybe quite a number of years before it will be ready for construction. The N24 Carrick Road Improvement Scheme is a discreet minor scheme that will address the safety issues owing to the substandard nature of the N24 along this section. See figure 1.1 below showing the extents of the scheme. Further proposed layout details are presented in the General Arrangement Drawings in Appendix A of this report.

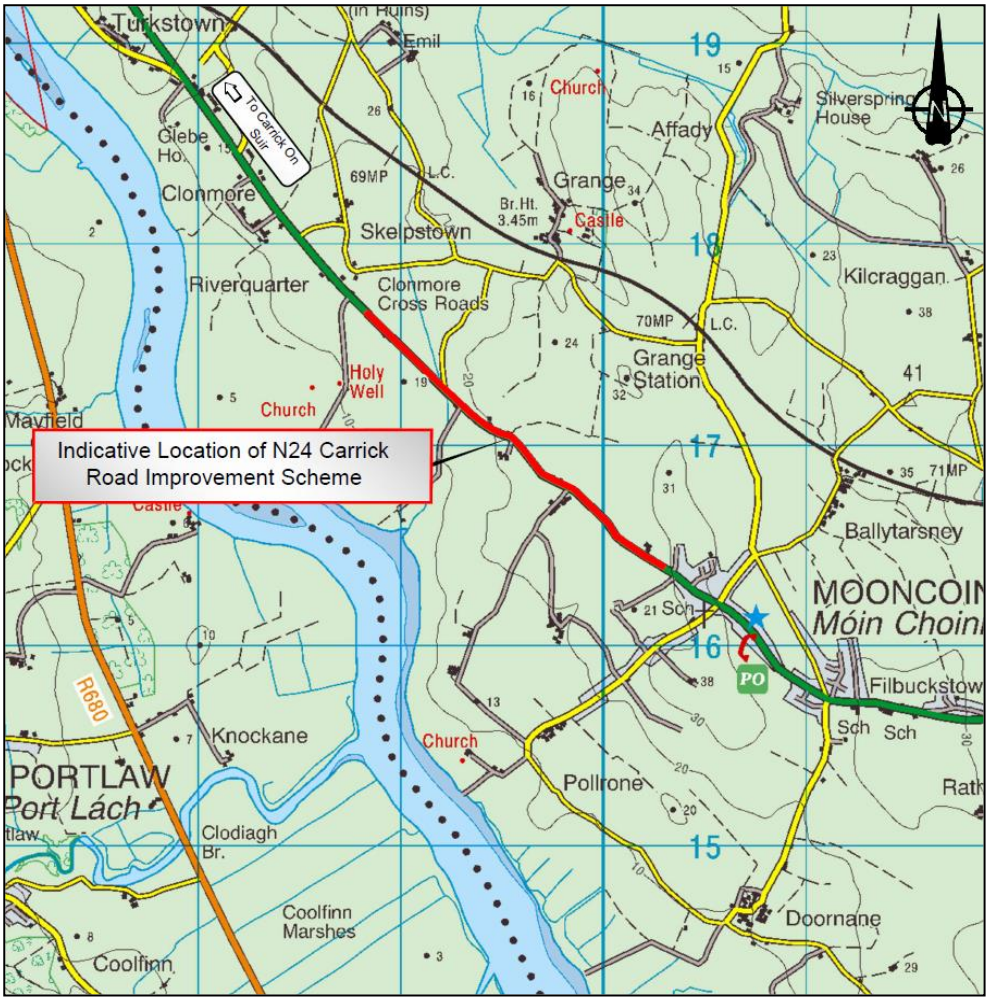


Fig 1.1: Extent of scheme

The N24 is a National Primary Route located in County Waterford, County Kilkenny, County Tipperary and County Limerick, with an overall total length of approximately 116km. The cities and towns located on or adjacent to the N24 are Waterford (City), Carrick-on-Suir, Clonmel, Cahir, Tipperary and Limerick (City). There are also numerous villages located along the N24 route and it provides a vital link in the region to both the M9 and M8 Motorways in the counties of Waterford, Tipperary and Limerick.

The existing section of the N24 which is under consideration within this report is a narrow rural single carriageway road with average driving lane widths in the order of 3.2m and hard-strips typically ⩽ 0.5m. There are two different speed limits over the extents of the scheme. From the western tie in toward the L7416 local road (circa 700m), the speed limit is 100kph. The remainder of the scheme has a speed limit of 80kph. The existing verge widths vary but are again predominantly narrow and sub-standard and they allow little or no scope for widening within the existing roadbed and for the provision of forgiving roadsides. The narrow nature of the cross-section effectively means that Vulnerable Road Users are typically in close proximity to vehicular traffic, with cyclists using the vehicular driving lanes. However, it is noted that there is an existing footpath in the verge from Mooncoin village adjacent to the westbound carriageway extending for a distance of circa 600m to Polerone Lane. Owing to the new on line realignment between Ch 0 and Ch415, this 1.5 m wide footpath will be replaced by a new 2.5m shared surface. Also as part of this scheme, the remaining 1.5m wide footpath will be upgraded to 2.5m out to Polerone Lane. Drawing KK1613403-P3-GA-008 in Appendix A of this report provides details of both horizontal and vertical geometry on the section of the existing N24 under consideration. The horizontal geometry is characterised by curves of short radius varying in length from 99m to 275m. On the vertical profile along the centre line of the existing carriageway, there are a number of locations, where hidden dips of differing severity are apparent. Flat spot locations are also apparent for distances of up to 40m along the existing route. Due to the substandard nature of this section of the N24 and the number of accesses, it is proposed to undertake an offline realignment of the N24 from circa Ch 415 to Ch 1800. Currently there are a total of 17 domestic access locations, 23 field access locations, 1 commercial access location, 2 pedestrian access locations and 3 local road junctions over the length of the scheme.

1.2 Existing Pavement

In 2020 Kilkenny County Council engaged Site Investigations Ltd to carry out ground investigations over the extents of the scheme. As part of these works pavement cores were extracted along the mainline for examination. Core lengths varied between 150mm and 300mm underlain with Clause 804. In general, the integrity of the existing pavement seems

satisfactory with no apparent cracking. However, hidden dips within the vertical alignment of the pavement along with the narrow cross-section means that forward visibility is poor with no overtaking opportunities. Visibility is also sub-standard for a considerable number of the existing private domestic and field accesses.

1.3 Existing Drainage

On the eastern section of the scheme, positive drainage exists, approximate details of which are available on drawing KK1613403-P3-DR-013 in Appendix B of this report. This road drainage network, outfalls directly to an existing land drain through a land drainage pipe.

On the western section of the scheme, the existing N24 crosses the Skelpstown Stream. The presence of positive drainage in this location is not obvious. However, it is reasonable to consider the Skelpstown Stream as the eventual receptor for the road runoff, as the N24 falls in both directions towards it.

1.4 Scheme Need

The need for the scheme is presented in the context of both the characteristics and associated deficiencies of the existing section of the N24 and National, Regional and Local policy documents.

1.4.1 Characteristics & Associated Deficiencies.

Within the past 10 years, Kilkenny County Council has implemented 80kph speed limit zones and low cost safety measures on the N24 within the N24 Carrick Road Improvement Scheme extents. These controls and measures came about primarily due to the recorded collision history at the location. The provision of an improved section of road, designed to contemporary standards and providing safe overtaking opportunities, will increase the overall consistency and efficiency of the route and provide safer journeys as well as more reliable and reduced journey times. Access, in terms of Vulnerable Road Users (VRUs) such as pedestrians and cyclists is quite limited on the western half of the scheme, due to the existing road cross-section, lack of verge and no hard shoulders. The provision of an improved section of road, designed to contemporary standards with segregated shared facilities for VRUs will provide safer access for all.

1.4.2 National, Regional and Local Policy Context.

The Need for the N24 Carrick Road Improvement Scheme is consistent with or in line with the following National, Regional and Local policy documents.

National Policy Context:

- National Planning Framework – Project Ireland 2040;
- National Development Plan 2018-2027 – Project Ireland 2040;
- Smarter Travel: A Sustainable Transport Future 2009 - 2020; and
- Road Safety Authority Road Safety Strategy 2013 – 2020.

Regional Policy Context:

- Regional Planning Guidelines for the South-East Region 2010 – 2022.

Local Policy Context:

- Kilkenny County Development Plan 2014 – 2020.

National Planning Framework – Project Ireland 2040: The National Planning Framework (NPF) – Project Ireland 2040 was published by the Government in February 2018. It sets out a new strategic planning and development context for Ireland and all of its regions up to 2040, setting a high-level framework for the co-ordination of a range of national, regional and local authority policies and activities, planning and investment, both public and private. The NPF is structured around a set of National Strategic Outcomes (NSOs) or goals. One of these NSOs, which is directly related to the proposed road development, is:

- *Enhanced Regional Accessibility i.e. National Strategic Outcome 2*

Under Enhanced Regional Accessibility, the NPF states the following national strategic outcomes of the plan for *"Inter – Urban Roads:*

- *Maintaining the strategic capacity and safety of the national road network including planning for future capacity enhancements; and*
- *Improving average journey time targeting an average inter-urban speed of 90kph."*

In relation to Ireland's cities, the following is the strategy as stated in the NPF:

- *"Supporting ambitious growth targets to enable the four cities of Cork, Limerick, Galway and Waterford to each grow by at least 50% to 2040 and to enhance their significant potential to become cities of scale.*
- *Enabling the four cities to be regional drivers and to lead in partnership with each other and as partners in regional/inter-regional networks as viable alternatives to Dublin.*
- *Focusing investment to improve the collective 'offer' within each of the four cities, i.e. infrastructure, quality of life and choice in terms of housing, employment and amenities."*

Given the close proximity of the N24 Carrick Road Improvement project to Waterford City, the above-mentioned targeted growth if realised is likely to result in a significant increase in traffic volumes on the N24 by 2040.

The N24 Carrick Road Improvement project would support the goals and targets contained within the NPF in relation to enhanced accessibility and growth targets for Waterford City.

National Development Plan – Project Ireland 2040: The National Development Plan 2018 – 2027 was published with the National Planning Framework in February 2018. The National Development Plan (NDP) will drive Ireland's long-term economic, environmental and social progress across all parts of the country over the next decade and will underpin the successful implementation of the new National Planning Framework (NPF).

The NDP provides €7.3 billion for investment in the national road network under National Strategic Outcome 2 – Enhanced Regional Accessibility as outlined in the previous section. In addition, the NDP provides €14.5 billion for compact growth targets.

The NDP states, *"A core priority under the NPF is the essential requirement to enhance and upgrade accessibility between urban centres of population and their regions, in parallel with the initiation of compact growth of urban centres. This has a crucial role to play in maximising the growth potential of the regional urban centres and the economy as a whole."*

The NDP has also specifically identified the "N24 Waterford to Cahir" project as a section of the national road network that *"will be progressed through pre-appraisal and early planning during 2018 to prioritise projects which are proceeding to construction in the National Development Plan."* It is noted that this section of the N24 lies within N24 Waterford to Cahir Scheme, which is within the early stages of development and maybe quite a number of years before it will be ready for construction. The N24 Carrick Road Improvement Scheme is a

discreet minor scheme that will address the safety issues owing to the substandard nature of the N24 along this section.

Smarter Travel – A Sustainable Transport Future 2009 – 2020: Smarter Travel, A Sustainable Transport Future 2009 - 2020, presents a transport policy framework for Ireland covering the period up to 2020. The policy, launched by the Department of Transport in 2009, sets out a vision, goals and targets to be achieved, and outlines 49 actions that form the basis for achieving a more sustainable transport future. One of the key goals of the initiative is:

"Improve economic competitiveness through maximising the efficiency of the transport system and alleviating congestion and infrastructural bottlenecks."

This key goal as defined within the policy document, in relation to maximising the efficiency of the transport system is consistent with the ambitions of the subject improvement scheme.

The policy recognises the need to focus population and employment in a way that will minimise the potential for excessive transport demand. This will be achieved through consolidation of future growth in residential, commercial and retail development within existing settlements. The N24 Carrick Road Improvement Scheme is located in a rural area some distance from Waterford City, with N24 access restricted to a strategic junction located away from the city. As such any proposed future N24 upgrades will support the future consolidated growth of Waterford City, but without unduly influencing the demand for travel, local development patterns or car use within urban centres.

Policies for improvements to public transport within Smarter Travel distinguish between Significant Urban Areas and Rural Areas. For public transport, the focus in urban areas is a transfer from car use to fast and frequent public transport services in order to reduce congestion and emissions in densely populated areas. For rural areas, public transport attracts less demand because of the dispersed population, and hence there is limited congestion or environmental benefit to be realised. Instead, rural services are focused more on filling a social need, providing for those who do not have access to private means of transport. The proposed scheme will maintain the existing rural public transport facilities, with the benefits of improvements to journey times and consistency of speeds specifically between Ch 450 and 2100 for inter-urban bus users and operators while maintaining the level of service as indicated in Table 6.1(Recommended Rural Road Layouts) of DN-GEO-03031. The provision of a standard single carriageway cross sections, with footpaths either side between circa Ch 0 and Ch 450, connecting Mooncoin Village to upgraded Non-Motorised User (NMU) access

extending from Mooncoin Village to the western extents of the scheme also incorporates a key aim of Smarter Travel; *car owners will be incorporated on other modes such as walking and cycling*.

RSA Road Safety Strategy 2013 – 2020: The Road Safety Authority (RSA) Road Safety Strategy 2013 – 2020, sets outs targets to be achieved in terms of road safety in Ireland as well as policy to achieve these targets. The primary target of this strategy is:

"A reduction of road collision fatalities on Irish roads to 25 per million population or less by 2020 is required to close the gap between Ireland and the safest countries. This means reducing deaths from 162 in 2012 to 124 or fewer by 2020.

A provisional target for the reduction of serious injuries by 30% from 472 (2011) to 330 or fewer by 2020 or 61 per million population has also been set."

The plan sets out strategies for engineering and infrastructure in terms of the benefits that they can have in terms of reducing collisions. The provision of an upgraded section of national roads proposed as part of this project would support and complement this RSA strategy.

South East Regional Planning Guidelines 2010-2022: The South East Regional Authority is one of the regional authorities established in Ireland and is responsible for implementing the National Spatial Strategy at regional level. The South-East Region covers Carlow, Kilkenny, South Tipperary, Waterford City, Waterford County and Wexford. The Authority operates with the assistance and cooperation of the local authorities and with input from a wide range of public and private sector organisations and individuals. In July 2010, it made the Regional Planning Guidelines for the South-East Region for the period 2010 to 2022, to replace those made in 2004.

These guidelines take account of the key issues affecting the development of the region, such as population and settlement; economic and employment trends; industrial and commercial development; transportation; water supply and wastewater facilities; energy and communications; education, healthcare, retail and community facilities; environmental protection etc.

Under the heading "N24 PRIORITISATION STUDY" the South East Regional Planning Guidelines state *"The current N24 is of variable standard and is certainly not consistent with*

its status as a National Primary route. This results in a number of problems, principally arising from congestion and safety issues. The Study, published in 2008, sets out the case for upgrading the route on the grounds of safety, efficiency and strategic importance of the route for the economic performance of the region. It is an objective of the Regional Authority to prioritise upgrading of the N24."

Consequently, the proposed N24 Carrick Road Improvement project is consistent with the objectives and visions for the N24 as set out in the South Eastern Regional Planning Guidelines. As previously noted, this section of the N24 lies within the extents N24 Waterford to Cahir Scheme, which is within the early stages of development and maybe quite a number of years before it will be ready for construction. The N24 Carrick Road Improvement Scheme is a discreet minor scheme that will address the safety issues owing to the substandard nature of the N24 along this section.

Kilkenny County Development Plan 2014 – 2020: The Kilkenny County Development Plan 2014 – 2020 is the current development Plan for County Kilkenny. It is stated in section 11.7.6 of the Kilkenny County Council Development Plan 2014 – 2020 that the Council with the support of the NRA (now TII) is progressing / developing a number of schemes within County Kilkenny and specifically mentions the "*N24 Mooncoin Bypass*". In terms of sustainable development for future needs, it's anticipated, subject to appraisal requirements in the context of scheme specific needs that the proposed N24 Carrick Road Improvement project will complement any future bypass scheme.

In terms of alternate modes of transport the plan also states that *"The Council will promote walking, cycling, public transport and other more sustainable forms of transport as an alternative to the private car, together with the development of the necessary infrastructure and promotion of the initiatives contained within Smarter Travel, A Sustainable Transport Future 2009 – 2020."* The provision of a standard single carriageway cross sections with footpaths either side between circa Ch 0 and Ch 450 connecting Mooncoin Village to upgraded NMU access extending from the western extents of the scheme will accommodate Vulnerable Road Users.

2 SCHEME OBJECTIVES

2.1 The Initial Objectives

The initial objectives for the project are as follows:

- To address deficiencies in terms of alignment, cross-section width, curvature and visibility thereby improving the consistency, accessibility and safety of the carriageway along the N24 Carrick Road Improvement Scheme

- To provide a suitable structural pavement to cater for existing and future traffic needs, including the anticipated increase in heavy vehicle trips as indicated within the TII National Transport Model NTpM.
- To avoid, reduce and, if possible, remedy any significant adverse impacts on the environment. This objective will be achieved by undertaking appropriate environmental assessments and screening, and implementing any specified mitigation measures and best practice guidelines.
- To provide an improved road drainage system, which is environmentally sustainable, having regard to the nearby River Suir SAC.
- To provide safer and more efficient accessibility to the N24 route to the local community and all road users including pedestrians and cyclists along this section.
- To minimise disturbance and severance affects to both residential and agricultural holdings.
- To provide a project which is consistent with and/or fulfils the objectives within local, regional and national policies as set out in section 1.4 above.

2.2 Design Objectives

In order to achieve the overall project objectives identified above, and in accordance with TII DMRB guidance and standards provided in DN-GEO-03030 and DN-GEO-03031 respectively, the main design objectives for the scheme are:

- To achieve a localised improvement having regard to road user demand and required level of service, collision history, design speed as well as identified local constraints and the environment.
- To improve road safety and make better use of the existing road network.
- to address substandard design features and existing deficiencies on this legacy route within existing environmental and budget constraints.

2.3 Design Philosophy

The main principles applied to achieve these design objectives are:

- Alterations to the road alignment shall be consistent with the existing road network.
- The impact of the realignment on existing accesses shall be considered and appropriate measures will be included to mitigate any adverse impacts.
- The proposed alignment should not introduce new safety problems along the section of road to be improved.
- The adopted geometric standards are appropriate for a design speed, which shall be consistent with the anticipated vehicle speeds on the road.

- The feasibility of providing enhanced overtaking opportunities will be examined and an attempt to achieve the minimum overtaking value specified in Table 1.3 of DN-GEO-03031 should be made.
- Overtaking and non-overtaking sections within the minor improvement shall be clearly identified by use of appropriate traffic signs and road markings in accordance with the requirements of the Traffic Signs Manual.

3 COLLISION HISTORY AND RECORD

Available collision history on the N24 from 2004 to 2016 was reviewed during the preparation of this report. The relevant sources used are listed as follows:

- Kilkenny County Council Pre-2005 records;
- Collisions 2005 to 2016 inclusive from the Road Safety Authority https://www.rsa.ie/RSA/Road-Safety/RSA-Statistics/Collision-Statistics/Ireland-Road-Collisions/; and

• Year	Fatal	Serious	Minor	Total
2004	1	0	0	**1**
2005	0	0	0	**0**
2006	0	0	0	**0**
2007	0	0	0	**0**
2008	0	0	0	**0**
2009	1	0	1	**2**
2010	0	0	0	**0**
2011	0	0	0	**0**
2012	0	0	0	**0**
2013	0	0	1	**1**
2014	0	0	0	**0**
2015	0	0	0	0
2016	0	0	1	1
Total	**2**	**0**	**3**	**5**

Table 3.1: Collision Data 2004-2016

Table 3.1 provides a summary of collision information from 2004 to 2016 within the minor project extents.

In addition, Transport Infrastructure Ireland (TII) produce collision maps of the national road network that indicate the safety ranking of the network relative to the national average collisions for particular road types. Figure 3.1 illustrates the current available results for a 3 year period from 2015-2017 along the N24 and includes Material Damage Collisions.

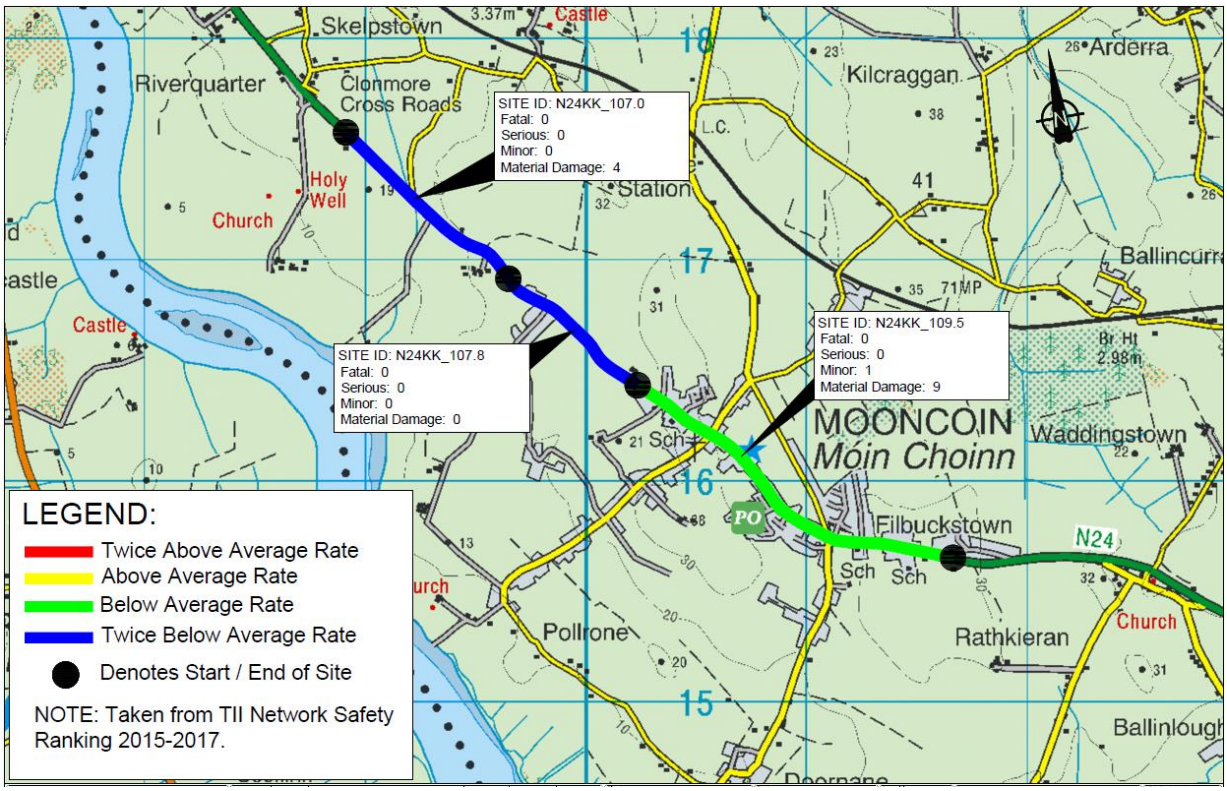


Figure 3.1: TII Network Safety Ranking 2015 to 2017 (Current Available Ranking)

Within the extents of N24 Carrick Road Improvement Scheme, it is noted that Kilkenny County Council has an 80kph speed limit zone in force since around 2008/2009. In addition, Kilkenny County Council also implemented low cost safety measures in 2012. Based on the review of collision history there were no specific road safety problems identified in terms of injury collisions subsequent to 2009. It is reasonable to say that the introduction of the reduced speed limit of 80kph and low cost measures implemented as stated above, for the moment at least, has assisted in reducing the number of recorded collisions and their severity along the N24, albeit with reduced average journey times and speeds. Drawing KK1613403-P3-GA-008 in Appendix A of this report highlights the issues with the existing section of the N24; substandard horizontal and vertical geometry, poor pavement drainage, adverse or insufficient camber and a high number of residential accesses from which there is very poor visibility. Table 3.2 below provides traffic growth projections in accordance with Table 6.2 of the Project Appraisal Guidelines (PAG) Unit 5.3 for the following projections:

Opening Year 2024

Design Year 2039

Forecast Year 2054

As previously stated the N24 Carrick Road Scheme lies within the extents of the N24 Waterford to Cahir Scheme which is in the very early stages of planning. It may be some time before it proceeds to construction phase. In light of this, the N24 Carrick Road Improvement Scheme is a discreet minor scheme that will address the issues as outlined above while taking cognisance of the projected growth rates as outlined in Table 3.2.

The safety objective will be to maintain the existing collision rankings at below or twice below the national average rates, with an improvement in average mainline speeds within the project extents.

Base Year & Projected AADT (THRDO ATC1) PAG UNIT 5.3 Summary							
Year	**2017**	**2024**	**HGV % (2024)**	**2039**	**HGV % (2039)**	**2054**	**HGV % (2054)**
Base	7875.000	-		-			
Low	-	8536	5.7%	9333	6.7%	9506	7.7%
Central	-	8631	5.7%	9707	6.7%	10115	7.7%
High	-	8642	5.8%	10051	6.8%	11187	8.0%

Table 3.2: Traffic Growth Projections

4 DESIGN SPEED

Drawing KK1613403-P3-GA-008 in Appendix A of this report shows the existing layout of the N24 along the length of the proposed scheme. At western extents of the scheme the existing N24 (Substandard Single Carriageway, Design Speed 100kph) ties into the Piltown Bypass (Type 3 Dual Carriageway, 100kph). Some 500 metres east of the tie in, heading toward Mooncoin Village, is the start of the 80 Kph mandatory speed limit section. This section continues east for another circa 1.3km to meet with the 50 kph Speed Limit zone for Mooncoin Village.

With regard to N24 Carrick Road Improvement Scheme, it is proposed to tie into the existing Piltown Bypass with a Type 1 Single Carriageway in accordance with Fig. 8.5 of DN-GEO-03031. The Type 1 Single Carriageway is required to provide the indicated level of service as per Table 6.1 of DN-GEO-03031. Starting from the western extents, the Type 1 Single Carriageway (100kph) will continue east toward Mooncoin realigned online for the first circa 400m. The realignment then moves offline north of the existing N24 carriageway for a further circa 1.3km before coming back online to meet the existing N24. Over these extents circa Ch 2100 at the western end to circa Ch 450, the provision of the Standard Type 1 Single Carriageway (100kph), requires only 3 accesses; two accesses for farm tracks and an access to the attenuation pond. Thus, the provision of the Standard Type 1 Single Carriageway will lead to an improvement in mainline average speeds and journey times while achieving the safety objective.

Where the proposed new offline section meets the existing N24 at circa Ch 450, the realignment will need to be online to Ch 0 in order to tie-in in advance of Mooncoin Village. Due to the number of accesses at this location and its proximity to Mooncoin Village, it is proposed that this section will be Type 2 Single Carriageway with the provision of 2.5m wide shared surfaces either side for Vulnerable Road User Access. With reference to Table 4.1 of DMURS, and noting that this section of the N24 while still arterial, the design speed will need to take account of both vehicular and pedestrian priority within this Rural Fringe to Mooncoin Village. As such it is proposed that this section from Ch 450 to Ch 0 will have a design speed of 70 kph with a mandatory speed limit of 60kph. DMURS and DN-GEO-03084 recognises that landscape has an important contribution to make in traffic calming and can assist in slowing vehicles when entering villages or towns. The aim of the landscape design for the rural fringe element is to indicate that there is a change in road context ahead so a resultant required reduction in speed is anticipated. Historically the rural fringe looked similar to the

adjoining rural sections. The landscape design proposed here aims to provide a gradual change in road landscape as the driver progresses through the rural fringe. Tree planting can create a sense of vertical enclosure that discourages drivers from speeding. Vertical enclosure has been found to have a traffic calming effect as drivers become more aware of their surroundings. Indicative landscaping details are shown on drawing KK1613403-P3-GA-002 in Appendix A of this report. Detailed landscaping proposals shall be developed within the Detailed Design Stage.

The provision of the Type 2 Single Carriageway between Ch 0 and Ch 450 while assisting with reducing traffic speeds within the rural fringe by narrowing carriageway width is also key to providing access for VRUs between Mooncoin Village and the western extents of the scheme . Drawing KK1613403-P3-GA-007 in Appendix A of this report shows the overall access arrangements throughout the extents of the scheme. 2.5 metre wide shared surfaces raised 125mm high shall be provided either side of the N24 from Ch 0 out to the junction between the offline realignment and the existing N24 at Ch 450. The existing 1.5 metre wide footpath along the existing N24 out to Polerone Lane will be upgraded to a 2.5m wide shared surface. In addition to this the, existing N24 carriageway will be reduced in width to 5m by the provision of a 2.5 wide shared surface for VRUs at the northern side as shown on drawing KK1613403-P3-GA-007. Design Speed (70kph) Calculations in accordance with DN-GEO-03031 for this reduced width are provided in Appendix G of this report. Calculations of the Design Speed (42 Kph) along the existing L7416 which has a variable pavement width of between 2.6 to 3.0 metres are also provided in Appendix G.

5 OPTIONS CONSIDERED

In 2018/2019 Kilkenny County Council engaged Tramore House Regional Design Office to undertake the Route Selection Process on The N24 Carrick Road Improvement Scheme. The Scheme Feasibility and Route Options Report is available in Appendix E of this report.
In summary an initial assessment was undertaken on 3 different route corridors as shown in Figure 5.1 below.

An initial Stage 1 preliminary engineering, environmental and an economy assessment was undertaken for preliminary designs within these three corridors. Further to these assessments, Corridor 2 (Green) was eliminated and Corridors 1 and 3 were brought forward to the Stage 2 assessment. This Stage 2 assessment was carried out in accordance with Unit 12.0 of the Project Appraisal Guidelines and as amended by the previously published Project Appraisal

Plan (PAP) dated August 2018. This was also in line with the guidance in the Department of Transport Tourism and Sport Common Appraisal Framework (DTTaS CAF) and required a Multi-Criterial Analysis (MCA) to be undertaken in order to assess both the quantitative and qualitative impacts of all feasible options, full details of which are provided in The Scheme Feasibility and Route Options Report.

With the conclusion of this assessment, it was determined that Corridor 1 was the preferred Option in respect to the Project Appraisal Guidelines for National Roads Unit 12.0 – Minor Projects (€5m to €20m) and as amended in the Project Appraisal Plan published by Kilkenny County Council in August 2018. In accordance with the PAP, a Project Appraisal Balance Sheet was prepared for Corridor 1 with the “Overall Description of the Scheme” described as “Slightly Positive”.

It should be noted, that as part of the route selection process, public consultation was undertaken at two stages during the route selection process. Initially during November and December 2018, a public consultation was undertaken of the Route Corridor Options. A further public consultation was undertaken on the Preferred Route Corridor in July and August 2019.

Further to assessing Corridor 1 as the preferred route option, the preliminary design was developed as shown on drawings KK1613403-P3-GA-001 to 006 inclusive.

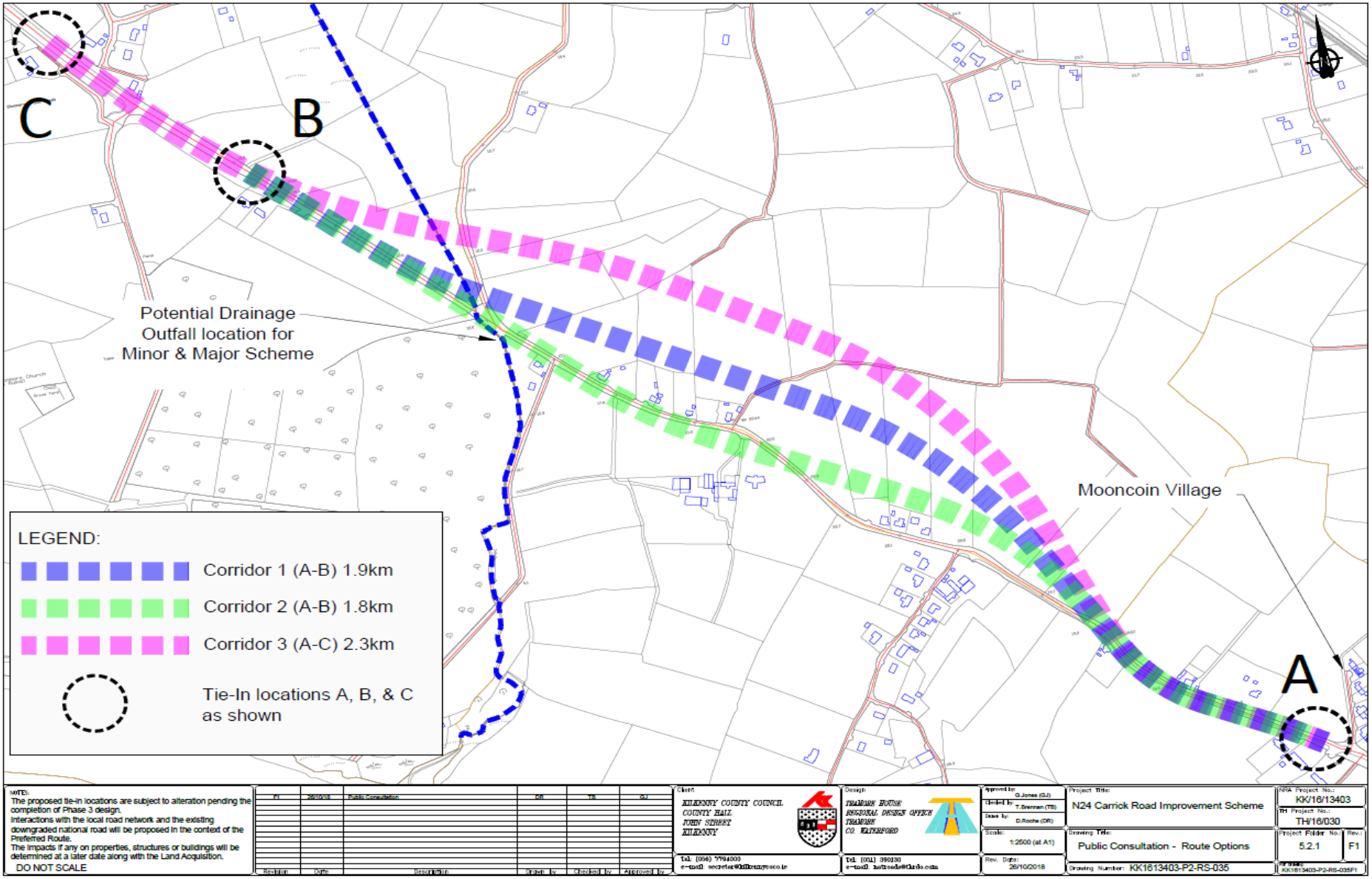


Figure 6.1: Route Corridor

6 CONSTRAINTS

The constraints and uncertainties to be considered in the progression of this scheme are outlined in the following table 6.1.

Constraint	Source of Data	Key Issues
Existing Road Layout in conjunction with high traffic volumes	OS Mapping & NRA Traffic Counters	Sub-standard horizontal geometry resulting in loss of control type collisions. 8000+ AADT. The existing traffic will be a Safety & Health hazard to personnel involved in the construction of the works. The works will cause delays to the N24 traffic and will be a hazard to road users during construction.
Domestic/ Field/Commercial accesses	There are a total of 17 Domestic access locations, 23 field access locations, 1 commercial access location, 2 pedestrian access locations and 3 local road junctions.	Maintaining access. Limiting the number of accesses on to realigned section by providing shared access where possible.
Presence of services	Service providers/Ground Investigations	Eircom and water services are located within existing verges of the N24. Overhead ESB cables are ubiquitous along the scheme. Services require being maintained, protected and occasionally diverted.
Archaeology	Record of Monuments and Places	Resolution of Archaeology within the extents of the scheme.
NATURA 2000 Sites	NPWS website	Proximity of River Suir SAC.
Land Requirements	Basemap and topographical survey	Segregation of landowner plots by the proposed scheme.

Table 6.1: Known Constraints

7 GEOMETRIC FEATURES

7.1 Cross Section

The mainline route is circa 2.1km in length. From Ch 0 to Ch 415 the carriageway comprises of a Type 2 Single Carriageway (reference Figure 7.1 below), with the provision of footpaths either side and designed in accordance with DN-GEO-03031. From Ch 415 to Ch 435, it transitions from a Type 2 Single carriageway to a Type 1 Single Carriageway. From Ch 435 to circa Ch 1890, the cross-section remains a Type 1 Single Carriageway (reference Figure 7.2 below) and from Ch 1890 to Ch 2100, it transitions to join the existing N24 Piltown Bypass Type 3 Dual Carriageway in accordance with Figure 8.5 of DN-GEO-03031.

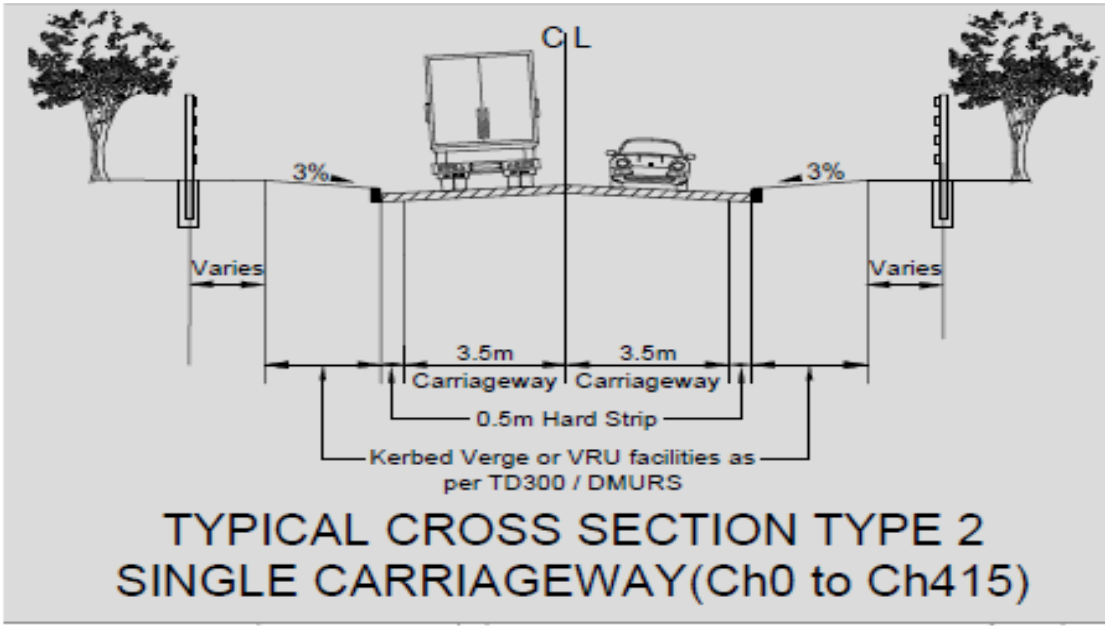


Figure 7.1: Type 2 Single Carriageway Road Cross Section

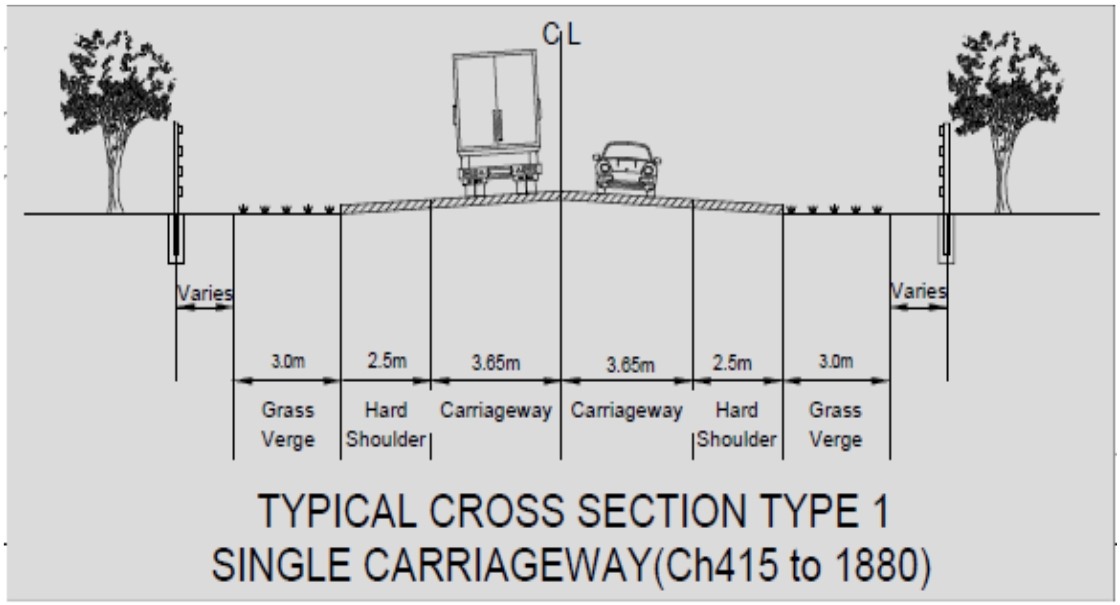


Figure 7.2: Type 1 Single Carriageway Road Cross Section

For the Type 1 & Type 2 Single Carriageway sections, cross-fall and super-elevation have been determined in accordance with DN-GEO-03031. As per Table 1.3 of DN-GEO-03031, a minimum cross-fall of 2.5% will be applied to straight elements and curves greater than or equal to 2040m radius for Design Speeds of 100kph. For Design Speeds of 70 kph a minimum cross-fall of 2.5% will be applied to straight elements and curves greater than or equal to 1020m. Table 1.3 of DN-GEO-03031 also provides details of super-elevation for curve elements less than minimum identified above for normal cross-fall of 2.5%, noting that for design speeds of 60kph and 70kph a maximum super-elevation of 5% shall apply. In addition to this super-elevation may be calculated in accordance with Section 3.2 of DN-GEO-03031 using the Formula $S = V^2/ (2.828xR)$. The fall applied to verges shall be nominally, 8% towards the drainage adjacent to the carriageway in cuttings and 8% away from the carriageway in areas of fill. The nominal workspace width between the outer edge of earthworks or verge is 3m. However, this width will vary depending on requirements for drainage, clear zones, visibility and land issues.

7.2 Horizontal and Vertical Alignment

The geometric alignment has been designed in accordance with the TII Publications and in particular DN-GEO-03030, DN-GEO-03031, DN-GEO-03084 and DN-GEO-03060.

The proposed alignment commences just west of the village of Mooncoin tying into the N24 Mooncoin Pavement Rehabilitation & Traffic Management Scheme (2014). From the starting point as shown on drawing KK1613403-P3-GA-002, the proposed new alignment proceeds in a northwesterly direction initially descending online at a 5% gradient to Ch 200 where it sweeps right on a 255m radius bend with a super-elevation of 5% in this 70 kph Design Speed Section . At Ch 300 it starts to ascend at an approximate gradient of 0.67% in a more northerly direction. At Ch 500 it continues it's ascent at 0.67%, sweeping left back to a northwesterly direction on a 720m radius bend with 5% super-elevation. At Ch 780 the vertical profile changes from a fixed and ascending gradient of 0.67% to a hog curve; K value 400 and remains in place until Ch 1790. At circa Ch 900 the horizontal alignment enters a straight section, which in turn ends at Ch 1450 where it enters a right-turning bend of radius 720m with super-elevation of 5%. This right-turning bend enters a short straight, (L = 130m excluding the transitions) at Ch 1740. This straight transitions into a left turning radius 2800m at Ch 1830 which in turn transitions into a right turning radius of 4378m to tie into the existing N24 Piltown Bypass as shown on drawing KK1613403-P3-GA-005 (Note; normal camber of 2.5% is applied from Ch 1740 to end).

Table 7.1 lists the geometric design parameters used in the Design.

Design Heading	Design Element	DMRB Standard Required	Standard Achieved
Design Speed	Ch 0 to Ch 415 Ch 415 to End	70kph 100kph	70kph 100kph
Horizontal Curvature (70kph Design Speed)	Desirable minimum radius with 5% super-elevation	360m	255m (One Step Below -5% super-elevation)
Horizontal Curvature (100kph Design Speed)	Desirable minimum radius with 5% super-elevation	720m	720m
Super-elevation	For desirable minimum radius	5%	5%
Vertical Curvature	Desirable max. Gradient. Desirable min. effective Gradient Desirable Minimum Crest K value Desirable Minimum Sag K value	5% 0.5% 100 37	5% 0.67% 120 40
Pavement Drainage	Resultant Gradient Water Film Depth	1% < 3.3mm	0.55% < 3.54mm
Visibility	Stopping Sight Distance (SSD) Full Overtaking Sight Distance (FOSD)	215m 580m	215m 580m

7.3 Visibility

Stopping Sight Distance of 120m for Design Speed 70Kph from Ch 0 to 415 and for 215m for Design Speed 100kph from Ch 415 to end has been checked and confirmed available in both carriageway lanes in accordance the requirements of DN-GEO-03031 (Para 2.1)

Visibility at local road and private road accesses has also been assessed and full visibility in accordance with DN-GEO-03060 has been confirmed at all locations with the exception of any listed in the Departures from Standard.

In the west bound direction, full over taking sight distance (FOSD= 580m) is continuously available between Ch 960 and Ch 1040. From Ch 1040, FOSD/2 is available continuously until Ch 1360. Therefore, it can be concluded that the full overtaking section in the west bound lane will extend from Ch 960 to Ch 1360, a length of 400m
In the east bound direction, FOSD becomes continuously available from Ch 1500 to Ch 1400. From Ch 1400 to Ch 1070, FOSD/2 is continuously available. Therefore, it can be concluded that the full overtaking section in the east bound lane will extend from Ch 1500 to Ch 1070, a length of 470m. While the overall scheme length is approximately 2.1km, it comprises of two different carriageway cross sections; Type 2 Single Carriageway CH 0 to Ch 415; providing access to Mooncoin Village for VRUs and Type 1 Single Ch 415 to Ch 2108, a length of 1693m. The Type 2 Single Carriageway with narrowing road width and reduced speed, facilitates the approach of the national route to Mooncoin Village, which has a speed limit 50Kph without any overtaking opportunity. Considering the Overtaking values of the proposed Type 1 single carriageway, 1.693Km length; in the eastbound direction there is an overtaking value of 24% and in the west bound direction there is an overtaking value of 28%. Considering Table 7.3 of DN-GEO-03031, as the scheme comprises of both Type 1 and Type 2 single carriageway for what is essentially an online improvement, the overtaking values provided comply with requirements.

8 SAFETY BARRIER RISK ASSESSMENT SHEETS

8.1 Safety Barriers

Proposed location of safety barriers are shown on Drawings KK1613403-P3-GA_001 to 005. Where possible, the design maintains the concept of “forgiving roadsides” by maintaining clear zones and utilising passively safe structures and fences.

Where unprotected hazards have been identified, a risk analysis has been carried out in accordance with Chapter 5 of DN-REQ-03079 (May 2019)

Further to the risk assessment and where the need for a safety barrier has been identified, a Safety Barrier Justification Sheet been included in this section of the report in accordance with the current edition of DN-REQ-03034 (May 2019)

8.2 Assessment of Unprotected Hazards

The following tables identify the requirement and justification for Vehicle Restraint Systems within the proposed scheme.

Risk Assessment Sheet for Safety Barriers

Date: 18/6/2020 **Completed By:** J. Leacy

Location ID/Description: N24 Carrick Road Improvement Scheme

Site Survey Conducted (Y/N): Y

	Hazard Type, Start and End Co-ordinates*	Is Hazard within Clear Zone (Y/N)	Can the Hazard be mitigated? (Y/N)	(1) Hazard Ranking	Sinuosity Index (SI)	(2) Sinuosity Ranking	(3a) Collision Rate Threshold	(3b) Collision Rate Ranking	(4) Risk of a Vehicle Leaving the Road	(5) Overall Risk Rating	Distance to Hazard (m)	Barrier to be Installed (Y/N) Start and End Co-ordinates	Reasons for Installing / Not Installing the Safety Barrier
Location 1	**Attenuation Pond adjacent to Verge/Footpath of Westbound carriagewayCh 220 to 330** Start: X: 650054 Y: 616535 End: X: 649981 Y: 616621	Y	N	H	1.0065	M	0	L	L	M	4.5	Y	Even though the risk of a vehicle leaving the road is low, the Hazard Ranking is high and therefore we will provide barrier
Location 2	**Embannkment Slopes =1:2** **Height > 6m & Location of Overbridge** **Location: West Bound Verge** **Ch 1290 to 1680** X: 649315 Y: 617267 End: X: 648988 Y: 617480	Y	N	H	1.0045	M	0	L	L	M	4	Y	Even though the risk of a vehicle leaving the road is low, the Hazard Ranking is high and therefore we will provide barrier

Risk Assessment Sheet for Safety Barriers	**Date:** 18/6/2020	**Completed By:** J. Leacy
	Location ID/Description:	N24 Carrick Road Improvement Scheme
	Site Survey Conducted (Y/N): Y	

	Hazard Type, Start and End Co-ordinates*	Is Hazard within Clear Zone (Y/N)	Can the Hazard be mitigated? (Y/N)	(1) Hazard Ranking	Sinuosity Index (SI)	(2) Sinuosity Ranking	(3a) Collision Rate Threshold	(3b) Collision Rate Ranking	(4) Risk of a Vehicle Leaving the Road	(5) Overall Risk Rating	Distance to Hazard (m)	Barrier to be Installed (Y/N) Start and End Co-ordinates	Reasons for Installing / Not Installing the Safety Barrier
Location 3	**Embannkment Slopes =1:2 Height > 6m & Location of Overbridge/Attenuation Pond Location: East Bound Verge Ch 1320 to 1690** X: 649298 Y: 617295 End: X: 648911 Y: 617498	Y	N	H	1.000	L	0	L	L	M	4m to Drainage Headwalls	Y	Even though the risk of a vehicle leaving the road is low, the Hazard Ranking is high and therefore we will provide barrier
Location 4	**Concrete/stone wall Location: East Bound Verge Ch 2060 to 2180** Start: X: 648725 Y: 617756 End: X: 648641 Y: 617843	Y	N	H	1.000	L	0	L	L	M	Varies 7.5m	Y	Even though the risk of a vehicle leaving the road is low, the Hazard Ranking is high and therefore we will provide barrier

VRS Justification Sheets

Location ID/Description:	N24 Carrick Road Improvement Scheme
Site Survey Conducted (Y/N): Y	

	Hazard Type /Description (Start and End Co-ordinates)	Is Hazard within the Clear Zone? (Y/N)	Hazard Ranking (Appendix D)	Mitigation/Modification Options Considered*	Can the Hazard be Mitigated? (Y/N)	Has Lifetime Cost Analysis of Barrier Been Carried Out? (SAVeRS)	Length of Hazard (m)	Barrier to be Installed (Y/N) Start and End Coordinates	Reasons for Installing the Safety Barrier
Location 1	**Attenuation Pond adjacent to Verge/Footpath of Westbound carriagewayCh 220 to 330** Start: X: 650054 Y: 616535 End: X: 649981 Y: 616621	Y	High	Provide suitable VRS	N	N	70m	Y Start: X: 650054 Y: 616535 End: X: 649981 Y: 616621	Attenuation Pond is just outside of clear zone. Pond is likely to contain depths of water in excess of 1m all year round.
Location 2	**Embannkment Slopes =1:2** **Height > 6m & Location of Overbridge** **Location: West Bound Verge** **Ch 1290 to 1680** X: 649315 Y: 617267 End: X: 648988 Y: 617480	Y	High	Provide suitable VRS	N	N	270	Y 649315 Y: 617267 End: X: 648988 Y: 617480	High Ranking Hazards in the form of High Embankments and overbridge within the clear zone

Location ID/Description:	N24 Carrick Road Improvement Scheme
Site Survey Conducted (Y/N): Y	

Hazard Type /Description (Start and End Co-ordinates)		Is Hazard within the Clear Zone? (Y/N)	Hazard Ranking (Appendix D)	Mitigation/Modification Options Considered*	Can the Hazard be Mitigated? (Y/N)	Has Lifetime Cost Analysis of Barrier Been Carried Out? (SAVeRS)	Length of Hazard (m)	Barrier to be Installed (Y/N) Start and End Coordinates	Reasons for Installing the Safety Barrier
Location 3	**Embannkment Slopes =1:2 Height > 6m & Location of Overbridge/Attenuation Pond Location: East Bound Verge Ch 1320 to 1690** X: 649298 Y: 617295 End: X: 648911 Y: 617498	Y	High	Provide suitable VRS	N	N	280	Y X: 649298 Y: 617295 End: X: 648911 Y: 617498	High Ranking Hazards in the form of High Embankments, attenuation pond and overbridge within the clear zone
Location 4	**Concrete/stone wall Location: East Bound Verge Ch 2060 to 2180** Start: X: 648725 Y: 617756 End: X: 648641 Y: 617843	N	High	Provide suitable VRS	N	N	80	Y Start: X: 648725 Y: 617756 End: X: 648641 Y: 617843	High Ranking Hazards in the form of concrete wall within the clear zone.

9 DRAINAGE REQUIREMENTS

On the eastern section of the scheme, positive drainage exists, approximate details of which are available on drawing KK1613403-P3-DR-010 in Appendix B of this report. This road drainage network, outfalls directly to an existing land drain through a land drainage pipe. Further details of runoff from adjacent lands at the eastern tie-in are as per drawing KK1613403-P3-DR-009 in Appendix B. On the western section of the scheme, the existing N24 crosses the Skelpstown Stream. The presence of positive drainage in this location is not obvious. However, it is reasonable to consider the Skelpstown Stream as the eventual receptor for the road runoff, as the N24 falls in both directions towards it.

The extent of proposed new drainage design is as per drawings KK1613403-P3-DR-001 to 008 and are included in Appendix B of this report. All proposed new drainage networks are in accordance with the requirements of DN-DNG-03022 . Due to the proposed realignment of the carriageway at the eastern location, it is our intention to replace the existing drainage with a new drainage network, Network 2 and outfall this to an attenuation pond as shown on drawing KK1613403-P3-DR-002. The provision of the attenuation pond will reduce flow rates down stream of this new network. Initial analysis of the existing network in terms of DN-DNG-03066, (Design of Earthworks Drainage, Network Drainage, Attenuation & Pollution Control) was undertaken to determine simulated peak network flows for different rainfall events. An approximation of the network was developed using available information such as topographical surveys, ground investigations and information received from Kilkenny County Council. This approximate network as shown on drawing KK1613403-P3-DR-010 was then modelled using Micro-drainage software in accordance with section 4.17 and 5.26 of DN-DNG-03066 and peak brown field runoff rates for different simulated rainfall return periods were determined. Details of these results are also shown on drawing KK1613403-P3-DR-010 and range from 79 litres/sec for 1 in 1 year return period to 154 litres/sec for 1 in 30. The design of the attenuation pond as presented for Network 2 is in accordance with the requirements of Section 5.11 of DN-DNG-03066 seeking to replicate the natural response of the undeveloped catchment by use of storage. An initial equivalent greenfield runoff was determined for the footprint underneath the pavement contributing to the proposed Network 2 using the ADAS method (section 5.5 of DN-DNG-03064). Considering the soil type potential runoff as low, it was determined that a 1 in 75 year return period would yield a flow rate of 92 litres/second. To comply with the requirements of section 5.14 of DN-DNG-03066 ; "*there should be no increased risk of flooding in the receiving watercourse due to construction of the road up to 100 year return period* ", it is proposed to limit the flow from the attenuation

pond to 32litres/sec for the critical storm duration up to 1 in 100 year return period. Details of the Attenuation Design are provided in Appendix C of this report.

On the western side of the scheme it is proposed that Network 4 will drain all surface water from the carriageway between Ch 940 and Ch 2060. Again Network 4 will outfall to an attenuation pond as shown on drawing KK1613403-P3-DR-005. Initial equivalent greenfield runoff was determined for the footprint underneath the pavement contributing to the proposed Network 4 using the ADAS method (section 5.5 of DN-DNG-03064). Considering the soil type potential runoff as low, it was determined that a 1 in 75 year return period would yield a flow rate of 94 litres/second. As it is proposed that the maximum outflow from the this attenuation pond will be 13litres/sec for a 1 in 100 year event, this complies with the requirements of section 5.14 of DN-DNG-03066. Details of the Attenuation Design are provided in Appendix C of this report.

10 TRAFFIC SIGNS AND ROAD MARKING REQUIREMENTS

Road markings are designed in accordance with Chapter 7 of the Department of Transport, Traffic Signs Manual and can be reviewed on drawings KK1613403-P3-GA-001 to 005. Signage for the proposed new scheme shall be designed in accordance with the Department of Transport, Traffic Signs Manual.

11 JUNCTION TREATMENT

The N24 Carrick Road Improvement Scheme, will replace all the existing direct accesses, some 46 in total as outlined in Section 1 .1 above with a total of 8 new direct accesses. From Ch 0 to Ch 415, the proposed Type 2 Single Carriageway is generally online, as such the 4 existing direct accesses are generally maintained noting that one field access is combined with the access for the attenuation pond. Between Ch 400 and Ch 2100 it is proposed that a total of 4 accesses will replace the remaining 42 accesses, with one of these new accesses proposed for the attenuation pond at circa Ch 1700 which will be infrequently used. Further to this full access to existing residences and landholdings toward the north west extents of the scheme will be maintained with the provision of an underbridge at circa Ch 1500. Without the provision of the under-bridge both motorized and non-motorized users from the north western extents of the scheme would have to utilize longer substandard residual routes to access Mooncoin Village.

12 REQUIREMENTS OF NON-MOTORISED USERS

The provision of the Type 2 Single Carriageway between Ch 0 and Ch 450 while assisting with reducing traffic speeds within the rural fringe by narrowing carriageway width is also key to providing access for NMUs to Mooncoin Village from the western extents of the scheme . Drawing KK1613403-P3-GA.007 in Appendix A shows the overall access arrangements throughout the extents of the scheme. 2.5 metre wide shared surfaces raised 125mm high shall be provided either side of the N24 from Ch 0 out to the junction between the offline realignment and the existing N24 at Ch 450. The existing 1.5 metre wide footpath along the existing N24 out to Polerone Lane will be upgraded to a 2.5m wide shared surface raised 125mm high. In addition to this the, existing N24 carriageway will be reduced in width to 5m by the provision of a 2.5 wide shared surface for VRUs at the northern side. This shared surface shall extend to beyond the underbridge to the L7416 albeit tapering to 1.5metres through the structure providing access to NMUs from the north western extents of the scheme. NMUs travelling between Mooncoin Village and the western extents of the scheme will be able to utilise a 4m wide offline track connected to a residential access road as shown on drawing KK1613403-P3-GA.007.

13 RELAXATIONS AND DEPARTURES

In accordance with the requirements of DN-GEO-03030 departures and relaxations are recorded in the preliminary design report. The departure applications are attached in Appendix D.

There are seven departures from standard within the overall scheme design. These are outlined in Table 13.1 below.

Table 13.1: Summary of Departures

Departure or Relaxation No.	Description & Location	Standard Required	Standard Provided
Departure 1a	Road Design. Visibility on local road approach to junction with N24 mainline at circa Ch 450. Design speed for local road is 70kph and	Table 1.3, DN-GEO-03031, Stopping Sight Distance for 70Kph is 120m	80m will be provided

Departure or Relaxation No.	Description & Location	Standard Required	Standard Provided
	therefore requires a SSD of 120m		
Departure 1b	Road Design, Pavement Drainage – N24 (circa Ch 950 to Ch 960)	DN-GEO-03031, Para 11.4 a) A maximum water film depth of 3.3mm shall apply to new single carriageway roads.	At the minimum allowed length for transitioning between super-elevations, a water film depth of 3.53 is provided with a minimum resultant gradient of 0.55%.
Departure 1c	Road Design, Horizontal Geometry- N24 (circa Ch 250)	Para 5.2.2, DN-GEO-03060, "*New or altered direct accesses or priority junctions shall not be sited at any location where the desirable minimum SSD envelope of the national road falls outside the paved surface of the road*"	This occurs at an existing domestic access at Ch 250. Full Stopping Sight Distance (120m) will be provided from the access, through verge widening
Departure 1d	Road Design. Visibility on local road. Design speed for local road is 70kph and therefore requires a SSD of 120m. Reference KK1613403-P3-DP-001 in Appendix A	Table 1.3, DN-GEO-03031, Stopping Sight Distance for 70Kph is 120m	70m of SSD will be provided.
Departure 1e	Road Design. Visibility from entrance on local road. Design speed for local road is 70kph and therefore requires a SSD of 120m. Reference KK1613403-P3-DP-001 in Appendix A	Table 1.3, DN-GEO-03031, Stopping Sight Distance for 70Kph is 120m	70m of stopping sight distance is available toward the L7416 pavement edge, 120m of visibility is provided to the centreline of the 3m wide carriageway along the L7416

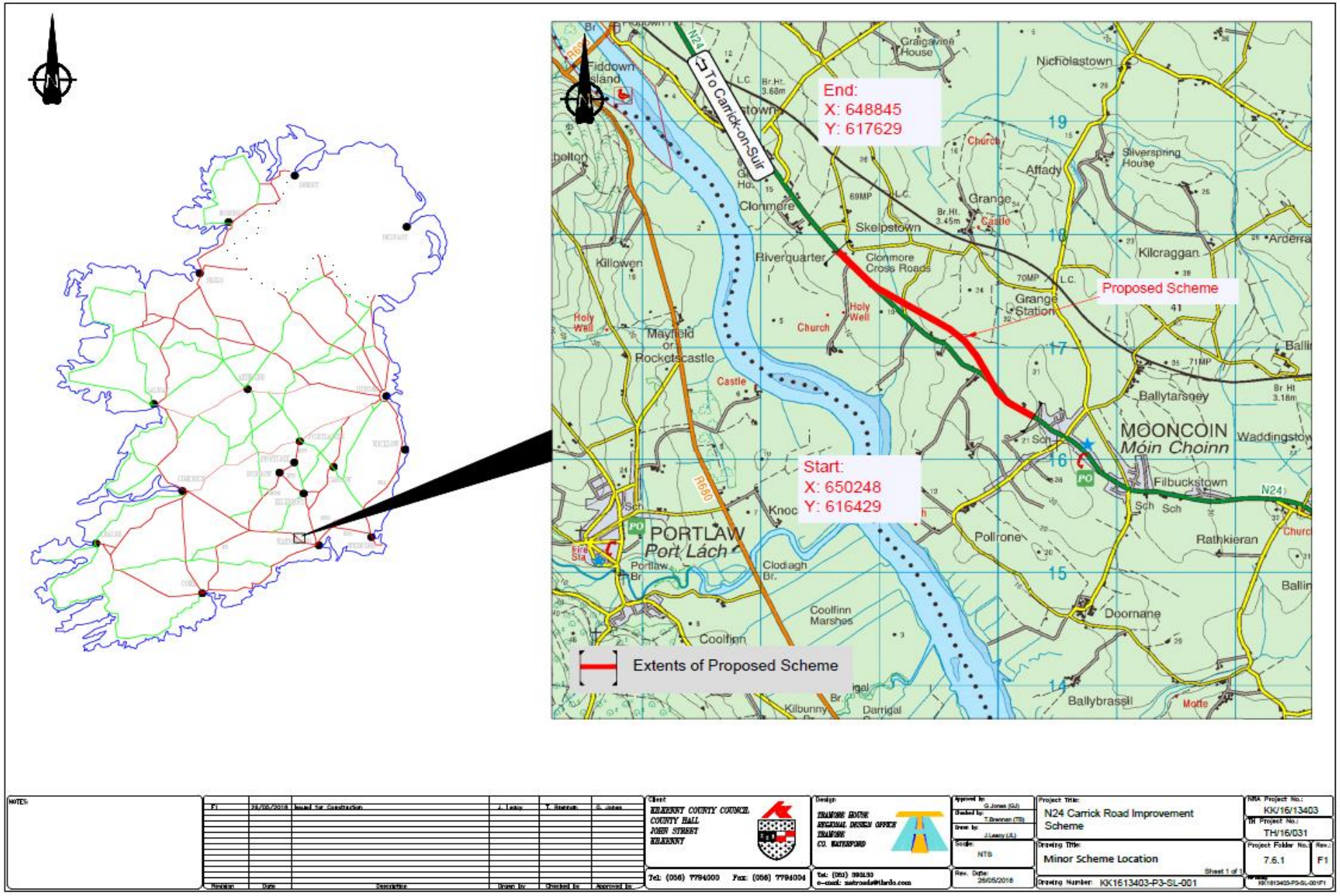
Departure or Relaxation No.	Description & Location	Standard Required	Standard Provided
Departure 1f	Road Design. Visibility from entrance on local road. Design speed for local road is 70kph and therefore requires a SSD of 120m. Reference KK1613403-P3-DP-001 in Appendix A	Table 1.3, DN-GEO-03031, Stopping Sight Distance for 70Kph is 120m	Existing SSD is circa 30m. With the provision of the 2.5m Wide shared surface, this will be increased to circa 60m
Departure 1g	Mini Roundabout/ Turning Loop. Reference KK1613403-P3-DP-001 in Appendix A	In accordance with Fig 5.29 of DN-GEO-03060, the provision of a turning loop on a Type 3 Dual Carriageway requires a departure from Standard.	There is an existing mini roundabout at the location.
Relaxation 1a	N24 (circa Ch 200 to Ch 320) (Type 2 Single Design Speed 70kph)	For 70Kph Design Speed, the Desirable Minimum Horizontal Curvature Radius is 360m	One Step below Desirable Minimum AT 255m

14 ROAD SAFETY AUDITS

A Stage F Road Safety Audit was undertaken at Route Selection Stage. The Stage F Safety Audit Report is available in Appendix E of this report.

A Stage 1 Road Safety Audit was undertaken at Preliminary Design Stage. The Stage 1 Safety Audit Report is available in Appendix F of this report.

APPENDIX A - SITE LOCATION & GENERAL ARRANGEMENT DRAWINGS



NOTES:						
	F1	28/05/2018	Issued for Construction	J. Lacey	T. Brennan	G. Jones
	Revision	Date	Description	Drawn by	Checked by	Approved by

Client: KILKENNY COUNTY COUNCIL, COUNTY HALL, JOHN STREET, KILKENNY
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Tel: (051) 399139
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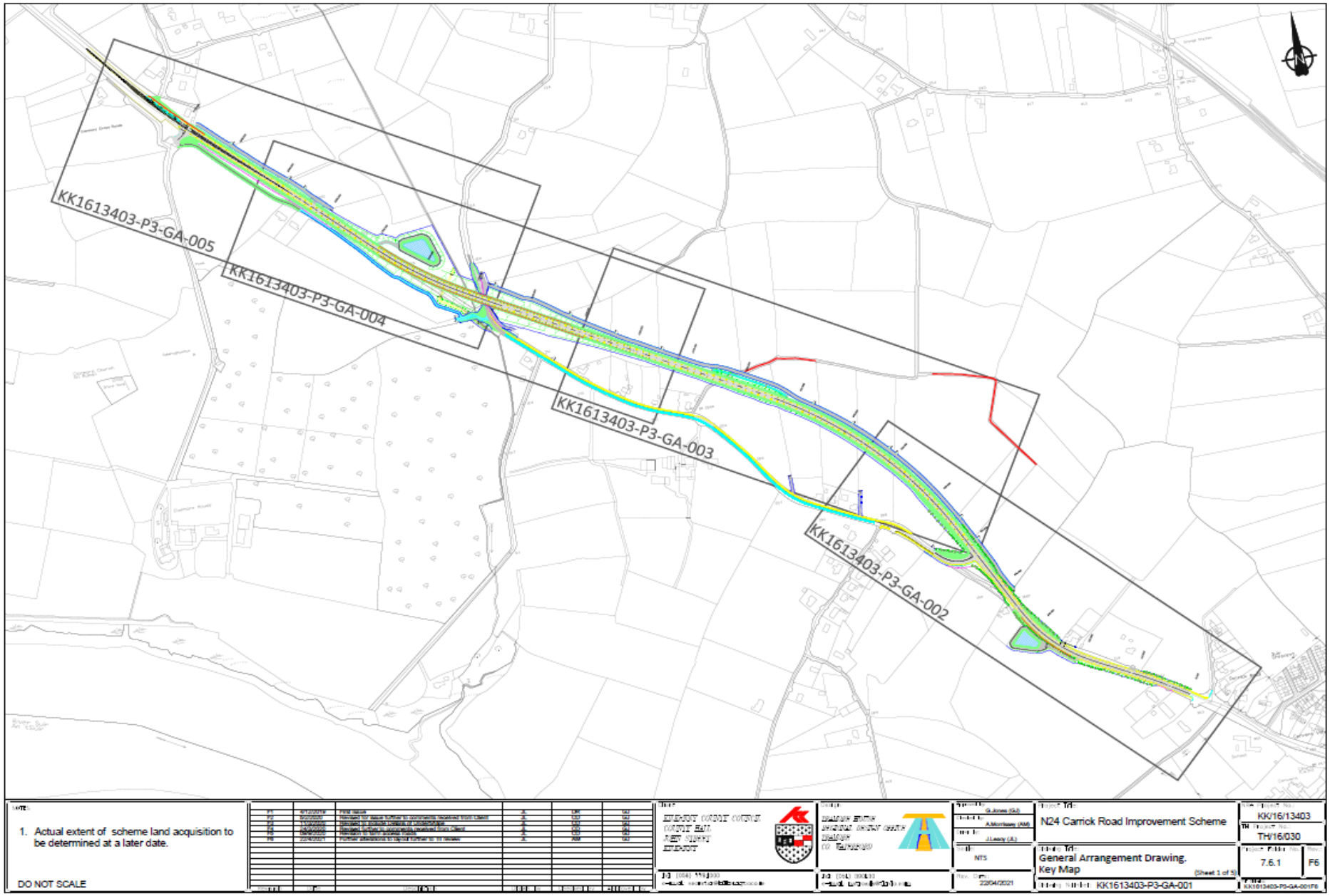
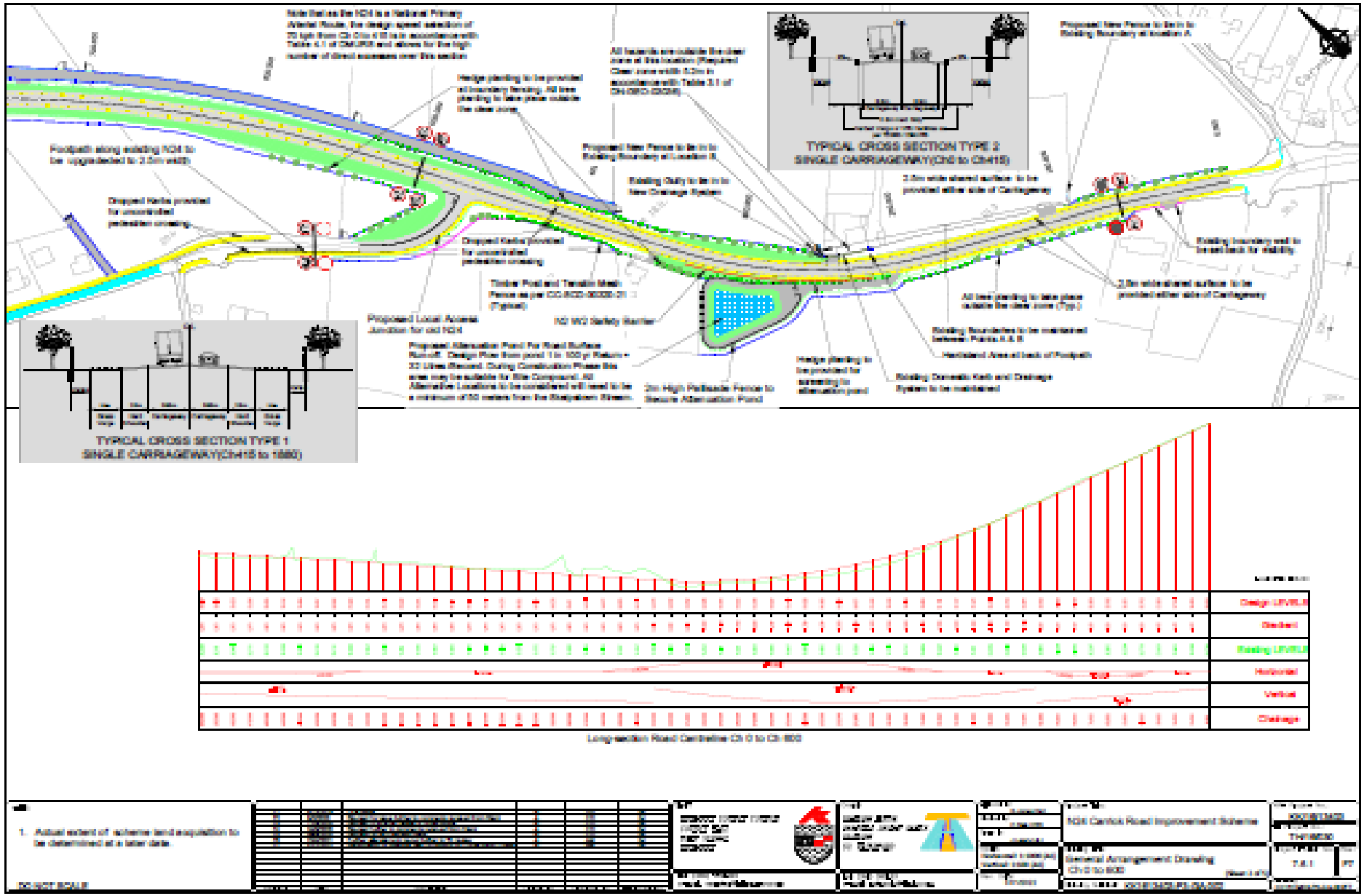
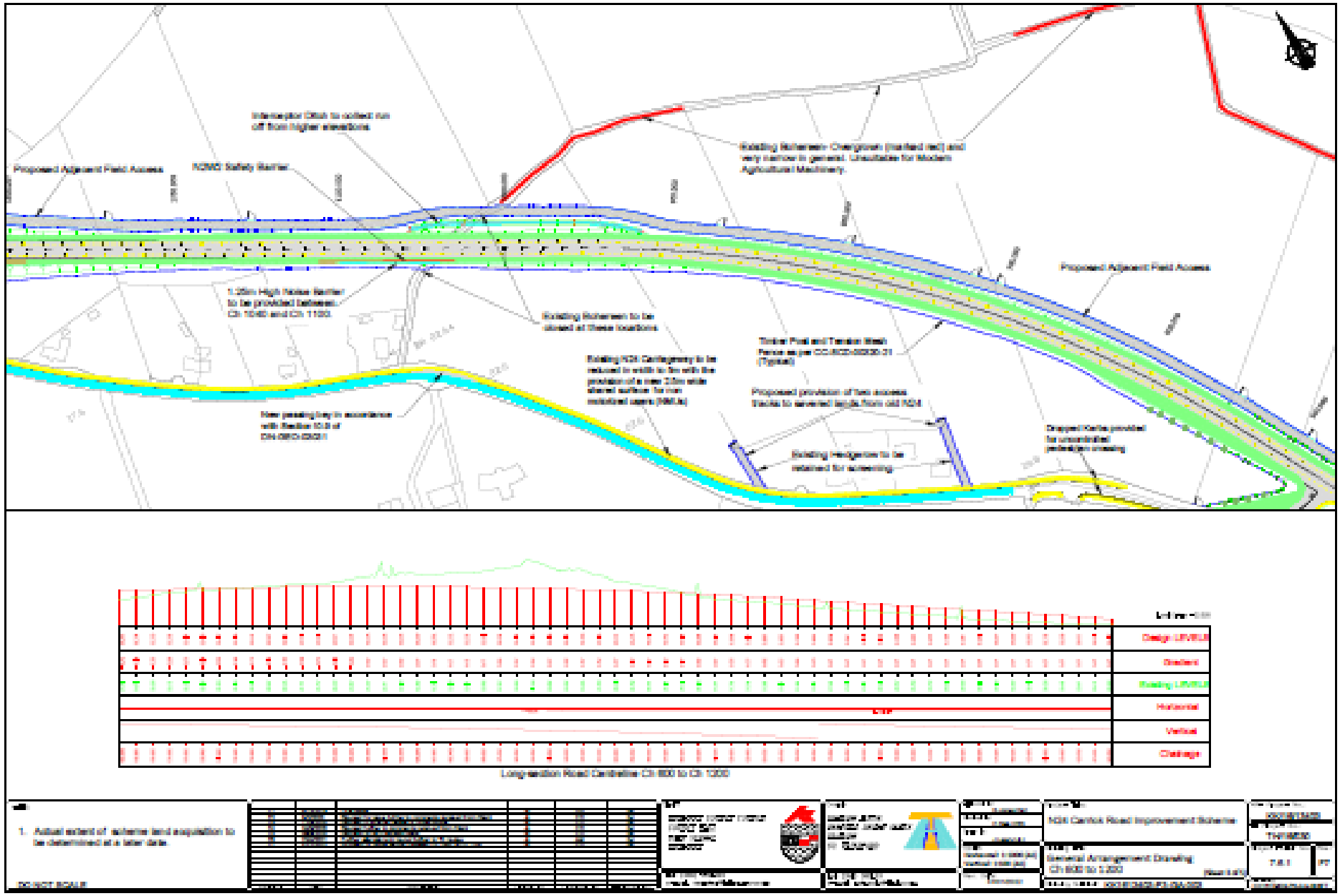
Approved by: G. Jones (GJ)
Checked by: T. Brennan (TB)
Drawn by: J. Lacey (JL)
Scale: NTS
Rev. Date: 28/05/2018

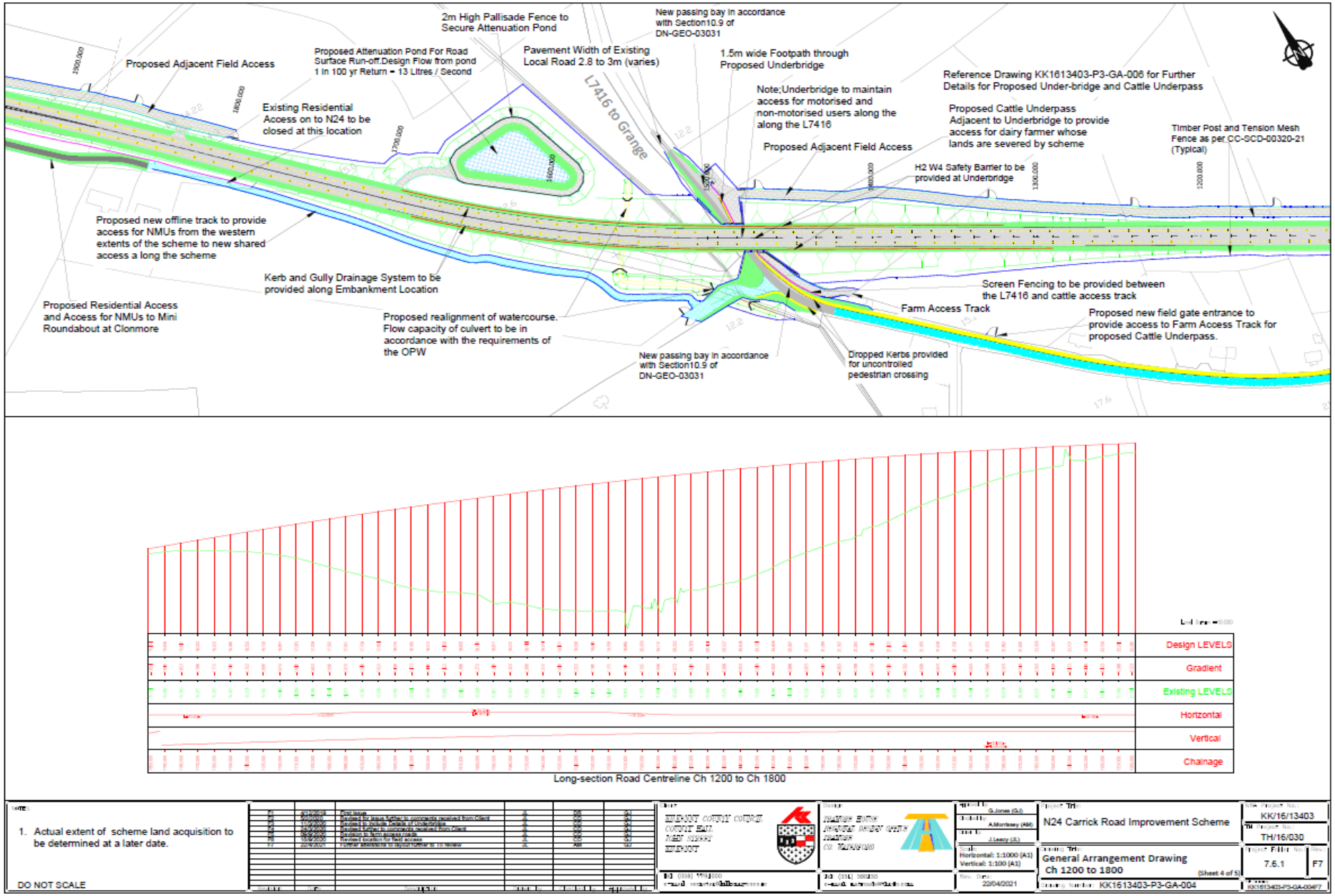
Project Title: N24 Carrick Road Improvement Scheme
Drawing Title: Minor Scheme Location
Sheet 1 of 1
Drawing Number: KK1613403-P3-SL-001

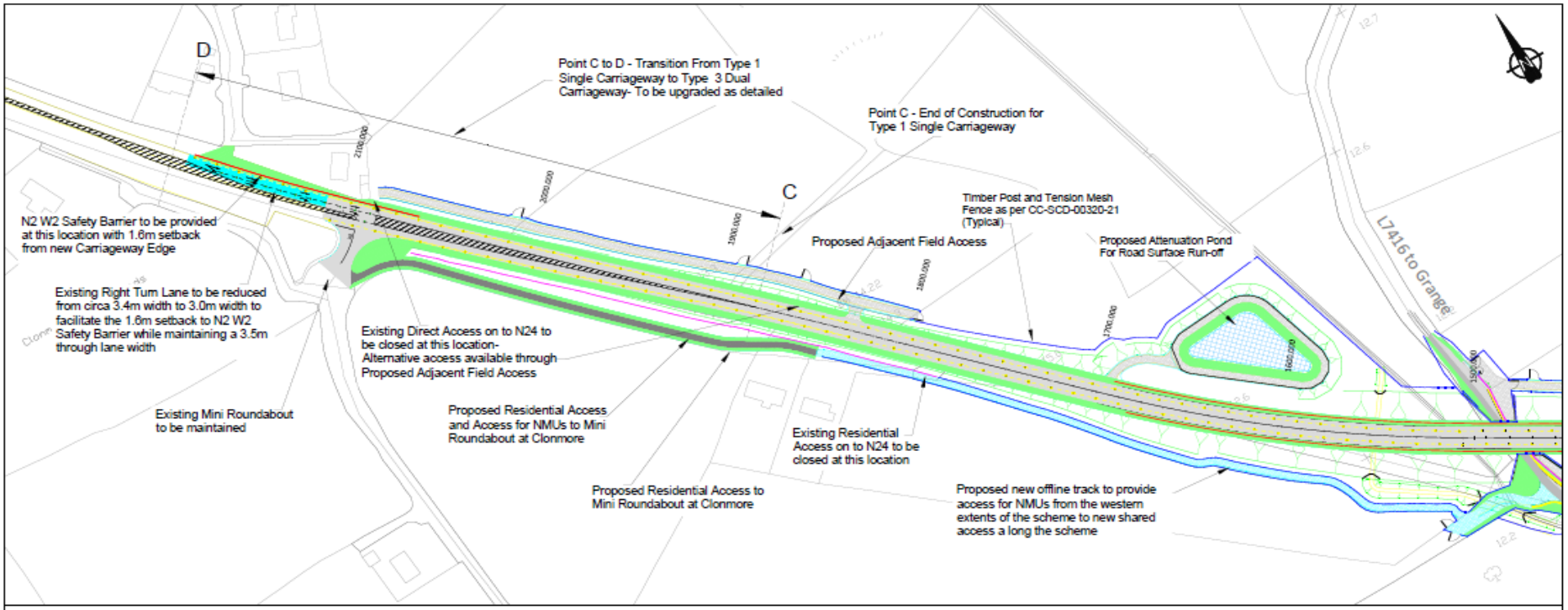
NRA Project No.: KK/16/13403
TII Project No.: TH/16/031
Project Folder No.: 7.5.1
Rev.: F1
File name: KK1613403-P3-SL-001F1

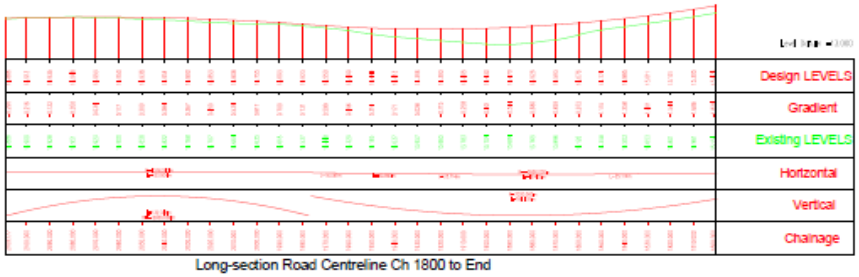

KK1613403-P3-GA-005
KK1613403-P3-GA-004
KK1613403-P3-GA-003
KK1613403-P3-GA-002
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
General Arrangement Drawing.
Key Map
7.6.1
F6
KK1613403-P3-GA-001


TYPICAL CROSS SECTION TYPE 2
SINGLE CARRIAGEWAY(Ch0 to Ch415)
TYPICAL CROSS SECTION TYPE 1
SINGLE CARRIAGEWAY(Ch415 to 1880)
Footpath along existing N24 to be upgraded to 2.0m width
Dropped Kerbs provided for uncontrolled pedestrian crossing
Hedge planting to be provided at boundary fencing. All tree planting to take place outside the clear zone
Proposed New Fence to tie in to Existing Boundary at Location B
Existing Gully to tie in to New Drainage System
Proposed Local Access Junction for old N24
N2 W2 Safety Barrier
2m High Palisade Fence to Secure Attenuation Pond
Existing Boundary wall to be set back for visibility
2.0m widened surface to be provided either side of Carriageway
Existing Boundaries to be maintained between Points A & B
Hardstand Area at back of Footpath
Existing Domestic Kerb and Drainage System to be maintained
Design LEVELS
Gradient
Existing LEVELS
Horizontal
Vertical
Chainage
Long section Road Centreline Ch 0 to Ch 800
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
General Arrangement Drawing
Ch 0 to 800


Proposed Adjacent Field Access
NCMC Safety Barrier
Existing Roherwin Overgrown (marked red) and very narrow in general. Unsuitable for Modern Agricultural Machinery
Proposed Adjacent Field Access
Existing Roherwin to be closed at these locations
Proposed provision of two access tracks to severed lands from old N24
Existing Hedgerow to be retained for screening
Dropped Kerbs provided for uncontrolled pedestrian crossing
Design LEVELS
Gradient
Existing LEVELS
Horizontal
Vertical
Chainage
Longitudinal Road Centreline Ch 800 to Ch 1200
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
General Arrangement Drawing
Ch 800 to 1200


2m High Pallisade Fence to Secure Attenuation Pond
New passing bay in accordance with Section10.9 of DN-GEO-03031
Proposed Adjacent Field Access
Proposed Attenuation Pond For Road Surface Run-off.Design Flow from pond 1 In 100 yr Return = 13 Litres / Second
Pavement Width of Existing Local Road 2.8 to 3m (varies)
1.5m wide Footpath through Proposed Underbridge
Reference Drawing KK1613403-P3-GA-006 for Further Details for Proposed Under-bridge and Cattle Underpass
Note;Underbridge to maintain access for motorised and non-motorised users along the along the L7416
Existing Residential Access on to N24 to be closed at this location
L7416 to Grange
Proposed Cattle Underpass Adjacent to Underbridge to provide access for dairy farmer whose lands are severed by scheme
Timber Post and Tension Mesh Fence as per CC-SCD-00320-21 (Typical)
Proposed Adjacent Field Access
H2 W4 Safety Barrier to be provided at Underbridge
Proposed new offline track to provide access for NMUs from the western extents of the scheme to new shared access a long the scheme
Kerb and Gully Drainage System to be provided along Embankment Location
Screen Fencing to be provided between the L7416 and cattle access track
Proposed Residential Access and Access for NMUs to Mini Roundabout at Clonmore
Proposed realignment of watercourse. Flow capacity of culvert to be in accordance with the requirements of the OPW
Farm Access Track
Proposed new field gate entrance to provide access to Farm Access Track for proposed Cattle Underpass.
New passing bay in accordance with Section10.9 of DN-GEO-03031
Dropped Kerbs provided for uncontrolled pedestrian crossing
Design LEVELS
Gradient
Existing LEVELS
Horizontal
Vertical
Chainage
Long-section Road Centreline Ch 1200 to Ch 1800
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
General Arrangement Drawing Ch 1200 to 1800
(Sheet 4 of 5)
7.6.1
F7
Horizontal: 1:1000 (A1)
Vertical: 1:100 (A1)
22/04/2021
KK1613403-P3-GA-004





Long-section Road Centreline Ch 1800 to End

NOTE:

1. Actual extent of scheme land acquisition to be determined at a later date.

DO NOT SCALE

Rev	Date	Description	Drawn	Checked	Approved
F5	4/12/2019	Final issue	JL	LBC	GJ
F4	22/10/2019	Revised for issue further to comments received from Client	JL	LBC	GJ
F3	11/09/2019	Revised to include Letters of Undertaking	JL	LBC	GJ
F2	24/8/2018	Revised further to comments received from Client	JL	LBC	GJ
F1	08/06/2018	Revised to take a comprehensive	JL	LBC	GJ
F0	22/04/2021	Further alterations to layout further to TII review	JL	AM	GJ

Client: STRATEGIC INFRASTRUCTURE DEVELOPMENT WEST DIVISION

Project: STRATEGIC STATION STRATEGIC ENERGY CONSTR STRATEGIC DEV TRANSPORTED

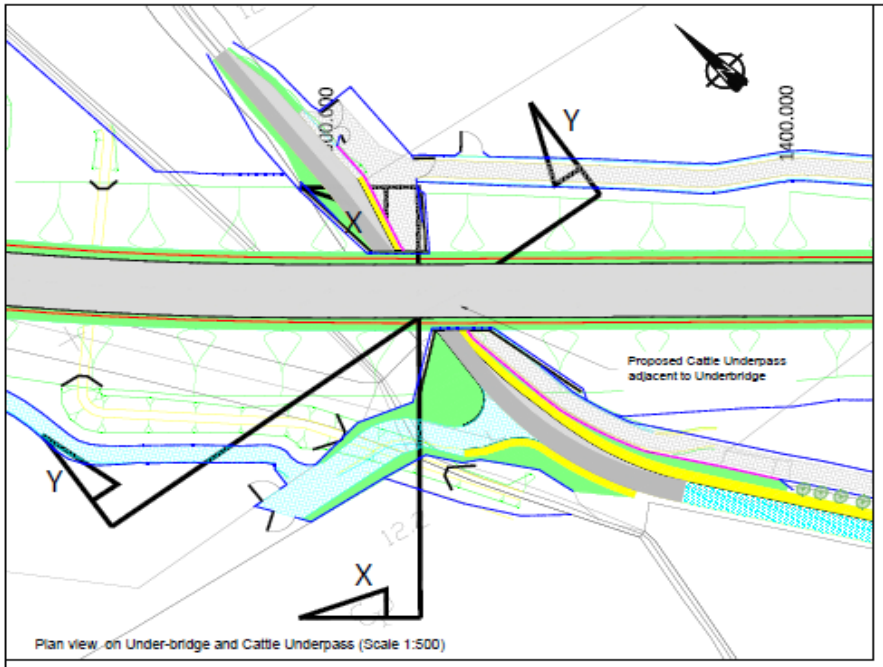
Approved by: G.Jones (GJ)
Checked by: A.Morrissey (AM)
Drawn by: J.Leacy (JL)
Scale: Horizontal: 1:1000 (A1) Vertical: 1:100 (A1)
Rev. Date: 22/04/2021

Project Title: N24 Carrick Road Improvement Scheme

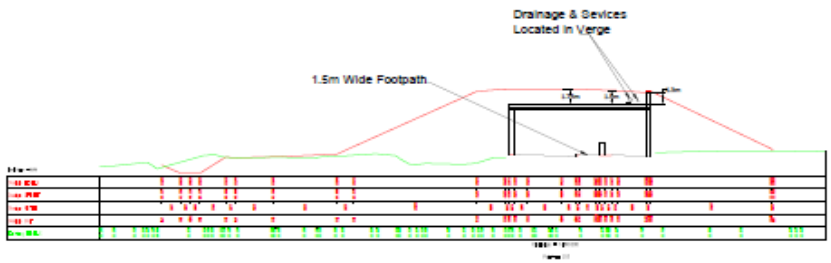
Drawing Title: General Arrangement Drawing Ch 1800 to End (Sheet 5 of 5)

Drawing Number: KK1613403-P3-GA-005

Project No: KK/16/13403
TII Project No: TH/16/030
Drawing No: 7.6.1
Rev: F6
File: KK1613403-P3-GA-005F6

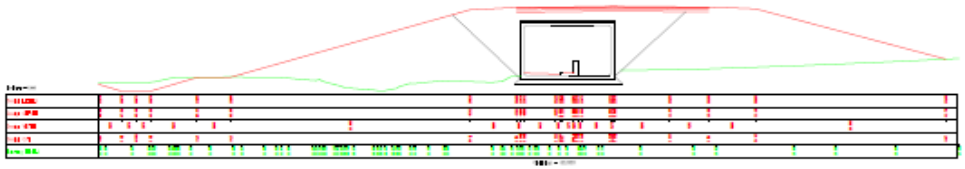


Plan view on Under-bridge and Cattle Underpass (Scale 1:500)

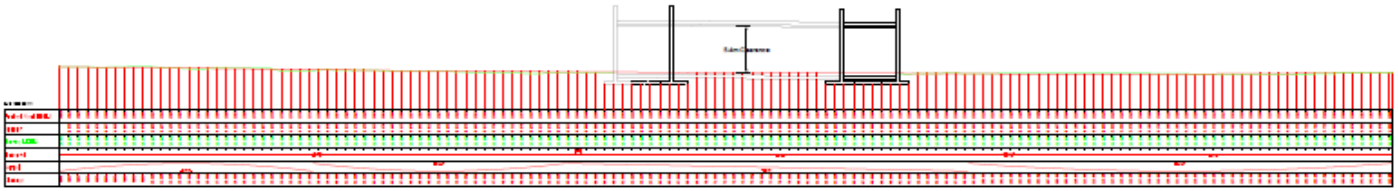


Section X - X (Proposed Under-Bridge) Scale 1:250

Construction of Combined Underbrige and Cattle Underpass shall be in accordance with the requirements of the TII approved Structures Options Report.



Section Y - Y (Proposed Under-Bridge) Scale 1:250



Long - section along Realigned Local Road (L7416) Scale 1:250

1. Actual extent of scheme land acquisition to be determined at a later date.

DO NOT SCALE

N24 Carrick Road Improvement Scheme

KK/16/13403

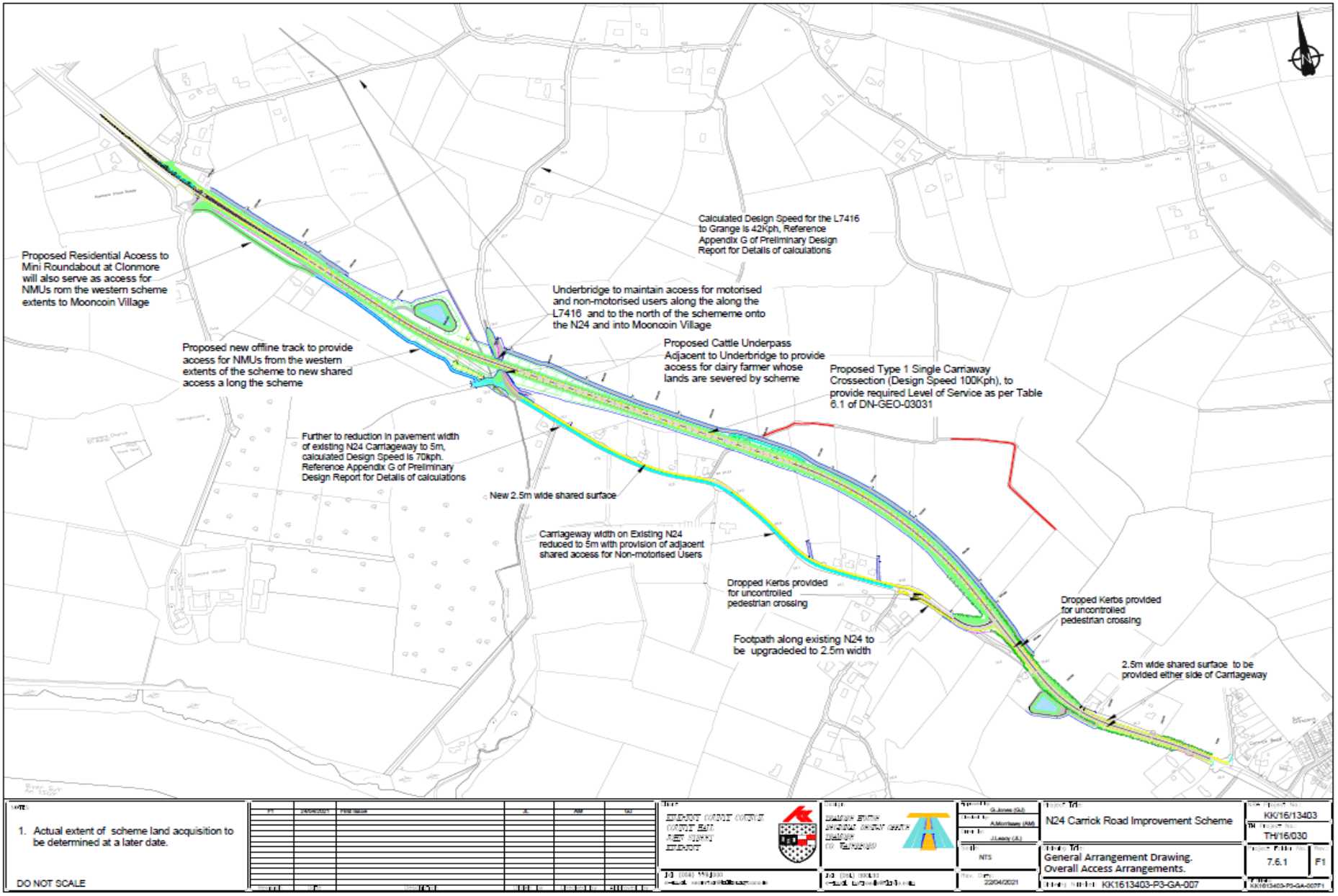
TH/16/030

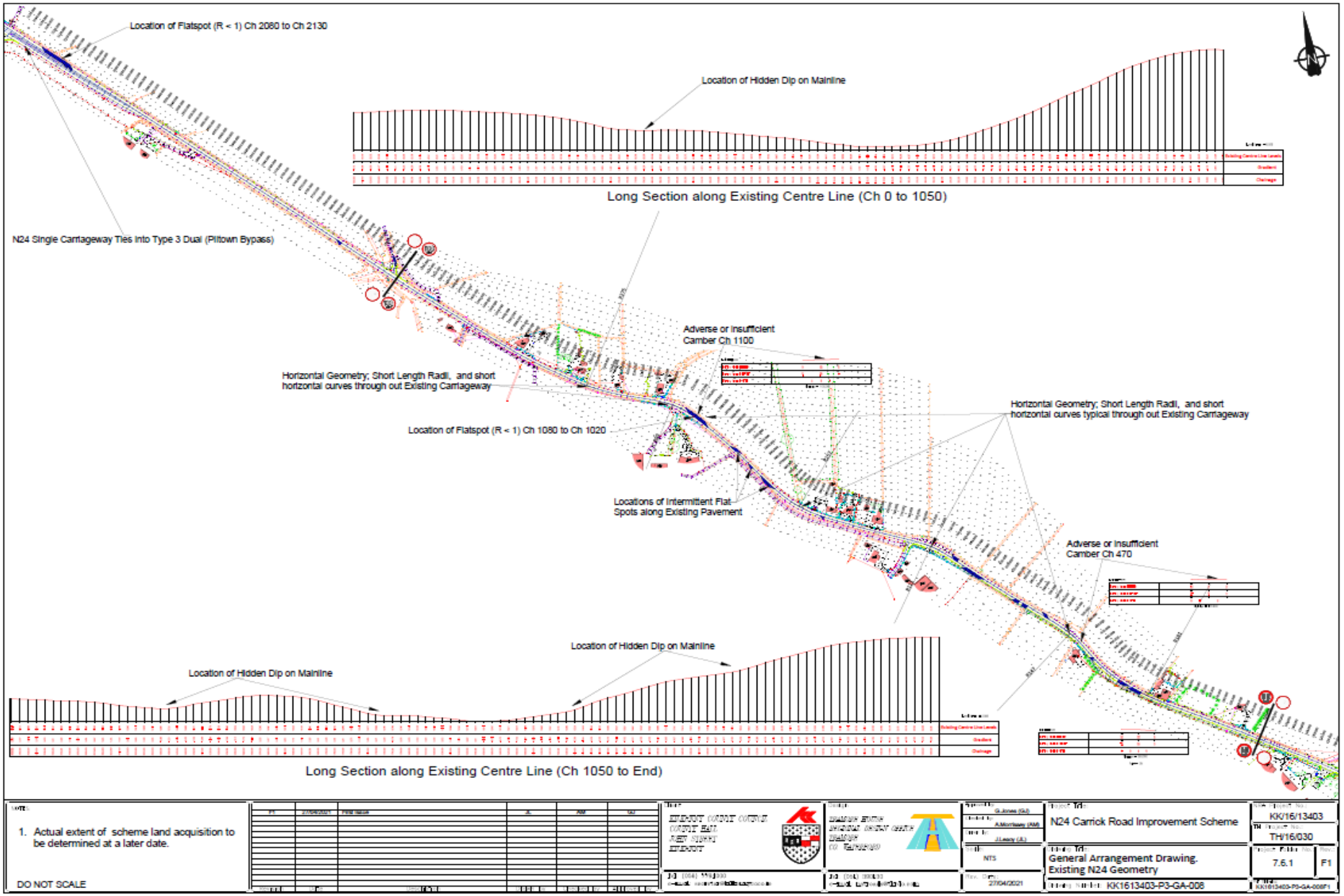
Indicative Details for combined Under-bridge & Cattle Underpass

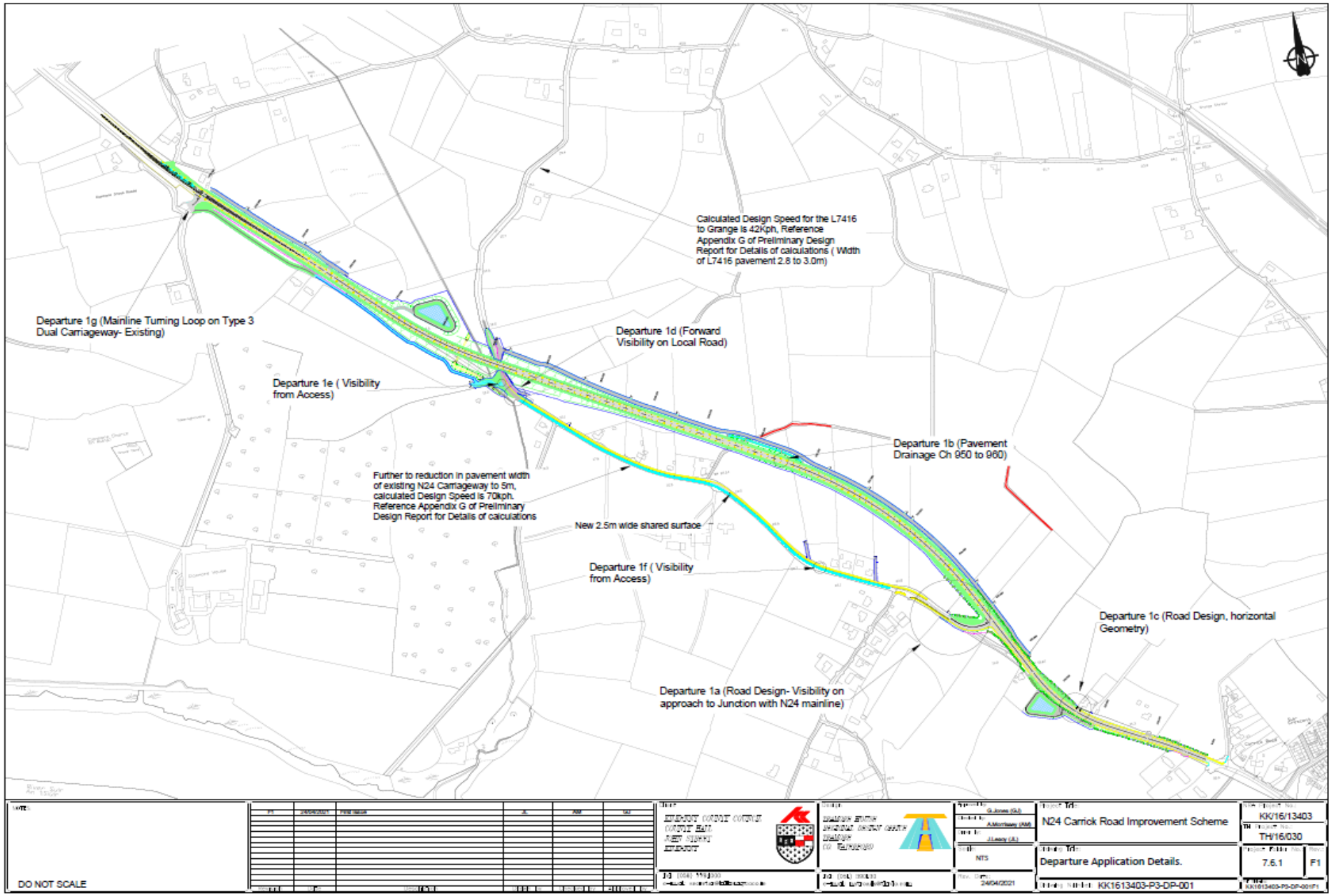
7.6.1

F6

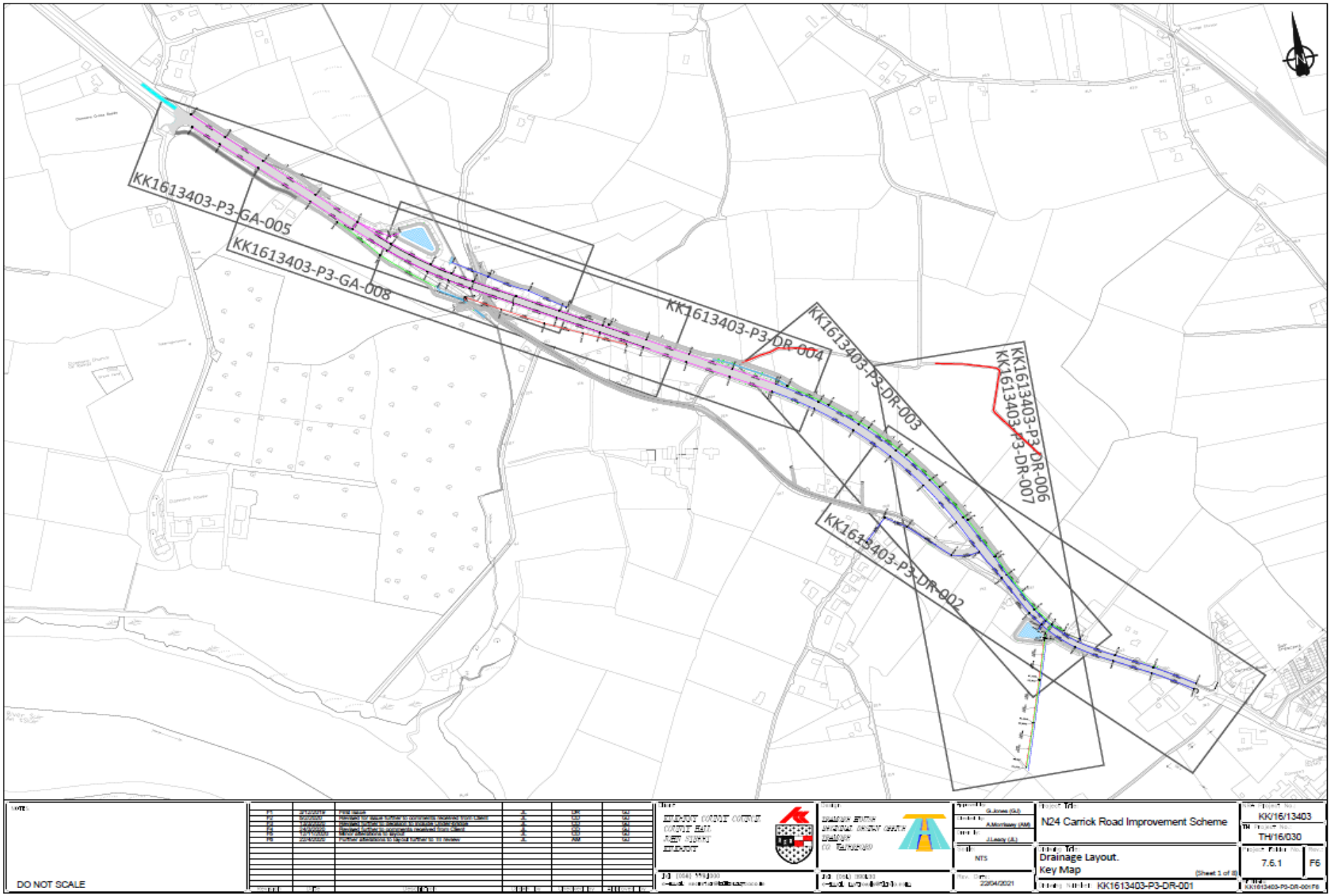
KK1613403-P3-GA-006

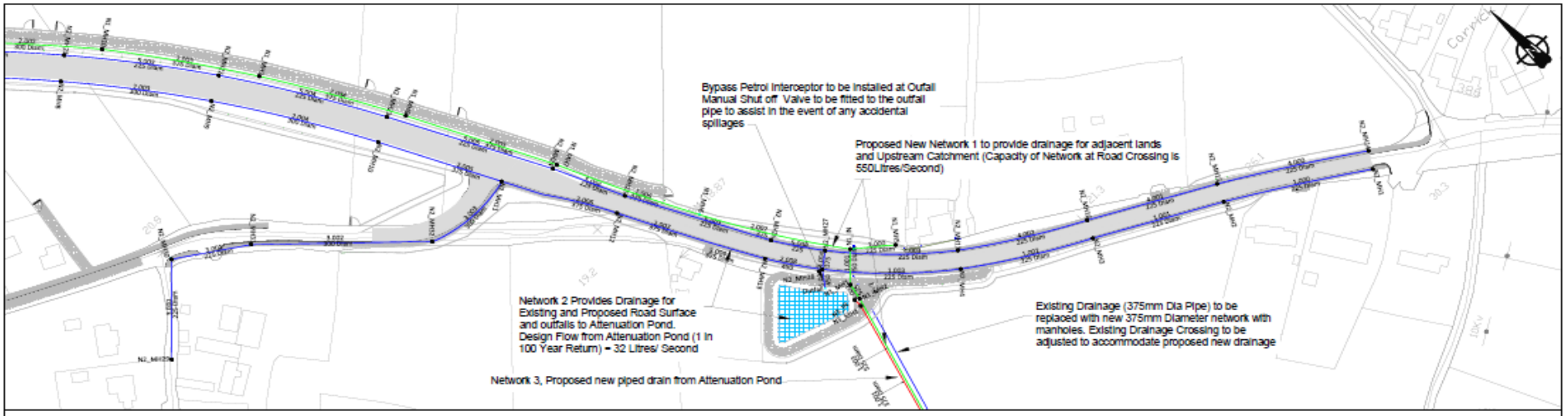

Proposed Residential Access to Mini Roundabout at Clonmore will also serve as access for NMUs rom the western scheme extents to Mooncoin Village
Calculated Design Speed for the L7416 to Grange is 42Kph, Reference Appendix G of Preliminary Design Report for Details of calculations
Underbridge to maintain access for motorised and non-motorised users along the along the L7416 and to the north of the schememe onto the N24 and into Mooncoin Village
Proposed new offline track to provide access for NMUs from the western extents of the scheme to new shared access a long the scheme
Proposed Cattle Underpass Adjacent to Underbridge to provide access for dairy farmer whose lands are severed by scheme
Proposed Type 1 Single Carriaway Crossection (Design Speed 100Kph), to provide required Level of Service as per Table 6.1 of DN-GEO-03031
Further to reduction in pavement width of existing N24 Carriageway to 5m, calculated Design Speed is 70kph. Reference Appendix G of Preliminary Design Report for Details of calculations
New 2.5m wide shared surface
Carriageway width on Existing N24 reduced to 5m with provision of adjacent shared access for Non-motorised Users
Dropped Kerbs provided for uncontrolled pedestrian crossing
Dropped Kerbs provided for uncontrolled pedestrian crossing
Footpath along existing N24 to be upgradeded to 2.5m width
2.5m wide shared surface to be provided either side of Carriageway
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
General Arrangement Drawing. Overall Access Arrangements.
7.6.1
F1
KK1613403-P3-GA-007
NTS
22/04/2021

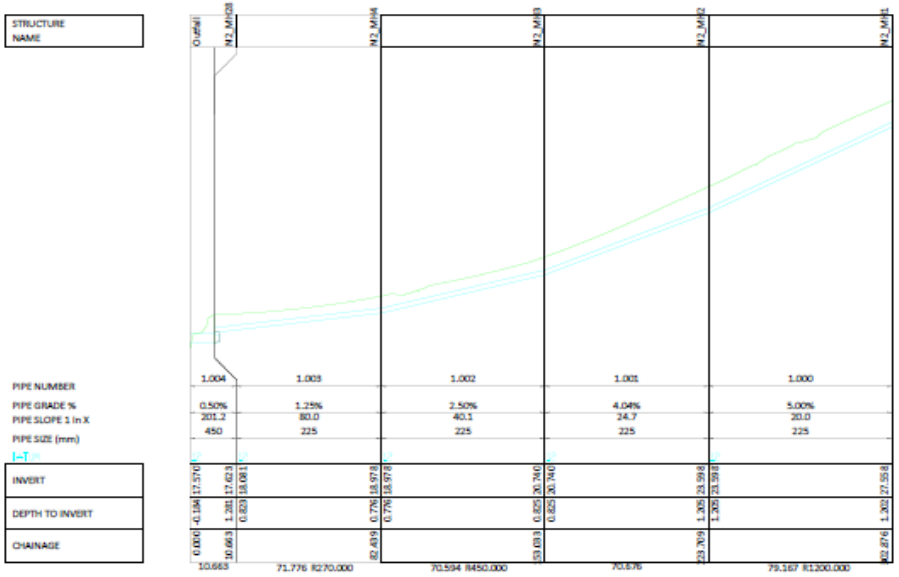

Location of Flatspot (R < 1) Ch 2080 to Ch 2130
Location of Hidden Dip on Mainline
Long Section along Existing Centre Line (Ch 0 to 1050)
N24 Single Carriageway Ties into Type 3 Dual (Pittown Bypass)
Adverse or insufficient Camber Ch 1100
Horizontal Geometry; Short Length Radii, and short horizontal curves through out Existing Carriageway
Horizontal Geometry; Short Length Radii, and short horizontal curves typical through out Existing Carriageway
Location of Flatspot (R < 1) Ch 1080 to Ch 1020
Locations of Intermittent Flat Spots along Existing Pavement
Adverse or insufficient Camber Ch 470
Location of Hidden Dip on Mainline
Location of Hidden Dip on Mainline
Long Section along Existing Centre Line (Ch 1050 to End)
1. Actual extent of scheme land acquisition to be determined at a later date.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
General Arrangement Drawing. Existing N24 Geometry
7.6.1
F1
KK1613403-P3-GA-008
NTS
27/04/2021


Calculated Design Speed for the L7416 to Grange is 42Kph, Reference Appendix G of Preliminary Design Report for Details of calculations (Width of L7416 pavement 2.8 to 3.0m)
Departure 1g (Mainline Turning Loop on Type 3 Dual Carriageway- Existing)
Departure 1d (Forward Visibility on Local Road)
Departure 1e (Visibility from Access)
Departure 1b (Pavement Drainage Ch 950 to 960)
Further to reduction in pavement width of existing N24 Carriageway to 5m, calculated Design Speed is 70kph. Reference Appendix G of Preliminary Design Report for Details of calculations
New 2.5m wide shared surface
Departure 1f (Visibility from Access)
Departure 1c (Road Design, horizontal Geometry)
Departure 1a (Road Design- Visibility on approach to Junction with N24 mainline)
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
Departure Application Details.
7.6.1
F1
NTS
24/04/2021
KK1613403-P3-DP-001

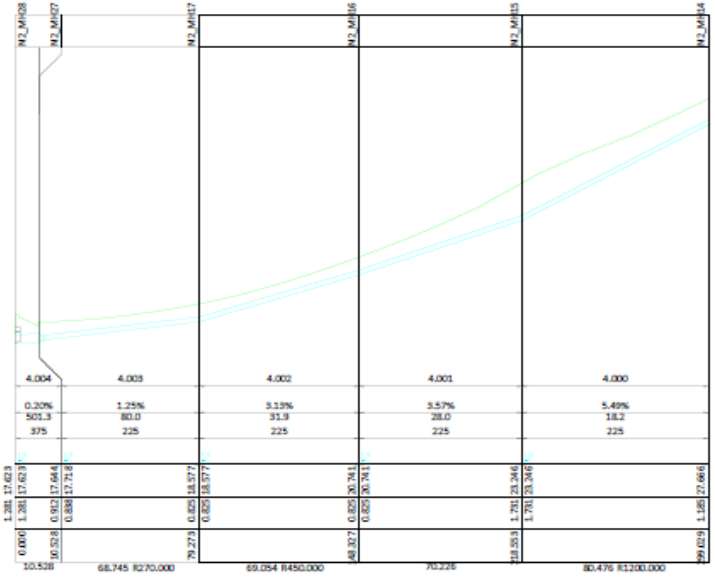
APPENDIX B – DRAINAGE DRAWINGS


KK1613403-P3-GA-005
KK1613403-P3-GA-008
KK1613403-P3-DR-004
KK1613403-P3-DR-003
KK1613403-P3-DR-006
KK1613403-P3-DR-007
KK1613403-P3-DR-002
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
Drainage Layout.
Key Map
7.6.1
F6
KK1613403-P3-DR-001

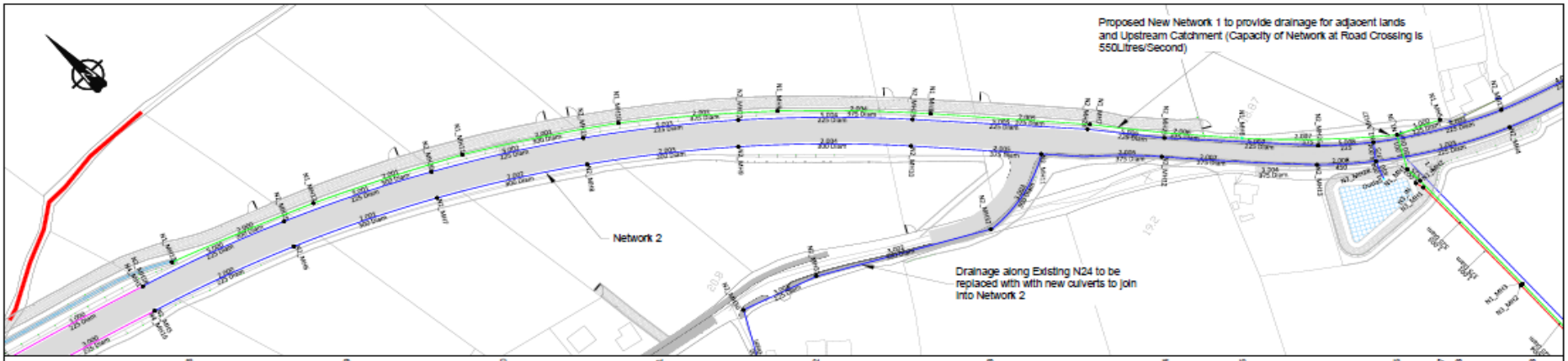


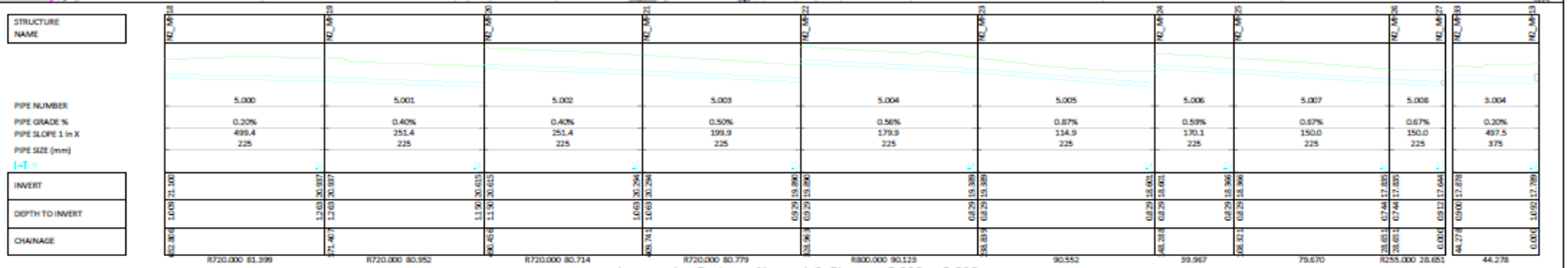


Longsection Drainage Network 2; Pipe-run 1.000 to 1.004

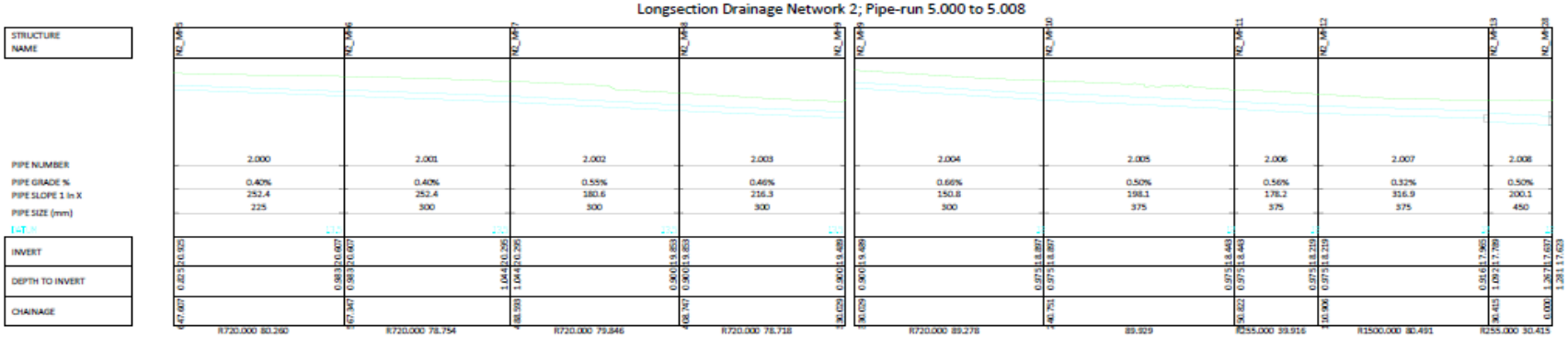


Longsection Drainage Network 2; Pipe-run 4.000 to 4.004





Longsection Drainage Network 2; Pipe-run 5.000 to 5.008



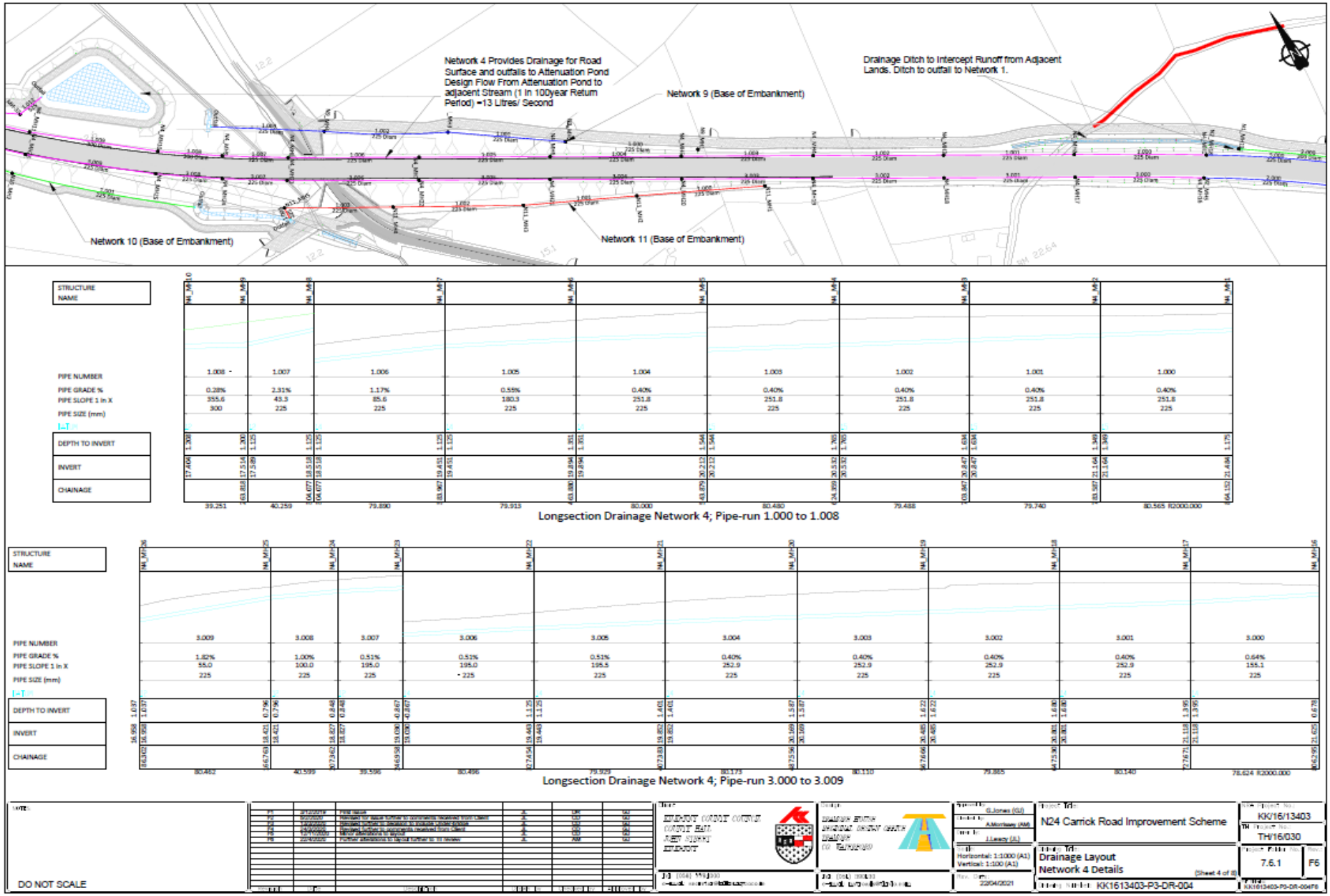
Longsection Drainage Network 2; Pipe-run 2.000 to 2.008

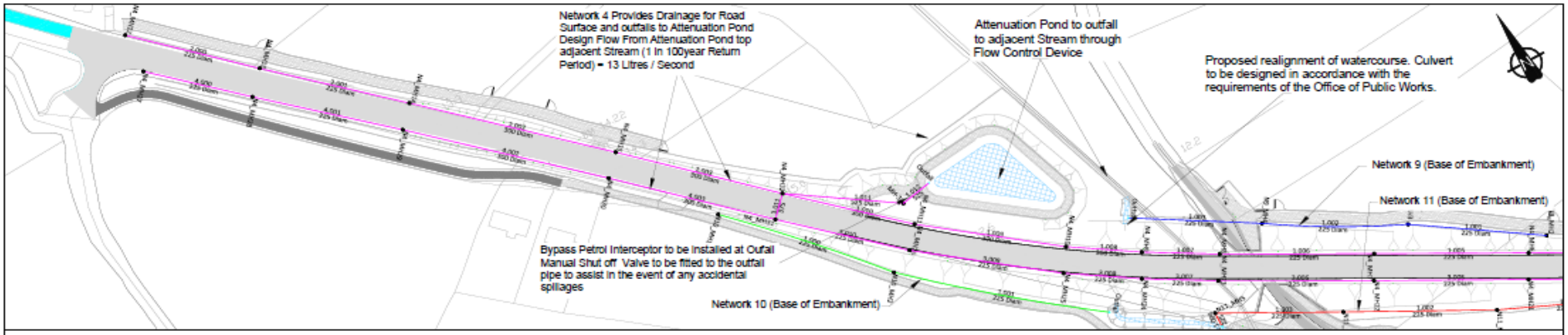
DO NOT SCALE

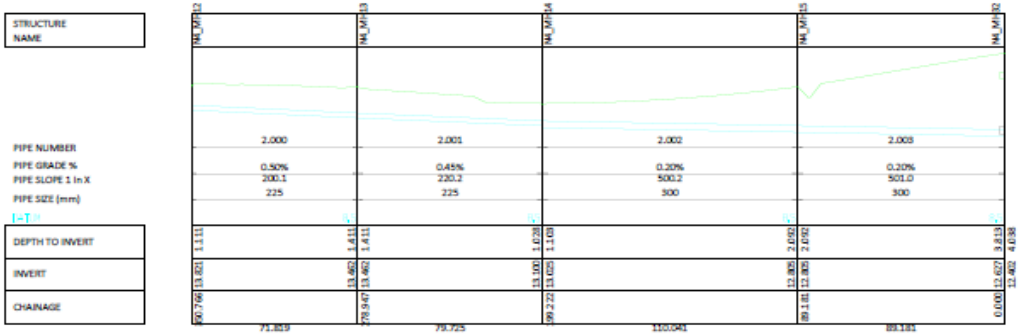
N24 Carrick Road Improvement Scheme

Drainage Layout
Network 2 Details

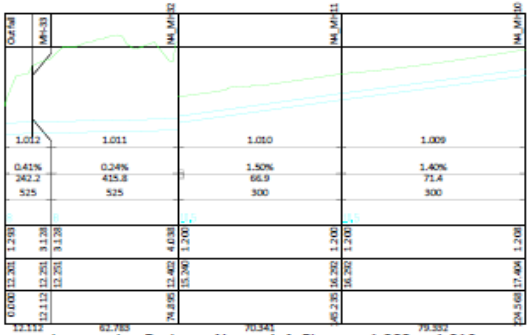
KK/16/13403
TH/16/030
7.6.1
F6
KK1613403-P3-DR-003


Network 4 Provides Drainage for Road Surface and outfalls to Attenuation Pond Design Flow From Attenuation Pond to adjacent Stream (1 In 100year Return Period) =13 Litres/ Second
Network 9 (Base of Embankment)
Drainage Ditch to Intercept Runoff from Adjacent Lands. Ditch to outfall to Network 1.
Network 10 (Base of Embankment)
Network 11 (Base of Embankment)
STRUCTURE NAME
PIPE NUMBER
PIPE GRADE %
PIPE SLOPE 1 In X
PIPE SIZE (mm)
DEPTH TO INVERT
INVERT
CHAINAGE
Longsection Drainage Network 4; Pipe-run 1.000 to 1.008
Longsection Drainage Network 4; Pipe-run 3.000 to 3.009
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
Drainage Layout
Network 4 Details
7.6.1
F6
KK1613403-P3-DR-004

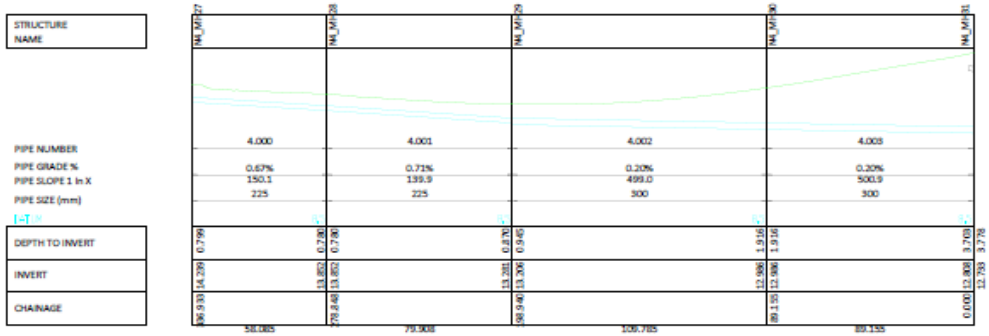




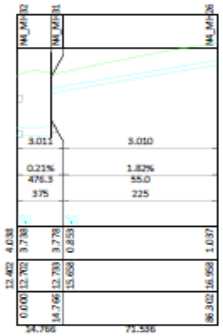
Longsection Drainage Network 4; Pipe-run 2.000 to 2.003



Longsection Drainage Network 4; Pipe-run 1.009 to 1.012



Longsection Drainage Network 4; Pipe-run 4.000 to 4.003



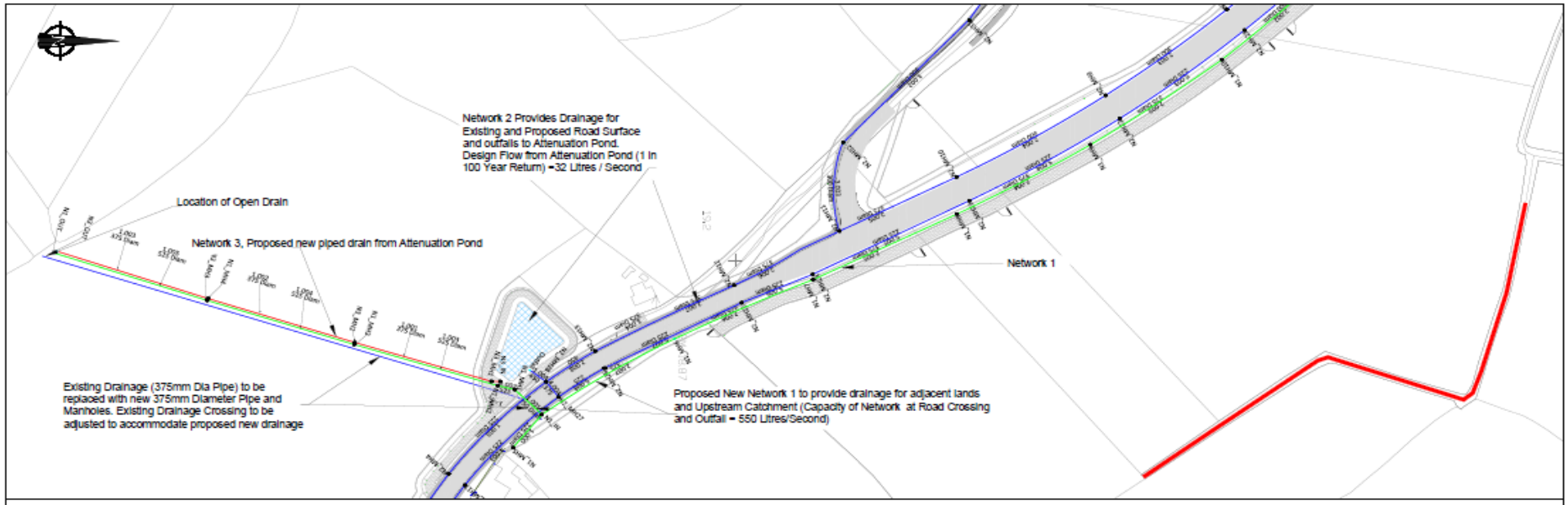
Longsection Drainage Network 4; Pipe-run 3.009 to 3.011

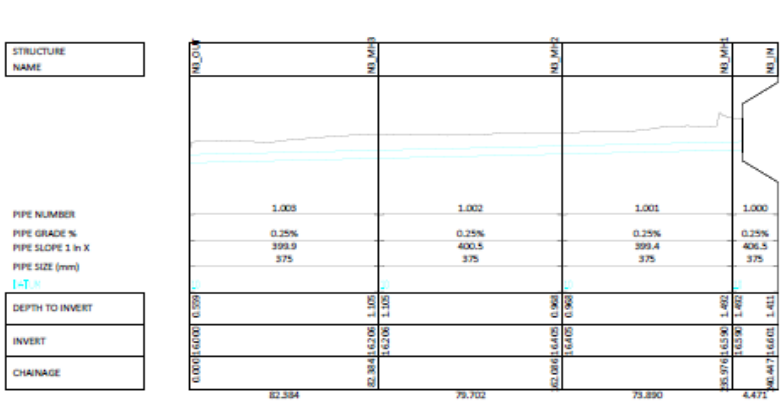
DO NOT SCALE

N24 Carrick Road Improvement Scheme

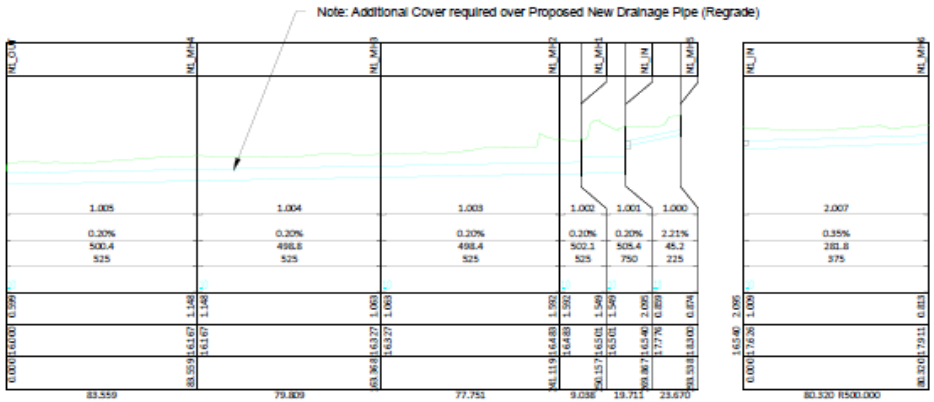
Drainage Layout
Network 4 Details

KK/16/13403
TH/16/030
7.6.1
F7
KK1613403-P3-DR-005





Longsection Drainage Network 3; Pipe-run 1.000 to 1.003



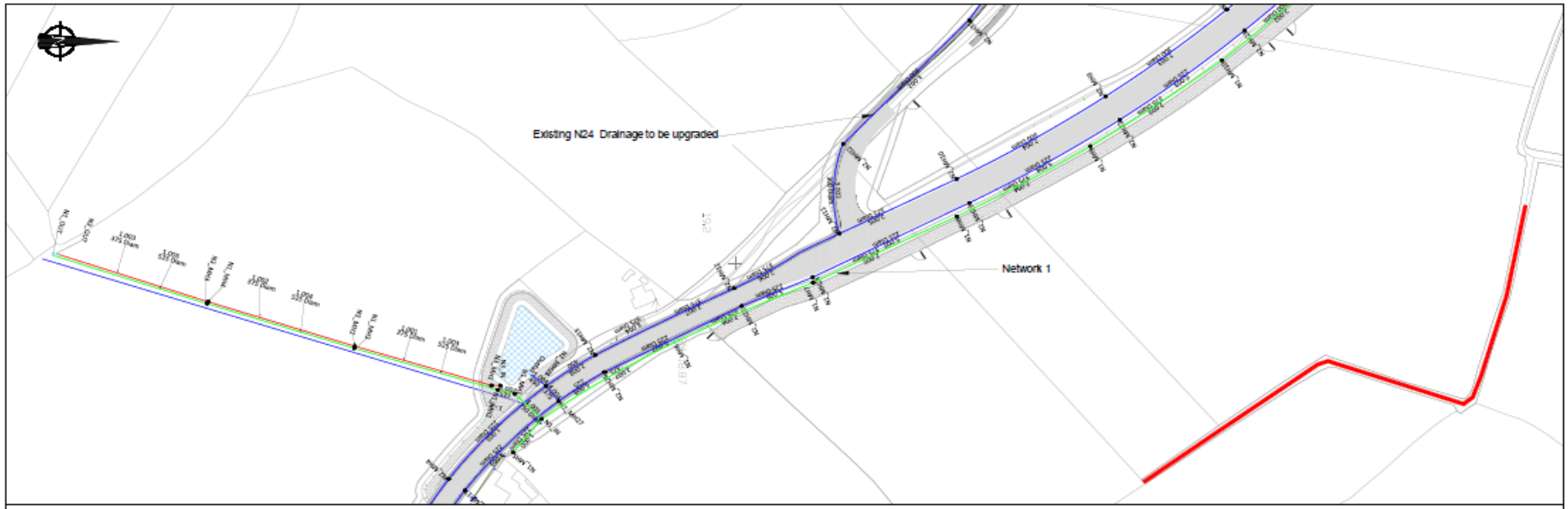
Longsection Drainage Network 1; Pipe-run 1.000 to 1.005 & 2.007

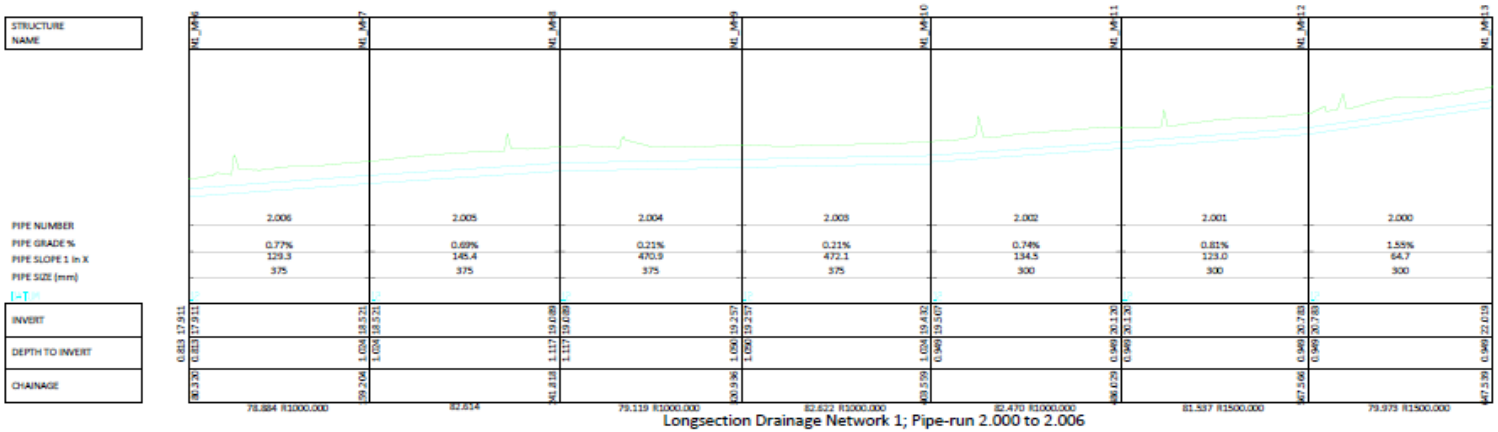
DO NOT SCALE

N24 Carrick Road Improvement Scheme

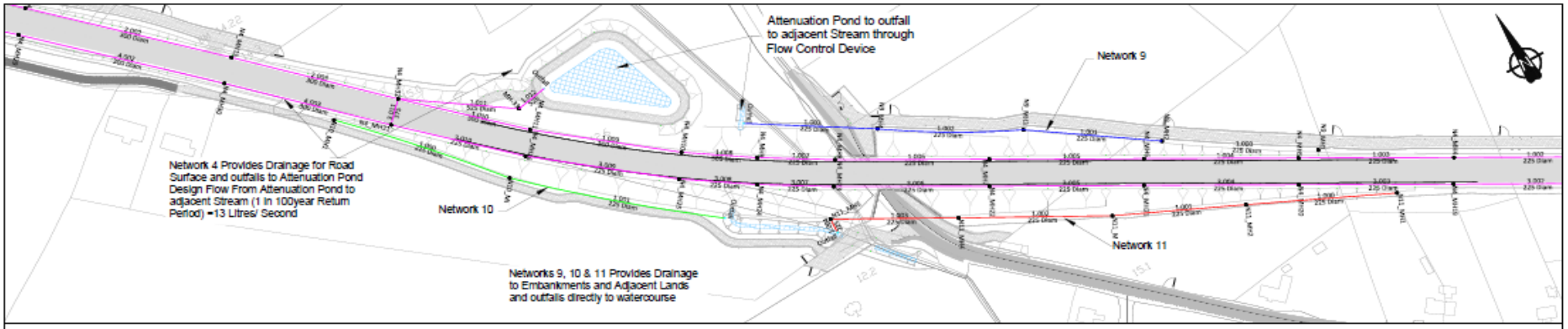
Drainage Layout
Network 1 & Network 3 Details

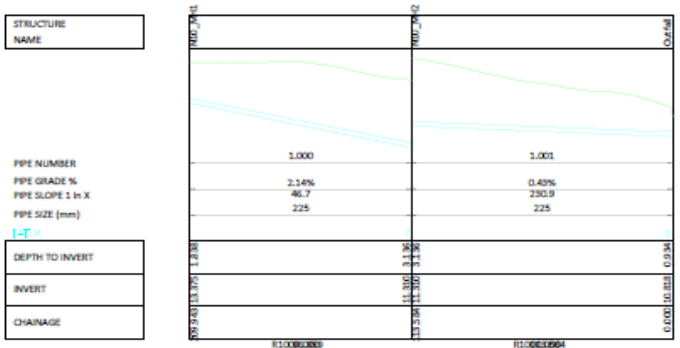
KK/16/13403
TH/16/030
7.6.1
F6
KK1613403-P3-DR-006



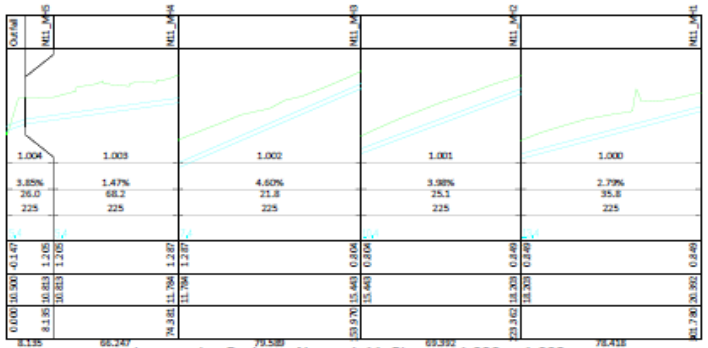


Longsection Drainage Network 1; Pipe-run 2.000 to 2.006

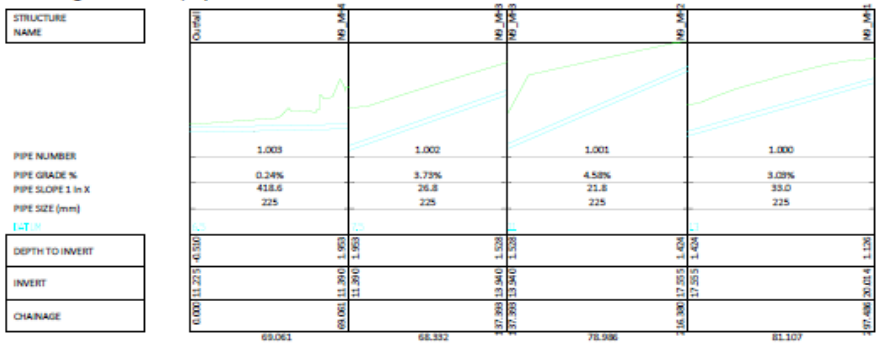




Longsection Drainage Network 10; Pipe-run 1.000 to 1.001



Longsection Drainage Network 11; Pipe-run 1.000 to 1.003



Longsection Drainage Network 9; Pipe-run 1.000 to 1.003

NOTES:

DO NOT SCALE

P1	21/12/2018	First issue	JL	DR	GJ
P2	30/2/2020	Revised for issue further to comments received from client	JL	CD	GJ
P3	14/4/2020	Revised further to issues raised above	JL	CD	GJ
P4	28/8/2020	Revised further to comments received from client	JL	CD	GJ
P5	12/11/2020	Minor alterations to layout	JL	CD	GJ
P6	22/4/2021	Further alterations to layout further to IR review	JL	AM	GJ

Client: KILDARE COUNTY COUNCIL COUNTY HALL NEW CENTRE STREET KILDARE

Consultant: DRAINAGE DESIGN SHEEHAN ENGINEERING CONSULTANTS DRAINAGE CO. TALLAGHT

Prepared by: G.Jones (GJ) Checked by: A.Morrissey (AM) Approved by: J.Leacy (JL)

Scale: Horizontal: 1:1000 (A1) Vertical: 1:100 (A1)

Rev. Date: 22/04/2021

Project Title: N24 Carrick Road Improvement Scheme

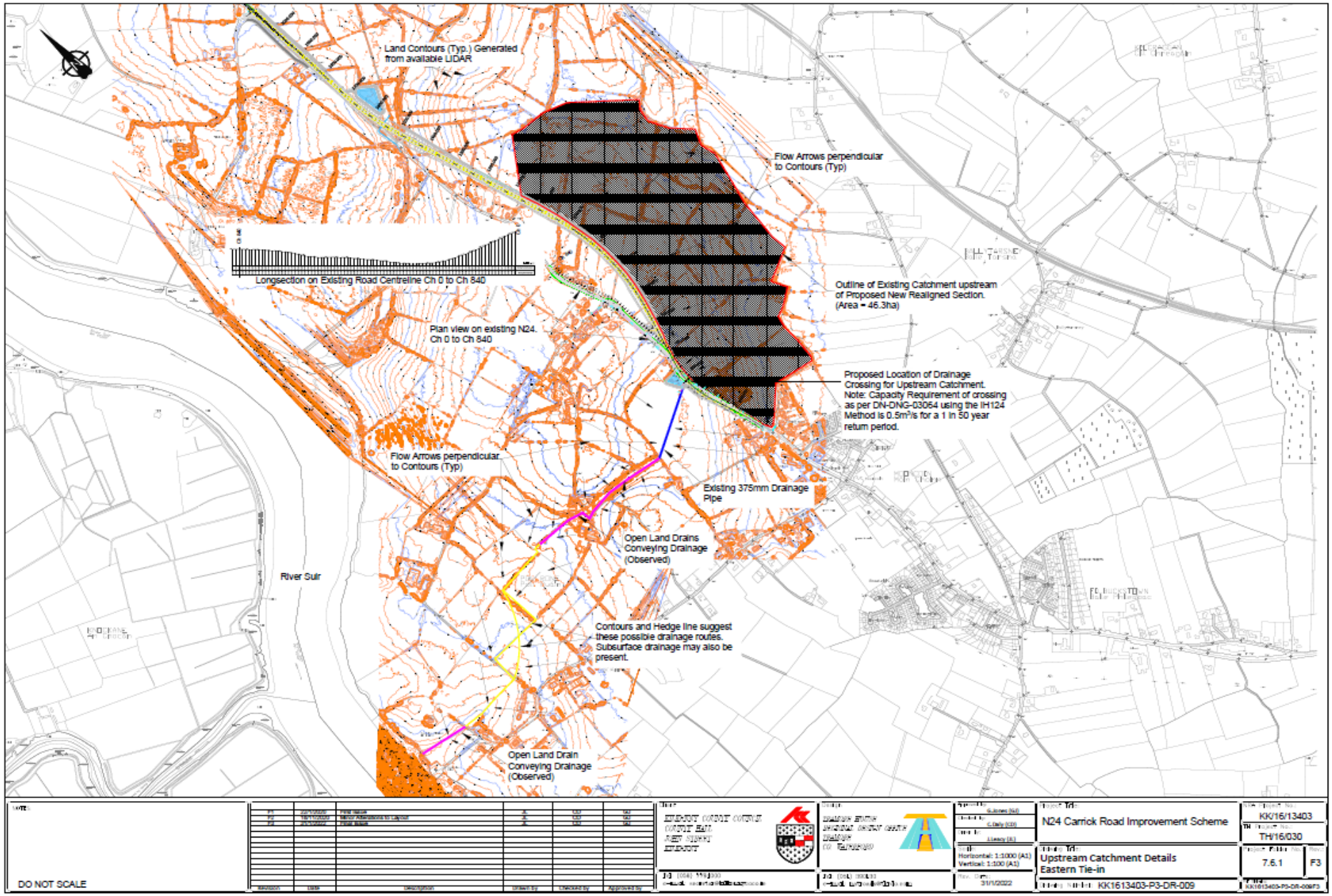
Drawing Title: Drainage Layout Network 9, 10 & 11 Details (Sheet 8 of 8)

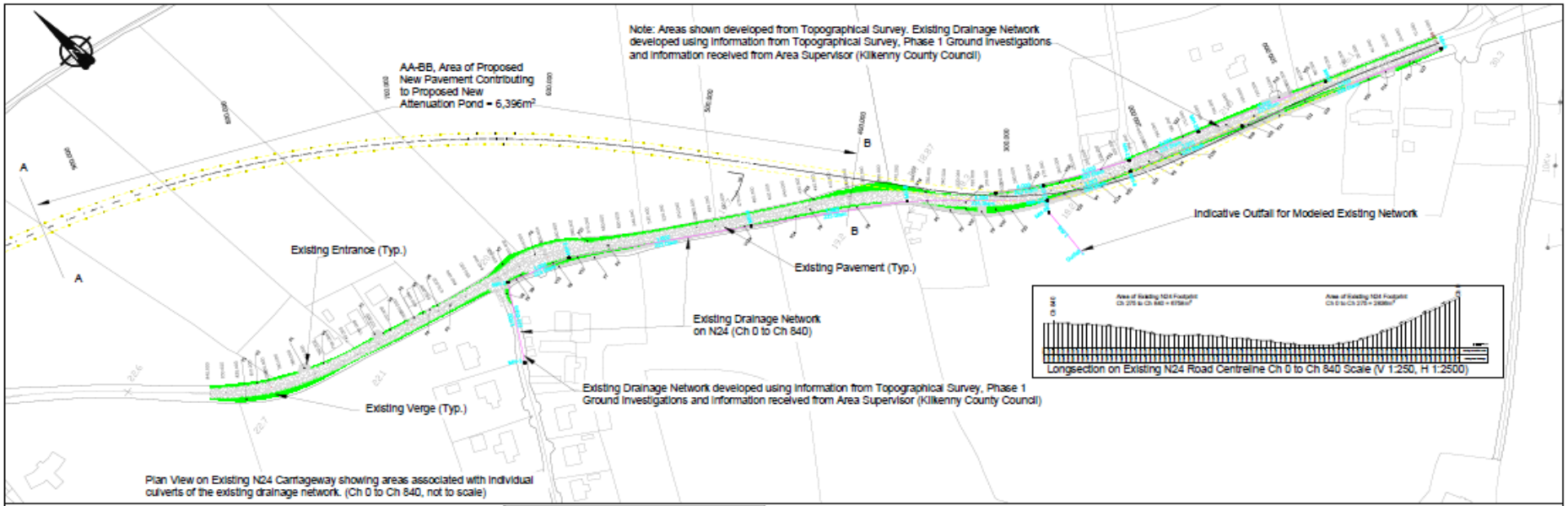
Drawing Number: KK1613403-P3-DR-008

Project Number: KK/16/13403 TH Project No.: TH/16/030

Project Phase No.: 7.6.1 Rev: F6

File: KK1613403-P3-DR-008F6


Land Contours (Typ.) Generated from available LIDAR
Flow Arrows perpendicular to Contours (Typ)
Longsection on Existing Road Centreline Ch 0 to Ch 840
Outline of Existing Catchment upstream of Proposed New Realigned Section. (Area = 46.3ha)
Plan view on existing N24. Ch 0 to Ch 840
Proposed Location of Drainage Crossing for Upstream Catchment. Note: Capacity Requirement of crossing as per DN-DNG-03064 using the IH124 Method is 0.5m³/s for a 1 in 50 year return period.
Flow Arrows perpendicular to Contours (Typ)
Existing 375mm Drainage Pipe
Open Land Drains Conveying Drainage (Observed)
River Suir
Contours and Hedge line suggest these possible drainage routes. Subsurface drainage may also be present.
Open Land Drain Conveying Drainage (Observed)
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK/16/13403
TH/16/030
Upstream Catchment Details
Eastern Tie-in
7.6.1
F3
KK1613403-P3-DR-009



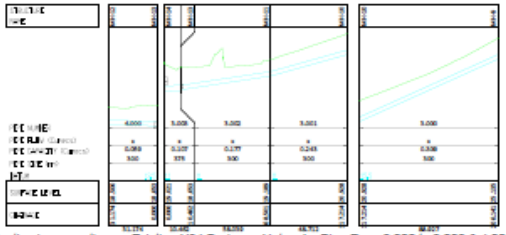
Plan View on Existing N24 Carriageway showing areas associated with individual culverts of the existing drainage network. (Ch 0 to Ch 840, not to scale)

Impermeable Area Pipe No. 1.000	*1747.9*	.175ha
Impermeable Area Pipe No. 1.001	*646.5*	.065ha
Impermeable Area Pipe No. 1.002	*1057.6*	.106ha
Impermeable Area Pipe No. 1.003	*1059.1*	.106ha
Impermeable Area Pipe No. 1.004	*321.9*	.032ha
Impermeable Area Pipe No. 4.000	*608.4*	.061ha
Impermeable Area Pipe No. 3.002	*432.1*	.042ha
Impermeable Area Pipe No. 2.002	*186.2*	.019ha
Impermeable Area Pipe No. 3.001	*236.1*	.024ha
Impermeable Area Pipe No. 3.000	*606.2*	.061ha
Impermeable Area Pipe No. 2.001	*494.5*	.05ha
Impermeable Area Pipe No. 2.000	*831.3*	.083ha

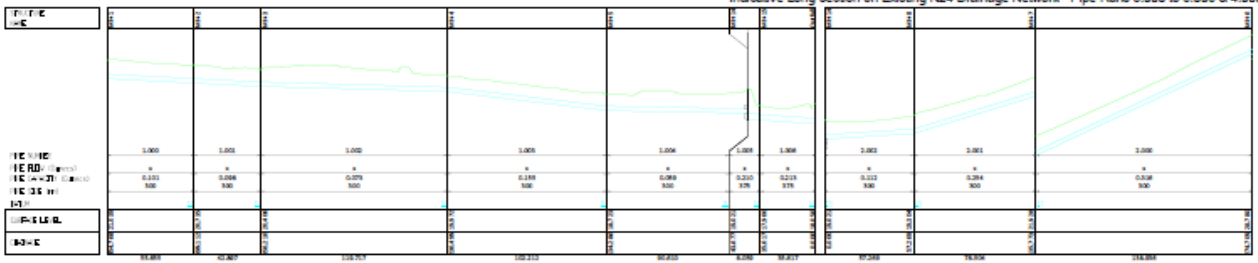
Summary of Existing Network Pipes & associated Factored Impermeable Areas

Summary of Equivalent Greenfield Flows Under Existing and Proposed Pavement Areas (Using ADAS Method, Referece Section 5.5 DN-DNG-03064) Unfactored		
Location	Return Period	Flow (Litres / Second)
Ch 0 to Ch 275 Existing Pavement	1 in 75	21
Ch 275 to Ch 840 Existing Pavement	1 in 75	34
Ch 400 to Ch 920 Proposed Pavement	1 in 75	37
Total	1 in 75	92

Summary of Equivalent Greenfield Flows under Existing and Proposed Pavement Areas. Note; as the attenuation on the eastern Tie in limits flow to 32l/s (1 in 100 year), the proposed design complies with the requirements of Para. 5.11 to 5.13 of DN-DNG-03066



Indicative Long-section on Existing N24 Drainage Network - Pipe Runs 3.000 to 3.003 & 4.000 (Not To Scale)



Indicative Long-section on Existing N24 Drainage Network - Pipe Runs 1.002 to 1.006 & 2.000 to 2.002 (Not To Scale)

Analysis of Existing Drainage System Eastern Tie-in	
Return Period	Simulated Flow From Outfall Pipe
1 in 1	79 Litres / Second
1 in 5	97 Litres / Second
1 in 30	154 litres / Second
1 in 50	165 litres / Second
1 in 100	182 litres / Second

Summary of Simulated Flows for different Return Periods for the Existing Drainage Network

NOTES

DO NOT SCALE

F1	20/12/2020	First Issue	JL	CD	GJ

Client: Kilkenny County Council, County Hall, Rath Street, Kilkenny

Consultant: Walsh South, Walsh Grant Smith, Walsh, Co. Tipperary

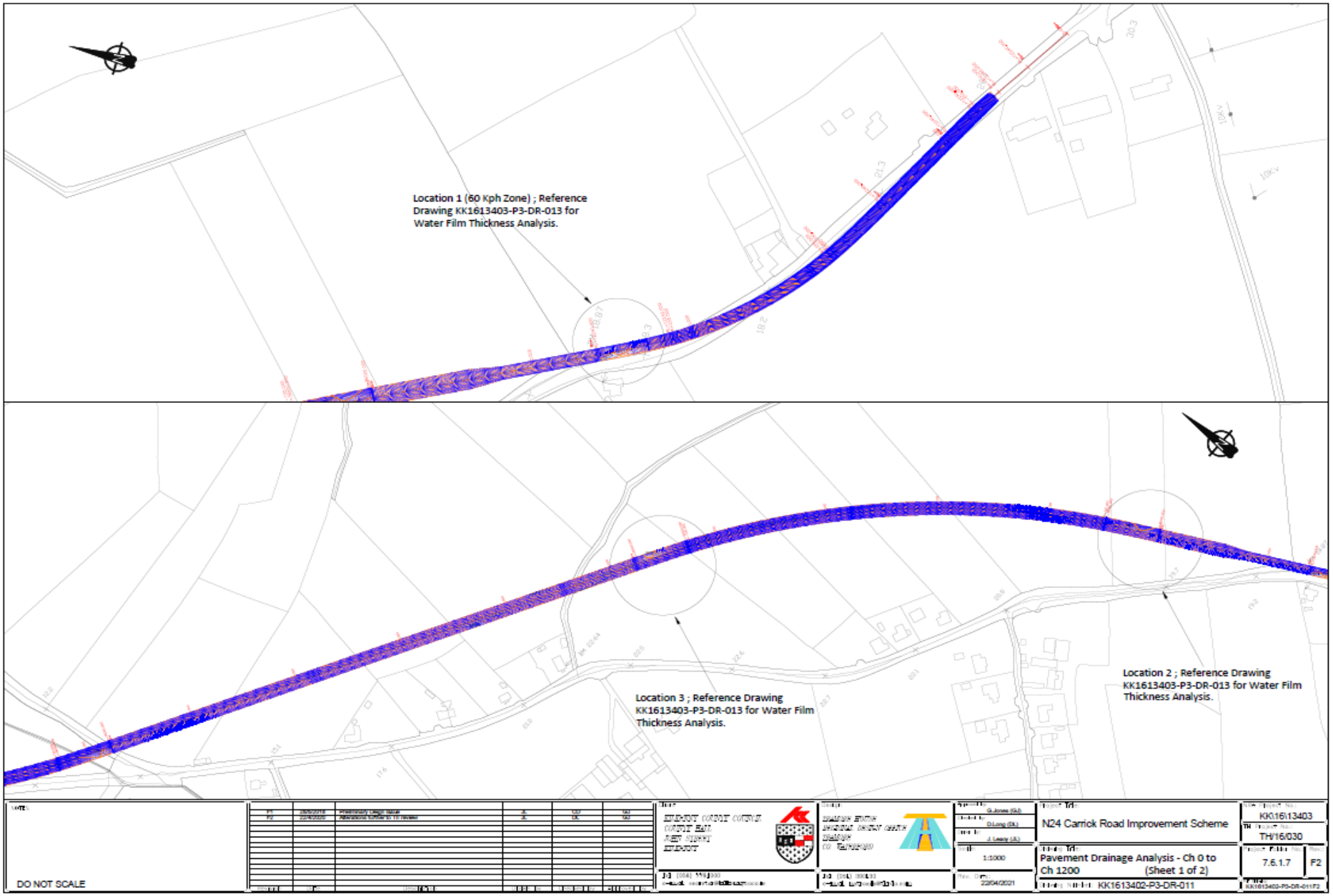
Approved: G.Jones (GJ)
Drawn by: C.Daly (CD)
Checked by: J.Leacy (JL)
Scale: Horizontal: 1:1000 (A1) Vertical: 1:100 (A1)
Rev. Date: 3/12/2019

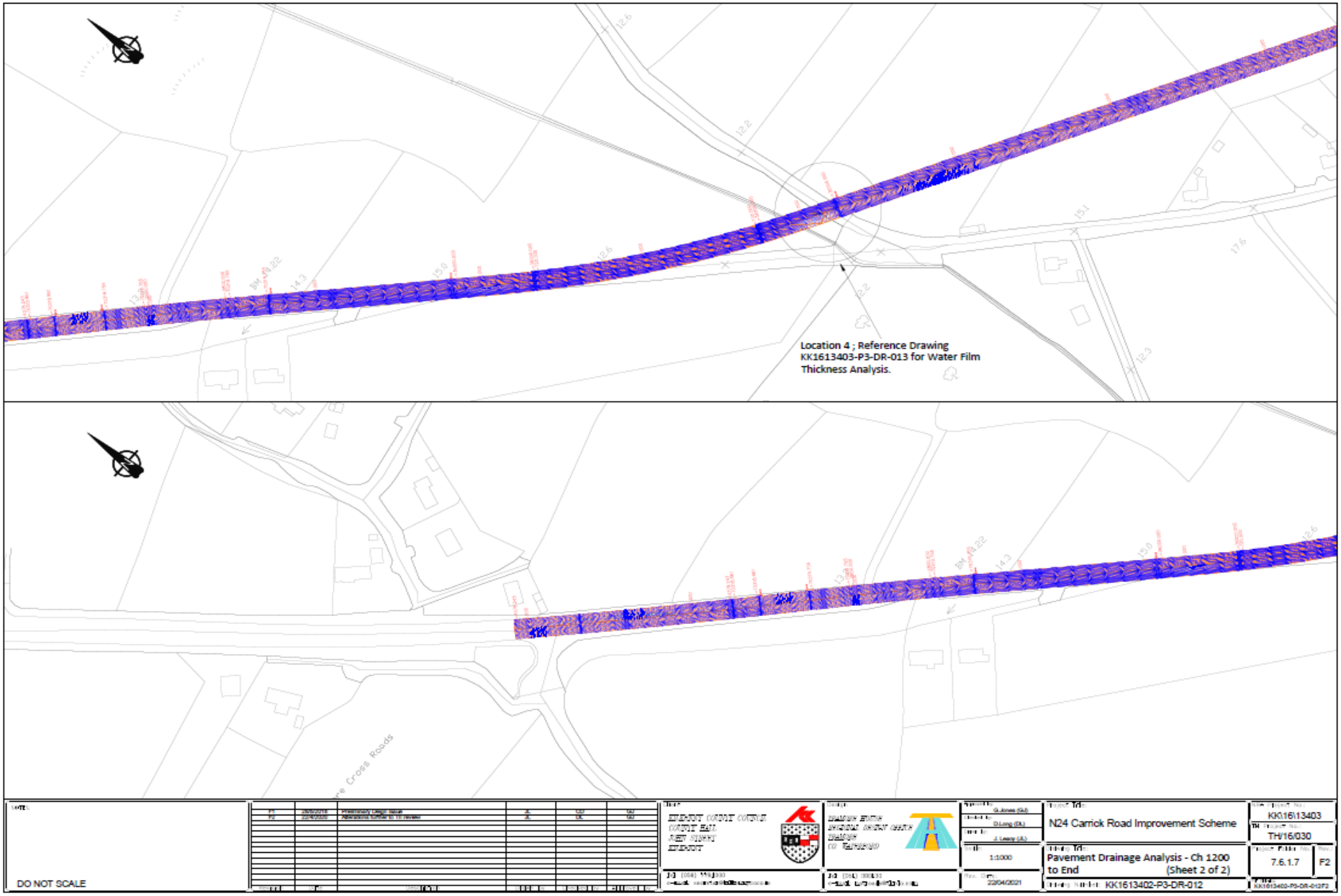
Project Title: N24 Carrick Road Improvement Scheme

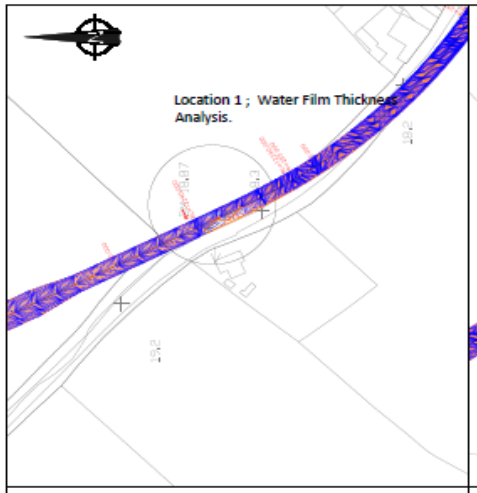
Drawing Title: Drainage Design - Details of Attenuation Assessment at Eastern Tie - in

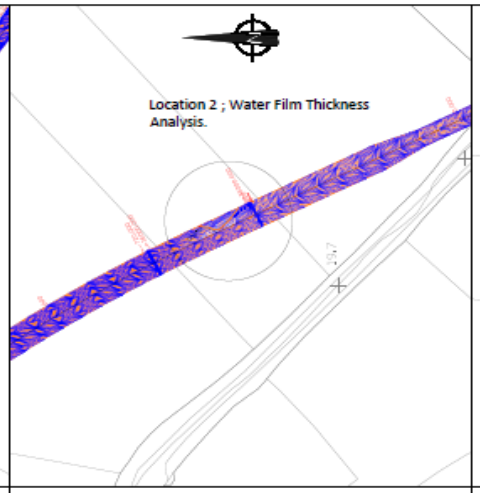
Drawing Number: KK1613403-P3-DR-010

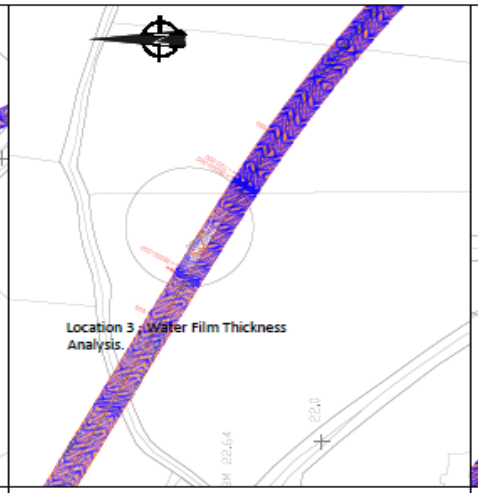
KK Project No.: KK/16/13403
TH Project No.: TH/16/030
Drawing Number: 7.6.1
Rev.: F1
File: KK1613403-P3-DR-010F1

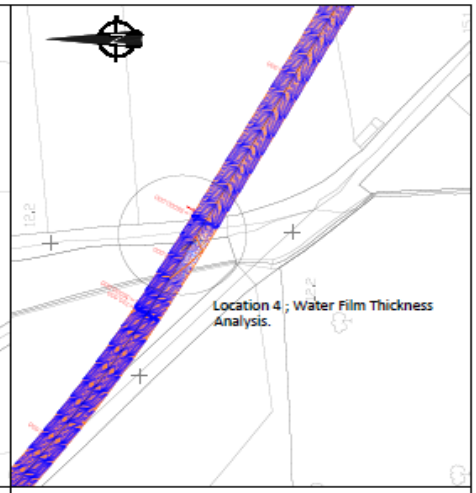

Location 1 (60 Kph Zone) ; Reference Drawing KK1613403-P3-DR-013 for Water Film Thickness Analysis.
Location 3 ; Reference Drawing KK1613403-P3-DR-013 for Water Film Thickness Analysis.
Location 2 ; Reference Drawing KK1613403-P3-DR-013 for Water Film Thickness Analysis.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK\16\13403
TH/16/030
Pavement Drainage Analysis - Ch 0 to Ch 1200 (Sheet 1 of 2)
7.6.1.7
F2
KK1613402-P3-DR-011
1:1000
22/04/2021

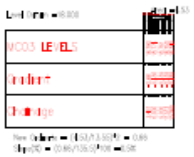

Location 4 ; Reference Drawing KK1613403-P3-DR-013 for Water Film Thickness Analysis.
DO NOT SCALE
N24 Carrick Road Improvement Scheme
KK1613403
TH/16/030
Pavement Drainage Analysis - Ch 1200 to End (Sheet 2 of 2)
7.6.1.7
F2
1:1000
KK1613402-P3-DR-012



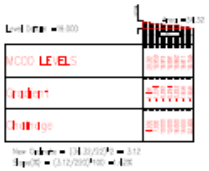




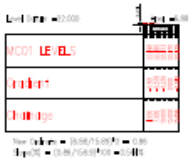




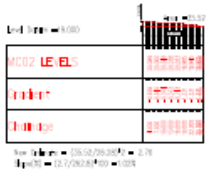
Gallaway Formula	Location 1			
D = (0.103*(T^0.12)*(L^0.43)*(I^.58)/(S^0.42))-T				
T=	0.4			
L =	13.5			
I =	50			
S =	0.5			
		D=	3.401481	



Gallaway Formula	Location 2			
D = (0.103*(T^0.12)*(L^0.43)*(I^.58)/(S^0.42))-T				
T=	0.4			
L =	22			
I =	50			
S =	1.42			
		D=	2.625223	



Gallaway Formula	Location 3			
D = (0.103*(T^0.12)*(L^0.43)*(I^.58)/(S^0.42))-T				
T=	0.4			
L =	15.89			
I =	50			
S =	0.544			
		D=	3.535577	



Gallaway Formula	Location 4			
D = (0.103*(T^0.12)*(L^0.43)*(I^.58)/(S^0.42))-T				
T=	0.4			
L =	26.28			
I =	50			
S =	1.02			
		D=	3.352352	

NOTES:

DO NOT SCALE

P1	28/6/2018	Preliminary Design Issue	JL	CD	GJ
P2	22/4/2021	Alterations further to TII review	JL	DL	GJ

Title: STADDOT (WEST WATER) (WEST BAY) KEY POINT STADDOT

Drawing Status: DRAWING STATUS DRAWING DENOTES DRAWING DO NOT REPRODUCE

Approved by: G.Jones (GJ)
Checked by: D.Long (DL)
Drawn by: J.Leacy (JL)
Scale: 1:1000
Rev. Date: 22/04/2021

Project Title: N24 Carrick Road Improvement Scheme

Drawing Title: Pavement Drainage Water Film Thickness Analysis

Drawing Number: KK1613402-P3-DR-013

Project Number: KK/16/13403
TII Project No.: TH/16/030
Project Folder No.: 7.6.1.7
Rev.: F2
File: KK1613402-P3-DR-013F2

APPENDIX C – DRAINAGE DESIGN DETAILS

Met Eireann Data utilized in Drainage Design

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 249704, Northing: 117024,

	Interval		Years													
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	3.3,	4.3,	4.9,	5.7,	6.2,	6.6,	7.9,	9.4,	10.3,	11.6,	12.7,	13.5,	14.8,	15.8,	16.6,	N/A ,
10 mins	4.5,	6.0,	6.8,	7.9,	8.7,	9.3,	11.1,	13.1,	14.3,	16.1,	17.6,	18.8,	20.6,	22.0,	23.1,	N/A ,
15 mins	5.3,	7.1,	8.0,	9.3,	10.2,	10.9,	13.0,	15.4,	16.9,	19.0,	20.8,	22.1,	24.2,	25.8,	27.1,	N/A ,
30 mins	7.1,	9.3,	10.5,	12.1,	13.2,	14.1,	16.7,	19.6,	21.4,	24.0,	26.2,	27.9,	30.4,	32.3,	33.9,	N/A ,
1 hours	9.4,	12.2,	13.7,	15.8,	17.1,	18.2,	21.5,	25.0,	27.3,	30.4,	33.0,	35.1,	38.1,	40.4,	42.3,	N/A ,
2 hours	12.5,	16.1,	17.9,	20.5,	22.2,	23.5,	27.5,	31.9,	34.7,	38.4,	41.7,	44.1,	47.8,	50.6,	52.9,	N/A ,
3 hours	14.7,	18.8,	20.9,	23.9,	25.8,	27.3,	31.9,	36.8,	39.9,	44.1,	47.7,	50.5,	54.6,	57.7,	60.3,	N/A ,
4 hours	16.5,	21.1,	23.4,	26.6,	28.7,	30.3,	35.4,	40.7,	44.1,	48.7,	52.6,	55.6,	60.0,	63.4,	66.1,	N/A ,
6 hours	19.5,	24.7,	27.3,	31.0,	33.4,	35.3,	40.9,	46.9,	50.7,	55.9,	60.3,	63.6,	68.5,	72.3,	75.3,	N/A ,
9 hours	23.0,	29.0,	32.0,	36.2,	38.9,	41.0,	47.4,	54.2,	58.4,	64.2,	69.1,	72.8,	78.3,	82.4,	85.8,	N/A ,
12 hours	25.9,	32.5,	35.7,	40.4,	43.3,	45.6,	52.6,	59.9,	64.5,	70.8,	76.1,	80.1,	86.0,	90.5,	94.1,	N/A ,
18 hours	30.6,	38.1,	41.8,	47.1,	50.4,	53.0,	60.9,	69.1,	74.3,	81.3,	87.2,	91.7,	98.3,	103.3,	107.3,	N/A ,
24 hours	34.4,	42.7,	46.7,	52.5,	56.2,	59.0,	67.5,	76.5,	82.1,	89.7,	96.1,	100.9,	108.0,	113.4,	117.7,	132.2,
2 days	43.6,	53.1,	57.8,	64.3,	68.4,	71.5,	81.0,	90.9,	97.0,	105.1,	112.0,	117.2,	124.8,	130.5,	135.0,	150.3,
3 days	51.2,	61.7,	66.9,	74.0,	78.5,	81.9,	92.1,	102.8,	109.3,	118.0,	125.4,	130.8,	138.8,	144.8,	149.7,	165.6,
4 days	57.9,	69.4,	74.9,	82.6,	87.4,	91.0,	102.0,	113.3,	120.2,	129.4,	137.1,	142.8,	151.3,	157.6,	162.6,	179.3,
6 days	70.0,	83.0,	89.2,	97.8,	103.2,	107.2,	119.4,	131.8,	139.4,	149.4,	157.8,	164.1,	173.2,	180.0,	185.4,	203.3,
8 days	80.8,	95.2,	102.0,	111.4,	117.3,	121.6,	134.8,	148.2,	156.4,	167.2,	176.2,	182.8,	192.6,	199.8,	205.5,	224.5,
10 days	90.9,	106.5,	113.8,	123.9,	130.2,	134.9,	149.0,	163.3,	172.0,	183.5,	193.0,	200.0,	210.3,	217.9,	223.9,	243.9,
12 days	100.4,	117.1,	125.0,	135.7,	142.4,	147.4,	162.3,	177.4,	186.6,	198.6,	208.6,	216.0,	226.8,	234.7,	241.1,	261.9,
16 days	118.4,	137.0,	145.8,	157.7,	165.1,	170.6,	187.1,	203.6,	213.6,	226.8,	237.6,	245.6,	257.3,	265.9,	272.7,	295.1,
20 days	135.3,	155.7,	165.2,	178.2,	186.3,	192.2,	210.0,	227.9,	238.6,	252.7,	264.4,	272.9,	285.3,	294.5,	301.8,	325.6,
25 days	155.3,	177.8,	188.2,	202.4,	211.2,	217.7,	237.0,	256.3,	267.9,	283.1,	295.6,	304.7,	318.1,	327.9,	335.7,	361.1,

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

Network 2 Design Details (Outfalls to Attenuation Pond Eastern Section of Scheme)

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for N24DRAINDESIGNNETWORK 2.SWS

Pipe Sizes STANDARD Manhole Sizes STANDARD

FSR Rainfall Model - England and Wales

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.200	Add Flow / Climate Change (%)	0
Ratio R	0.254	Minimum Backdrop Height (m)	0.000
Maximum Rainfall (mm/hr)	550	Maximum Backdrop Height (m)	0.000
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	0.900
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	1.000	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for N24DRAINDESIGNNETWORK 2.SWS

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.352	4-8	0.952	8-12	0.458	12-16	0.060

Total Area Contributing (ha) = 1.823

Total Pipe Volume (m^3) = 117.600

Design Details for Attenuation Pond Eastern Section of Scheme.

Model Details

Storage is Online Cover Level (m) 17.400

Tank or Pond Structure

Invert Level (m) 16.600

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1010.0	0.200	1010.0	0.400	1010.0	0.600	1010.0	0.800	1010.0
0.100	1010.0	0.300	1010.0	0.500	1010.0	0.700	1010.0		

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0190-3200-0800-3200	Sump Available	Yes
Design Head (m)	0.800	Diameter (mm)	190
Design Flow (l/s)	32.0	Invert Level (m)	16.600
Flush-Flo™	Calculated	Minimum Outlet Pipe Diameter (mm)	225
Objective	Linear discharge profile	Suggested Manhole Diameter (mm)	1200
Application	Surface		

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	32.0	Kick-Flo®	0.283	19.5
Flush-Flo™	0.225	20.0	Mean Flow over Head Range	-	21.1

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Network 4 Design Details (Outfalls to Attenuation Pond Western Section of Scheme)

STORM SEWER DESIGN by the Modified Rational Method

Design Criteria for NETWORK 4_OPTIMISED.SWS

Pipe Sizes Network 4_Optimised Manhole Sizes Network 4_Optimised

FSR Rainfall Model - Scotland and Ireland

Return Period (years)	1	PIMP (%)	100
M5-60 (mm)	18.200	Add Flow / Climate Change (%)	0
Ratio R	0.254	Minimum Backdrop Height (m)	0.000
Maximum Rainfall (mm/hr)	550	Maximum Backdrop Height (m)	0.000
Maximum Time of Concentration (mins)	30	Min Design Depth for Optimisation (m)	0.900
Foul Sewage (l/s/ha)	0.000	Min Vel for Auto Design only (m/s)	1.00
Volumetric Runoff Coeff.	1.000	Min Slope for Optimisation (1:X)	500

Designed with Level Soffits

Time Area Diagram for NETWORK 4_OPTIMISED.SWS

Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)	Time (mins)	Area (ha)
0-4	0.212	4-8	0.737	8-12	0.556	12-16	0.209

Total Area Contributing (ha) = 1.713

Total Pipe Volume (m^3) = 126.196

Design Details for Attenuation Pond Western Section of Scheme.

Model Details

Storage is Online Cover Level (m) 12.300

Tank or Pond Structure

Invert Level (m) 11.500

Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)	Depth (m)	Area (m²)
0.000	1070.0	0.200	1070.0	0.400	1070.0	0.600	1070.0	0.800	1070.0	1.000	1070.0
0.100	1070.0	0.300	1070.0	0.500	1070.0	0.700	1070.0	0.900	1070.0		

Hydro-Brake® Optimum Outflow Control

Unit Reference	MD-SCU-0119-1300-0800-1300	Sump Available	Yes
Design Head (m)	0.800	Diameter (mm)	119
Design Flow (l/s)	13.0	Invert Level (m)	11.500
Flush-Flo™	Calculated	Minimum Outlet Pipe Diameter (mm)	150
Objective	Linear discharge profile	Suggested Manhole Diameter (mm)	1200
Application	Surface		

Control Points	Head (m)	Flow (l/s)	Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	0.800	13.0	Kick-Flo®	0.179	6.4
Flush-Flo™	0.147	6.6	Mean Flow over Head Range	-	8.7

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake® Optimum as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

APPENDIX D - DEPARTURE APPLICATIONS

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
100kph	8000	
Carriageway Type/Cross Section		
Type 2 Single Carriageway (Ch 0 to Ch 415) & Type 1 Single Carriageway (Ch 415 to Ch 2100)		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1a	

Departure Information:
Departure Location and Chainage:
N24 (circa Ch 450) on approach along local road to junction with mainline
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Design speed for local road is 70kph and therefore requires a SSD of 120m
Standard Provided
80m SSD will be provided
Departure Justification
The junction is close to the tie in of the offline section and the online section at the eastern extents of the proposed scheme and as such it is quite constrained. However, its location maximizes the number of direct accesses removed from the proposed new alignment. Advanced warning of the junction will be provided and a Stage 2 Road Safety Audit will be carried out before construction

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03031	Table 1.3
Additional Information and Supporting Documentation List:	
Refer to Drawing Nos KK1613403-P3-GA-002 and KK1613403-P3-DP-001 for further details on departure	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
100kph	8000	
Carriageway Type/Cross Section		
Type 2 Single Carriageway (Ch 0 to Ch 415) & Type 1 Single Carriageway (Ch 415 to Ch 2100)		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1b	

Departure Information:
Departure Location and Chainage:
N24 (circa Ch 950 to CH 960)
Departure Category *(e.g. Road Design, Structures etc.)*
Pavement Drainage
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Para 11.4 a) A maximum water film depth of 3.3mm shall apply to new single carriageway roads.
Standard Provided
At the minimum allowed length for transitioning between super-elevations, a water film depth of 3.53mm is provided with a minimum resultant gradient of 0.55%.
Departure Justification
Due to constraints such as the provision of under-bridge and requirement to tie into existing alignment, it is not possible to alter the vertical profile to reduce the water film thickness. The flow path length is quite short spanning only 8metres along the length of the carriageway and the water film thickness is only 0.24 mm above what is allowed. The departure is sought as an alternative to the provision of a rolling crown.

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03031	Para 11.4 a
Additional Information and Supporting Documentation List:	
Refer to Drawing Nos KK1613403-P3-DR-013 and KK1613403-P3-DP-001 for details of the proposed departure.	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
100kph	8000	
Carriageway Type/Cross Section		
Type 2 Single Carriageway (Ch 0 to Ch 415) & Type 1 Single Carriageway (Ch 415 to Ch 2100)		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1c	

Departure Information:
Departure Location and Chainage:
N24 (circa Ch 250)
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Para 5.2.2, DN-GEO-03060, "*New or altered direct accesses or priority junctions shall not be sited at any location where the desirable minimum SSD envelope of the national road falls outside the paved surface of the road*"
Standard Provided
This occurs at an existing domestic access at Ch 250. Full Stopping Sight Distance (120m) will be from the access through verge widening.
Departure Justification
The scheme is online at this location and the access is existing. Full Stopping Sight Distance (120m) will be provided from the access through verge widening. This is an improvement on what is there presently.

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03060	Para 5.2.2
Additional Information and Supporting Documentation List:	
Refer to Drawing No. KK1613403-P3-DP-001 for location of the proposed departure.	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
70kph	150 AADT	
Carriageway Type/Cross Section		
Local Road with 5m pavement width and 2.5m wide shared surface		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1d	

Departure Information:
Departure Location and Chainage:
Reference drawing KK1613403-P3-DP-001
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Design speed for local road is 70kph and therefore requires a SSD of 120m
Standard Provided
70 metres of Stopping sight distance will be provided
Departure Justification
At the location where the departure is occurring, the pavement width is tapering from 5m to 3m on approach to the L7416. The Design speed along the existing L7416 which has a pavement width of 3m is calculated at 42kph (Calculations are available in Appendix G of this report) Road narrowing signage and warning markings will be provided along the local road. In addition to this passing bays will be provided either side of under-bridge structure.

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03031	Table 1.3
Additional Information and Supporting Documentation List:	
Refer to Drawing No. KK1613403-P3-DP-001 for location of the proposed departure.	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
70kph	150 AADT	
Carriageway Type/Cross Section		
Local Road with 5m pavement width and 2.5m wide shared surface		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1e	

Departure Information:
Departure Location and Chainage:
Reference drawing KK1613403-P3-DP-001
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Design speed for local road is 70kph and therefore requires a SSD of 120m
Standard Provided
70 metres of Stopping sight distance will be provided to the nearside pavement edge looking toward the L7416 From the proposed new entrance
Departure Justification
At the location where the departure is occurring, the pavement width is tapering from 5m to 3m on approach to the L7416. The Design speed along the existing L7416 which has a pavement width of 3m is calculated at 42kph (Calculations are available in Appendix G of this report) Vehicles travelling along the L7416 would only require a stopping sight distance of 50metres in accordance with table 10.3. While 70m of stopping sight distance is available toward the L7416 pavement edge, 120m of visibility is provided to the centre of the 3m wide carriageway along the L7416

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03031	Table 1.3
Additional Information and Supporting Documentation List:	
Refer to Drawing No. KK1613403-P3-DP-001 for location of the proposed departure.	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
70kph	150 AADT	
Carriageway Type/Cross Section		
Local Road with 5m pavement width and 2.5m wide shared surface		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1f	

Departure Information:
Departure Location and Chainage:
Reference drawing KK1613403-P3-DP-001 for location on local road.
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
Design speed for local road is 70kph and therefore requires a SSD of 120m visibility from entrance
Standard Provided
60 metres of Stopping sight distance will be provided to the nearside pavement edge looking toward the west from the existing entrance
Departure Justification
At the location where the departure is occurring, there presently only exists about 30 m of stopping sight distance from the entrance. The provision of the 2.5m wide shared surface at this location will increase the SSD to 65m. This is an improvement on what is there and with the reduced design speed and AADT, exiting from the entrance will be safer.

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Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03031	Table 1.3
Additional Information and Supporting Documentation List:	
Refer to Drawing No. KK1613403-P3-DP-001 for location of the proposed departure.	

General Information:		
Route:	*Scheme:*	*Contract Type:* *(e.g. PPP /D&B/Traditional)*
N24	N24 Carrick Road Improvement Scheme	Traditional
Design Speed	Traffic Flow and Composition *(if applicable):*	
100kph	8000 AADT	
Carriageway Type/Cross Section		
Type 2 Single Carriageway (Ch 0 to Ch 415) & Type 1 Single Carriageway (Ch 415 to Ch 2100)		

Applicant Information:	
Applicant Name:	Contact Person and Contact Details:
Con Daly	Con Daly Tramore House Regional Design Office Tramore Co. Waterford
Applicants Departure Reference No.	
TH16030 DP-1g	

Departure Information:
Departure Location and Chainage:
Reference drawing KK1613403-P3-DP-001 for location on local road.
Departure Category *(e.g. Road Design, Structures etc.)*
Road Design, Horizontal Geometry
Departure Type *(e.g. Horizontal Geometry, Vertical Geometry, Cross Section, etc.)*
Horizontal Geometry
Standard Required by NRA DMRB
In accordance with Fig 5.29 of DN-GEO-03060, the provision of a turning loop on a Type 3 Dual Carriageway requires a departure from Standard
Standard Provided
A mini roundabout with the capability of acting as a turning loop is existing at the tie in between the proposed new scheme and the existing Type 3 Dual Carriageway (Piltown Bypass)
Departure Justification
The mini roundabout is existing.

Other Departures or Relaxations at same location	
None	
DMRB References:	
DMRB Reference	DMRB Paragraph/Table/Figure:
DN-GEO-03060	Figure 5.29
Additional Information and Supporting Documentation List:	
Refer to Drawing No. KK1613403-P3-DP-001 for location of the proposed departure.	

APPENDIX E – STAGE F SAFETY AUDIT

APPENDIX F – STAGE 1 SAFETY AUDIT

APPENDIX G – DESIGN SPEED CALCULATIONS

Design Speed Calculations were carried out in accordance with Chapters 1 and 10 of DN-GEO-03031. Within this process we checked the design speeds along 2 different sections of the local road network;

- Section 1 (Existing L7416) which has a very narrow pavement with 1m verges either side.
- Section 2 (Existing N24 reduced in width to accommodate 2.5m Shared surface for NMUs)

In addition to this a design speed check was carried out over these two sections combined.

Section 1 Calculations;

Before UnderBridge on L7416 (700m) Heading East toward Mooncoin on Local road
3m pavement width with 1m verges either side
Bendiness Calculation from Os Map 308.7 Degree Rotation
Acceses/Km 20.7

Log_{10} VISI	=	2.46 +(1/25)-(308.7/400)	1.72825
VISI	=		53.487217
Single Carriageways			
Ac	=	12-VISI/60 +2B/45	24.828546

From Table 10.2
Considering 3.0 m carriageway with 1.5m Verge and High Access > 9/km
Lc = 49
From Figure 10.2; Lc = 49, Ac = 24, Therefore Design Speed = 42kph

Section 2 Calculations;

After UB to Mainline (984m) Heading East toward Mooncoin on Local road
5.5m wide pavement with 2.5m footpath one side only (1.25m average verge width)
Bendiness Calculation from Os Map 161.5 Degree Rotation
Acceses/Km 21.4

Log_{10} VISI	=	2.46 +(1.25/25)-(161.5/400)	2.10625
VISI	=		127.71738
Single Carriageways			
Ac	=	12-VISI/60 +2B/45	17.049155

From Table 10.2
Considering 5.0 m carriageway with 1.5m Verge and High Access > 9/km
Lc = 35
From Figure 10.2; Lc = 35, Ac = 17, Therefore Design Speed = 70kph

Calculation for Section 1 and 2 Combined;

Condidering the Whole Section (L7416 and N24 Reduced Width) 1684m
Average Carriageway Width = 4.17
Average Verge Width= 1.15
Bendiness Calculation from Os Map 222.7 Degree Rotation
Acceses/Km 20.4

Log_{10} VISI	=	2.46 +(1.15/25)-(222.7/400)	1.94925
VISI	=		88.971313
Single Carriageways			
Ac	=	12-VISI/60 +2B/45	20.414923

From Table 10.2
Considering 4.0 m carriageway with 1.5m Verge and High Access > 9/km
Lc = 41
From Figure 10.2; Lc = 35, Ac = 17, Therefore Design Speed = 60kph