Highways England

A63 Castle Street Improvement Scheme

Review of Central Reservation Barrier Options

HE514508-ARP-HRR-S0_ML-RP-CH-000001

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Executive Summary

According to Highways England's aims, they strive "to ensure that major roads are more dependable, durable and most importantly safe." These aims for the road network are expanded on as follows:

- Free flowing
- Safe and serviceable
- Accessible and integrated

The A63 Improvement Scheme is a challenging scheme, as it tries to balance the aims and objectives of Highways England, whilst being sensitive to the urban environment it traverses. One of these challenges relates to the potential need for a central reserve barrier along the full extents of the scheme.

During the design development of the illustrative design, Mott MacDonald Sweco Joint Venture (MMS) proposed the use of a Concrete Central Reserve Barrier (CCRB). This proposal was reviewed and adopted by Balfour Beatty Arup during the Preliminary Design and was submitted as part of the draft Development Consent Order (dDCO). The CCRB has been part of the proposed scheme since the illustrative design in 2014. However, during the dDCO issue specific hearings, Hull City Council (HCC) raised an objection to the use of a concrete barrier. Their preference would be something more in line with their current kerb and pedestrian guardrail proposal, as they feel this is better in keeping with the aesthetics of the conservation area. This report records the history of the design development of the CCRB, the challenges it faced, the consultation that informed these decisions and finally the assessment of alternatives.

From the outset of this report it was agreed between the Highways England project team, Balfour Beatty and Arup, the necessity of including the CCRB within the underpass section on safety grounds. The justification for this is recorded in Section 1.4 of this report. Therefore, the review of alternative options only takes in the section that falls within the Hull City Council conservation area (Chainage 1+770 to Chainage 2+300).

This report therefore seeks to assess in detail what viable options are available to replace the CCRB, by considering the advantages and disadvantages of each. The three options under consideration were determined during a sifting workshop that was attended by HCC, Highways England Safety, Engineering and Standards (SES) representatives, Area maintenance representatives, Highways England's Technical Adviser - MMS, Balfour Beatty and Arup. The three options are the CCRB proposal, trief kerbs and guardrail proposal and a vehicle parapet proposal. The intention of this report is to objectively review the three options within the conservation area. The criteria for assessing these options were:

- Safety Assessment (GG104);
- Construction Programme;
- High Level Cost Estimate;
- Network Performance;
- Maintenance Safety;

- Maintenance Costs;
- Aesthetics; and
- Deterring pedestrians.

The assessment and further investigation still highlight that that the CCRB outperforms the other two options on all criteria, except Aesthetics and Deterring pedestrians. The road layout on this section of the A63 will change significantly in the future when open for traffic; the number of vehicles stopping and starting will dramatically reduce as all crossings are to be removed, which will increase the speed of vehicles will be traveling compared to the current levels. Changing the barrier will introduce unnecessary risk to road users and operatives in the future. Therefore, the CCRB is still the preferred barrier option for the A63 Castle Street Improvement Scheme. It is therefore the recommendation of the A63 Castle Street Project Team that the CCRB should be used throughout the full extents of the scheme.

1 Introduction

1.1 Purpose of this Report

This report records the assessment of the three suitable central reserve barrier options for the A63 Castle Street Improvement scheme. It provides the background to the design development, as well as the methodology for the assessment and recommendation for the proposed central reserve barrier.

All three options were assessed under the following headings:

- GG104 Safety Risk Assessment
- Construction Programme
- High level cost estimate
- Network performance (relating to maintenance requirements)

The three options were assessed against each other and the results are recorded in an assessment matrix.

In an attempt to make an objective assessment of the proposals, alternative Balfour Beatty and Arup teams unfamiliar with the scheme were tasked to review and assess the three options. They were given the design criteria of the scheme, the environmental context of the scheme and drawings reflecting the three proposals (see Appendix A). The feedback received from these parties, as well as additional research into performance of different barriers and safety statistics on similar networks were used to inform the outcome of this report.

1.2 Design parameters

The scheme proposal is to upgrade the existing A63 Castle Street scheme to a free-flowing route, by removing four at grade signalised crossings and an at-grade signalised hamburger roundabout. This will change the nature of the route, from a stop-start slow moving section, into free-flowing traffic consistently travelling at 40mph.

The following is a list of design parameters and considerations used in the assessment of these proposals:

- Design speed = 70A kph;
- Speed limits = 40mph;
- Traffic volumes = Exceeding 36,000 AADT (12% HGVs);

Year		A63 Castle Street EB (Mytongate to Myton Bridge)	A63 Castle Street WB (Humber Dock Str. To Mytongate)
2023	Without Scheme	27,688	24,443
	With Scheme	32,756	29,632
2033	Without Scheme	28,330	25,337
	With Scheme	35,297	31,579
2040	Without Scheme	28,456	25,913
	With Scheme	36,568	32,603

- The design standards set out in TD 19/06 are not enforceable, as the speed limit is below 50mph. However, TD 19/06 Clause 1.22 does state that:

  "1.22 RRS must also be provided on the Trunk Road network where the Design Speed or Imposed Speed Limit is less than 50mph and the Design Organisation considers such provision is needed and the Overseeing Organisation has agreed that a RRS must be provided."; and

- The alternative barrier solution will only be considered in the HCC conservation area. (See Section 1.4 below).

1.3 Background

The A63 Castle Street Improvement scheme is being promoted by Highways England (HE) and involves the improvement by grade separation of the existing A63/A1079 Mytongate intersection in Hull, East Riding of Yorkshire. The scheme will replace the existing signalised roundabout with a grade-separated junction including an underpass for through traffic on the A63 mainline, and slip roads and an overbridge to provide a full-movement junction

As part of the A63 Castle Street Improvement Scheme, Mott Macdonald Sweco Joint Venture (MMS) produced an illustrative design which was handed over to Balfour Beatty/Arup in 2014. Their proposed illustrative design included a concrete central reserve barrier for the entire length of the scheme.

In 2014 Balfour Beatty/Arup did a design validation assessment of the illustrative design. On review, BB/Arup, agreed with the recommendation made by MMS regarding the central reserve barrier. The justification for the concrete central reserve barrier was the following:

- The potential for vehicles exceeding the 40mph proposed speed limit;
- The combination of the vertical and horizontal geometry of the alignment;
- The requirement for a concrete barrier in the underpass due to the proposed central reinforced concrete leaf pier at Mytongate Junction;
- The necessity for maintaining traffic movements due to the high levels of traffic – (Exceeding 36,000 AADT in 2040 projection);
- The concern regarding the high percentage of Heavy Goods Vehicles (HGV) along this section – 12%; and
- The consideration for the safety of maintenance contractors.

This proposed design was adopted and taken forward as part of the design development. This was recorded and agreed with Highways England and Balfour Beatty in January 2015.

In September 2017 a Stage 1 Road Safety Audit (RSA) was done, which included the CCRB proposal. The only problem the RSA team picked highlighted was that the CCRB did not provide sufficient discouragement to pedestrians from crossing the main carriageway at grade (Problem Location 64). The recommendation was mitigated by highlighting the alternative grade-separated crossings that have been proposed by the scheme, thus providing pedestrians sufficient alternative routes to cross the main carriageway and therefore it would be a low risk for pedestrians to cross at uncontrolled locations.

During the Development Consent Order (DCO) issue specific hearings in June 2019, Hull City Council (HCC) expressed their objection to the concrete central reserve proposal.

> *'In light of the sensitive built context of the scheme, passing as it does through the Old Town Conservation Area, and the settings of listed and locally listed structures, and given the concerns raised over pedestrian safety during through the relevant stage 1 safety audit, an additional requirement for design details to be to be submitted to and approved in writing by the Secretary of State following consultation with the local planning authority is requested, with a view to ensuring that fullest consideration is given to identifying a design solution which addresses both highway safety and the historic environment.'*

They objected on the following grounds:

- Aesthetics;
- Visual impact of barrier not in-keeping with Hull Old Town Conservation Area;
- Visual Permeability; and

- Whether the proposed barrier would deter pedestrians crossing the A63.

In May 2019, a technical note was written which recorded the background of the proposal and highlighted all the consultation that has taken place up to this point. A summary of the associated consultation is recorded in Appendix B.

In order to discuss and address HCC's concerns, a barrier workshop was held on 27 June 2019. The workshop was attended by Highways England project management team, HCC, Highways England Safety, Engineer and Standards (SES) representatives, Area maintenance representatives, MMS, Balfour Beatty and Arup. The workshop aimed to review and assess several options (See appendix C).

It was agreed in the workshop, that Balfour Beatty/Arup will assess the three suitable options in more detail. This report is a review of these three options.

1.4 Underpass section

The section of the underpass requires a concrete central reserve barrier for several reasons:

- The new proposed Mytongate Bridge is a two-span bridge supported by a leaf type pier at chainage 1+510. The pier, which will be designed to withstand vehicle impact, is supported on either side by a transition into the proposed concrete central reserve barrier, which will reduce the risk of head on vehicle collision with the pier;
- According to TD19/06 Clause 3.26 the minimum required length of barrier needed in front of a hazard is 45m (See Table 3-1 in TD 19/06). Secondly, Clause 3.28 states that "The safety barrier provided to protect a single hazard, or group thereof, must be a continuous length that may or may not be made from one type of product (e.g. a metal safety barrier – concrete safety barrier – metal safety barrier would constitute a continuous length);
- Several changes in geometry, as well as potential hazards such as the start of the Diaphragm Wall, require a consistent safety barrier throughout the section. These geometric changes are highlighted in the section below;
- Due to the nature of the underpass, it is crucial that network operation is maintained through the underpass, i.e. if there is an incident on the one carriageway, the other carriageway needs to remain unaffected. Therefore, it is crucial that no cross-over accidents occur in this region; and
- As the Mytongate Bridge plays an important part in the propping the underpass Diaphragm walls, it is extremely important to protect this pier with as high a containment level as possible. Therefore, a concrete barrier is necessary for this support (See AIP document HE514508-ARP-SSP-SO_ML_UP-RP-CB-000001).

Geometry changes

The following is a list of geometry changes in the section of the underpass:

- Start of underpass: 1+280
- End of underpass: 1+780
- Highway alignment changes:

Table 1: Highway alignment through underpass

Alignment Parameters	**1+380 to 1+425**	**1+425 to 1+585**	**1+585 to 1+620**	**1+620 to 1+700**
Vertical	G = 4%	R = 2000 (S)	G = 4%	R = 4300 (C)
Horizontal	R = 1020	Ls = 24 & 42	R = 575	R = 575
Superelevation	2.5%	2.5% to 3.5%	3.5%	3.5%

Location of slip road nosing's:

- Eastbound diverge = 1+180
- Eastbound merge = 1+940 (Which connects to the weaving lane)
- Westbound merge = 1+180
- Westbound diverge = 1+740

These changes in geometry, potential conflict areas and hazards along the underpass section is recorded in Figure 1 below (See Appendix D). See Appendix D for a key.

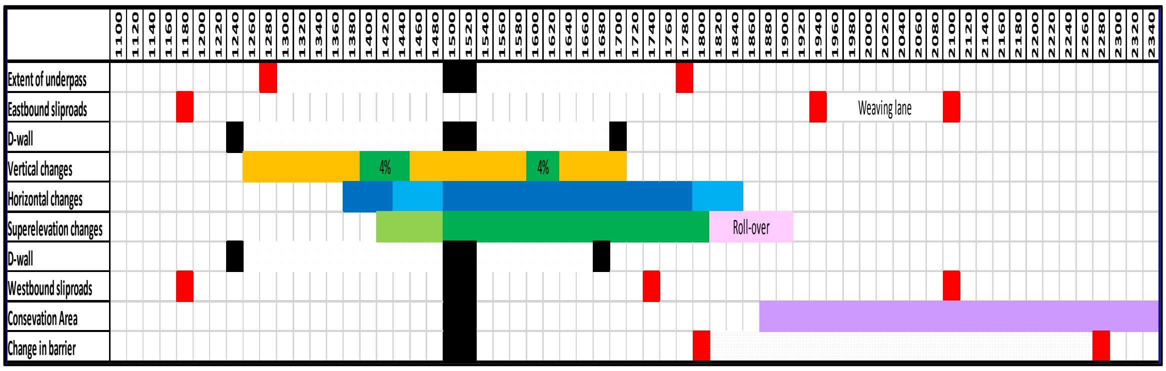


Figure 1: Geometry changes and conflicting points

It is therefore our position that a concrete central reserve barrier is absolutely necessary through the section up to chainage 1+800.

2 Option description

The three options to be considered through the section of the HCC conservation area are:

- Option 1 – Concrete central reserve barrier (CCRB)
- Option 2 – Trief kerb and pedestrian guardrail (TPG)
- Option 3 – Parapets (PAR)

The performance specifications for each option is listed below:

Table 2: Barrier performance specifications

Option	Containment Level	Working Width	Impact Severity Level	Dynamic Deflection
Option 1: CCRB	H1	0.6m	ASI B	0.0m
Option 2: TPG	N1	1.75m	A	0.0m
Option 3: PAR	N2	0.6m	B	0.4m

2.1 Option 1 – Concrete central reserve barrier

The first option is a concrete central reserve barrier (CCRB) throughout the entire extent of the scheme (See figure and picture 1 below).

The concrete barrier is 900mm in height and has a containment level of H1.

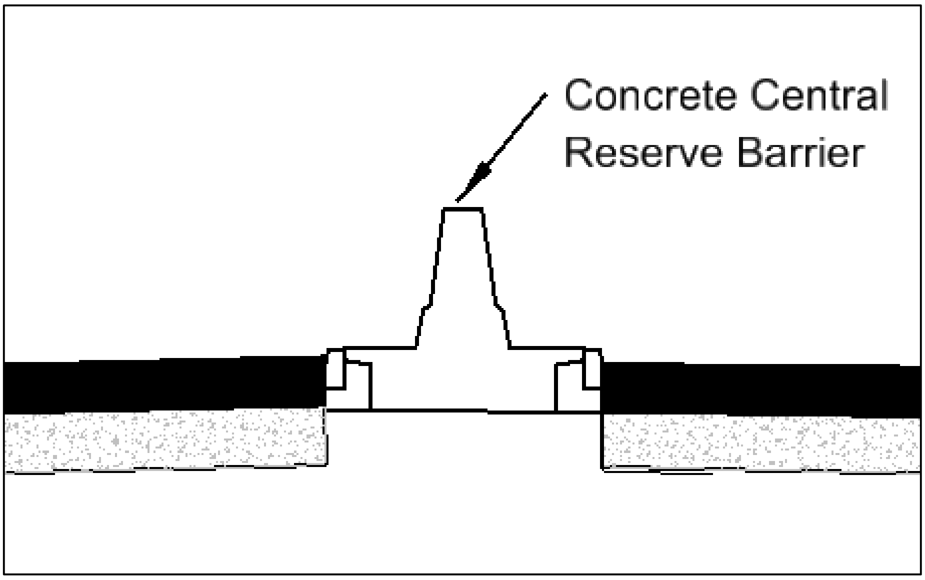


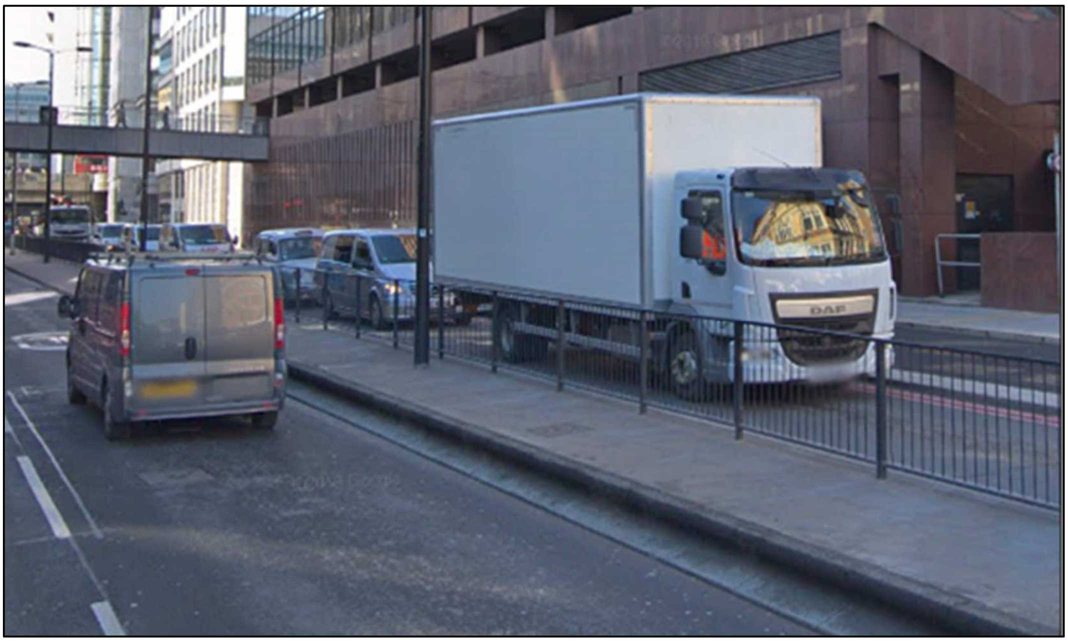
Figure 2: Concrete Central Reserve Barrier

Picture 1: Concrete central reserve barrier

2.2 Option 2 – Trief kerb and pedestrian guardrail

Option 2 is a combination of trief kerbs and a pedestrian guardrail (See picture 2 below).

The trief kerb upstand height is 0.24m and the pedestrian guardrail height is 1.25m. The pedestrian guardrail provides an unobtrusive appearance but will not provide any protection against cross-over accidents. Anecdotal evidence indicates that currently pedestrians are not deterred from climbing over the existing pedestrian guardrail when wanting to cross the A63 Castle Street.



Picture 2: Trief kerb and pedestrian guardrail

Two items to highlight about trief kerbs are:

- Currently trief kerbs are not approved on Highways England networks and therefore would require a departure from standards.
- Trief kerbs have successfully passed a TRL test to BS EN 1317-2 (N1) standards. Therefore, it is fully compliant with the criteria of the TB31 test and received an A rating for impact severity. However, the trief kerb has not been tested for any vehicle greater than 1500 kg, which raises concerns regarding the suitability of the proposal with respect to the high number of HGVs on this section. The testing regime was reiterated by Highways England's Vehicle Restraint Systems Team, recorded below:

> *N1 means that one full scale impact test (to the European standard EN1317) has been carried out on the Trief kerb, i.e.:*
>
> - *Impact Speed: 80km/h (49.7mph)*
> - *Impact Angle: 20°*
> - *Test Vehicle: 1,500kg saloon car (Rover75)*
>
> *The Trief kerb has not, to my knowledge, been tested with an LGV/HGV.*
>
> *The following might help – it is a Table from the European standard EN1317 which shows what tests could be carried out on a vehicle restraint system….it will hopefully provide clarity on the tests which are possible. Not all tests are carried out on all systems – it is up to the manufacturer of the product to choose which level he/she wants to test at.*

Table 1 — Vehicle impact test descriptions

Test	Impact speed km/h	Impact angle °	Total mass kg	Type of vehicle
TB 11	100	20	900	Car
TB 21	80	8	1 300	Car
TB 22	80	15	1 300	Car
TB 31	80	20	1 500	Car
TB 32	110	20	1 500	Car
TB 41	70	8	10 000	Rigid HGV
TB 42	70	15	10 000	Rigid HGV
TB 51	70	20	13 000	Bus
TB 61	80	20	16 000	Rigid HGV
TB 71	65	20	30 000	Rigid HGV
TB 81	65	20	38 000	Articulated HGV

The Trief kerb has had the 'TB31' test carried out on it.

Once the required test level has been selected, it will make it easier to identify the products which could suit the specific site…. although please note that (typically) the higher the test level, the more rigid and structurally higher the barrier.

- When assessing the suitability of the trief kerb proposal, the Highways England SES indicated their reservations based on their engineering judgement. The trief kerb is more likely to induce spinning vehicles or high impact angels to rollover or could potentially launch vehicles onto the opposite carriageway. Secondly, when vehicles impact the trief kerb, even at low speeds, it will damage a vehicles suspension and steering system.

2.3 Option 3 – Parapets

The third option is using normal HB2 kerbs and steel parapets. Parapets are not generally used as central reserve barriers, but they do provide a potentially more visually appealing alternative to concrete central reserve barriers.

The parapet example used for this report is a 1.275m high steel parapet, which is similar in height to a pedestrian guardrail. As deterring pedestrians is a key concern for HCC, it would be necessary to provide a mesh screen on the parapets to not allow for pedestrians to get a foothold to climb over the fence.

Picture 3: Parapet with mesh

In general, parapets are designed to contain vehicles only from one side, it would either be necessary to design a bespoke barrier system that could contain vehicles from both sides, or to use two barriers and maintaining the minimum dynamic deflection width of 0.4m. At this stage we have assumed the latter, as it is not within the scope of this scheme to design and test a completely new parapet system.

3 Options Assessment

3.1 Safety Risk Assessment (GG104)

As safety is crucial to the delivery of Highways England's schemes and operation of road networks, Balfour Beatty and Arup performed a GG104 Safety Risk Assessment to assess the potential hazards, assessing and evaluating these hazards and managing risks and assuring safety risk governance.

The GG104 Safety Risk Assessment is attached in Appendix C.

The Assessment considered the following sections of the population:

- Highways England employees/contractors
- Car drivers
- HGV drivers
- Motorcyclists
- Pedal cyclists

- Pedestrians
- Mobility-impaired pedestrians
- Emergency services
- People living alongside the scheme
- Businesses located alongside the scheme
- Motorised users wishing to cross the scheme
- Pedestrians wishing to cross the scheme
- Cyclists wishing to cross the scheme

Due to the limited time and information available for assessors to perform a GG104, the assessment was caveated by the following assumptions.

Inclusions

The following items were included in the assessment:

- Assessment and comparison of the safety implications of the provision of the three different proposed central reserve kerb and barrier options.
- The section of central reserve between ch.1+770 and 2+280 (Option 1) and ch.1+770 and ch.2+260 (Options 2 and 3).

Exclusions

The following elements of the scheme were excluded from the assessment:

- Comparison against existing, which is not considered appropriate due to the significant change the proposals are expected to make on the nature of the scheme.
- Any other considerations, including but not limited to cost and aesthetics.

Key elements highlighted in GG104

The following key elements were identified in the assessment. These elements also highlight the differences between the different options:

- Motorised vehicles crossing the central reserve leading to head on collisions;
- Motorised vehicles colliding with barrier leading to vehicle occupant injury;
- A collision with the central reserve barrier in the westbound direction at the transition between the two barrier types at ch.2+260. A sudden decrease in the dynamic deflection between the two barrier types may lead to 'pocketing' and the vehicle effectively colliding with the end of the proposed concrete barrier, leading to vehicle occupant injuries;
- Pedestrians may not be deterred from attempting to cross the A63 Castle Street by the presence of the central reserve barrier, potentially leading to climbing the barrier and being struck by a vehicle. Pedestrians attempting to

cross may also fail to climb over the barrier and become 'stranded' in the central reserve increasing the risk of conflict with vehicles;

- Workers undertaking scheduled maintenance/inspection of the central reserve barrier and transitions may be struck by passing vehicles;
- While responding to an incident, emergency services may need, and be prevented by the central barrier from achieving, access across the central reserve; and
- In the event of an incident, emergency services may need to clear the carriageway quickly and be prevented by the central barrier from directing vehicles to cross the central reserve to exit via the other carriageway.

3.2 Construction Programme

Balfour Beatty assessed the impact on the construction programme for each of the options listed. This assessment was based on the last approved scheme programme (MHC01005-A63 Castle Street: Cl.32 Programme P21rev0).

Below is a summary of the impact on the construction programme:

- Concrete Central reserve barrier is quicker to extrude and install by machine. Though, due to traffic and work phasing, some sections will be done in-situ;
- There is a some longer lead in time for both Option 2 and 3. Additionally, due to the additional transition points, there would be more time required than what is necessary for the current proposal;
- In regard to Option 2, trief kerbs are relatively easy to install mechanically. However, additional time would be required to install the posts and fence for the pedestrian guardrails; and
- Due to the requirement of two parallel parapet lengths for Option 3, this would double the length of work. Additionally, assuming these are post-drilled and fixed the central reserve could be completed prior to fixing the parapet, although the central reserve would need to be structural for the barrier foundations.

It is therefore clear that both Option 2 and 3 will have a negative impact on the current construction programme, however slightly.

3.3 High level cost estimate

As part of the review, a very high-level cost comparison was done to review the impact on the scheme. The cost was based on the assumption that the length of the different required barrier is 510m. Below is a summary of the cost implications:

Table 3: High-level cost comparison

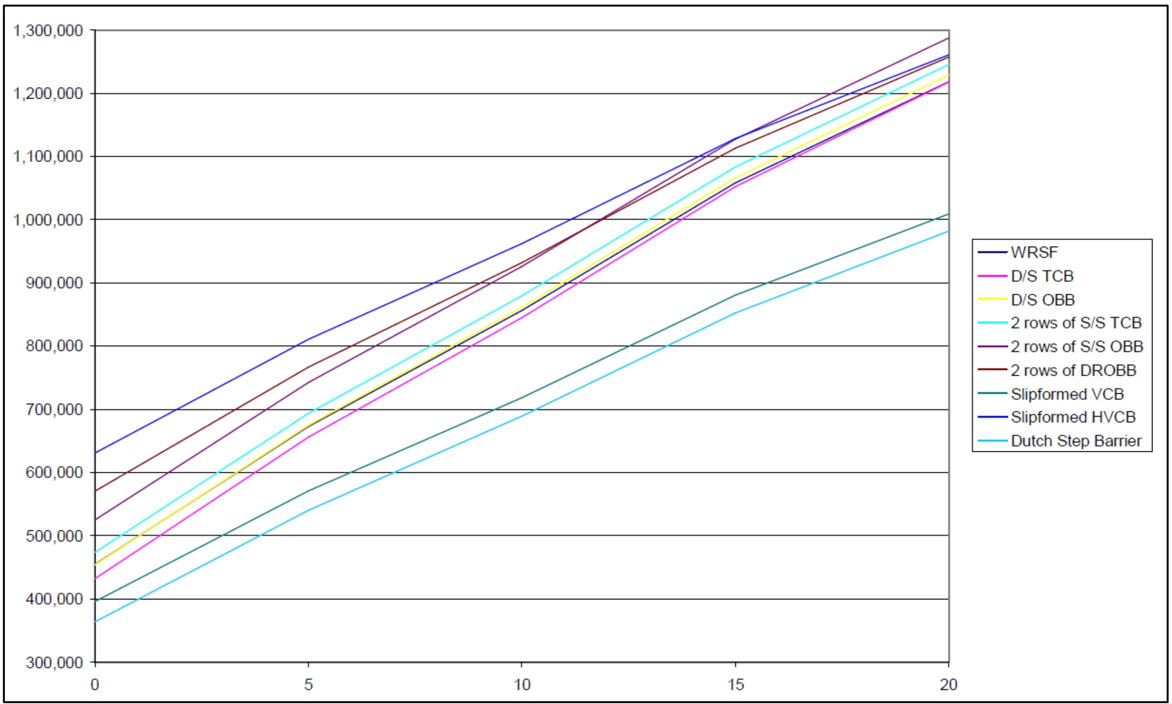
Option	Qty (m)	Rate (£/m)	Cost (£)
Option 1	510	£ 250.00	£ 127,500.00
Option 2	510	£ 310.00	£ 158,100.00
Option 3	510	£ 480.00	£ 244,800.00

In addition to the high-level construction costs, the whole life costs of the different proposals were reviewed and summarised by Williams in their paper 'Whole life cost-benefit analysis for median safety barriers' (Williams, 2007).

The report determined that both the Dutch Step and Vertical Concrete Barriers (VCB) have the lowest whole life costs (Williams, 2007). This is due to a number of factors which include the following:

- Lower accident costs as a result of reducing crossover accidents (which generally have a higher fatal and serious injury rate, and hence accident cost)
- No repairs generally being required following an impact
- Lower routine maintenance costs
- Longer working life, and hence no need to replace the system after 25 years
- Reduced initial installation costs due to reduced installation times, and hence resulting traffic management and traffic delay costs (which can exceed the installation costs themselves)

This can be seen in the graph below:



Picture 4: Whole life cost graph (Williams, 2007)

3.4 Network performance

As part of the scheme development we have engaged with A-one+, the Area Maintenance Contractor (AMC) for Area 12, on several occasions. The consultation is recorded in the technical note to be found in Appendix B.

However, as part of this report, we contacted the AMC to get their opinion on the three alternatives being considered. We have recorded their comments below:

- Although concrete central reserve barrier is our preferred option from a whole life cost point of view it may not be appropriate in a semi urban environment such as Castle Street. We are assuming the 40mph speed limit will remain in place after the scheme is constructed. The speed limit in existence may provide a concrete barrier option and more aesthetically pleasing than the norm but this is likely to be short in height and will allow pedestrians to step over which is likely to be undesirable.
- Steel safety fence is appropriate for keeping conflicting traffic flows apart but again would depend on the speed and if there is a wish to match the system to any used on nearside.
- Trief kerbs are not approved for use on the Highways England networks.
- When assessing the suitability of the trief kerb proposal, the Highways England SES indicated their reservations based on their engineering judgement. The trief kerb is more likely to induce spinning vehicles or high impact angels to rollover or could potential launch vehicles onto the opposite

carriageway. Secondly, when vehicles impact the trief kerb, even at low speeds, it will damage a vehicles suspension and steering system.

- If HCC are concerned about aesthetics they may need to consider the frequency of their sweeping to prevent build-up of detritus.
- Parapets would be expensive to repair, and access would require lane closures, possibly a full closure. You also need to carefully consider whether parapets would comply here – i.e. kerb upstand height (parapet plinths are generally c50mm), and then the verge width from upstand to parapet. As shown in your drawing, a car would tend to "launch" upwards when hitting the kerb and then might not hit the parapet at the intended/tested height. To facilitate the higher kerb upstand, you might need a substantial verge in front of the parapet.

In addition to these comments, we have highlighted the following issues pertaining to the network performance:

- Concerns regarding the impact of cross-over accidents, which would require the closure of both lanes. Additionally, the statistics on of cross-over accidents and the severity of these accidents:
  - The highest number of causalities per accident result from crossover accidents, the lowest being those in which vehicle remains on, or close, to the median (Williams, 2007);
  - For impacts by cars and HGVs, the highest percentage of serious injuries also results from crossover accidents (Williams, 2007);
  - As with the data concerning accidents, the casualty statistics also indicate that a cross over accident is less numerous than one in which the vehicle is rebounded or retained. However, when such a crossover accident does occur, it is almost three times as more likely that a fatal injury will result (Williams, 2007); and
  - The Mouchel Case Study indicated that no fatal casualties have resulted from an impact with a concrete barrier (Williams, 2007).
- Cross-over accidents would be classified as Category 1 Defects, according to Highways England's Defect Definitions. Therefore, requiring urgent or prompt attention because they represent an immediate or imminent hazard or because there is a risk for short-term structural deterioration. This would severely impact on the performance of the network.; and
- Due to the double parapet requirement for Option 3, there is a potential that debris and litter could get trapped in between the two barriers with the mesh. This would require a higher maintenance regime that require lane closures, which would impact on the operation of the network.

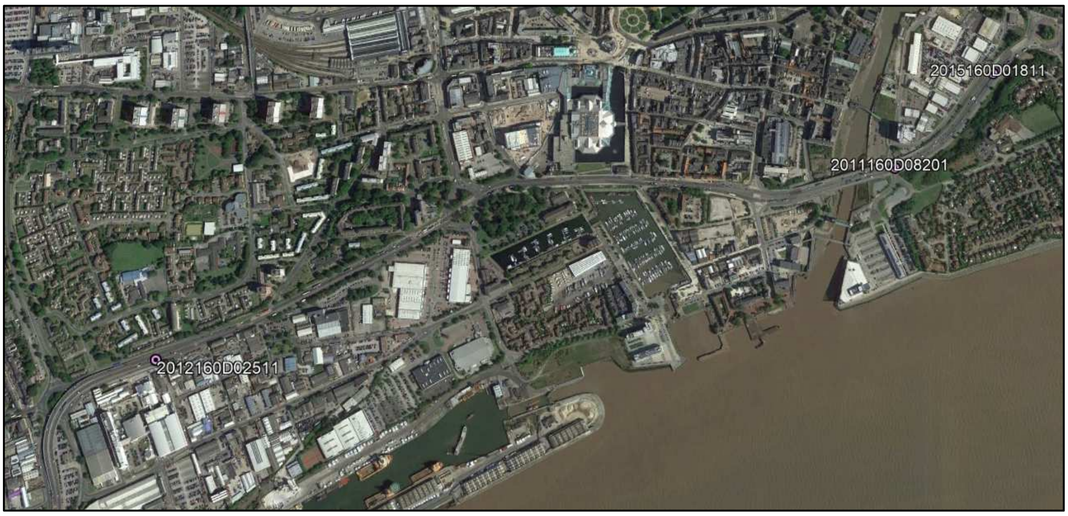
3.5 Accident Statistics

As part of the assessment, the team did a high-level review of cross-over accidents based on similar roads. A review of the Road Safety Data between 2009 and 2017 were sorted by the following data:

- Vehicle Leaving Carriageway – (6) Offside – crossed central reservation, i.e. cross-over accidents;
- Speed limit on road; and
- Accident Severity (1 – Fatal, 2 – Serious, 3 – Slight).

The data indicated the following features:

- Between 2009 and 2017 there were 5,268 cross-over accidents across the UK;
- 2,208 of these were on roads between 20mph and 40mph;
- 1,111 were on roads with 40mph;
- Between the speed limit of 20mph and 40mph, 32 of the accidents were fatal, and 328 were serious accidents;



Picture 5: Cross-over accidents HCC

Picture 5 above, shows the three cross-over accidents in Hull since 2009, one of which was classified as a severe accident. However, it should be noted that the scheme will now be changed from a stop-start route with several at grade pedestrian crossings, to a free-flowing route, where vehicles will be traveling at 40mph without any hindrance.

4 Assessment Matrix

Using the information above, we have produced an Assessment Matrix (AM) to determine the most suitable solution (Table 4 below and Appendix E for the full spreadsheet).

The AM has several criteria based on the report above, and the requirements from HCC. The scores for each item were weighted against each option to understand the different impact, with the maximum score being 5. Secondly, the different assessment criteria were given a distinct weighting. As safety is our highest concern, we have given both the Safety Assessment and the Maintenance Safety the highest weighting. Whilst pedestrian safety is also an important factor, due to the availability of alternative crossing locations it is considered that inappropriate crossing will be rare, and therefore a normal weighting has been applied. The criteria and the associated weighting are listed below:

Table 4: Assessment Matrix

Weighting	Option	Option 1 - Concrete central reserve barrier	Option 2 - Trief kerb and pedestrian guardrail	Option 3 - Parapets
20%	**Safety Assessment (GG104)**	1.00	0.90	0.94
10%	**Construction Programme**	0.50	0.48	0.45
10%	**High Level Cost Estimate**	0.50	0.48	0.41
10%	**Network performance**	0.30	0.00	0.10
20%	**Maintenance Safety**	1.00	0.20	0.20
10%	**Maintenance Costs**	0.50	0.30	0.10
10%	**Aesthetics (Hull Conservation Area)**	0.00	0.50	0.20
10%	**Deter pedestrians**	0.23	0.50	0.31
100%	**Total Score**	**4.03**	**3.36**	**2.71**

The assessment matrix shows that the concrete central reserve barrier is the best performing option over the different categories.

5 Recommendation

Based on the assessment above BB/Arup still recommends Option 1, the Concrete Central reserve barrier for the following reasons:

- The CCRB outperform the other two options on safety grounds, as trief kerbs have not been assessed for HGV impact and both Option 2 and 3 require an additional transition which introduces a new risk;
- Even though the construction programme is not considerably different between the three options, there is still additional time required for Option 2 and 3;
- The high-level costs estimate indicated that Option 1 is less expensive than Option 2 and 3. The cost estimate for Option 3 is quite substantial and therefore not a viable solution;
- The study done by Williams in 2007 clearly indicates that concrete barriers have a considerably lower whole life cost than other barriers, and there provides better value from a cost-benefit perspective;
- The network performance is better for Option 1, as the potential cross-over risk is basically negated, and therefore does not put the opposite carriageway at risk;
- The maintenance safety is considerably better for Option 1, as the AMC reiterated on several occasions. As the CCRB requires very low maintenance, and would almost never require repairs and replacement, the AMC would not be exposed to live traffic on a regular basis;
- Due to the repair costs of Option 3 and the potential frequency for repairs on Option 2, the cost of maintenance is by far the least with Option 1;
- The assertion that one barrier is more aesthetically pleasing than another is somewhat subjective and cannot be measured objectively (other than doing extensive surveys);
- Even though Option 2 and 3 are physically slightly higher than Option 1, there is no evidence that this height difference would comprehensively deter pedestrians from trying to climb over these barriers. Secondly, additional deterrence of pedestrian crossing would be provided by the free-flowing 40mph nature of the road and the availability of the new, purpose-built Princes Quay Bridge and the proposed High Street Pedestrian underpass;
- The bespoke transitions between concrete barrier and either pedestrian guardrail or parapets would require specialist designs prepared by manufacturers. Secondly, these transitions would most likely require Departures from Standards. In order to get approval for these departures, extensive testing would be required for these proposals. Secondly, there is no guarantee that these departures would be approved by Highways England SES; and
- As the CCRB was included in all Road Safety Audits throughout the scheme, any changes to the barrier proposal will have to be highlighted in any

subsequent RSAs. Secondly, there is no guarantee that the RSA team would approve or accept alternative proposals.

It is therefore the recommendation of the Design Organisation and the Overseeing Organisation that the concrete central reserve barrier is continued through the full extent of the scheme as per the proposed design (TD 19/06 Clause 1.22).

6 References

The following references have been used in the production of this report:

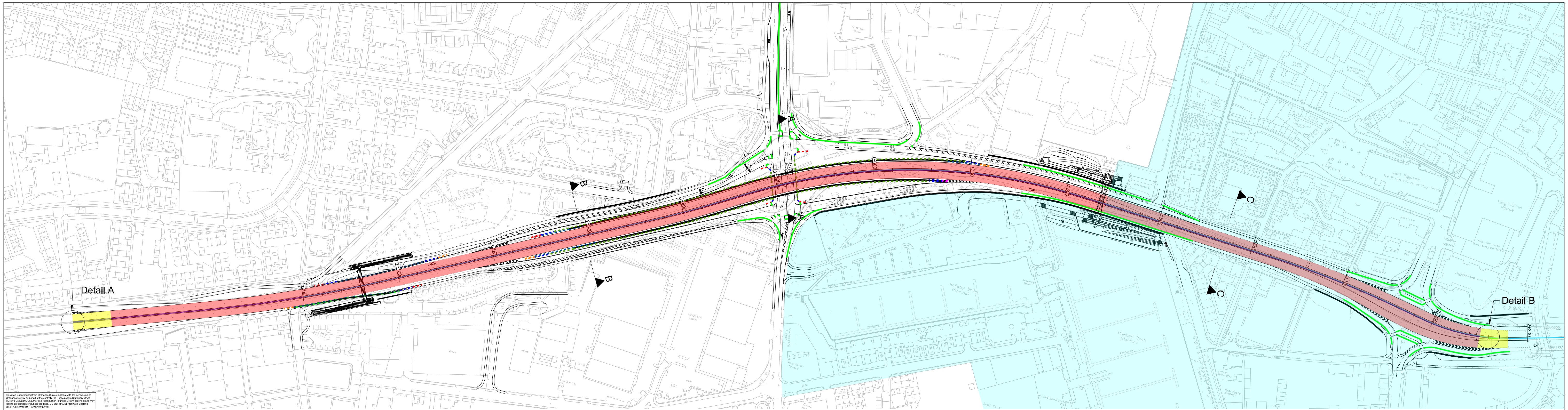
- HE514508-ARP-SSP-S0_ML_UP-RP-CB-000001 – Underpass Approval in Principle
- HE514508-ARP-GEN-S0-RP-CH-000002 - Technical note
- TD 19/06 Requirement for Road Restraint Systems (Volume 2 Highway Structures: Design substructures and special structures) materials, Section 2: Special Structures, Part 8)
- GG104 Requirements for Safety Risk Assessment
- Williams, G.L., 2007. *Whole life cost-benefit analysis for median safety barriers*. TRL.
- https://www.gov.uk/government/collections/road-accidents-and-safety-statistics, accessed on 19 August 2019

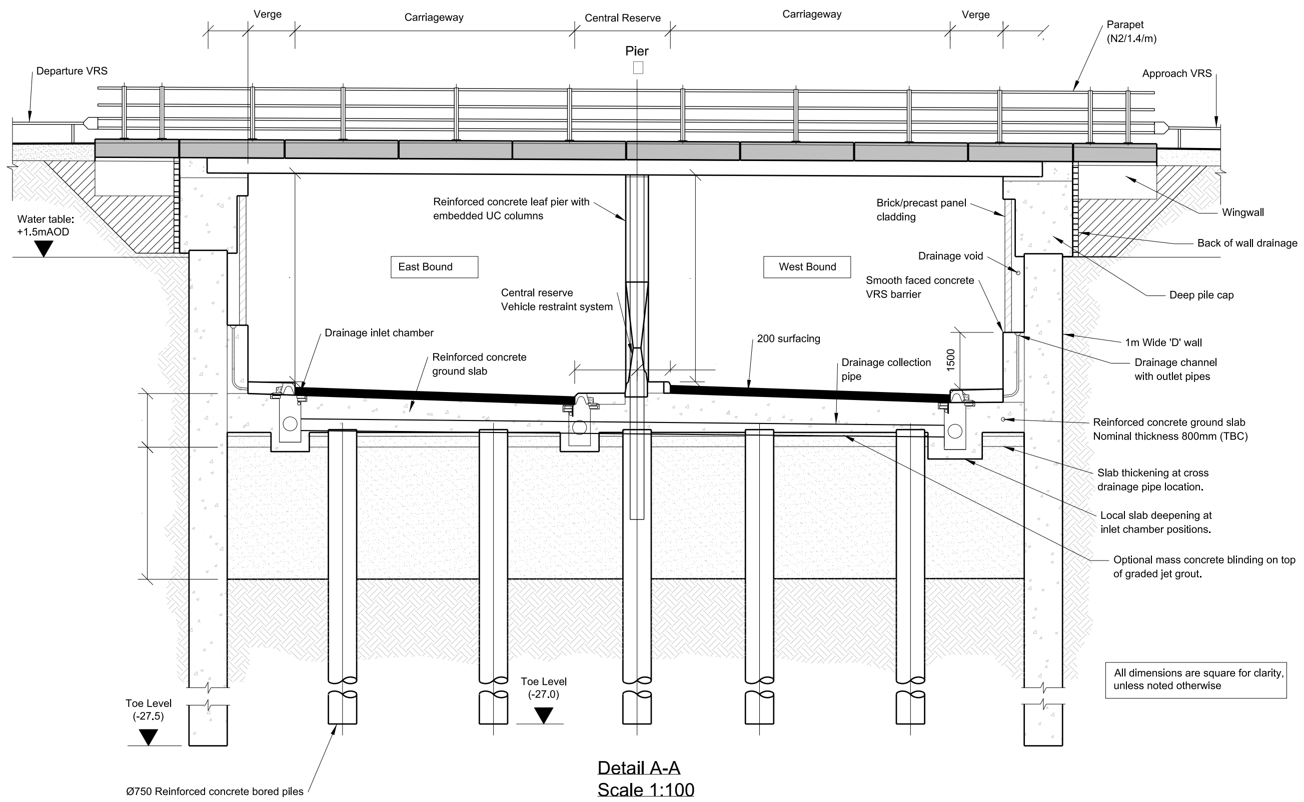
Appendix A

Options Drawings

Millimetres

DO NOT SCALE





Detail A-A
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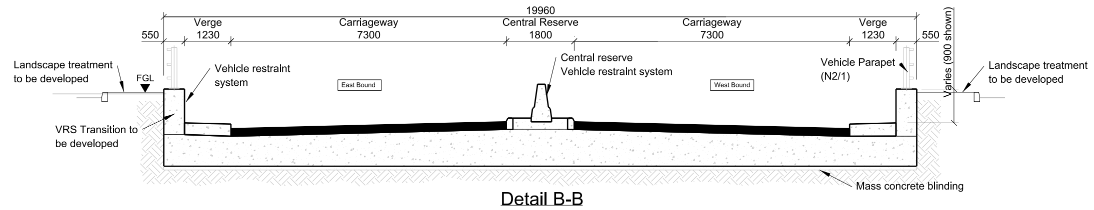

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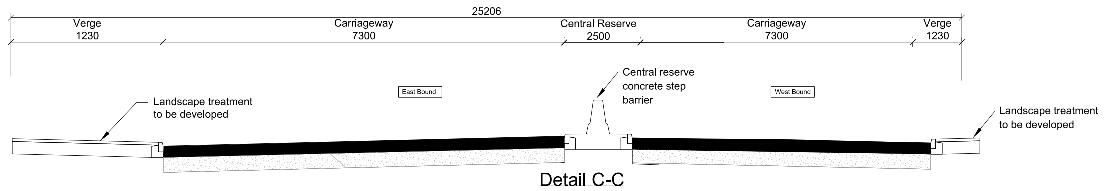
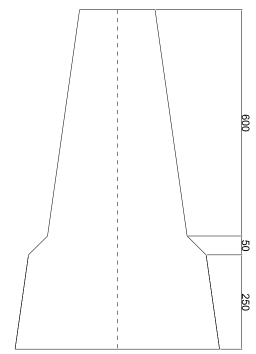
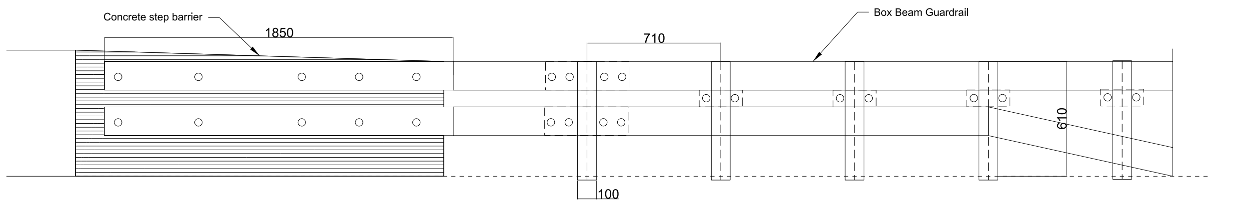
Scale 1:100



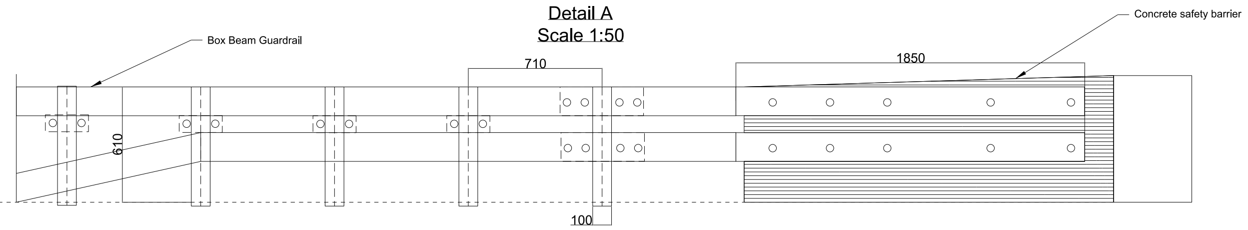
Detail C-C
Scale 1:100



Detail of kerb
Scale 1:20



Detail A
Scale 1:50



Detail B
Scale 1:50

CONCRETE STEP BARRIER PERFORMANCE, BS,EN,1317-1 and BS,EN,1317-2,	
IMPACT TEST CRITERIA.	TB11 and TB32.
CONTAINMENT LEVEL.	H1.
WORKING WIDTH.	W1, (0,6m.)
IMPACT SEVERITY LEVEL.	ASI B.
DYNAMIC DEFLECTION.	0,0m.

Key:

- Hull City Council Conservation Area
- Proposed single sided leading terminal
- Proposed single sided trailing terminal
- Proposed vehicle parapet
- Proposed crash cushion
- Proposed transition
- Proposed transition to existing road restraint system.
- Proposed safety barriers
- Proposed rigid concrete step barrier
- Proposed pedestrian guardrail
- Proposed retaining walls / structures
- Concrete Step Barrier
- Barrier Transition Sections

Notes:

1. This drawing is indicative and should not be used under any circumstance for design or construction purposes.
2. All connection types and transitions are bespoke indicative proposals. None of the transitions or connections has been designed by barrier manufacturers or reviewed by Highways England Safety, Engineering and Standards (SES) specialists. None of the transitions has been tested whether they meet the necessary British Standards.
3. All dimensions are in millimetres unless noted otherwise.
4. Only written dimensions shall be used, do not scale.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
(Enter "None" if applicable)

Maintenance / Cleaning
(Enter "None" if applicable)

Use
(Enter "None" if applicable)

Decommissioning / Demolition
(Enter "None" if applicable)

Rev.	Date	Description	By	Chk'd	App'd	Auth'd
P01	22/07/19	FOR REPORT CONSIDERATION	LH	AV	ID	--

Suitability: S2 SUITABLE FOR INFORMATION

ARUP | Balfour Beatty

Client: highways england

Project Title: A63 CASTLE STREET

Drawing Title: A63 CENTRAL RESERVE BARRIER OPTION 1 CURRENT PROPOSAL

Scale	By	Checked	Approved	Authorised
As Shown	LH	AV	ID	---

Original Size	Date	Date	Date	Date
A1	19/07/19	22/07/19	22/07/19	---

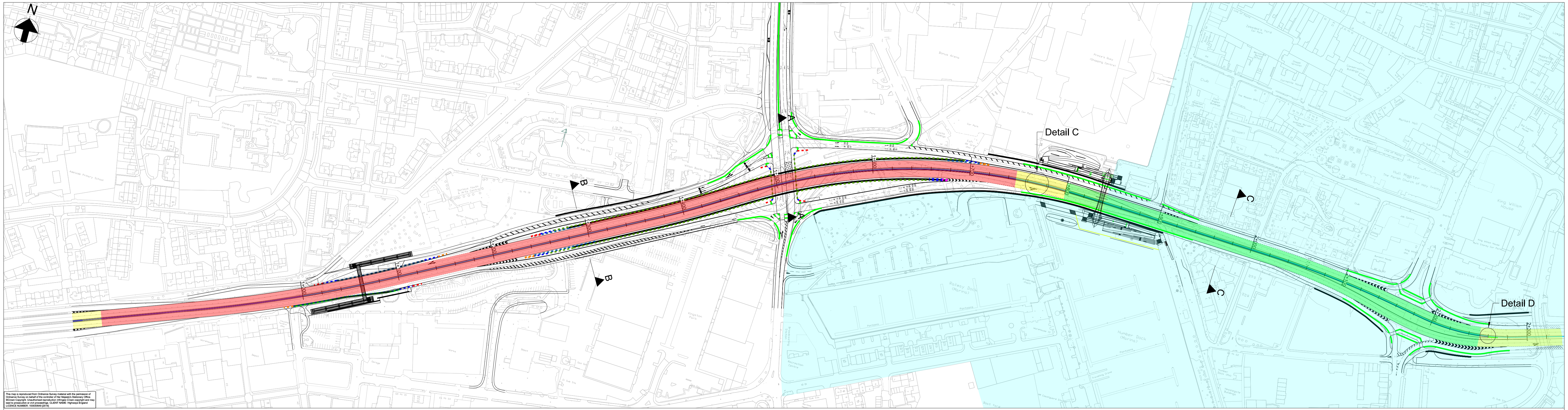
Drawing Number: HE PIN HE514508 - Originator ARP - Volume HRR - Location S0_ML - Type SK - Role CH - Number 000001

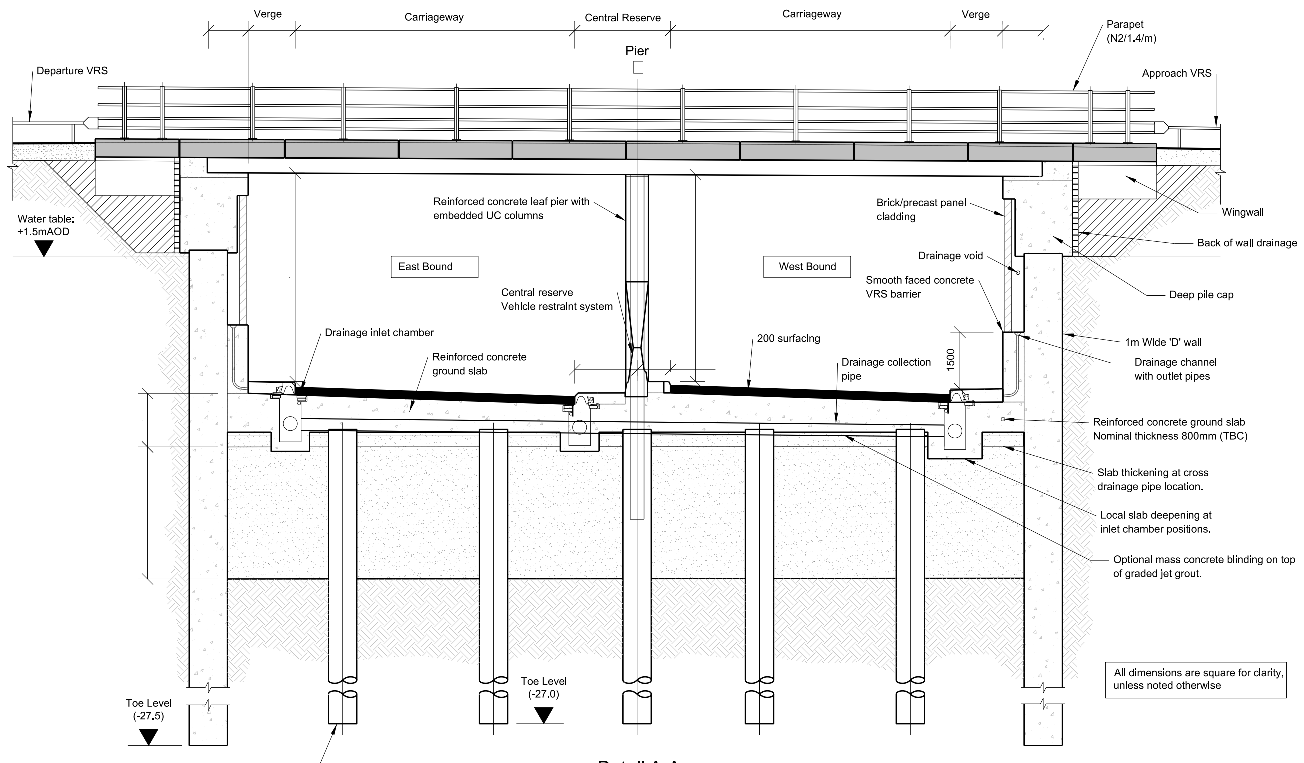
Project Ref. No. 237912-00

Revision P01

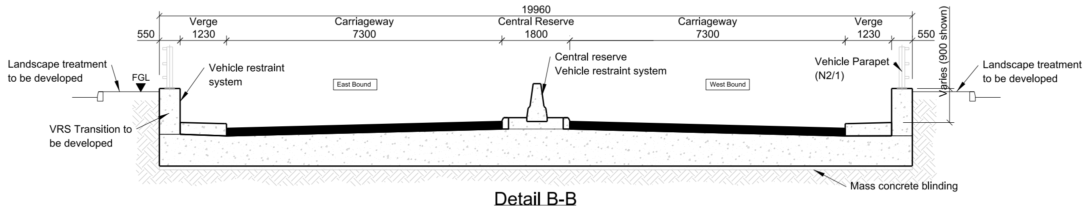
DO NOT SCALE

Millimetres

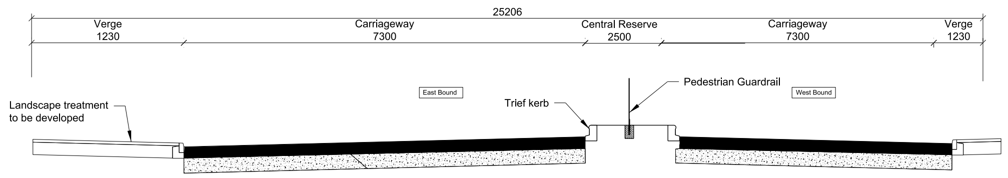




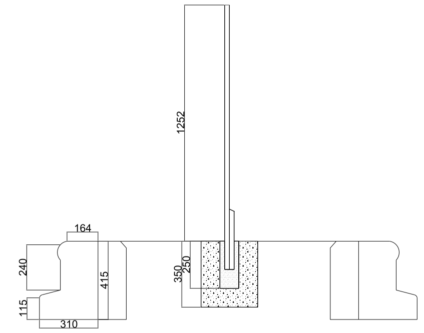
Detail A-A
Scale 1:100



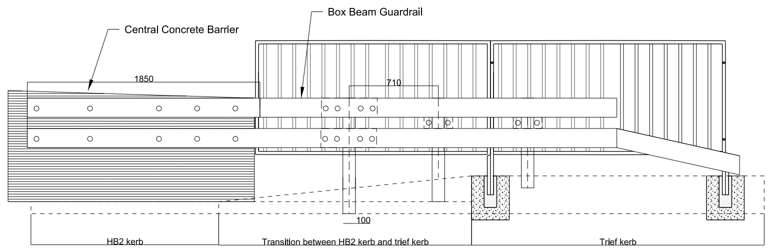
Detail B-B
Scale 1:100



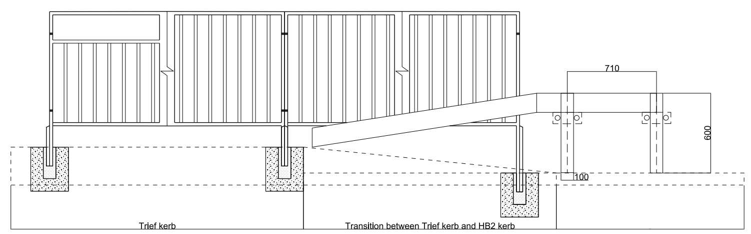
Detail C-C
Scale 1:100



Detail of Trief Kerb
and Pedestrian Guardrail
Scale 1:20



Detail C
Scale 1:30



Detail D
Scale 1:30

TRIEF KERB PERFORMANCE.	
BS.EN.1317-1 and BS.EN.1317-2.	
IMPACT TEST CRITERIA.	TB31.
CONTAINMENT LEVEL.	N1
WORKING WIDTH.	W5. (1.38m.)
IMPACT SEVERITY LEVEL.	A
DYNAMIC DEFLECTION.	0.0m.

CONCRETE STEP BARRIER PERFORMANCE.	
BS.EN.1317-1 and BS.EN.1317-2.	
IMPACT TEST CRITERIA.	TB11 and TB32.
CONTAINMENT LEVEL.	H1.
WORKING WIDTH.	W1. (0.6m.)
IMPACT SEVERITY LEVEL.	ASI B.
DYNAMIC DEFLECTION.	1.4m.

Key:

- Hull City Council Conservation Area
- Proposed single sided leading terminal
- Proposed single sided trailing terminal
- Proposed vehicle parapet
- Proposed crash cushion
- Proposed transition
- Proposed transition to existing road restraint system.
- Proposed safety barriers
- Proposed rigid concrete step barrier
- Proposed pedestrian guardrail
- Proposed retaining walls / structures
- Concrete Step Barrier
- Barrier Transition Sections
- Trief Kerb and Pedestrian Guardrail

Notes:

1. This drawing is indicative and should not be used under any circumstance for design or construction purposes.
2. All connection types and transitions are bespoke indicative proposals. None of the transitions or connections has been designed by barrier manufacturers or reviewed by Highways England Safety, Engineering and Standards (SES) specialists. None of the transitions has been tested whether they meet the necessary British Standards.
3. All dimensions are in millimetres unless noted otherwise.
4. Only written dimensions shall be used, do not scale.
5. Trief kerb solutions have not been tested for Heavy Goods Vehicles (HGVs)

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
(Enter "None" if applicable)

Maintenance / Cleaning
(Enter "None" if applicable)

Use
(Enter "None" if applicable)

Decommissioning / Demolition
(Enter "None" if applicable)

Rev.	Date	Description	By	Chk'd	App'd	Auth'd
P01	22/07/19	FOR REPORT CONSIDERATION	LH	AV	ID	—

Suitability
S2 SUITABLE FOR INFORMATION

ARUP Balfour Beatty

Client
highways england

Project Title
A63 CASTLE STREET

Drawing Title
A63 CENTRAL RESERVE BARRIER
OPTION 2
TRIEF KERB:PEDESTRIAN GUARD RAIL

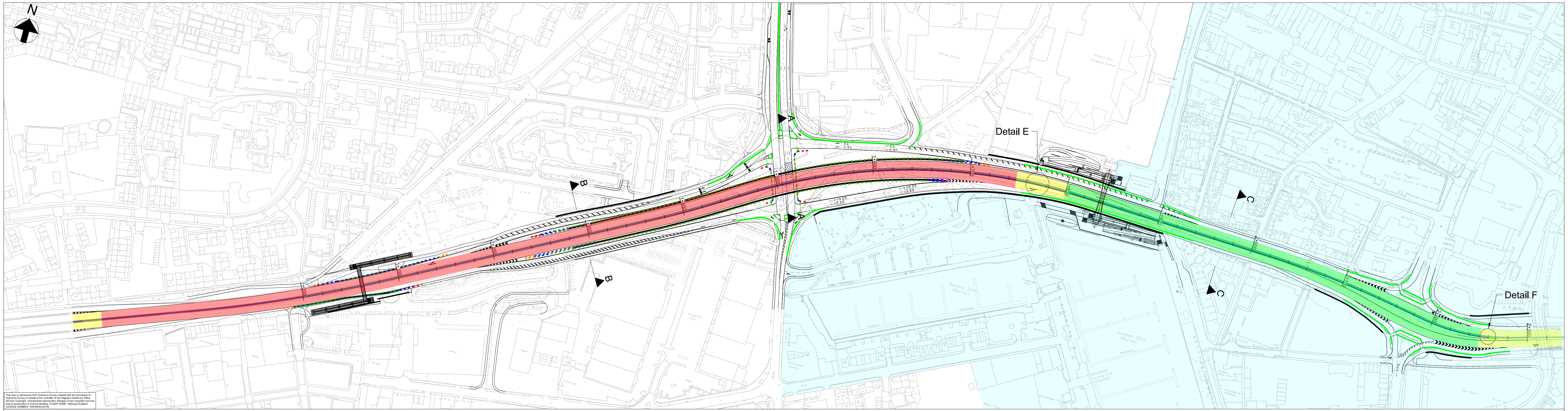
Scale	By	Checked	Approved	Authorised
As Shown	LH	AV	ID	—
Original Size	Date	Date	Date	Date
A1	19/07/19	22/07/19	22/07/19	—

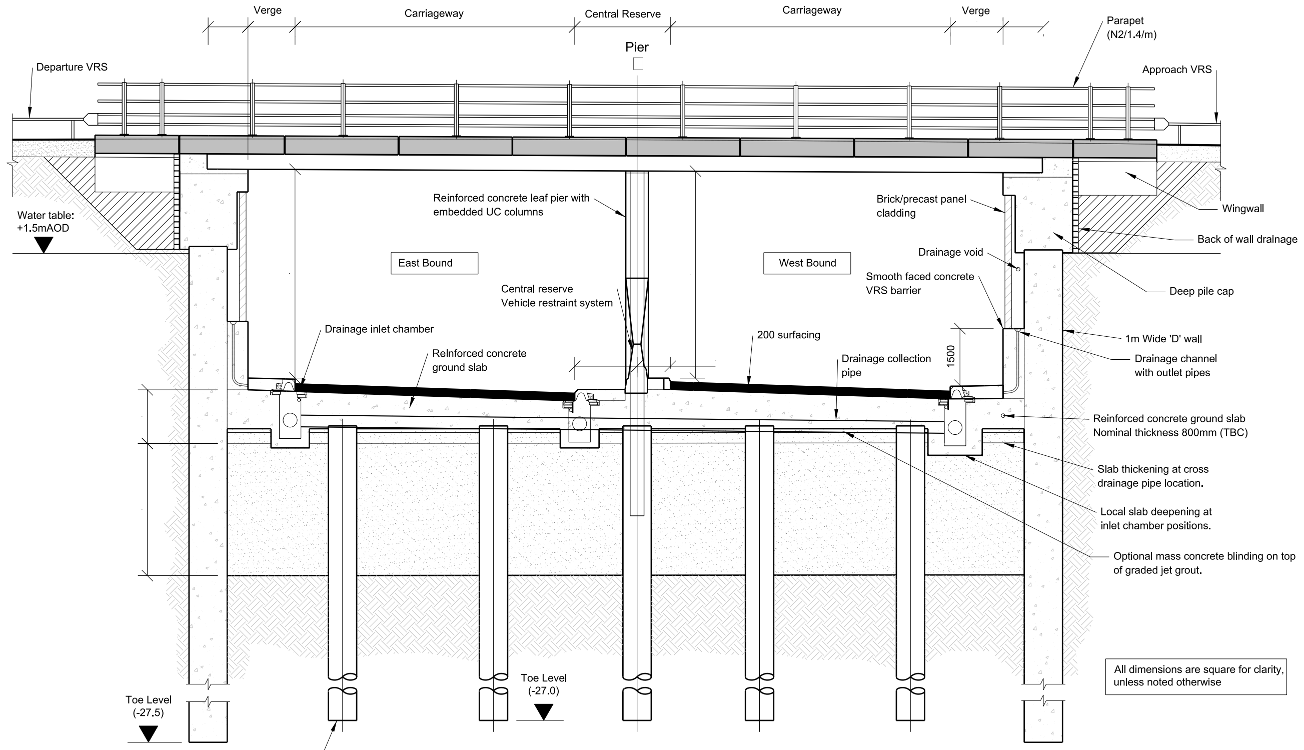
Drawing Number
HE PIN | Originator | Volume
HE514508 - ARP - HRR
S0_ML - SK - CH - 000002
Location | Type | Role | Number

Project Ref. No.
237912-00

Revision
P01

DO NOT SCALE





Detail A-A
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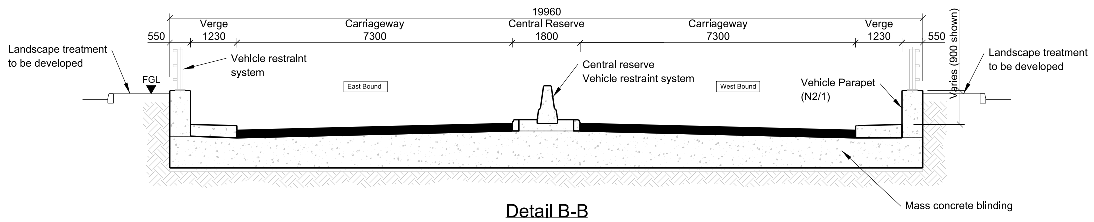
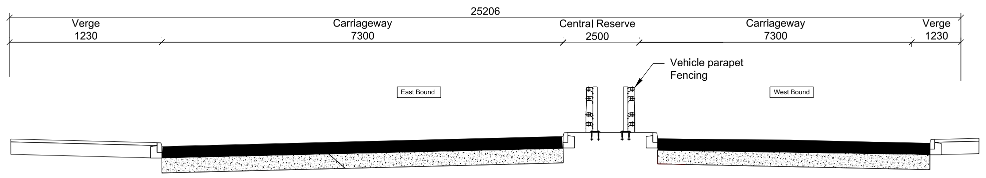
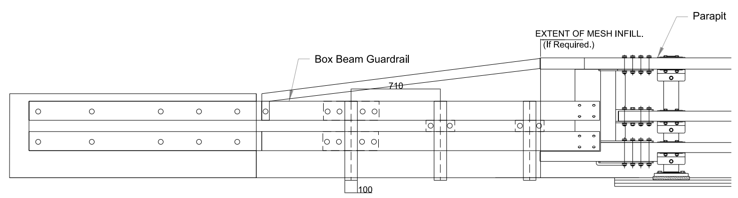


Detail B-B
Scale 1:100



Detail C-C
Scale 1:100



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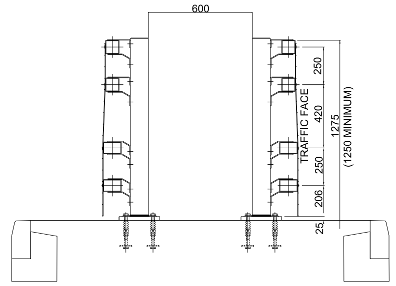
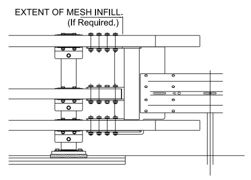


Detail of parapet proposal
Scale 1:20



Detail F
Scale 1:30

PARAPET PERFORMANCE.	
BS.EN.1317-1 and BS.EN.1317-2.	
IMPACT TEST CRITERIA.	TB11 and TB32.
CONTAINMENT LEVEL.	N2.
WORKING WIDTH.	W1. (0.6m.)
IMPACT SEVERITY LEVEL.	B.
DYNAMIC DEFLECTION.	0.4m.

Key:

- Hull City Council Conservation Area
- Proposed single sided leading terminal
- Proposed single sided trailing terminal
- Proposed vehicle parapet
- Proposed crash cushion
- Proposed transition
- Proposed transition to existing road restraint system.
- Proposed safety barriers
- Proposed rigid concrete step barrier
- Proposed pedestrian guardrail
- Proposed retaining walls / structures
- Concrete Step Barrier
- Barrier Transition Sections
- Proposed Parapet Barrier

Notes:

1. This drawing is indicative and should not be used under any circumstance for design or construction purposes.
2. All connection types and transitions are bespoke indicative proposals. None of the transitions or connections has been designed by barrier manufacturers or reviewed by Highways England Safety, Engineering and Standards (SES) specialists. None of the transitions has been tested whether they meet the necessary British Standards.
3. All dimensions are in millimeters unless noted otherwise.
4. Only written dimensions shall be used, do not scale.

SAFETY, HEALTH AND ENVIRONMENTAL INFORMATION

In addition to the hazards/risks normally associated with the types of work detailed on this drawing, note the following significant residual risks (Reference shall also be made to the design hazard log).

Construction
(Enter "None" if applicable)

Maintenance / Cleaning
(Enter "None" if applicable)

Use
(Enter "None" if applicable)

Decommissioning / Demolition
(Enter "None" if applicable)

Rev.	Date	Description	By	Chk'd	App'd	Auth'd
P01	22/07/19	FOR REPORT CONSIDERATION	LH	AV	ID	

Suitability
S2 SUITABLE FOR INFORMATION

ARUP Balfour Beatty

Client
highways england

Project Title
A63 CASTLE STREET

Drawing Title
A63 CENTRAL RESERVE BARRIER
OPTION 3
PARAPIT

Scale	By	Checked	Approved	Authorised
As Shown	LH	AV	ID	—
Original Size	**Date**	**Date**	**Date**	**Date**
A1	19/07/19	22/07/19	22/07/19	—

Drawing Number
HE PIN | Originator | Volume
HE514508 - ARP - HRR
S0_ML - SK - CH - 000003
Location | Type | Role | Number

Project Ref. No.
237912-00

Revision
P01

Appendix B

Summary of Consultation

Date	Between	Summary
March 2014	MMS / Highways England / BB/Arup	Illustrative design issued: Doc 1168-02-348-RE-005. • Section 3.4 specified concrete central reserve barrier.
January 2015	Andrew Drake (Arup) to Bruce Candy (BB)	After a design validation, Arup confirmed to BB that the CCRB will be included as the basis of design.
The CCRB has been in the design from March 2014 onwards.		
March 2019	James Leeming (HE) to Nico Bentall (HE SES)	James Leeming contacted HE SES regarding issued raised by HCC
April 2019	Adriaan van den Berg (Arup) to Daniel Ruth (HE SES)	AvdB contacted HE SES regarding their design proposal, highlighting the key design considerations and potential implications.
April 2019	Daniel Ruth (HE SES) to AvdB (Arup)	DR confirmed that TD 19/06 applies to Trunk roads and roads with speed limits greater than 50mph. therefore, the standards do not comply to this scheme.
April 2019	AvdB (Arup) to Daniel Ruth (HE SES)	AvdB confirmed that the design is based on consultation with the Area Maintenance Contractor (AMC) and HE. AvdB requested whether HE has any precedents regarding CCRB. AvdB reiterated their concerns: • Reducing the frequency for maintenance on the network • Reducing the potential risk to AMC working on network • Discourage pedestrians crossing the A63 • Avoid cross-over accidents
April 2019	Paul Goward (HE SES) to AvdB (Arup)	PG responded to AvdB regarding HE's policy regarding CCRBs. The policy relates to standards and the project decision informed by the AMC and the HE Project Manager.
April 2019	AvdB (Arup) to Simon Chambers (AMC)	AvdB contacted SM regarding their input on the CCRB.
April 2019	Simon Chambers (AMC) to AvdB (Arup)	SM confirmed to AvdB that the CCRB is the preferred solution for the AMC. They reiterated that it requires less maintenance as it rarely needs fixing when struck, so reduced worker exposure and it stops cross-over type accidents.

Date	Between	Summary
June 2019	Barrier Workshop: • HE • HE SES • HCC • BB • Arup • MMS	A workshop was held with all parties listed. The workshop reviewed several different alternative barrier solutions, and compared them in a decisions matrix. Based on the workshop, three options were taken forward: • CCRB • Trief kerb and pedestrian guardrail • Parapet and HB2 kerbs
July 2019	Several parties	During the preparation of the report, several parties were consulted to assess the different options: • HE SES • AMC • BB Programme and costing teams • Arup Safety Team (GG104) • Arcadis – Traffic Modelling

Appendix C

GG104 Safety Risk Assessment

Workers	Highways England employees/contractors
Users	Car drivers
	HGV drivers
	Motorcyclists
	Pedal cyclists
	Pedestrians
	Mobility-impaired pedestrians
	Emergency services
Other parties	People living alongside the scheme
	Businesses located alongside the scheme
	Motorised users wishing to cross the scheme
	Pedestrians wishing to cross the scheme
	Cyclists wishing to cross the scheme

Inclusions

Assessment and comparison of the safety implications of the provision of the three different proposed central reserve kerb and barrier options.

The section of central reserve between ch.1+770 and 2+280 (Option 1) and ch.1+770 and ch.2+260 (Options 2 and 3).

Exclusions

All other elements of the scheme, including but not limited to:

- the effect on safety of the expected change in traffic behaviour following removal of signalised junctions and provision of a grade separated junction.

Comparison against existing, which is not considered appropriate due to the significant change the proposals are expected to make on the nature of the scheme.

Any other considerations, including but not limited to cost and aesthetics.

Notes

A number of assumptions have been made in the course of this Safety Risk Assessment. The accuracy of these assumptions should be verified before any conclusions are used to inform a decision.

In order to facilitate comparison between the three options, the same/equivalent hazard/risk is included in each of the three assessments. This may occasionally result in an apparently spurious hazard being raised for a particular option.

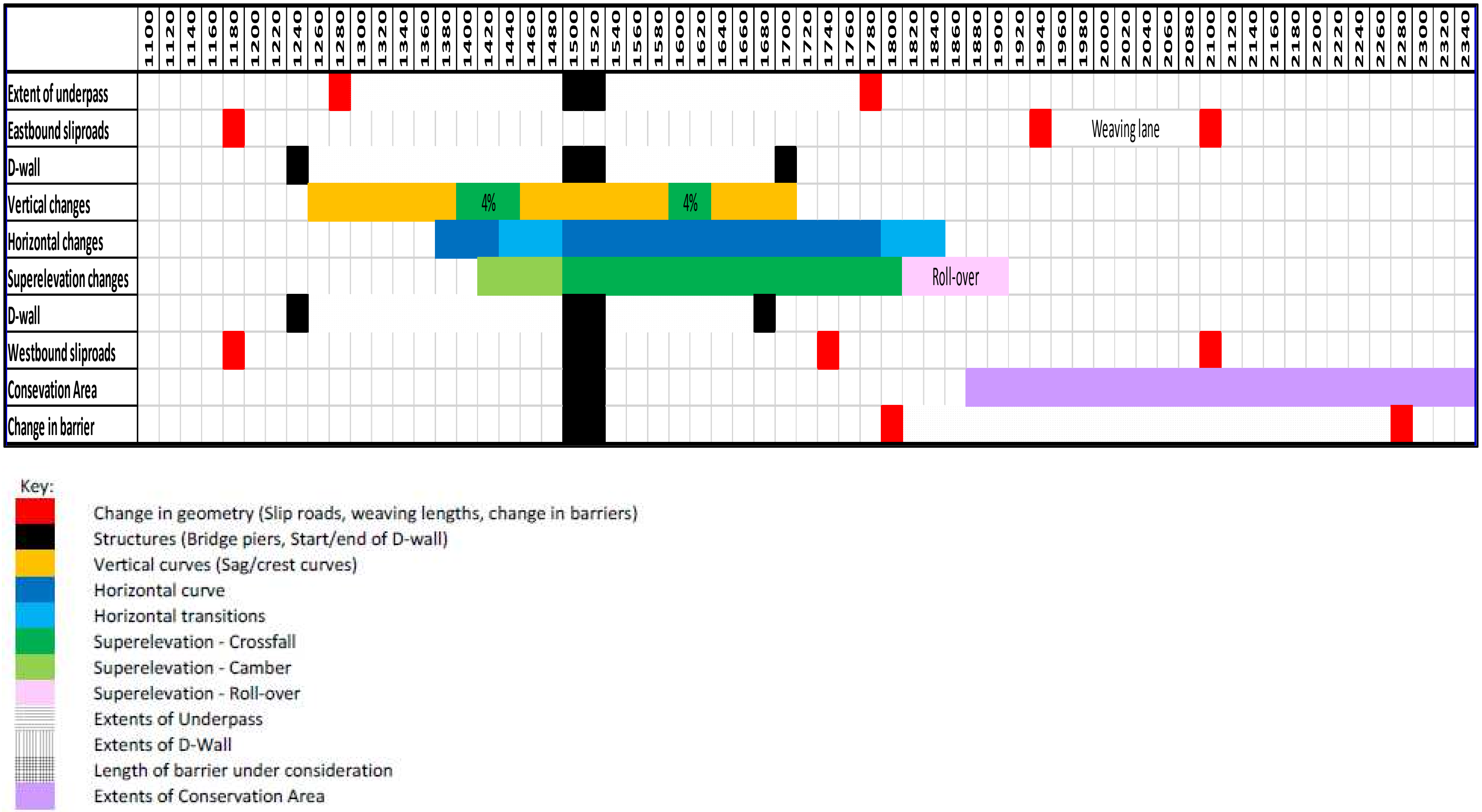
Ref	Hazard/ Risk Description	L	S	R	Response/ Control Measure	L	S	R	Details/assumptions/ monitoring
Activity/ Decision					Provision of concrete central reserve barrier throughout.				25/07/2019
Decision Maker/ Assessor					Ellen Pickett				Arup
Ref	**Hazard/ Risk Description**	**L**	**S**	**R**	**Response/ Control Measure**	**L**	**S**	**R**	**Details/assumptions/ monitoring**
1	Motorised vehicle(s) crossing the central reserve leading to a head on collision.	1	4	4				0	Containment level = H1; W=0.6m; D=0.0m. Therefore encroachment is only likely by buses or articulated HGVs. Also, SL/DS is only 40mph/70kph, so high speed collisions with the concrete barrier would only occur if the speed limit is appreciably exceeded.
2	Motorised vehicle(s), having collided with the concrete central reserve barrier, being redirected back onto the carriageway leading to a collision.	3	3	9				0	SL/DS is only 40mph/70kph, so high speed collisions with the concrete barrier would only occur if the speed limit is appreciably exceeded.
3	Motorised vehicle(s) colliding with the concrete central reserve barrier leading to vehicle occupant injury.	3	2	6				0	ISL=B. SL/DS is only 40mph/70kph, so high speed collisions with the concrete barrier would only occur if the speed limit is appreciably exceeded.
4	Motorcycle colliding with the concrete central reserve barrier leading to motorcyclist injury.	3	2	6				0	No motorcycle count data available. Concrete barriers are smooth, with no posts, allowing a motorcyclist to slide along the barrier sustaining relatively fewer/less severe injuries than might be sustained from a collision with other types of barrier.
5	A collision with the central reserve barrier in the westbound direction at the transition between the two barrier types at ch.2+260. A sudden decrease in the dynamic deflection between the two barrier types may lead to 'pocketing' and the vehicle effectively colliding with the end of the proposed concrete barrier, leading to vehicle occupant injuries.	2	4	8	A transition is indicated in the drawings though the notes explain this has not been designed. A suitable transition should be designed and installed to act as a safe transition between the differing containment properties levels of the box beam guardrail and concrete barrier.	2	2	4	Properties of the box beam guardrail are not indicated on the drawing, but dynamic deflection is assumed to be greater than that for the concrete barrier.
6	In the event of a collision, the concrete central reserve barrier may 'guide' a vehicle to collide with other infrastructure (such as lighting columns, traffic sign posts, structures…) leading to vehicle occupant injury.	3	4	12	No infrastructure should be located in front of or within the working width of the concrete barrier.	1	4	4	It is assumed that the proposed barrier transition will be designed appropriately.
7	Pedestrians may not be deterred by the presence of the concrete central reserve barrier from attempting to cross the A63 Castle Street by climbing the barrier, and be struck by a vehicle. Pedestrians attempting to cross may also fail to climb over the barrier and become 'stranded' in the central reserve increasing the risk of conflict with vehicles.	3	4	12	Adequate alternative means of crossing the A63 should be provided.	2	4	8	It is believed from anecdotal evidence that pedestrians currently attempt to climb the existing guardrail on a regular (at least monthly) basis, and will continue to do so under the proposed scheme. However, it is unknown how many (if any) pedestrians have been injured attempting to cross the A63 by climbing the barrier. Inspection of the Crashmap.co.uk database shows 5 collisions involving pedestrians in the study area in the five years 2014-18; 2 of these were classed as Serious. The proposed concrete barrier is 900mm high, which is presumably lower than the existing guardrail and therefore may be less of a deterrent.
8	There are currently three signalised crossings within the study area which are to be closed, and one proposed pedestrian/cyclist overbridge. Pedestrians may be obliged to walk in excess of an additional 650 metres to use the proposed overbridge. Safe, convenient means for pedestrians and cyclists to cross the A63 Castle street may be insufficient, resulting in pedestrians attempting to cross the A63 by climbing the concrete central reserve barrier, and being struck by a vehicle.	4	4	16	Adequate alternative means of crossing the A63 should be provided.	2	4	8	The design team confirms that a WCHAR (or similar) assessment has been undertaken which supports the proposed level of provision.
9	Pedestrians may choose to walk along the central reserve, and be struck by a passing vehicle, or step/fall off the kerb and be struck by a passing vehicle.	2	4	8				0	CR width = 2500mm and concrete barrier is approximately 500mm wide, meaning approximately 1.0m would be available to walk along, which some pedestrians may deem sufficient.
10	Workers undertaking scheduled maintenance/inspection of the concrete central reserve barrier and transitions may be struck by passing vehicles.	1	5	5	Use appropriate methods of working, including road/lane closures and temporary traffic management as necessary, to ensure the risk to workers is As Low As Reasonably Practicable.	1	5	5	
11	While responding to an incident, emergency services may need, and be prevented by the concrete barrier, access across the central reserve.	2	5	10				0	
12	In the event of an incident, emergency services may need to clear the carriageway quickly and be prevented by the concrete barrier from directing vehicles to cross the central reserve in order to exit via the other carriageway.	2	5	10	Develop an emergency response plan. This may include installing removable section(s) of concrete barrier and dropped kerbs, or means to leave the carriageway on the nearside.	1	5	5	
13	The concrete central reserve barrier may restrict forward visibility for westbound drivers along the A63 in the vicinity of the bend at Market Place, increasing the risk of collisions with obstructions in the carriageway ahead, or loss of control under braking and shunt collisions whilst drivers react to an obstruction in the carriageway ahead.	4	5	20	Assess the effect on SSD of the proposed concrete barrier to determine whether an alternative product would provide better SSD.	2	5	10	This hazard is related to Departure D021, details of which were not made available but it is believed that the reduced visibility is due to the central reserve barrier.

Activity/ Decision		Provision of concrete central reserve barrier throughout.							25/07/2019
Decision Maker/ Assessor		Ellen Pickett							Arup
Ref	**Hazard/ Risk Description**	**L**	**S**	**R**	**Response/ Control Measure**	**L**	**S**	**R**	**Details/assumptions/ monitoring**
1	Motorised vehicle(s) crossing the central reserve leading to a head on collision.	3	4	12				0	Containment level = N1; W=1.38m; D=0m. Therefore only light vehicles are likely to be contained, and even those could strike the pedestrian guardrail. Note however that SL/DS is only 40mph/70kph, so high speed collisions with the Trief kerb would only occur if the speed limit is appreciably exceeded.
2	Motorised vehicle(s), having collided with the central reserve Trief kerb, being redirected back onto the carriageway leading to a collision.	3	3	9				0	SL/DS is only 40mph/70kph, so high speed collisions with the Trief kerb would only occur if the speed limit is appreciably exceeded.
3	Motorised vehicle(s) colliding with the central reserve Trief kerb leading to vehicle occupant injury.	4	2	8				0	ISL=A. SL/DS is only 40mph/70kph, so high speed collisions with the Trief kerb would only occur if the speed limit is appreciably exceeded.
4	Motorcycle colliding with the central reserve Trief kerb and/or pedestrian guardrail leading to motorcyclist injury.	4	3	12	Obtain data/expert opinion on the likelihood and severity of motorcyclist injury sustained upon impact with this type of vehicle restraint, and use an alternative product if appropriate. The significance of this decision may be influenced by a motorcycle count and historic collision data involving motorcycles at this location.	3	2	6	No motorcycle count data available. Motorcyclists can sustain severe injuries from colliding with fence posts.
5	A collision with the central reserve barrier in the eastbound direction at the change from pedestrian guardrail to box beam guardrail at ch.2+280. An errant vehicle, having mounted the trief kerb, may collide with the end of the box beam guardrail, leading to vehicle occupant injuries.	2	4	8	A terminal is indicated in the drawings though the notes explain this has not been designed. A suitable terminal should be designed and installed to protect vehicle occupants in the event of a collision with the end of the box beam guardrail.	2	2	4	
6	Loss of control in the westbound direction involving a vehicle mounting the kerb at the transition from HB2 kerb to Trief kerb at ch.2+280. The kerb transition may have a 'ramp effect' on the vehicle, lifting the vehicle and increasing the severity of any occupant injuries.	2	2	4				0	SL/DS is only 40mph/70kph, so high speed collisions with the Trief kerb resulting in significant 'ramping' would only occur if the speed limit is appreciably exceeded.
7	A collision with the central reserve barrier in the westbound direction at the change from pedestrian guardrail to concrete barrier at ch.1+770. An errant vehicle, having mounted the trief kerb, may collide with the end of the proposed concrete barrier, leading to vehicle occupant injuries.	2	4	8	A terminal is indicated in the drawings though the notes explain this has not been designed. A suitable terminal should be designed and installed to protect vehicle occupants in the event of a collision with the end of the concrete barrier.	2	2	4	
8	Loss of control in the eastbound direction involving a vehicle mounting the kerb at the transition from HB2 kerb to Trief kerb at ch.1+770. The kerb transition may have a 'ramp effect' on the vehicle, lifting the vehicle and increasing the severity of any occupant injuries.	2	2	4				0	SL/DS is only 40mph/70kph, so high speed collisions with the Trief kerb resulting in significant 'ramping' would only occur if the speed limit is appreciably exceeded.
9	In the event of a collision, the central reserve Trief kerb may 'guide' a vehicle to collide with other infrastructure (such as lighting columns, traffic sign posts, structures…) leading to vehicle occupant injury.	2	4	8	No infrastructure should be located within the working width of the Trief kerb.	1	4	4	It is assumed that the proposed barrier terminals will be designed appropriately.
10	The proposed pedestrian guardrail lies within the working width of the proposed Trief kerb. In the event of a collision with the Trief kerb, a vehicle may also collide with the pedestrian guardrail, increasing the number and/or severity of vehicle occupant injuries.	3	2	6				0	
11	Pedestrians may not be deterred by the presence of the central reserve guardrail from attempting to cross the A63 Castle Street by climbing the guardrail, and be struck by a vehicle. Pedestrians may also fail to climb over the guardrail and become 'stranded' in the central reserve increasing the risk of conflict with vehicles.	2	4	8	Adequate alternative means of crossing the A63 should be provided.	2	4	8	It is believed from anecdotal evidence that pedestrians currently attempt to climb the existing guardrail on a regular (at least monthly) basis, and will continue to do so under the proposed scheme. However, it is unknown how many (if any) pedestrians have been injured attempting to cross the A63 by climbing the barrier. Inspection of the Crashmap.co.uk database shows 5 collisions involving pedestrians in the study area in the five years 2014-18; 2 of these were classed as Serious. The proposed guardrail is 1.25m high.
12	There are currently three signalised crossings within the study area which are to be closed, and one proposed pedestrian/cyclist overbridge. Pedestrians may be obliged to walk in excess of an additional 650 metres to use the proposed overbridge. Safe, convenient means for pedestrians and cyclists to cross the A63 Castle street may be insufficient, resulting in pedestrians attempting to cross the A63 by climbing the concrete central reserve barrier, and being struck by a vehicle.	4	4	16	Adequate alternative means of crossing the A63 should be provided.	2	4	8	The design team confirms that a WCHAR (or similar) assessment has been undertaken which supports the proposed level of provision.
13	Pedestrians may choose to walk along the central reserve, and be struck by a passing vehicle, or step/fall off the Trief kerb and be struck by a passing vehicle.	2	4	8				0	CR width = 2500mm and guardrail is taken to be approximately 50mm wide, meaning approximately 1.2m would be available to walk along, which some pedestrians may deem sufficient.
14	Workers undertaking scheduled maintenance/inspection of the Trief kerb, pedestrian guardrail and barrier terminations may be struck by passing vehicles.	3	5	15	Use appropriate methods of working, including road/lane closures and temporary traffic management as necessary, to ensure the risk to workers is As Low As Reasonably Practicable.	2	5	10	
15	While responding to an incident, emergency services may need, and be prevented by the Trief kerb and pedestrian guardrail, access across the central reserve.	2	5	10				0	
16	In the event of an incident, emergency services may need to clear the carriageway quickly and be prevented by the Trief kerb and pedestrian guardrail from directing vehicles to cross the central reserve in order to exit via the other carriageway.	2	5	10	Develop an emergency response plan. This may include installing removable section(s) of guardrail and dropped kerbs, or means to leave the carriageway on the nearside. Note the installation of transitions between Trief and dropped kerbs would introduce a risk of 'ramping'; see hazard ref 6/8.	1	5	5	
17	The central reserve pedestrian guardrail may restrict forward visibility for westbound drivers along the A63 in the vicinity of the bend at Market Place, increasing the risk of collisions with obstructions in the carriageway ahead, or loss of control under braking and shunt collisions whilst drivers react to an obstruction in the carriageway ahead.	4	5	20	Assess the effect on SSD of the proposed pedestrian guardrail fence to determine whether an alternative product would provide better SSD.	2	5	10	This hazard is related to Departure D021, details of which were not made available but it is believed that the reduced visibility is due to the central reserve barrier.
18	HGV striking trief kerb and either mounting the trief kerb, or falling over due to speed and impact location. Pedestrian Guardrail will provide no protection against overhang or overtopping HGV. HGV to then fall into oncoming traffic. Secondly, damaged pedestrian guardrail could fall into the oncoming carriageway and pose a potential risk.	2	5	10		2	5	10	

Activity/ Decision		Provision of concrete central reserve barrier throughout.							25/07/2019
Decision Maker/ Assessor		Ellen Pickett							Arup
Ref	Hazard/ Risk Description	L	S	R	Response/ Control Measure	L	S	R	Details/assumptions/ monitoring
1	Motorised vehicle(s) crossing the central reserve leading to a head on collision.	2	4	8				0	Containment level = N2; W=0.6m; D=0.4m. Therefore only light vehicles are likely to be contained. Note however that SL/DS is only 40mph/70kph, so high speed collisions with the parapet fence would only occur if the speed limit is appreciably exceeded.
2	Motorised vehicle(s), having collided with the central reserve parapet fence, being redirected back onto the carriageway leading to a collision.	2	3	6				0	SL/DS is only 40mph/70kph, so high speed collisions with the parapet fence would only occur if the speed limit is appreciably exceeded.
3	Motorised vehicle(s) colliding with the central reserve parapet fence leading to vehicle occupant injury.	3	2	6				0	ISL=B. SL/DS is only 40mph/70kph, so high speed collisions with the parapet fence would only occur if the speed limit is appreciably exceeded.
4	Motorcycle colliding with the central reserve parapet fence leading to motorcyclist injury.	3	3	9	Obtain data/expert opinion on the likelihood and severity of motorcyclist injury sustained upon impact with this type of vehicle restraint, and use an alternative product if appropriate. The significance of this decision may be influenced by a motorcycle count and historic collision data involving motorcycles at this location.	2	2	4	No motorcycle count data available. Motorcyclists can sustain severe injuries from colliding with parapet posts. While the drawings indicate a 'mesh infill', it is unclear whether this would offer protection to motorcyclists in the event of a collision.
5	A collision with the central reserve barrier at the transition between the two barrier types at ch.2+260. A sudden decrease in the dynamic deflection between the two barrier types may lead to 'pocketing' and the vehicle effectively colliding with the end of the proposed parapet fence or box beam guardrail (depending on direction), leading to vehicle occupant injuries.	2	4	8	A transition is indicated in the drawings though the notes explain this has not been designed. A suitable transition should be designed and installed to act as a safe transition between the differing containment properties levels of the box beam guardrail and	2	2	4	
6	A collision with the central reserve barrier in the westbound direction at the transition between the parapet fence and the concrete barrier at ch.1+770. A sudden decrease in the dynamic deflection between the two barrier types may lead to 'pocketing' and the vehicle effectively colliding with the end of the proposed concrete barrier, leading to vehicle occupant injuries.	2	4	8	A transition is indicated in the drawings though the notes explain this has not been designed. A suitable transition should be designed and installed to act as a safe transition between the differing containment properties levels of the box beam guardrail and concrete barrier.	2	2	4	
7	In the event of a collision, the central reserve parapet fence may 'guide' a vehicle to collide with other infrastructure (such as lighting columns, traffic sign posts, structures…) leading to vehicle occupant injury.	3	4	12	No infrastructure should be located in front of or within the working width of the parapet fence.	1	4	4	It is assumed that the proposed barrier transitions will be designed appropriately.
8	Pedestrians may not be deterred by the presence of the central reserve parapet fence from attempting to cross the A63 Castle Street by climbing the fence, and be struck by a vehicle. Pedestrians may also fail to climb over the fence and become 'stranded' in the central reserve increasing the risk of conflict with vehicles.	2	4	8	Adequate alternative means of crossing the A63 should be provided.	2	4	8	It is believed from anecdotal evidence that pedestrians currently attempt to climb the existing guardrail on a regular (at least monthly) basis, and will continue to do so under the proposed scheme. However, it is unknown how many (if any) pedestrians have been injured attempting to cross the A63 by climbing the barrier. Inspection of the Crashmap.co.uk database shows 5 collisions involving pedestrians in the study area in the five years 2014-18; 2 of these were classed as Serious. The proposed parapet fence is 1.25 metres tall. It is unclear whether the proposed mesh infill would be visible enough from the footway in order to deter pedestrians from crossing with the intention to climb the fence.
9	There are currently three signalised crossings within the study area which are to be closed, and one proposed pedestrian/cyclist overbridge. Pedestrians may be obliged to walk in excess of an additional 650 metres to use the proposed overbridge. Safe, convenient means for pedestrians and cyclists to cross the A63 Castle street may be insufficient, resulting in pedestrians attempting to cross the A63 by climbing the central reserve parapet fence, and being struck by a vehicle.	4	4	16	Adequate alternative means of crossing the A63 should be provided.	2	4	8	The design team confirms that a WCHAR (or similar) assessment has been undertaken which supports the proposed level of provision.
10	Pedestrians may choose to walk along the central reserve, and be struck by a passing vehicle, or step/fall off the kerb and be struck by a passing vehicle.	1	4	4				0	CR width = 2500mm, and parapet fences are approximately 300mm wide and separated by 600mm, meaning approximately 650mm would be available to walk along, which few pedestrians are likely to deem sufficient.
11	Workers undertaking scheduled maintenance/inspection of the central reserve parapet fence and transitions may be struck by passing vehicles.	3	5	15	Use appropriate methods of working, including road/lane closures and temporary traffic management as necessary, to ensure the risk to workers is As Low As Reasonably Practicable.	2	5	10	
12	While responding to an incident, emergency services may need, and be prevented by the parapet fence, access across the central reserve.	2	5	10				0	
13	In the event of an incident, emergency services may need to clear the carriageway quickly and be prevented by the parapet fence from allowing vehicles to cross the central reserve in order to exit via the other carriageway.	1	5	5	Develop an emergency response plan. This may include installing removable sections of parapet fence and dropped kerbs, or means to leave the carriageway on the nearside.	1	5	5	It is assumed that the proposed parapet fence could be relatively easily deconstructed even if removable sections aren't installed, and vehicles would be able to mount the kerb in order to cross the central reserve.
14	The central reserve parapet fence may restrict forward visibility for westbound drivers along the A63 in the vicinity of the bend at Market Place, increasing the risk of collisions with obstructions in the carriageway ahead, or loss of control under braking and shunt collisions whilst drivers react to an obstruction in the carriageway ahead.	4	5	20	Assess the effect on SSD of the proposed parapet fence and determine whether an alternative product would provide better SSD.	2	5	10	This hazard is related to Departure D021, details of which were not made available but it is believed that the reduced visibility is due to the central reserve barrier.
15	Parapet fence may not perform as expected in the event of a collision. Parapet fence is designed for use on structures, not in central reserves, and is tested accordingly. Therefore it may not provide the level of protection specified and may not be suitable for use in the proposed scenario.	5	5	25	Confirm that the proposed product will perform as expected when used in the way proposed.	1	1	1	

Appendix D

Changes in Geometry


1100 1120 1140 1160 1180 1200 1220 1240 1260 1280 1300 1320 1340 1360 1380 1400 1420 1440 1460 1480 1500 1520 1540 1560 1580 1600 1620 1640 1660 1680 1700 1720 1740 1760 1780 1800 1820 1840 1860 1880 1900 1920 1940 1960 1980 2000 2020 2040 2060 2080 2100 2120 2140 2160 2180 2200 2220 2240 2260 2280 2300 2320 2340
Extent of underpass
Eastbound sliproads
Weaving lane
D-wall
Vertical changes
4%
4%
Horizontal changes
Superelevation changes
Roll-over
D-wall
Westbound sliproads
Consevation Area
Change in barrier
Key:
Change in geometry (Slip roads, weaving lengths, change in barriers)
Structures (Bridge piers, Start/end of D-wall)
Vertical curves (Sag/crest curves)
Horizontal curve
Horizontal transitions
Superelevation - Crossfall
Superelevation - Camber
Superelevation - Roll-over
Extents of Underpass
Extents of D-Wall
Length of barrier under consideration
Extents of Conservation Area

Appendix E

Assessment Matrix

A63 Castle Street

Assessment Matrix of Central Reservation Barrier Options

	1	2	3	4	5	6	7	8	
Weighting	20%	10%	10%	10%	20%	10%	10%	10%	**100%**
Option	**Safety Assessment (GG104)**	**Construction Programme**	**High Level Cost Estimate**	**Network performance**	**Maintenance Safety**	**Maintenance Costs**	**Aesthetics (Hull Conservation Area)**	**Deter pedestrians**	**Total Score**
Option 1 - Concrete step barrier	1.00	0.50	0.50	0.30	1.00	0.50	0.00	0.23	**4.03**
Option 2 - Trief kerb and pedestrian guardrail	0.90	0.48	0.48	0.00	0.20	0.30	0.50	0.50	**3.36**
Option 3 - Parapets	0.94	0.45	0.41	0.10	0.20	0.10	0.20	0.31	**2.71**

A63 Castle Street

Safety Assessment GG104 Summary

Option	Safety Assessment (GG104)	Hazard/Risk Rating (Combined)	Mitigated Risk Rating (Combined)	Hazard/Risk Rating (%)	Mitigated Risk Rating (%)
Option 1 - Concrete step barrier	5.00	126.00	44.00	5.00	5.00
Option 2 - Trief kerb and pedestrian guardrail	4.52	176.00	69.00	4.60	4.43
Option 3 - Parapets	4.71	160.00	58.00	4.73	4.68

A63 Castle Street

Construction Programme

Option	Construction Programme	Programme	Programme Rating
Option 1 - Concrete step barrier	5.00	41.00	5.00
Option 2 - Trief kerb and pedestrian guardrail	4.76	51.00	4.76
Option 3 - Parapets	4.51	61.00	4.51

Concrete step barrier

CH1690 - 2100	23	
CH2100 - 2250	18	
	41	

Trief kerb and pedestrian guardrail

Base central reserve barrier duration	41	
Additional connection	5	5
Longer lead in	5	
	51	

Trief kerb and pedestrian guardrail

Base central reserve barrier duration	41	
Longer lead in	5	15
Additional connection	5	
Double length of parapet and fixing foundations	10	
	61	

A63 Castle Street

High Level Cost Estimate

Option	High Level Cost Estimate	Programme Cost	Material Cost	Programme Cost	Material Cost
Option 1 - Concrete step barrier	5.00	£ -	£127,500.00		5
Option 2 - Trief kerb and pedestrian guardrail	4.76	£ -	£158,100.00		4.76
Option 3 - Parapets	4.08	£ -	£244,800.00		4.08

	BB 31/07			
Option	**QTY**	**Rate**	**Cost**	
Option 1	510	£250.00	£127,500.00	
				£127,500.00
Option 2	510	£310.00	£158,100.00	
				£158,100.00
Option 3	510	£480.00	£244,800.00	
				£244,800.00

A63 Castle Street

Maintenance Considerations

Option	Network performance	Maintenance Safety	Maintenance Costs	Proposal suitability
Option 1 - Concrete step barrier	3.00	5.00	5.00	3.00
Option 2 - Trief kerb and pedestrian guardrail	0.00	1.00	3.00	0.00
Option 3 - Parapets	1.00	1.00	1.00	1.00

Maintenance Safety		
Option 1 - Concrete step barrier	5	Preferred option - Almost no maintenance required. Therefore no exposure to maintenance team
Option 2 - Trief kerb and pedestrian guardrail	1	Replacement of guardrail exposes maintenance team to safety. Lane closures required. Impact on network
Option 3 - Parapets	1	Replacement of parapet exposes maintenance team to safety. Lane closures required. Impact on network

Maintenance Costs		
Option 1 - Concrete step barrier	5	Preferred option - Almost no maintenance cost as concrete barrier would almost never be replaced
Option 2 - Trief kerb and pedestrian guardrail	3	Pedestrian guardrail easy to replace. Not that expensive. Cost relates to TM
Option 3 - Parapets	1	Expensive to repair, and access would require lane clsoures, possible full closures.

Proposal Suitability		
Option 1 - Concrete step barrier	3	Potentially not suitable for urban environment. 900mm height might not deter pedestrian climbing over CSB
Option 2 - Trief kerb and pedestrian guardrail	0	Trief kerbs are not approved for use on Highways England network. Secondly, they have not yet been tested for HGV impact, and pose a potential risk
Option 3 - Parapets	1	Require consideration whether parapets would comply here – i.e. kerb upstand height (parapet plinths are generally c50mm), and then the verge width from upstand to parapet. As shown in your dwg, a car would tend to “launch” upwards when hitting the kerb and then might not hit the parapet at the intended/tested height. To facilitate the higher kerb upstand you might need a substantial verge in front of the parapet

A63 Castle Street

Hull City Council Objections

Option	Aesthetics (Hull Conservation Area)	Deter pedestrians
Option 1 - Concrete step barrier	0.00	2.34
Option 2 - Trief kerb and pedestrian guardrail	5.00	5.00
Option 3 - Parapets	2.00	3.09

Deter pedestrians	Height	Permeability	Height (rating)	Permeability (Rating)
Option 1 - Concrete step barrier	1.025	0%	4.69	0.00
Option 2 - Trief kerb and pedestrian guardrail	1.49	100%	5.00	5.00
Option 3 - Parapets	1.375	25%	4.92	1.25