Option Selection Report

Version 03

Project Name:	**Gipsy Patch Lane**
OP Reference:	139886 Gipsy Patch Lane
Sponsor/Client:	Angela Edmonds / South Gloucestershire Council
Project Manager:	Dave Lovell

Prepared by: G Skehel (Mott MacDonald)	Signature: [signature]
	Job Title: Civil Engineer
Reviewed by: Tom Smith (Network Rail)	Signature: [signature]
	Job Title: Project Engineer
Accepted by: Mike Smith (Network Rail)	Signature: [signature]
	Job Title: Route Structures Engineer

This page left deliberately blank

Network Rail

139886 Gipsy Patch Lane

Option Selection Report

Issue and Revision Record:

Rev	Date	Originator	Checked	Approved	Description
01	05 June 2015	G Skehel	A Georgiev	C Bishop	Draft report for preliminary review of Options 1 to 4
02	10 July 2015	G Skehel	A Georgie	C Bishop	Revised to include review of Options 1 to 6
03	21 September 2015	J Harrison-King	G Skehel	C Bishop	Revised to address comments
04					

Group Disclaimer

"This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties"

"This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it."

Mott MacDonald
10 Temple Back
Bristol BS1 6FL
United Kingdom

This page left deliberately blank

Contents

APPENDICES

A. Drawings
B. Project Hazard Log
C. Not Used
D. Cost Estimating (redacted for commercial reasons)
E. Photographs
F. Environmental Appraisal
G. Geotechnical Design Report
H. Carbon Footprint Calculation
I. Project Risk Register (redacted for commercial reasons)

Issue Record

Issue No	Brief History Of Amendment	Date of Issue
01	Draft report for preliminary review of Options 1 to 4	05/06/2015
02	Revised to include review of Options 1 to 6	10/07/2015
03	Revised to address comments	22/09/2015

Distribution List

Name	Organisation	Issue No.
Angela Edmonds	Network Rail	03
Tamsin Dangerfield	Network Rail	03
Mark Gratland	Network Rail	03
Tom Smith	Network Rail	03
Bethan Colman	South Gloucestershire Council	02
Ben McGee	South Gloucestershire Council	02
Mike Johnson	South Gloucestershire Council	02
Charles Bishop	Mott MacDonald	03
Alexander Georgiev	Mott MacDonald	03
Georgina Skehel	Mott MacDonald	03

1 Executive Summary

Gipsy Patch Lane is a single span underline structure located south of Bristol Patchway Station at BSW 5miles and 60chains. The existing superstructure comprises a masonry arch bridge constructed square to the track. It carries four lines that converge to three via switches located on the bridge over Gipsy Patch Lane, which consists of a single carriageway and narrow footpath.

The bridge has limited clearance with a 4m height restriction which forms a pinch point on South Gloucestershire Council's (SGC) travel network. Further disruption to travel occurs during incidents of bridge strikes which Network Rail reports are a regular occurrence.

SGC previously commissioned a feasibility study which looked at options to address the issues at Gipsy Patch Lane which recommended providing a jacked box subway for pedestrians and cyclists adjacent to the existing structure. Since this feasibility study, additional requirements to consider the provision for enabling the passage of double decker buses and potential for designated bus lanes along the route have arisen as part of the Cribbs Patchway MetroBus Extension project.

The Cribbs Patchway MetroBus Extension Project aims to provide an express bus service which includes improved cycling and pedestrian facilities. It will form an extension to part of an already planned MetroBus route to provide a faster and more direct route between Parkway Station and Cribbs Causeway via the Cribbs Causeway new neighbourhood on the former Filton Airfield. The proposed route will use Gipsy Patch Lane, hence further optioneering is required to consider a new bridge structure in order to increase the headroom and width of the carriageway to facilitate the increase in buses and non-motorised users traffic.

The new structure will be designed for a 120 year design life and will be owned and maintained by Network Rail with a one-off maintenance contribution made by SGC on completion of the works.

An option selection process has been undertaken to consider different carriageway layouts, constructability and structural arrangement. Options that were immediately identified as unsuitable, and hence discarded, have been included for completeness and to illustrate the design process. Six main options for the bridge structure have been considered and for each of these a detailed description has been provided. SGC have commissioned CH2M to undertake the highway design for the different carriageway layouts and design of the bridge structure has been co-ordinated with these.

Sheet piled and reinforced concrete wing walls, either straight with the bridge abutments or splayed have been considered. Discussions regarding the wing wall options have considered their construction and aesthetics in order to identify which would be best suited for the bridge proposal.

In order to provide the bearing resistance required for the main options for the bridge structure considered in this report, six foundation options have been reviewed and a comparison of these options are detailed in Section 2.5 of this report. It is considered that the preferred option would be ground beams spanning between piles at either end however targeted ground investigation in later design stages may present value engineering options to further develop the foundation design by reducing or eliminating the piles at either ends of the ground beam.

The recommended solution is to provide a pre-cast concrete portal frame with an 18.7m clear span and abutments aligned with the carriageway (option 2). This is sufficient to include a single designated bus lane whilst keeping the overall structure size to a minimum. The wing walls should be pre-cast, integral with the main bridge structure for more efficient construction. Ground beams supporting the wing walls and the abutments, spanning between large diameter piles are considered to be appropriate, however targeted ground investigations in later design stages may present opportunity to refine the foundation design.

The proposed construction sequence involves pre-casting the portal frame in a compound located in the Rolls Royce East Works site adjacent to the existing bridge. During an abnormal possession the embankment can be excavated and the existing bridge demolished prior to the pre-cast structure being driven into place using self-propelled modular transporter units (SPMT).

To provide the required improved headroom below the proposed bridge, the carriageway will need to be lowered. This will impact on the existing buried services below the carriageway and the extent of the regrading required to tie in with the existing highway. The construction of the new bridge will need to be co-ordinated with the associated highway realignment and further works being undertaken as part of the wider Cribbs Patchway MetroBus Extension Project.

2 Options Report & Concept Designs

An option selection process has been carried out to evaluate and compare options to determine the most effective solution for the replacement bridge structure. A brief description of the discarded options has been included to illustrate the design process. Six options have been considered in greater detail for option selection and a preferred solution identified.

2.1 Considerations for Option Selection

The areas requiring consideration during the option selection process include:

- Type of structure – the materials used and structural arrangement need to be suitable for the required spans, constructability, durability, appearance and maintenance.
- Alignment of structure – the alignment will need to consider track sensitivity, road users' sightlines, appearance, maintenance access and most efficient structural arrangement to provide sufficient clear span for the proposed carriageway.
- Foundations – the foundation solution will need to consider the construction method, particularly with the limited possession time available, whilst suiting the existing ground conditions and the applied loading.
- Carriageway layout - three main options are proposed for the carriageway to facilitate the increase in buses and non-motorised users: 14.5m clear width, the required minimum span allowing for a two lane single carriageway with shared cycle/footway on each side; 18.7m clear width, allowing for a two lane single carriageway with designated bus lane and with cycle/footways on each side; or a 24.4m clear width, allowing for a two lane single carriageway with a designated bus lane on each side and with cycle/footways on each side.
- Wing walls – construction and alignment of the wing walls will need to consider the construction method and the aesthetics of the structure.
- Feasibility of construction – the impact on route operation, for both the railway and highway and the method of construction will impact on the suitability of the options considered. The construction method will also need to consider any interaction with the existing structure and services.
- Impact on existing services – a large number of services are located at this site as shown by MMD-350164-C-DR-GP-XX-0001 in Appendix A. In order to maintain the existing track alignment the road below will require some lowering so provision for relocating services and their interaction with the construction phase will need to be considered when costing and planning all options.

2.2 Discarded Options

The following options were considered during the option selection process and discarded:

2.2.1 Prestressed, Precast Concrete Frame

In order to reduce the construction depth of the structure, a prestressed concrete frame including pre-tensioning and post-tensioning was considered, particularly for the wider carriageway options. Prestressed concrete results in a greater stiffness and improved elastic behaviours which could reduce the thickness of the slab required. Prestressing reduces cracking in the concrete, providing a more durable and aesthetically pleasing solution. The overall steel weight required for reinforcement can be reduced and is generally less congested than traditional reinforced concrete sections.

These benefits are particularly relevant to the largest option that will require a large construction depth to span the wider carriageway option and hence has a greater impact on the extent the carriageway will need to be lowered.

The prestressed concrete frame would need to be designed for the temporary load case of lifting and transporting the structure to its permanent position. This would result in requirement for a significantly more complex and expensive temporary support and bracing system for lifting and transportation.

However prestressing would present a maintenance issue as it would introduce hidden elements at anchorage points that could not be easily inspected as part of the Network Rail structures maintenance regime. Furthermore, due to the high loading from the track supported above, deflection will generally govern the thickness of the slab and hence the benefits of a prestressed system reduce.

2.2.2 Network Rail Standard Designs and Details

Network Rails Standard Design and Details (SDDs) as per NR/L3/CIV/151/F010 have been reviewed to determine whether any were suitable for the replacement bridge structure. The SDDs have been developed and approved with an aim of reducing the volume of maintenance and management, limiting hidden details and facilitating precast/preassembled construction methods. A series of concrete and steel arrangements are available to suit various spans and alignments.

The concrete underbridge standard details are generally suited to 2.5m to 20m spans which is not sufficient for the larger span options being considered. Whilst longer spans can be achieved, the increased weight and construction depth makes these options less favourable. The span/depth ratios are also greater than could be achieved from a bespoke design. The concrete elements can be precast offsite and the structure can be erected adjacent to the final position and manoeuvred into place, however this is not a common construction method when using the concrete SDDs or a cost effective solution.

The steel underbridge standard details Type D and Type E (NR/CIV/SD/1411 and NR/CIV/SD/1511 respectively) are suited to 12 to 30m spans and greater spans can be achieved using the half through box girder arrangement (NR/CIV/SD/1012). Whilst this is sufficient for the options considered, the designs only provide sufficient width for single or double track lines. Therefore two bridge decks would be necessary to carry the existing tracks and the switches and crossings (S&C) where the tracks converge. The eastern tracks (Up Tunnel and Down Bristol, with S&C) could be supported on a Type E deck and the western track (Up Bristol) on a Type D deck as shown in Figure 1. However a few issues arise with the use of the SDDs:

- There is currently insufficient space in the 10 foot to accommodate the two adjacent edge girders for each bridge without track realignment and creation of hidden critical elements.
- Additional checks would be required to ensure the Type E deck can accommodate the different load distribution of the S&C.

- The Type E deck is at its limit for width when providing a cess walkway.
- A cess could only be provided along the western edge of the bridge.

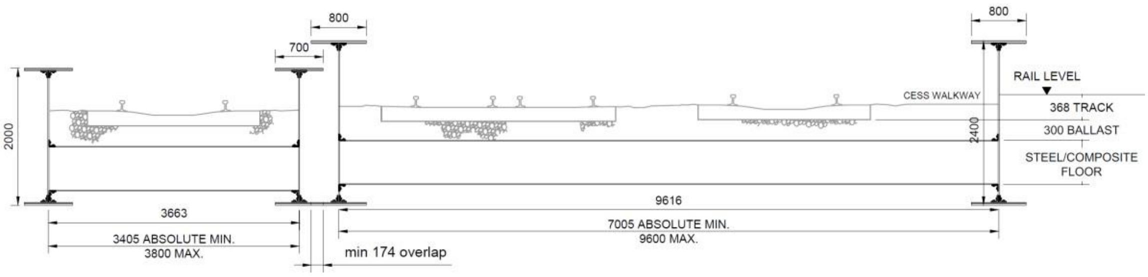


Figure 1 - Cross section illustrating a SDD deck arrangement without track alignment

The design does provide a relatively thin deck profile and therefore a reduced overall construction depth which results in less highway regrading. The deck can be manoeuvred into place by either lifting, sliding or self-propelled modular transporters (SPMT) and as a result a steel underbridge deck is suitable for installation during a possession.

The steel underbridge arrangement outlined above would have a reduced width compared to the existing bridge. To allow for the addition of another track in the future, the abutments can be extended and designed to allow for the installation of a further Type D deck to the west of the lines when required, or two Type E decks can be installed with only one track initially run on western span.

The design of the substructure and foundations is not part of the SDD. These structural elements have a key role in the considered construction phasing to minimise railway disruptions. The construction of separate abutments and foundations would have significant impact on the length of main possession required and hence is considered as one of the main disadvantages of using SDDs for this bridge replacement.

To limit the possession time required abutments could be created by boring/jacking through the embankment and filling with concrete. However overall construction time would increase as installation of bored/jacked elements is a slow procedure. Another limit to this method of abutment construction is access. Works to the southern abutment could be completed from the Rolls Royce east works site. However due to the close proximity of buildings to the north western embankment works could not be carried out from this side. There is space to the east however this would require additional site space and access restrictions.

Lifting the abutments together with the deck was considered, however due to the nature of the spans and bearing arrangement this is not preferred.

Due to the form of the bridges, the vertical loading on the abutment will be particularly high at midpoint where the main girders for each deck are located. To accommodate this, piles are likely to be required locally. As this falls between the tracks, this work would be carried out during shorter possessions prior to the main works. To limit overall track disruption, the piling rig could be positioned on the western side of the tracks, utilising the Down Bristol line for the work and allowing for shorter closures to the remaining lines. The width of the 10 foot and the available working space will restrict the number and position of the piles.

Although the use of steel SDDs may provide cost savings, the need for two bridges could remove much of the financial incentive for a standard design, requiring the construction of two bridges and the associated abutments which are not provided in the SDDs.

The requirements for joints and bearings in each of the concrete and steel standard designs present an additional maintenance issue and may pose difficulties in controlling differential movement of the supported track. Due to the track arrangement and presence of the S&C above the bridge, a fully integral structure would be better suited to reduce differential movement. The presence of multiple joints could also pose a corrosion problem, particularly to the underbridges utilising steel girders and beams. A filler beam deck, where the steel beams are encased in concrete, could be employed to reduce the risk.

Additional vehicle collision restraining devices may be required as the soffit of the new bridge will be lower than 5.7m and the bridge self-weight and rigidity alone is not likely to be sufficient to resist deck uplift in the event of a bridge strike.

Overall, the SDDs are less favourable options. The concrete underbridge provides issues with installation during a possession that would require design changes, thereby reducing the attractiveness of a 'standard' design and the deck depth would be greater than could be achieved with a bespoke design. The steel underbridge designs also have shortcomings; the necessity for two bridge deck installations, required track realignment, construction of abutments, the risk of corrosion and differential settlement are critical. Both steel and concrete underbridge SDDs will also limit any future changes that can be made to the track arrangement.

2.2.3 Bespoke Steel Deck

To avoid the need for track realignment and to suit the larger span options, a nonstandard steel deck could be utilised. However due to the width of the structure being approximately equal to the span, the transverse elements will need to be large to span between the main longitudinal girders, resulting in a greater construction depth. This could be reduced by using multiple box/plate girders. Having two unequally loaded spans creates torsion issues and may rely on large central girder with significant rotational stiffness. Box girders could be used for the main longitudinal members to overcome this.

As illustrated in Figure 2, if the span widths are matched, sufficient space for a cess and future additional track to the west can be provided. However this bespoke design is likely to require an increase in construction depth and will face the same issues regarding abutment and foundation construction as outlined for the steel SDDs above.

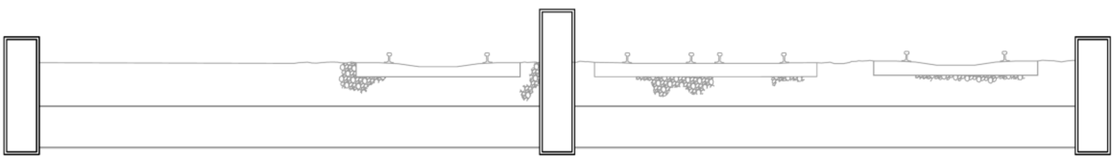


Figure 2 - Cross section illustrating a box girder deck arrangement

As identified for the steel underbridge SDDs, it is likely that additional vehicle collision restraining devices will be required to resist deck uplift in the event of a bridge strike. It will also be difficult to accommodate the additional overhead line equipment (OLE) gantry identified as being located on the bridge by the Great Western Electrification Programme (GWEP) and will limit any further changes to track alignment that may be required in the future.

Steel underbridges also present further maintenance requirements. Additional painting for corrosion protection is required and access to hidden/confined elements will also need be considered, particularly the confined space access required to inspect the inside of the box girders.

Overall it is concluded that due to the width of the bridge requiring deeper transverse elements and additional vehicle collision restraining devices, a more efficient design may be achieved through a reinforced concrete deck.

2.2.4 Jacked Concrete Box

Box jacking would involve thrusting a precast concrete box unit through the embankment, with materials from the face removed through the box. This construction method would allow for the tracks to remain operational, albeit with a speed restriction, whilst the precast box is jacked through the embankment. No track replacement would be required.

Although a thinner roof slab could be achieved with this option compared to a portal frame structure, the concrete box would require sufficient cover to prevent interaction with the track above in order to jack through the embankment below the operational railway. It will also be difficult to work around the existing masonry arch bridge when jacking the box through the embankment. The arch could be demolished ahead of the box as it is driven through the embankment but it will be difficult to maintain sufficient stability of the arch to keep the railway above operational. High resistance forces are required to jack the box through the embankment meaning extensive temporary works would be required. Therefore this would not be a cost-effective solution, particularly when compared to a cut and fill construction.

The base of the box would need to be below the carriageway build up. Additional space is also necessary for the relocated services which would further increase the box height. The existing services will require diverting prior to the box-jacking operations being undertaken, which will not be possible without top-down excavation. Realistically, the large and deep buried services cannot be relocated inside the box and therefore they will be inaccessible for maintenance for the length of the jacked box. The variability of embankment fill would pose another risk to box-jacking operations; any weak ground encountered would need additional treatment to stabilise the surrounding soil which will also impact on the time taken to carry out the works.

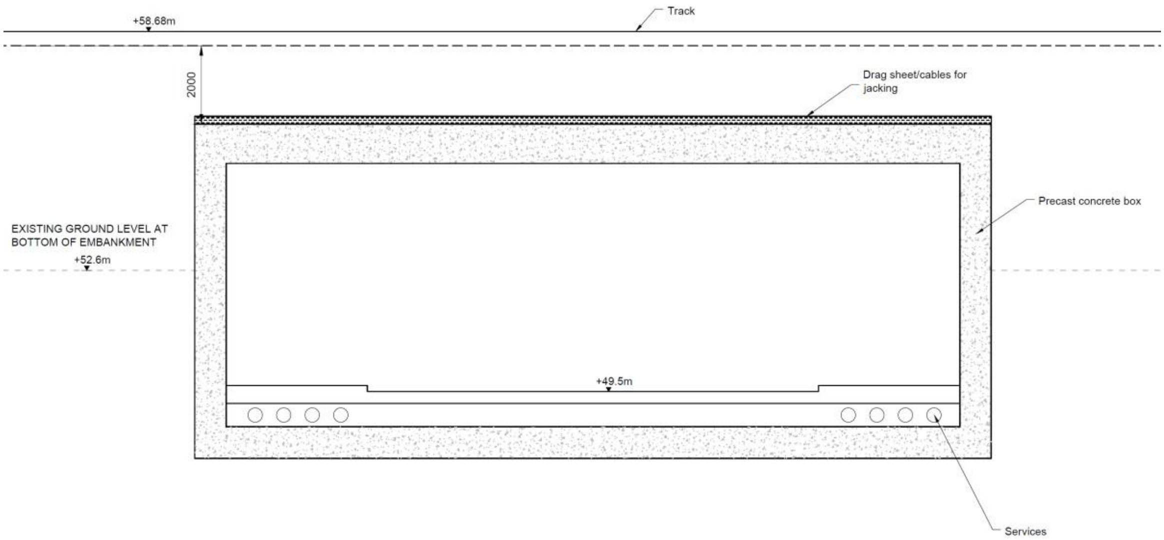


Figure 3 - Cross section of a jacked concrete box solution

2.2.5 Re-use of Existing Structure

The existing structure is considered to be in fair condition with no significant works planned in the immediate future, therefore consideration has been made for retaining and reusing the existing masonry arch bridge.

The existing structure has insufficient headroom for the bus route, consequently the carriageway would need to be lowered to provide the necessary clearances. Without significant underpinning works, lowering of the road to provide the desired clear headroom would undermine the existing foundations and pose a risk to the stability of the existing structure. The minimum carriageway clear width of 14.5m could not be achieved if both existing abutments are retained.

An option for adding cycle/pedestrian subways adjacent to the existing structure was considered, but this has been discounted as the space available for the highway alignment due to land ownership constraints is insufficient to provide suitable access to an adjacent subway.

Utilising part of the existing structure was also considered by breaking down the existing arch bridge and using the abutments in conjunction with a con arch; however this was deemed unfavourable as the option is better suited for overbridges carrying highways, and are not appropriate for rail loading.

Neither of the above two options could be adapted to provide an additional designated bus lane.

The Detailed Examination Report (dated 22/05/2013) considers the existing structure to be in fair condition, although it is clear that the waterproofing has failed and bridge strikes do occur. The work to replace the waterproofing to the masonry arch could be extensive, and it is likely that the condition of the existing structure will continue to deteriorate. For this reason, and the construction risks discussed, re-use of the existing structure has been discounted.

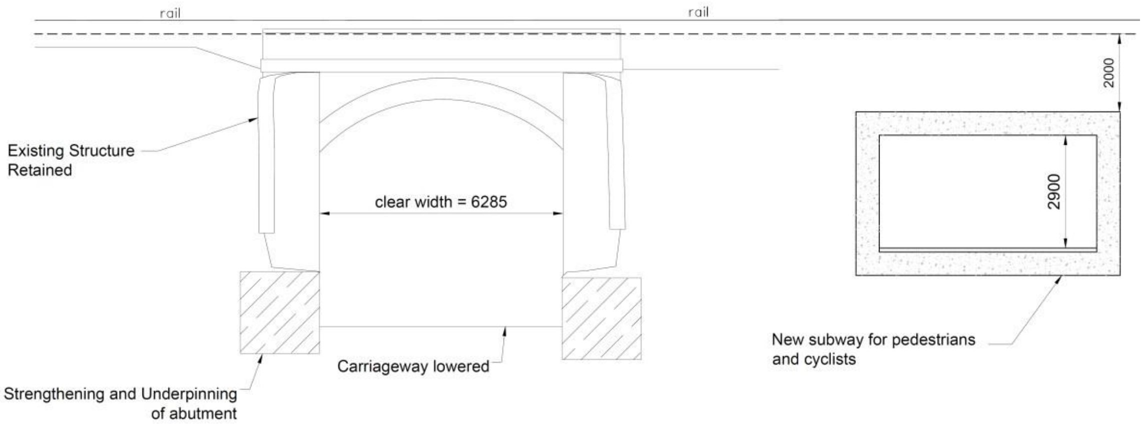


Figure 4 - General arrangement for retaining the existing structure

2.2.6 Raised Cycle/Footway

An option to construct the new cycle/footways at the existing ground level, with only the carriageway lowered to suit the head room requirements, was considered during the option selection process.

This would reduce the height of the new abutments as the foundations could be constructed at a higher level to suit the cycle/footway level, resulting in less excavation works for the highway and structure. The carriageway gradient could be steepened because it would no longer be limited by the shallower gradients required for cyclist and pedestrian users. This would reduce the extent of highway re-grading that would be required and the extent of buried services affected; although the sag curve compensation for headroom would need to be increased to account for the steeper gradient. A structure free zone to TD 27/05 would also not be required above the cycle/footway and the space could be utilised to form a haunch to the portal frame corners which would result in a reduced slab thickness. Additionally, the area below the cycle/footway could be used to relocate the buried services preventing the need to lower them further.

As the raised cycle/footway would be significantly higher than the new carriageway, a retaining wall capable of withstanding vehicle impact would be necessary. This retaining wall would need to extend beyond the bridge until the footway and carriageway levels meet. Fall protection would need to be provided at the footway level in the form of a guardrail. Both the guardrail and the retaining wall would create additional assets requiring maintenance by SGC and are not considered favourable aesthetically.

Temporary signals would be required to inspect or maintain the retaining wall and these retaining walls could hinder maintenance access for inspection of the bridge soffit. The retaining walls will prevent broken down vehicles moving to the side of the carriageway, and so will hamper traffic flow in the event of an incident.

SGC have advised that both the carriageway and footway width would need to be widened for this option, which would increase the overall span of the structure: the requirement would be a 1m (minimum) wide hardstrip to both sides of the carriageway and the footway width would need increasing to 4m to provide additional handlebar allowance. The guardrail and level difference would also prevent pedestrians from crossing the road. Furthermore, concern was raised over the pedestrian sightlines of this arrangement.

For these reasons, and following consultation with SGC this option has been discounted.

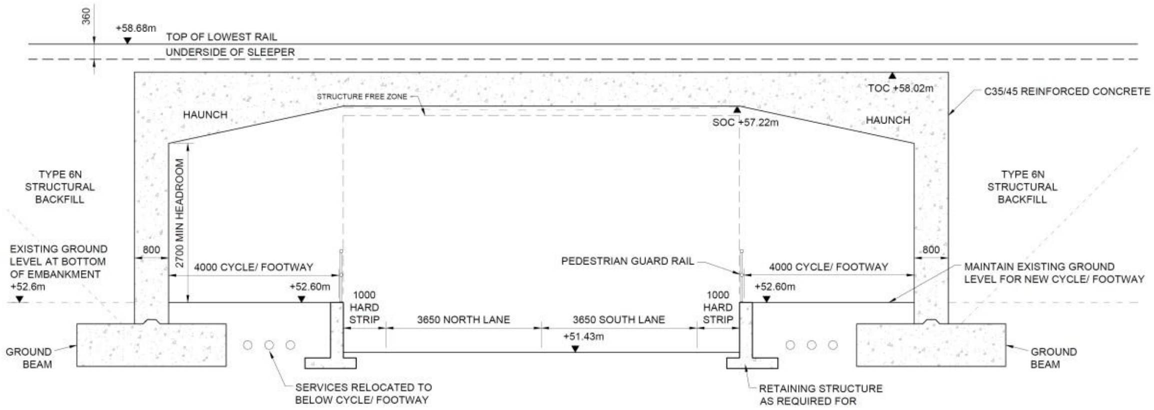


Figure 5 – Cross section of the raised cycle/footway option

2.2.7 Intermediate Supports

To accommodate the wider carriageway option, additional intermediate supports were considered. Additional piers would reduce the individual span lengths and hence the construction depth could be reduced. This in turn would reduce the extent to which the carriageway would require lowering to achieve the minimum clear headroom. The additional support would also further disperse the foundation loading.

As shown in Figure 6, various arrangements of intermediate supports were considered to suit the carriageway layout and construction methods.

A single intermediate support could be provided as per Figure 6a, segregating the wider cycle/footway from the main carriageway. This would provide an integral structure, with no joints to maintain, and results in a reduced construction depth. However the mid-support location will clash with the existing structure so would require earlier road closure to undertake any preliminary foundation works.

Two intermediate supports as per Figure 6b or Figure 6c could be provided, segregating both cycle/footways from the main carriageway. This option would further reduce the construction depth.

The arrangement as per Figure 6b considers providing boxes to the outer spans that could be ground bearing in order to further spread the loads to the foundations. This structure can also be cast integral with no requirements for joints and the construction depth can be reduced even further. The top of the boxes could incorporate a sloping transition zone as the headroom required for the cycle/footway is less than that of the main carriageway. This option would present issues in moving the proposed structure into place using SPMTs as there is insufficient space within the central span to fit enough SPMT units to lift the full structure weight and overcome the uneven loading due to the wider cycle/footway on one side. To overcome this, temporary brackets could be fitted to the outside of the structure for SPMT lifts but this would require much larger excavation of the embankment to manoeuvre the structure into place.

By removing the bottom slab as per Figure 6c, SPMTs could be used from within each span of the portal to lift the structure. However a fully integral arrangement as shown presents uplift issues to the outer spans under live loading that cannot be overcome without providing oversized footings which would significantly increase the cost and further increase the embankment excavation required. Constructing the structure in separate spans would present further difficulties. Additional cranes would be required to lift the smaller outer spans into position or significant temporary works would be required to use SPMTs for the full lift.

The option to construct a central portal frame for the main carriageway and further box subways for the cycle/footways was also considered (Figure 6d). The main portal would be manoeuvred into position and the outer box subways lifted in sections using cranes. This arrangement would also allow the transition zone to be incorporated within the main structure envelope. The box subways could be ground bearing and the reduced portal size would also result in smaller foundations being required for the main span. However multiple lifts would be required to manoeuvre the box subways into position extending the construction time and the joints introduced could pose a maintenance issue. Consideration would need to be made to accommodate any differential settlement between the main portal frame and the outer box culverts.

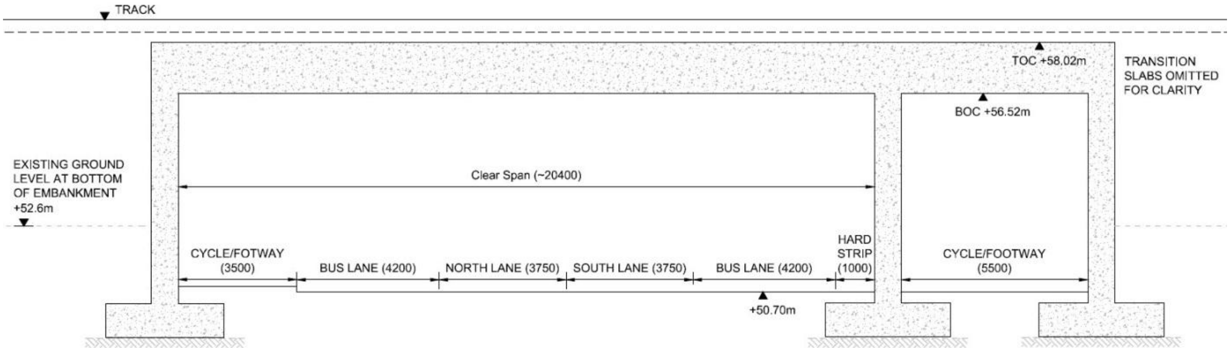


Figure 6a

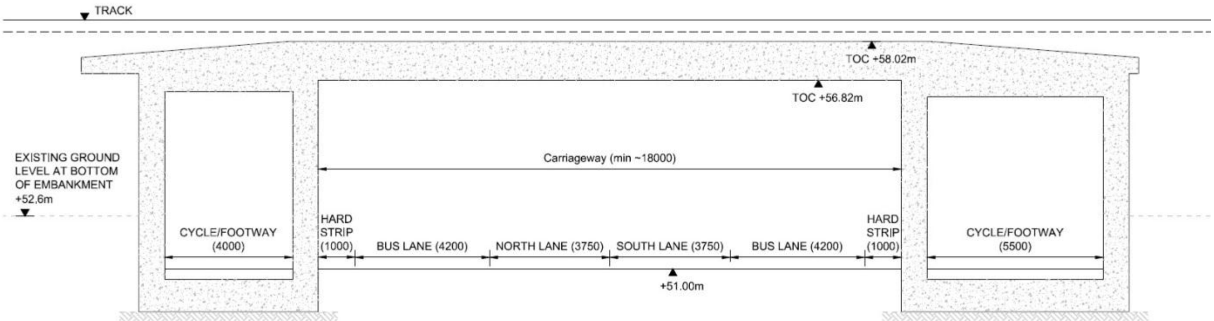


Figure 6b

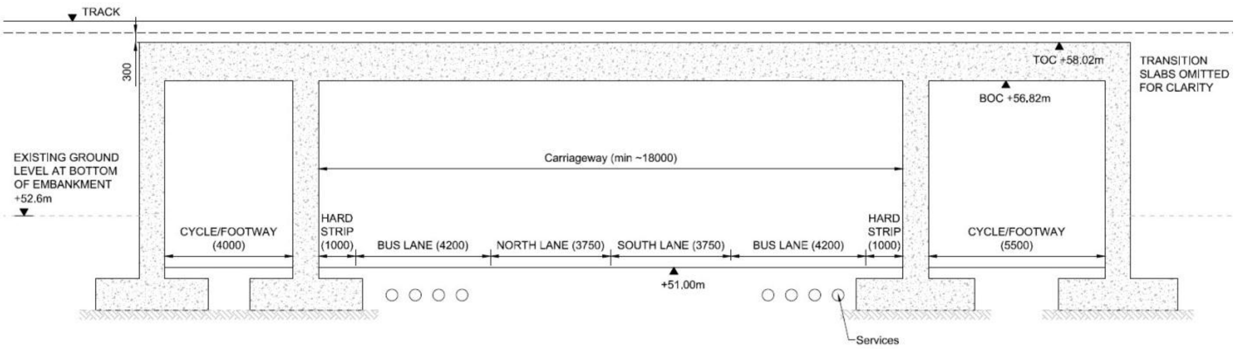


Figure 6c

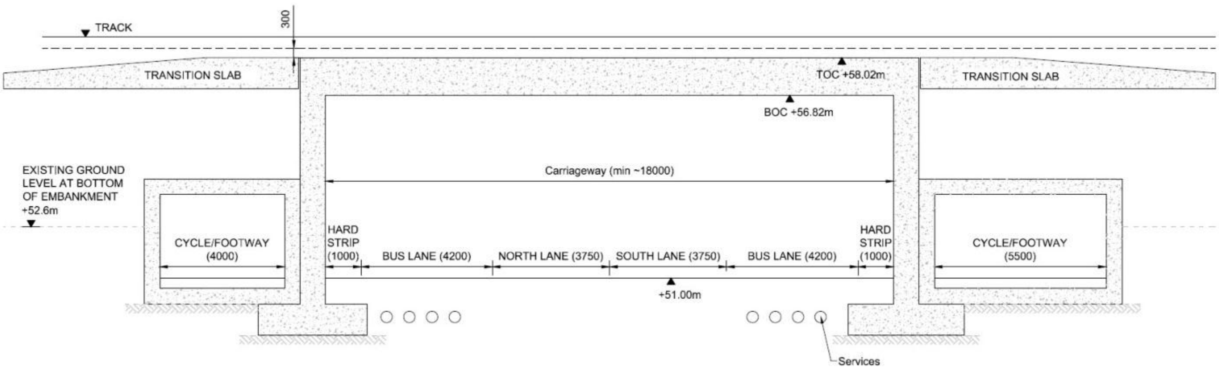


Figure 6d

Figure 6 - Various intermediate support arrangements

As per the raised cycle/footway option previously discussed, the introduction of intermediate supports would mean the carriageway and cycle/footway width would need to be increased to accommodate additional hardstrips and handlebar allowance. This, along with the width of the additional piers, will increase the overall size of the structure required. The constructability issues related to each option outlined above will also outweigh the benefits gained from the reduced construction depth.

Maintenance, inspection and repair works to the whole structure could not be undertaken from the cycle/footway if they are segregated from the main carriageway so road closure would be required. The intermediate piers will also restrict the opportunity for any future carriageway layout options and create additional buffer zones on the highway approach to the structure.

For these reasons and following further consultation with SGC and Network Rail, these options for providing intermediate supports have been discounted and a preference for a clear single span structure indicated.

2.3 Bridge Structure Options Considered

A concrete portal frame structure was determined to be better suited for the bridge replacement. A portal frame can be precast and manoeuvred into position in order to significantly reduce the possession time required to replace the existing bridge structure. The potential availability of a pre-casting yard adjacent to the existing structure has made this option particularly viable.

A portal frame will provide an open base to suit the existing buried services and will not impede on future maintenance access. A cut and cover construction will permit shallow ballast depths which overall reduces the amount of road lowering needed to provide the required headroom below. A structure-free zone must be provided above the full carriageway, including the cycle/footway, so a haunch cannot be used to further reduce the construction depth.

Concrete structures are more durable and therefore require less maintenance. A plain, smooth concrete finish is considered desirable to SGC.

This arrangement has been further developed into six main options for consideration. These incorporate different carriageway arrangements and different alignments of the structure relative to the track. These options have been summarised in the matrix found in Table 1 in Section 2.19. The matrix table has been used to evaluate each option and aid selection of the preferred option.

2.3.1 Option 1 – No Bus Lane (skewed to the track)

Option 1 is to provide a precast reinforced concrete portal frame structure with a 14.5m clear span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width for a 7.5m single carriageway with 3.5m wide cycle/footways either side. For analysis purposes, the effective span of the portal frame 15.5m.

Due to the skew to the track, transition slabs will be required for each track to limit track movement due to any differential settlement. Separate transition slabs will be provided for each track with a 1:30 crossfall towards the cess to facilitate drainage.

Refer to drawing number MMD-350164-C-DR-GP-XX-0011 in Appendix A for further details.

This proposal is the smallest option and therefore has the least materials required, less cut and fill and the least spoil to remove. The smaller span allows for a thinner slab which reduces the overall construction depth and the extent to which the road will require lowering. Therefore this option will have the least impact on the existing buried services.

The proposed alignment of the abutments allows for the wing walls to also be aligned parallel to the carriageway and they could be integral with the main structure. However, the reduced span will pose construction issues as the envelope of the new structure will clash with that of the existing masonry arch bridge making it difficult to commence any construction, such as preliminary foundation works, prior to demolition or without temporary works.

This option does not provide sufficient clear width to achieve a carriageway layout with a designated bus lane(s).

2.3.2 Option 2 – Single Bus Lane (skewed to the track)

With this option it is proposed to provide a precast reinforced concrete portal frame structure with a clear 18.7m span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width, sufficient to provide a 7.5m single carriageway plus a 4.2m designated bus lane with 3.5m wide cycle/footways either side. For analysis purposes, the effective span of the portal frame is 20.5m.

As per option 1, transition slabs will be required for each track to limit track movement due to any differential settlement. Due to the wider span of the structure, the new bridge abutment will be located closer to the crossing point of the central track S&C. As this is more sensitive, the transition slab will need to be extended past the crossing in order to reduce movement of the track at the crossing point.

Refer to drawing number MMD-350164-C-DR-GP-XX-0012 in Appendix A for further details.

This option provides sufficient width for a designated bus lane whilst keeping the overall structural envelope to a minimum. By aligning the abutments with the carriageway, no redundant areas are created and, as with option 1, the wing walls can be aligned parallel to the carriageway and constructed as part of the main structure.

The increased span will require a thicker slab so the overall construction depth will be increased. The road level will need to be lowered accordingly to provide the necessary headroom which will result in a greater length of the existing road needing reconstruction in order to tie into the existing highway alignment. This will result in a greater impact on the existing services.

The alignment of the proposed carriageway should be carefully considered for this option. Currently two alignments have been proposed by CH2M with the additional bus lane located on either the north or the south side of the main carriageway. Providing the bus lane on the north side of the main carriageway results in the proposed south abutment and wing wall clashing with the existing bridge. This will limit any work that can be undertaken prior to demolition. If the bus lane is located on the south side, then the proposed structure should be sufficiently clear of the existing bridge to undertake preliminary foundation works.

2.3.3 Option 3 – No Bus Lane (square to the track)

Option 3 is to provide a precast reinforced concrete portal frame structure with a 19.5m clear span, square to the track alignment. To provide a structure square to the track alignment, the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear carriageway width of 14.5m which is sufficient for a 7.5m single carriageway and 3.5m wide cycle/footways either side.

Providing a structure that is square in relation to the track alignment is the preferred option with regard to track sensitivity. It ensures that the support to the track is uniform across the width of the sleepers and the risk of issues arising from differential settlement is reduced. However, a larger structure is required to ensure sufficient clearance is provided for the carriageway whilst maintaining the straight alignment to the track. This will move the proposed abutments closer to the crossing of the S&C. Due to the sensitivity of the S&C to track movement, it is likely that a transition slab will still be required despite the abutment being square to the track. The transition slab will need to extend past the crossing point to accommodate the tighter tolerances on this track.

Refer to drawing number MMD-350164-C-DR-GP-XX-0013 in Appendix A for further details.

This proposal has a greater span but does not gain any additional clear width available for the carriageway. However, this greater span does result in the proposed structure being sufficiently clear of the existing masonry arch bridge to allow for preliminary foundation works to be undertaken prior to demolition of the existing structure.

The larger span and angle of the structure creates redundant areas which can become a maintenance issue. A thicker slab is needed to achieve the larger span therefore a lower road level will be required, having a greater impact on the existing services.

With this proposed arrangement it will not be possible to align the wing walls with the abutments as they would impede on the carriageway alignment. Greater excavation of the embankment will be required to drive a portal frame with skewed wing walls into place. Skewed abutments in relation to the highway alignment are not desired as they are aesthetically unpleasant to the travelling public at road level.

2.3.4 Option 4 – Single Bus Lane (square to the track)

This option is to provide a precast reinforced concrete portal frame structure with a 23.44m clear span, square to the track alignment. As with option 3, in order for the structure to be square to the track alignment, the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear width for a carriageway of 18.7m which is sufficient for a 7.5m single carriageway, 4.2m designated bus lane and 3.5m wide cycle/footways either side.

As with option 3, the alignment of the structure is most suitable to reduce the risk of differential settlement, however the much larger span will result in the abutments being located below the sensitive track crossing and therefore a transition slab will still be required below this track. The transition slab will need to extend past the crossing point in order to accommodate the tighter tolerances of the S&C track.

Refer to drawing number MMD-350164-C-DR-GP-XX-0014 in Appendix A for further details.

As with option 3, the angle of the structure also creates redundant areas which can become a maintenance issue. The additional span length ensures sufficient clearance to the existing structure to facilitate undertaking early foundation works.

This option presents a larger structure than option 2 and therefore it will require more materials, greater excavation and larger volume of spoil to be removed but does not benefit from any additional carriageway space. The longer span will require a thicker slab and therefore further lowering of the existing road level below to maintain the existing track level. The extent of the road lowering and the additional span will have a much greater impact on the existing services.

The envelope of the structure comes close to the Network Rail and SGC land ownership boundaries and it is likely that excavations to construct the new structure will extend outside of the land ownership boundaries.

As with option 3, the wing walls cannot be aligned with the abutments as there is not sufficient clearance to the carriageway so greater excavation of the embankment will be required to drive a portal frame with skewed wing walls into place. Skewed abutments in relation to the highway alignment are not desired as they are aesthetically unpleasant to the travelling public at road level.

2.3.5 Option 5 – Dual Bus Lane (skewed to track)

This option is to provide a precast reinforced concrete portal frame structure with a 24.4m clear span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width for a 7.5m single carriageway plus a 4.2m designated bus lane with a 3.5m cycle/footway to the north and a 4.2m designated bus lane with a 5.0m cycle/footway to the south. For analysis purposes, the effective span of the portal frame is 24.8m.

As per options 1 and 2, transition slabs will be required for each track to limit track movement due to any differential settlement as a result of the skewed alignment. Due to the wider span, the abutments will be located below the S&C and as such the transition slabs will need to extend past the crossing to reduce movement in the sensitive mechanisms.

Refer to drawing number MMD-350164-C-DR-GP-XX-0015 in Appendix A for further details.

This option provides sufficient width for two designated bus lanes and wider shared cycle/footway to the south, whilst minimising the overall structural envelope required. As with option 1 and 2, the wing walls can be aligned parallel to the carriageway and constructed as part of the main structure.

The envelope of the structure comes close to the Network Rail and SGC land ownership boundaries and it is likely that the carriageway will exceed the SGC ownership boundaries on the approach to the bridge. It is anticipated that excavations to construct the new structure will need to extend outside of the land ownership boundaries.

2.3.6 Option 6 – Dual Bus Lane (square to track)

This option is to provide a precast reinforced concrete portal frame structure with a 29.3m clear span, square to the track alignment. As with options 3 and 4, to accommodate a structure square to the track alignment, the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear width for a carriageway of 24.4m which is sufficient for a 7.5m single carriageway plus a 4.2m designated bus lane with a 3.5m cycle/footway to the north and a 4.2m designated bus lane with a 5.0m cycle/footway to the south.

As with options 3 and 4, the alignment of the structure is most suitable to reduce the risk of differential settlement, however the much larger span results in the abutments being located directly below the sensitive track crossing. Therefore a transition slab will still be required to extend past the S&C in order to accommodate the tighter settlement tolerances for this track.

Refer to drawing number MMD-350164-C-DR-GP-XX-0016 for further details.

This option presents the largest structure therefore it will require the greatest space, most materials, greater excavation and larger volume of spoil to be removed. The longer span will require the thickest slab and therefore the most lowering of the existing road level below to maintain the existing track level. The extent of the road lowering and wider span will have the greatest impact on the existing services.

As with options 3 and 4 the wing walls cannot be aligned with the abutments as there is not sufficient clearance to the carriageway so greater excavation of the embankment will be required to drive the portal frame into place. As previously discussed, this wing wall arrangement is not preferable aesthetically to the travelling public at road level.

2.4 Wing Wall Options

Two types of wing wall construction have been considered during the option selection process: sheet piles or reinforced concrete wing walls. These could either be straight and aligned with the bridge abutments, or splayed. Refer to drawing number MMD-350164-C-DR-GP-XX-0021 in Appendix A for further details. Gabion wing walls were also considered however they would require more excavation, slower construction and present a maintenance issue so this option was discarded.

Sheet pile wing walls could be utilised to create a clear worksite and reduce the amount of excavation required and the extent of backfilling. They could be installed in smaller possessions if necessary, ahead of the main construction works. Some pre-auguring may be required due to the mudstone bearing strata. The sheet piles would require some form of facing or cladding to improve their appearance and suit SGC's preference for concrete finish. This would hide the structural element, which is not preferable for Network Rail as it presents access issues for their inspection and maintenance regime.

Reinforced concrete wing walls can be pre-cast either as part of the main portal bridge structure or separately. They will require further excavation and backfilling to construct but will suit SGC's preferences for a plain smooth concrete finish whilst remaining easily accessible for Network Rail's inspection and maintenance regime.

Splayed wing walls will take up a larger area and hence will require more excavation (and backfilling if constructed from concrete), however they are generally preferred aesthetically by public users as they differentiate between the main bridge abutment and the ground retaining wing wall. Splayed wing walls will need to be much longer in order to accommodate the existing ground topography which will result in greater cost and construction time. This will also result in the wing walls clashing with the existing pill box and they may begin to impede on the nearby buildings such as the local business to the north west and residential garden to the south east. For the larger bridge spans, this arrangement may extend past the current Network Rail and SGCs land ownership boundaries.

Straight wing walls, in line with the bridge abutments, will take up much less space and a shorter length is required to retain the existing embankment.

Any reduction in the main possession time from constructing sheet piled wing walls is expected to be relatively small and hence it is recommended that the wing walls are constructed from precast concrete and cast integral with the main bridge structure. This will allow for the entire structure to be lifted and moved into position together. Straight wing walls, in-line with the abutments will be most suitable for lifting with the main bridge structure. If splayed wing walls are preferred or necessary due to the bridge alignment, greater excavation of the embankment will be required to drive a portal frame with skewed wing walls into place. Alternatively the wing walls can be precast separately or cast in-situ and connected to the main bridge structure after it has been positioned, however this will increase the construction timing and may impact on the re-opening of the line.

2.5 Foundation Options

Given that the demolition of the existing structure and installation of the precast portal frame will be required to be completed under an abnormal 100 hour possession, construction of piled foundations along the length of the abutments during the possession is not considered to be feasible due to the construction time.

As the foundation will need to be incorporated with the other construction activities to be undertaken within the limited possession time available, it is considered that precast strip footings would be the preferred foundation option for the portal frame structure due to the speed and ease of construction, and the fact that the portal frame can also be slid into place and form an integral unit with the strip footings.

However, it is uncertain whether the foundation is to be founded on the firm to stiff clay layer or the underlying Blue Lias mudstone/limestone formation due to the variation in the historical borehole logs, with the mudstone/limestone stratum encountered at between 47.54 and 49.52m AOD.

In the absence of more accurate soil information, the foundation has been designed to be founded on firm to stiff clay at this stage of the scheme and therefore some form of ground improvement or piled supports to be constructed offline will be required in order to provide the bearing resistance required for the new structure.

The following foundation options have been considered to provide the bearing resistance required for the new portal frame structure.

Options	Advantages	Disadvantages
Ground beam spanning between piles and pile caps on either ends of the beams	• least disruption to the railway as the piling works can be done offline	• Differential settlement along the spread footing
Spread footings with dig and replacement	• Cost saving as no piles are required • Simple and quick to construct	• Uncertainty in depth of excavation and foundation required due to the variation indicated in historical borehole logs • Extra time required to excavate and backfill material during the possession
Spread footings with ground improvement	• Cost saving as no piles are required	• Uncertainty in design based on the limited information to inform ground improvement • More expensive than dig and replace
Spread footings with stone columns/pre-cast piles below the shallow foundation	• No concrete curing time required compared to RC piles	• Additional construction time required during the abnormal possession to install the stone columns/piles • More expensive than the shallow foundation options

Options	Advantages	Disadvantages
Piled foundation through tunnel rings to be driven through the embankment on either side of the existing masonry bridge	• Most foundation works can be done prior to the main possession	• Very expensive • Risk of settlement at track level during the piling work • Risk of being unable to bore through the natural ground using piling rigs that can operate within the restricted headroom of the tunnel rings • Uncertainty as to the stability of the tunnel rings during the piling works • Possible additional bracing to tunnel rings whilst forming piles

On the basis of the table above, it is considered that the preferred option at this stage of the scheme would be ground beams spanning between piles at either end due to the lowest possession time requirement compared to other options whilst providing a design to accommodate the uncertainty of rock head levels. However, targeted ground investigation in later design stages may present value engineering options to further develop the foundation design by reducing or eliminating the piles at either ends of the ground beam.

2.6 Works Not Requiring Option Selection

Areas which do not require option selection are outlined below:

2.6.1 Track Alignment

Network Rail have advised that the track construction in the areas around Gipsy Patch Lane Bridge has recently been replaced and some of the S&C track is modular. As such, the existing track is to be reinstated to the same line and level as existing following the construction of the new bridge. There are no further known track works proposed in the vicinity of the bridge.

2.6.2 Headroom

In accordance with NR/L3/CIV/020, in the design of new spans over highways the headroom from the soffit should be not less than 5.3m and at least 5.7m "where this can be achieved with reasonable economy". Providing 5.7m headroom below the replacement structure will require extensive lowering of the existing carriageway which will have a significant impact on the existing buried services under the bridge and the length of the carriageway that will need regrading. Major diversion of the multiple services and the extensive works required to tie the lowered carriageway in with the existing highway is not considered achievable without unreasonable cost.

Therefore the minimum highways requirement of 5.3m + allowance for sag will be adopted. This is an improvement on the existing structure and in line with the requirements of TD27/05. As this is less than 5.7m the superstructure will need to be designed for vehicle collision loads as per NR/L3/CIV/020 cl 9.11.2.

Following consultation with the Structures Route Asset Manager (RAM) at Network Rail, as a result of the design having 5.3m + sag headroom, it was identified that additional mitigation is required to prevent projectiles landing within the railway kinematic envelope in the event of a bridge strike. It is proposed that this is addressed by providing parapets to act as a sufficient barrier as outlined below.

2.6.3 Parapets

The parapets will be constructed from precast reinforced concrete and installed after the main bridge structure has been constructed and driven into place. The parapets could be precast with the main portal frame but this would increase the overall height of the structure so it may impede on the temporary cable bridge supporting services at track level.

The parapets will need to be capable of preventing any debris from a bridge strike at highway level being thrown forward into the train envelope. To further allow for this the parapets will be 1.25m above rail level, this is also higher than the parapet level of the current structure so is an overall improvement in terms of protection of the railway.

2.6.4 Drainage and Waterproofing

A trackbed investigation was undertaken by URS prior to track renewals in 2013/2014. The investigation found that the trackbed drainage was poor and recommended that a full lineside drainage system be installed and tied in with the proposed track bed design. It is not clear if this was provided as part of the track bed renewal works, but it is recommended that cess drainage be provided as part of the track replacement works for the construction of the new bridge.

In order to prevent build-up of pore water pressure behind the new abutments, drainage should be provided at the bottom of the abutments, running the full width of the portal frame and wing walls. Design should consider discharge of this drainage into the existing highways surface water system however it should be noted that this will need to be allowed for in the carriageway pump capacity and drainage being installed as part of the highways design.

Waterproofing of the proposed bridge structure should be provided to suit requirements of NR/L3/CIV/041. It is proposed to provide two layers of bituminous paint to all buried faces. It is anticipated that the entire structure can be cast integral without any joints so special waterproofing around joints will not be required for the main structure. If transition slabs are required, the waterproofing should extend over the transition slab and waterproof buried joints should be provided between the transition slab and bridge abutments.

2.6.5 Width of Bridge

It is proposed to replace the existing bridge with a structure of the same width in order to suit the existing track and embankment alignment. The proposed bridge will follow the same alignment as the existing parapets and track is to be reinstated to the same alignment.

The existing arrangement provides sufficient room for a place of safety to the east side of the tracks and a larger, mostly redundant area to the west, sufficient to provide a safe cess walkway.

It is anticipated that an overhead line equipment (OLE) gantry will be located on the bridge as part of the GWEP which could impede on the place of safety to the east of the track. There is the opportunity as part of the GRIP 3 process to consider the bridge alignment to ensure sufficient room is provided for a cess walkway to the east of the track after the OLE gantry is installed without significant impact on the design or cost.

The mostly redundant area to the west of the tracks will be retained to avoid major realignment of the embankment and retain the available width at track level. Whilst no further track works have been identified for this area, this will also maintain potential growth opportunities for the route. As such, the proposed replacement structure will be designed to accommodate loading from an additional track.

2.6.6 Finishing Works

There is no requirement for additional lighting to be provided to the finished structure. All exposed concrete surfaces are to receive a plain, smooth finish with an anti-graffiti coating.

The carriageway will be reinstated in accordance with the highways design following the bridge construction.

2.6.7 Foundation Connection

The ground beams will be constructed integral with the portal frame and lifted onto the pile caps. A shear key can be provided if the friction between the ground beam and the pile cap or ground is not sufficient to resist the lateral loading.

2.7 Constructability Assessment

2.7.1 Construction Sequence

The design options for the replacement bridge structure have been developed alongside a proposed construction sequence in order to limit the impact on the operational route and highway traffic as far as reasonably practicable during the works.

The highway works are being designed by CH2M and are not included in the below construction procedure unless pertinent to the bridge design.

A construction sequence drawing can be found in Appendix A ref. MMD-350164-C-DR-GP-XX-SK004. A proposed sequence for installing the bridge replacement is as follows:

Construction stage	Access Provision
• Set up pre-casting yard on Rolls Royce East Works site and site compound at a suitable location • Construct the portal frame in one element with wing walls, waterproofing, ground beams and wing wall fencing pre-attached	None
• Install traffic management and close highway • Undertake relevant highways work, including buried and overhead services relocation where required • Undertake site clearance, including relocation of electrical cabinets located to the north west of the bridge • Construct large diameter piles and pile caps for new structure (this activity may require advance temporary works) • Prepare highways for SPMTs (additional work will be required at later stage once the bridge has been removed and highway widened) • Ground water management	Full carriageway and footway closure Diversion in place Railway operational
• Install temporary cable bridge for track level services • Construct access road up embankment from site compound	Short railway possession prior to main works
• Remove track and ballast • Demolish the existing masonry arch bridge, contractor to ensure that arch is uniformly unloaded during demolition to maintain stability • Remove embankments back to required slope (sheet piles could be utilised to reduce extent of excavation), all spoil temporarily stored in site compound • Prepare excavated area below demolished bridge and embankment for SPMTs • Dig ground beam foundation pits and prepare bearing strata	Abnormal rail possession of all tracks Full carriageway and footway closure Diversion in place

Construction stage	Access Provision
• Move portal frame into location using SPMTs, legs of portal frame to be propped during transport • Backfill bridge and regrade embankment slopes using type 6N structural fill, compacted as required • Lift and install pre-cast transition slabs • Install embankment and track drainage • Lift in precast parapets and guardrails (if not constructed integral with the main bridge structure) • Reinstate bridge deck services and remove temporary cable bridge • Re-lay ballast and tracks	
• Finish embankments profile, apply top soil and seeding • Reinstate services • Undertake carriageway works, including re-profiling the road and new cycle/footway • Demobilise site and return highway to local authority	Full carriageway and footway closure Diversion in place Railway operational

2.7.2 SPMTs

A number of self-propelled modular transporter units (SPMTs) will be utilised to support and lift the pre-cast portal frame into place. The SPMTs as a whole are capable of turning around its centre and moving sideways.

They can move over a variety of surfaces provided the bearing capacity is great enough; loading is likely to be in the order of 10 tonnes/m^2 or less. For fill material a trackway is required to prevent the wheels from digging into the fill. If required, the trackway, timber mats or a geocell system can be utilised to further spread the loading and protect buried services below.

One of the major advantages of using SPMTs is the ability to lift a whole structure into place without the needs for joints; as a result many potential maintenance problems can be avoided such as hidden details and waterproofing issues.

From guidance given by Mammoet, a single 8400x2430mm train unit can support a structure of 168 tonnes, taking into account the weight of supporting steelwork.

Figure 7 and Figure 8 provide an example of the SPMT arrangements based on this capacity for the smallest (Option 1) and larger (Option 4) portal frame proposed.

An important feature of these arrangements is horizontally propping the legs of the frame during lifting. This will have implications for the loading cases used in the structural design.

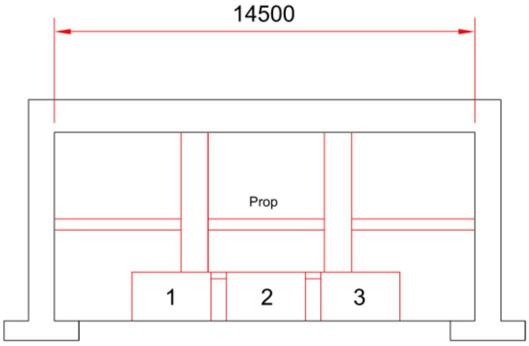


Figure 7 - Section view of potential Option 1 SPMT arrangement

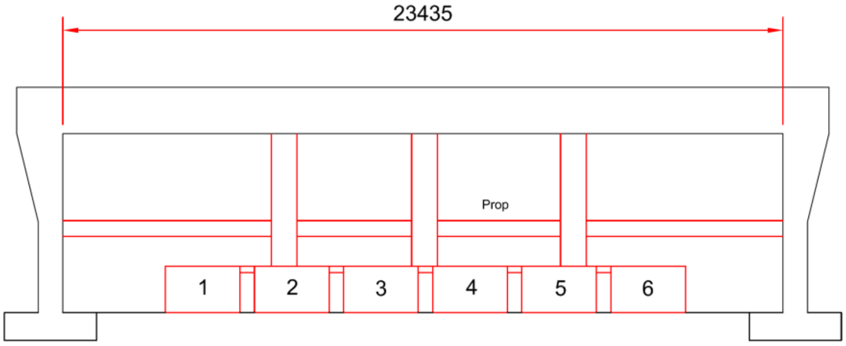


Figure 8 - Section view of potential Option 4 SPMT arrangement

For the largest (Option 6) portal frame proposed, sufficient clear width between the ground beams must be provided to fit the required arrangement of SPMTs in order to lift the full structure as shown in Figure 9. To accommodate this, the ground beams will be aligned off centre from the main abutments. Alternatively the structure will need to be constructed in parts and each section moved into position separately and jointed, however this will increase the construction time and introduce joints which will require future maintenance.

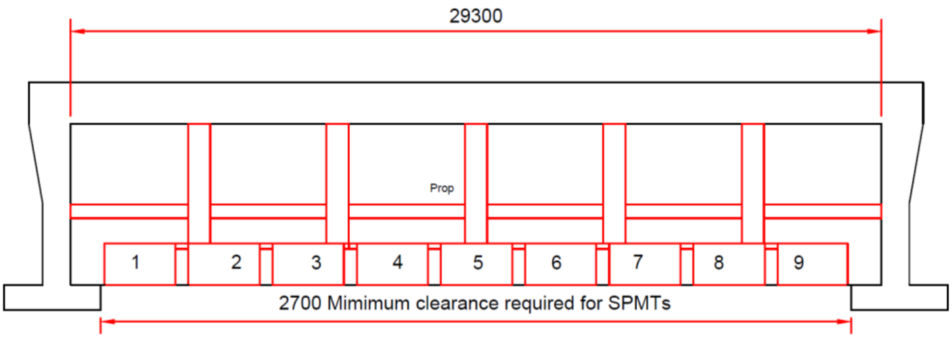


Figure 9 - Section view of potential Option 6 SPMT arrangement

2.7.3 Construction Risks

The key construction risks that have been identified are:

- The existing water table (+50.87m) is within the construction zone, and must be considered for foundation design and construction
- Completion of the necessary works within the possession time
- The use of SPMTs is an innovative construction method
- The instability of the existing structure. Although the visible bridge structure appears in fair condition, the soffit could not be inspected due to steel sheeting. Later design stages must ensure the demolition sequence is fully considered.

For the full project hazard log see Appendix B.

2.7.4 Site Compound

During the works it is anticipated that the site compound will require:

- Area for casting of the portal frame and associated works (75m x 75m = 5625m^2)
- Site offices, welfare and parking – 5625m^2
- Spoil storage – 5625m^2

Considerations for the selection of the site compound(s) should include:

- Casting of the portal frame should be carried out close to the site to limit the route of the SPMTs
- Mains water provision will be required
- Site access and impact on residents
- Haulage availability to remove spoil during proposed works
- Walking distance from site to the welfare facilities

The contractor is to confirm exact site requirements at a later GRIP Stage.

For option 6 it should be noted that a relatively larger area will be required for the pre-casting area and spoil storage.

2.7.5 Fence and Boundary Review

As part of the works the Network Rail boundary fences will require temporary removal local to the works. This includes all fencing along the wing walls and to a distance along the embankment sufficient to allow for the bridge widening and access for the works.

The widening of the highway will also require the removal of an access gate for electrical cabinets on the north west of the bridge. This is to be reinstated to suit the relocated electrical cabinets.

New wing wall fencing is to be installed as part of the proposed works.

Private fencing will also be affected by the works, with the extent also dictated by the highway works.

Private fencing will also be affected by the works, with the extent also dictated by the highway works.

The private boundary to the north west of the bridge should be maintained during the works, due to the proximity of the property to the fence line. The fence line should be protected as necessary throughout the works.

The Rolls Royce East Works site, road side and rail side boundary fence will be removed as part of the works with the length of the removal to allow for provision of an access route up the embankment to the track level and for the SPMT route.

Trees along the road and in proximity to the slope will also require removal and this is detailed further in the Environmental Impact Assessment in Section 7.

For details for the existing fence and boundary refer to Existing General Arrangement drawing re MMD-350164-C-DR-GP-XX-0002 in Appendix A.

2.8 Access and Possession Strategy

It is anticipated that an abnormal, up to 100 hour possession will be required to undertake the bridge replacement works and reinstate the track.

The large diameter piles and pile caps will be constructed ahead of the main works. These may need to be carried out in smaller possessions prior to the main possession works.

Monitoring and re-tamping of the track will be required following the works and therefore a temporary speed restriction may be required in the period immediately after the construction works.

Gipsy Patch Lane will require closure to undertake the associated highway works, bridge construction and lowering of the carriageway to suit the new bridge. It is anticipated that the highway works will take significantly longer than the construction time required for the bridge replacement. Ideally all the works should be undertaken with one closure as the closure of Gipsy Patch Lane will require long diversion routes and will impact on local businesses, traffic on other highways and local commuting times.

2.9 Project Schedule

GRIP 3 Form F001 AIP is programmed to follow on directly from the option selection stage.

GRIP 4-5 are programmed to be undertaken in 2016/2017/2018 with GRIP 6 following in 2018/2019 and GRIP 7-8 is planned for 2019/2020 in line with the overall Cribbs MetroBus Extension Programme (dated February 2015).

2.10 Whole Life Cost Assessment of Options

The Whole Life Cost Assessment of this Grip level 3 quantified estimate, for each of the 6 options, provides a bespoke analysis of which option has the better combined future renewal cost, operation cost and maintenance cost over a 60 year period.

- Renewal costs comprise the predicted cost of renewing the structure.
- Operation cost in this case are considered to be any costs associated with the planning of the repairs, inspections and maintenance.

- Maintenance cost these are the assessment of the value of the concrete repairs, painting repairs, fencing etc that are expected to occur over a 60 year period.

The total cost over 60 years and average cost per annum for each option are summarised in the table below.

	Total over 60 years	Average per annum
Option 1	£6,380,509.19	£106,341.82
Option 2	£6,671,566.63	£111,192.78
Option 3	£6,761,085.15	£112,684.75
Option 4	£7,274,579.77	£121,243.00
Option 5	£7,723,716.93	£128,728.62
Option 6	£8,286,818.80	£138,113.65

See Appendix D for further details.

2.11 Estimates (excluding whole life costings)

The GRIP level 3 estimates were prepared utilising the new RMM1 Method of Measurement and they are all base dated to 1st Quarter 2015, All the estimates are based on using concrete rather than sheet piling for the wing walls, as this is the current preferred option.

Risk has been included at the standard 30% which is acceptable for a Grip Level 3 Estimate.

The current values including Indirect, Direct, Risk and possession costs, but not including other Network Rail costs are as follows:

- Option 1 with a 14.5m span is £10,113,067
- Option 2 with a 18.7m span is £10,530,166
- Option 3 with a 19.5m span is £10,663,739
- Option 4 with a 23.45m span is £11,415,937
- Option 5 with 24.4m span is £12,084,967
- Option 6 with 29.3m span is £12,917,577

See Appendix D for further details.

2.12 Sustainability Consideration

The replacement structure will improve pedestrian and cyclist routes along Gipsy Patch Lane, potentially provide a designated bus lane for improved public transport routes in the area and removes the current pinch point within the local highways infrastructure. The proposed construction method has been developed to reduce the impact on the operational railway whilst also creating opportunities to incorporate sustainable targets into the design and construction.

The largest options, whilst providing sufficient width for two designated bus lanes and a wider cycle/footway, will require demolition of the existing pill box located to the north west of the existing structure.

Pre-casting the portal frame adjacent to the final location reduces the transporting distance once assembled and an efficient work site can reduce the amount of waste created. The contractor should look to use BES 6001 accredited and locally sourced materials where reasonably practicable.

Concrete is a durable material with a long design life resulting in low maintenance costs and disruptions. At the end of life, all cured concrete and reinforcing steel waste can be recycled to create new construction materials.

To assist in evaluating each of the options a carbon footprint calculation was undertaken to estimate and compare the amount of embodied carbon in each of the six options. Embodied carbon is the amount of carbon released during the production and processing of materials. This has been calculated by taking the quantities of each material used and multiplying it by its embodied carbon coefficient. The embodied carbon coefficients have been taken from the Inventory of Carbon & Energy database. Full results can be found in Appendix H. The carbon footprint calculation has only included the embodied carbon for the materials used in the construction of the bridge replacements; it does not capture the temporary works, highway works or construction activities. The amount of embodied carbon from the Carbon Crunch calculations for each option is as follows and is measured in tonnes of carbon dioxide equivalents:

- Option 1 with no lane = 914.6 tCO^2e
- Option 2 with single bus lane = 1039.4 tCO^2e
- Option 3 with no bus lane = 1110.7 tCO^2e
- Option 4 with single bus lane = 1412.9 tCO^2e
- Option 5 with dual bus lane = 1595.0 tCO^2e
- Option 6 with dual bus lane = 1980.5 tCO^2e

2.13 Diversity Impact Assessment

The diversity impact assessment has highlighted the positive impact this project will have through the provision of inclusive travel routes. This is one of the fundamental drivers of the project which will include a cycleway and footway wide enough to allow many different users to feel safe and comfortable using the cycle/footway. A full Diversity Impact Assessment for the proposed options can be found in 350164/WTD/BTL/06, which is submitted as a standalone document to Network Rail.

2.14 QRA

A risk workshop has been undertaken and a quantitative risk assessment conducted by Network Rail. The critical risks that may lead to significant additional costs and/or programme delays are summarised below:

- Interface between the highway and rail designs giving rise to the risk of design errors/delays and costs

- Protracted negotiation of implementation agreement due to lack of understanding between parties
- The unavailability of land owned by third parties for the site compound
- Unsuitable ground conditions preventing the bridge from being constructed on the compound site or requiring improvements to be made
- Damage to buried/overhead utilities
- The presence of invasive species such as Japanese knotweed which require removal
- Delays caused by elongated internal procedures between NR and SGC
- Discovery of unexploded ordnance on the site as a left over from historic WW2 bombing of the area

Refer to Appendix C for the complete risk register.

2.15 Risk Register

The key risks and their impacts are as follows:

- Stability of the existing structure and embankment during demolition
- Ground water level
- Completion of works within possession time

The full project hazard log can be found in Appendix B.

2.16 Assumptions

The following has been assumed:

- The findings of the Detailed Examination Report are valid and the existing structure is in fair condition
- There is sufficient slack in the signal and telecommunication (S&T) cables and that they will not be cut as part of works and temporary cable bridge will be provided

2.17 Signed Design Compliance Certificate

A Design Compliance Certificate is not relevant to this option selection stage.

2.18 Asset Condition Surveys / GI / Topographical

A review of the Detailed Examination Report (dated 22/05/2013) and the Visual Examination Report (dated 26/02/2014) for the existing structure at Gipsy Patch Lane has noted that the condition of the existing bridge is generally fair.

A number of defects have been identified (see Appendix E for photographs from site visit):

- There is significant water leakage, which is evidence of failed waterproofing
- Evidence of bridge strikes including bent steel sheeting and chipped and spalled brickwork to the arch rings

- Surface corrosion to all soffit plates
- Spandrels; drummy with hairline separation fractures and open joints in places
- Abutments; drummy and spalling in places with individual jumper stones showing shatter fractures, along with some slight bulging to 40mm
- Wing walls; some open joints to 20mm deep, and fractures, drummy in places and shatter fractured jumper stones
- Stone parapet; approximately 45mm bow and leans away from the road. Weak mortar and open joints and spalled / weathered stoned in places
- Brick parapet; vertical fractures in places.
- Extension walls to the parapet have suffered foundation failure and have displaced and separated from main wall
- The arch soffit is clad with steel plates, and therefore inspection of the underlying masonry arch was not possible

The reports recommended that sections of the steel lining were removed for future examination to further investigate the water leakage, joints and areas of loose stonework are repointed, the cause of the parapet displacement is investigated, vegetation to the top of the walls is removed and bulged area of arch soffit is monitored annually.

A topographical survey of the existing structure, embankments and surrounding area has previously been carried out. A detailed track survey of the existing track has been undertaken in order to inform GRIP 3 Form 001 and Form A.

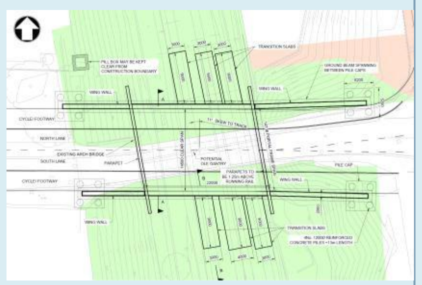
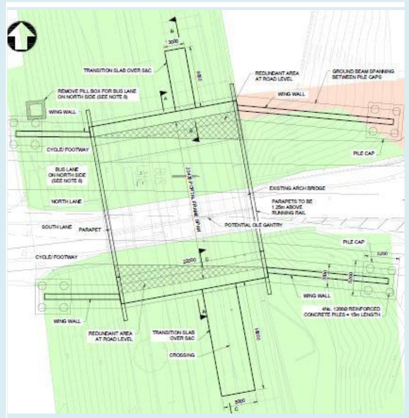
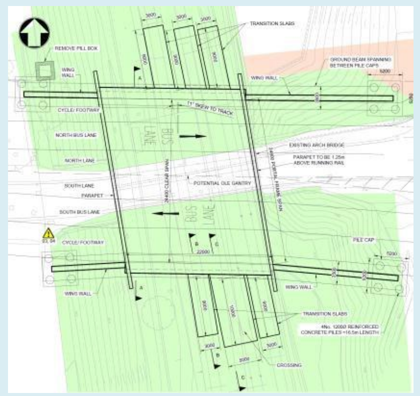
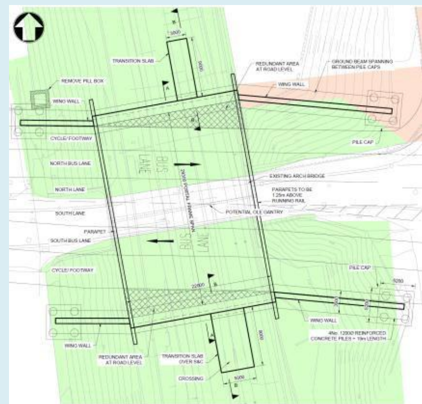
2.19 Options Evaluation

An Options Matrix has been developed to compare and evaluate each of the proposed options for the main bridge structure. Each scorable Key Determining Factor has been given a rating from 1 to 5, with 1 being least desirable and 5 being most. These ratings have been multiplied by a weighting factor that each key determining factor has been given to reflect the project drivers in the scoring.

Table 1 Options Matrix

Each scorable Key Determining Factor has been given a relative score from 1 to 5, with 1 being least desirable and 5 being most.

Each Key Determining Factor has been weighted to represent project drivers: 1 = low importance 2= medium importance 3 = high importance.

Key Determining Factor (score weighting)	Option 1 – No Bus Lane (skewed to track)	Option 2 – Single Bus Lane (skewed to track)	Option 3 – No Bus Lane (square to track)	Option 4 – Single Bus Lane (square to track)	Option 5 – Dual Bus Lane (skewed to track)	Option 6 – Dual Bus Lane (square to track)
Basic scheme concept (description)	Reinforced concrete 14.5m clear span portal frame with 11° skew to track alignment Ground beam spanning between large diameter piles Refer to drawing no. MMD-350164-C-DR-GP-XX-0011 Refer to Section 2.7.1 for proposed construction sequence 	Reinforced concrete 18.7m clear span portal frame with 11° skew to track alignment Ground beam spanning between large diameter piles Refer to drawing no. MMD- 350164-C-DR-GP-XX-0012 Refer to Section 2.7.1 for proposed construction sequence 	Reinforced concrete 19.5m clear span portal frame, square with track alignment Ground beam spanning between large diameter piles Refer to drawing no. MMD-350164-C-DR-GP-XX-0013 Refer to Section 2.7.1 for proposed construction sequence	Reinforced concrete 23.44m clear span portal frame, square with track alignment Ground beam spanning between large diameter piles Refer to drawing no. MMD-350164-C-DR-GP-XX-0014 Refer to Section 2.7.1 for proposed construction sequence 	Reinforced concrete 24.4m clear span portal frame with 11° skew to track alignment Ground beams spanning between large diameter piles Refer to drawing on MMD-350164-C-DR-GP-XX-0015 Refer to Section 2.7.1 for proposed construction sequence 	Reinforced concrete 28.7m clear span portal frame, square with the track alignment Ground beams spanning between large diameter piles Refer to drawing on MMD-350164-C-DR-GP-XX-0016 Refer to Section 2.7.1 for proposed construction sequence 
Highways cross-section and headroom (3)	Single Carriageway Cycle/footway provided both sides Standard headroom to TD 27/05 1	Single Carriageway Bus lane Cycle/footway provided both sides Standard headroom to TD 27/05 3	Single Carriageway Cycle/footway provided both sides Standard headroom to TD 27/05 1	Single Carriageway Bus lane Cycle/footway provided both sides Standard headroom to TD 27/05 4	Single Carriageway Two bus lanes Cycle/footway provided both sides with extra width to south side Standard headroom to TD 27/05 5	Single Carriageway Two bus lanes Cycle/footway provided both sides with extra width to south side Standard headroom to TD 27/05 5

Key Determining Factor (score weighting)		Option 1 – No Bus Lane (skewed to track)		Option 2 – Single Bus Lane (skewed to track)		Option 3 – No Bus Lane (square to track)		Option 4 – Single Bus Lane (square to track)		Option 5 – Dual Bus Lane (skewed to track)		Option 6 – Dual Bus Lane (square to track)	
Track Sensitivity	(2)	Skewed to track so transition slabs required to all tracks	1	Skewed to track so transition slabs required to all tracks	1	Square to track but close proximity to S&C so transition slab still required to this track	4	Square to track but close proximity to S&C so transition slab still required to this track	4	Skewed to track so transition slabs required to all tracks	1	Square to track and abutment located below S&C so transition slabs still required to this track	4
Indicative possession and access requirements	(3)	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 72 hours Highway closure throughout	4	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 72 hours Highway closure throughout	3	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 72 hours Highway closure throughout	3	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 100 hours Highway closure throughout	2	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 100 hours Highway closure throughout	2	The following possessions (outside of rules of route) are envisaged: - Piles and pile cap construction - Temporary cable bridge 28 hours - Main possession 100 hours Highway closure throughout	1
Impact on highway and extent of regrading	(1)	Lowest overall structural depth so extent of carriageway requiring regrading is least	4	Larger span requires greater construction depth so further regrading of carriageway required	3	Larger span requires greater construction depth so further regrading of carriageway required	3	Larger span requires greater construction depth so further regrading of carriageway required	2	Larger span requires greater construction depth so further regrading of carriageway required	2	Greatest overall structural depth so extent of carriageway regrading required is greatest	1
Key construction risks	(3)	Use of SPMT[1]s is an innovative construction method Proximity to existing bridge structure Stability of existing structure Ground water level	2	Use of SPMT[1]s is an innovative construction method Stability of existing structure Ground water level	4	Use of SPMT[1]s is an innovative construction method Completing works within possession time available Stability of existing structure Ground water level	4	Use of SPMT[1]s is an innovative construction method Proximity to land boundaries Completing works within possession time available Stability of existing structure Ground water level	2	Use of SPMT[1]s is an innovative construction method Proximity to land boundaries Completing works within possession time available Stability of existing structure Ground water level	2	Use of SPMT[1]s is an innovative construction method Proximity to land boundaries Completing works within possession time available Stability of existing structure Ground water level	1
Safety during construction	(3)	Precast main structure to reduce working at height risk Stability of embankment Water table during foundation works Shortest exposure to the risks Demolition of existing structure	4	Precast main structure to reduce working at height risk Stability of embankment Water table throughout construction Longer exposure to the risks Demolition of existing structure	3	Precast main structure to reduce working at height risk Stability of embankment Water table throughout construction Longer exposure to the risks Demolition of existing structure	3	Precast main structure to reduce working at height risk Stability of embankment Water table throughout construction Longer exposure to the risks Demolition of existing structure	2	Precast main structure to reduce working at height risk Stability of embankment Water table throughout construction Longer exposure to the risks Demolition of existing structure	2	Precast main structure to reduce working at height risk Stability of embankment Water table throughout construction Longest exposure to the risks Demolition of existing structure	1

[1]SPMT denotes Self Propelled Modular Transporter

Key Determining Factor (score weighting)		Option 1 – No Bus Lane (skewed to track)		Option 2 – Single Bus Lane (skewed to track)		Option 3 – No Bus Lane (square to track)		Option 4 – Single Bus Lane (square to track)		Option 5 – Dual Bus Lane (skewed to track)		Option 6 – Dual Bus Lane (square to track)	
Safety during operation	(3)	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope	3	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope Bus lane creates greater space and reduces likelihood of cars trying to overtake slow buses	4	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope	3	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope Bus lane creates greater space and reduces likelihood of cars trying to overtake slow buses	4	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope Multiple bus lanes create greater space and reduces likelihood of cars trying to overtake slow buses	5	Parapets provided are sufficient to prevent debris from bridge strike entering train envelope Multiple bus lanes create greater space and reduces likelihood of cars trying to overtake slow buses	5
Maintenance and inspection access	(2)	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways	3	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways Bus lane can be utilised for traffic management/closure during inspection and maintenance	4	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways	2	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways Bus lane can be utilised for traffic management/closure during inspection and maintenance Larger structure so longer exposure to risks during inspection and maintenance	3	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways Bus lanes can be utilised for traffic management/closure during inspection and maintenance Larger structure so longer exposure to risks during inspection and maintenance	3	Place of safety or safe cess walkway and handrails provided at track level Sufficient width for footways either side of carriageways Bus lanes can be utilised for traffic management/closure during inspection and maintenance Largest structure so longer exposure to risks during inspection and maintenance	2
Sustainability	(1)	Pill box can be retained No designated bus lane Least material and excavation required Embodied carbon = 914.6 tCO^{2}e	3	Close proximity to pill box so may not be feasible to retain during construction Smallest structure that can provide designated bus lane Embodied carbon = 1039.4 tCO^{2}e	4	Close proximity to pill box so may not be feasible to retain during construction Larger material required and further spoil removal without benefitting from designated bus lane Embodied carbon = 1110.7 tCO^{2}e	2	Close proximity to pill box so may not be feasible to retain during construction Designated bus lane Larger material required and further spoil removal Embodied Carbon = 1412.9 tCO^{2}e	2	Close proximity to pill box so cannot be retained during construction Two designated bus lanes Larger material required and further spoil removal Embodied Carbon = 1595.0 tCO^{2}e	2	Close proximity to pill box so cannot be retained during construction Two designated bus lanes Most materials required, most spoil requiring removal Embodied Carbon = 1980.5 tCO^{2}e	1
Diversity Impact Assessment	(2)	Sufficient width for cycle/footway suitable for diverse range of users No designated bus lane	2	Sufficient width for cycle/footway suitable for diverse range of users Designated bus lane	4	Sufficient width for cycle/footway suitable for diverse range of users No designated bus lane Hidden corners / sight lines due to bridge skew	1	Sufficient width for cycle/footway suitable for diverse range of users Designated bus lane Hidden corners / sight lines due to bridge skew	3	Sufficient width for cycle/footway suitable for diverse range of users and additional width to south Two designated bus lane	5	Sufficient width for cycle/footway suitable for diverse range of users and additional width to south Two designated bus lane Hidden corners / sight lines due to bridge skew	4
Environmental Impact Assessment	(1)	Pill box can be retained Smallest structure therefore smallest impact	4	Close proximity to pill box so may not be feasible to retain during construction	3	Close proximity to pill box so may not be feasible to retain during construction	3	Close proximity to pill box so may not be feasible to retain during construction Large structure therefore greater impact	2	Close proximity to pill box so may not be feasible to retain during construction Large structure therefore greater impact	2	Close proximity to pill box so may not be feasible to retain during construction Largest structure therefore greatest impact	1

Key Determining Factor (score weighting)		Option 1 – No Bus Lane (skewed to track)		Option 2 – Single Bus Lane (skewed to track)		Option 3 – No Bus Lane (square to track)		Option 4 – Single Bus Lane (square to track)		Option 5 – Dual Bus Lane (skewed to track)		Option 6 – Dual Bus Lane (square to track)	
Aesthetics	(2)	Smallest impact	4	More natural light	4	Road level view of abutments is not aligned with line of travel Wing walls are not aligned with abutments and may impede natural light	3	More natural light due to wider span but wing walls are not aligned with abutments so may impede light Road level view of abutments is not aligned with line of travel	3	More natural light	3	Greatest impact More natural light due to wider span but wing walls are not aligned with abutments so may impede light Road level view of abutments is not aligned with line of travel	2
Innovation	(1)	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3	Use of SPMT[1]s to reduce construction time and limit impact of works on operational railway	3
Whole Life Costs (average per annum)	(2)	[redacted]	4	[redacted]	3	[redacted]	3	[redacted]	2	[redacted]	2	[redacted]	1
GRIP 4-8 Costs (Including Network Rail project management and possession costs, risk fees and commuted sums)	(2)	[redacted]	4	[redacted]	3	[redacted]	3	[redacted]	2	[redacted]	2	[redacted]	1
Overall Cost	(3)	Additional cost for: Highway works Buried services diversion	4	Additional cost for: Highway works Buried services diversion	3	Additional cost for: Highway works Buried services diversion	3	Additional cost for: Highway works Buried services diversion	2	Additional cost for: Highway works Buried services diversion	2	Additional cost for: Highway works Buried services diversion	1
Key Advantage s		Smallest structure Least impact on existing services		Smallest structural envelope that provides designated bus lane		Sufficient clearance to existing structure for early construction phases Straight with track alignment		Designated bus lane Sufficient clearance to existing structure for early construction phases Straight with track alignment		Two designated bus lanes and wider cycle/footway to the south Sufficient clearance to existing structure for early construction phases		Two designated bus lanes and wider cycle/footway to the south Sufficient clearance to existing structure for early construction phases Straight with track alignment	

Key Determining Factor (score weighting)	Option 1 – No Bus Lane (skewed to track)	Option 2 – Single Bus Lane (skewed to track)	Option 3 – No Bus Lane (square to track)	Option 4 – Single Bus Lane (square to track)	Option 5 – Dual Bus Lane (skewed to track)	Option 6 – Dual Bus Lane (square to track)
Key Disadvantages	No provision for designated bus lane Envelope not clear of existing structure so cannot undertake any construction works prior to demolition of existing bridge Transition slabs required to all tracks	Greater impact on existing services Transition slabs required to all tracks	No provision for designated bus lane Redundant areas created by alignment Significant extra weight Proximity to crossing (of S&C) therefore transition slabs may still be required for this track	Structure envelope reaches limit of land ownership boundaries Significant extra weight Proximity to crossing (of S&C) therefore transition slabs may still be required for this track	Structure envelope reaches limit of land ownership boundaries Significant extra weight Transition slabs required to all tracks	Largest structure and greatest impact on existing services including trackside equipment Structure envelope reaches limit of land ownership boundaries Significant extra weight Proximity to crossing (of S&C) therefore transition slabs still required for this track
Total score	**104**	**111**	**94**	**88**	**95**	**76**
[1]SPMT denotes Self Propelled Modular Transporter						

2.20 Selected Option

It is recommended that a pre-cast portal frame with an 18.7m clear span and 11° skew to the track alignment as per Option 2 is progressed as the preferred option for the bridge replacement. The score from the options matrix in Table 1 identifies that this is the most suitable option when considering all evaluation points and project drivers.

Option 2 presents the minimum structure size required to achieve suitable carriageway width for one designated bus lane in addition to the single carriageway and shared cycle/footways. Whilst this option does not have the preferred alignment in relation to the track, it is a significantly smaller structure than that required to provide a bridge that is square to the track alignment. This reduces the overall construction time and costs, removes redundant areas that could become a maintenance issue and allows the wing walls and foundations to be aligned straight with the abutments. Transition slabs will be required to prevent any differential movement in the track due to the structure skew.

Whilst two designated bus lanes and a wider cycle/footway may be more desirable, the increased construction time and costs, the extensive carriageway works and significant impact on the buried services are considered to outweigh the benefits.

The wing walls should be constructed from reinforced concrete and aligned straight with the bridge abutments. This ensures it is feasible to precast them integral with the main portal frame.

The foundations will consist of ground beams spanning between pile caps. The ground beams will be cast integral with the main structure. The entire structure: portal frame, wing walls and ground beams, can then be manoeuvred into place using SPMTs and located on the precast pile caps.

3 Interfaces with Other Projects

The anticipated interfaces with other projects are as follows:

South Gloucestershire Council – Cribbs Patchway MetroBus Extension

Network Rail – Intercity Express Programme, Stoke Gifford Depot

Bristol Area Signalling Renewals

Great Western Electrification Programme (GWEP)

Rolls Royce Site Development

MetroWest Phase 2

In particular, it has been identified that an OLE gantry will be located on Gipsy Patch Lane Bridge as part of the Great Western Electrification Programme. Network Rail have expressed a preference for the gantry to be mechanically separate to the bridge structure and hence the design of the main structure will need to accommodate these loadings.

4 CDM Information

The CDM arrangements for this project are as follows:

Client: Network Rail

Client's Representative: Angela Edmunds, Commercial Scheme Sponsor, Western House, 1 Holbrook Way, Swindon, SN1 1BD, 07739 775382

Principal Designer: Network Rail

Principal Designer Representative: Jane Austin, Head of Engineering, SN1, Station Road, Swindon, SN1 1DG, 07887 896484

Designer: TBA

Person acting on behalf of the Designer: TBA

Principal Contractor: TBA

Client appointed Contractors: TBA

Refer to Appendix B for a Project Hazard Log.

5 Safety Verification Recommendations

The project has been classified by the Network Rail Acceptance Panel (NRAP) as a Category 1 in terms of ROGS (Railway and Other Guided Transport Systems (Safety) Regulations). This classification means that the project introduces no new transport system safety risks that are significant and has no potential to significantly increase safety risk.

6 Consents Strategy

The appropriate consents will be required to close Gipsy Patch Lane temporarily for the bridge replacement and the local highway construction. The road closure will form part of the highways design but will need to be co-ordinated with the bridge replacement works.

As discussed in Section 2.7.4, land will be required for the various site compound requirements. It is anticipated that part of the Rolls Royce East Works site will be obtained by South Gloucestershire Council for use as the pre-casting yard and further appropriate sites will be allocated/rented to provide remaining compound areas.

Appropriate possessions as per Section 2.8 will need to be obtained from Network Rail.

7 Environmental Impact Assessment

An Environmental Appraisal for the proposed options at Gipsy Patch Lane and the identified site compound areas has been undertaken and the key risks are summarised below. The full Environmental Appraisal can be found in Appendix F.

7.1 General Risks

Option 4, 5, 6 and any site compounds are likely to require land lease/purchase. Discussions with internal/external stakeholders will be required. Residents of Little Stoke are likely to be adversely affected during the construction works due to vehicular movements, noise disturbance and air quality. Early consultation with external stakeholders is recommended. Work programme should consider residents immediately adjacent to the trackway and access areas and should obtain Section 61 consent on nuisance (noise) during construction (under the Control of Pollution Act 1974). All work should adhere to CIRIA guidelines (e.g. C692 and C715).

Construction traffic and works will need road management and likely to require a Temporary Traffic Regulation Order (TTRO). Works will also close off and re-divert a public footpath and cycle pass during the works. Consultation with the Local Council in regards to a temporary closure or diversion of a public right of way (PROW) is required.

7.2 Water

The site is situated on a minor aquifer (high vulnerability) and a secondary bedrock aquifer. Proposed site compounds 1, 2, 4 and 5 as per Section 2.7.4 are at medium risk of flooding from surface water. A Surface Water Drainage Assessment may be required. Pollution prevention measures should be implemented for all works and adhere to Network Rails contract requirements for the Environment NR/L2/ENV/015.

7.3 Historical

An undesignated World War 2 pill box is adjacent to the site works. Every reasonable effort should be made to avoid damaging the structure.

7.4 Ecology

There are no statutory designated sites within the area of works however vegetation is present and likely to be impacted by works. Vegetation comprises scrub as well as a strip on Biodiversity Action Plan (BAP) priority broadleaved woodland habitat and grassland. This vegetation is connected to habitats within the disused Filton Airfield via the railway embankment. Japanese knotweed is known to be present in the stream located approximately 40m from the railway bridge.

There is potential for great crested newts (GCN), nesting birds, common reptiles and bats (roosting, commuting and foraging) within the working area. GCN have been recorded within the pods and surrounding area of Filton Airfield. These species could be impacted during construction and operation. Biological records within 1km of the site are required to find out what protected species are within the immediate locality.

Bat transect surveys may be required along the embankment and bridge due to potential for severance of a linear habitat feature used by commuting bats. Inspections for bat roost potential will be required on mature trees that are to be removed as part of works.

Further surveys for GCN may be required within nearby ponds due to potential for GCN within the working footprint.

Any vegetation clearance should be undertaken in the winter (October to February inclusive) to avoid the breeding bird season and reptile active season. Excavation works should take place during the summer months (April – October) to avoid impacts on hibernating species.

7.5 Contaminated land

It is likely for railway ballast and the embankment to be contaminated with chemicals/oil. Additionally, land required for a temporary site compound could be contaminated. It is recommended that soil, leachate and ground water sampling as well as analysis is undertaken to provide further information for a comprehensive contaminated land risk assessment. Pollution prevention measures should be implemented for all works. Follow RT/LS/P/044 for used ballast and/or Special Waste requirements.

7.6 Waste

Waste will be generated during construction and will require removal off-site. All necessary Environment Agency permits should be in place prior to removing any waste from site. Adhere to Network Rail's Contractor's Responsible Engineer and obtain appropriate waste storage/removal permits from the Environment Agency. If required, a Site Waste Management Plan (SWMP) should be produced.

8 Maintenance and Operations Strategy

Once completed, the bridge is to be owned and maintained by Network Rail with a maintenance contribution to be made by South Gloucestershire Council upon completion of the works.

The structure will be subject to detailed and visual examinations as part of Network Rail's inspection and maintenance regime for bridge structures. The proposed scheme has no hidden critical elements and all structural elements will be visible from one side with the only exception being the foundations and transition slabs.

Concrete is durable and has low maintenance requirements. The abutments and wing walls will have a plain concrete finish with anti-graffiti paint. Lighting is not being provided but as the span and height of the structure are being increased from existing, it is anticipated that the natural light available will be sufficient and is an improvement on the existing arrangement.

Access to track level can be gained via an existing authorised access point approx. 80m north of Gipsy Patch Lane along Station Road at BSW 5m 62ch. During the site visit it was noted that the access steps are slightly overgrown. It is recommended that this is cleared and that the access steps are maintained for future use.

At track level, there is sufficient room to provide a cess walkway to the west of the tracks and a continuous place of safety to the east of the tracks. It is anticipated that an OLE gantry will be located on the bridge as part of the Great Western Electrification Programme which could impede on the place of safety. The current bridge width has been proposed to match the existing structure but there is the opportunity as part of the GRIP 3 process, to consider shifting the bridge envelope to the east in order to provide sufficient space for the OLE gantry and a cess walkway to the east of the tracks. It is anticipated that this could be achieved without significant impact on the design or costs and without compromising the cess walkway to the west of the tracks. The bridge design and gantry foundation design should be co-ordinated to ensure as a minimum a safe cess is provided through the structure to both sides of the track.

9 Engineering Outputs

To develop this scheme in the future, the design should be progressed in accordance with the Network Rail GRIP processes. The next stage should be the development of the GRIP 3 outline design, presented under cover of a Form F001.

10 Conclusion and Recommendations

The recommended solution is to provide a pre-cast concrete portal frame with an 18.7m clear span in order to provide sufficient clear width for a single carriageway, a shared cycle/footway on each side and one designated bus lane. The wing walls will be aligned with the abutments and precast integral with the main portal frame. The foundation ground beams will also be cast integral with the main structure and the entire structure manoeuvred into position so the ground beams span between pile caps constructed ahead of the main works.

It is recommended that the following should be investigated further in the later GRIP stages:

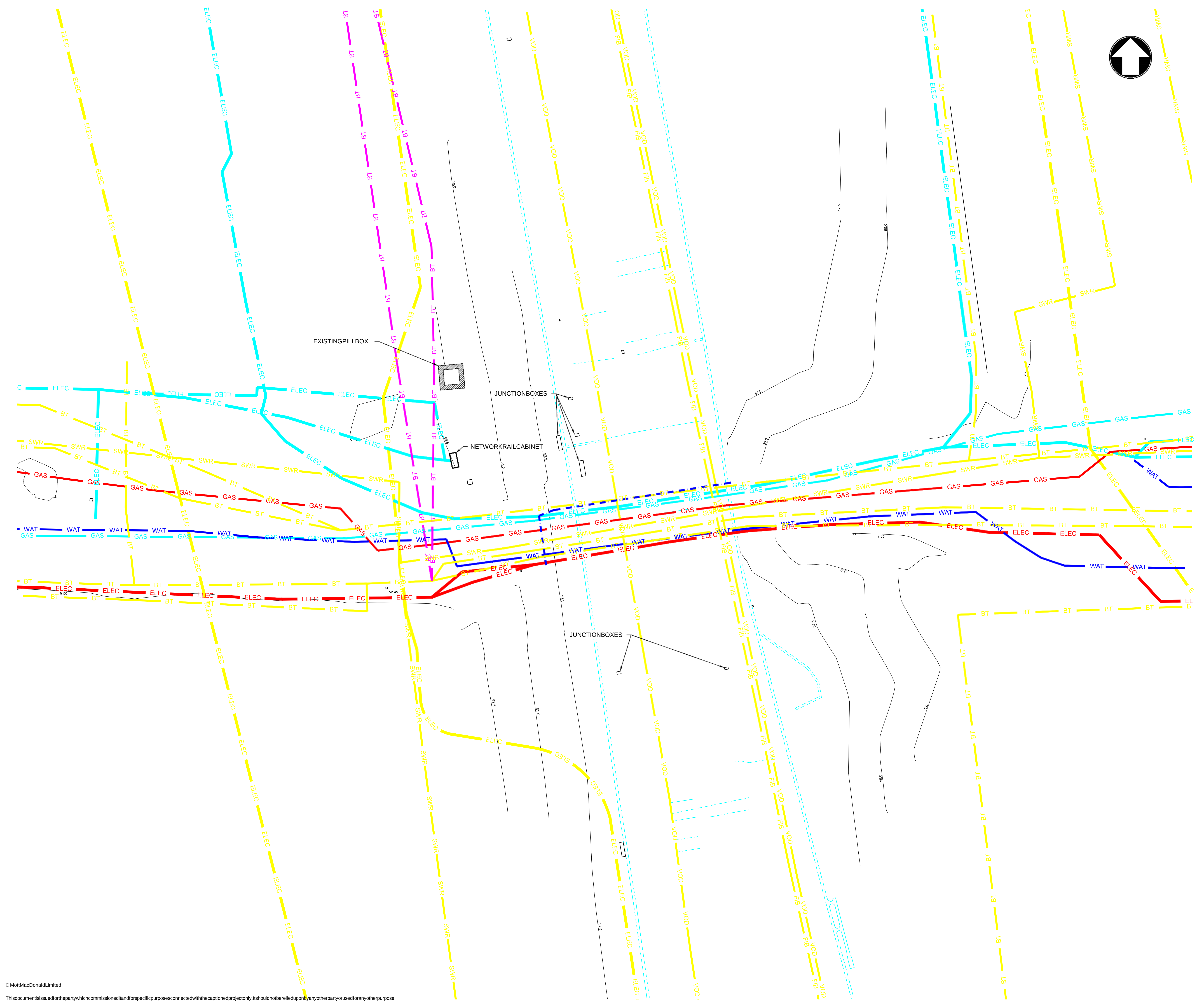
- Consider targeted ground investigation to inform value engineering for the foundation design
- Consider shifting the structure east to accommodate GWEP gantry and cess walkway
- Continued liaison with all stakeholders and coordination with the other projects identified in Section 3
- Survey the size and extent of the existing structure to inform the demolition process and integration into the construction phasing
- Obtain more accurate level, location and type of existing buried and overhead services

11 Formal Acceptance of Selected Option by Client, Funders and Stakeholders

Client:	Angela Edmonds		
Comments: This reflects what NR and the Designer concludes as the best option. Due to the works being funded by a 3rd Party (South Gloucester Council) there is a potential for the preferred option to be at variance to this Option Selection Report.			
Acceptance:	A. Edmonds.	Date:	October 2015.

Appendix A

Drawings



Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTARCHITECTURAL,BUILDINGSERVICESANDOTHER ENGINEERINGDRAWINGS,CIVILANDSTRUCTURALSPECIFICATIONS, WRITTENINSTRUCTIONS,DESIGNDEVELOPMENTRISKSCHEDULE, HEALTHANDSAFETYRISKSCHEDULESANDOTHERDOCUMENTATION RELEVANTTOTHISPROJECT.
5. THISINFORMATIONISGIVENASAGUIDEONLYANDITSACCURACY CANNOTBEGUARANTEED.THELOCATIONOFALLSERVICESMUSTBE CONFIRMEDPRIORTOUNDERTAKINGANYWORKS.
6. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALFILENAME:PATCHWAY5641-1.DWG).

Keytosymbols

	LIGHTINGCABLEATTACHEDTOUNDERBRIDGE
	CABLETROUGH
BT	BTLINEBURIED
BT	BTLINEOVERHEAD
	ELECTRICITYCABLE11kV
	ELECTRICITYCABLE33kV
	ELECTRICITYCABLELOWVOLTAGE
	ELECTRICITYSITELOCATIONLINE
	ELECTRICITYSERVICECABLE
FIB	FIBREOPTICCABLE
SWR	FOULSEWER-INVERTLEVELBELOWBRIDGE=46.56m
GAS	LOWPRESSUREGASMAIN
GAS	MEDIUMPRESSUREGASMAIN
VOD	VODAFONECABLE
WAT	POTABLEWATERPIPE
	DISUSEDWATERPIPE
	NETWORKRAILLAND REGISTRYBOUNDARY
	HIGHWAYSBOUNDARY
	ADOPTEDHIGHWAY

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	ADDRESSCHANGE	GS	CB
P1	290515	TF	FIRSTISSUE	GS	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch) ExistingServicesPlanand LandOwnership

Designed	TFoot	TF	Engcheck	GSkehel	GS
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
1:200	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-1

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-0001.dwg
Jul9,2015-5:01PM FOO73213

Notes

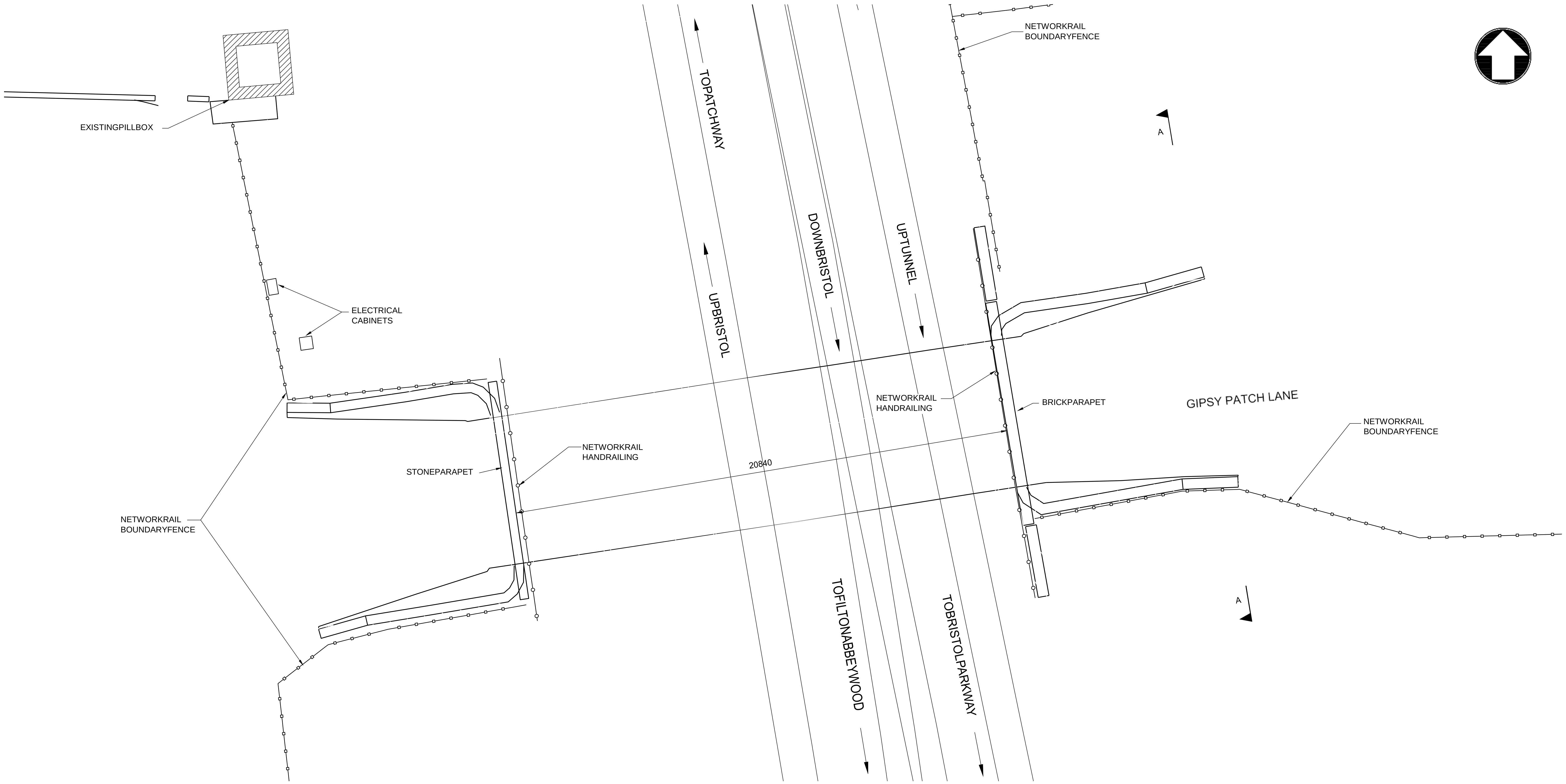
1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALFILENAME:PATCHWAY5641-1.DWG).

Keytosymbols

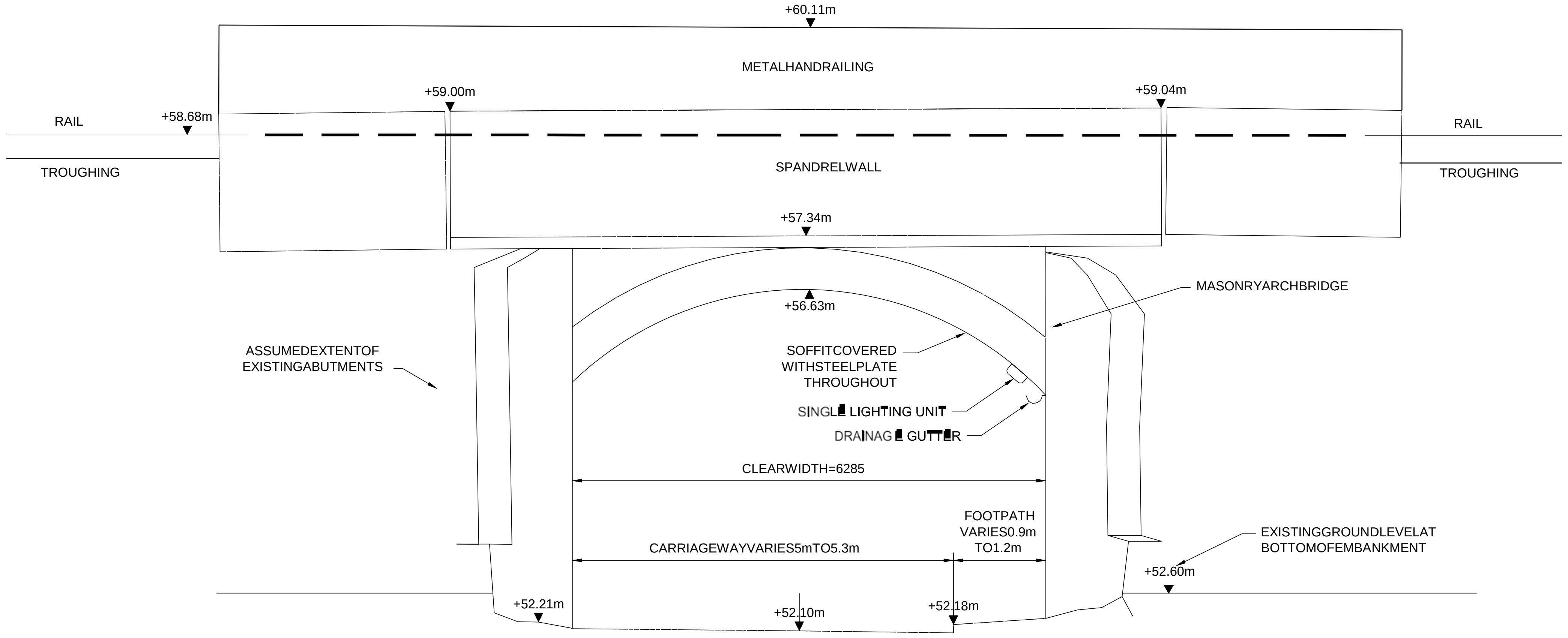
NETWORKRAILLAND REGISTRYBOUNDARY

ADOPTEDHIGHWAY

FOLIAGE



PLAN
1:100



ELEVATIONA-A
1:50

SITELOCATIONPLAN

Ordnance Survey © Crown copyright 2015. All rights reserved. Licence number 100026791.

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	ADDRESSCHANGE	GS	CB
P1	030615	TF	FIRSTISSUE	GS	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
ExistingGeneralArrangement

Designed	REvans	RAE	Engcheck	GSkehel	GS
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	GSkehel	GS	Approved	CBishop	CB

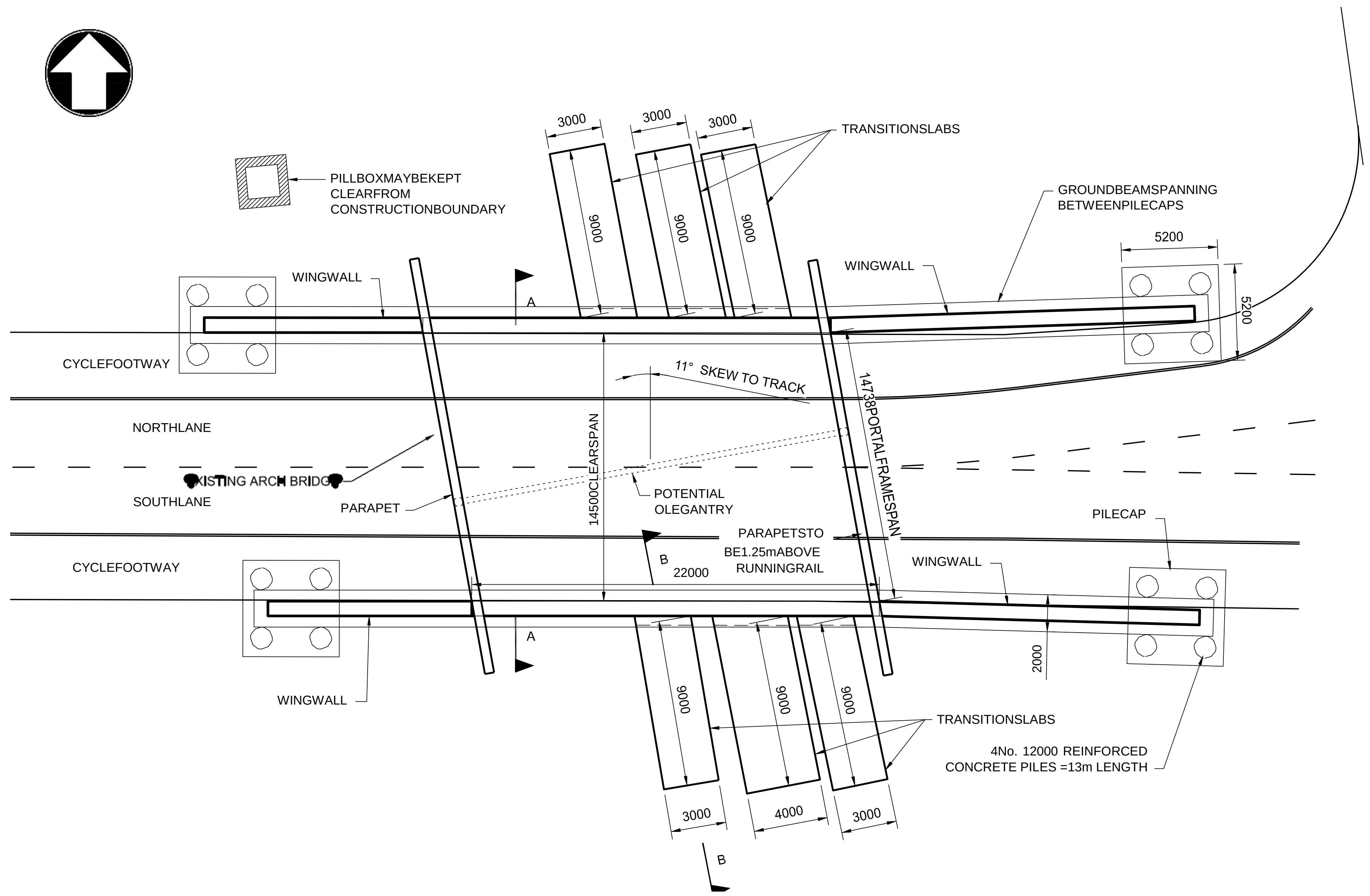
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-2

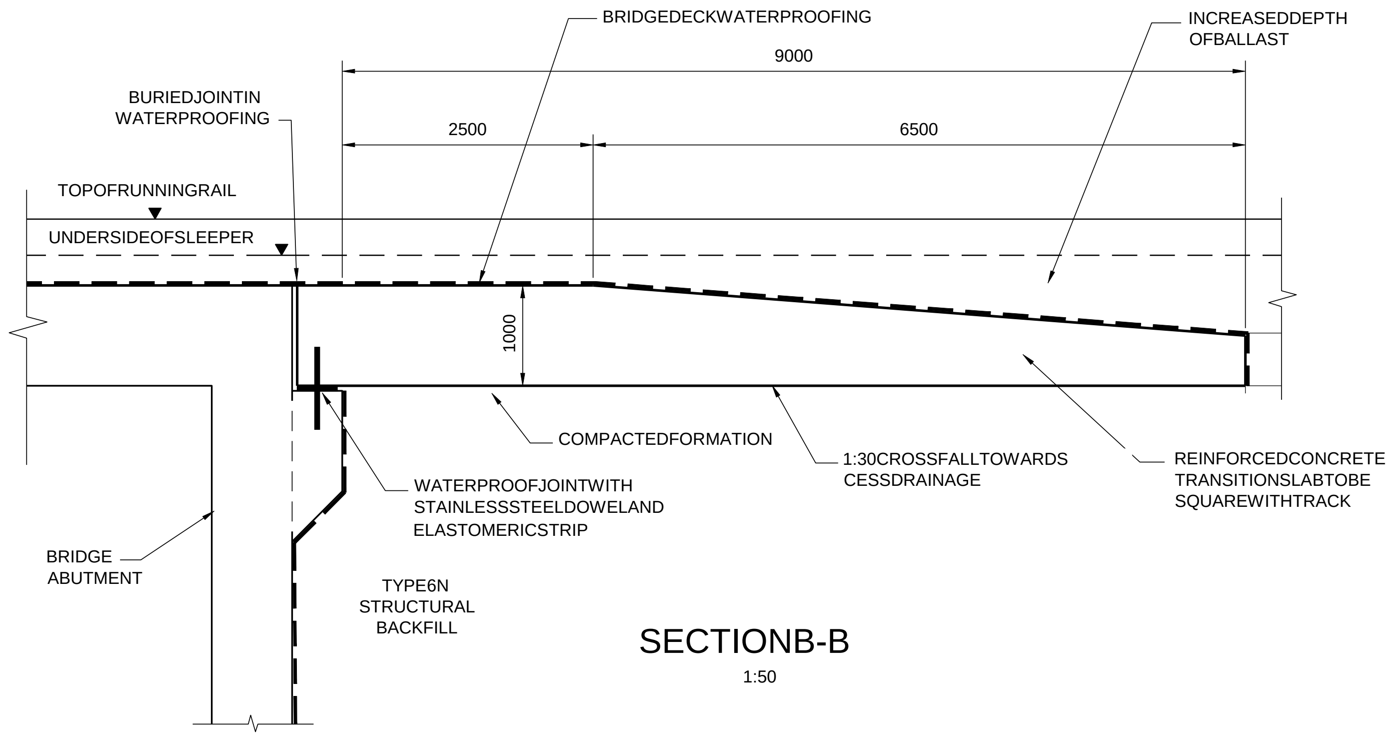
1:50 0 2.5m 5m

1:100 0 5m 10m

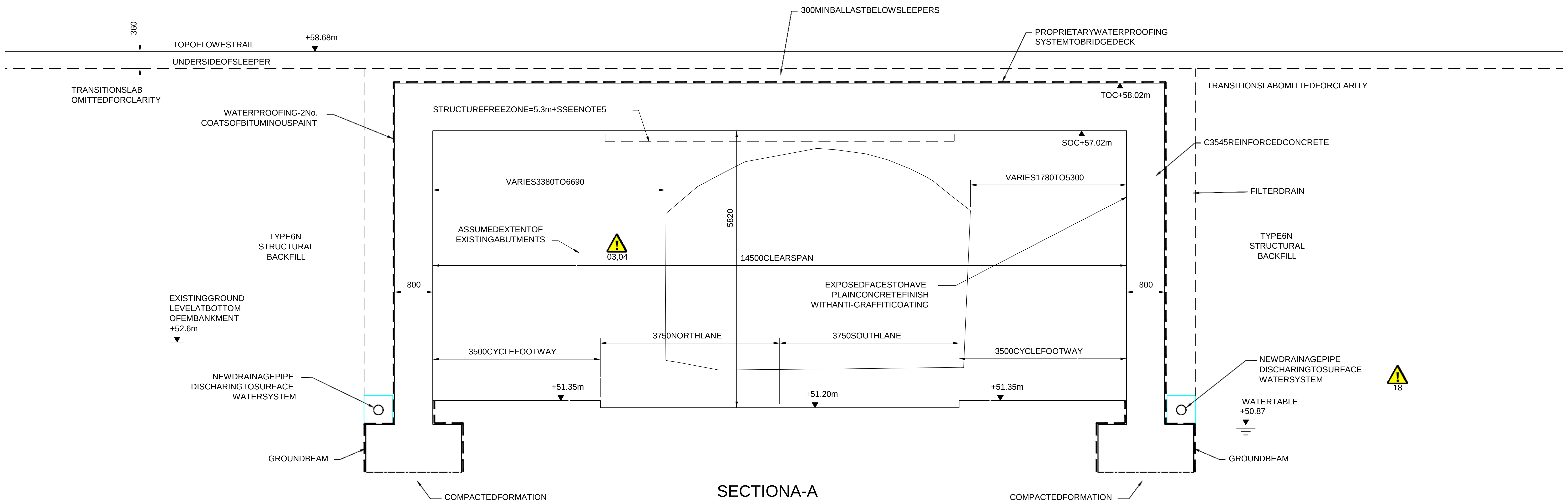
P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-0002.dwg
Jul9,2015-5:01PM FOO73213



PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONA-A
1:50

1:50 0 2.5m 5m

1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-0011.dwg
Jul9,2015-5:01PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL -001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=2715 TONNES. P2

Keytosymbols

TOC - TOPOFCONCRETE

SOC - SOFFITOFCONCRETE

NETWORKRAILLAND REGISTRYBOUNDARY

ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	ADDRESSCHANGE&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client

Network Rail

Title

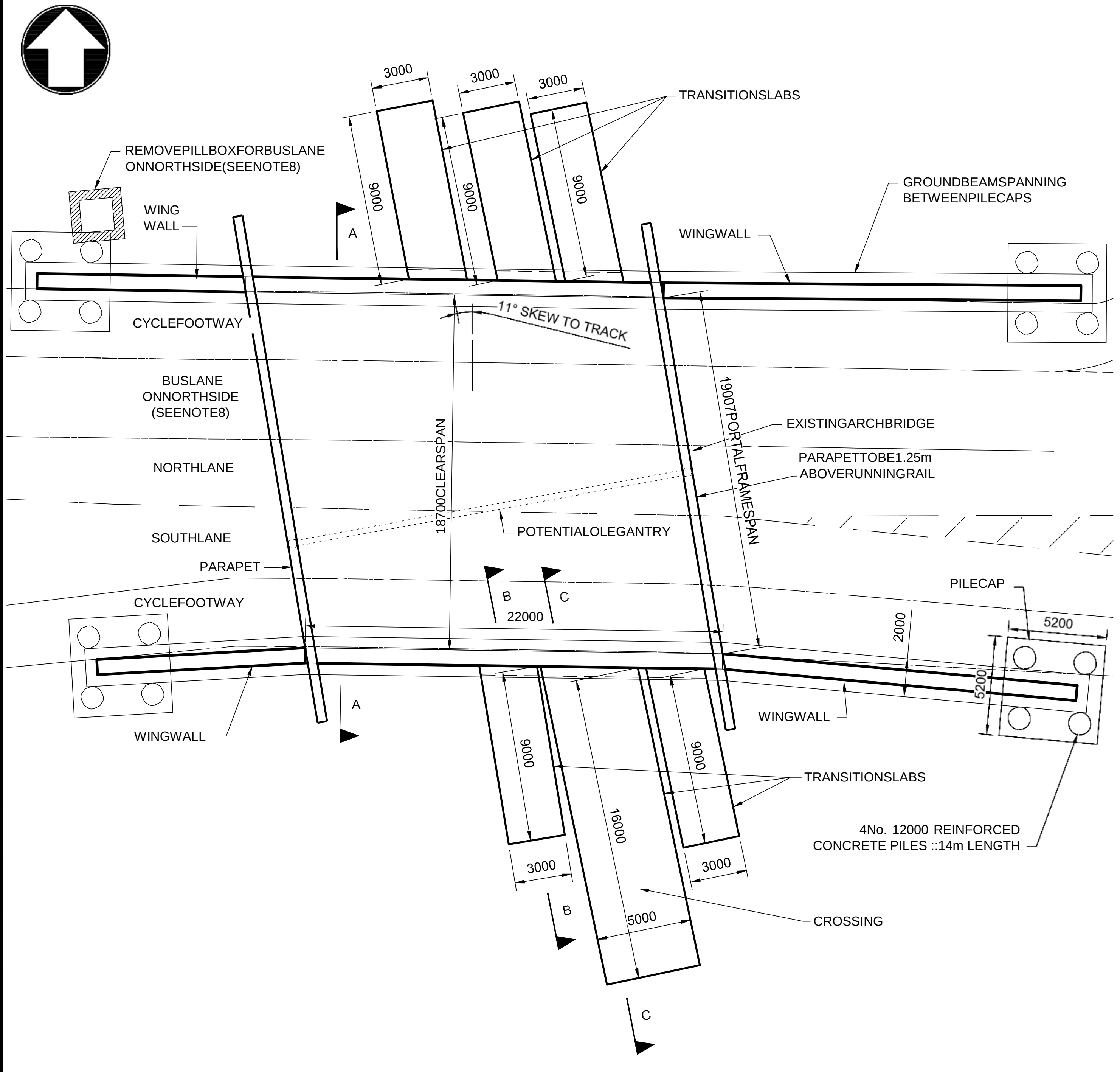
GipsyPatchLaneBridge(BSW5m60ch)
Option1-NoBusLane
SkewedtoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

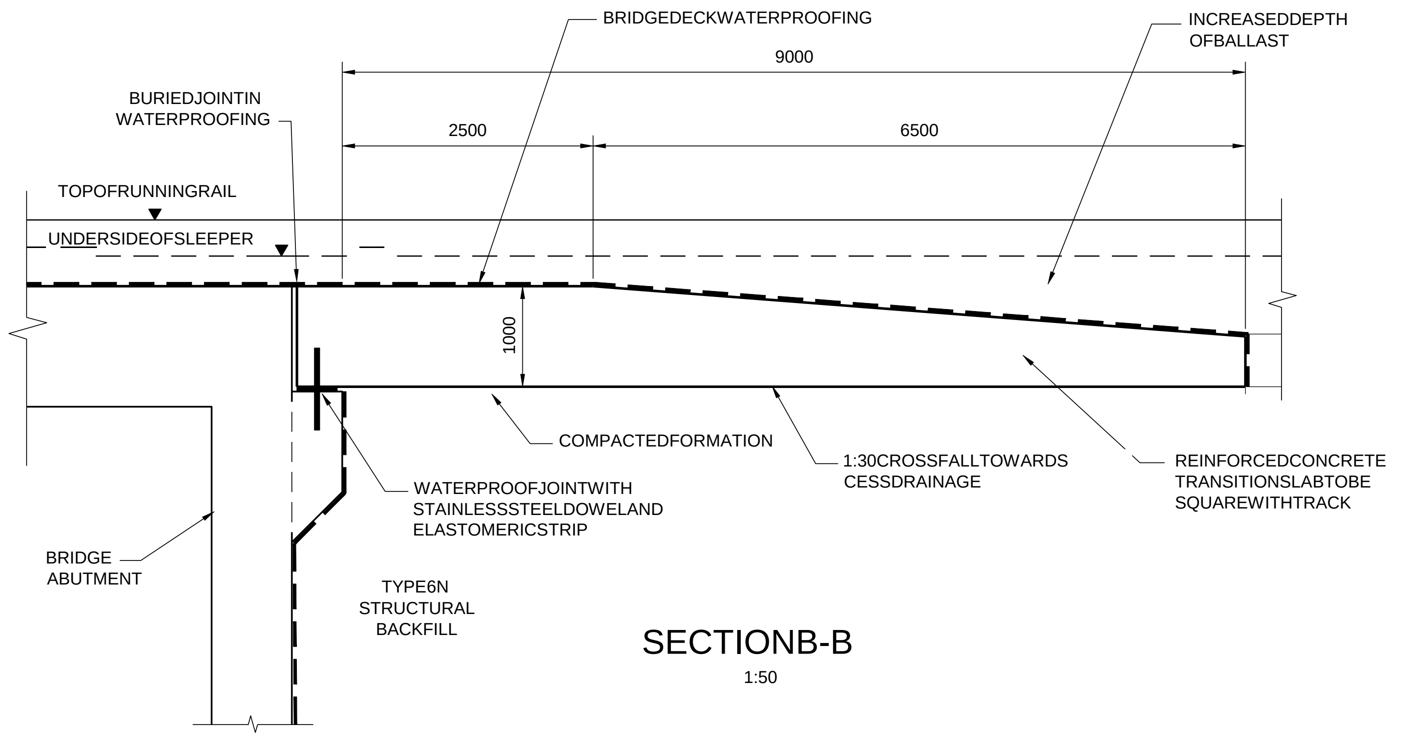
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber

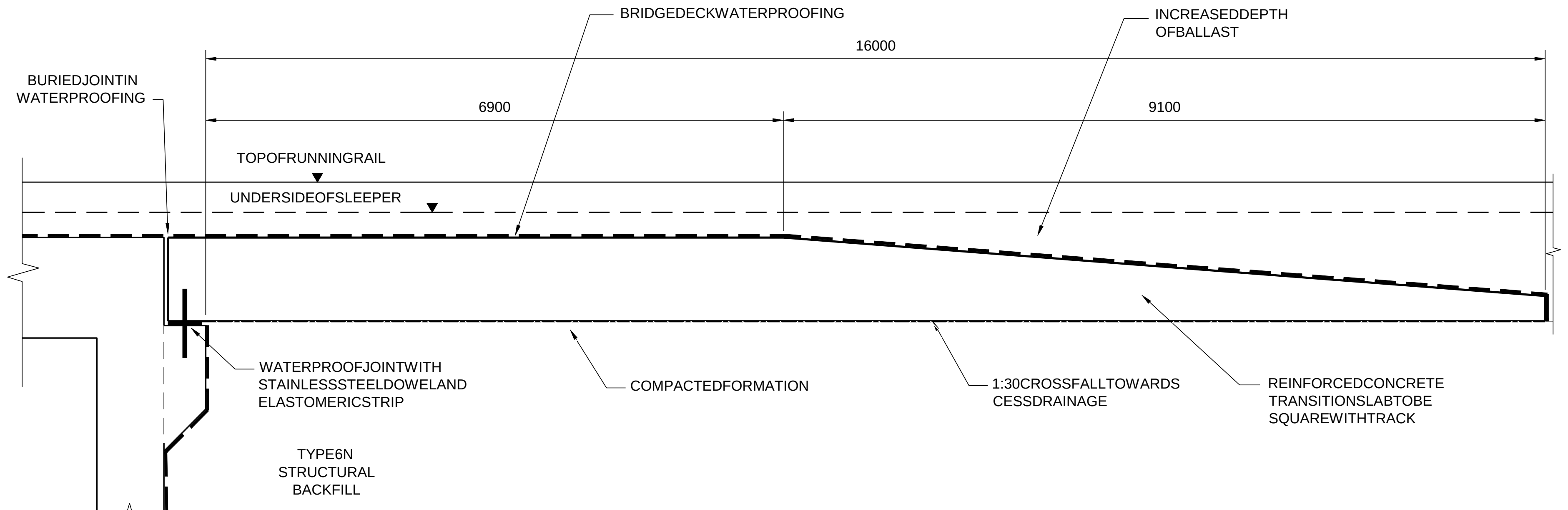
MMD-350164-C-DR-GP-XX-0011



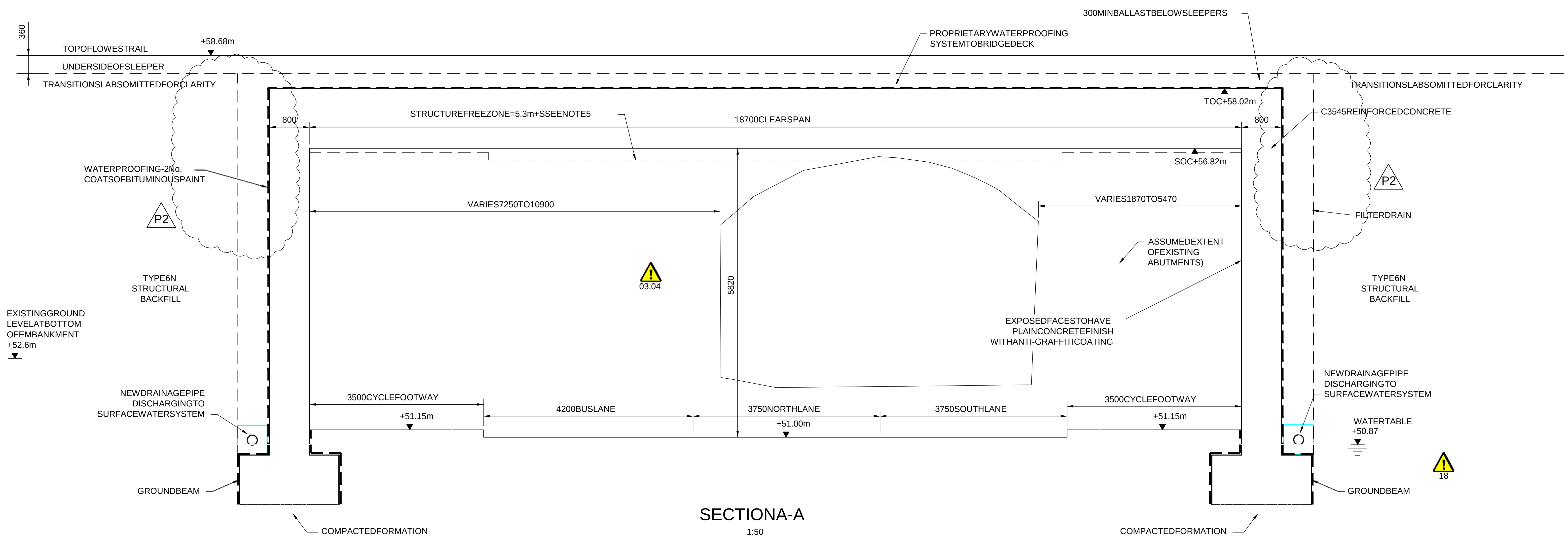
PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONC-C
1:50



SECTIONA-A
1:50

©MottMacDonaldLimited

Thisdocumentisissuedforthepartywhichcommissioneditandforspecificpurposesconnectedwiththecaptionedprojectonly. Itshouldnotberelieduponbyanyotherpartyorusedforanyotherpurpose.
Weacceptnoresponsibilityfortheconsequencesofthisdocumentbeingrelieduponbyanyotherparty,orbeingusedforanyotherpurpose,orcontaininganyerrororomissionwhichisduetoanerrororomissionindatasuppliedtousbyotherparties.

1:50 0 2.5m 5m
1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-12 Jul9,2015-5:01PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL-001OPTIONSELECTIONREPORT
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TWOBUSLANEALIGNMENTSHAVEBEENPROPOSEDBYTHEHIGHWAY DESIGNERS;ONEOPTIONWITHDESIGNATEDBUSLANELOCATEDON THENORTHSIDEANDONEOPTIONONTHESOUTHSIDEOFTHE CARRIAGEWAY.THISDRAWINGPRESENTSTHEOPTIONWITHTHEBUS LANEONTHENORTHSIDE,WHICHBEARSGREATERRISKTOTHE BRIDGECONSTRUCTION.
9. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=3350TONNES.

P2

Keytosymbols

TOC - TOPOFCONCRETE
SOC - SOFFITOFCONCRETE
NETWORKRAILLAND REGISTRYBOUNDARY
ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN
18 WATERLEVELAT50.87m
REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	WALLTHICKNESSUPDATED, ADDRESSCHANGE&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald

10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client

Network Rail

Title

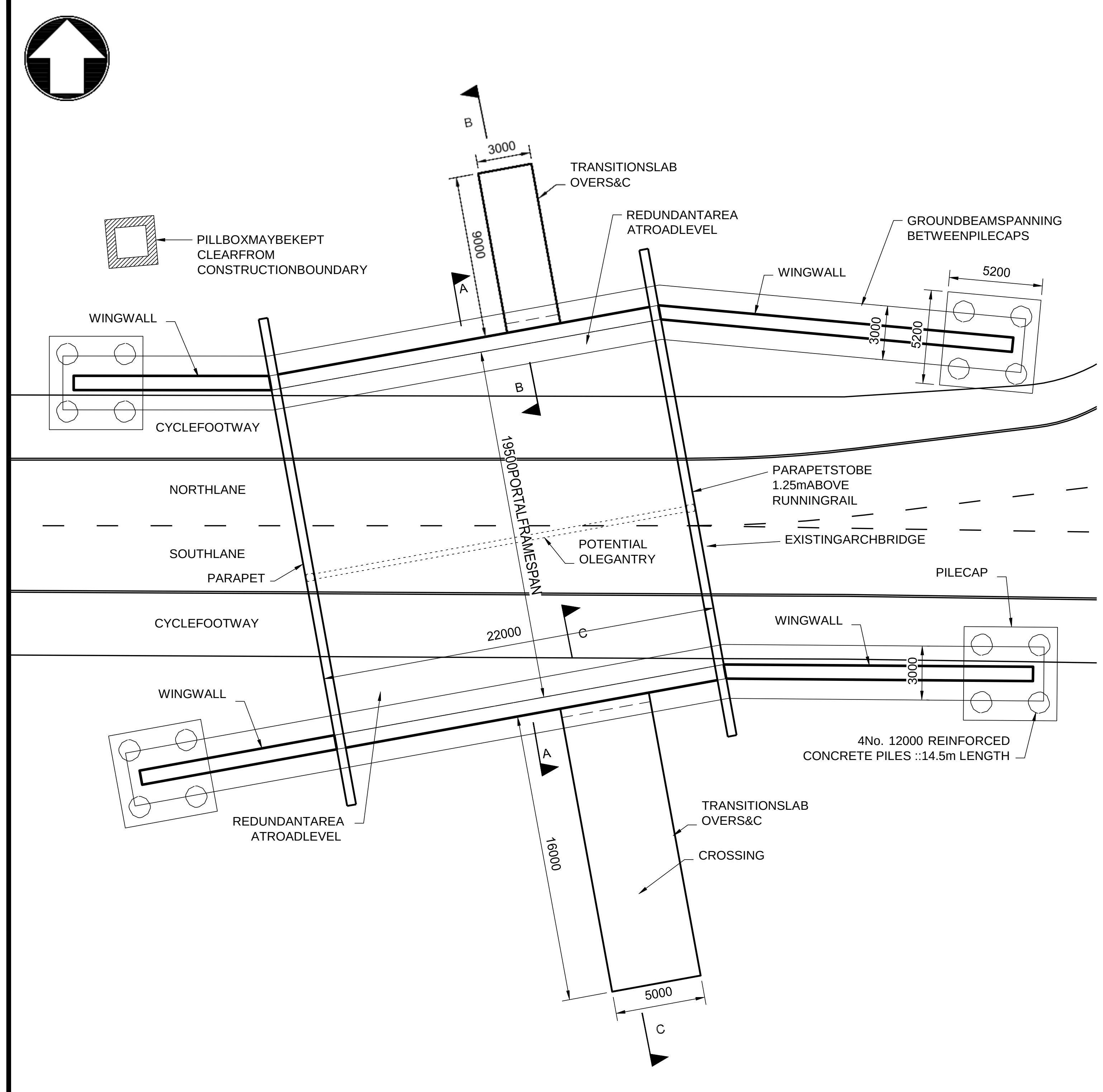
GipsyPatchLaneBridge(BSW5m60ch)
Option2-SingleBusLane
SkewedtoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

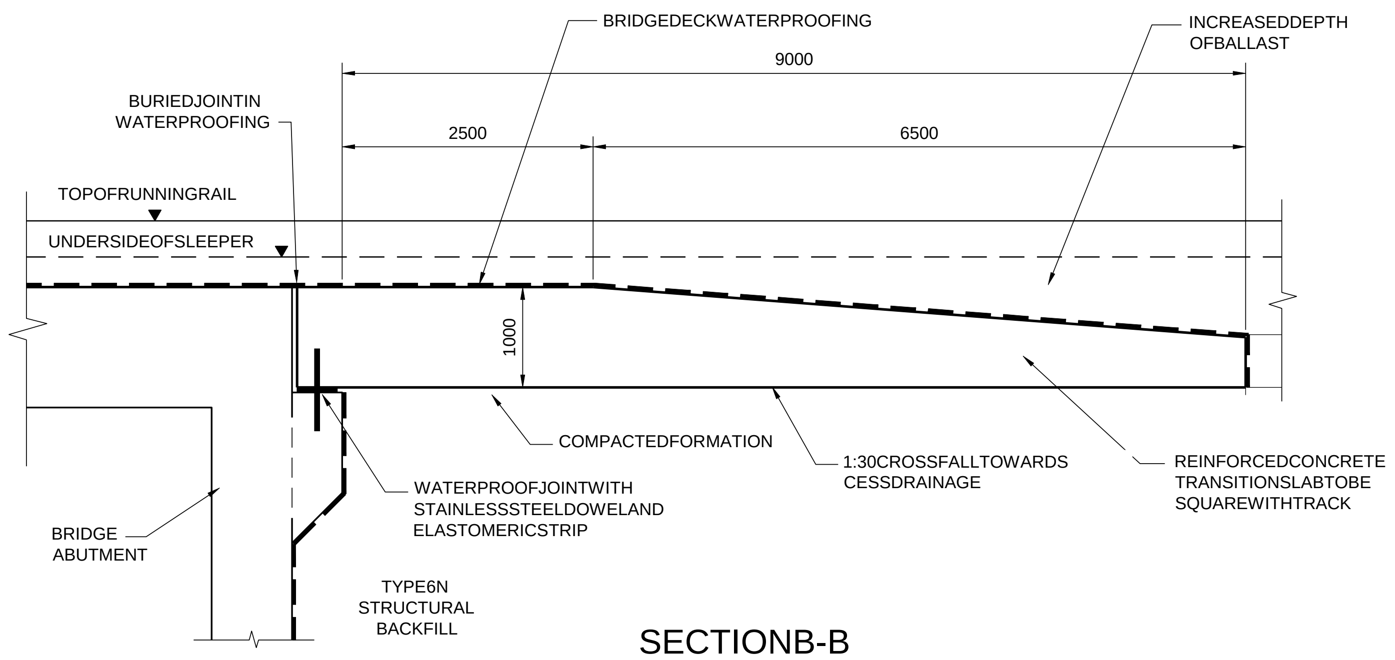
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber

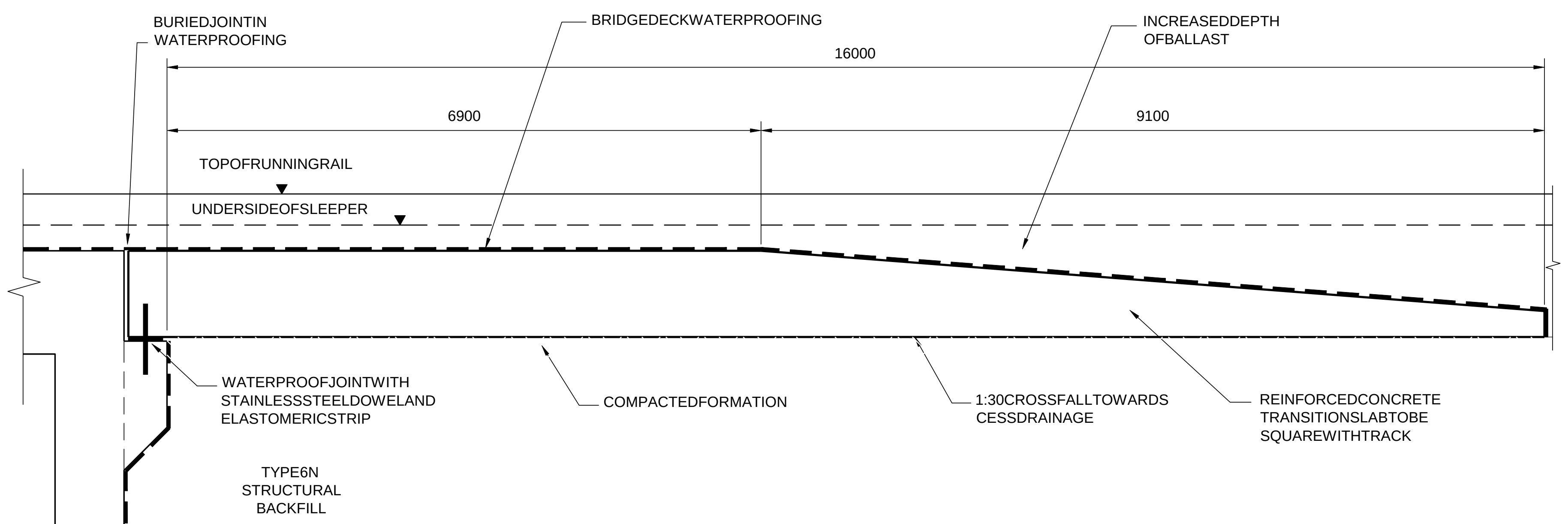
MMD-350164-C-DR-GP-XX-0012



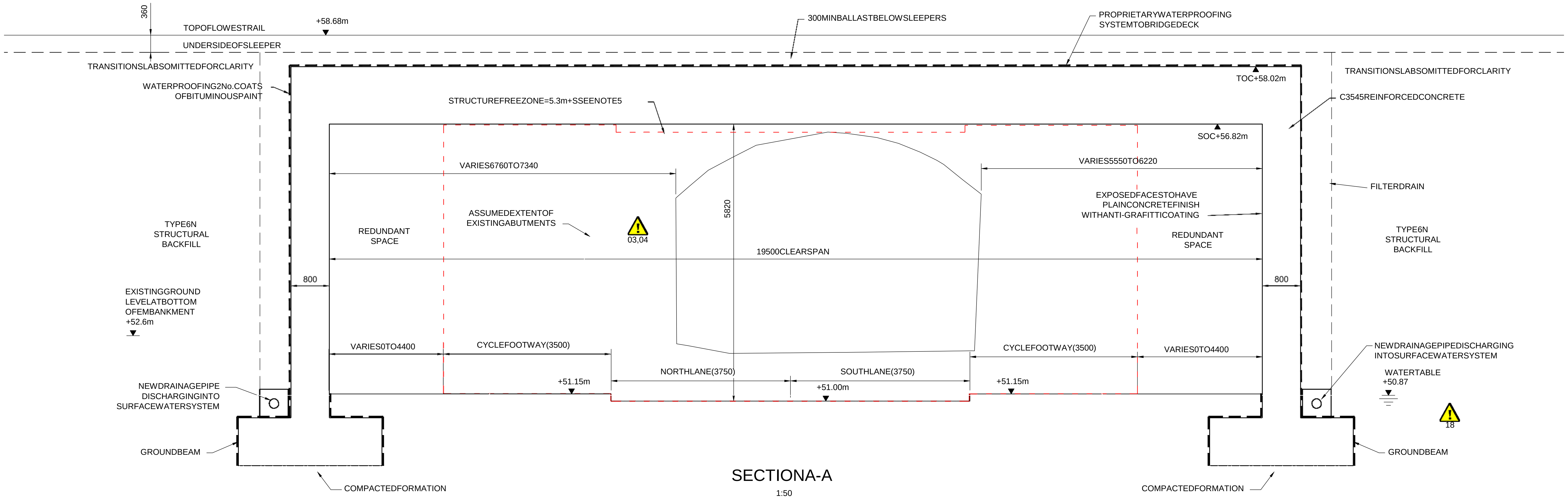
PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONC-C
1:50



SECTIONA-A
1:50

1:50 0 2.5m 5m

1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-13 Jul9,2015-
5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm.
6. DRAWINGSSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=3605 TONNES. P2

Keytosymbols

(XXXX)	-	SKEWEDDIMENSION
TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	CHANGEOFADDRESS&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

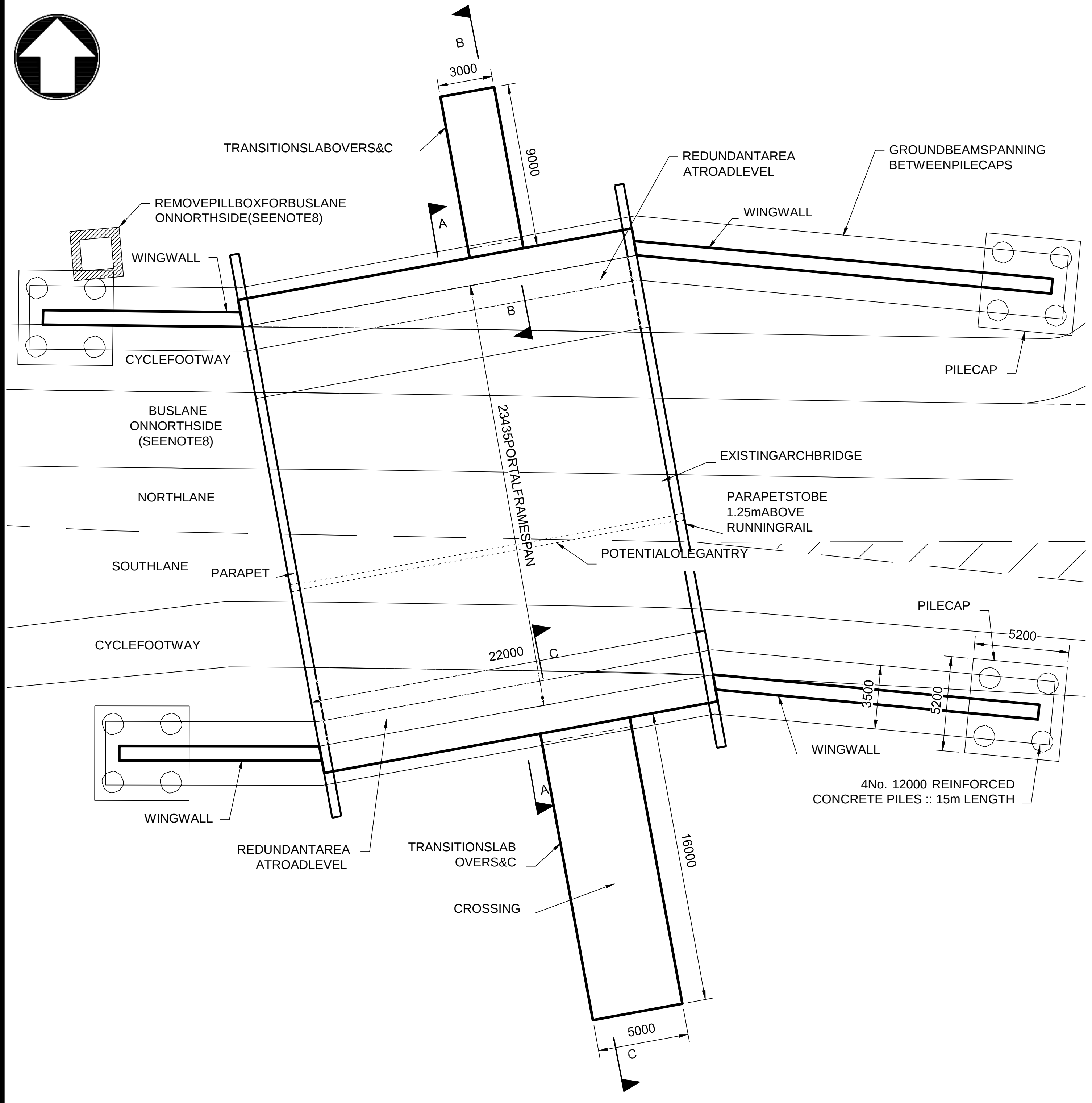
Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
Option3-NoBusLane
SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

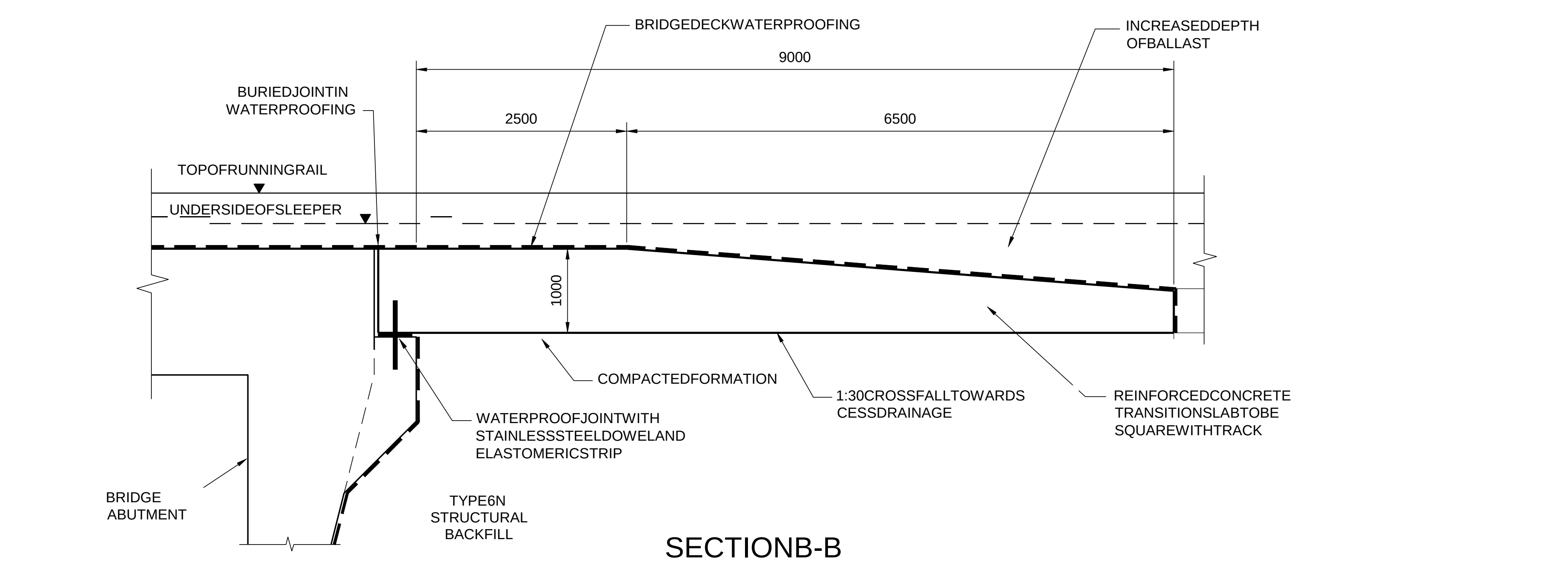
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0013



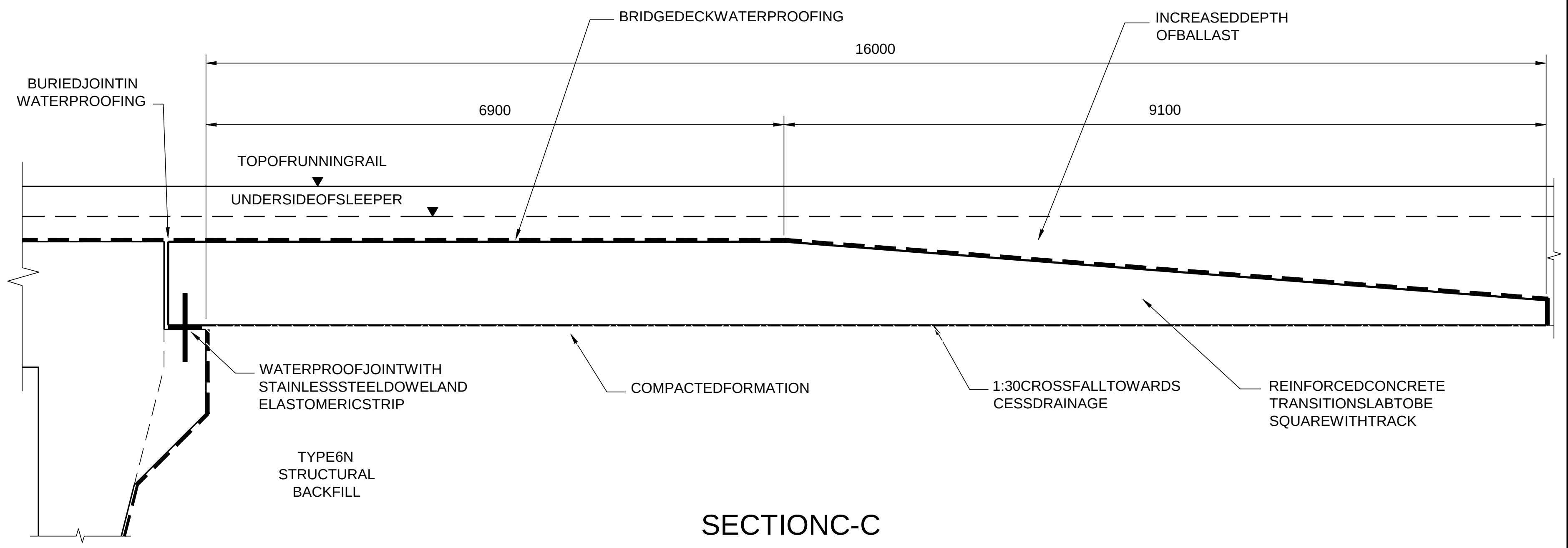
PLANOFSTRUCTURE

1:200



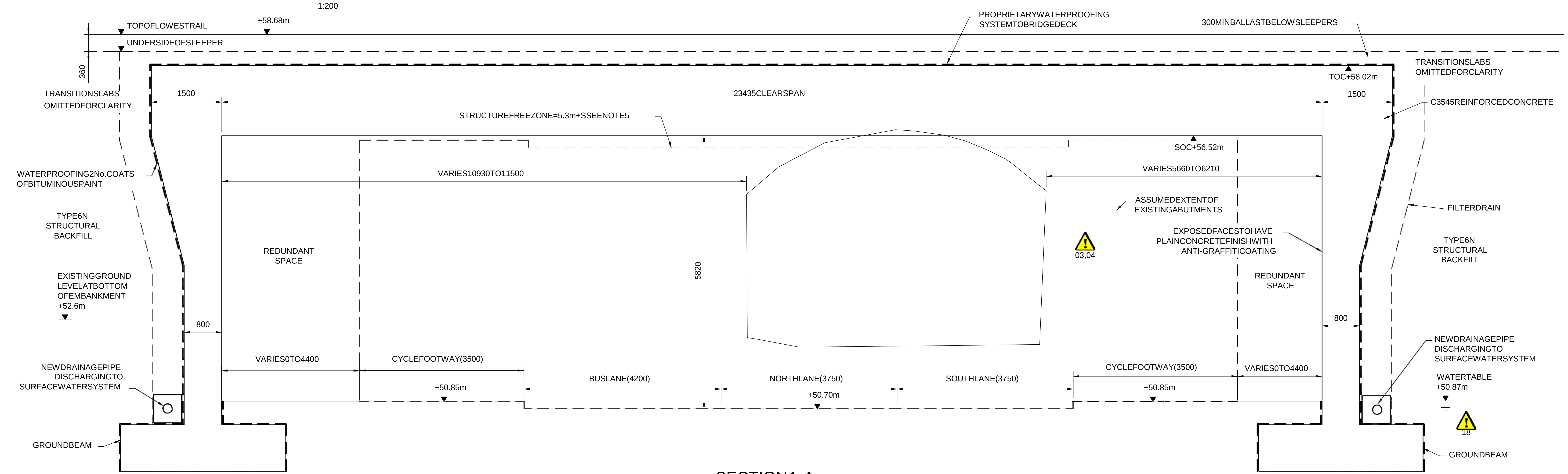
SECTIONB-B

1:50



SECTIONC-C

1:50



SECTIONA-A

1:50

©MottMacDonaldLimited

1:50 — 0, 2.5m, 5m
1:200 — 0, 10m, 20m

P:\Bristol\BN\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-14 Jul9,2015-5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm.
6. DRAWINGSSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TWOBUSLANEALIGNMENTSHAVEBEENPROPOSEDBYTHE HIGHWAYDESIGNERS;ONEOPTIONWITHDESIGNATEDBUSLANE LOCATEDONTHENORTHSIDEANDONEOPTIONONTHESOUTHSIDE OFTHECARRIAGEWAY.THISDRAWINGPRESENTSTHEOPTIONWITH THEBUSLANEONTHENORTHSIDE,WHICHBEARSGREATERRISKTO THEBRIDGECONSTRUCTION.
9. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=4860 TONNES. P2

Keytosymbols

(XXXX)	-	SKEWEDDIMENSION
TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 — EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 — WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	CHANGEOFADDRESS&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

P2

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

Client

Network Rail

Title

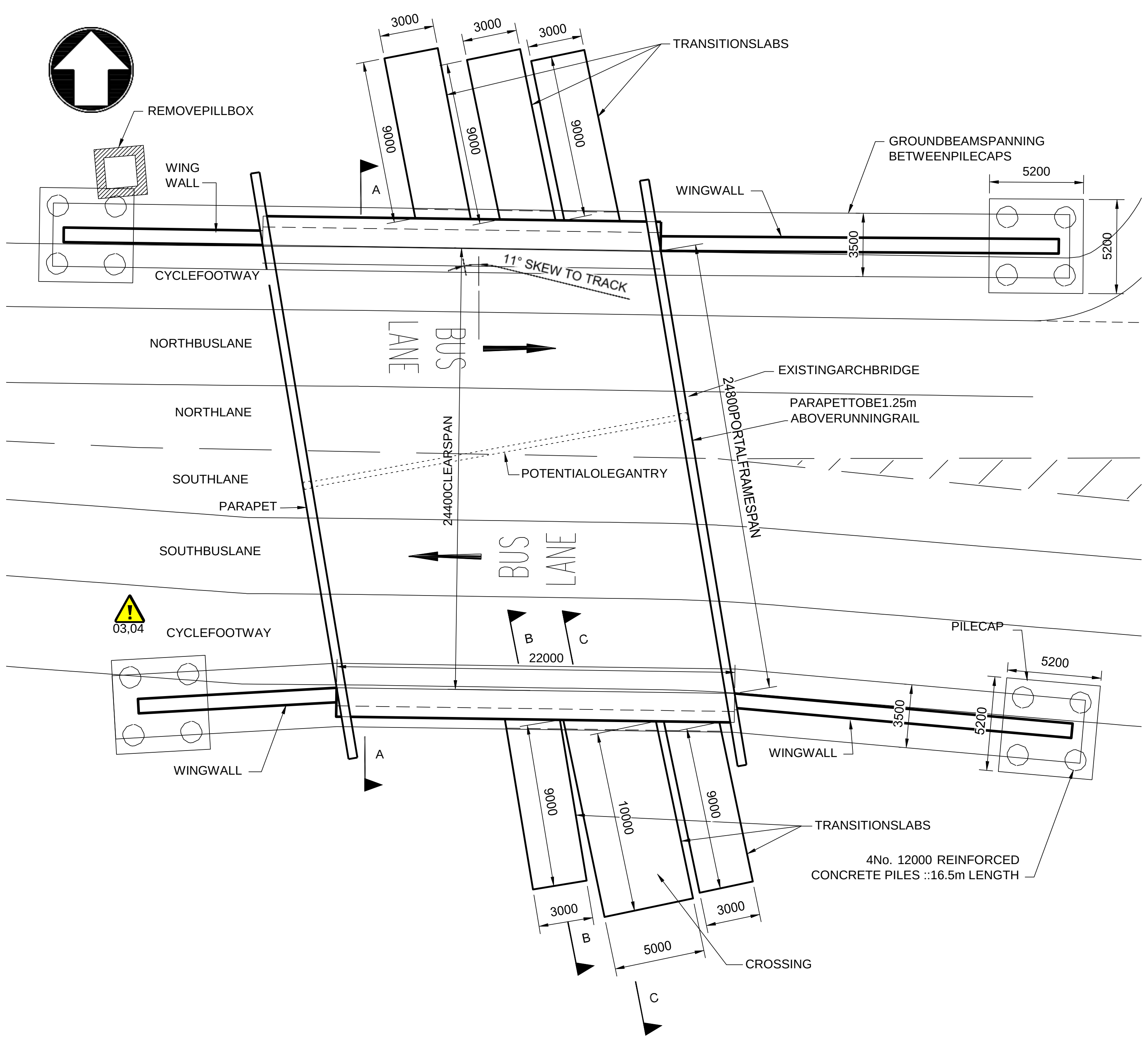
GipsyPatchLaneBridge(BSW5m60ch) Option4-SingleBusLane SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

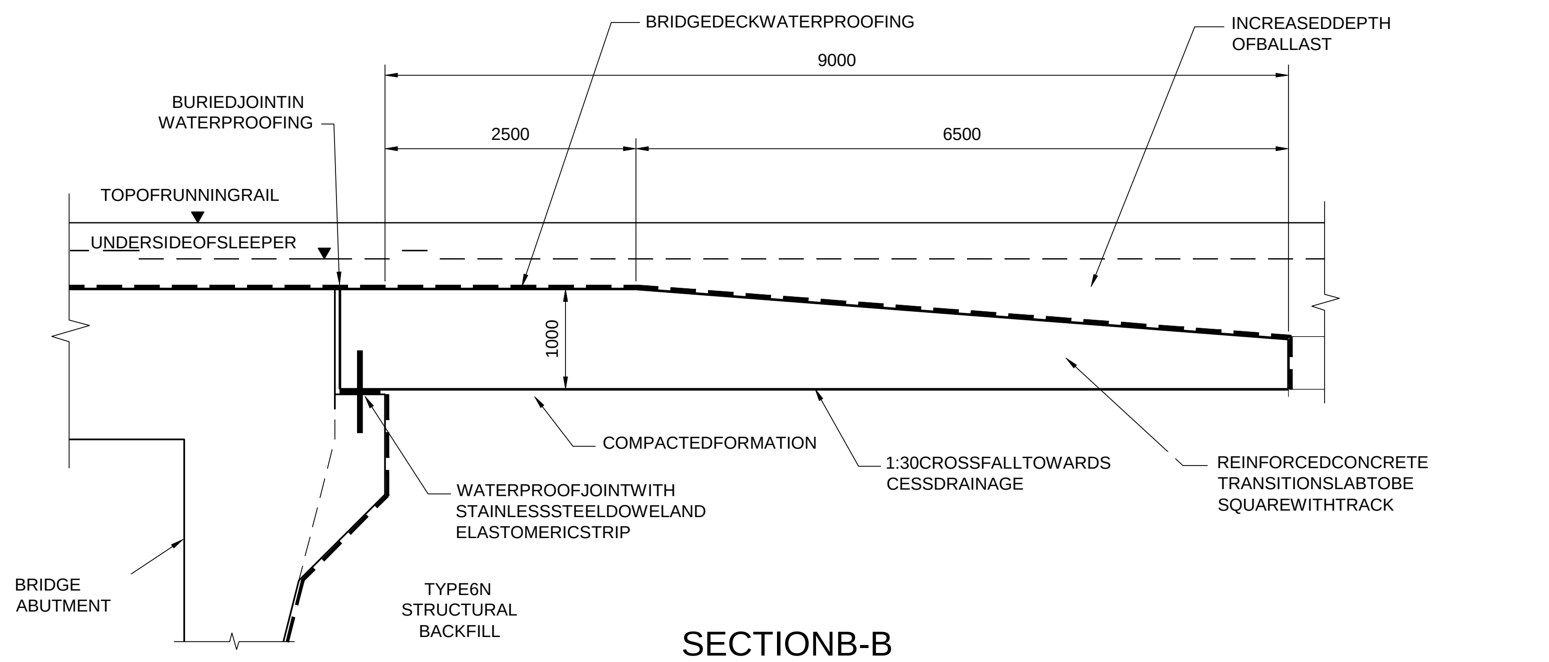
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber

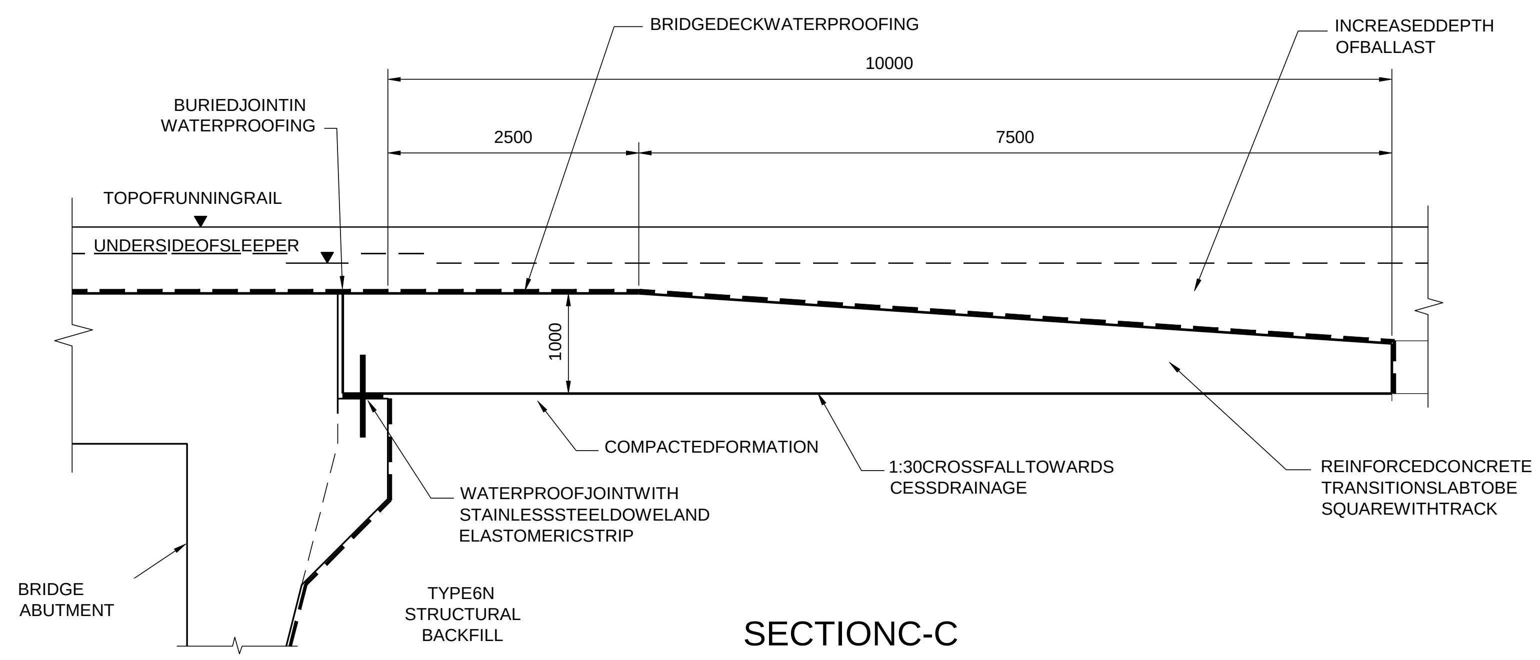
MMD-350164-C-DR-GP-XX-0014



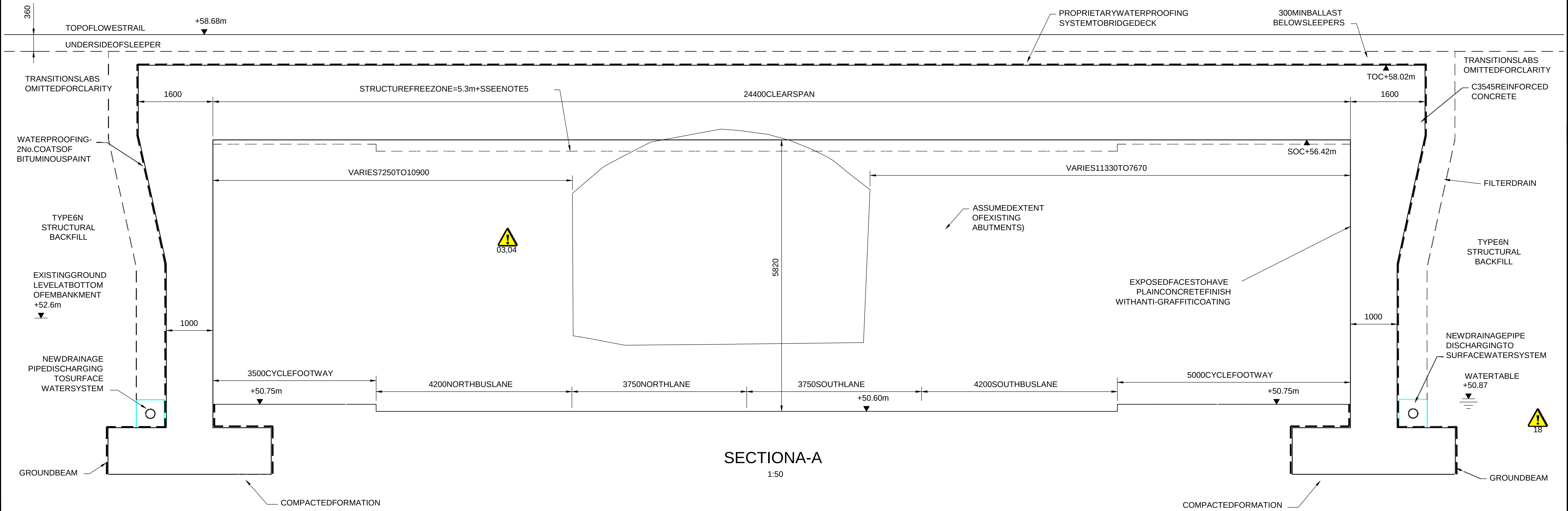
PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONC-C
1:50



SECTIONA-A
1:50

1:50 0 2.5m 5m
1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-15 Jul9,2015- 5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL-001OPTIONSELECTIONREPORT
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=5280TONNES.

Keytosymbols

TOC - TOPOFCONCRETE
SOC - SOFFITOFCONCRETE
NETWORKRAILLAND REGISTRYBOUNDARY
ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN
18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	090715	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

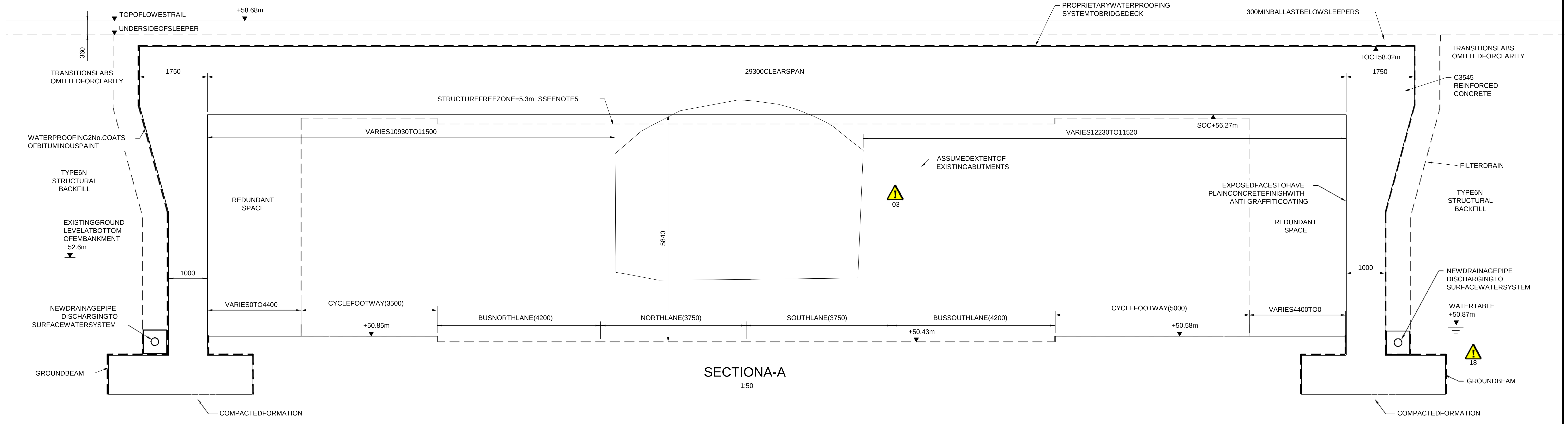
Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
Option5-DualBusLane
SkewedtoTrack

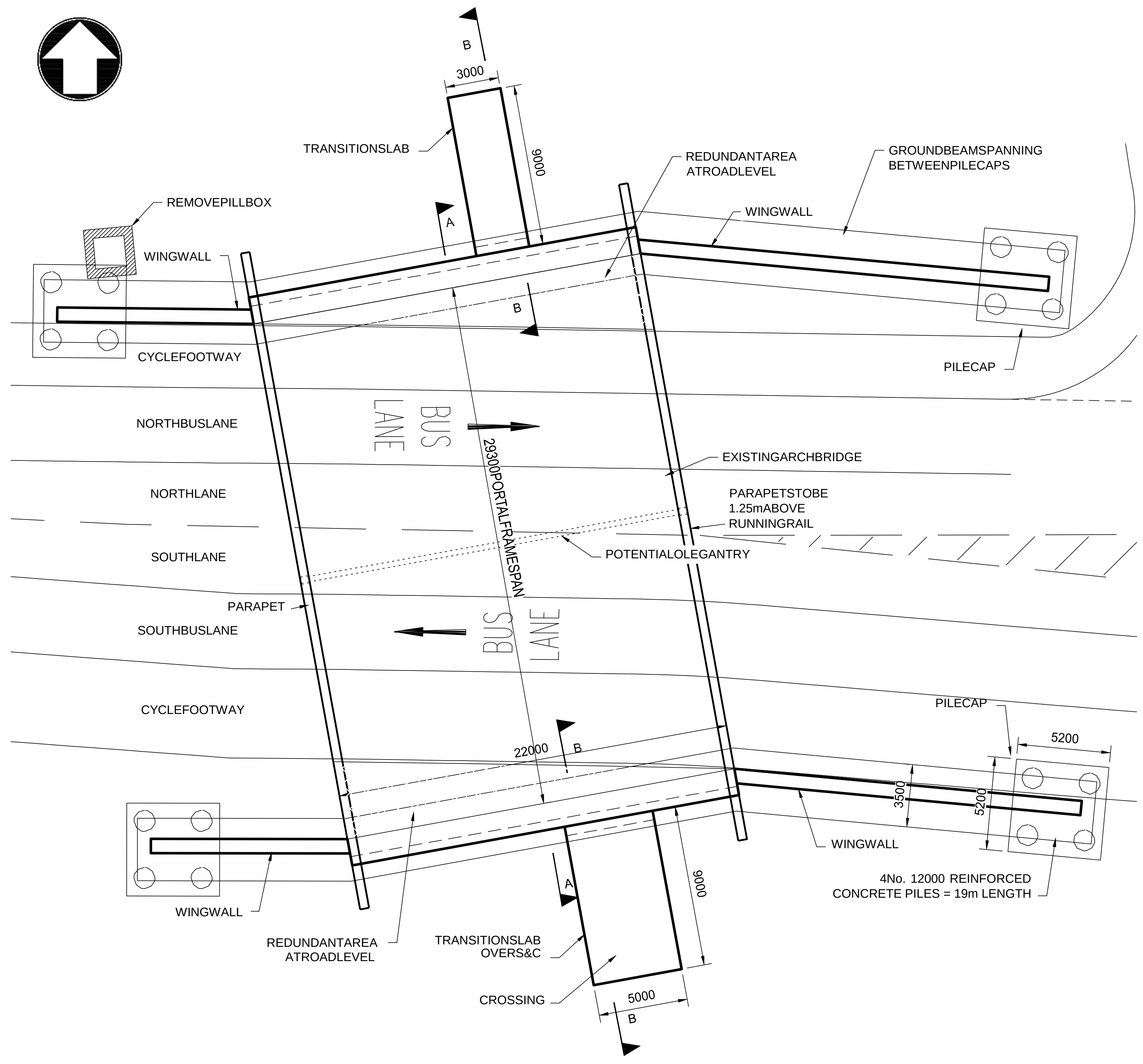
Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P1	STD

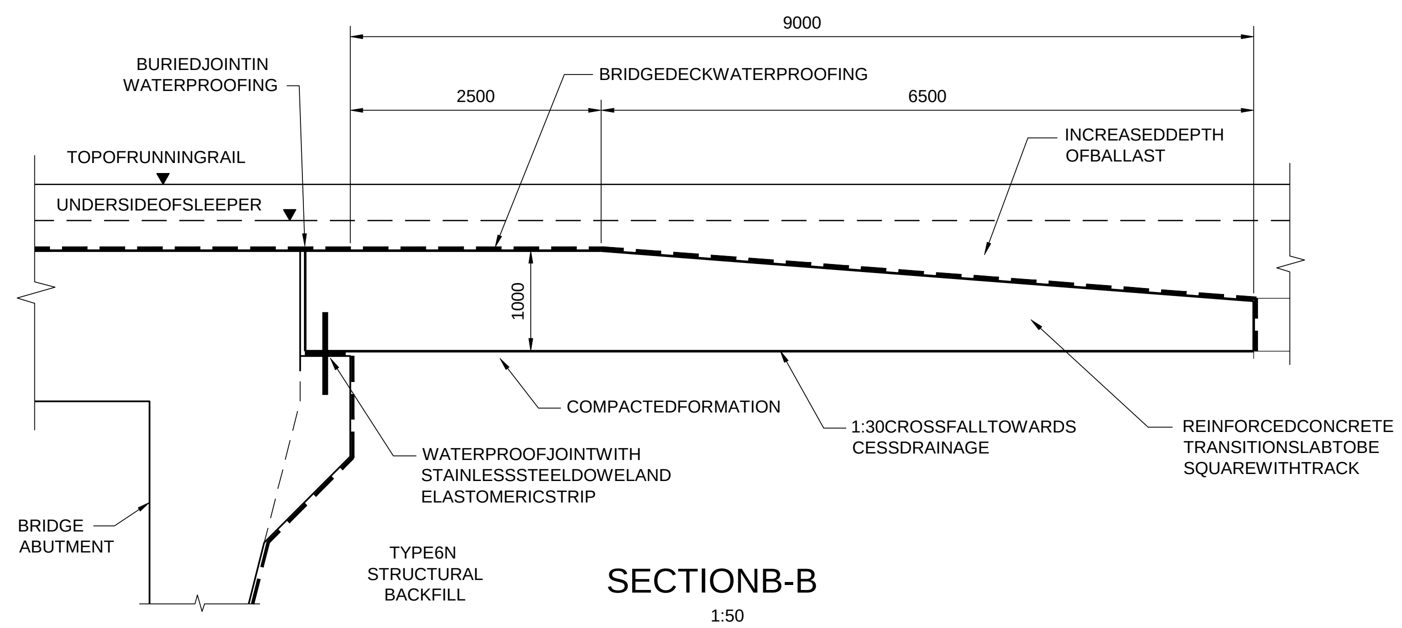
DrawingNumber
MMD-350164-C-DR-GP-XX-0015



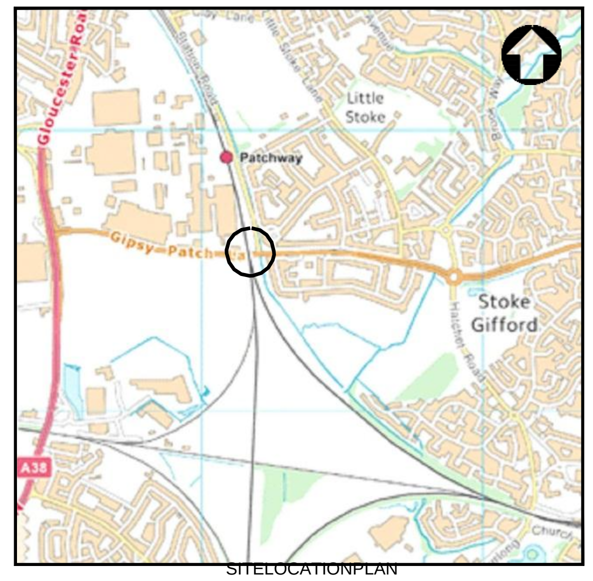
SECTIONA-A
1:50



PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SITELOCATIONPLAN

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTED OTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEY LEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROM THESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTION WITHALLTHERELEVANTENGINEERINGDRAWINGS, CIVILANDSTRUCTURALSPECIFICATIONS,WRITTEN INSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESAND OTHERDOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m, S=270mm.
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLIN MARCH2015(ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTING INCLUDINGPORTALFRAME,GROUNDBEAMSANDALL WINGWALLS=5970TONNES.

(XXXX)	-	SKEWEDDIMENSION
TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

1:50 0 2.5m 5m

1:200 0 10m 20m

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	090715	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

Client
Network Rail

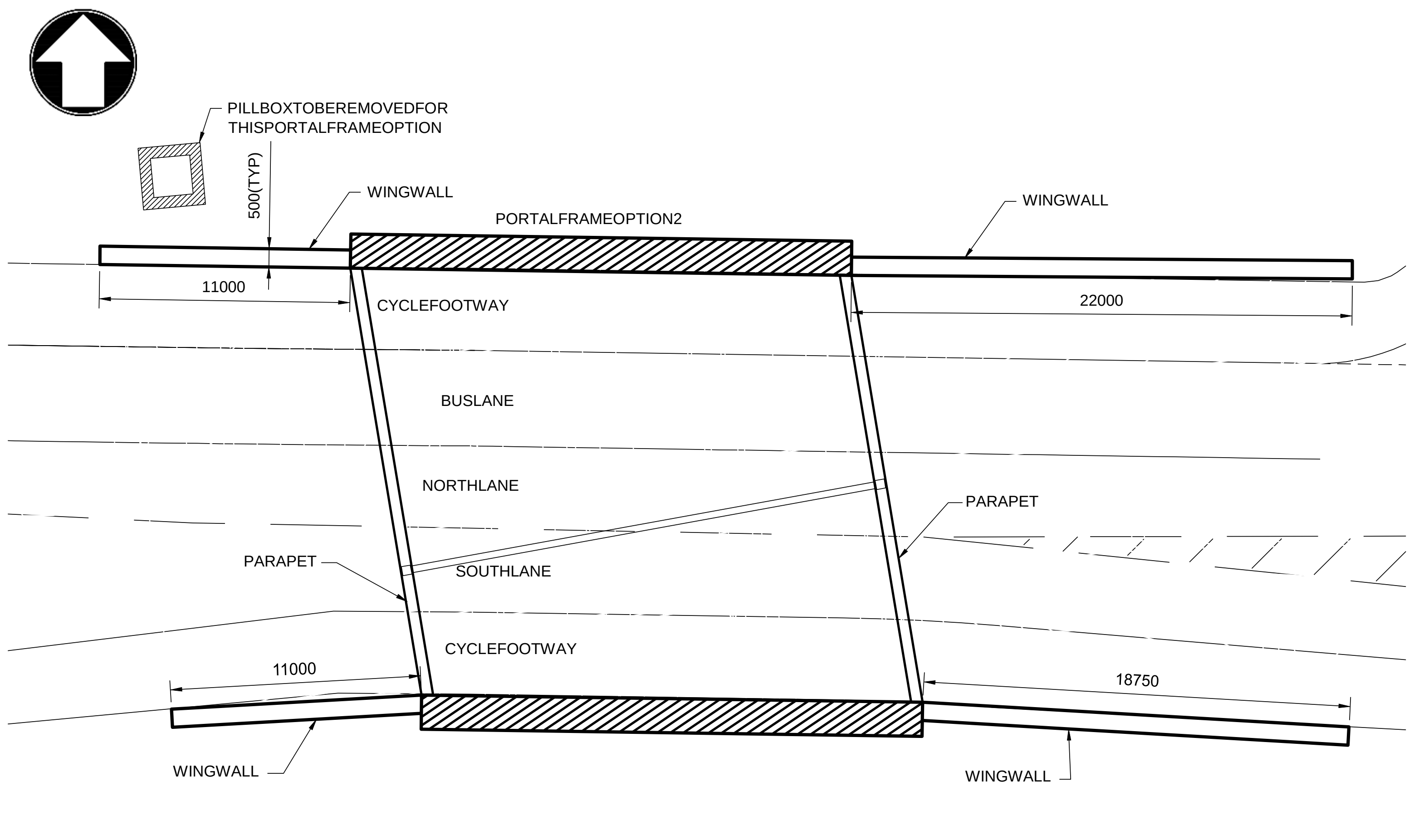
Title
GipsyPatchLaneBridge(BSW5m60ch)
Option6-DualBusLane
SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

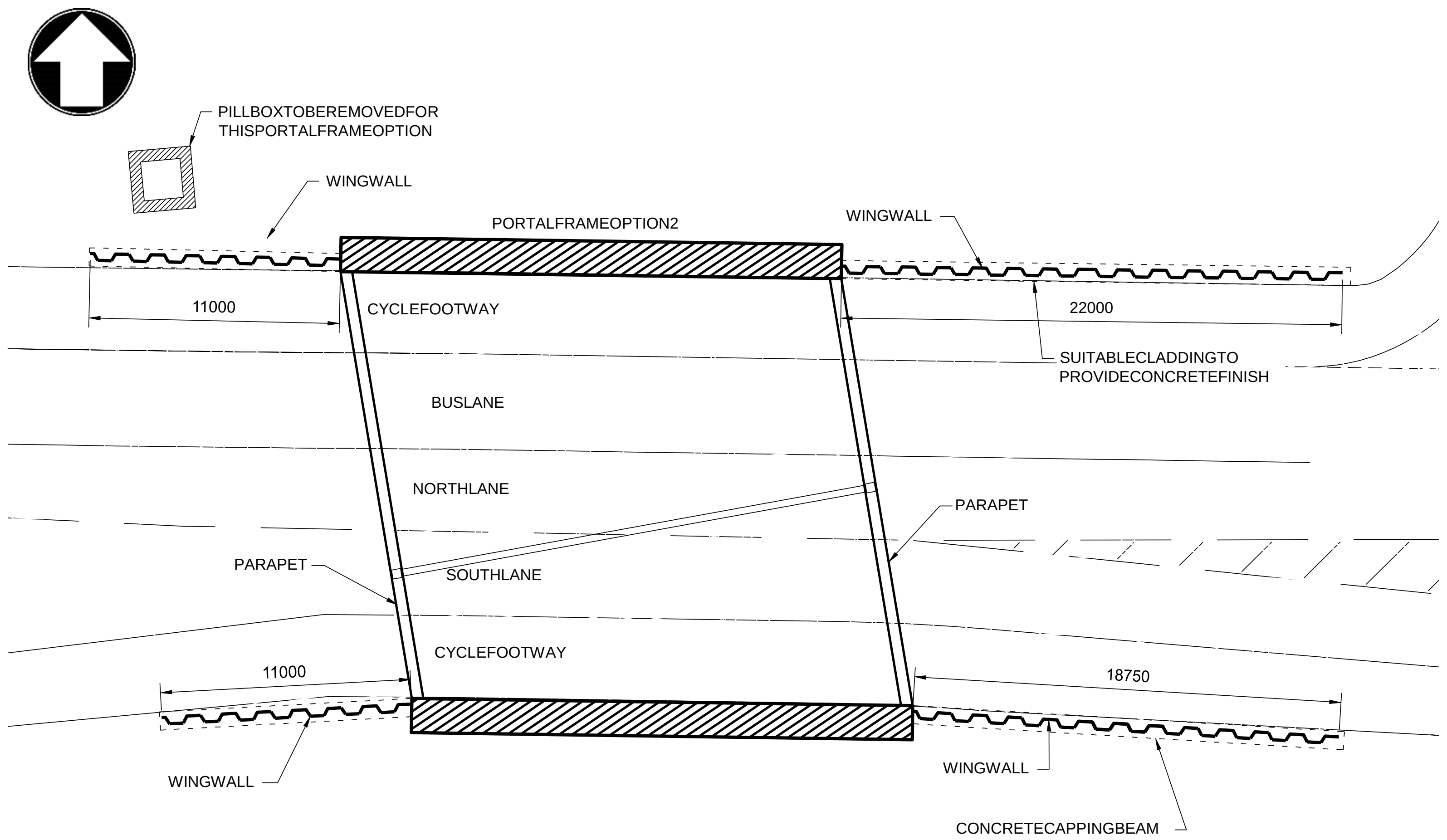
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P1	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0016

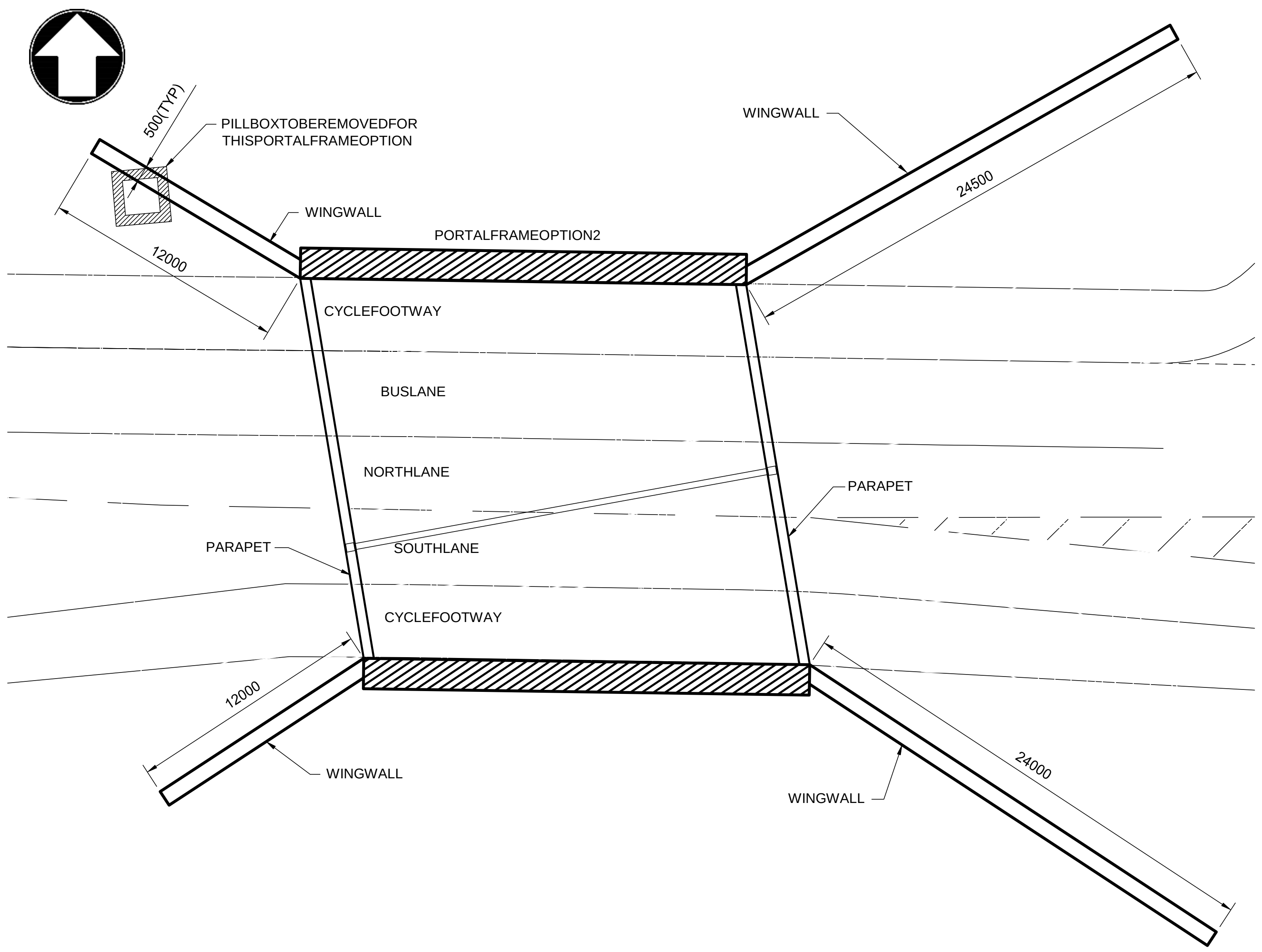
P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-16 Jul9,2015- 5:02PM FOO73213



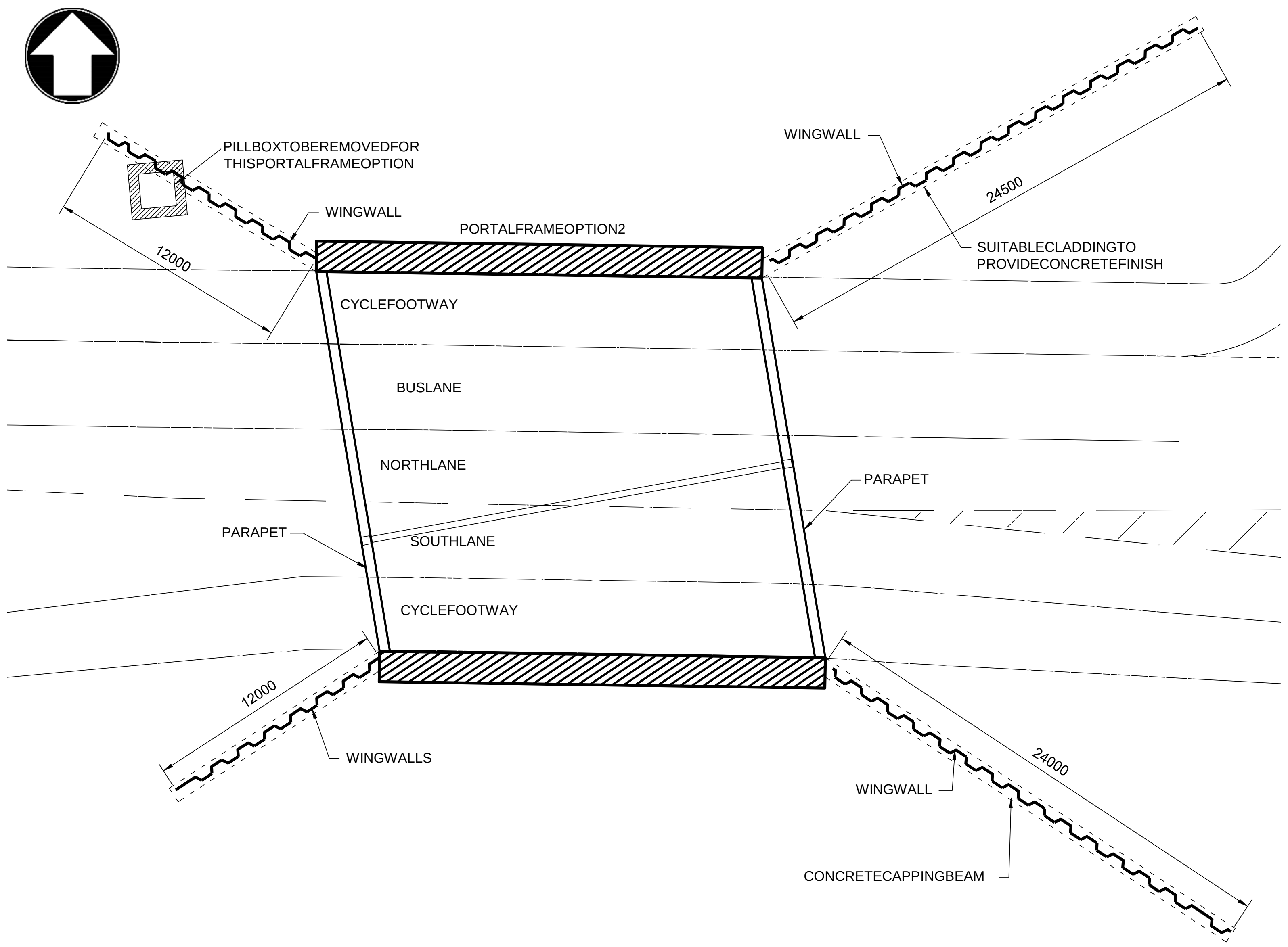
PRECASTCONCRETE
STRAIGHTWINGWALLS
1:200



SHEETPILE
STRAIGHTWINGWALLS
1:200



PRECASTCONCRETE
SPLAYEDWINGWALLS
1:200



SHEETPILE
SPLAYEDWINGWALLS
1:200

1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-0021.dwg
Jul9,2015-5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
3. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
4. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
5. WINGWALLOPTIONSAREPRESENTEDONPORTALFRAMEOPTION2. WINGWALLGENERALARRANGEMENTISSIMILARFORTHEOTHER BRIDGESTRUCTUREOPTIONS.FORDETAILSOFTHEBRIDGE STRUCTUREOPTIONS,REFERTODRG.NOS. MMD-350164-C-DR-GP-XX-0011,0012,0013,0014,0015AND0016.

Keytosymbols

NETWORKRAILLAND
REGISTRYBOUNDARY

ADOPTEDHIGHWAY

SITELOCATIONPLAN
Ordnance Survey © Crown copyright 2015. All rights reserved. Licence number 100026791.

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	ADDRESSCHANGE	AVG	CB
P1	030615	NJV	FIRSTISSUE	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

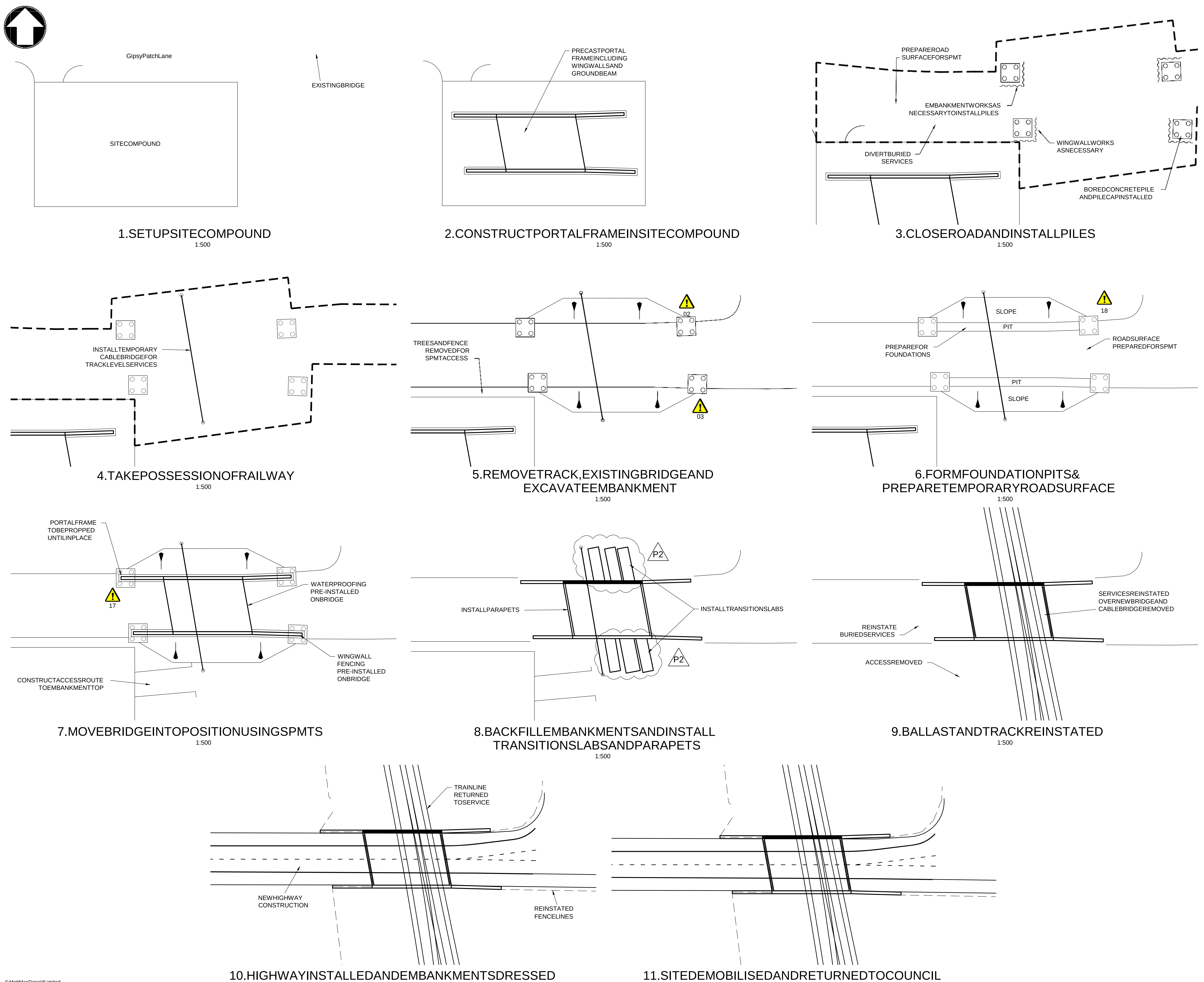
Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch) WingwallOptions

Designed	GSkehel	GS	Engcheck	AGeorgiev	AG
Drawn	NJVanstone	NJV	Coordination	AGeorgiev	AG
Dwgcheck	AGeorgiev	AG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
1:200	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0021



P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-SK004.dwg
Jul9,2015-5:03PM FOO73213

Notes

1. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
2. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
3. FOREXISTINGSERVICESANDLANDOWNERSHIPSEEDRAWING MMD-350164-C-DR-GP-XX-001
4. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
5. CONSTRUCTIONSEQUENCEISPRESENTEDONPORTALFRAME OPTION1.CONSTRUCTIONSEQUENCEPROPOSEDISSIMILARFORALL BRIDGESTRUCTUREOPTIONS.FORDETAILSOFOTHERBRIDGE STRUCTUREOPTIONS,REFERTODRGNos MMD-350164-C-DR-GP-XX-0011,0012,0013,0014,0015,0016

Keytosymbols

SPMT-SELF-PROPELLEDMODULARTRANSPORTERS

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

- 02 STABILITYOFSTRUCTUREDURINGDEMOLITION
- 03 EXISTINGSTRUCTUREEXTENTSUNKNOWN
- 17 SPMTLOADINGONROADWAY
- 18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	TRANSITIONSLABSADDED	GS	CB
P1	050615	TF	FIRSTISSUE	GS	CB

Mott MacDonald

10TempleBack
Bristol,BS16FL
UnitedKingdom

T +44(0)1179069500
W www.mottmac.com

Client

Network Rail

Title

GipsyPatchLaneBridge(BSW5m60ch)
ConstructionSequence

Designed	REvans	RE	Engcheck	Gskehel	GS
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	GSkehel	GS	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber

MMD-350164-C-DR-GP-XX-SK004

Appendix B

Project Hazard Log

Notice

This report was produced by Mott MacDonald for Network Rail for the sole purpose of Gypsy Patch Lane (BSW Sm 60ch).

It may not be used by any person for any other purpose other than that specified without the express written permission of Network Rail and Mott MacDonald.
Any liability arising out of use by Network Rail or a third party of this document for purposes not wholly connected with the above shall be the responsibility of that party who shall indemnify Mott MacDonald against all claims cosls damages and losses arising out of such use.

Gipsy Patch Lane
Hazard Log

Document Historv

Document Reference: 350164-WTD-BTL-003	Revision: B
CEM	Robert Sanderson
Date	f//7/IJ-
Signature	/f r:.---r .J ......

Project Hazard Log

Project Title: Gipsy Patch Lane & Brierly Furlong

Location: Gipsy Patch Lane (BSW 5m 60ch)

Doc Ref: 350164-WTD-BTL-003

Revision Number: B

DESIGN STAGE: GRIP 3

Date: 06 July 2015

HAZARD ASSESSMENT									Risk			DESIGNER CONTROL MEASURES							RESIDUAL RISK						HAZARD TRANSFER
Hazard ID	Location	Source	Discipline	Sub-discipline - Topic within the engineering discipline (eg. Cess).	**Hazard Description** - Description of the Hazard relating to building construction, use (as a workplace), operating in normal/abnormal/emergency/degraded modes, cleaning and maintaining, altering, dismantling and demolition of a structure.	Hazard Consequences	Red List Hazard	Persons at Risk	F	C	Result	**Measures Taken by Designer** - Detail the hazard elimination or risk reduction actions.	F	C	Result	Location of details	Status	**Designer comments** - Designer comments on the designer control measures section contents that records decisions taken and clarification of actions taken by the designer.	**Residual Hazard Description** - Description of the Residual Hazard relating to building construction, using (as a workplace), operating in normal/ abnormal/emergency/degraded modes, cleaning and maintaining, altering, dismantling and demolition of a structure.	Persons at Risk	Possible Residual Control Measures	Residual Hazard Owner	Residual Hazard Information Transmission	**Designer Comments to Explain Residual Hazard** (To be completed where necessary for clarity and convey intent)	**Project Transfer Status** - Details of status of hazard when residual risk is being transferred to identified owner. No entry required until hazard formally offered to residual risk owner.
1	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Buried services information	Civils	Utilities	Contact with buried services and overhead cables. Buried services information, provided by Network Rail may be out-of-date at the time of construction works.	Electrocution, gas leak or water leak, during works	No	Workers, Members of the Public	3	4	Intolerable Risk	Known services have been marked on drawing MMD-350164-C-DR-GP-XX-0001. This should be reviewed and updated as necessary in future GRIP stages.	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0001.	Mitigation Identified	Future GWEP works will introduce OLE to the route	Contact with buried services: Electrocution, gas leak or water leak, during works. Potential for clash with unknown services during future maintenance or alterations works.	Workers	An investigation into services within the proximity of the structure is to be undertaken prior to commencement of works. Services to be rerouted as part of works where necessary. Maintain and update hazard logs.	Contractor			
2	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Demolition	Instability of existing structure during demolition	Collapse causing - Injury/serious injury / death	No	Workers	2	4	Tolerable Risk	Bridge to be demolished as part of scope therefore not possible to design out. Demolition staging to be specified by designer as part of detailed design. Latest NWR Assessment and inspections for the structure reviewed by designer to understand the condition and inform demolition staging. Structure noted to be in fair condition but soffit was not visible during inspections.	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-SK004.	Mitigation Identified	Risk highlighted on drawings	Collapse of existing structure during demolition / structural instability	Workers	Detailed demolition staging to be provided at later design stages. Staging to ensure excavation to arch is even to both sides of the arch.	Contractor			
3	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Demolition	Extent of existing structure unknown	Programme and cost increase COMMERCIAL - NWR	No		3	3	Tolerable Risk	Ground penetrating radar to be undertaken to establish dimensions of existing structure. Extent of structure to be shown on drawings once confirmed.	2	3	Tolerable Risk	MMD-350164-C-DR-GP-XX-0002.	Mitigation Identified	Risk highlighted on drawings	Extent of existing structure unknown		Review following ground penetrating radar	Designer			
4	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction & Demolition	Extent of existing structure unknown	Striking structure during preliminary works, leading to collapse	No	Workers, Members of the Public	3	3	Tolerable Risk	Ground penetrating radar to be undertaken to establish dimensions of existing structure. Extent of structure to be shown on drawings once confirmed.	2	3	Tolerable Risk	MMD-350164-C-DR-GP-XX-0002.	Mitigation Identified	Risk highlighted on drawings	Extent of existing structure unknown	Workers, Members of the Public	Review following ground penetrating radar	Designer			
5	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Demolition	Potential contaminants e.g. Asbestos in embankments exposed during demolition	Long term illness / death	No	Workers	2	4	Tolerable Risk	Not practicable within scope to conduct asbestos / contaminants survey, should be undertaken prior to commencement of works	2	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Open		Potential contaminants e.g. Asbestos in embankments exposed during demolition	Workers	Further Ground Investigations to be carried out at later design stage. Suitable method for disposal of contaminated material to be identified by contractor prior to undertaking works.	Designer			
6	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Demolition / Construction	The National Hazard Directory has identified the following – "This stretch of railway has been identified as being at risk from the migration of landfill gasses. Appropriate precautions should be taken."	Injury/serious injury / death	No	Workers	2	4	Tolerable Risk	Not practicable within scope to monitor landfill gases on site.	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Open		Landfill gases	Workers	During excavation and foundation construction, the contractor must ensure adequate measures are taken for hazard management.	Contractor			
7	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Embankment excavation	Detailed make up of embankment unknown, soft / hard spots and slope instability may be encountered	Injury/serious injury / death	No	Workers	2	4	Tolerable Risk	Available GI used to inform design	1	4	Tolerable Risk	GDR	Mitigation Identified	None	Make up of embankment unknown Slope instability	Workers	Undertake further GI to inform later grip stages. Geotechnical input to ensure slope angle is maintained.	Designer			
8	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Manual handling	Injury/serious injury	No	Workers	3	3	Tolerable Risk	Pre-cast elements to be used in design and lifted in to place with SPMTs & cranes	2	3	Tolerable Risk	350164-WTD-BTL-001 Gipsy Patch Lane Option Selection Report	Mitigation Identified	None	Manual handling	Workers	Suitable construction method to be developed to minimise manual handling.	Contractor			
9	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Use of Mortars / Concrete	Chemical burns (mortars, concrete) leading to injury or impacting on long term health	No	Workers	3	3	Tolerable Risk	Pre-cast elements to be used in design where possible to reduce use of wet concrete and mortars on site.	2	3	Tolerable Risk	350164-WTD-BTL-001 Gipsy Patch Lane Option Selection Report	Mitigation Identified	None	Injury, burn	Workers	Contractor to follow safe systems of work	Contractor			
10	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Working at height	Injury through falling from height, falling equipment	No	Workers, Members of the Public	4	4	Intolerable Risk	Not practicable to design out working at height for bridge works. Design to incorporate precast elements that can be lifted into position and thus reducing the construction time and time working at height. Number of elements to be limited where possible to limit the assembly time whilst working at height. Main concrete structure to be pre-cast in controlled environment to reduce the risk of working at height.	2	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Mitigation Identified	None	Fall from height Objects falling from height	Workers	Contractor to consider temporary handrails and fall arresting equipment.	Contractor			
11	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Maintenance	Working at height during maintenance	Injury through falling from height, falling equipment	No	Workers, Members of the Public	2	4	Tolerable Risk	Not practicable to design out working at height for bridge maintenance, due to the nature of standard maintenance and inspection regimes. New parapet to be provided to a minimum of 1.25m and handrails to be provided (as per NWR standards)	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Mitigation Identified	None	Fall from height Objects falling from height	Workers	Maintain parapet handrails	Maintainer			
12	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Public access	Harm to public, conflict, liability	No	Workers, Members of the Public	3	2	Tolerable Risk	Road / Footpath closure required for demolition of existing bridge. Therefore not possible to design out.	3	2	Tolerable Risk		Open	None	Harm to public, conflict, liability	Workers, Members of the Public	Consideration should be given to the alternative routes for the public	Contractor			
13	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Working adjacent to a road	Disruption to traffic flows, struck by vehicle, injury, serious injury, death	No	Workers, Members of the Public	3	5	Intolerable Risk	Portal frame structure to be constructed within site compound to reduce roadside construction time. Road to be closed for main works.	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-SK004	Open	None	Struck by vehicle	Workers, Members of the Public	Contractor to detail and maintain traffic management and site extents.	Contractor			
14	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Working adjacent to rail	Struck by train, injury, serious injury, death	No	Workers, Members of the Public	2	5	Intolerable Risk	All trackside works to be completed during a possession, as detailed in construction sequence. Form A completed for track replacement.	1	2	Negligible Risk	MMD-350164-C-DR-GP-XX-SK004	Open	None	Struck by train	Workers, Members of the Public	Contractor to ensure track side works are completed under possession.	Contractor			
15	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Sensitivity of the track – the skewed option will present differential settlement which could lead to track twist and derailment	Derailment, injury, death	No	Passengers, Members of the Public	3	5	Intolerable Risk	Transition slabs to be installed where required. Settlement predictions to be included as part of GDR.	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016 GDR	Open	None	Derailment	Passengers, Members of the Public	Monitoring & retamping of ballast to be undertaken.	Maintainer			
16	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Disruption to rail	Cost to NWR, risk to asset COMMERCIAL NWR	No		2	4	Tolerable Risk	Pre-cast elements to be used in design and lifted in to place with SPMTs & cranes where possible to reduce possession time.	1	4	Tolerable Risk		Mitigation Identified	Risk to asset	Disruption to rail	Passengers	Construction activities to be well planned.	Contractor			

HAZARD LOG Form

Project Title	Gipsy Patch Lane & Brierly Furlong	DESIGN STAGE	GRIP 3
Location	Gipsy Patch Lane (BSW 5m 60ch)		
Doc Ref	350164-WTD-BTL-003		
Revision Number	B	Date	06 July 2015

Project Hazard Log

HAZARD ASSESSMENT									Risk			DESIGNER CONTROL MEASURES							RESIDUAL RISK						HAZARD TRANSFER
Hazard ID	Location	Source	Discipline	Sub-discipline - Topic within the engineering discipline (eg. Cess).	Hazard Description - Description of the Hazard relating to building construction, use (as a workplace), operating in normal/abnormal/emergency/degraded modes, cleaning and maintaining, altering, dismantling and demolition of a structure.	Hazard Consequences	Red List Hazard	Persons at Risk	F	C	Result	Measures Taken by Designer - Detail the hazard elimination or risk reduction actions.	F	C	Result	Location of details	Status	Designer comments - Designer comments on the designer control measures section contents that records decisions taken and clarification of actions taken by the designer.	Residual Hazard Description - Description of the Residual Hazard relating to building construction, using (as a workplace), operating in normal/ abnormal/emergency/degraded modes, cleaning and maintaining, altering, dismantling and demolition of a structure.	Persons at Risk	Possible Residual Control Measures	Residual Hazard Owner	Residual Hazard Information Transmission	Designer Comments to Explain Residual Hazard (To be completed where necessary for clarity and convey intent)	Project Transfer Status - Details of status of hazard when residual risk is being transferred to identified owner. No entry required until hazard formally offered to residual risk owner.
17	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Driving portal frame in to place - high loading on road surface	Damage to buried services COMMERCIAL NWR	No	Workers, Members of the Public	2	4	Tolerable Risk	SPMT providers contacted for further advice. Temporary protection of the road surfacing and services has been allowed for in the cost estimate.	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-SK004	Open	None	Damage to buried services	Workers, Members of the Public	Buried services to be identified and appropriate temporary road surface installed.	Contractor			
18	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction/ Operation	Existing water table at 50.87m - close to proposed carriageway level.	Injury/serious injury / death	No	Workers, Members of the Public	3	4	Intolerable Risk	Permanent highway design, being undertaken by others, will need to include provision for pumping as necessary. Water table to be shown and highlighted as hazard on drawings.	1	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Open	None	Existing water table	Workers, Members of the Public	Highways designer to include provision for pumping as necessary. Contractor to ensure worksite is kept free of water.	Designer			
19	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Temporary stability of portal frame	Injury/serious injury / death	No	Workers	3	5	Intolerable Risk	Portal frame to be designed for the temporary case and propped during construction	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-SK004	Open	None	Temporary stability of portal frame	Workers	Portal frame to be designed for temporary case. Portal frame to be propped whilst manoeuvring into position.	Designer			
20	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Operation	Minimum headroom provided (5.3 + sag), whilst this is the minimum required by Highways, it is not the NWR preferred height of 5.7m	Bridge strike, risk to asset	No	Passengers, Workers, Members of the Public	2	4	Tolerable Risk	Design new bridge to be a reinforced concrete portal that is robust enough for (and designed to take) the collision loading. Consideration was given to specifying full 5.7m +sag, but this requires greater construction depth and likely increased impact on buried services making it not economically viable. 5.3m + sag headroom is improvement on existing.	2	4	Tolerable Risk		Mitigation Identified	Risk to asset	Bridge strike	Passengers, Workers, Members of the Public	Repair structure if struck by abnormal vehicle.	Maintainer			
21	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Operation	Reduced Headroom leading to debris being thrown into the train envelope as result of bridge strike	Disruption to traffic flows, injury, serious injury, death	No	Passengers, Workers, Members of the Public	2	5	Intolerable Risk	Design to provide parapets that can withstand the impact and prevent debris launched by a vehicle from entering the train envelope.	1	5	Tolerable Risk	350164-WTD-BTL-001 Gipsy Patch Lane Option Selection Report	Mitigation Identified	None	Debris enter rail envelope	Passengers, Members of the Public	Repair structure if hit by debris.	Maintainer			
22	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Use of machinery	Injury/serious injury / death	No	Workers	3	4	Intolerable Risk	Main concrete structure to be pre-cast in controlled environment to reduce risk from use of machinery	2	4	Tolerable Risk		Mitigation Identified	None	Use of machinery	Workers	Constructor to follow safe system of work.	Contractor			
23	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Construction of the bridge after the Great Western Electrification Programme (GWEP) has taken place	Injury/serious injury / death, risk to asset COMMERCIAL NWR	No	Workers	3	4	Intolerable Risk	Option selection report highlights need to co-ordinate work with GWEP. Potential gantry location highlighted on drawings.	2	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Mitigation Identified	None	Construction of the bridge after the Great Western Electrification Programme (GWEP) has taken place	Workers	Design and construction to be co-ordinated with GWEP	Designer			
24	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Site compound location proposed to be adjacent to existing bridge with restricted sightlines	Injury/serious injury / death	No	Workers, Members of the Public	4	5	Intolerable Risk	Most suitable location to pre-cast portal frame so not possible to fully mitigate at this stage. Site compound entrance to be located in a position that minimises risk to traffic users	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-SK004	Mitigation Identified	None	Site compound location proposed to be adjacent to existing bridge with restricted sightlines	Workers, Members of the Public	Site compound entrance to be located in a position that minimises risk to traffic users. Appropriate signage to be provided on approach to bridge to warn of site entrance.	Contractor			
25	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Stability of embankment, existing bridge and railway during piling works	Injury/serious injury / death, risk to asset, due to collapse of bridge or embankment COMMERCIAL NWR	No	Passengers, Workers, Members of the Public	3	5	Intolerable Risk	Pile locations proposed at the ends of the new wing walls to locate them as far from the track as reasonably practicable and at the toe of the embankment. Stabilising works to embankment and piling rig to be undertaken as necessary.	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016 MMD-350164-C-DR-GP-XX-SK004	Mitigation Identified	None	Stability of embankment, existing bridge and railway during piling works	Workers	Contractor to monitor track and existing bridge structure throughout piling works and undertake appropriate stabilising works as necessary.	Contractor			
26	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction	Stability of piling rig	Injury/serious injury / death, risk to asset, due to overturning piling rig COMMERCIAL NWR	No	Passengers, Workers, Members of the Public	3	5	Intolerable Risk	Pile locations proposed at the ends of the new wing walls to locate them as far from the track as reasonably practicable. Preparation works to embankment and stabilisation of piling rig to be undertaken as necessary.	1	5	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016 MMD-350164-C-DR-GP-XX-SK004	Mitigation Identified	None	Stability of piling rig	Workers	Consider undertaking piling works under shorter possessions as appropriate.	Contractor			
27	Gipsy Patch Lane Bridge (BSW 5m 60ch)	Design Proposal	Civils	Construction & Demolition	Stability of existing pill box during construction and demolition works	Injury/serious injury/death	No	Workers	3	4	Intolerable Risk	Condition of existing pill box is unknown. Location of pill box shown on all drawings. Where appropriate pill box is noted as being removed. For larger options it is not practicable to design out the requirement for demolition of the pill box.	2	4	Tolerable Risk	MMD-350164-C-DR-GP-XX-0011, 0012, 0013, 0014, 0015, 0016	Mitigation Identified	None	Stability of existing pill box during construction and demolition works	Workers	Consider undertaking dilapidation survey (including asbestos survey) to inform demolition plan for existing pill box.	Contractor			

Appendix C

Not Used

Appendix D

Cost Estimating

Local Government (Access to Information) Act 1985: The cost estimates have been redacted from publication because it is commercially sensitive, such that it would dis-advantage the commercial position of the council in relation to the cost and delivery of the scheme.

Ref:	**350164/WTD/BTL/01**
Version:	**03**
Date:	**September 2015**

Appendix E

Photographs

Ref:	350164/WTD/BTL/01
Version:	03
Date:	September 2015

Photographs from site visit on 02/04/2015

Impact damage

Displaced Parapet

Wet staining, rust staining to sheeting, spalling and open joints

Pill box

Vegetation to top of wing walls and parapets

West approach

Appendix F

Environmental Appraisal

Environmental Appraisal/ Action Plan

139886

Project Name:	Gipsy Patch Lane Bridge
Sponsor:	Angela Edmonds / South Gloucestershire Council
Project Manager: Dave Lovell	OP number: 139886

Signature	
Prepared by	Name: Gemma Western
	Job Title: Ecologist
	Date: 08/07/2015

CONTENTS

1 INTRODUCTION

1. Project Name: Gipsy Patch Lane Bridge
2. Address/Location: BSW - 5m 1309yds OS GR: ST611795
3. Project Manager: Dave Lovell
4. The project is currently at GRIP Stage 3

2 PURPOSE

The purpose of this document is to identify potential environmental issues and risks that may arise during the design and construction of the Gipsy Patch Lane Bridge project and to ensure that actions are undertaken to manage these aspects.

This document is in reference to the Gipsy Patch Lane Option Selection Report 350164/WTD/BTL/001.

3 SCOPE AND PROJECT DESCRIPTION

Scope

Optioneering is required to consider a new structure at Gipsy Patch Lane in order to facilitate the increase in buses and non-motorised users and allow for widening of the carriageway in both directions.

Four feasible options have been considered.

Option 1 – to provide a precast reinforced concrete portal frame structure with a 14.5m span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width for a single carriageway with cycle/footways either side.

Option 2 - to provide a precast reinforced concrete portal frame structure with a 18.7m span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width, sufficient to provide a single carriageway plus a dedicated bus lane with cycle/footways either side.

Option 3 – to provide a precast reinforced concrete portal frame structure with a 19.5m span, straight with the track alignment. To provide a structure straight with the track alignment the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear width for a straight carriageway of 14.5m which is sufficient for a single carriageway and cycle/footways either side.

Option 4 – to provide a precast reinforced concrete portal frame structure with a 22.2m span, straight with the track alignment. As with option 3 in order for the structure to be straight with the track alignment, the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear width for a straight carriageway of 18.7m which is sufficient for a single carriageway, dedicated bus lane and cycle/footways either side.

Option 5 - to provide a precast reinforced concrete portal frame structure with a 24.4m clear span and an 11° skew to the track alignment. The proposed abutments are parallel to the carriageway and provide clear width for a 7.5m single carriageway plus a 4.2m designated bus lane with a 3.5m cycle/footway to the north and a 4.2m designated bus lane with a 5.0m cycle/footway to the south.

Option 6 - to provide a precast reinforced concrete portal frame structure with a 29.3m clear span, square to the track alignment. As with options 3 and 4, to accommodate a structure square to the track alignment, the abutments will be skewed to the carriageway alignment by 11°. This option provides a clear width for a carriageway of 24.4m which is sufficient for a 7.5m single carriageway plus a 4.2m designated bus lane with a 3.5m cycle/footway to the north and a 4.2m designated bus lane with a 5.0m cycle/footway to the south.

Multiple site compound locations have been proposed for the project, refer to appendix C of the option selection report (Gipsy Patch Lane – Site Compound memo 350164/WTD/BTL/04) for further detail.

Description

As part of the Cribbs Patchway Metro Bus Extension Project South Gloucestershire Council (SGC) commissioned an option selection report to address the issues at Gipsy Patch Lane, however following a review of the feasibility of the proposed options by Network Rail, South Gloucestershire Council have proposed an additional requirement to consider the provision for a double decker bus along the route.

Mott MacDonald Ltd. has been commissioned by Network Rail to undertake an option selection report to evaluate and compare options for a new structure at Gipsy Patch Lane to facilitate the increase in buses and non-motorised users and allow for widening of the carriageway in both directions.

The current structure in place is Gipsy Patch Lane Bridge is a single span underline structure located in Little Stoke, South Gloucestershire just south of Patchway Railway Station. The railway is orientated approximately north-south within a largely urban area. The disused Bristol Filton Airport is located to the west of the site.

4 ENVIRONMENTAL ISSUES FROM EARLIER GRIP STAGES

GRIP stage	Status
1-2	Environmental Appraisal previously undertaken by Mouchel (2014)

3	This report

NOTE: IF CHECKED "YES", BEST TO EVALUATE WHETHER THE PROJECT/SITE AND/OR ACTIVITIES CAN BE MOVED TO AVOID THE NEED TO ADDRESS THESE ENVIRONMENTAL RISKS/CONSTRAINTS.

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
5.1	Project Description, Town Planning/ Infrastructure Liabilities/ Operational Surveyor Teams, MARLIN	Does land or land rights (easements/way leaves/permanent – temporary site compounds, etc.) need to be purchased? Note: even if works are within permitted development (PD) rights there may be restrictions as to what activities are allowed (e.g. vegetation clearance during nesting season).	✓			• Seek advice from Town Planning/Property/ Environment/Community Relations Teams and consult with external stakeholders/ local authorities (LA) where necessary • Site investigation/ surveys • Design aspects: include in/modify design/relocate to avoid the need to address these issues/ incorporate mitigation measures • Develop a Consent/ Environment/Communication Strategy Plan(s) as required • Obtain consent (TWA Order/ planning permission/ area land rights) if required • Specify protective measures in design/contract/construction requirements	Multiple locations for a temporary site compounds within 500m of the site works are proposed, either land rights or land purchase will be required (See Gipsy Patch Lane – Site Compound memo 350164/WTD/BTL/04) . The structure envelopes of Option 4, 5 and 6 come close too or will exceed the Network Rail and SGC ownership boundaries. It is anticipated that excavations for these 3 options, to construct the new structure, will need to extend outside of the land ownership boundaries.
5.2	Project Description, Town Planning/ Infrastructure Liabilities/ Operational Surveyor Teams, MARLIN, RAR, Utility Diagrams	Is the land leased out or are there 3rd party interests or onsite utilities, telecommunication, etc.)?	✓				There are a number of existing services, including telecoms, in the area which will require diverting.

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
5.3	Town Planning Team	Does the acquisition or lease of the land change the status of the land			✓		It is unlikely that any land acquisition or lease of land will change its status due to the urban nature of the area.
5.4	Project Description, MARLIN, Town Planning Team	Is land that may need to be purchased/leased contaminated or a licensed waste facility?	✓				Land required for a temporary site compound has potential to be contaminated; particularly if using land located on old industrial sites. Site compound option 6 is located on the Filton Junction Tip, a historical landfill. Site compound options 4 and 9 are located near the old Bristol OCGT Power Station Rolls-Royce Mael Works (See Gipsy Patch Lane – Site Compound memo 350164/WTD/BTL/04).

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
5.5	Town Planning Team	Does the project require Transport and Works Act (TWA) order/planning permission or similar?	✓				Gipsy Patch Lane/B4057 is a road used heavily during school and commuting hours. Construction traffic and works required works within this area should be assessed for the need for road management. A cycle trail and footpath are present along the road and under the existing bridge and will require closure during the works.
5.6	Town Planning/ Environment/ Community Relations Teams	Has the Local Planning Authority or any other Statutory Body expressed concern over the project or similar projects?	✓			• Seek advice from Town Planning/Property/ Environment/Community Relations Teams • Consult with external stakeholders/LA	South Gloucestershire Council (SGC) is an external stakeholder and supports the project to enhance the road infrastructure. NR is likely to have concerns over the project if construction has potential to affect rail services.

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
5.7	Town Planning/ Community Relations/ Environment Teams	Have residents or any other interest group indicated concern over the project or similar projects? Note: even if the works are within PD rights and are common activities, e.g. vegetation/tree clearance, this may still be sensitivity for stakeholders.	✓			• Seek advice from Town Planning/Property/ Environment/Community Relations Teams • Consult with external stakeholders/LA	The public have indicated concerns over the Cribbs Patchway MetroBus Extension Project. Private fencing will be affected by the works.
5.8	Town Planning Team/local authority	Are there any local plans/development proposals of land adjacent to/near the project that may have future ramifications on the project?	✓			• Seek advice from Town Planning/Property/ Environment/Community Relations Teams	Filton Airfield redevelopment is nearby; this development involves the construction of up to 5,000 new homes, new schools and public transport connections. Rolls Royce East Works redevelopment is adjacent to the works; this development involves the construction of industrial and distribution units, offices, a hotel and car dealerships. The project is part of Cribbs Patchway MetroBus Extension Project.

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
5.9	Project Description	Are there new or unusual features associated with the project that may become an issue with internal/external stakeholder's e.g. tall masts, incompatible features with existing Network Rail structures?	✓			• Consult internal Network Rail stakeholders • Design aspects: include in/modify design/incorporate mitigation measures	The construction of a new bridge will need to be compatible with existing NR infrastructure. There are also significant utility structures within the footprint of works.
5.10	Guidance from Asset steward/ other Network Rail departments,	Any relevant Network Rail policies (such as TWA/planning process)/conditions that may require derogation (e.g. siting issues: substations next to telecommunication masts) or adjacent Network Rail projects?	✓			• Consult internal Network Rail stakeholders • Design aspects: include in/modify design/incorporate mitigation measures	Possessions will be required Interfacing projects include: 1. Network Rail – Intercity Express Programme, Stoke Gifford Depot 2. Bristol Area Signalling Renewals 3. Proposed OHL gantry on the bridge for Great Western Electrification Programme
	Environmental Constraints						
5.11	Project Description, MARLIN, RAR, site investigation	Does the local environment constrain the project e.g.:				• Consult internal Network Rail stakeholders • Design aspects: include in/modify design/incorporate mitigation measures • Consult with/obtain consent if	
		Flood plain?			✓		The main site is located on a minor aquifer (high vulnerability) and a secondary B bedrock aquifer.

	Information Sources	Environmental Considerations and Risks	Yes	?	No	Possible action (but not limited to)	Comments
5	**GENERAL RISKS**						
		Flooding?	✓			required (e.g. building on a flood plain/change to coastal defences)	Site compound option 5 (Park land to the South east - Mead Park) is located within a medium flood risk area. Site compound options 2 and 4 are at high risk from surface water flooding. Site compound option 1 is at low risk from surface water flooding.
		Landslide?	✓				Works are located on a steep railway embankment. Works such as excavation has the potential to cause bank instability. Options 5 and 6 have the largest impact in terms of bank excavation.
		Difficult access (e.g. steep embankment)?	✓				Works are located on a steep embankment with potential access difficulties. The busy road network that surrounds the site could cause access difficulties for construction vehicles.
		Other (specify e.g. pests such as rabbits)?		✓			None observed during the site visit but rabbits could be present within the embankment.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
6	**AGRICULTURE /FORESTRY/VEGETATION MANAGEMENT**						
6.1	MARLIN, BAP, Site survey	Does the project require taking good quality agricultural land, or affect any agriculture holding (e.g. severance)?			✓	• Site investigation • Consult with external stakeholders (particularly if noticeable amounts of vegetation/trees/ habitat are affected) • Design aspects: include in/ modify design/incorporate mitigation measures • Obtain consent (LA permission, etc.) if required • Specify protective measures	No.
6.2		Does the project need to clear vegetation or trees on railway land or access routes?	✓				Vegetation (scrub, trees and ruderal) clearance on the railway embankment will be required. Minor vegetation clearance for any temporary site compounds may also be required. No hedgerows will be affected.
6.3		Does the project need to remove hedgerows?			✓		
6.4	MARLIN, BAP, HERITAGE, Town Planning/ Environment Teams	Will the project need to remove, trim, cut trees under Tree Preservation Order (TPO) or in local planning conservation areas?		✓			Unlikely but SGC should be consulted to check presence of TPO's. The project is not located within a Conservation Area.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
7	**AIR QUALITY**						
7.1	Project Description, MARLIN, Town Planning Team/ LA – (Environmental Health Officers)	Will there be significant project activity that could generate large quantities of dust/noxious fumes or change the local air quality?	✓			• Modify design/ incorporate mitigation measures • Consult with local authorities • Specify protective measures	Due to the large scale of construction, the works are likely to generate significant levels of dust within the local area.
7.2		Are there adjacent/nearby receptors: residences, businesses, schools, medical facilities, etc.?	✓				Little Stoke residential area is located directly to the east of the site. Several residences back directly onto the railway embankment. There also several businesses, and industrial area, recreation area and a church within 500m.
7.3		Are there any local authority policy constraints (e.g. within/close to an Air Quality Management Area, breaching of government air quality objectives or limit values)?			✓		There are no AQMA's within this area.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
8	**BUILDING, STRUCTURES, HISTORIC ASSOCIATION**						
8.1	MARLIN, RAR, HERITAGE, LA, Town Planning Team	Does the project affect a Listed Building, structure and/or Scheduled Ancient Monument; e.g. from piling, excavation, demolition, change of use, visual obstruction, potential for subsidence, cable attachments, bridge platforms?			✓	• Seek advice from Town Planning • Consult with LA/Heritage Agencies • Design aspects: include in/ modify design/ incorporate mitigation measures • Obtain local authority/ heritage consent if required	There are no statutory designated historical sites within 500m.
8.2		Does the project affect a local planning Conservation Area, historic landscape features or similar designated area?			✓		No.
8.3		Does the project affect any other historical or man made feature likely to be of value?		✓			There is a WW2 pill box located on the east side of the railway line, directly adjacent to the site, north of Gipsy Patch Lane Bridge. The local council would like this to be retained if possible. However, if options 4, 5 or 6 are chosen then the pill box will have to be removed.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
9	**CONTAMINATED LAND**						
9.1	MARLIN, RAR, Contaminated land reports/ database, Railway Estates/ Environment team	Will the project disturb contaminated land?	✓			• Site investigation • Seek advice from Environment Team • Consult with LA if remediation required • Specify protective measures	Potential for railway ballast and the embankment to be contaminated with chemicals/oil. Land required for a temporary site compound could be contaminated; particularly land located on old industrial sites or within areas of historic landfill.
9.2	MARLIN, RAR Contaminated land reports/ database, site survey, Railway Estates/ Environment team	Is the project site located adjacent to/near an externally owned (e.g. landfill/industrial site) or Network Rail potentially contaminated site or sidings?	✓			• Seek advice from Environment Team • Seek alternative site • Site investigation • Specify protective measures, including possible remediation	As above
9.3	Project Description, MARLIN, RAR	Will the project activities open up pathways (e.g. channels) from contaminated areas to environment/stakeholder receptors; e.g. SSSIs			✓	• Site investigation • Seek advice from Environment Team • Design aspects: include in/modify design/ incorporate mitigation measures • Specify protective measures	

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
9.4	Project Description	Will produced wastes/spent ballast likely to be contaminated?	✓			• Seek advice from Environment Team • Site investigation/ sampling • Follow RT/LS/P/044 for used ballast and/or Special Waste requirements	Potential for railway ballast and the embankment to be contaminated with chemicals/oil.
10	**ECOLOGY (protected species/areas and invasive species)**						
10.1	MARLIN, BAP, RAR, HERITAGE, Town Planning/ Environment Teams, site survey, LA BAP local conservation organisations	Is the project site/access/staging areas/ compounds on/adjacent/nearby a statutory nature conservation site (e.g. SSSI, RAMSAR, SPA/SAC/cSAC/pSPA site) or other ecological designations?			✓	• Seek advice from Environment Team • Site survey • Consult with local Conservation Agencies/LA • Design aspects: include in/ modify design/ incorporate mitigation measures • Obtain protected species license if required • Specify protective measures/follow site	The project is located 1km west of the Three Brooks Local Nature Reserve (LNR). It is considered works are at a sufficient distance not to affect this LNR. There is a strip of BAP Priority broadleaved woodland habitat along the railway line south of Gipsy Patch Lane Bridge, east of the railway line.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
		Will the activity (e.g. working in a culvert, drainage works) and/or materials used have the potential to indirectly affect the designation and/or a protected area (e.g. downstream SSSI water quality)?			✓	management plan (SMS) if SSSI • Train staff • Continue monitoring if required	

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
10.2		Are there any protected species and/or habitats e.g. bats, badgers, newts etc. at or near the project site?	✓				There is suitable habitat for nesting birds and reptile species within the embankment vegetation and bordering gardens. Reptiles may also be present within the track ballast. Great crested newts (GCN) are known to be present within a pond located at Filton Airfield (approximately 700m west of the site). The precise location of this pond GCN is unknown and there is potential habitat for GCN within the adjacent ditch and the railway embankment vegetation as it connects with Filton airfield habitat. Bats are likely to commute along the embankment vegetation. Works will break a linear feature by removing the current structure and therefore has potential to disturb commuting bats. The current structure lacks features suitable for roosting bats and there is a high level of noise disturbance.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
10.3	BAP, RAR, Site survey	Are there any invasive vegetation species (Japanese knotweed, Giant hogweed, etc.) at or near the project site?	✓			• Site investigation • Enabling works for removal • Specify protective measures	Japanese knotweed is known to be present in the stream located approximately 40m from the railway bridge.
11	**LANDSCAPE/TOWNSCAPE/VISUAL**						
11.1	Project Description, Town Planning/ Environment Teams, LA/ Heritage/ Conservation Agencies	Is the site at/near or can be seen from a National Park/World Heritage Site/Area of Outstanding Natural Beauty (AONB)/local landscape/coastal/townscape designation?			✓	• Site investigation • Consult with local Heritage/ Conservation Agencies • Design aspects: include in/ modify design/incorporate mitigation measures (e.g. restoration plan) • Specify protective measures	No
11.2		Will the visual amenity of lineside residents be affected; e.g. removing vegetation, erecting new/taller structures than existing surroundings, demolition in Conservation Areas?	✓				There are lineside residents immediately adjacent to a strip of broadleaved woodland (a BAP priority habitat) located on the south side of the bridge. Removal of these trees and the general construction of a new bridge are likely to affect the visual amenity of the residents.
11.3		Will new structures/project components obstruct visual amenity of dwellings/recreational areas/cultural heritage/conservation areas?	✓				As above
11.4		Will grading and vegetation removal with subsequent landscaping be required?	✓				It is likely that re-grading of the embankment with subsequent landscaping will be required.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
12	**NUISANCE: NOISE, VIBRATION AND LIGHT**						
12.1	Project Description, MARLIN	Is noise/vibration likely to increase from existing levels at site during construction?	✓			• Site noise investigation • Consult w/local authorities (EHO) • Design aspects: include in/ modify design/incorporate mitigation measures • Neighbour letter drops/ consultation • Obtain Section 61 consent if required • Specify protective measures • Train staff • Continue monitoring	Although located within an urban area the scale of construction is likely to increase noise levels.
12.2		Will it affect?					
		Adjacent/nearby residences?	✓				Little Stoke residential area is located directly to the east of the railway. Several residences back directly onto the railway embankment. Light levels will increase during night working. There also several businesses, and industrial area, recreation area and a church within 500m. The embankments (particularly south of the road, east of the railway line) have potential to support nesting birds, GCN and reptiles.
		Adjacent/nearby businesses, worship, schools, hospitals, hotels etc.?	✓				
		Adjacent/nearby SPA/SAC, nesting birds, seasonal constraints?	✓				

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
12.3		Will the project occur at night/weekend or public holiday (use of lights/noise)	✓				Night & weekend working will be required. Long possession of the railway will be required for the main bridge works which is likely to include Christmas and Easter bank holidays. Options 5 and 6 have the longest possession time frames due to their size.
12.4	Project Description/ Noise Insulation Regulations	Is noise/vibration likely to increase from existing levels at site during operation?	✓			• Site noise investigation • Seek advice from Environment Team/Other Network Rail departments • Design aspects: include in/ modify design/incorporate mitigation measures	The nature and number of vehicular movements post construction is dependent upon option taken forward. Review further following Option Selection.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
13	**TRAFFIC GENERATION AND ACCESS**						
13.1	Project Description	Will significant traffic (vehicular/heavy loads) particularly through villages and along farm/country roads be generated (Public Rights of Way)?	✓			• Consult local authorities/highways dept. • Design aspects: include in/ modify design • Obtain Highways consent if required • Specify protective measures	Construction traffic will temporarily close off a PROW and Gipsy Patch Lane. Gipsy Patch Lane is a heavily congested commuting route that leads to Bristol Parkway Railway Station and the A38. Road access will be required for construction therefore a temporary traffic diversion will be needed.
13.2		Will the scheme result in new vehicular traffic flows? (Before and/or after)	✓				As above A new structure will potentially allow for a new pedestrian routes and additional lanes for buses post construction.
13.3		Will it cause new pedestrian movements? (Before and/or after)	✓				Construction will result in temporary closure of the footpath under the bridge. A new structure will potentially allow for a new pedestrian routes post construction.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
13.4	As above	Any footpath, road closures/diversions required during construction?	✓			• As above	As above
13.5	Project Description	Will parking outside railway land be required (e.g. on streets, on/near lineside neighbour's land)	✓			• Specify protective measures • Train staff	Parking is likely to be located within a temporary site compound outside of NR owned land. The location of this site is yet to be confirmed.
13.6		Are access points near adjacent properties (nuisance including noise)	✓				Likely access points are located within 30m of residential properties.
14	**WATER RESOURCES, POLLUTION (including Silt) AND DRAINAGE**						
14.1	Project Description, MARLIN, RAR, Surface water risk assessment model, Site investigation	Is the project on/near/adjacent to a watercourse and drainage channels?	✓			• Site investigation • Consult with local Environment Agency/DEFRA for coastal/ marine/estuary areas • Design aspects: include in/ modify/design to remove the need for a consent • Obtain work near watercourses, obstruction to watercourse, discharge to controlled waters and/or sewerage system, etc. consents if required • Specify protective measures	There is a drainage ditch located south of Gipsy Patch Lane and east of the railway line, adjacent to the embankment.
14.2		Will the works occur within 8-m of the bank and/or in a **designated** main river			✓		No
14.3		Will the project need to remove vegetation close to/on or in a riverbank?			✓		No
14.4		Is it likely to affect the flow of watercourses?			✓		No
14.5		Will works occur around a water source protection area or require abstraction of water from a well?			✓		No

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
14.6		Will works occur near marine waters, on coastal areas below mean high tide or affecting navigation?			✓	(e.g. Site Drainage Plan, Emergency Incident Plan) • Continue monitoring	No
14.7		Will it generate a discharge either directly to a watercourse or to soakaway/ground; e.g. dewatering operation/discharge from a bund?			✓		No
14.8		Will it generate a discharge to a foul sewer?			✓		No
14.9	Project Description, MARLIN, RAR, Site investigation	Will waste/spoil be stockpiled, materials/chemicals/fuels/oils stored at site that could enter a watercourse, major aquifer underneath or on a flood plain?	✓			• Establish protective measures • Train staff	Due to the scale of the project, on-site waste storage is a likely requirement. Storage of waste is also likely within the temporary compound areas. Therefore risk of pollution exists in areas close to a surface water drain or at risk of flooding. Site compound options 1, 2, 4 and 5 are at risk from surface water flooding.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
15	**WASTE/SURPLUS MATERIAL**						
15.1	Project Description, NDS/ Town Planning/ Environment Teams	Will it generate large quantities of surplus material; i.e. spoil, sleepers?	✓			• Design aspects: include in/ modify design: reuse, recover, recycle • Consult with and obtain consent from local authorities/Environmental Agencies for storage/ management concerns • Specify protective measures (e.g. Waste Management Strategy/Plan)	Due to the scale of the project, a large quantity of spoil will be generated and stockpiled on-site or at a temporary site compound.
15.2	Project Description, NDS/ Town Planning/ Environment Teams	Can surplus material be reused (spares, spoil, etc.)?		✓		• Design aspects: include in/ modify design/incorporate mitigation measures • Ensure that the surplus remains in the chain of utility and is not seen as "getting rid of"; a waste exemption if applicable may also be required, seek advice from Environment Team	Potentially, will confirm at a later GRIP stage.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
15.3		Will onsite disposal or land purchase be required?	✓			• Seek advice from Planning/Environment Team • Consult with LA/Environment Agency • Design aspects: include in/ modify design/incorporate mitigation measures • Obtain waste management consent/exemption if required • Specify protective measures	SGC is looking to purchase an area for a temporary site compound. An EA permit is likely to be required to hold waste on site, particularly if contaminated
15.4	Project Description, NDS/ Town Planning/ Environment Teams	Will it generate special wastes; e.g. oil, paint cans, contaminated land?	✓			• Design aspects: include in/ modify design/incorporate mitigation measures • Obtain consent if required/follow Special Waste regulations • Specify protective measures Specify protective measures (e.g. Waste Management Strategy/Plan)	The project is likely to generate spoil and/or ballast that are contaminated.
16	**SUSTAINABILITY: ENVIRONMENTAL OPPORTUNTITIES**						
16.1	Project Description/ Environment Team	Can recycled/reclaimed materials such as sleepers/ballast/spoil/cables be used instead of raw materials?		✓		• Modify design/contract/ construction strategy to capitalise on opportunities	Potentially. Unknown at this stage.
16.2		Can energy/water efficiency be gained through building design/supply chain?	✓				Use of local suppliers.

	Information Sources	Environmental Implications and Risks	Yes	?	No	Possible action (but not limited to)	Comments
16.3	Project Description/ Environment Team	Can work be performed in parallel with another project reducing wastage, duplication and redundancy of materials, timing and resources?		✓		• Modify design/contract/ construction strategy to capitalise on opportunities	Unknown at this stage, will confirm at a later GRIP stage.
16.4		Can effluents and discharges be minimised?	✓				
16.5		Can potentially polluting materials be replaced with less harmful materials (e.g. biodegradable oils)?	✓				
16.6		Are there other areas where environmental and sustainable benefits can be gained; such as					
		Positive communication/interactive consultation with lineside neighbours/other stakeholders?	✓				Yes
		Innovative environmental designs/methods of work?		✓			To be reviewed at the detailed design stage.
		Positive contribution to habitats/protected species?		✓			To be reviewed at the detailed design stage.
16.7		Other (specify on action log)?			✓		
OTHER							
17.1		Are there any other possible environmental effects specific to this project? If so list them: e.g. electro-magnetic effects, settlement, local issues/policies			✓		

ACTION PLAN

Note: For each positive or ? response, the issue must be taken forward into the action plan for further management with the specific actions required, the responsible party for that action, start and target completion date identified. Evaluating the probability and the significance of the risk will assist to prioritise the issues and identify areas with unacceptable risk that will need to be eliminated, reduced and/or controlled.

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
5.1 & 5.2			✓		✓		• SGC and NR should be consulted early on to ascertain if a new site compound requires purchasing/leasing, Planning permission may be required; • Discussions with Network Rail, the Highways land ownership and SGC over land ownership boundaries are likely to be required; • A utilities report should be referred to in order to establish all structures within the working area.	Network Rail/ Design Team	GRIP 3 onwards	
5.4, 9.1 & 9.2			✓	✓			• It is recommended that soil, leachate and ground water sampling as well as analysis is undertaken to provide further information for a comprehensive contaminated land risk assessment. • Specify protective measures	Design Team	GRIP 4	
5.5, 13.3			✓		✓		• Obtain a Temporary Traffic Regulation Order (TTRO). • Obtain consent for temporary closure of a PROW. • Obtain consent (planning permission/ area land rights) if required.	Design Team	GRIP 5	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK [2]			ACTIONS TO BE TAKEN [3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
5.6, 5.7, 5.8, 5.10, & 13.6			✓		✓		• Consultation with NR / SGC / external stakeholders early on is recommended. • Consult NR Asset Steward about adjacent NR projects. • Design aspects: include in/ modify design/ incorporate mitigation measures	Design Team	GRIP 4	
5.9		✓		✓			• Ensure reference to utility drawings/report is carried out as well as consultation with the utility companies; • Consult internal Network Rail stakeholders	Network Rail/ Design Team	GRIP 4/5	
5.11 & 11.4			✓		✓		• A Surface Water Drainage Assessment may be required. • Ground investigation should take place to establish any geotechnical/waste Considerations. • Specify protective measures (e.g. Site Drainage Plan, Emergency Incident Plan). • Consult NR, SGC and Highways Agency as land access/permissions may be required. • Adhere to Network Rails Contract • Requirements for the Environment NR/L2/ENV/015; • Consult landscape specialist regarding any landscaping required.	Network Rail/ Design Team	GRIP 4	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
6.2, 6.4 & 12.2			✓		✓		• Undertake vegetation clearance in the winter to avoid the breeding bird season and reptile active season (October to February inclusive). • If vegetation clearance is done outside of this period, a nesting bird check should be conducted by an ecologist 24 hours prior to works. • Excavation works should take place during the summer months (April – October inclusive) to avoid impacts on hibernating species such as reptiles and GCN. • Any mature trees that may need removing/cutting back should be subject to a bat inspection to check for roost potential. • Consult SGC about TPO's within the works area (including the chosen temporary site compound if vegetation clearance is required).	Contractor/ Design Team	GRIP 6	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
7.1 & 7.2							• All work should adhere to CIRIA guidelines (e.g. C692 and C715). • Adhere to Network Rails Contract Requirements for the Environment NR/L2/ENV/015; • Consultation with NR / SGC / external stakeholders early on is recommended. • Design aspects: include in/ modify design/ incorporate mitigation measures	Contractor/ Design Team	GRIP 5/6	
9.3	✓				✓		• Pollution prevention measures to be put in place during construction to avoid contamination of surface water by any of the work activities.	Contractor	GRIP 6	
9.4, 14.1, 14.2 & 14.9		✓			✓		• All work should adhere to CIRIA guidelines (e.g. C692 and C715). • Adhere to Network Rails Contract Requirements for the Environment NR/L2/ENV/015; • Follow RT/LS/P/044 for used ballast and/or Special Waste requirements; • Pollution prevention measures should be implemented for all works. • All waste should be stored and protected on site at least 10m from all water courses, ditches etc.	Contractor/ Design Team	GRIP 6	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
8.3		✓		✓			• A toolbox talk for the pill box (archaeological value) may be required. If the pill box is to be removed, then the SGC should be informed prior to removal.	Contractor/ Design Team	GRIP 6	
10.2			✓		✓		• Biological records should be sought from within 1km of the site footprint; • Further surveys for GCN may be required within nearby ponds due to potential for GCN within the working footprint ; • Further bat transect surveys may be required along the embankment and bridge due to potential for severance of a linear feature used by commuting bats. • Vegetation clearance should take place during winter (October – mid February inclusive) to avoid nesting birds and reptile species; • Excavation works should take place during the summer months (April – October inclusive) to avoid impacts on hibernating species. • Any mature trees that need removing/cutting back should be subject to a tree inspection to check for bat roost potential. • Reduce lighting at night where possible due to potential impacts on bat species.	Design Team	GRIP 3 onwards	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
10.3		✓			✓		• Carry out site investigation to ascertain presence of invasive species within the site extent. • Specify any protective measures within the CEMP.	Contractor/ Design Team	GRIP 4/5	
11.2 and 11.3			✓		✓		• Consult landscape specialist regarding any landscaping required. • Work programme to consider residents immediately adjacent to the trackway and access areas. • Neighbour letter drops/ consultation • Consultation with NR / SGC / external stakeholders early on is recommended.	Design Team	GRIP 4/5	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
12.1, 12.2, 12.3 and 12.4		✓			✓		• BS5228 - Code of Practice for Noise and Vibration Control on Construction and Open Sites should be adhered to (as well as NR's CR-E and CIRIA best practice guidelines); • Work programme to consider residents immediately adjacent to the trackway and access areas. • Work programme to consider the noise levels on the species present within the site and the surrounding area. • Obtain Section 61 consent on nuisance (noise) during construction (under the Control of Pollution Act 1974) • Local Authority Environmental Health Officer (EHO) should be consulted; • Carry out a site noise investigation • Neighbour letter drops/ consultation • The nature and number of vehicular movements post construction is dependent upon option taken forward. Review further following Option Selection.	Design Team / Network Rail / Construction Team	GRIP 5/6	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK[2]			ACTIONS TO BE TAKEN[3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
13.1, 13.2, 13.4 & 13.5			✓		✓		• Consult local authorities/highways dept. • Apply to the LPA for Temporary Traffic Regulation Order; • Consult the Local Council in regards to a temporary closure or diversion of a PROW. • Consult with NR. • Obtain Highways consent if required • Adhere to Network Rails Contract Requirements for the Environment NR/L2/ENV/015.	Design Team / Network Rail	GRIP 4/5	
15.1 & 15.3, 15.4			✓	✓			• Development of a Site Waste Management Plan may be required. • An EA permit required to hold waste on site. • Obtain consent if required/follow Special Waste regulations • Specify protective measures Specify protective measures (e.g. Waste Management Strategy/Plan)	Design Team	GRIP 4/5	
15.2 & 16.1		✓		✓			• Soil should be reused on site. If this is not possible, testing will be required to ensure correct classification and disposal is carried out; • Adhere to NR's standards for used ballast and other rail materials; • Where possible, prefabricated parts should be used to ensure the design is as energy efficient as possible.	Design Team/ Contactor	GRIP 5/6	

ISSUE	PROBABILITY OF OCCURRENCE [1]			LEVEL OF RISK [2]			ACTIONS TO BE TAKEN [3]	RESPONSIBLE PARTY(IES)	GRIP STAGE	TARGET DATE
	Low	Medium	High	Low	Medium	High				
16.3, 16.4, 16.5 & 16.6		✓		✓			• Discuss opportunities with NR; • Review at the detailed design stage. • Do not leave equipment running when idle etc.; • NR's CR-E and CIRIA best practice guidelines should be adhered to; • Biodegradable oil and diesel should be used on site machinery where possible. • Neighbour letter drops/ consultation • Use bio-oils with construction machinery; • Follow CIRIA best practice guidelines during construction.	Network Rail/ Contractor	GRIP 5/6	

Note: The Environmental Appraisal and Action Plan should be reviewed through the GRIP design stages and/or if the project design is modified

NOTES:

[1] Probability	[2] Risk
4. Low: Unlikely to occur during the lifetime of the project 5. Medium: Can be expected to occur 6. High: Almost certain to occur	1. Low: Unlikely to affect to cost or schedule of the programme 2. Medium: Fairly likely to affect the cost or schedule of the programme 3. High: Almost certain to have a significant adverse impact on the project
[3] Actions to be Taken: Be specific in what, where, how and who	
1. Undertake more detailed assessment work/site investigation 2. Consult with affected parties and/or statutory authorities 3. Obtain environmental consents/permissions 4. Modify design to reduce or mitigate impact 5. Specify environmental protective measures within EMP to mitigate during construction	6.

GLOSSARY

Abbreviations

AONB	Area of Outstanding Natural Beauty
BAP	Biodiversity Action Plan (plus accompanying guidance sheets/toolkits)
CR-E	RT/LS/S/015 Network Rail Contract Requirements, Environment
cSAC	Candidate Special Areas of Conservation
EA	Environmental Appraisal
EHO	Environmental Health Officer
EMP	Environment Management Plan
GRIP	Guide to Railway Investment Projects
HERITAGE	Network Rail-wide database of protected land and/or buildings
LA	Local Authority
MARLIN	Network Rail-wide property Geographical Information System
NDS	National Delivery Service
PD	Permitted Development
PSPA	Potential Special Protection Area
RAMSAR Site	Wetlands of International Importance Designation
RAR	Railtrack Asset Register
SAC	Special Areas of Conservation
SMS	Site Management Statement
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
TPO	Tree Preservation Order
TWA	Transport and Works Act

Statutory Agencies

Environment Agencies	Environment Agency (England) Natural Resources Wales (NRW) Scottish Environment Protection Agency (SEPA)
Conservation Agencies	Department of Environment, Food and Rural Affairs (DEFRA) Scotland’s Environment and Rural Services (SEARS) Natural England (NE) Natural Resources Wales (NRW) Scottish Natural Heritage (SNH)
Heritage Agencies	English Heritage and Historic England Welsh Heritage Agency (CADW) Historic Scotland

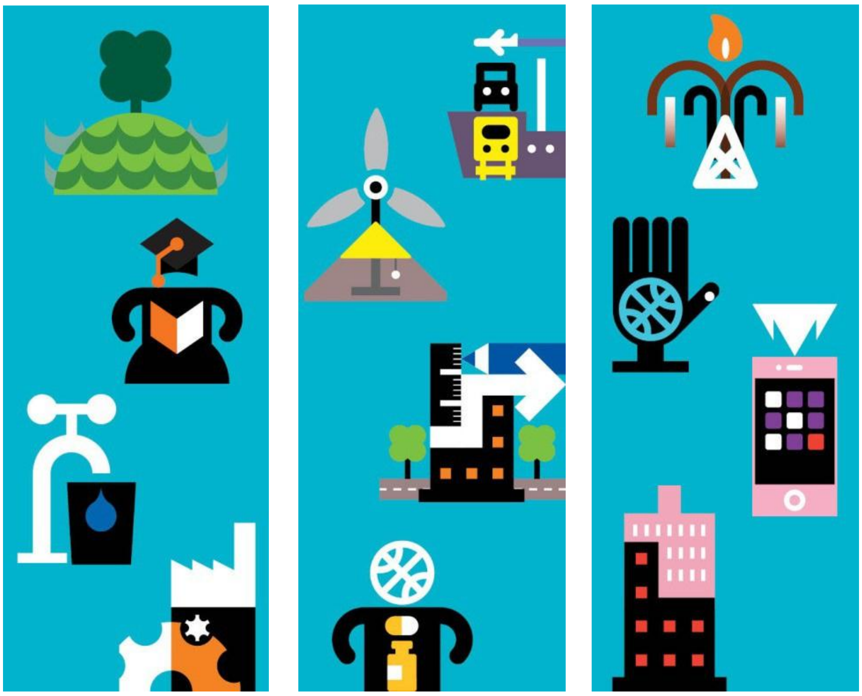
Possible Consent Needed for Project Work

Landtake	Responsible Agency
• TWA Order if require compulsory purchase of land	Planning authority
• Planning permission from local authorities (Town and Country Planning Act 1990). Prior Approval or Permitted Development	Local Planning Authority
Scheduled Ancient Monument/Listed Building/Conservation Area	
Consent to disturb a scheduled ancient monument (Ancient Monument and Archaeological Areas Act 1979)	Secretary of State/Local Planning Authority
• Listed Buildings/Conservation Area (Town and Country Planning Act)	Planning authority
Trees and Ecology	
• Work affecting Tree Preservation Orders, which offer legal protection to trees (Town and Country Planning (Trees) Regulations 1999)	Local Planning Authority
• Licence for felling timber (Forestry Act 1967)	Local Planning Authority
• Works affecting Important Hedgerows (Hedgerow Regulations 1997)	Local Planning Authority
• Licence for disturbance to badgers (Protection of Badgers Act 1992)	DEFRA
• Other wildlife consents required for works affecting protected species e.g. great crested newts, bats	NE/SNH/NRW; DEFRA
Noise and Vibration	
• Section 61 consent on nuisance (noise) during construction (under the Control of Pollution Act 1974)	Local Authority – Environment Health Officer
Traffic Generation and Access	
• Highways stopping/diversion consent (including temporary closures) • Vehicle crossing consents (Highways Act 1980)	Highways authority
Water Resources (quality and hydrology)	
• Consent for works over, under or adjacent to **designated** main rivers (Land Drainage Act /Water Resources Act 1991)	Environment Agency/NRW/SEPA
• Works affecting flow/structures in watercourse or navigation (Land Drainage Act 1991)	Environment Agency/NRW/SEPA
• Works around water source protection area (Water Resources Act 1991)	Environment Agency/NRW/SEPA
• Consent for works within 8m of a watercourse (Land Drainage bylaws)	Local Planning Authority
• Water abstraction license (Water Resources Act 1991)	Environment Agency/NRW/SEPA
• Consent for dewatering/discharge of water from excavations (Land Drainage Act 1991)	Environment Agency/NRW/SEPA
• Consent for discharge to controlled water and/or groundwater (Water Resources Act 1991/Groundwater Regulations)	Environment Agency/NRW/SEPA
• Water Authority Consent to discharge to foul sewer (Water Industries Act 1991)	Sewerage undertaker/ Environment Agency/NRW/SEPA
• Consent for works in coastal areas and marine waters (Coastal Protection Act 1949/Harbours Act 1964)	Marine Consents & Environment Unit (DEFRA)/Local Harbour Authority
Waste Management	
• Waste management licences under the Waste Management Licensing Regulations 1994	Environment Agency/NRW/SEPA

Note Legislation refers to regulations in England and Wales; regulation in Scotland differs; however, similar permission/consents apply

Appendix G

Geotechnical Design Report



Gipsy Patch Lane Bridge

Geotechnical Design Report

July 2015

Network Rail

Network Rail

Mott MacDonald

Gipsy Patch Lane Bridge

Geotechnical Design Report

July 2015

Network Rail

Western House
1 Holbrook Way
Swindon
SN2 1UY

Mott MacDonald, 10 Templeback, Bristol, BS1 6FL, United Kingdom
T +44 (0)117 906 9500 F +44(0) 117 376 3688 W www.mottmac.com

Mott MacDonald

Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
P1	June 2015	P Kwok	T Bird	IDuncan	First Draft
A	July 2015	P Kwok	T Bird	I Duncan	First Issue

Information Class: Standard

This document is issued for the party which commissioned it and for specific purposes connected with the above-captioned project only. It should not be relied upon by any other party or used for any other purpose.

We accept no responsibility for the consequences of this document being relied upon by any other party, or being used for any other purpose, or containing any error or omission which is due to an error or omission in data supplied to us by other parties.

This document contains confidential information and proprietary intellectual property. It should not be shown to other parties without consent from us and from the party which commissioned it.

Contents

1 Earthworks

1.1 General

Gipsy Patch Lane is a single span underline structure located south of Bristol Patchway Station at BSW 5miles and 60chains. The existing superstructure comprises a masonry arch bridge constructed square to the track. It carries four lines in total over Gipsy Patch Lane, which consists of a single carriageway and narrow footpath.

As part of the Cribbs Patchway MetroBus Extension Project, South Gloucestershire Council commissioned an option selection report to address the issues at Gipsy Patch Lane which recommended a box jacked subway for pedestrians and cyclists adjacent to the existing structure. However, following a review of the feasibility of the proposed options by Network Rail, South Gloucestershire County Council has identified an additional requirement to consider the provision for a double decker bus along the route. As a result, further optioneering has been undertaken to consider a new structure in order to increase the headroom and the width of the carriageway to facilitate the increase in buses and non-motorised users.

As part of the option selection process of the proposed structure, a Geotechnical Design Report has been prepared to inform the selection of the foundation type for the proposed structure.

General arrangement drawings, MMD-350164-C-DR-GP-XX-0011 to MMD-350164-C-DR-GP-XX-0016 showing different options for the proposed new structure are included within Appendix A.

1.2 Selection of parameters for design

1.1.1 Generalised sequence of strata

In order to inform the foundation design a ground model has been developed for the site based upon information from the topographical survey and soil information obtained from the following factual ground investigation reports and historical borehole logs.

- Factual report prepared in 2010 by CJ Associates Geotechnical Limited (CJ Associates Geotechnical Limited, 2010) for the original scope of the scheme comprising a box jacked subway adjacent to the existing underline masonry arch bridge
- Factual report prepared in 2006 by Conestoga-Rovers & Associates (Europe) Ltd (Conestoga-Rovers & Associates (Europe) LTD, 2006) for Prologis Developments Limited in 2006 for the Rolls Royce East Works located immediately to the south west of the site
- BGS records of a borehole (BH503, BGS borehole ref. ST68SW140) sunk within the site area from road level obtained from BGS website (British Geological Survey, 2015)

A generalised ground model of the site is presented in Table 1.1 below and a cross section showing the ground formation is presented in Figure B.2.

Table 1.1: Generalised ground model of the site

Soil Type	Soil description	Thickness (m)	Depth to top (m BGL) [Level to top (m AOD)]
Granular Embankment Fill	Loose red brown with grey mottling slightly sandy very clayey angular to sub-angular fine to coarse SAND or GRAVEL of mudstone and limestone, interbedded with bands of red brown sandy gravelly clay.	3.00	(0.00) [58.30]
Cohesive Embankment Fill	Soft to firm red brown with grey mottling sandy gravelly CLAY.	2.80	(3.00) [55.30]
Reworked materials/Made Ground	Firm to very stiff blue green brown mottled slightly sandy gravelly SILT/silty CLAY to light brown sandy clayey fine to coarse GRAVEL. Gravels are flint, brick, concrete and subangular to subrounded fine to coarse of mudstone and sandstone	0.60 – 2.40	0.00 (5.80)(1) [52.40 – 52.72]
Heavily Weathered Blue Lias Formation	Firm to stiff fissured grey brown to orange brown CLAY with some angular to sub-angular fine to coarse size lithorelicts of very weak to weak mudstone and brown micritic banded stone.	1.80 – 3.16	0.60 – 2.4 (7.55)(1) [50.32 – 51.90]
Blue Lias Mudstone/Limestone	Light grey sandy shelly moderately strong thinly interlaminated LIMESTONE with green grey calcareous moderately weak MUDSTONE.	0.65 – 4.40	3.10 – 4.86 [47.54 – 49.52]
Westbury Mudstone Formation	Firm thinly laminated and very closely fissured friable grey and dark shelly CLAY with bands of medium grey moderately strong slightly sandy shelly LIMESTONE.(2)	1.44 – 3.80	5.51 – 8.60 [44.12 – 46.89]
Mercia Mudstone	Red grey green thinly bedded moderately weak to moderately strong slightly sandy dolomitic MUDSTONE.	Not proven (maximum penetration of 14.05m in BGS borehole BH503)	6.95 – 12.30 [40.42 – 45.45]

Note:

1. Borehole BH101 was the only borehole sunk at track level, into an approximately 6m high embankment. It terminated at 10.16m BGL within the heavily weathered Blue Lias Formation. As such, depths to top of strata for this borehole are shown separately in brackets ( ).
2. The thickness of clay is variable and in some cases very weak to moderately weak dark grey black mudstone was encountered

1.1.2 Groundwater

Results from groundwater monitoring undertaken in 2006 for the piezometers installed in boreholes BH503 and BH504 of the 2006 ground investigation were included in the factual report (Conestoga-Rovers & Associates (Europe) LTD, 2006), giving groundwater elevations of 49.82 to 50.87m AOD.

The results of the groundwater monitoring undertaken for this ground investigation were plotted on a location plan in Figure 5.11 and 5.12 of the 2006 factual report (Conestoga-Rovers & Associates (Europe) LTD, 2006) , which show the shallow and deep groundwater elevation contours of the Rolls Royce East Works located immediately to the south west of the site. Copies of the figures are included in Appendix B for reference.

In addition to this, water strikes were also recorded in boreholes sunk for the 2010 GI (CJ Associates Geotechnical Limited, 2010). These borehole logs indicated water strikes within the possible reworked material/weathered bedrock layer at 7.5m BGL (~50.8m AOD) in BH 101 and 1.0m BGL in BH 102(~51.5m AOD). These raised slightly to 7.2m BGL to 0.9m BGL respectively.

This indicates that the highest recorded groundwater level is within the construction zone, and careful consideration shall be made for foundation design in later Governance for Railway Investment Projects (GRIP) stages.

1.1.3 Characteristic geotechnical parameters

With reference to the general arrangement drawings, the base level of the proposed portal frame is proposed to be constructed at approximately 0.35m below the proposed road level at between 50.08m AOD and 50.85m AOD, depending on the options. It is therefore expected that the embankment fill and made ground within the footprint of the foundation will be removed prior to the construction works.

As such soil parameters for these strata are not considered relevant to the foundation assessment and have not been considered further.

1.1.3.1 Derivation of soil parameters

Characteristic geotechnical parameters have been derived for strata relevant to the foundation design based on soil descriptions, laboratory and *in situ* testing results from the ground investigations undertaken at or near the site as detailed in Section 1.1.1, and with reference to appropriate standards and literature references.

Laboratory testing in the C J Associates Limited investigation (CJ Associates Geotechnical Limited, 2010) was confined to the Made Ground and embankment fill at this site. Testing undertaken as part of the Rolls-Royce East works investigation (Conestoga-Rovers & Associates (Europe) LTD, 2006) was limited to geo-environmental analyses.

Bulk unit weight (γ)

As no reliable test data for bulk density was available from the historical ground investigations, the characteristic bulk unit weight for each of the relevant strata has been estimated using Table 1 from BS 8002 (British Standards Institution, Amended 2001) based on the soil descriptions, and with reference to the recommended values presented in Tables B7 and B8 of the Geological Society Special Publication

No. 21 edited by G M Reeves (Geological Society, 2006) for various Lower Jurassic and Triassic formations.

Effective angle of shearing resistance (ϕ')

In the absence of relevant laboratory testing results, the characteristic effective angle of shearing resistance, ϕ', for each of the relevant strata has been obtained based on descriptions on the borehole logs and the recommended values in Tables B7 and B8 of the Geological Society Special Publication No.21 (Geological Society, 2006). Reference has also been made to the recommended values presented in Table 4 of BS 8002 (British Standards Institution, Amended 2001) for rocks and CIRIA C570 (CIRIA, 2001) for Mercia Mudstone, assuming a weathering grade of III.

Effective cohesion (c')

In the absence of direct laboratory testing to determine the effective cohesion, c', characteristic values have been assumed based on the recommended values presented in Tables B7 and B8 of the Engineering Geology Special Publication No. 21 (Geological Society, 2006)

Undrained shear strength (c_u)

Characteristic undrained shear strength of cohesive material, c_u, has been correlated from SPT N values obtained from the historical ground investigations using the equation below from Stroud published in CIRIA 143 (CIRIA, 1995).

$$c_u = f_1 \times N_{60}$$

Where

f_1 is the factor relating to the plasticity index of the material and can be deduced from Figure 31 from CIRIA report 143 (CIRIA, 1995)

N_{60} is the equivalent Standard Penetration Test resistance corrected to 60% of the theoretical free fall hammer energy

For the weak rock strata that reported SPT refusals in the exploratory logs, a conventional relationship between uniaxial compressive strength (UCS) and undrained shear strength of UCS = $2c_u$ has been used to derived the characteristic c_u values.

Young's Modulus (E' & E_u)

The characteristic undrained Young's Modulus, E_u for each of the cohesive or mudstone strata has been estimated based on the following relationship with undrained shear strength, c_u, after Burland presented in WALLAP manual (Burland, 1979), assuming a strain level of 0.4%.

$$E_u = 400 \cdot c_u$$

Where

c_u is the undrained shear strength

The value of drained Young's Modulus can be calculated using the following equation.

$$E = E_u \cdot \frac{2(1 + \quad)}{3}$$

Where

v' is the drained Poisson's Ratio

Uniaxial compressive strength (UCS)

As no reliable *in situ* or laboratory test data were available to determine the uniaxial compressive strength, characteristic values have been conservatively determined based on the rock descriptions in the historical boreholes and the associated strength given in BS 5930 (British Standards Institution, 1999) or Table 5 of BS EN ISO 14689-1 (British Standards Institution, 2003), depending on the standards that the rock descriptions are based upon.

Coefficient of compressibility (m_v)

As no consolidation testing was undertaken to determine the coefficient of compressibility of the soil encountered on site, characteristic m_v values have been adopted based on the recommended values presented in Tomlinson (Tomlinson, Foundation Design and Construction, 2001) for different materials and with reference to recommended soil parameters of various formations of Jurassic and Triassic age presented in the Geological Society Special Publication No. 21 (Geological Society, 2006).

Poisson's ratio (v' and v_u)

A characteristic drained Poisson's Ratio of v' =0.15 has been adopted based the recommended values presented in Tomlinson (Tomlinson, Foundation Design and Construction, 2001).

The undrained Poisson's Ratio, v_u, is assumed to be 0.5 for cohesive soils.

1.1.3.2 Characteristic geotechnical parameters

The characteristic geotechnical parameters to be used for design purposes are summarised in Table 1.2 below.

Table 1.2: Characteristic Geotechnical Parameters for Foundation Selection

Geology	Bulk Unit Weight, γ (kN/m3)	Angle of Shearing Resistance, ϕ (°)	Effective Cohesion, c' (kPa)	Undrained shear strength, c_u (kPa)	Young's Modulus, E_u (MPa)	Uniaxial compressive strength UCS (MPa)	Coefficient of compressibility, m_v (m^2/MN)	Poisson's Ratio v
Heavily weathered Blue Lias Formation	20.5	26	0	80	32	-	0.10 – 0.15	0.15
Blue Lias Mudstone/Limestone	21	27	5	-	200	1	<0.05	0.15
Westbury Mudstone Formation Clay	20	26	0	80	32	Note 1	0.10 – 0.15	0.15
Mercia Mudstone	22	32	10	-	100	2	<0.05	0.15

Note:

1. Westbury Mudstone has been conservatively assumed to be firm to stiff clay over its full thickness in preliminary design based on the descriptions in borehole logs

1.3 Cutting stability

None

1.4 Embankment stability

In order to accommodate the increased footprint of the underline structure for the proposed footpath and carriageways, it is proposed that the existing embankment will be excavated back and the existing bridge will be demolished during an abnormal possession prior to the pre-cast portal frame structure being driven into place using Self-Propelled Modular Transporter (SPMT) units.

It is envisaged that temporary embedded retaining structures such as sheet piled walls or Odex piled walls dependent on driveability may be required to be installed in the side slopes prior to the demolition works. These will provide the necessary temporary support to the embankment slopes on both sides of the bridge, and to reduce the amount of excavation required and the extent of backfilling.

The geotechnical design of any embedded wall shall include geotechnical analysis of the soil-structure interaction between the proposed wall and the surrounding soils to determine the embedded pile length and provide soil stiffnesses to be used in the structural analysis. This can be undertaken using Geosolve's WALLAP v6.05 (Geosolve, 2013) or similar software. Detailed assessment of the wall has not been included in this report as the embedded walls are considered to be part of the temporary structures to be considered at later GRIP stages.

Given that no changes other than structural backfill behind the portal frame structure are required for the earthworks, and that the imported granular fill would be expected to have higher drained shear strength parameters than the existing embankment fill, overall stability analyses for the embankment slopes on either side of the new structure are not considered to be required at this stage.

The presence of a significant thickness of existing granular fill within the embankment will have an impact on the temporary works design for the temporary excavations allowing construction of the portal frame. Granular fill will be susceptible to ravelling and local instability if cut slopes are formed at oversteep angles. Particular consideration will be required to this element of temporary works design.

With reference to the option selection report (Mott MacDonald, 2015), one of the wingwall options is to utilise the temporary sheet piled retaining structures as the permanent wing walls for the new structure by installing some form of facing or cladding to improve their appearance to suit South Gloucestershire Council requirements.

However, sheet piled wingwalls are not the preferred option presented in the Option Selection Report due to the additional short possessions may be required for the piling works, and the required cladding works will impede on future maintenance or inspection access. As such no further development of this option has been undertaken.

The preferred wingwall option comprises pre-cast reinforced concrete wingwalls integrated with the main bridge structure. These will be designed to accommodate the relevant earth pressures and permanent and variable actions associated with railway operation.

1.5 Re-use of materials

It is anticipated that the majority of the materials to be excavated will comprise a layer of ballast underlain by embankment fill based on the general arrangement drawings and ground formation discussed in Section 1.1.1. As such, the excavated material is likely to comprise slightly sandy very clayey angular to sub-angular fine to coarse SAND or sandy gravelly CLAY. It is expected that any site won cohesive material will be disposed of with consent of Scheme Engineer whilst reuse of the granular material may be possible subject to testing.

Details of waste classification of the site won materials shall be investigated further during the single option development to detailed design stages of the scheme (Guide to Railway Investment Projects (GRIP) Stages 4 to 5).

2 Structure

2.1 Portal frame structure

With reference to the option section report a concrete portal frame structure has been proposed for the bridge replacement as the portal frame can be precast at the adjacent site compound and driven into place using Self-Propelled Modular Transporter (SPMT) units to significantly reduce the possession time required to replace the existing bridge structure. A portal frame will also provide an open base to suit the existing buried services and will not impede on future maintenance access.

In order to incorporate different carriageway arrangements and alignments relative to the track, six different portal frame options has been considered. Details of these options can be found in the option selection report.

The ground beams will be constructed integral with the portal frame and lifted onto the pile caps. A shear key can be provided if the friction between the ground beam and the pile cap or ground is not sufficient to resist the lateral loading.

2.2 Foundations options for portal frame

Given that the demolition of the existing structure and installation of the precast portal frame will be required to be completed under an abnormal 100 hour possession, construction of piled foundations along the length of the abutments during the possession is not considered to be feasible due to the construction time.

As the foundation will need to be incorporated with the other construction activities to be constructed within the limited possession time available, it is considered that precast strip footings would be the preferred foundation option for the portal frame structure due to the speed and ease of construction, and the fact that the portal frame can also be slid into place and form an integral unit with the strip footings.

However, it is uncertain whether the foundation is to be founded on the firm to stiff clay layer or the underlying Blue Lias mudstone/limestone formation due to the variation in the historical borehole logs, with the mudstone/limestone stratum encountered at between 47.54 and 49.52m AOD.

In the absence of more accurate soil information, the foundation has been designed to be founded on firm to stiff clay at this stage of the scheme and therefore some form of ground improvement or piled supports to be constructed offline will be required in order to provide the bearing resistance required for the new structure.

The following foundation options have been considered to provide the bearing resistance required for the new portal frame structure.

Table 2.1: Summary of foundation options

Options	Advantages	Disadvantages
Ground beam spanning between piles and pile caps on either ends of the beams	- least disruption to the railway as the piling works can be done offline	- Differential settlement along the spread footing
Spread footings with dig and replacement	- Cost saving as no piles are required - Simple and quick to construct	- Uncertainty in depth of excavation and foundation required due to the variation indicated in historical borehole logs - Extra time required to excavate and backfill material during the possession
Spread footings with ground improvement	- Cost saving as no piles are required	- Uncertainty in design based on the limited information to inform ground improvement - More expensive than dig and replace
Spread footings with stone columns/pre-cast piles below the shallow foundation	- No concrete curing time required compared to RC piles	- Additional construction time required during the abnormal possession to install the stone columns/piles - More expensive than the shallow foundation options
Piled foundation through tunnel rings to be driven through the embankment on either side of the existing masonry bridge	- Most foundation works can be done prior to the main possession	- Very expensive - Risk of settlement at track level during the piling work - Risk of being unable to bore through the natural ground using piling rigs that can operate within the restricted headroom of the tunnel rings - Uncertainty as to the stability of the tunnel rings during the piling works - Possible additional bracing to tunnel rings whilst forming piles

On the basis of the table above, it is considered that the preferred option at this stage of the scheme would be ground beams spanning between piles at either end due to the lowest possession time requirement compared to other options whilst providing a design to accommodate the uncertainty of rock head levels. As such, further discussion of this option is included in Section 2 of this report.

However, targeted ground investigation in later design stages may present value engineering options to further develop the foundation design by reducing or eliminating the piles at either ends of the ground beam.

2.3 Further Ground Investigation

Ground investigation should include boreholes sunk from natural ground level in close proximity to the structure, using techniques suited to reliable recovery of the anticipated ground conditions, in particular to recovery of extremely weak to weak mudstones. Techniques are expected to include rotary coring with suitable bits and flush medium to ensure high quality core samples and minimal degradation of such rock strata.

Records in historical boreholes of varying thicknesses of clay within the Westbury Mudstone Formation may be related to such degradation. *In situ* testing within the boreholes should include permeability testing, particularly within soils near the proposed founding level to aid in the design of any potential ground improvement.

It may be of benefit to incorporate geophysical surveys such as the use of seismic refraction techniques to aid in the identification of rockhead level beneath the proposed foundations. Results of such surveys would require calibration against the results of the intrusive investigation.

2.4 Ground beam

2.4.1 Bearing resistance

In accordance with Clause 6.5.2.1 of BS EN 1997 (British Standards Insitution, 2004) the following inequality shall be satisfied for all ultimate limit state load cases and load combinations in order to demonstrate that the foundation will support the design load with adequate safety against bearing failure.

$$V_d \leq R_d$$

Where
V_d is the design vertical load, or component of the total action acting normal to the foundation base
R_d is the design value of bearing resistance

This can also be expressed using the utilisation factor: E_d/R_d (expressed as a percentage). The design is considered unacceptable if utilisation factor is > 100%.

2.4.1.1 Drained analysis

As discussed in Section 1.1.3, the proposed foundation supporting the portal frame is expected to be founded on the heavily weathered Blue Lias Formation predominately described as firm to stiff fissured grey brown CLAY with lithorelicts of very weak to weak mudstone and brown micritic banded limestone. As such, the bearing resistance of this layer has been calculated using the following equation presented in Appendix D.4 of BS EN1997-1 (British Standards Insitution, 2004).

$$R/A' = c'\, N_c\, b_c\, s_c\, i_c + q'\, N_q\, b_q\, s_q\, i_q + 0.5\, \gamma' B N_\gamma\, b_\gamma\, s_\gamma\, i_\gamma$$

Where:
R/A' is the design bearing resistance
c' is the effective cohesion
γ' is the design effective weight density of the soil below the foundation level

q'	is the design effective overburden pressure at the level of the foundation base
N_q, N_c and N_γ	are the bearing resistance factors
b_q, b_c and b_γ	are the inclination factors
s_q, s_c and s_γ	are the shape factors
i_q, i_c and i_γ	are the load inclination factors

The preliminary analyses indicate that the design drained bearing resistances for the proposed ground beam under vertical actions are approximately 380 to 530kPa for Design Approach DA1-1 and 220 to 290kPa for DA1-2. However, the design bearing resistance of the ground beam is dependent on the eccentricity of the resultant forces and will be subject to the load and moment distribution between the ground beam and the pile cap to be assessed in the structural analyses in later design stages.

2.4.1.2 Undrained analysis

Given the ground beam is assumed to be found on firm to stiff clay of heavily weathered Blue Lias stratum, an undrained bearing resistance analysis has also been undertaken using the equation presented in Appendix D.3 of BS EN 1997-1 (British Standards Insitution, 2004).

$$R/A' = (\pi+2)\, c_u\, b_c\, s_c\, i_c + q$$

Where

R/A'	is the design bearing resistance
c_u	is the undrained shear strength
q	is the design total overburden pressure at the level of the foundation base
b_c	is the inclination factor
s_c	is the shape factor
i_c	is the load inclination factor

The preliminary analyses indicate that the design undrained bearing resistances for the proposed ground beam under vertical actions are approximately 450kPa for Design Approach DA1-1 and 330kPa for DA1-2. However, the results will be subject to the load and moment distribution along the foundation which will be assessed in the structural analyses in later design stages.

2.4.1.3 Eccentricity

In order to prevent contact with the ground being lost at the edges of the foundations, an assessment will need to be undertaken to ensure the resultant reaction from the ground lies within the 'middle-third' of the ground beam. The eccentricity of the resultant force from the centre of the beam will be assessed using the following limits.

$$e_B \leq \frac{B}{6} \text{ and } e_l \leq \frac{L}{6}$$

Where

B is the breadth of the foundation

L	is the length of the foundation
e_B	is the eccentricities in the direction of B
e_L	is the eccentricities in the direction of L

2.5 Piled foundation

As discussed in Section 2.2, the proposed foundation option to achieve the required bearing resistance to support the new structure is to construct ground beams spanning between pile groups on either ends of the beam. The design of the piles will be undertaken using the following methods.

2.5.1 Axial resistance

In accordance with Clause 7.6.2.1 of BS EN 1997 (British Standards Insitution, 2004) the following inequality shall be satisfied for all ultimate limit state load cases and load combinations in order to demonstrate that the pile foundation will support the design load with adequate safety against compressive failure.

$$F_{c;d} \leq R_{c;d}$$

Where
$F_{c;d}$	is the design axial compression load on a pile or a group of piles
$R_{c;d}$	is the design compressive resistance of the ground against a pile at the ultimate limit state

With reference to Clause 2.4.7.3.4.2(2) of the BS EN 1997 (British Standards Insitution, 2004) the following combinations of sets of partial factors should be used for the design of axially loaded piles to ensure that a limit state of rupture or excessive deformation will not occur.

Combination 1: A1 “+” M1 “+” R1
Combination 2: A2 “+” (M1 or M2) “+” R4

Where:
A	represents the set of partial factors on the actions or effects of actions
M	represents the set of partial factors on strength (material) values of the ground
R	represents the set of partial factors on resistance
“+”	means ‘used in combination with’

In accordance with clause A.3.3.2 of the NA to BS EN 1997-1 (British Standards Institution, 2014) a model factor of 1.4 has been applied to the axial pile resistance calculated using the combinations above in order to ensure that the predicted compressive resistances are sufficiently safe.

2.5.1.1 Method of analysis

The load carrying capacity of each bored pile has been determined using the concept of separate evaluation of shaft friction and base resistance. With reference to Tomlinson (Tomlinson, Pile Design and Construction Practice, 2008) the weight of the pile is usually small in relation to the ultimate resistance to the pile, Q_p, and therefore this term has been ignored in the calculation of the axial capacity of piles in compression.

With reference to Tomlinson (Tomlinson, Pile Design and Construction Practice, 2008) the weight of the pile, W_p, is usually small in relation to the ultimate resistance to the pile, Q_p, and therefore this term has been ignored in the calculation of the axial capacity of piles in compression.

$$R_{c;d} = R_{b;d} + R_{s;d}$$

Where:

$R_{c;d}$	is the design compressive resistance of the ground against a pile at the ultimate limit state
$R_{b;d}$	is the design base resistance of the pile (ignored at this stage of design)
$R_{s;d}$	is the design shaft resistance of the pile

The shaft resistance have been determined using the relationships below.

2.5.1.2 Shaft resistance in clay

The shaft resistance within the firm to stiff clay has been determined using effective stress approach published in Tomlinson (Tomlinson, Pile Design and Construction Practice, 2008).

$$Q_s = K_s \cdot \sigma'_{vo} \cdot \tan\delta \cdot A_s$$

Where

K_s	is the coefficient of horizontal soil stress ($K_s = 0.7K_0$ for bored and cast-in-place piles)
σ'_{vo}	is the average effective overburden pressure over the length of the clay layer
δ	is the characteristic angle of friction between pile and soil ($\delta = \phi'$ for bored and cast-in place piles)
A_s	is the area of shaft in contact with soil

The shaft resistance in clay has also been determined using an empirical relationship with undrained shear strength published in Tomlinson (Tomlinson, Pile Design and Construction Practice, 2008).

$$R_{s;d} = \propto \cdot c_u \cdot A_s$$

Where:

α	is the adhesion factor determined based on the relationship with undrained shear strength given in Figure 11.5 in CIRIA C504 (CIRIA, 1999).
c_u	is the average undrained shear strength over the length of the pile
A_s	is the surface area of the pile shaft contributing to the support of the pile in shaft resistance

2.5.1.3 Shaft resistance in weak rock

The shaft friction (τ_{su}) of weak rock can be calculated using the equation below after Horvath published in CIRIA Report 181 (CIRIA, 1999), where the shaft resistance per metre length of pile can be calculated by multiplying τ_s by the circumference of the pile (i.e. $R_{s;d} = \tau_s \times A_s$).

$$r_{s;d} = 0.33\ (UCS)^2$$

Where:

$\tau_{s;d}$ is the design shaft resistance (in MPa)
UCS is the uniaxial compressive strength (in MPa)

2.5.1.4 Base resistance in weak rock

The base resistance in weak rock can be calculated using the equation below using an empirical relationship with UCS after Rowe and Armitage published in CIRIA Report 181 (CIRIA, 1999).

$$R_{b;d} = 2.5 \cdot UCS \cdot A_b$$

Where:

$R_{b;d}$ is the design base resistance of the pile
A_b is the base area of the pile
UCS is the design uniaxial compressive strength

Given the presence of the thin beds of water softened green grey friable and very closely fissured clay encountered within the Mercia Mudstone stratum in the historical borehole logs, it is difficult to be certain if the pile will terminate in a 'soft spot' and hence the pile has been designed at this stage as a purely frictional pile. However, targeted ground investigation in later design stages may support value engineering to further develop the pile design by considering the base resistance of the piles that can be mobilised within the settlement constraints.

The preliminary foundation calculation of axial capacity has shown that piles bored from ground level would require depths of 14 to 18m BGL. However, these pile lengths may change following a lateral capacity check to serviceability limit state and ultimate limit states.

2.5.2 Lateral resistance

Since the length of the piles will likely exceed 10 times the diameter (i.e. greater than 12m), for consideration of lateral pile design the piles can be considered to be 'long'. The major failure mechanism of a 'long' pile is considered to be pile fracture at the point of maximum bending, which for a pile restrained by a pile cap will likely occur just beneath the pile cap.

Analysis of the maximum moments and lateral loads developed within the piled foundations on the basis of the combined lateral, vertical and moment load combinations from the permanent actions of the portal frame and other variable actions will be undertaken by applying linear elastic methods using a structural analysis using LUSAS v14.7.

The bending moment and shear force determined at the top of each pile in the pile group will be used in single pile analyses in Geosolve WALLAP (Version 6.05, 2013) to assess the design bending moments and shear forces for the piles for structural analysis.

Detailed analyses of the pile lateral resistance will be undertaken in later stages of the scheme.

2.6 Serviceability limit state

2.6.1 Settlement prediction

Due to the load concentration at the pile cap at the ends of the ground beam and the deflection of the beam, vertical deflection will vary along the length of the foundation (ground beam and pile caps).

In order to model this variation, an analysis will be undertaken to determine the moduli of vertical subgrade reaction based on predicted settlements using CEMSET analysis (Fleming, 1992) for the piles and the Skempton-Bjerrum method for soil supporting the ground beams. Details of these methods are discussed in Sections 2.6.1.2 and 2.6.1.3.

The subgrade moduli will then be employed in the LUSAS v14.7 structural model to provide a more accurate estimation of vertical movements along the beam, and bending moments and shear forces generated in them, and will also help to ensure that the ground beam, piles and pile cap have adequate structural strength to be able to safely redistribute loads across the group as designed.

The structural aspects of the analyses will be covered in a separate calculation prepared by Structures team in a later stage of the scheme.

2.6.1.1 Modulus of vertical subgrade reaction at foundation level

As mentioned in Sections 2.6.1, the soil-structure interaction between the superstructure and the founding strata will be undertaken at the preliminary stage using LUSAS v14.7 and the moduli of vertical subgrade reaction, k_s, determined using the following relationship between predicted settlement and net applied pressure from the proposed structure.

$$k_s \text{ (kPa/mm)} = \frac{\text{Net applied pressure (kPa)}}{\text{Settlement at foundation level (mm)}}$$

2.6.1.2 Predicted pile settlements

The vertical deflections of the piles will be estimated based on the analysis and prediction of single pile behaviour under maintained loading by undertaking a CEMSET analysis (Fleming, 1992) incorporating the group reduction factor for deformation of pile groups (O'Brien & Bown, 2008). This predication of pile settlement will be based on the maximum axial load observed in a single pile within the pile group.

2.6.1.3 Predicted soil settlement

The settlement estimation for the cohesive material below the strip footing will be undertaken using Skempton-Bjerrum method given in Tomlinson (Tomlinson, Foundation Design and Construction, 2001):

$$\rho_{oed} = m_v \cdot \sigma_z \cdot H$$

Where,

m_v is the average coefficient of volume compressibility

σ_z is the average effective vertical stress imposed on the clay layer

H is the thickness of the particular layer under consolidation

ρ_{oed} is the oedometer settlement

The consolidation settlement will be estimated using the following empirical correlation after Skempton-Bjerrum given in Tomlinson (Tomlinson, Foundation Design and Construction, 2001):

$$\rho_c = \mu \cdot \rho_{oed}$$

Where,

ρ_c is the consolidation settlement

ρ_{oed} is the oedometer settlement

μ is a coefficient depending on the type of clay

2.7 Summary of results

The results of preliminary settlement analyses have indicated that moduli of vertical subgrade reaction, k_s, of 1500 to 2300kN/mm underneath the piles and 3 to 8kPa/mm underneath the ground beam can be used for the preliminary LUSAS analyses.

Because of the uncertainty and variability of the values of k_s, analyses were undertaken using LUSAS software for the range of values quoted, including combinations of low and high values beneath the ground beams and pile groups, to assess critical values of bearing pressure as well as vertical displacement at the level of the ground beam, bending moments and shear forces within the structure and actions at the tops of the piles.

The results of the preliminary assessment are summarised in Table 2.2below.

Table 2.2: Summary of LUSAS results

Combination (Portal frame option)	Clear span of portal frame (m)	Pile diameter (m)	Ground beam		Maximum ULS vertical deflection below ground beam		Design pressure below ground beam (kPa)	Pile length (m)
			Width (m)	Depth (m)	Live load (mm)	Total (mm)		
1 (Option 1)	14.5	1.2	2	1	5	<30	160 – 180	13
2 (Option 2 & 3)	19.5	1.2	3	1	5	<40	200 – 280	14 - 15
3 (Option 4)	23.4	1.2	3.5	1	5	<40	200 - 300	16
4 (Option 5 & 6)	30.2	1.2	3.5	1	6	<50	230 - 350	19

Note:

1. A pile cap over four 1200mm diameter concrete bored piles has been assumed at either end of the ground beam
2. Lateral actions and moments were not included in the LUSAS model undertaken for the preliminary design

The results from the preliminary LUSAS analysis indicate that total vertical displacement of the ground beam under ULS loading is in the order of 30 to 40mm. However, further development of the model to incorporate the lateral actions and moments under SLS loading will be required in the later GRIP stages.

2.7.1 Differential settlement

Differential settlement between the foundations of the portal frame has been considered in the option selection report (Mott MacDonald, 2015). It is considered that a structure that is square in relation to the track alignment is the preferred option with regard to track sensitivity as it ensures that the support to the track is uniform across the width of the sleepers and the risk of issues arising from differential settlement is reduced. Transition slabs have also been proposed for the options to further mitigate the movement of the track at the crossing point to accommodate the tighter tolerances on this track.

It is envisaged that the foundations will be constructed to the same depth in similar ground conditions. Since the proposed structure is symmetrical the axial loads applied on the foundations will be approximately the same for each abutment. Any settlement of the foundations is therefore expected to be similar for the abutments and hence differential settlement between them is expected to be minimal.

However, further assessment to confirm the design of the transitional slab and assess the differential settlement shall be undertaken in later design stage.

2.8 Chemical classification

Sulphate content and pH value determinations were undertaken on three soil samples recovered from the Embankment Fill and the made ground strata in borehole BH101 and BH102 as part of the 2010 ground investigation (CJ Associates Geotechnical Limited, 2010), giving water soluble sulphate contents of 51 to 329mg/l and associate pH values of 7.7 and 8.2.

With reference to Table C1 in BRE Special Digest 1 (BRE, 2001) and the chemical test results, both the embankment fill and the made ground can be classified as Design sulphate (DS) DS-1 and Aggressive Chemical Environment for Concrete (ACEC) Class AC-1[d].

In the absence of chemical testing for the natural deposits within the site area, reference has been made to the testing undertaken for the 2006 ground investigation for Rolls-Royce East Works located immediately to the south west of the site. The results give in Table 15 of the factual report (Conestoga-Rovers & Associates (Europe) LTD, 2006) shows the site has DS and ACEC classes of DS-1 to DS-2 and AC-1 to AC-2 for samples recovered between 0.3 and 6m BGL within the made ground and Blue Lias Formation strata based on the water-soluble sulphate and pH results. However, Box C6 in BRE Special Digest 1 (BRE, 2001) suggests that Blue Lias Formation of the Lias Group is known to contain pyrite and hence total sulphur and acid soluble sulphate content testing should be undertaken in order to determine the DS and ACEC class.

In the absence of testing on acid soluble sulphate and total sulphur content, a higher DC and ACEC class of DS-3 and AC-3 has been assumed in preliminary design and will be subject to confirmation from chemical testing to be undertaken in later stages of the design.

3 Strengthened Earthworks (NOT USED)

4 Drainage

Details of the proposed drainage were not available at the time of writing this report. However, due to the high water table suggested from the historical groundwater monitoring data, it is considered that further assessment will be required to confirm if any improvement works to the existing drainage system are required.

5 Pavement Design, Subgrade and Capping

Details of the proposed pavement and layout of the road were not available at the time of writing this report, however it is expected that the proposed subgrade is likely to comprise weathered Lower Lias Formation based on the GA drawings.

Given that California Bearing Ratio (CBR) testing was not undertaken as part of the 2014 intrusive investigation, CBR values for the subgrade design of the proposed footpath and carriageway have been determined in accordance with Table 5.1 in IAN 73 (Highways England, 2009) based on the soil description and plasticity index.

It is considered that a characteristic CBR for the heavily weathered Blue Lias Formation of 3% is appropriate based on the recommended values for silty clay and a plasticity index of 24 to 34% recommended in the Geological Society Special Publication No. 21 (Geological Society, 2006) for Blue Lias Clay.

6 Geotechnical Risk Register

A geotechnical risk assessment has been carried out to cover the construction phase of the scheme. Table 6.1, Table 6.2, Table 6.3 and Table 6.4 show the methodology used, whilst the risk assessment and register is presented in Table 6.5.

It is important to note that whilst the items within this register are presented as risks, in many cases they represent opportunities for considerable refinement and value engineering of the design options. For example, additional ground investigation confirming soil and rock strength parameters, permeability and groundwater levels would be likely to allow pile lengths to be reduced, potentially by a considerable amount.

Table 6.1: Impact Index

Impact			Cost (C)	Time (T)	Reputation (R)	Health and Safety (H&S)	Environment (E)
1	very low	negligible	negligible	negligible effect on programme	negligible	negligible	negligible
2	low	significant	> 1% budget	> 5% effect on programme	minor effect on local company image/ business relationship mildly affected	minor injury	minor environmental incident
3	med	serious	> 10% budget	> 12% effect on programme	local media exposure/ business relationship affected	major injury	environmental incident requiring management input
4	high	threat to future work and client relations	> 20% budget	> 25% effect on programme	nationwide media exposure / business relationship greatly affected	fatality	environmental incident leading to prosecution or protestor action
5	very high	threat to business survival and credibility	> 50% budget	> 50% effect on programme	permanent nationwide effect on company image/ significant impact on business relationship	multiple fatalities	major environmental incident with irreversible effects and threat to public health or protected natural resource

Table 6.2: Likelihood Index

Likelihood		Probability
1	negligible/improbable	<1%
2	unlikely/remote	>1%
3	likely/possible	>10%
4	probable	>50%
5	very likely/almost certain	>90%

Table 6.3: Risk Matrix

		IMPACT				
		1	2	3	4	5
LIKLIHOOD	1	N	N	N	A	A
	2	N	A	A	H	H
	3	A	H	H	S	S
	4	H	H	S	S	S
	5	H	H	S	S	S

Table 6.4: Designers' Actions

RISK LEVEL	DESCRIPTION	ACTION BY DESIGNER
N	Negligible	None
A	Acceptable	Check that risks cannot be further reduced by simple design changes
H	High	Amend design to reduce risk, or seek alternative option. Only accept option if justifiable on other grounds.
S	Severe	

Table 6.5: Geotechnical Risk Register

Ref	Hazard	Consequences	Impact	Likeli -hood	Risk	Risk Type	Potential Risk Control Measure	Impact	Likeli-hood	Residual Risk	Owner	Action
1	Ground conditions below ground beam differ to historical GI reported	Over / Inadequate design and programme/ cost impact on construction	4	3	S	C, T, R, H&S	Targeted GI to confirm the soil parameters of each relevant stratum. Abnormal ground conditions should be reported to the design engineer to validate the design.	4	1	A	Designer & Contractor	Designer & Contractor
2	Ground conditions over pile length differ to historical GI reported	Over / Inadequate design and programme/ cost impact on construction	4	3	S	C, T, R, H&S	Targeted GI to sufficient depth to confirm the ground conditions for the pile design. Abnormal ground conditions should be reported to the design engineer to validate the design.	4	1	A	Designer & Contractor	Designer & Contractor
3	Groundwater conditions differ to historical GI reported	Inadequate design and programme/ cost impact on construction	4	2	H	C, T, R, H&S	Targeted GI to inform the groundwater conditions at the site. Higher than assumed groundwater conditions should be reported to the design engineer to validate the design	4	1	A	Designer & Contractor	Designer & Contractor
4	Inappropriate method of ground improvement being adopted	Over/ Inadequate design and programme/ cost impact on construction	4	2	H	C, T, R, H&S, E	Targeted GI to inform the nature and permeability of the strata relevant to the ground improvement works	4	1	A	Designer & Contractor	Designer & Contractor
5	Undiscovered buried services encountered on site	Damage and loss of infrastructure, injury.	4	2	H	C, T, R, H&S	Ensure most recent service location plans are available. Positively locate known services ahead of breaking ground	4	1	A	Designer & Contractor	Designer & Contractor

Ref	Hazard	Consequences	Impact	Likeli -hood	Risk	Risk Type	Potential Risk Control Measure	Impact	Likeli-hood	Residual Risk	Owner	Action
6	Chemically aggressive ground conditions	Loss of design life/ performance of construction	3	2	A	C, T, R, H&S, E	Additional chemical testing to confirm the ground aggressivity. Provide adequate protection to areas of construction that are susceptible to chemical attack.	3	1	N	Designer & Contractor	Designer & Contractor
7	Unexpected contamination encountered	Health risks to construction workers. Programme Delay. Pollution of local environmental receptors	3	3	H	C, T, R, H&S, E	Precautionary measures to minimise leachate generation. Appropriate method statement and PPE for construction workers. All pollution prevention guidelines and best practice to be followed.	3	2	A	Designer & Contractor	Designer & Contractor

Risk Type: C = Cost; T = Time; R = Reputational; H&S = Health and Safety; E = Environmental

7 REFERENCES

BRE. (2001). *Concrete in aggressive ground.* Garston: Building Research Establishment.

British Geological Survey. (2015). *British Geological Survey: Onshore Geoindex*. Retrieved 2015, from British Geological Survey: Onshore Geoindex: http://www.bgs.ac.uk/GeoIndex/

British Standards Insitution. (2004). *BS EN 1997-1:2004 Eurocode 7: Geotechnical design - Part 1: General rules.*

British Standards Institution. (1999). *BS 5930, 'Code of practice for site investigations' (Superseded).*

British Standards Institution. (2003). *BS EN 14689-1:2003; Geotechnical investigation and testing - identification and classification of rock - Part 1: Identification and description.*

British Standards Institution. (2014). *NA+A1:2014 to BS EN 1997-1; UK National Annex to Eurocode 7: Geotechnical design - Part 1: General rules.*

British Standards Institution. (Amended 2001). *BS 8002: Code of practice for earth retaining structures.* London: British Standards Institution.

Burland, J. B. (1979). *Movements around excavations in London Clay. Proc. 7th European Conf. SMFE. Vol 1.*

CIRIA. (1995). *CIRIA Report 143: The Standard Penetration Test (SPT): Method of Use.* CIRIA.

CIRIA. (1999). *CIRIA C504: Engineering in glacial tills.*

CIRIA. (1999). *CIRIA Report 181, 'Piled Foundation in Weak Rock'.* London: CIRIA.

CIRIA. (2001). *CIRIA C570 - Engineering in Mercia Mudstone.* London.

CJ Associates Geotechnical Limited. (2010). *Ground Investigation No. X0440, 'Parkway & Patchway Station Subways Bristol'.*

Conestoga-Rovers & Associates (Europe) LTD. (2006). *Phase II Site Investigation Final Report, 'Rolls-Royce PLC, East Works, Filton, Bristol', Ref. No. 933317(4).*

Fleming, W. G. (1992). A new method for single pile settlement prediction and analysis. *Geotechnique, 42*(No. 3, 411-425).

Geological Society. (2006). Engineering Geology Special Publications 2006; v21- Appendix B. Properties data. P. 461-474.

Geosolve. (2013). WALLAP Retaining Wall Analysis Programme Version 6.05.

Highways England. (2009). *IAN 73/06 Revision 1 (2009) - Design Guidance for Road Pavement Foundations.*

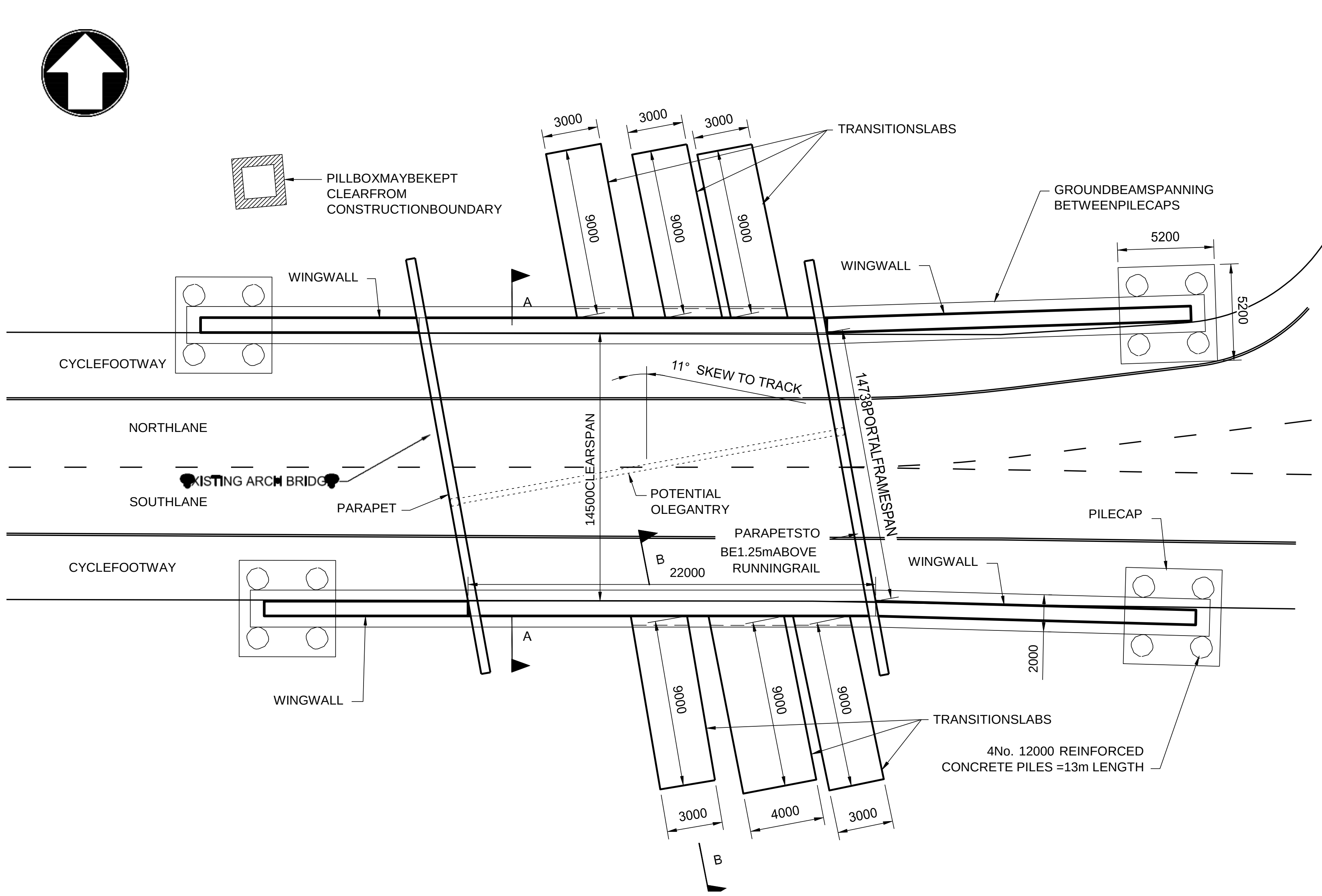
Mott MacDonald. (2015). *Gypsy Patch Lane Option Selection Report, Report Ref. 350164/WTD/BTL/01.*

O'Brien, A. S., & Bown, A. S. (2008). Pile Foundations - Emerging Design Methods. *Piling and Foundations, Ground Engineering Conference*.

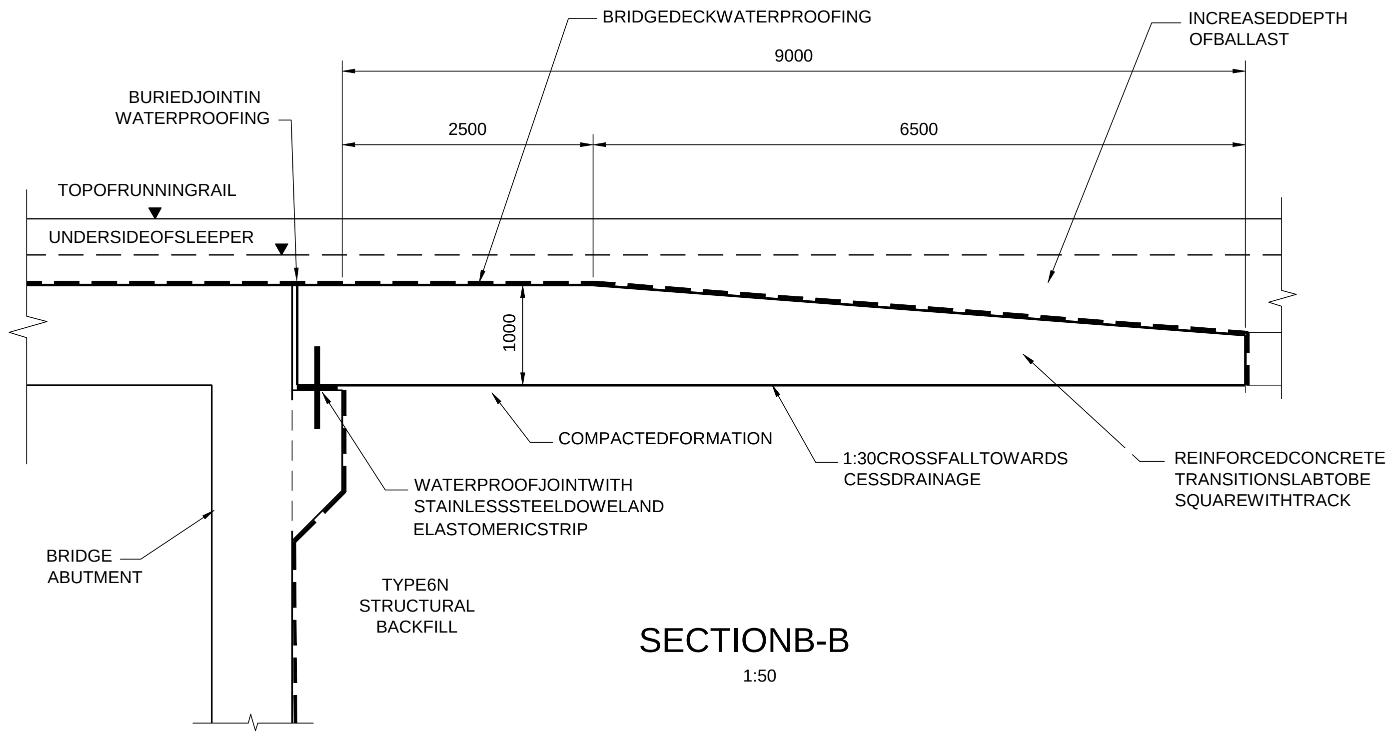
Tomlinson, M. J. (2001). *Foundation Design and Construction* (7th ed.). Harlow: Pearson Education Ltd.

Tomlinson, M. J. (2008). *Pile Design and Construction Practice* (5th ed.). Abingdon: Taylor & Francis.

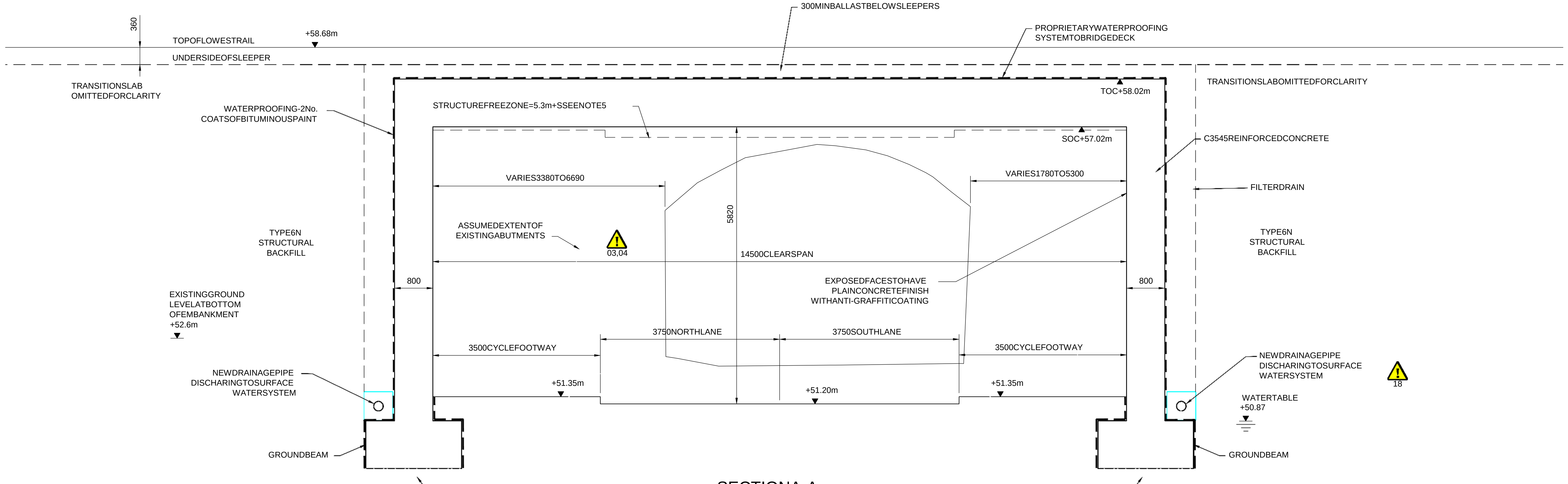
Appendix A. Drawings



PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONA-A
1:50

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL -001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=2715 TONNES. P2

Keytosymbols

TOC - TOPOFCONCRETE
SOC - SOFFITOFCONCRETE
NETWORKRAILLAND REGISTRYBOUNDARY
ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN
18 WATERLEVELAT50.87m
REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN
Ordnance Survey © Crown copyright 2015. All rights reserved. Licence number 100026791.

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	ADDRESSCHANGE&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack Bristol,BS16FL UnitedKingdom
T +44(0)1179069500
W www.mottmac.com
P2

Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
Option1-NoBusLane
SkewedtoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0011

1:50 0 2.5m 5m
1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-0011.dwg
Jul9,2015-5:01PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL-001OPTIONSELECTIONREPORT
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TWOBUSLANEALIGNMENTSHAVEBEENPROPOSEDBYTHEHIGHWAY DESIGNERS;ONEOPTIONWITHDESIGNATEDBUSLANELOCATEDON THENORTHSIDEANDONEOPTIONONTHESOUTHSIDEOFTHE CARRIAGEWAY.THISDRAWINGPRESENTSTHEOPTIONWITHTHEBUS LANEONTHENORTHSIDE,WHICHBEARSGREATERRISKTOTHE BRIDGECONSTRUCTION.
9. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=3350TONNES.

P2

Keytosymbols

TOC - TOPOFCONCRETE

SOC - SOFFITOFCONCRETE

NETWORKRAILLAND REGISTRYBOUNDARY

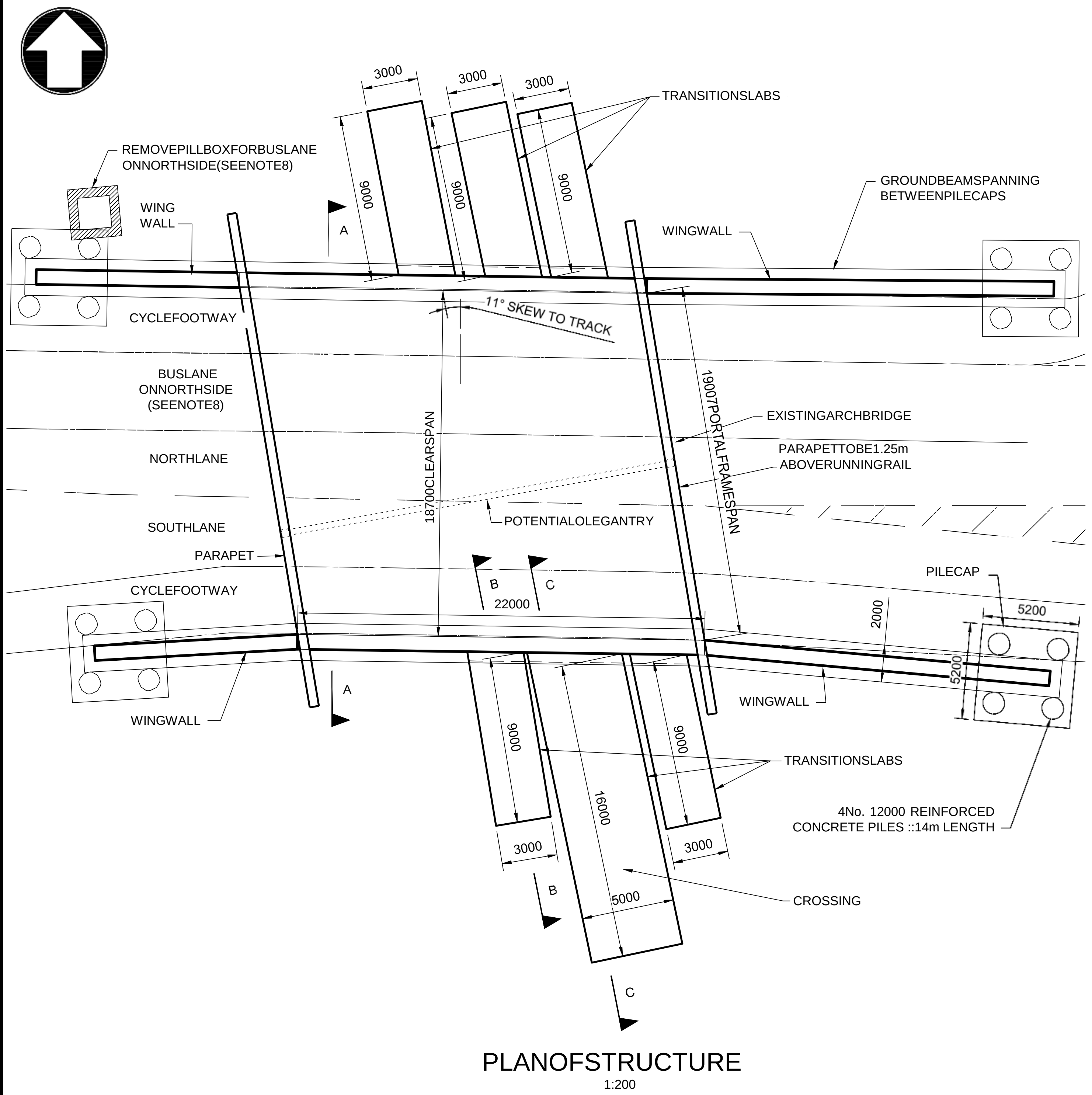
ADOPTEDHIGHWAY

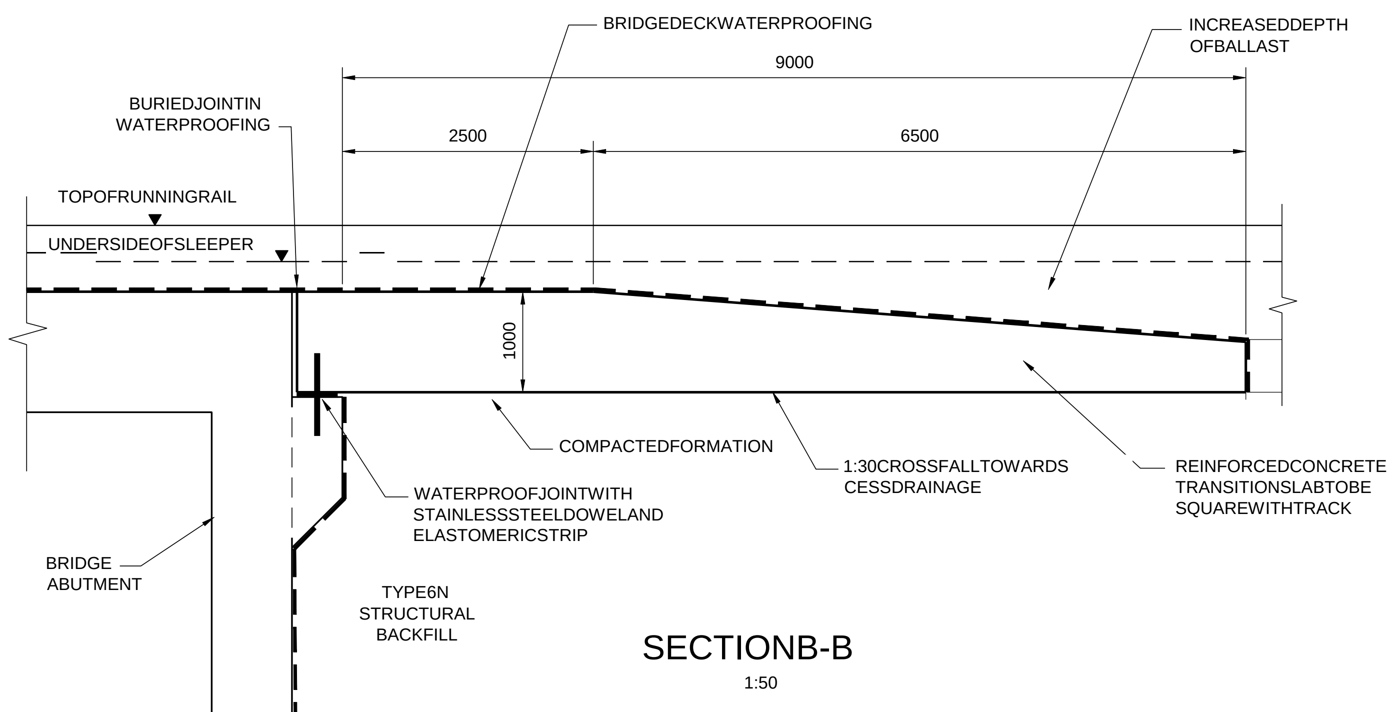
SIGNIFICANTCDMHEALTHANDSAFETYRISKS

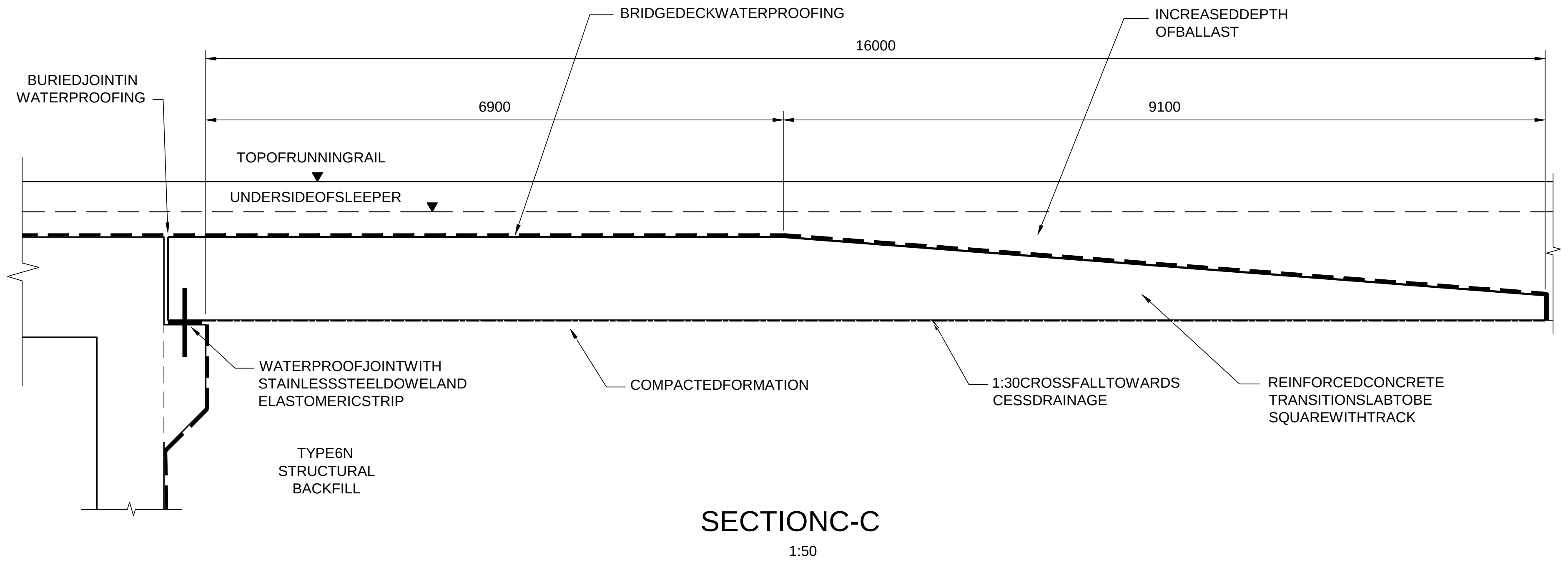
03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN

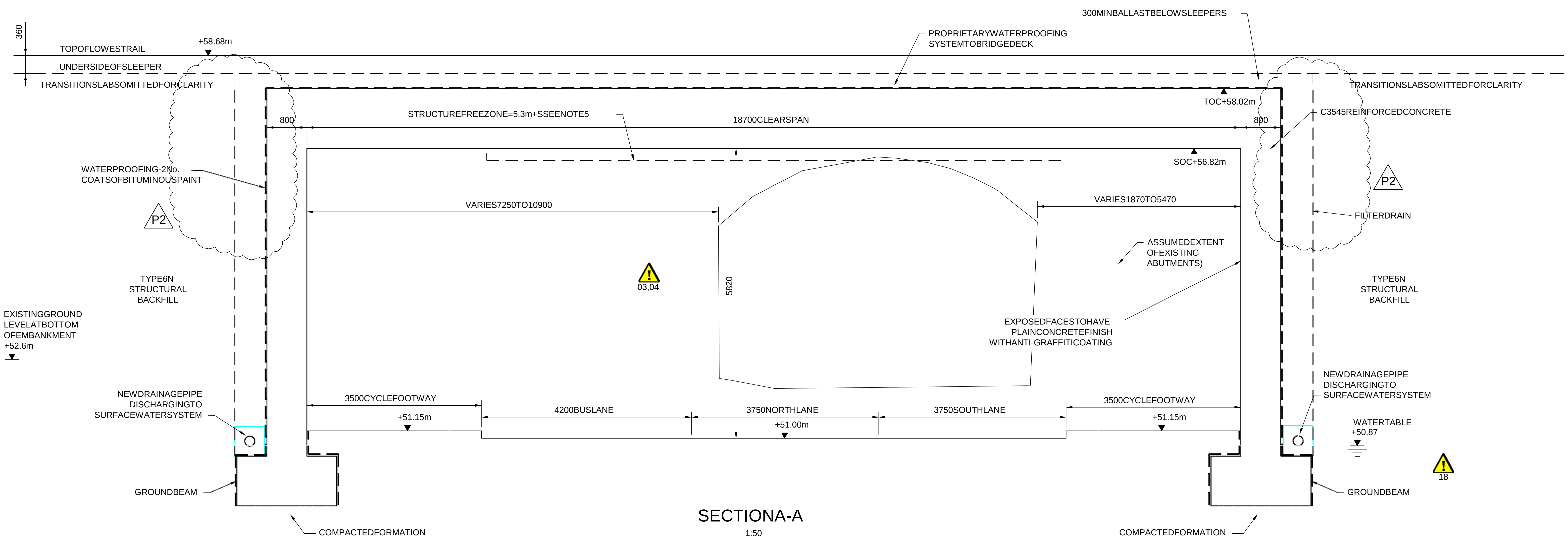
18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003









SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	WALLTHICKNESSUPDATED, ADDRESSCHANGE&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client

Network Rail

Title

GipsyPatchLaneBridge(BSW5m60ch) Option2-SingleBusLane SkewedtoTrack

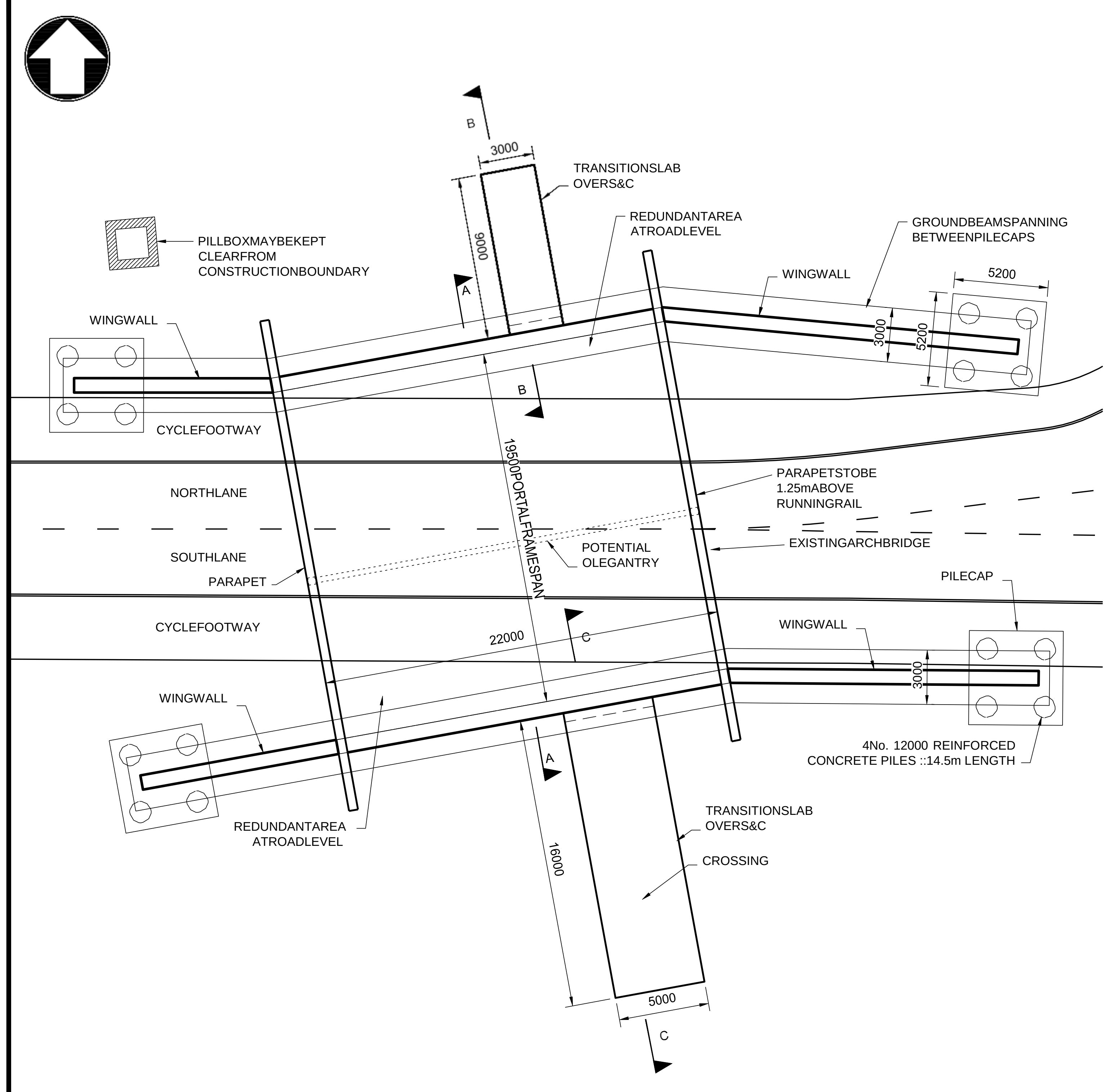
Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

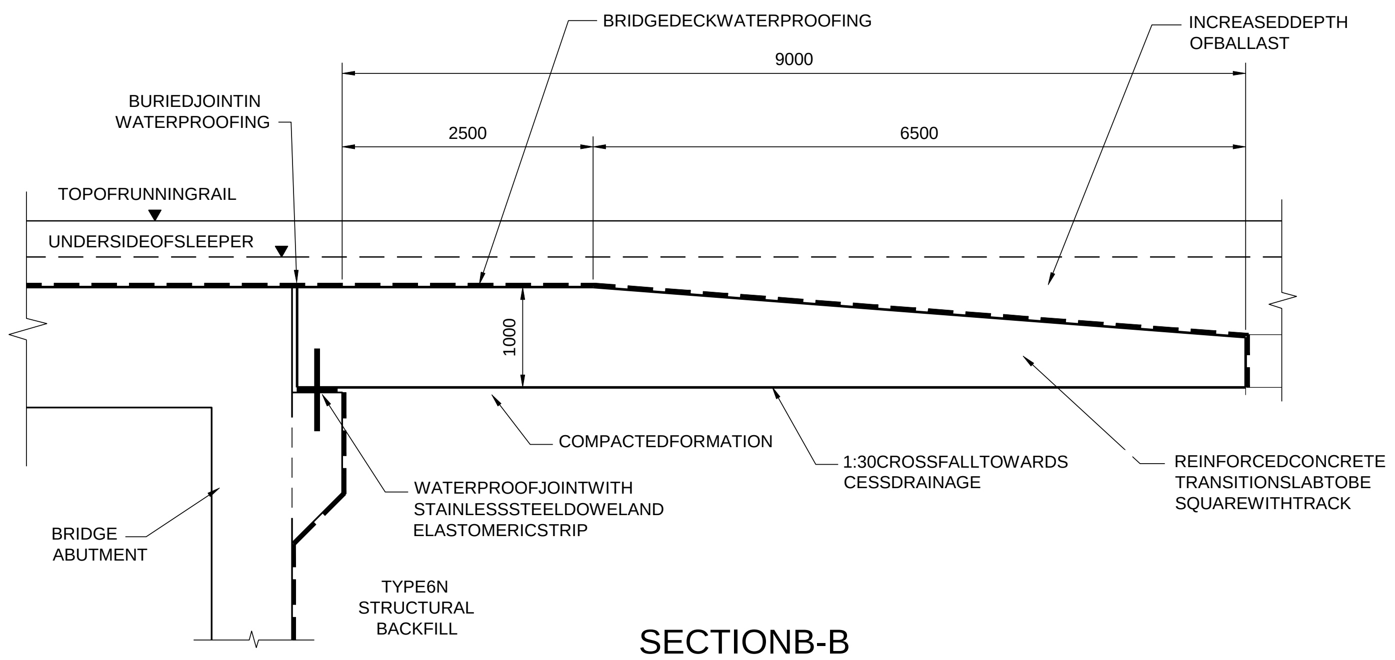
DrawingNumber

MMD-350164-C-DR-GP-XX-0012

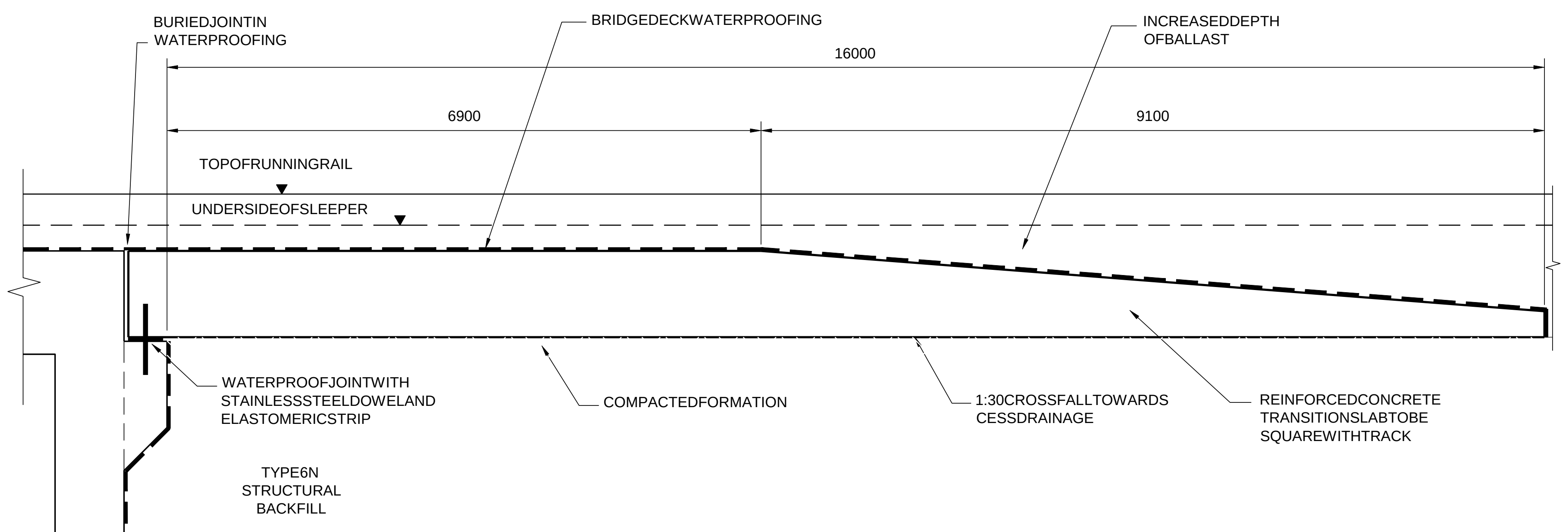
1:50 0 2.5m 5m 1:200 0 10m 20m



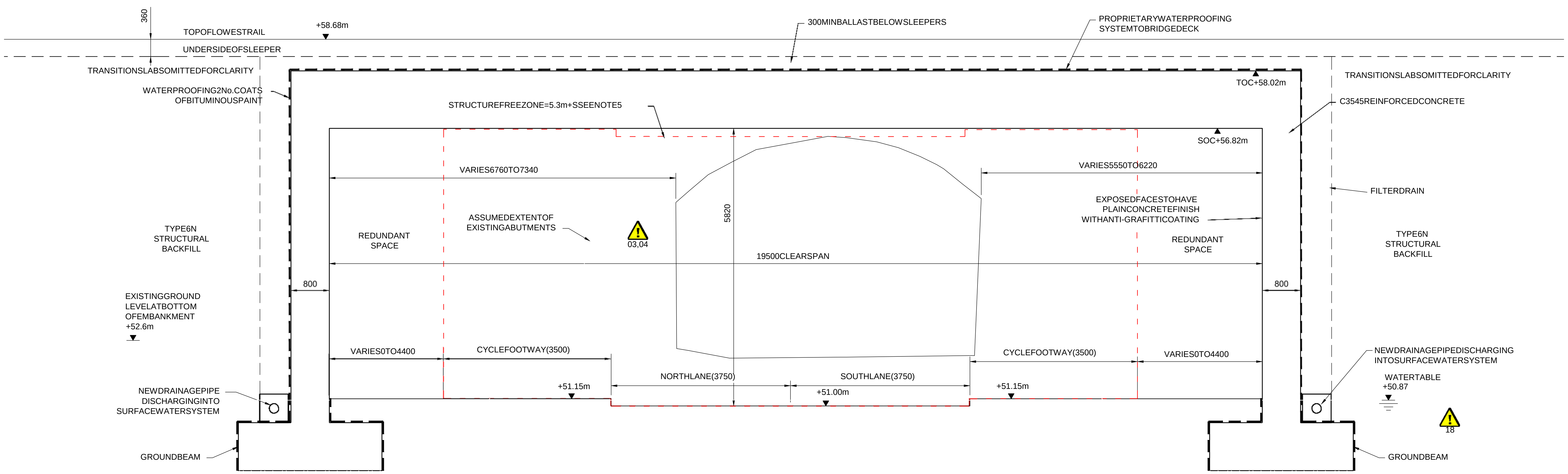
PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SECTIONC-C
1:50



SECTIONA-A
1:50

1:50 0 2.5m 5m
1:200 0 10m 20m

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-13 Jul9,2015-5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm.
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=3605 TONNES. P2

Keytosymbols

(XXXX) - SKEWEDDIMENSION
TOC - TOPOFCONCRETE
SOC - SOFFITOFCONCRETE
NETWORKRAILLAND REGISTRYBOUNDARY
ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN
18 WATERLEVELAT50.87m
REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN
Ordnance Survey © Crown copyright 2015. All rights reserved. Licence number 100026791.

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	CHANGEOFADDRESS&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack Bristol,BS16FL UnitedKingdom
T +44(0)1179069500
W www.mottmac.com
P2

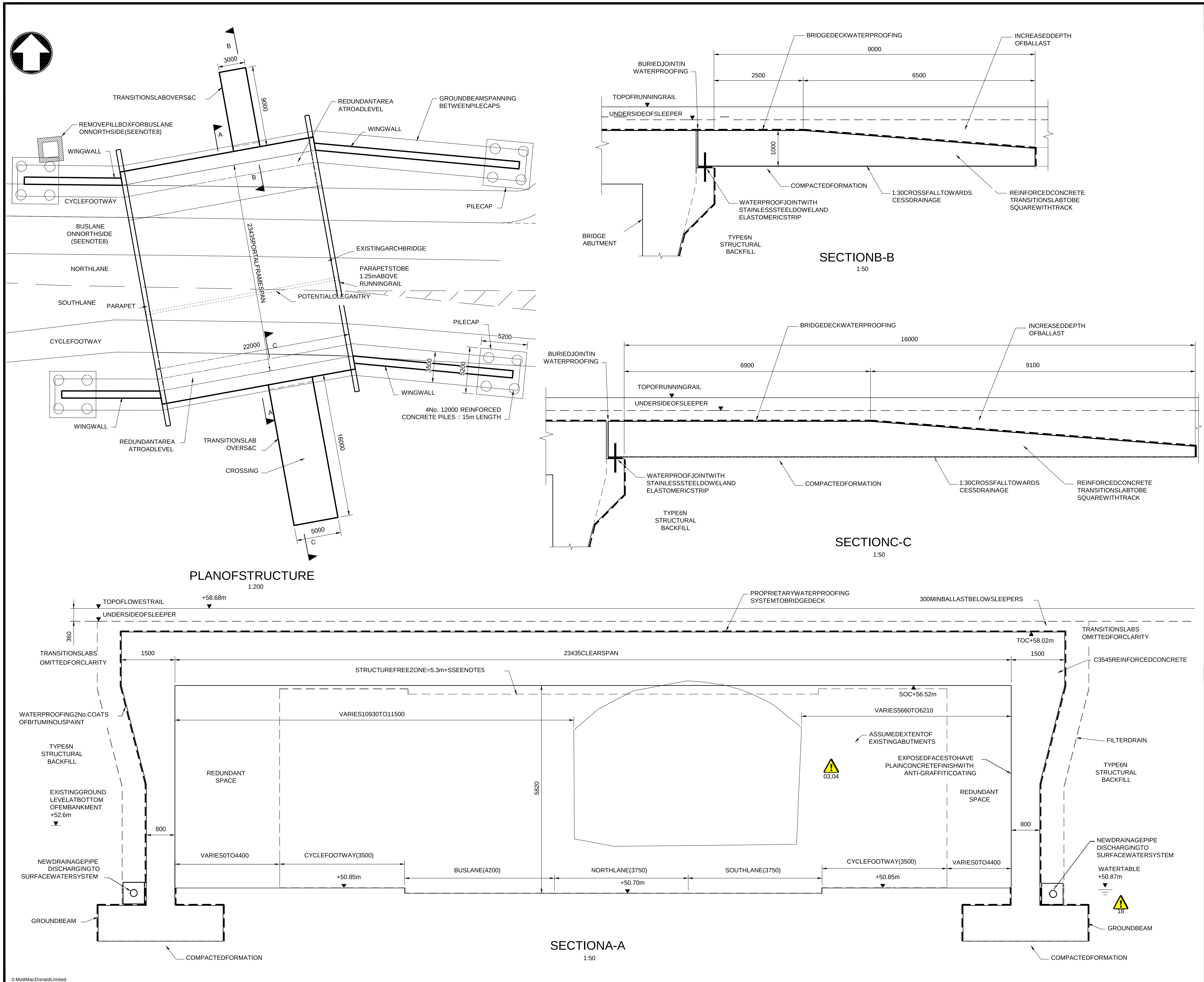
Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
Option3-NoBusLane
SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1: ASSHOWN | Status: PRE | Rev: P2 | Security: STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0013



Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENT RISKSCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm.
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TWOBUSLANEALIGNMENTSHAVEBEENPROPOSEDBYTHE HIGHWAYDESIGNERS;ONEOPTIONWITHDESIGNATEDBUSLANE LOCATEDONTHENORTHSIDEANDONEOPTIONONTHESOUTHSIDE OFTHECARRIAGEWAY.THISDRAWINGPRESENTSTHEOPTIONWITH THEBUSLANEONTHENORTHSIDE,WHICHBEARSGREATERRISKTO THEBRIDGECONSTRUCTION.
9. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=4860 TONNES. P2

Keytosymbols

(XXXX)	-	SKEWEDDIMENSION
TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P2	090715	TF	CHANGEOFADDRESS&ADDITIONALNOTE	AVG	CB
P1	050615	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald
10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

P2

Client
Network Rail

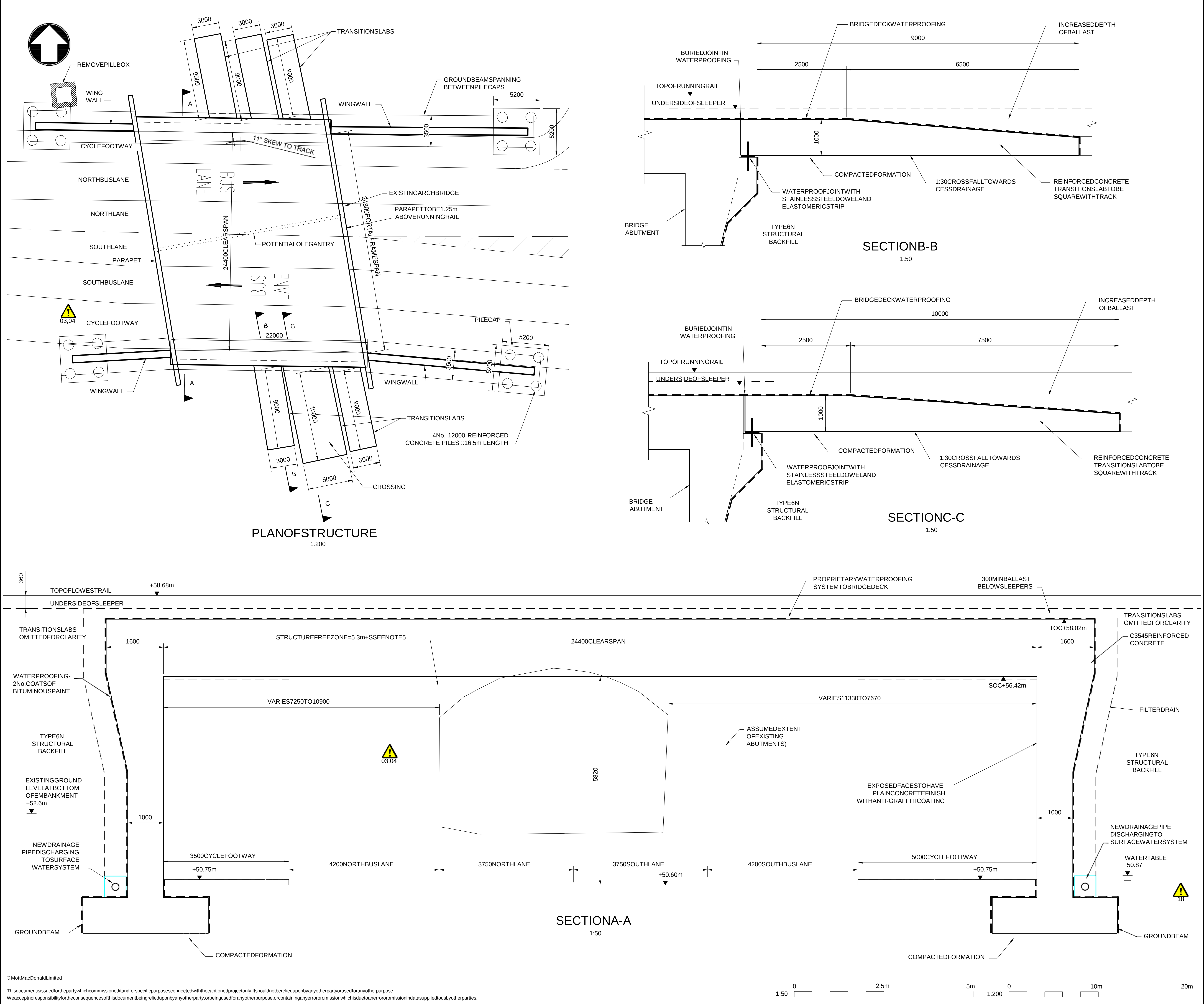
Title
GipsyPatchLaneBridge(BSW5m60ch) Option4-SingleBusLane SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P2	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0014

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-14 Jul9,2015- 5:02PM FOO73213



©MottMacDonaldLimited

Thisdocumentisissuedforthepartywhichcommissioneditandforspecificpurposesconnectedwiththecaptionedprojectonly.Itshouldnotberelieduponbyanyotherpartyorusedforanyotherpurpose.
Weacceptnoresponsibilityfortheconsequencesofthisdocumentbeingrelieduponbyanyotherparty,orbeingusedforanyotherpurpose,orcontaininganyerrororomissionwhichisduetoanerrororomissionindatasuppliedtousbyotherparties.

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-15 Jul9,2015- 5:02PM FOO73213

Notes

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTEDOTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEYLEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROMTHESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTIONWITHALLTHE RELEVANTENGINEERINGDRAWINGS,CIVILANDSTRUCTURAL SPECIFICATIONS,WRITTENINSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESANDOTHER DOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m,S=270mm
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH350164-WTD-BTL-001OPTIONSELECTIONREPORT
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLINMARCH2015 (ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTINGINCLUDING PORTALFRAME,GROUNDBEAMSANDALLWINGWALLS=5280TONNES.

Keytosymbols

TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03,04 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

SITELOCATIONPLAN

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	090715	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald

10TempleBack
Bristol,BS16FL
UnitedKingdom

T +44(0)1179069500
W www.mottmac.com

Client

Network Rail

Title

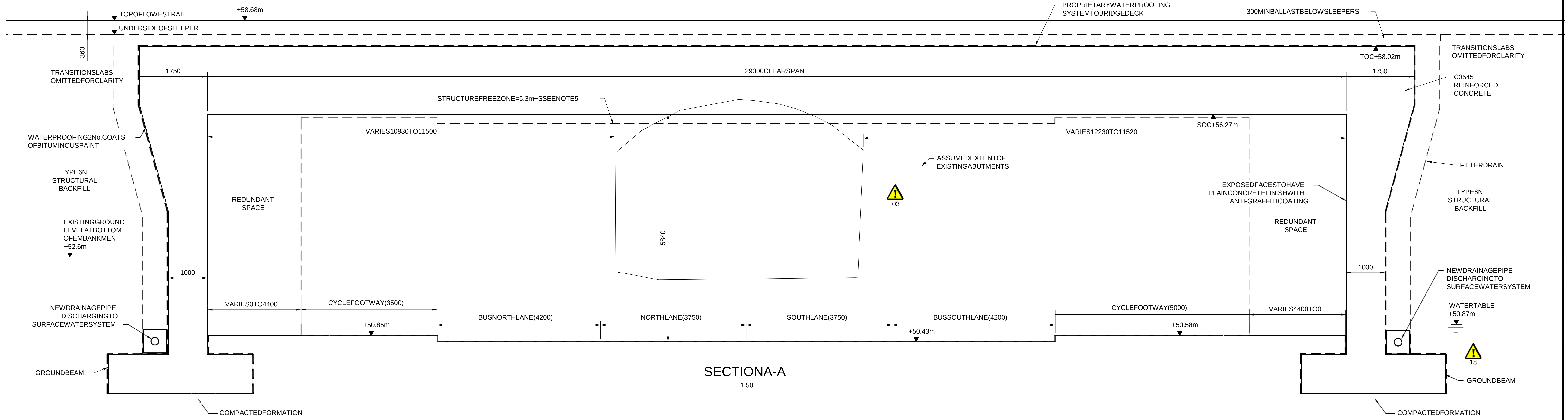
GipsyPatchLaneBridge(BSW5m60ch)
Option5-DualBusLane
SkewedtoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

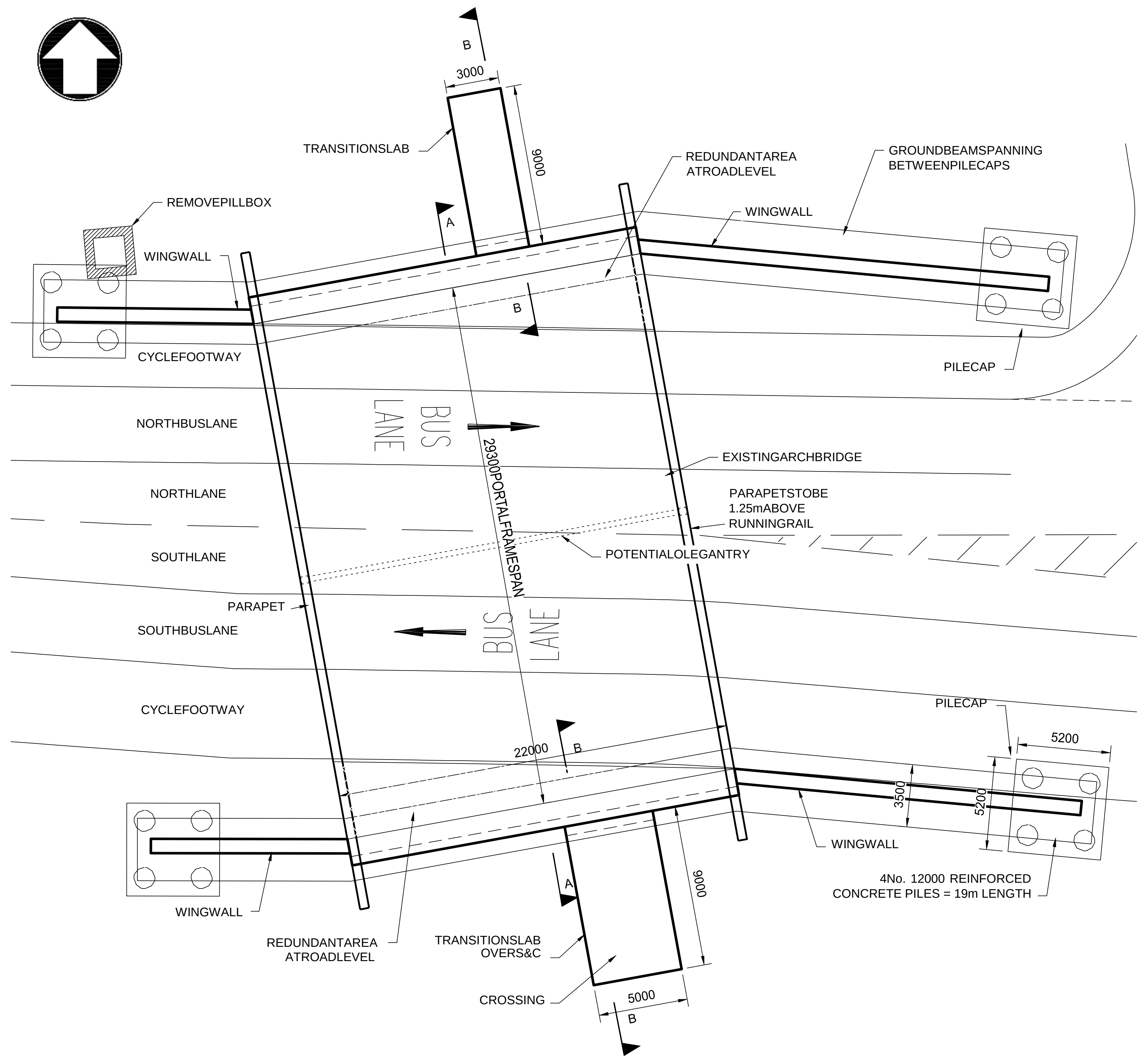
ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P1	STD

DrawingNumber

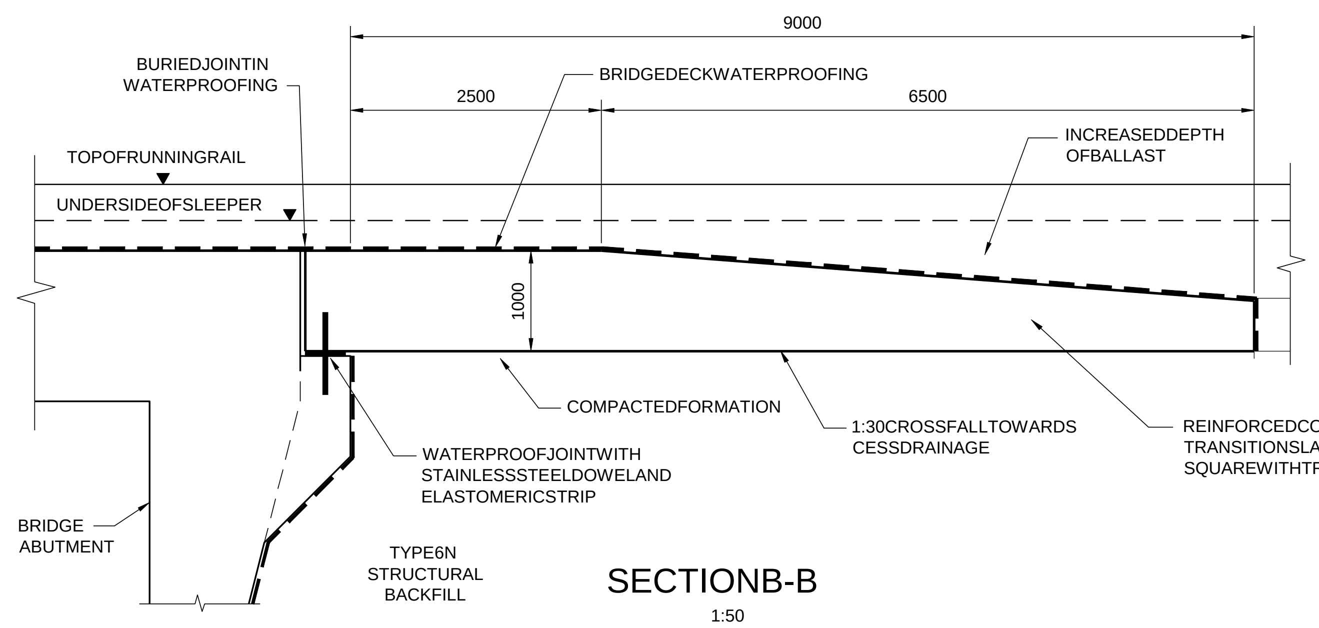
MMD-350164-C-DR-GP-XX-0015



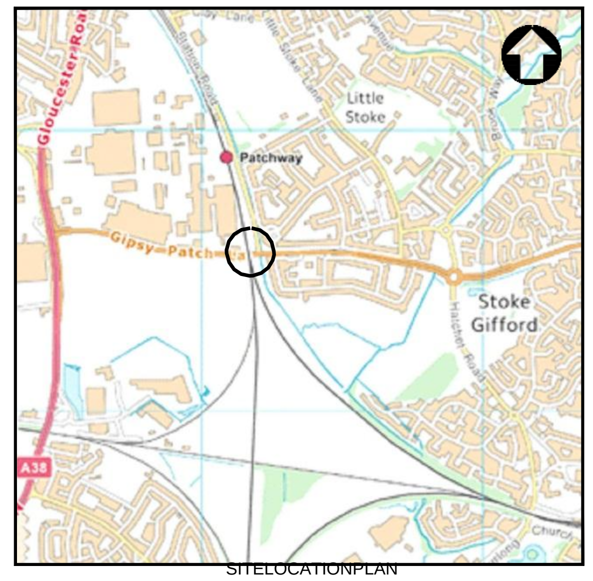
SECTIONA-A
1:50



PLANOFSTRUCTURE
1:200



SECTIONB-B
1:50



SITELOCATIONPLAN

1. ALLDIMENSIONSAREINMILLIMETRESUNLESSNOTED OTHERWISE.
2. ALLLEVELSAREINMETRESTOEXISTINGSURVEY LEVELS.
3. DONOTSCALEANYITEMSORINFORMATIONFROM THESEDRAWINGS.
4. THESEDRAWINGSSHALLBEREADINCONJUNCTION WITHALLTHERELEVANTENGINEERINGDRAWINGS, CIVILANDSTRUCTURALSPECIFICATIONS,WRITTEN INSTRUCTIONS,DESIGNDEVELOPMENTRISK SCHEDULE,HEALTHANDSAFETYRISKSCHEDULESAND OTHERDOCUMENTATIONRELEVANTTOTHISPROJECT.
5. FORPROPOSEDCARRIAGEWAYSAGCURVEOF290m, S=270mm.
6. DRAWINGSHOULDBEREADINCONJUNCTIONWITH 350164-WTD-BTL-001OPTIONSELECTIONREPORT.
7. TOPOGRAPHICALLAYOUTPROVIDEDBYCH2MHILLIN MARCH2015(ORIGINALNAME:PATCHWAY5641-1.DWG).
8. TOTALNOMINALWEIGHTOFSTRUCTUREFORLIFTING INCLUDINGPORTALFRAME,GROUNDBEAMSANDALL WINGWALLS=5970TONNES.

(XXXX)	-	SKEWEDDIMENSION
TOC	-	TOPOFCONCRETE
SOC	-	SOFFITOFCONCRETE
		NETWORKRAILLAND REGISTRYBOUNDARY
		ADOPTEDHIGHWAY

SIGNIFICANTCDMHEALTHANDSAFETYRISKS

03 EXISTINGSTRUCTUREEXTENTSUNKNOWN

18 WATERLEVELAT50.87m

REFERTOPROJECTHAZARDLOG:350164-WTD-BTL-003

1:50 0 2.5m 5m

1:200 0 10m 20m

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	090715	TF	FIRSTDRAFT	AVG	CB

Mott MacDonald

10TempleBack
Bristol,BS16FL
UnitedKingdom
T +44(0)1179069500
W www.mottmac.com

Client
Network Rail

Title
GipsyPatchLaneBridge(BSW5m60ch)
Option6-DualBusLane
SquaretoTrack

Designed	GSkehel	GS	Engcheck	AGeorgiev	AVG
Drawn	TFoot	TF	Coordination	AGeorgiev	AVG
Dwgcheck	AGeorgiev	AVG	Approved	CBishop	CB

ScaleatA1	Status	Rev	Security
ASSHOWN	PRE	P1	STD

DrawingNumber
MMD-350164-C-DR-GP-XX-0016

P:\Bristol\BNI\350164GipsyPatch&BrierlyFurlong\5.0Outgoing(Workingdocuments)\5.0WorkingDrawings\MMD-350164-C-DR-GP-XX-16 Jul9,2015-5:02PM FOO73213

Appendix B. Figures

Figure B.1: Borehole location plan

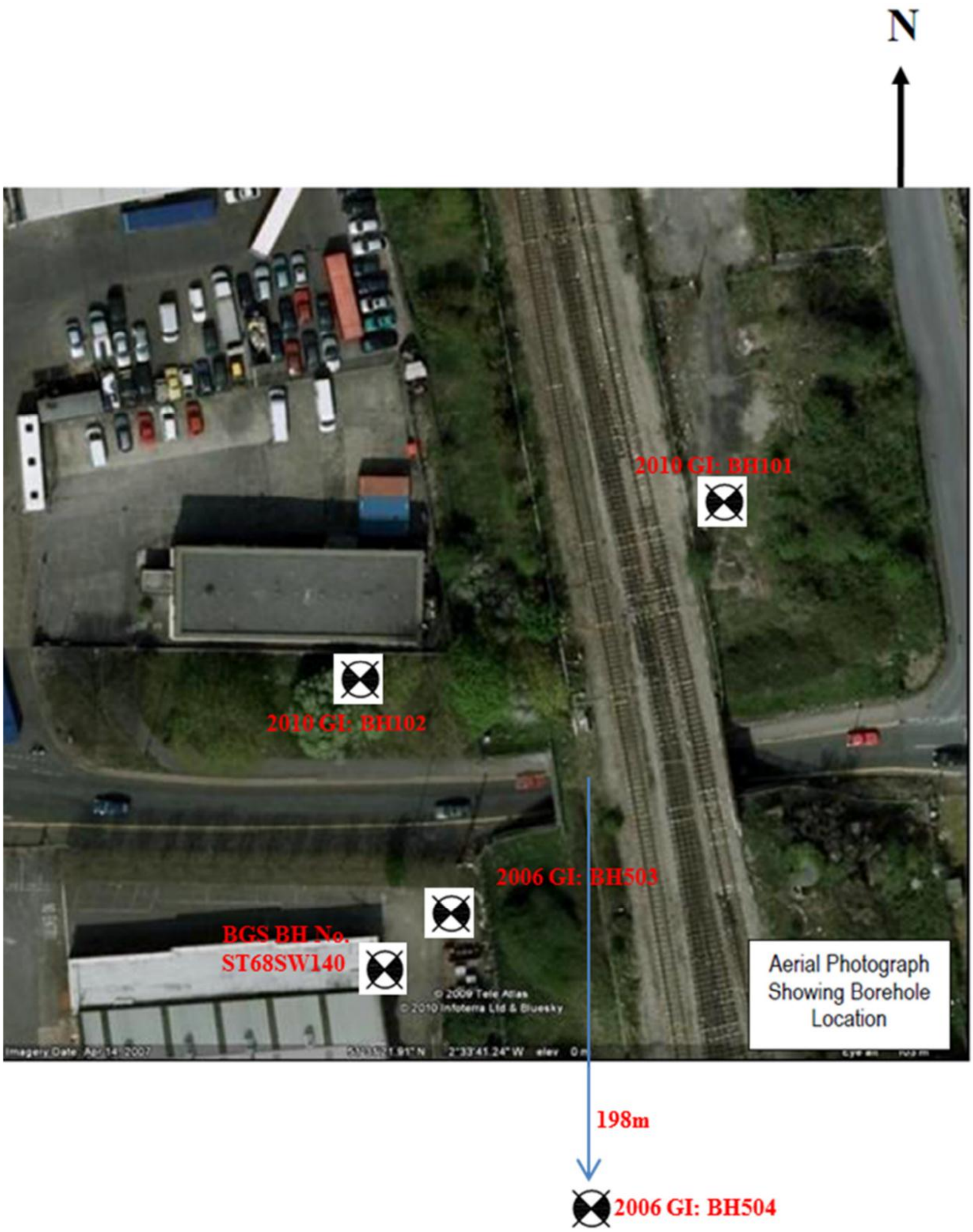
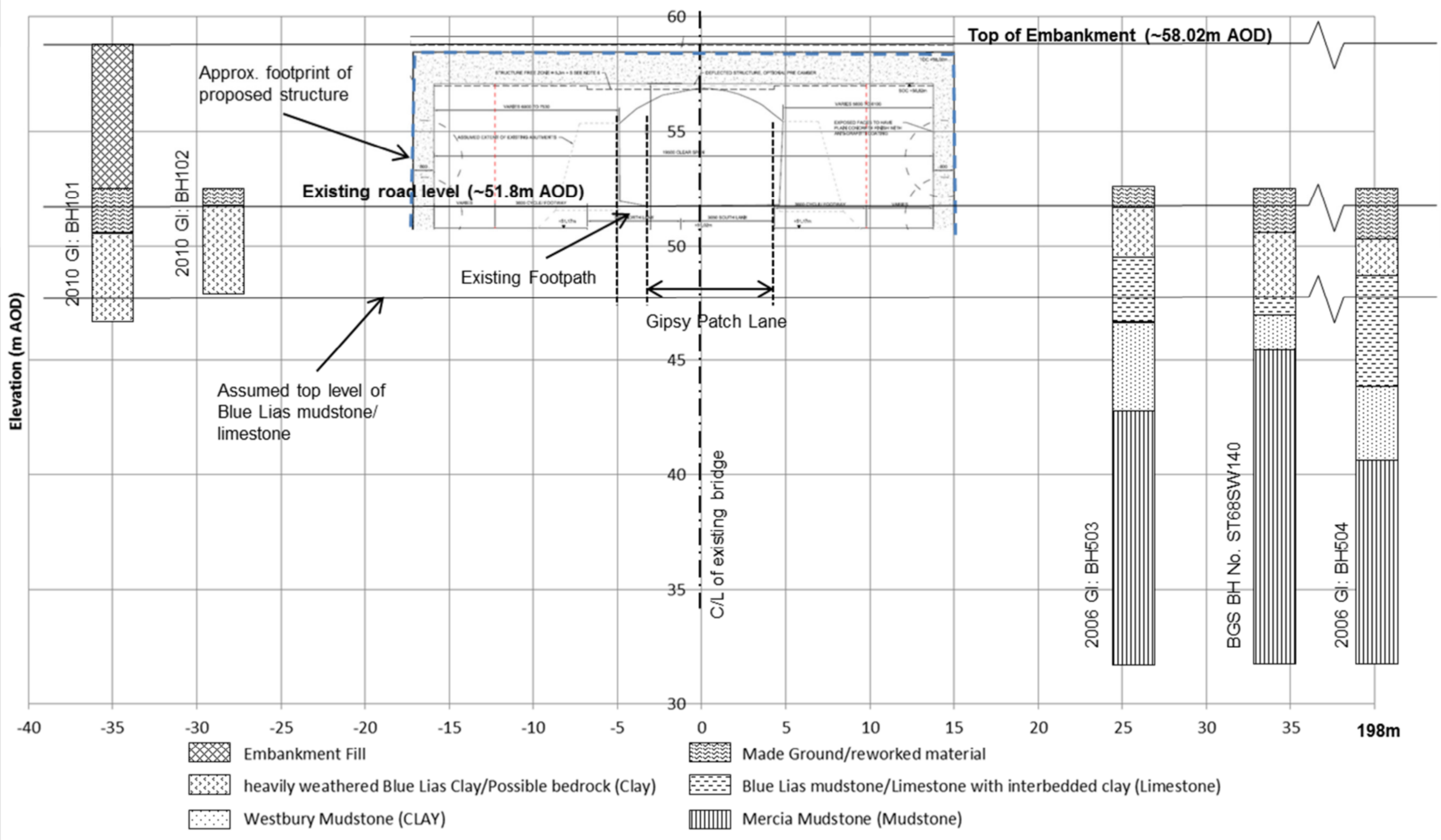


Figure B.2: Generalised ground model



Appendix H

Carbon Footprint Calculations

Gipsy Patch Lane - Option 1

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	206	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	60,811	$kgCO_2e$	385.4 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	354	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	104,501	$kgCO_2e$	
Reinforcement; to Bridge Portal	168036	kg			1.31	$kgCO_2e/kg$	220127.16	$kgCO_2e$	

Ground Beams	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Ground Beams	14	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	4,133	$kgCO_2e$	148.5 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	210	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	61,992	$kgCO_2e$	
Reinforcement; to Ground Beams	62889	kg			1.31	$kgCO_2e/kg$	82,385	$kgCO_2e$	

Wing Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Wing Walls	104	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	30,701	$kgCO_2e$	64.9 tCO2e
Reinforcement; to Wing Walls	26,075	tonne			1.31	$kgCO_2e/kg$	34,158	$kgCO_2e$	

Parapet Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); 400mm thick to Parapet walls	24	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	7,085	$kgCO_2e$	16.8 tCO2e
Reinforcement; to parapet walls	7,380	kg			1.31	$kgCO_2e/kg$	9,668	$kgCO_2e$	

Transition Slabs	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); to Transition Slabs	138	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	40,738	$kgCO_2e$	99.1 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	14	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	4,133	$kgCO_2e$	
Reinforcement; to Transition Slabs	41400	kg			1.31	$kgCO_2e/kg$	54,234	$kgCO_2e$	

Concrete Pilecaps	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	

Concrete Piles	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Piles; 1.2m diameter - Concreted Length	235	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	69,444	$kgCO_2e$	115.6 tCO2e
Piles; 1.2m diameter - Reinforcement	35,256	kg		kg/m^3	1.31	$kgCO_2e/kg$	46,185	$kgCO_2e$	

Total Carbon	**914.6 tCO2e**

Gipsy Patch Lane - Option 2

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	493	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	145,534	$kgCO_2e$	428.4 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	302	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	89,150	$kgCO_2e$	
Reinforcement; to Bridge Portal	147900	kg			1.31	$kgCO_2e/kg$	193749	$kgCO_2e$	

Ground Beams	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Ground Beams	15	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	4,428	$kgCO_2e$	152.6 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	215	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	63,468	$kgCO_2e$	
Reinforcement; to Ground Beams	64656	kg			1.31	$kgCO_2e/kg$	84,699	$kgCO_2e$	

Wing Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Wing Walls	109	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	32,177	$kgCO_2e$	68.0 tCO2e
Reinforcement; to Wing Walls	27,350	tonne			1.31	$kgCO_2e/kg$	35,829	$kgCO_2e$	

Parapet Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); 400mm thick to Parapet walls	33	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	9,742	$kgCO_2e$	22.8 tCO2e
Reinforcement; to parapet walls	9,947	kg			1.31	$kgCO_2e/kg$	13,031	$kgCO_2e$	

Transition Slabs	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); to Transition Slabs	177	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	52,250	$kgCO_2e$	126.9 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	17	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	5,018	$kgCO_2e$	
Reinforcement; to Transition Slabs	53169	kg			1.31	$kgCO_2e/kg$	69,651	$kgCO_2e$	

Concrete Pilecaps	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	

Concrete Piles	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Piles; 1.2m diameter - Concreted Length	253	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	74,785	$kgCO_2e$	156.4 tCO2e
Piles; 1.2m diameter - Reinforcement	62,304	kg		kg/m^3	1.31	$kgCO_2e/kg$	81,618	$kgCO_2e$	

Total Carbon	**1,039.4 tCO2e**

Gipsy Patch Lane - Option 3

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	206	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	60,811	$kgCO_2e$	525.1 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	557	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	164,426	$kgCO_2e$	
Reinforcement; to Bridge Portal	228890	kg			1.31	$kgCO_2e$/kg	299845.9	$kgCO_2e$	

Ground Beams	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Ground Beams	21	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	6,199	$kgCO_2e$	221.8 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	313	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	92,398	$kgCO_2e$	
Reinforcement; to Ground Beams	94074	kg			1.31	$kgCO_2e$/kg	123,237	$kgCO_2e$	

Wing Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Wing Walls	104	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	30,701	$kgCO_2e$	64.6 tCO2e
Reinforcement; to Wing Walls	25,887	tonne			1.31	$kgCO_2e$/kg	33,912	$kgCO_2e$	

Parapet Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); 400mm thick to Parapet walls	33	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	9,742	$kgCO_2e$	22.8 tCO2e
Reinforcement; to parapet walls	9,972	kg			1.31	$kgCO_2e$/kg	13,063	$kgCO_2e$	

Transition Slabs	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); to Transition Slabs	88	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	25,978	$kgCO_2e$	63.1 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	9	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	2,527	$kgCO_2e$	
Reinforcement; to Transition Slabs	26400	kg			1.31	$kgCO_2e$/kg	34,584	$kgCO_2e$	

Concrete Pilecaps	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	

Concrete Piles	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Piles; 1.2m diameter - Concreted Length	262	m^3	2400	kg/m^3	0.123	$kgCO_2e$/kg	77,456	$kgCO_2e$	129.0 tCO2e
Piles; 1.2m diameter - Reinforcement	39,336	kg		kg/m^3	1.31	$kgCO_2e$/kg	51,530	$kgCO_2e$	

Total Carbon	**1,110.7 tCO2e**

Gipsy Patch Lane - Option 4

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	245	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	72,324	$kgCO_2e$	769.1 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	873	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	257,710	$kgCO_2e$	
Reinforcement; to Bridge Portal	335190	kg			1.31	$kgCO_2e/kg$	439098.9	$kgCO_2e$	

Ground Beams	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Ground Beams	26	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	7,675	$kgCO_2e$	267.2 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	377	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	111,290	$kgCO_2e$	
Reinforcement; to Ground Beams	113142	kg			1.31	$kgCO_2e/kg$	148,216	$kgCO_2e$	

Wing Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Wing Walls	109	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	32,177	$kgCO_2e$	68.0 tCO2e
Reinforcement; to Wing Walls	27,353	tonne			1.31	$kgCO_2e/kg$	35,832	$kgCO_2e$	

Parapet Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); 400mm thick to Parapet walls	40	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	11,808	$kgCO_2e$	27.7 tCO2e
Reinforcement; to parapet walls	12,120	kg			1.31	$kgCO_2e/kg$	15,877	$kgCO_2e$	

Transition Slabs	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); to Transition Slabs	88	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	25,978	$kgCO_2e$	63.1 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,527	$kgCO_2e$	
Reinforcement; to Transition Slabs	26400	kg			1.31	$kgCO_2e/kg$	34,584	$kgCO_2e$	

Concrete Pilecaps	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	

Concrete Piles	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Piles; 1.2m diameter - Concreted Length	271	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	80,127	$kgCO_2e$	133.5 tCO2e
Piles; 1.2m diameter - Reinforcement	40,728	kg		kg/m^3	1.31	$kgCO_2e/kg$	53,354	$kgCO_2e$	

Total Carbon	**1,412.9 tCO2e**

Gipsy Patch Lane - Option 5

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	271	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	79,999	$kgCO_2e$	855.4 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	972	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	286,934	$kgCO_2e$	
Reinforcement; to Bridge Portal	372900	kg			1.31	$kgCO_2e/kg$	488499	$kgCO_2e$	

Ground Beams	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Ground Beams	29	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	8,561	$kgCO_2e$	213.2 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	383	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	113,062	$kgCO_2e$	
Reinforcement; to Ground Beams	69900	kg			1.31	$kgCO_2e/kg$	91,569	$kgCO_2e$	

Wing Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Wing Walls	263	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	77,638	$kgCO_2e$	181.2 tCO2e
Reinforcement; to Wing Walls	79,086	tonne			1.31	$kgCO_2e/kg$	103,603	$kgCO_2e$	

Parapet Walls	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); 400mm thick to Parapet walls	41	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	12,103	$kgCO_2e$	28.2 tCO2e
Reinforcement; to parapet walls	12,300	kg			1.31	$kgCO_2e/kg$	16,113	$kgCO_2e$	

Transition Slabs	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); to Transition Slabs	138	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	40,738	$kgCO_2e$	99.1 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	14	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	4,133	$kgCO_2e$	
Reinforcement; to Transition Slabs	41400	kg			1.31	$kgCO_2e/kg$	54,234	$kgCO_2e$	

Concrete Pilecaps	Estimate Quantities	Units	Estimate Quantities	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	

Concrete Piles	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Piles; 1.2m diameter - Concreted Length	271	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	80,127	$kgCO_2e$	133.5 tCO2e
Piles; 1.2m diameter - Reinforcement	40,728	kg		kg/m^3	1.31	$kgCO_2e/kg$	53,354	$kgCO_2e$	

Total Carbon	**1,595.0 tCO2e**

Gipsy Patch Lane - Option 6

Bridge Portal Frame	Estimate Quantities (length)	Units	Estimate Quantities (mass)	Units	Emissions Factors*	Units	Total	Units	Capital Carbon in Design
Concrete (35/45); exceeding 500mm thick to Portal Walls	311	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	91,807	$kgCO_2e$	1,119.0 tCO2e
Concrete (35/45); exceeding 500mm thick to Deck Portal	1,315	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	388,188	$kgCO_2e$	
Reinforcement; to Bridge Portal	487800	kg			1.31	$kgCO_2e/kg$	639018	$kgCO_2e$	
Ground Beams	**Estimate Quantities**	**Units**	**Estimate Quantities**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Blinding concrete; 75mm thick to Ground Beams	35	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	10,332	$kgCO_2e$	331.1 tCO2e
Concrete (32/40); exceeding 500mm thick to Ground Beams	467	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	137,858	$kgCO_2e$	
Reinforcement; to Ground Beams	139650	kg			1.31	$kgCO_2e/kg$	182,942	$kgCO_2e$	
Wing Walls	**Estimate Quantities**	**Units**	**Estimate Quantities**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Concrete (35/45); exceeding 500mm thick to Wing Walls	291	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	85,903	$kgCO_2e$	200.3 tCO2e
Reinforcement; to Wing Walls	87,300	tonne			1.31	$kgCO_2e/kg$	114,363	$kgCO_2e$	
Parapet Walls	**Estimate Quantities**	**Units**	**Estimate Quantities**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Concrete (35/45); 400mm thick to Parapet walls	50	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	14,760	$kgCO_2e$	34.4 tCO2e
Reinforcement; to parapet walls	15,000	kg			1.31	$kgCO_2e/kg$	19,650	$kgCO_2e$	
Transition Slabs	**Estimate Quantities**	**Units**	**Estimate Quantities**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Concrete (35/45); to Transition Slabs	59	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	17,417	$kgCO_2e$	42.3 tCO2e
Blinding concrete; 75mm thick to Transition Slabs	6	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	1,771	$kgCO_2e$	
Reinforcement; to Transition Slabs	17652	kg			1.31	$kgCO_2e/kg$	23,124	$kgCO_2e$	
Concrete Pilecaps	**Estimate Quantities**	**Units**	**Estimate Quantities**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Blinding concrete; 75mm thick to Pile Caps	9	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	2,657	$kgCO_2e$	84.3 tCO2e
Concrete (32/40); exceeding 500mm thick to Pile Caps	208	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	26	$kgCO_2e$	
Reinforcement; to Pile Caps	62304	kg			1.31		81,618	$kgCO_2e$	
Concrete Piles	**Estimate Quantities (length)**	**Units**	**Estimate Quantities (mass)**	**Units**	**Emissions Factors***	**Units**	**Total**	**Units**	**Capital Carbon in Design**
Piles; 1.2m diameter - Concreted Length	344	m^3	2400	kg/m^3	0.123	$kgCO_2e/kg$	101,494	$kgCO_2e$	169.1 tCO2e
Piles; 1.2m diameter - Reinforcement	51,579	kg		kg/m^3	1.31	$kgCO_2e/kg$	67,568	$kgCO_2e$	
						Total Carbon			**1,980.5 tCO2e**

Gipsy Patch Lane - Summary

	Total Capital Carbon in Design
Option 1	914.6 tCO2e
Option 2	1,039.4 tCO2e
Option 3	1,110.7 tCO2e
Option 4	1,412.9 tCO2e
Option 5	1,595.0 tCO2e
Option 6	1,980.5 tCO2e

Appendix I

Project Risk Register

Local Government (Access to Information) Act 1985: The project risks have been redacted from publication because it is commercially sensitive, such that it would dis-advantage the commercial position of the council in relation to the cost and delivery of the scheme.