Highbridge Road / Itchen Navigation Bridge Replacement Options

Bridge Concept Report
A-093273

Highwood Group / Galliford Try Partnerships
June 2018
Prepared on behalf of WYG Engineering Limited

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Document control

Document:	Highbridge Road Bridge Replacement Structural Concept Report
Project:	Highbridge Road Bridge Replacement
Client:	Highwood Group & Galliford Try Partnerships
Job Number:	A093273
File Origin:	

Revision:	Issue	
Date:	June 2018	
Prepared by: Katerina Frangoullidou BSc MSc	Checked by: Richard Gregory BEng CEng MICE PhD	Approved By: Martin Hawthorne
Description of revision:		

Revision:		
Date:		
Prepared by: [name]	Checked by: [name]	Approved By: [name]
Description of revision:		

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Executive Summary

Highwood Group and Galliford Try Partnerships are exploring opportunities to relocate an existing bridge as part of a proposed new road alignment at Highbridge Road as it crosses the Itchen Navigation to the east of Allbrook, Hampshire. WYG have been instructed to consider the feasibility of and potential design solution options that would facilitate a realigned Highbridge Road to be carried over the Navigation. In addition to accommodating all necessary road construction standards, the solution identified should deliver:

- the required road alignment both vertically and horizontally;
- an increase in deck width to accommodate a wider carriageway and pedestrian crossing solutions;
- minimised ecological impact of the new structure and ideally improvement against the existing situation. In particular, shadowing under the bridge should be minimised by keeping the bridge superstructure as slender as possible and lifting it up from the water level as far as possible.

Five concepts have been outlined in this report for consideration:

Option 1 – Concrete Bridge – similar to existing
Option 2 – Arch Bridge
Option 3 – Arch Bridge – increased span
Option 4 – Open Truss Bridge Deck
Option 5 – Half Through Bridge Deck

Of these, Options 1, 4 and 5 are technically feasible from a structural engineering perspective, when considered against the constraints set by the road alignment parameters and the 1:100 year flood level.

It is apparent that of the options reviewed, the concrete option (Option 1 - specifically, **Option 1B** which utilises a sloped deck) will provide the optimum void area beneath the bridge, whilst also being feasible within the parameters set by the road and flood levels.

A reinforced concrete superstructure provides some benefit in terms of the ecological impact of the structure compared to the existing by facilitating light passage through the area where the brick-built parapet on the existing bridge currently blocks light, railings will instead allow light through. The bridge span will also be wider allowing more light beneath and will also facilitate other ecological benefits to be achieved.

As the project progresses, detailed designs and confirmed proposals for the scheme will be developed and evolved in greater detail.

1.0 Introduction

WYG Engineering were instructed by Highwood Group and Galliford Try Partnerships to carry out a structural concept report of outline options for a new bridge being considered as part of the proposed improvements to Highbridge Road located east of Allbrook, Hampshire, where it crosses the Itchen Navigation.

Options being explored for the improvement of Highwood Road to the east of Allbrook include realignment with the potential to provide a new crossing of the Itchen Navigation and removal of the existing (see Options H3/H4 in the Eastleigh Strategic Transport Study, Interim Report - Issues and Options, December 2015). Other options include retention of the existing, but there are highway and pedestrian user benefits associated with a new crossing.

A visual inspection of the existing bridge and associated structures in the vicinity of the Itchen Navigation at Highbridge Road was undertaken by Richard Gregory BEng CEng MICE PhD and Katerina Frangoullidou for WYG on the 17th May 2018.

Two record drawings showing the existing bridge and structures were provided to WYG by Eastleigh Borough Council as shown in Appendix D:
B641 Plan Location & stats –subsequently referred to as "location plan"
B641 Plan and details – subsequently referred to as the "general arrangement"

The description of the existing structures and materials are all based on the above as well as observations made during the time of inspection, and any dimensions provided are approximate and taken for information only, subject to further detailed survey.

2.0 Conditions and Limitations

The inspection undertaken was a non-intrusive inspection and was undertaken from the footpaths alongside the road and the watercourse. As such, it was not possible to inspect several elements:

- The drainage channel, which is believed to culverted under the road, was overgrown so that it was not visible for inspection adjacent to the road.
- Whilst it is understood from the EBC drawings that the culvert is formed from a concrete pipe, it was not possible to confirm this during the inspection.
- It was not possible to review the foundations and other buried elements of the existing bridge.
- The soffit of the superstructure was not visible from a position of safety.

3.0 Location

The existing bridge is located on the B3335 Highbridge road between Highbridge and Allbrook, Hampshire as shown in Figure 1 below.

Figure 1: Location plan of the site

4.0 Description of Existing Structure

The existing bridge consists of a reinforced concrete deck spanning between brickwork abutments and wing walls. The general arrangement drawing confirms that the existing bridge deck was cast in-situ in two sections and is reinforced with mild steel bars.

The South West wing wall has been extended in concrete as shown in Photograph 7.

Brickwork parapets are provided to both sides of the road, with openings to provide access to the towpath between the main watercourse and the drainage channel. Areas of extensive damage were noted to the parapets as shown in Photograph 6. This is likely to be the result of vehicle impact(s).

The general arrangement drawing (see **Figure 19**) confirms that an articulated bearing is not present but that the superstructure is pinned to the abutments.

As the record drawings available do not show the foundations, it is difficult to provide much detail on these. However, it is anticipated that both piled foundations and gravity concrete foundations are appropriate for a bridge of this span.

At the time of the inspection the depth of water downstream of the bridge was estimated to be 0.8m, and the clearance from the water level to the soffit of the bridge was estimated to be 0.9m.

The tow path runs adjacent to the watercourse on the East side, and openings are formed through the parapet to provide access. It is noted that the tow path slopes upwards as it approaches the bridge to allow it to pass over the bridge.

A pipe, noted to be "2'-0" dia. main" on the location plan record drawing, is noted to be present to the North of the bridge. The pipe is supported off to sections and it is independent of the bridge structure other than the fact it is built off the same abutments.

Further 15" and 6" mains are also noted on the location plan (see Figure 18) but these were not observed during the inspection. As such it is unclear if they are suspended from the underside of the bridge, embedded within/below the bridge structure or have been removed.

A "4" duct" is shown on the general arrangement drawing embedded within the curb to the South of the bridge.

4.1 Potential Road Realignment

Any realignment of Highbridge Road to the east of Allbrook will need to consider the following constraints:

- It is necessary to achieve adequate clearance/area under the bridge structure to satisfy flooding criteria. Whilst not resolved as part of this concept report, provided these parameters can be maintained as existing or improved it is considered that this requirement will be met.

- The vertical alignment of the road needs to comply with highways standards. It is noted that the Allbrook Rail Bridge to the west of the Navigation imposes a height restriction which gives rise to a maximum value for the road surface level over the proposed new bridge.

5.0 Considerations applicable to all Options

Whilst different concept options have be identified for the bridge superstructure, there are some parameters that are anticipated to be common to all the structural forms identified in this report as follows:

5.1 Loading

The current bridge does not show a load restriction, and it therefore assumed to have capacity for full 40/44T live loading. For the purposes of this report, it has been assumed that any replacement structure should achieve this same capacity.

5.2 Services

The available drawings show at least one service passing over the bridge. A pipe bridge supporting, a what appeared to be, a water main was noted to the North of the existing bridge, as shown in Photograph 10. The pipe bridge structurally independent of the existing bridge although it shares the bridge abutments.

5.3 Substructure

The alignment of the bridge is not yet confirmed, but it is understood that it will need to be changed to accommodate the new road layout. The existing abutments are not appropriate as the bridge is required to move to the south and accommodate a wider deck. It is therefore assumed that the existing abutments will be partially demolished (with sufficient remaining to accommodate the pipe bridge) to allow new abutments to be built. However, the abutments can therefore be built at the correct angle and for the purposes of this report it is assumed that the superstructure will be square to the abutments.

At this time no investigations have been undertaken to confirm the ground conditions in the area. However, BGS records provide 2 no. bore hole logs within reasonable proximity of the site, and these are provided in Section 8.2.

The bore hole logs suggest that reasonably stiff clay is present some 3.5m below ground level, and this is anticipated to be an adequate foundation layer. It is noted that whilst the site is close to the boundary between several different surface deposits they are all marine deposits. It is also noted that as the watercourse is believed to be man-made it is likely that made ground is present in the surrounding areas.

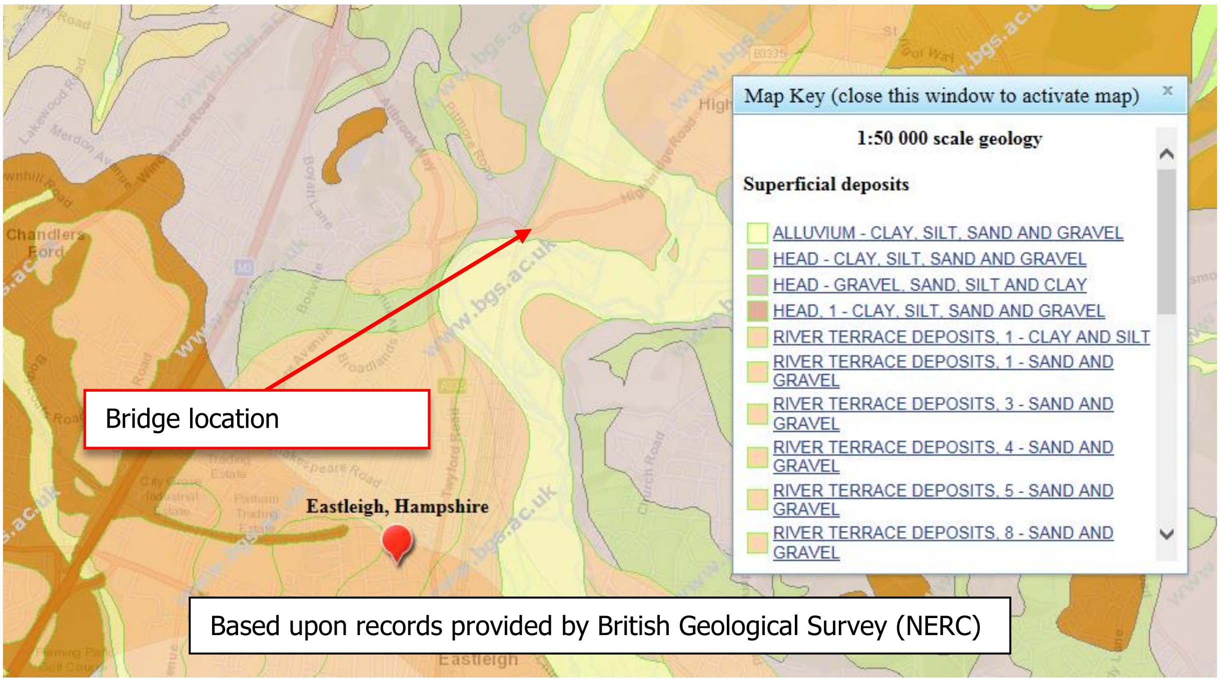

Figure 2: BGS Visible geology

In order to provide definitive advice on the foundation design it would be necessary to undertake detailed borehole testing. However, in our professional opinion a reinforced concrete foundation is potentially feasible but, especially given the potential for scour, it is anticipated that a piled foundation would be preferable. In addition, the arch structures give rise to a lateral thrust at the foundations and as such it is anticipated that piled foundations would be required for both the arch concepts proposed in this report.

5.4 VRS

Structures carrying road traffic over a vertical drop are required to provide a VRS (vehicle restraint system) to prevent vehicles falling in the event of an accident. Masonry parapets, such as those provided to the existing bridge are not typically compliant with modern standards. A masonry parapet could be used, but it would need to contain steel elements to provide additional strength and tie it into the bridge deck to enable it to achieve the required lateral load capacity. Alternative options are available, but the usual approach would be the installation of a metallic "Armco" type barrier. It is also noted that the main girders of the Half Through bridge deck option would provide a physical barrier. However, it is anticipated that a VRS would still be required for this option.

5.5 Construction process

The construction of the new bridge will require motorised plant and access around the sub structures to both sides of the watercourse. We would recommend that in conjunction with the clients' ecologist we would prepare a detailed construction plan to minimise any harm during the construction process. It is also noted that the watercourse edge is currently defined with trench sheets/lightweight sheet piles, as shown in Photograph 8. These would not be able to support construction loads and would need to be replaced as part of the preliminary works.

6.0 Options Study

Bridge design concept Options must allow the realigned road to be carried over the water course. In addition to accommodating the road, the solution identified should deliver:

- the required road alignment both vertically and horizontally;
- an increase in deck width to accommodate a wider carriageway and pedestrian crossing solutions;
- minimised ecological impact of the new structure and ideally improvement against the existing situation. In particular, shadowing under the bridge should be minimised by keeping the bridge superstructure as slender as possible and lifting it up from the water level as far as possible.

The aims from an ecological perspective are to first minimise the adverse effects of the bridge construction and operation, and second to improve the existing condition of the Itchen Navigation in this location. Key design parameters include:

- Minimise shading as a result of the bridge structure – ideally achieving a net decrease in shading through a combination of the new design and removal of existing structure;
- Avoid in-channel structures or footings;
- Avoid creating shear downstream of the new structure and improve structure of substrate through reducing water velocity and shear associated with existing structure;
- Allow access for mammals such as otter, including at peak flows;
- Minimise bankside habitat loss required for footings;
- Avoid or minimise requirement for piling to reduce construction-phase disturbance; and

- Minimise construction-phase effects by positioning supporting structures as far from bankside as possible – also maximising connectivity beneath the structure during operation. It is noted that identifying a solution that is deemed acceptable on the above items is the primary purpose of this report. As the new bridge is required as part of a wider scheme, cost is not the primary consideration. However, the above requirements being achieved, the usual consideration has subsequently been given to identifying a concept that is buildable and economically reasonable.

Illustrative drawings showing each of the proposed options described below are contained within Appendix C.

6.1 Options 1A/1B - Concrete Bridge Deck - Similar to the Existing

The existing reinforced concrete superstructure is technically straightforward and a like-for-like replacement is therefore technically feasible.

The replacement structure could be reinforced with either steel bars, or beams encased in concrete.

The analysis undertaken indicates that the overall deck thickness would be some 600mm. It is anticipated that the superstructure would be installed as eight similar main units and two parapet units with a maximum mass of the order of 16.5T. The precast units would typically be secured together with post-tensioned tendons. The parapet units would be adequate for a VRS so a steel Armco type barrier would not be required.

An exercise has been undertaken to provide estimated tonnages for this form of construction, and the results are shown in Figure 3.

Option 1A comprises an option utilising a concrete superstructure but with a horizontal alignment. Option 1B has a sloped deck elevation to facilitate an increased sub-deck void area (i.e. the area between the underside of the deck and the 1:100 year flood level) and is therefore the preferred option of the two.

6.2 Option 2 - Arch Bridge

The maximum span required would be readily achievable with an arch structure and Options 2 and 3 were reviewed as the profile of an arch would (subject to the required road alignment and flood level constraints) potentially assist with the aim of maximising the level difference between the water and the underside of the bridge and result in more ecological benefit compared to other Options.

Whilst the arch could be built as a traditional brickwork arch, this process is not regularly undertaken for highway bridges. However, a pre-cast concrete arch, installed as either a rigid unit or delivered to site as a flat "mat" and shaped during installation, could be adopted. The method used to secure the VRS to the arch structure would be confirmed during detailed design, but it is anticipated that this would be achieved by either by a concrete unit or a steel Armco type barrier.

The typical rise on a 9m arch would be some 2.25m and the preliminary calculations undertaken to inform this report indicate that the total deck height (the combined thickness of the concrete arch barrel and the compacted fill above) would be some 700mm as per Figure 8.

It is noted that whilst tonnages have been provided for a concrete arch in Figure 3 it is anticipated that a specialist supplier/installer will need to be consulted to assist with any pricing exercise.

Unfortunately, when the construction parameters for an arch as highlighted above were applied to the road alignment and 1:100-year flood level constraints, it was evident that an arch would not be feasible in this case due to a combination of the flood level being too high and the bridge depth being too deep to adequately accommodate the structure – see Appendix C.

6.3 <u>Option 3</u> - Arch Bridge - Increased Span

In addition to an arch bridge of circa 9m span, an increased span bridge of circa 12m was also reviewed. This potentially could have allowed the current Itchen Way tow path that crosses over the road to pass underneath the bridge superstructure.

The commentary on the construction of an arch set out in Section 6.2 above would apply equally to the longer span arch. The rise on a 12m arch as shown in Figure 10 would be some 3m and the preliminary calculations undertaken to inform this report indicate that the total deck height (the combined thickness of the concrete arch barrel and the compacted fill above) would be some 850mm.

It is noted that whilst tonnages have been provided for a concrete arch in Figure 3 it is anticipated that a specialist supplier/installer will need to be consulted to assist with any pricing exercise.

Unfortunately, when the construction parameters for an arch as highlighted above were applied to the road alignment and 1:100-year flood level constraints, it was evident that an arch would not be feasible in this case due to a combination of the flood level being too high and the bridge depth being too deep to adequately accommodate the structure – see Appendix C.

6.4 <u>Options 4A/4B</u> - Open Truss Bridge deck

An open truss deck may be beneficial from an environmental perspective as it would minimise shadowing, as per sketch Figure 12. However, the truss beams would need to be deeper than a solid beam, and it is therefore anticipated that the overall construction depth of the deck would be increased. In addition, in times of high water flow, water-borne debris can accumulate on/around the bottom flange of a truss bridge. The beam can also be vulnerable to damage from lateral loads, which can be imposed by larger debris items. The superstructure would need to be lifted sufficiently above the water levels to prevent this, but the preliminary design work undertaken demonstrates this can be achieved.

For the purposes of this report it has been assumed that the superstructure will be supported off eight primary truss elements. It is noted that this number of trusses reduces the overall depth of the bridge superstructure and avoids the need for cross girders.

A VRS would need to be provided and it has been assumed that this would be achieved by providing a steel Armco type barrier.

An exercise has been undertaken to provide estimated tonnages for this form of construction and the results are shown in Figure 3.The analysis undertaken to estimate the material quantities did not allow for composite action but was assumed that the deck provides lateral stability to the main girders.

Option 4A comprises an option utilising an open truss bridge deck but with a horizontal alignment. Option 4B has a sloped deck elevation to facilitate an increased sub-deck void area (i.e. the area between the underside of the deck and the 1:100 year flood level) and is therefore the preferred option of the two.

6.5 Options 5A/5B - Half-Through Bridge Deck

A half through bridge minimises the deck thickness by positioning the road within the two primary girders. To minimise the shadowing on the water truss, girders could be used for the longitudinal main beams. The lower portion of the truss would be in-filled with mesh and support hand rails to allow them to act as the pedestrian handrail/restraint.

However, the primary girders would not resist the loads from a vehicle impact, so an independent VRS would be required. For the purposes of this report it has been assumed that this would be a steel Armco type barrier.

A half through bridge structure would require the deck to be supported by structural elements spanning between the main girders as shown in Figure 15. There are several deck solutions that could be used, but for the purposes of this report it has been assumed that the primary truss girders will support a series of cross girders at 1.5m c/c spacings and a 150mm thick concrete deck.

Option 5A comprises an option utilising a half through bridge deck superstructure but with a horizontal alignment. Option 5B has a sloped deck elevation to facilitate an increased sub-deck void area (i.e. the area between the underside of the deck and the 1:100 year flood level) and is therefore the preferred option of the two.

6.6 Material Estimate Data

Preliminary calculations based on experience of other similar bridges have been undertaken to provide quantities for the primary structural elements of the bridge superstructures to facilitate an initial costing exercise. It should be noted that as the information available is limited, it has been necessary to make assumptions and exercise engineering judgement to complete this process.

Should the process continue to a formal design stage the calculations will need to be undertaken in accordance with the related Design Standards, primarily the Design Manual for Roads and Bridges (DMRB).

The results of the preliminary calculations undertaken to enable an initial costing to be undertaken by a Quantity Surveyor are summarised in Figure 3 below and the breakdown for each proposal is provided in Figure 3 below.

	Foundation	Concrete / arch barrel Conc. /T	Fill Fill /T	Reinforcing Rebar /T	Primary Steel Steel /T	Cross girders + ancillary Steel /T	VRS needed
Precast concrete	Piles recommended	138	66	15	-	-	no
9m span arch	Piles required	90	66	-	-	-	yes
12m span arch	Piles required	150	106	-	-	-	yes
Steel beam deck	Piles recommended	30	66	1.5	12	2	yes
Half through	Piles recommended	30	66	1.5	14	4	yes

Figure 3: Summary of Primary Structural Quantities

7.0 Conclusions

Five concepts have been outlined in this report for consideration:

Option 1 – Concrete Bridge – similar to existing
Option 2 – Arch Bridge
Option 3 – Arch Bridge – increased span
Option 4 – Open Truss Bridge Deck
Option 5 – Half Through Bridge Deck

Of these, Options 1, 4 and 5 are technically feasible from a structural engineering perspective, when considered against the constraints set by the road alignment parameters and the 1:100 year flood level.

The overall deck construction depth for the bridge deck options are similar across all the options so there is little to choose between these regarding the size of the opening beneath the bridge.

It is apparent that of the options reviewed, it is the concrete option (Option 1 - specifically, Option 1B which utilises a sloped deck) will provide the optimum void area beneath the bridge whilst also being feasible within the parameters set by the road and flood levels.

A reinforced concrete superstructure with use of handrails provides some benefit in terms of the ecological impact of the structure compared to the existing by facilitating light passage through the area where the brick-built parapet on the existing bridge currently blocks light. The bridge span will also be wider allowing more light beneath and will also facilitate other ecological benefits to be achieved.

As the project progresses, detailed designs and confirmed proposals for the scheme will be developed and evolved in greater detail.

8.0 Appendices

8.1 Appendix A - Photographs

Photograph 1 Looking west over the top of the bridge

Photograph 2 Looking south east over the top of the bridge

Photograph 3 Looking north over the top of the bridge

Photograph 4 Looking west over the river to the north of the bridge – view towards the bridge obscured by vegetation

Photograph 5 View of the South elevation of the bridge

Photograph 6 Cracking/separation of the South West parapet, assumed due to vehicle impact

Photograph 7 View of the concrete extension to the South West wing wall looking along the approximate line of the proposed new structure.

Photograph 8 Trench sheets / lightweight sheet piles forming the edge of the tow path to the south of the bridge

Photograph 9 Brickwork abutment at the North west corner of the bridge

Photograph 10 Pipe bridge to the North of the existing bridge

8.2 Appendix B – Bore hole logs

4611 5786 SU 42 SE/39

RECORD OF BOREHOLE No: 10/7

HAMPSHIRE RESERVOIRS,

Location : SITE 10

SHEET 1 OF 2

Contract No. : CF 669/1529

Type of Boring : Shell & Auger

Date (started) : 15-6-76

Borehole Dia : 200mm. & 150mm.

Casing : 200mm. to 4.70m.

Ground Level : 14.50m. O.D.

Date & Time	Depth of Casing	Water Level	Samples Depth	Samples Type	Samples No.	Strata Depth	Strata Thickness	Description of Strata
15.5-76						G. L.		
			0.40m.	D	1	0.40m.	0.40m	TOPSOIL.
			0.75m.	D	2	0.75m.	0.35m	Soft light grey brown clayey SILT.
			0.85m.-1.30m	U	3			
Water	Inflow	Test						
10 30 / 11 00	1.50m.	1.50m. / 0.80m.						
			2.00m.	U*, D	4	2.00m.	1.25m.	Grey fine sandy clayey SILT with m. f. gravel.
			2.50m.	B / W	5 / 6	2.50m.	0.50m	Soft to firm grey silty organic CLAY with fine gravel.
12 30 / 13 00	3.50m	2.10m. / 1.80m.	3.50m.	U*, D	7	3.50m.	1.00m	Medium dense c.m.f. flint GRAVEL.
			3.95m.-4.40m.	U	8			
			4.40m / 4.50m.-4.95m.	D / U	9 / 10			
			4.95m. / 5.00m.-5.45m.	D / U	11 / 12	5.00m.	1.50m.	Stiff grey silty CLAY with sand and gravel.
			5.50m.-5.95m.	U	13			
			5.95m.	D	14			
16.6.76			6.40m.-6.85m.	U	15			
Water	Inflow	Test at 8.55m.						
15 30 / 15 32 / 15 34 / 15 36 / 15 38 / 15 40 / 15 45 / 15 50 / 15 55 / 16 00	4.70m.	8.22m. / 8.20m. / 8.17m. / 8.14m. / 8.11m / 8.07m. / 7.95m. / 7.90m. / 7.84m. / 7.81m.	6.85m. / 7.00m.-7.45m.	D / U	16 / 17			
			7.45m. / 7.60m.-8.05m.	D / U	18 / 19		6.50m	Stiff grey fissured silty CLAY.
			8.05m. / 8.10m.-8.55m.	D / U	20 / 21			
18 00	4.70m.	6.70m	8.55m.	D	22			
17.6.76 / 08 00	4.70m.	4.40m.						
			9.00m.-9.45m.	U	23			
			9.45m. / 9.60m.-10.05m.	D / U	24 / 25	(10.00m.)		
						Cont'd		

REMARKS: Water encountered at 1.50m.. Water added to assist boring.

SCALE 1 : 50

Foundation Engineering Ltd.

Based upon records provided by British Geological Survey (NERC)

[4624 2127] SU 42 SE/32

RECORD OF BOREHOLE No: 9/5

Location : HAMPSHIRE RESERVOIRS, SITE 9

SHEET 1 OF 1

Contract No. : CF669/1529

Borehole Dia : 200mm.

Type of Boring : Shell & Auger

Casing : 200mm. to 5.00m.

Date (started) : 23-6-76

Ground Level : 19.25m. O.D.

Date & Time	Depth of Casing	Water Level	Samples: Depth	Type	No.	Strata: Depth	Thickness	Description of Strata
23.6.76						G.L. 0.10m.	0.10m.	TOPSOIL.
			0.30m.	D	1			
			1.00m.	D	2		1.60m.	Sandy c. m. f. GRAVEL.
			1.40m.	B	3			
			1.70m.	D	4	1.70m.		
			2.30m.-2.72m.	U	5			
			2.75m.	D	6			
			2.80m.-3.21m.	U	7		2.70m.	Stiff grey brown fissured silty CLAY with gravel at top. Becoming more silty at depth.
			3.25m.	D	8			
			3.50m.-3.92m.	U	9			
			3.95m.	D	10			
			4.00m.-4.42m.	U	11			
18:00	3.00m.	4.30m.	4.40m.	D, W	12	4.40m.	0.30m.	Hard CLAYSTONE.
24.6.76 08:00	3.00m.	2.71m.	4.70m.	D	13	4.70m.		
Water Inflow Test			5.00m.-5.41m.	U	14			
No water made after 30 minutes.	4.80m.							
			5.45m.	D	15			
			5.50m.-5.93m.	U	16			
			5.95m.	D	17			
			6.00m.-6.43m.	U	18			
			6.45m.	D	19			
			6.50m.	U*				
			6.95m.	D	20		5.30m.	Stiff grey fissured silty CLAY.
			7.00m.-7.40m.	U	21			
			7.45m.	D	22			
			7.50m.-7.92m.	U	23			
			7.95m.	D	24			
			8.00m.-8.32m.	U	25			
			8.45m.	D	26			
			8.50m.-8.93m.	U	27			
			8.95m.	D	28			
			9.00m.-9.30m.	U	29			
Water Inflow Test @	10.03m.		9.45m.	D	30			
			9.50m.-9.92m.	U	31			
No water made after 30 minutes.	5.00m.		10.00m.	D	32	10.00m. End		

REMARKS: Water added to assist boring through gravel.
Water encountered at 4.40m.

SCALE 1 : 50

Foundation Engineering Ltd.

Based upon records provided by British Geological Survey (NERC)

8.3 Appendix C – Options – Sections and Elevations

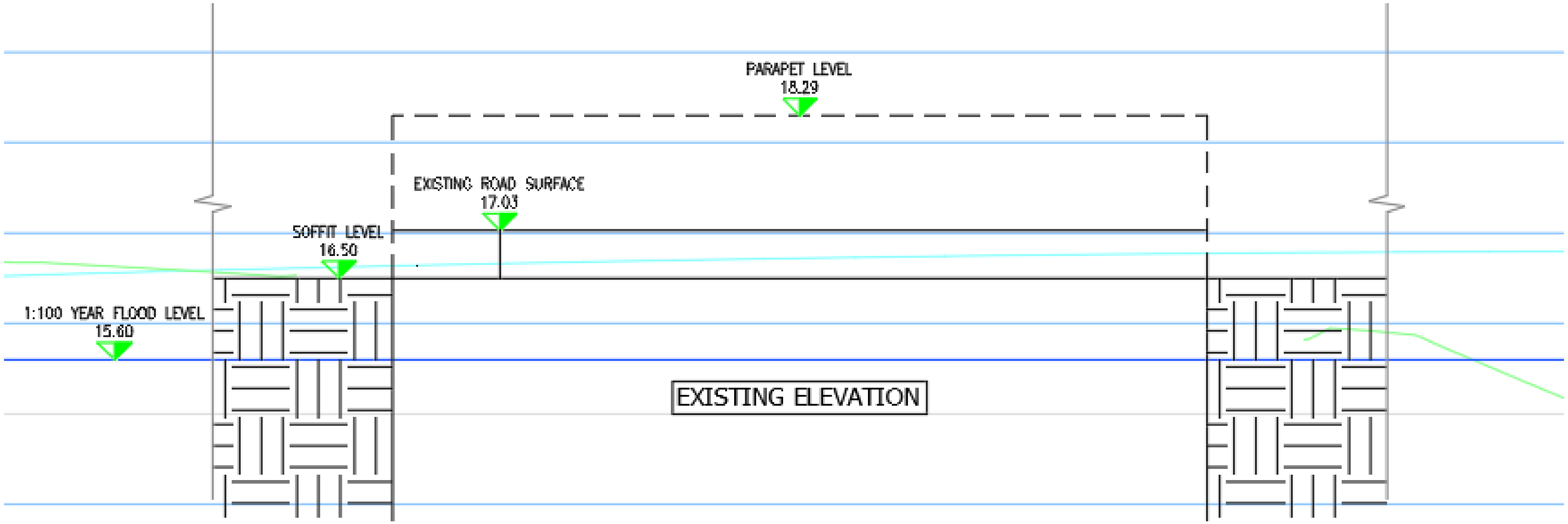

Figure 4: Existing Bridge Elevation

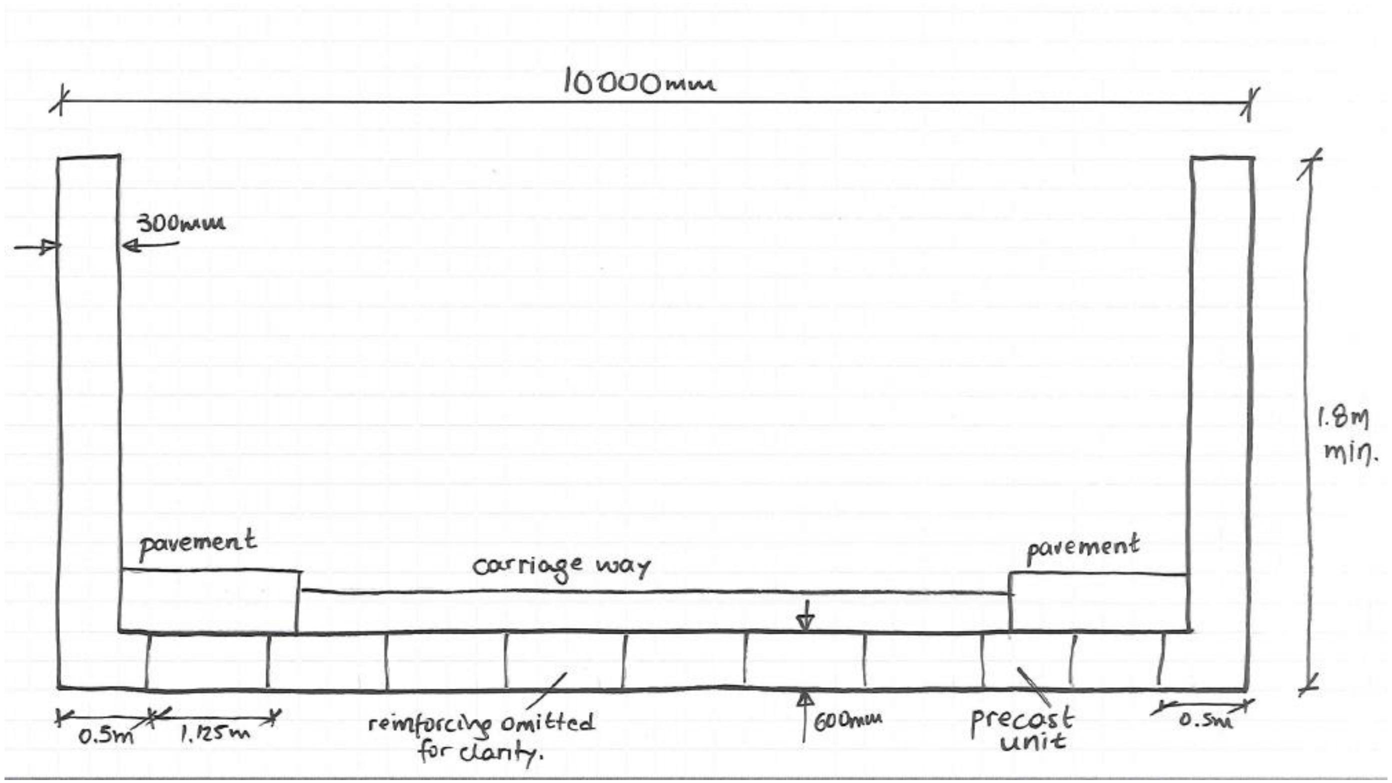

Figure 5: **Option 1** cross section - New bridge similar to the existing sketch

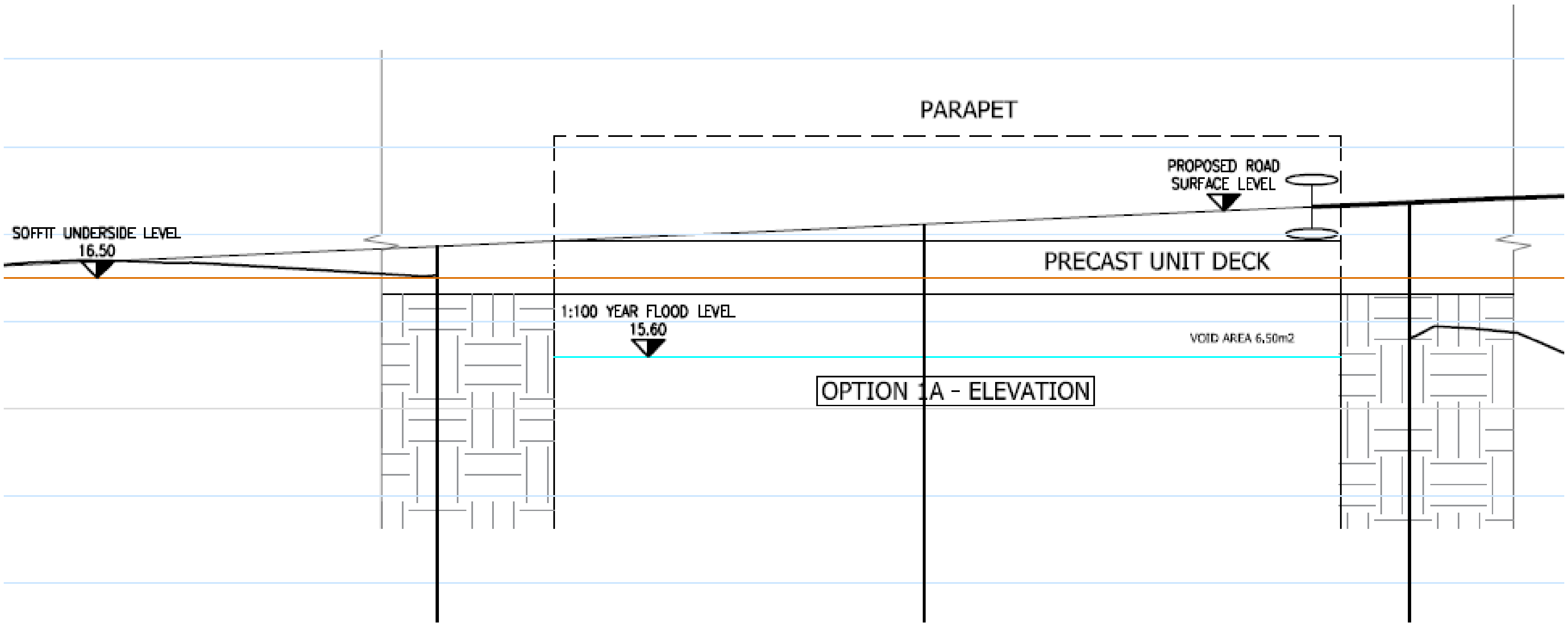

Figure 6a: **Option 1a** elevation - New bridge similar to the existing (horizontal)

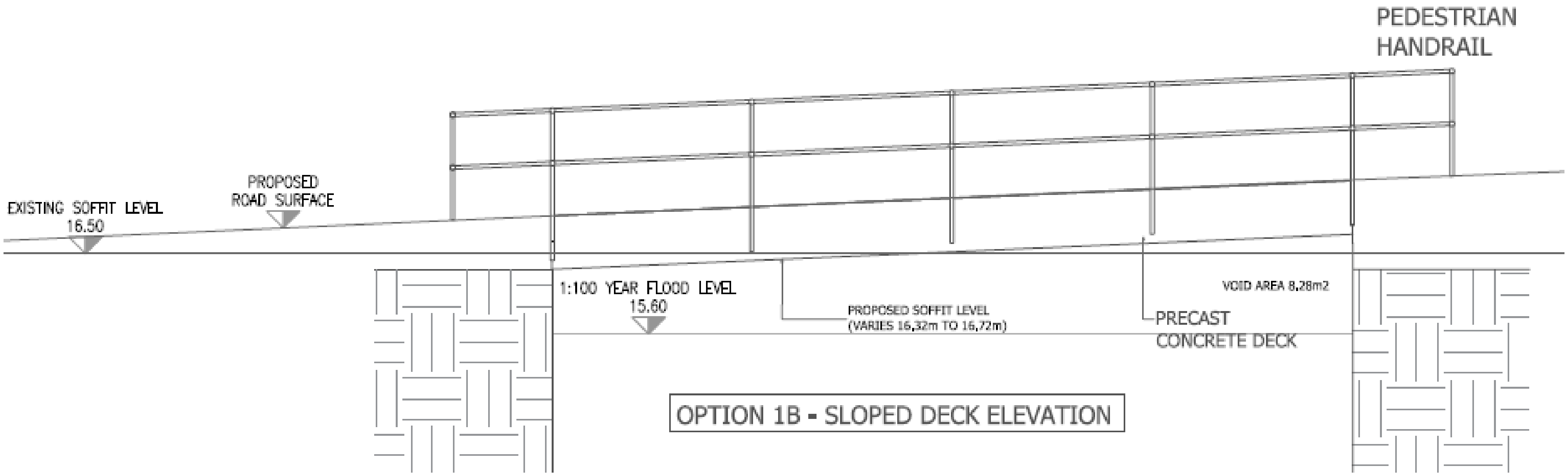

Figure 7b: **Option 1b** elevation - New bridge similar to the existing (sloped deck)

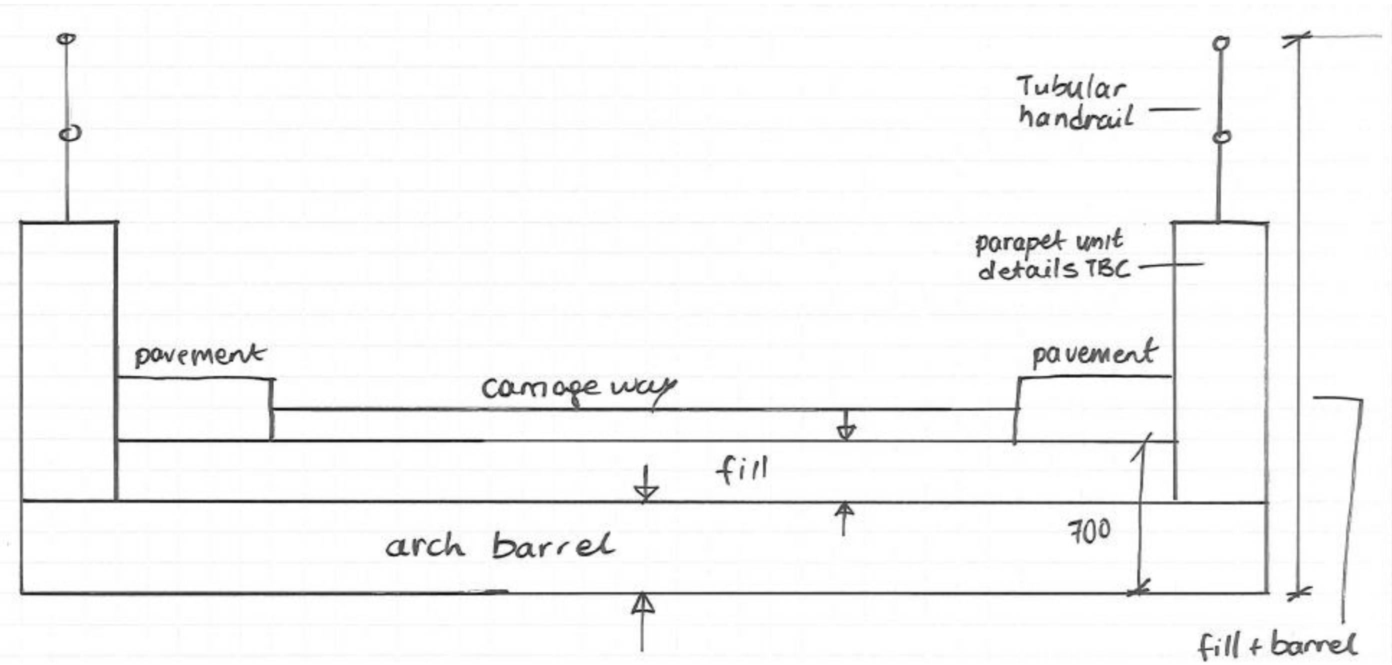

Figure 8: **Option 2** cross section - Arch bridge sketch

Figure 9: **Option 2** elevation - Arch bridge sketch

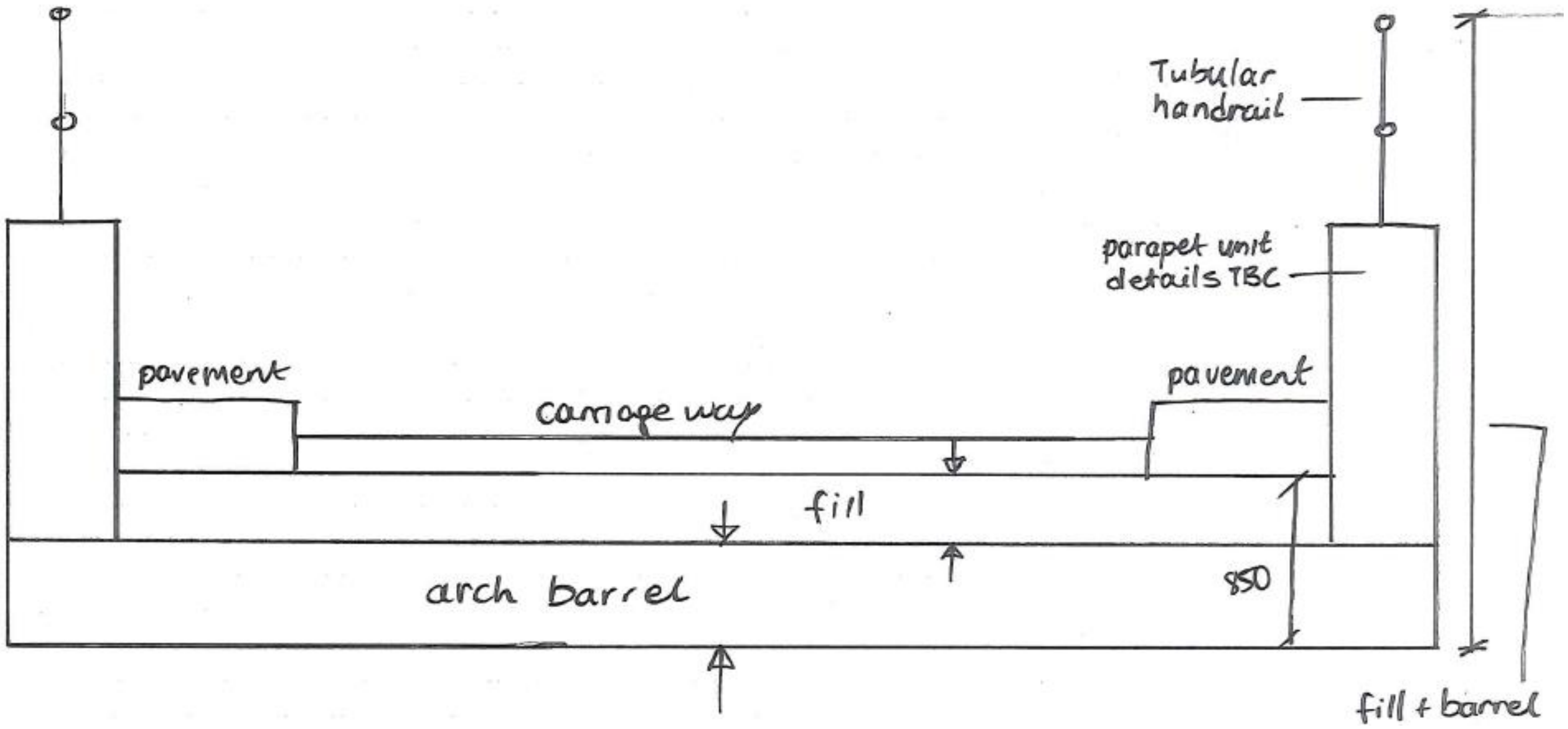

Figure 10: **Option 3** cross section - Arch bridge cross section with increased span sketch

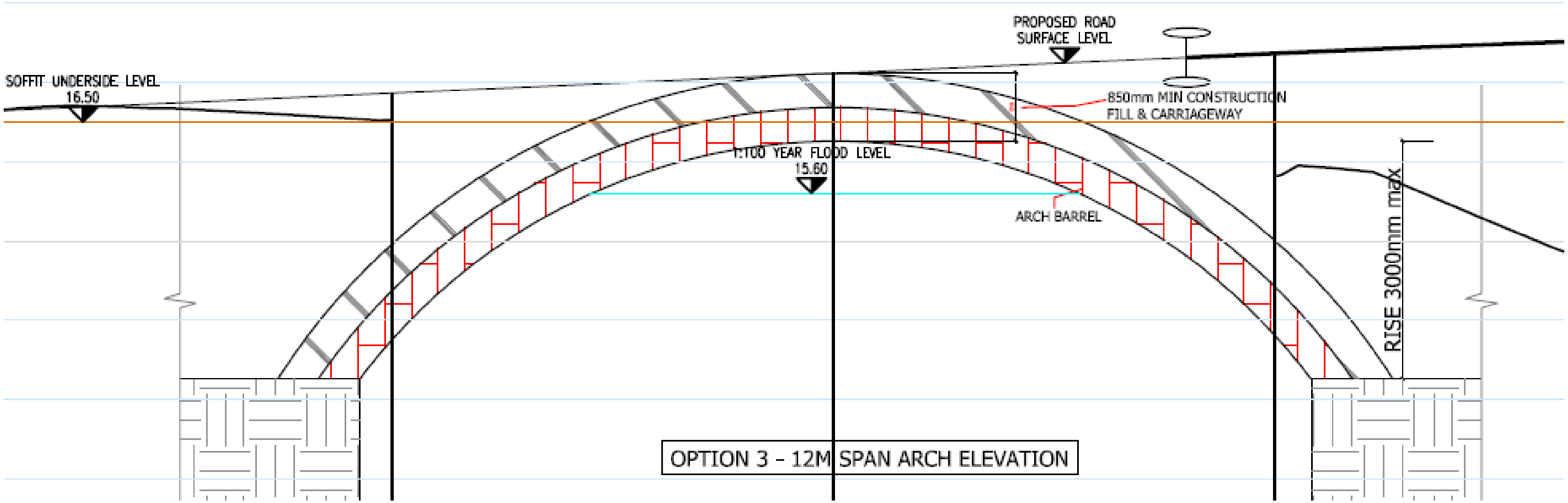

Figure 11: **Option 3** elevation - Arch bridge elevation with increased span sketch

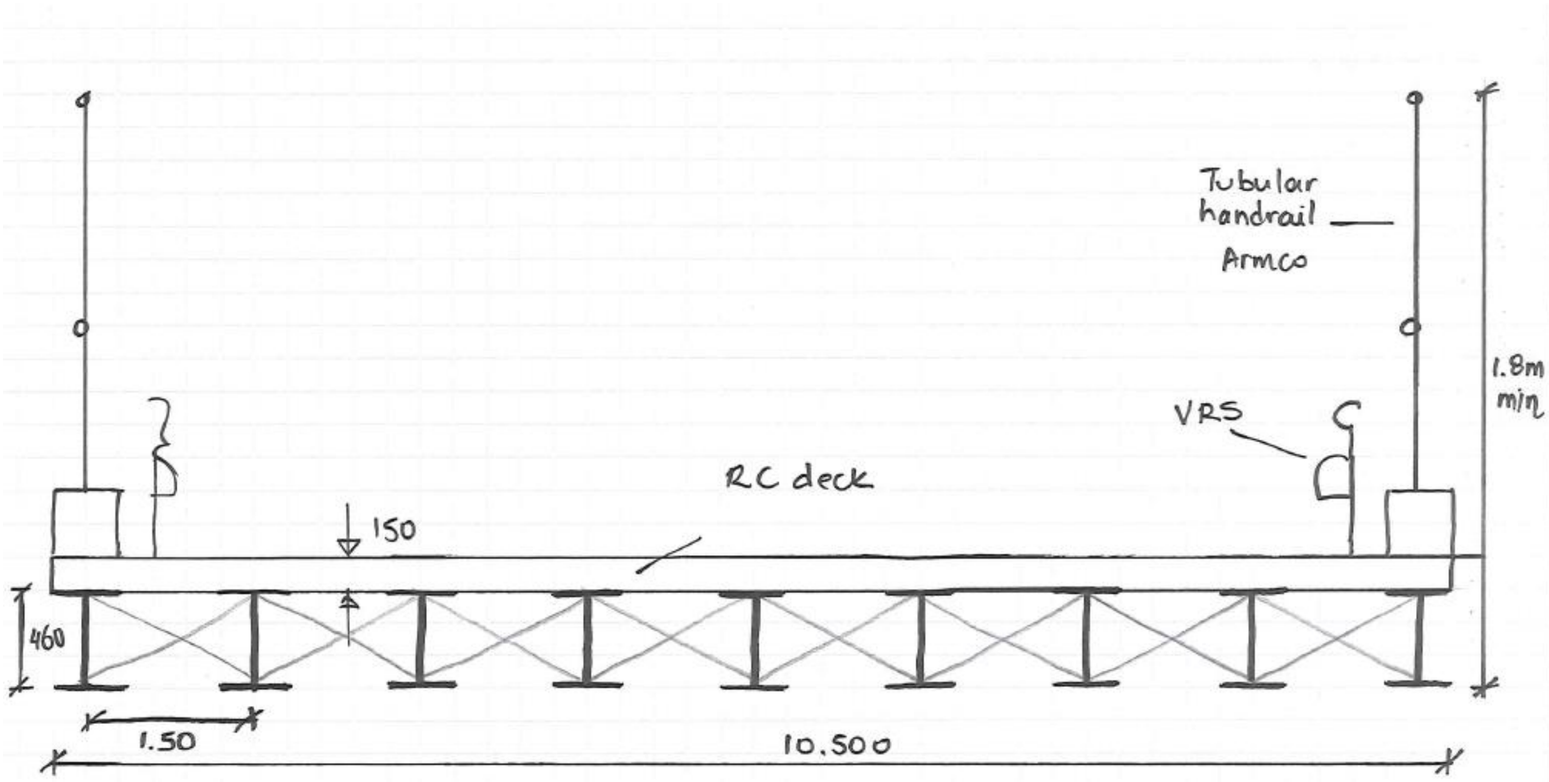

Figure 12: **Option 4** cross section - Open truss bridge deck sketch

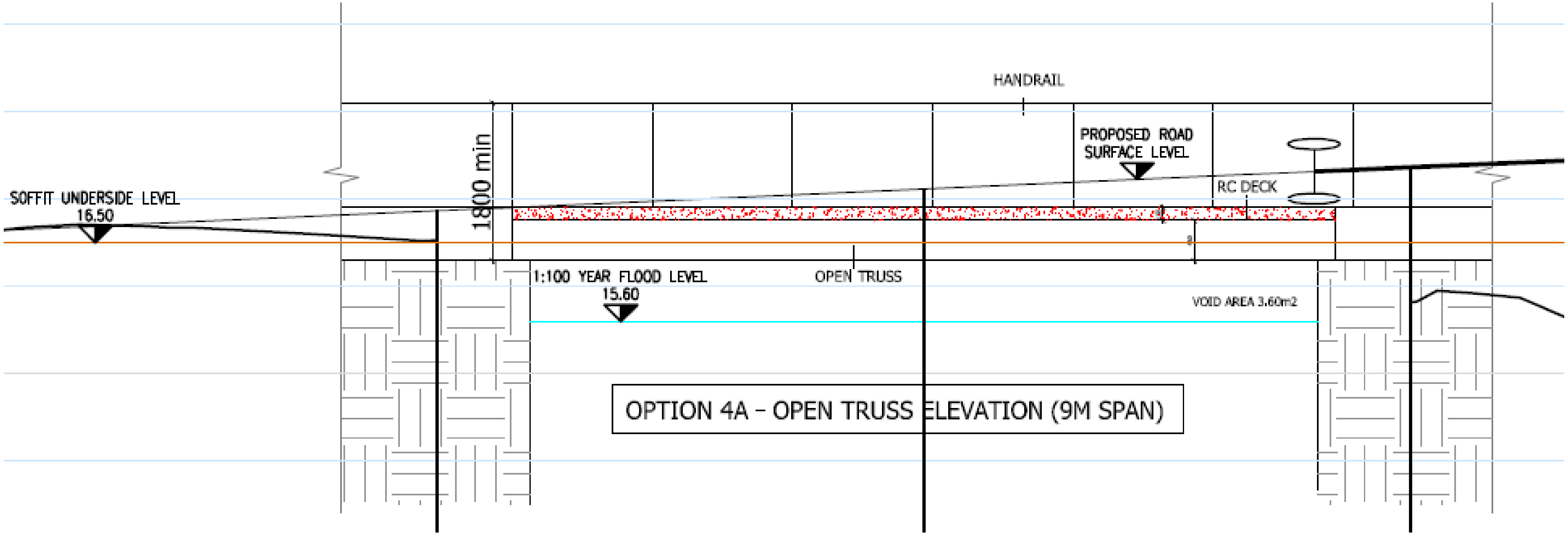

Figure 13a: **Option 4a** elevation - Open truss bridge deck sketch (horizontal)

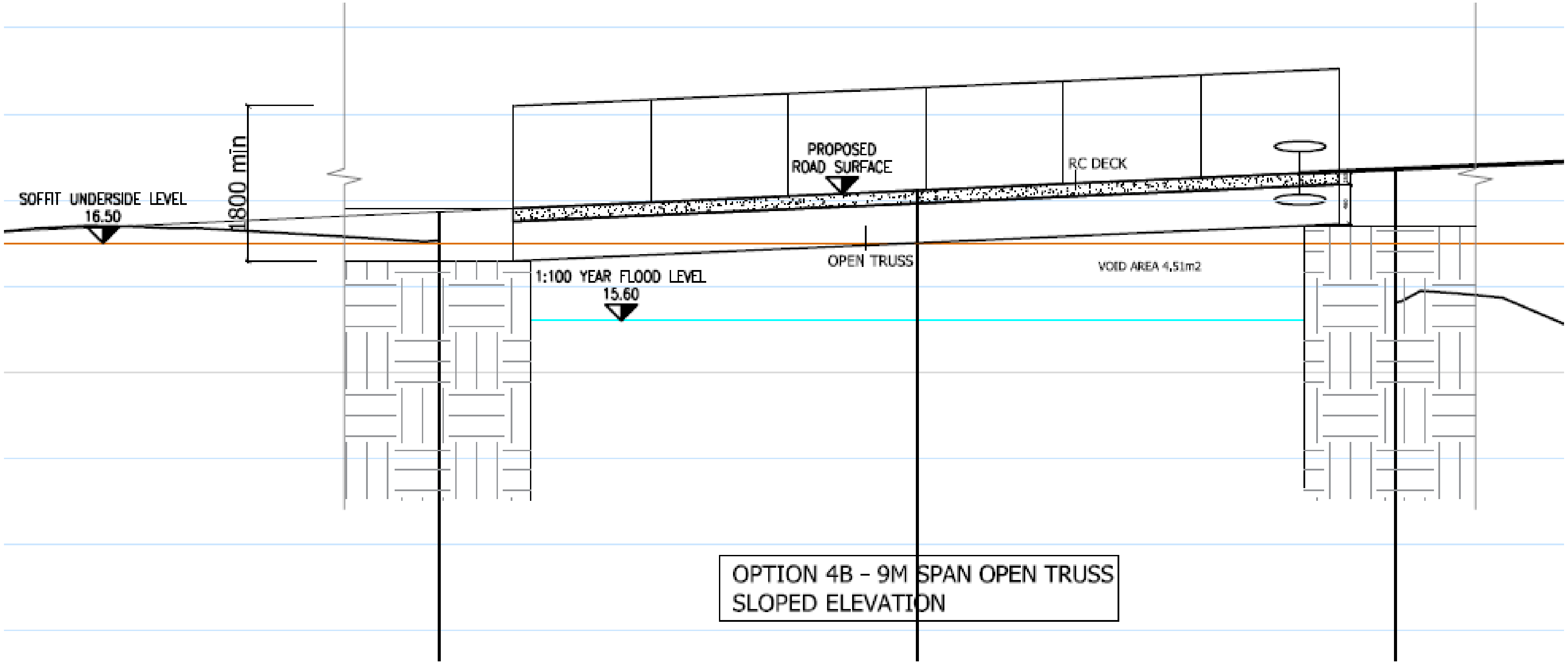

Figure 14b: **Option 4b** elevation - Open truss bridge deck sketch (sloped deck)

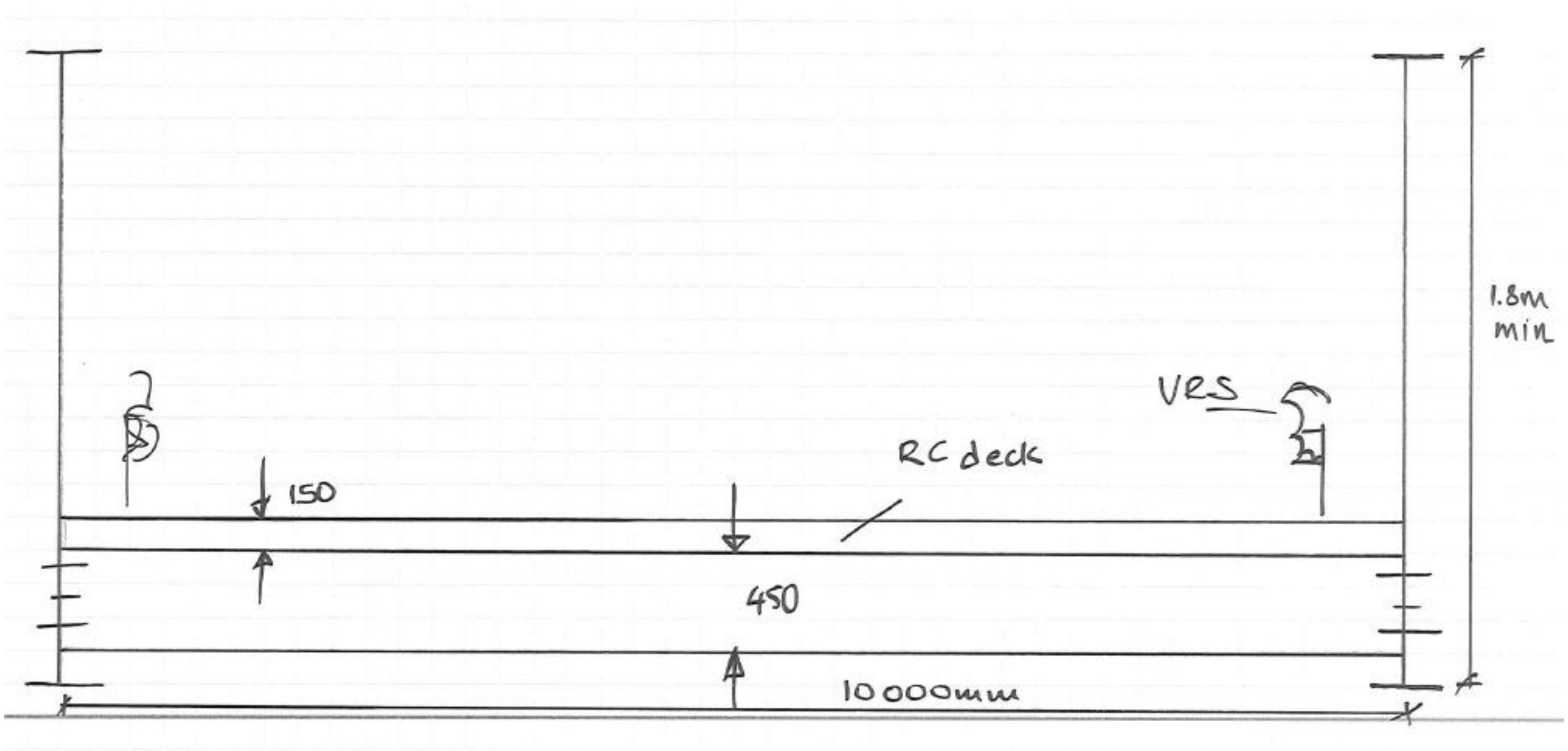

Figure 15: **Option 5** cross section - Half-through bridge deck sketch

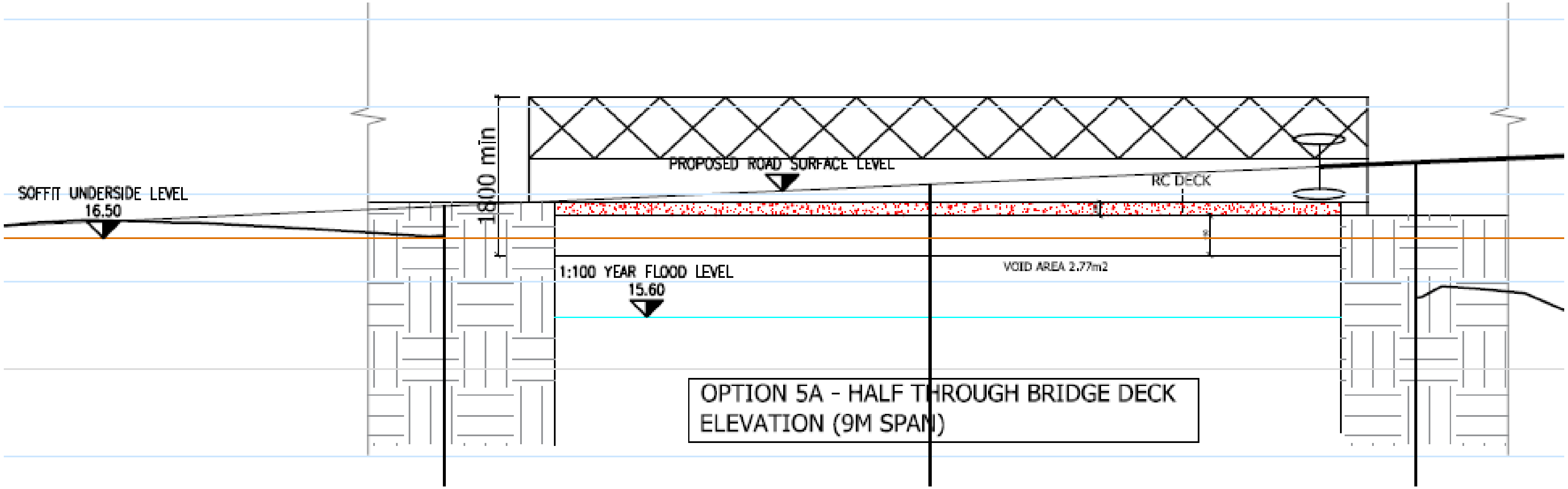

Figure 16a: **Option 5a** elevation - Half-through bridge deck sketch (horizontal)

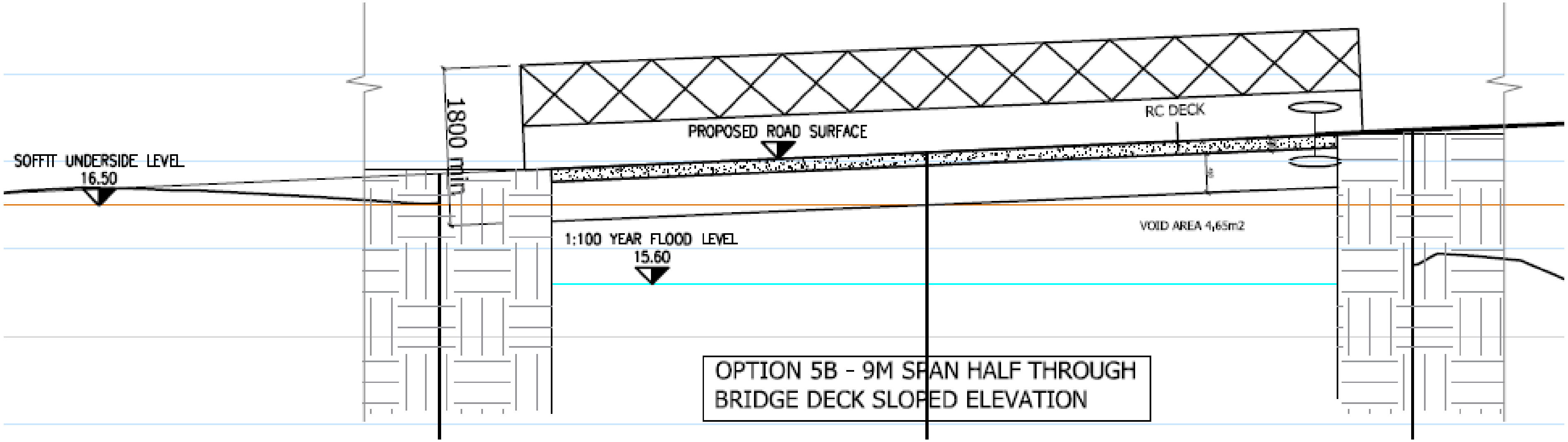

Figure 17b: **Option 5b** elevation - Half-through bridge deck sketch (sloped deck)

8.4 Appendix D – Record drawings

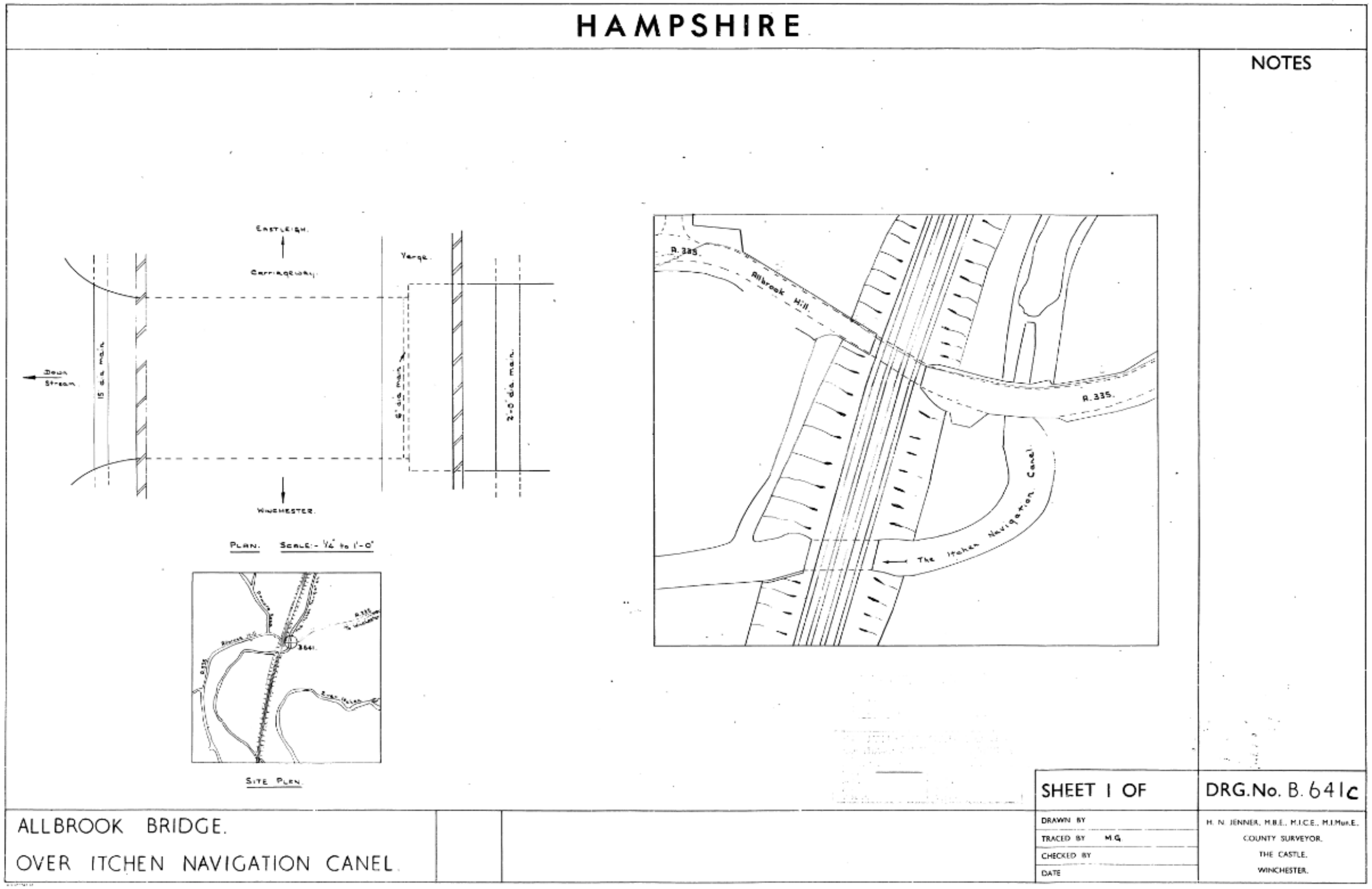

Figure 18: B641 Plan Location Stats drawing – referred to as location plan drawing

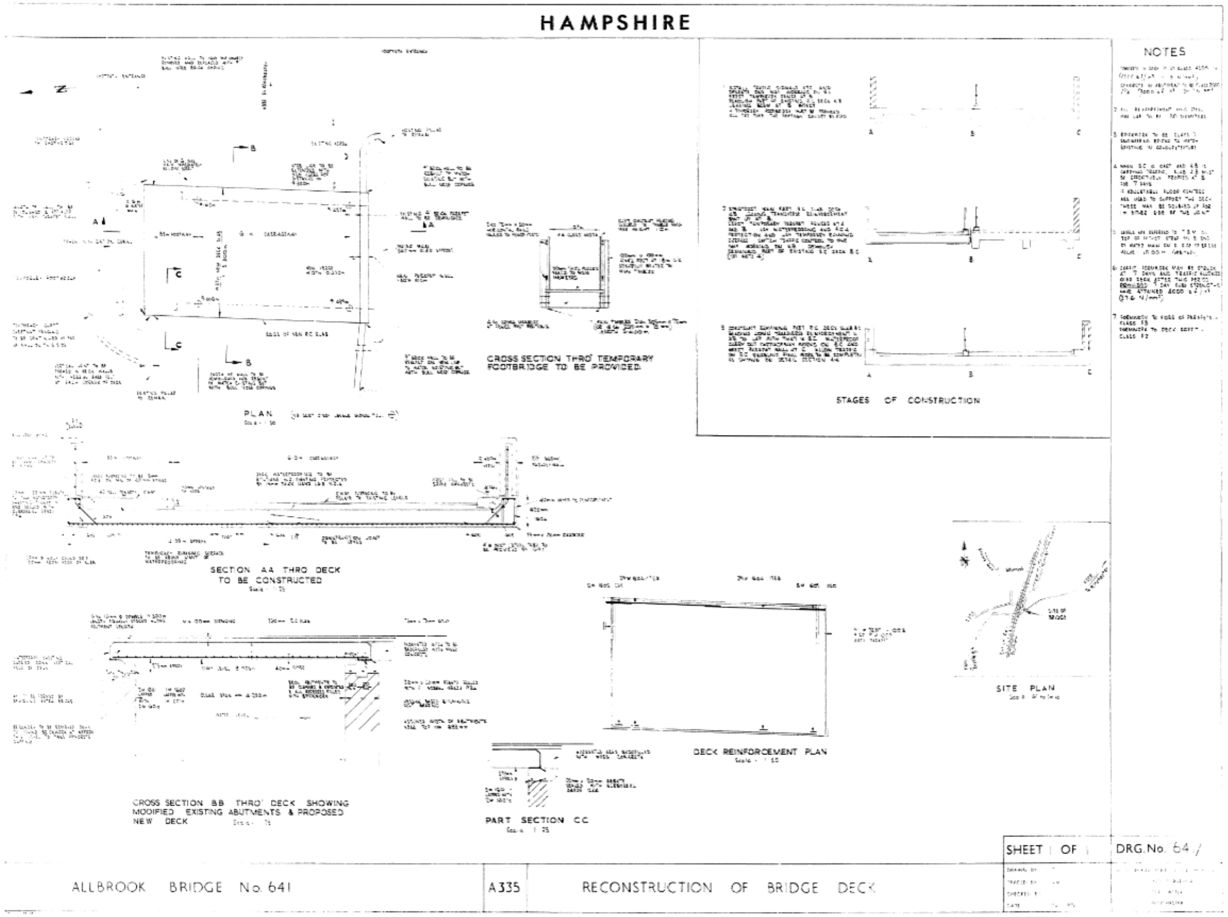

Figure 19: B641 Plan Details original drawing – referred to as general arrangement drawing