Australian Government
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NSW GOVERNMENT
Transport
Roads & Maritime Services

Richmond Bridge and Approaches Congestion Study

Stage 1 summary report | Volume 2

JULY 2012

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RICHMOND BRIDGE AND APPROACHES CONGESTION STUDY

STAGE 1 APPENDIX 1

CONCEPT PROPOSAL FOR THE WIDENING OF RICHMOND BRIDGE

This report was prepared in August 2011 by the Bridge Engineering Section, Engineering Technology Branch, NSW Roads and Maritime Services for

Sydney Infrastructure Development Section, NSW Roads and Maritime Services

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1. INTRODUCTION

NSW Roads and Maritime, Sydney Infrastructure Development Section, is proposing to widen the bridge on Kurrajong Road (Main Road 184) over the Hawkesbury River, 3.14km North West of Richmond.

2. SCOPE OF WORK

Bridge Engineering was requested by Mr Siva Satchi, from Sydney Infrastructure Development Section, to prepare a concept proposal for the widening of Richmond Bridge. This report summarises the investigations in the form of a concept proposal so that a decision can then be made with regard to the preferred bridge option prior to submission of a formal bridge proposal.

Analysis of the existing structure is beyond the scope of this investigation.

3. SURVEY ALIGNMENT AND GRADING

No survey information was provided for the preparation of this proposal. However, drawings of the existing structure show that the bridge is on a straight horizontal and vertical alignment with no grade. The two-way cross fall of the existing bridge deck is 1:48.

4. THE EXISTING BRIDGE

The existing bridge comprises one 15.85 metre, eleven 16.46 metre and one 15.85 metre spans of reinforced concrete arch, constructed in 1906, and widened on the downstream side in 1927 with twin riveted steel girders. The steel girders rest on cast steel rocker bearings, and have a variable cross section depth to match the arched shape of the original structure. The superstructure was further modified in 1966, when a precast reinforced concrete deck slab was placed on the steel girders. The slab on the upstream side of the original bridge was removed to accommodate a footway with large utilities underneath. In 1974, a 762mm diameter water main was also attached to the downstream side of the bridge by means of a bracket system bolted to the pier headstocks.

The existing piers are supported on two lightly reinforced precast concrete tubular piles filled with cast in-place concrete and founded on rock. The upstream pile is connected to the rock with tie rods. There is a very deep cross girder above the piles, integral with the arch superstructure, and tapered vertically. The steel girder widening is supported on a headstock extension, which is doweled to the original pier headstock and supported on a single circular concrete pile. This headstock extension was later strengthened with steel channel sections bolted through the headstock, which were cast into recesses.

The bridge has a carriageway width of 8.53 metres and carries one lane of traffic in each direction, with narrow shoulders. A propped longitudinal deck joint separates the original and widening decks, and is positioned at the road centreline. There are single rail steel pipe traffic barriers on each side. The deck is drained by scuppers in each span at the piers.

5. CONCEPT DESIGN CRITERIA

The objective of this project is to provide facility for additional traffic lanes across the bridge capable of carrying the current SM1600 design loads. Design criteria, derived from the design meetings and discussions between Mr Siva Satchi and Adj Prof Wije Ariyaratne, Mr Salah Assi, Mr Lindsay Brown and Mr Phanta Khamphounvong from Bridge Engineering, and Mr Peter Ellis from Road Design Engineering, are as summarised below:

- The objective is widening of the bridge with a separate structure located on the downstream side of the existing bridge.
- Investigation is to be undertaken of two options for widening: one option for three traffic lanes with a moveable median and traffic contraflow, and another option for four traffic lanes lanes.
- The span length and superstructure shape are to match the existing structure.
- The widening is to be a compatible low maintenance structure capable of carrying SM1600 loads.
- There is to be provision for cyclists on the widened carriageway.
- Relocation of the water main is to be on the downstream side of the existing bridge.
- The widened structure is to be designed for submergence with holding down bolts because the existing deck level is between the two and five year ARI flood levels.
- Traffic lanes are to be arranged to ensure no wheel paths are located at the joint between the existing structure and the new structure.

6. FOUNDATION MATERIALS

No geotechnical investigation has been carried out for the proposed bridge site. However, drawings of the existing structure indicate sandstone at approximately eight metres below the existing ground level, with overlying gravel and sand.

7. SERVICES ON THE BRIDGE

All concept proposals discussed in this report will carry an unplasticised polyvinyl chloride (UPVC) duct in each concrete parapet. The existing water main on the downstream side of the bridge is to be relocated to accommodate the widening.

8. CONCEPT BRIDGE OPTIONS

8.1 The Bridge Substructure

The substructure required for this structure should permit relocation of the water main prior to construction of the superstructure. The supports for the main should ensure that the water main is located above the soffit level of the arch at the crown. The headstock width would therefore be increased to provide support for the main and to permit its relocation.

Based on information shown on the existing bridge drawings, sandstone was encountered at reasonably shallow depths at this site. On this basis, the use of cast-in-situ reinforced concrete piles socketted into sandstone provides significant savings in the construction cost of the substructure and provides ease of construction compared with other types of substructure.

8.2 Superstructure

8.2.1 General

8.2.1.1 Span Length

The optimal span length for a bridge widening is governed by several factors such as:

- The span length of the existing bridge.
- Vertical and horizontal clearances.
- Superstructure type and depth.
- Constructability.
- Aesthetics and costs.

For this site, the span length is influenced by the span lengths of the existing structure, which are approximately 16.480 metres for interior spans and 16.820 metres for the end spans.

8.2.1.2 Superstructure Type

Recent flood information for Richmond Bridge, based on the flood frequencies at Penrith and Windsor indicate that this bridge is submerged for floods with an average recurrence interval of two to five years.

The superstructure required for a crossing of this type should match the shape of the existing bridge superstructure and should be chosen from durable materials to minimise the ongoing maintenance costs due to the frequency of deck submergence. The cross section of the superstructure should be closed without any gap or infill in order to minimise the buoyancy effect on the structure.

A cast-in-situ post tensioned T-girder structure will meet the above criteria. The cross section is solid and will be of variable depth in order to match the curved profile of the existing structure.

8.2.1.3 Traffic Barriers

A Medium Performance Level traffic barrier is considered appropriate for this bridge considering factors such classification of the road, design speed, traffic volumes, approach alignments and height over the river. A truncated type 'F' profile with two steel traffic barrier railings is adequate to provide this level of protection. The height of the barrier will be 1300mm to accommodate the requirements for cyclists.

8.2.2 Widening Options Considered

The possibility of modification of the existing structure and widening on both sides of the structure was investigated at an early stage and not further considered for the following reasons:

- The existing structure will not have the capacity to carry the widening and an independent substructure will be required.
- Strengthening work would be required to the existing deck, which would be expensive.
- Bridge Engineering experience has found that widening on both sides of a bridge is always more expensive than restricting work to one side.
- Relocation of utilities would be required on both the upstream and downstream side of the bridge, and in the approaches.
- The existing bridge is included in RTA heritage list S170.

Since widening on the upstream side of the bridge would also require modification and strengthening as above, it is concluded that widening on the downstream side is the most suitable alternative.

8.3 Concept Options

The widening will be supported by an independent substructure and will be designed for current SM1600 loads. The following bridge options were considered suitable for this site, and warranted detailed investigation for this report:

Option 1 - Cast-in-situ post tensioned triple T girder for four traffic lanes.
Sketch No KD946CS1 (copy attached)

Option 2 - Cast-in-situ post tensioned double T girder for three traffic lanes, with moveable median for traffic contraflow.
Sketch No KD946CS2 (copy attached)

8.3.1 Concept 1 – Post Tensioned Triple T Girders for Four Traffic Lanes.

This option comprises eleven 16.46 metre interior spans and two 16.82 metre end spans of cast-in-situ post tensioned T girders, constructed on the downstream side of the bridge. The girders are to be continuous over the piers, and the cross sectional depth varies to match the circular curved soffit of the existing bridge girders. A longitudinal deck joint will be provided between the widening and the existing bridge. This option has the following advantages and disadvantages:

ADVANTAGES -

- The three girder system can provide four traffic lanes and shoulders wide enough to accommodate cyclists in both directions at minimal additional cost to the three lane option.
- The curved profile of the soffit is considered aesthetically pleasing as it matches the shape of the existing arched structure.
- Location of the piers in line with the existing piers will improve the appearance and eliminate adverse interference with the waterway.
- The cast-in-situ construction method is easier than a precast option in this case, due to the curved shape.
- The initial and ongoing costs for this type of superstructure are lower than the cost of steel materials.
- The longitudinal deck joint will allow for differential movements between the widening and the existing structure, and can be positioned away from wheel paths.
- The cost of maintaining contraflow traffic associated with the three lane option is eliminated.
- The widening is an independent structure designed for SM1600 loading and can be utilised for two lane, two way traffic if the existing aged structure is demolished and replaced in the future.

DISADVANTAGES -

- The initial cost of this option is slightly higher compared to that of the three lane option.

8.3.2 Concept 2 – Post Tensioned Double T Girders for Three Traffic Lanes.

This option comprises a cross section with two cast-in-situ post tensioned girders with monolithic deck slab, constructed on the downstream side of the bridge. The girders are to be continuous over the piers, and the cross sectional depth varies to match the circular curved soffit of the existing bridge girders. A longitudinal deck joint will be provided. This option has the following advantages and disadvantages:

ADVANTAGES -

- The curved profile of the soffit is considered aesthetically pleasing as it matches the shape of the existing arched structure.
- Location of the piers in line with the existing piers will improve the appearance and eliminate adverse interference with the waterway.
- The cast-in-situ construction method is easier than a precast option in this case, due to the curved shape.
- The initial and ongoing costs for this type of superstructure are lower than the cost of steel materials.
- The longitudinal deck joint will allow for differential movements between the widening and the existing structure, and can be positioned away from wheel paths.

DISADVANTAGES -

- There is an ongoing cost of maintaining contraflow traffic.
- Though the widening is an independent structure designed for SM1600 loading, it cannot be utilised to take all road traffic in the event of future replacement of the aging existing structure, as the carriageway has insufficient width.
- The width of the shoulder is reduced to prevent placement a traffic wheel line above the new longitudinal joint.

9. RECOMMENDATIONS

An investigation into the widening of Richmond Bridge has been undertaken.

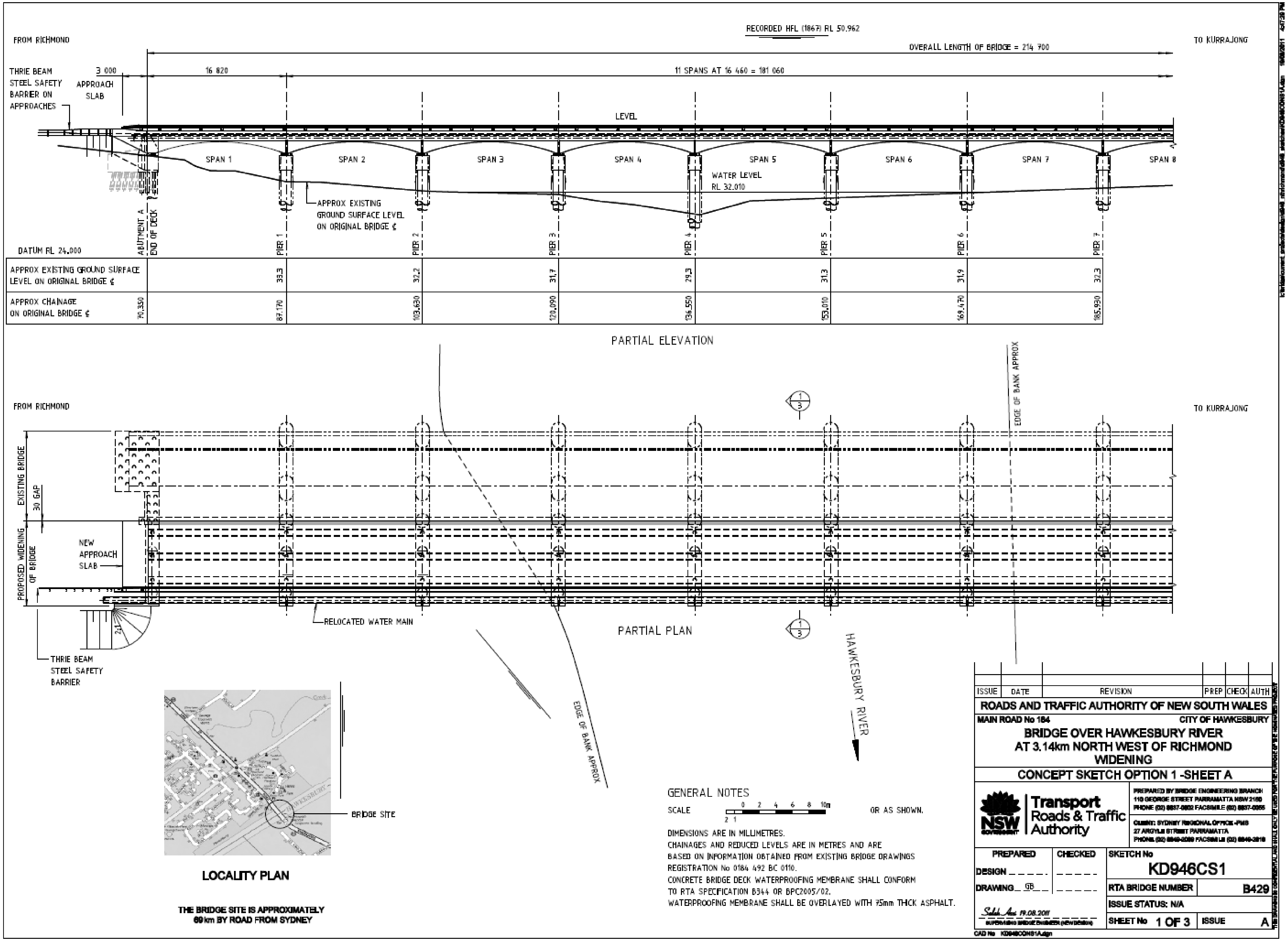
Two possible bridge options were investigated and were considered as meeting the design criteria.

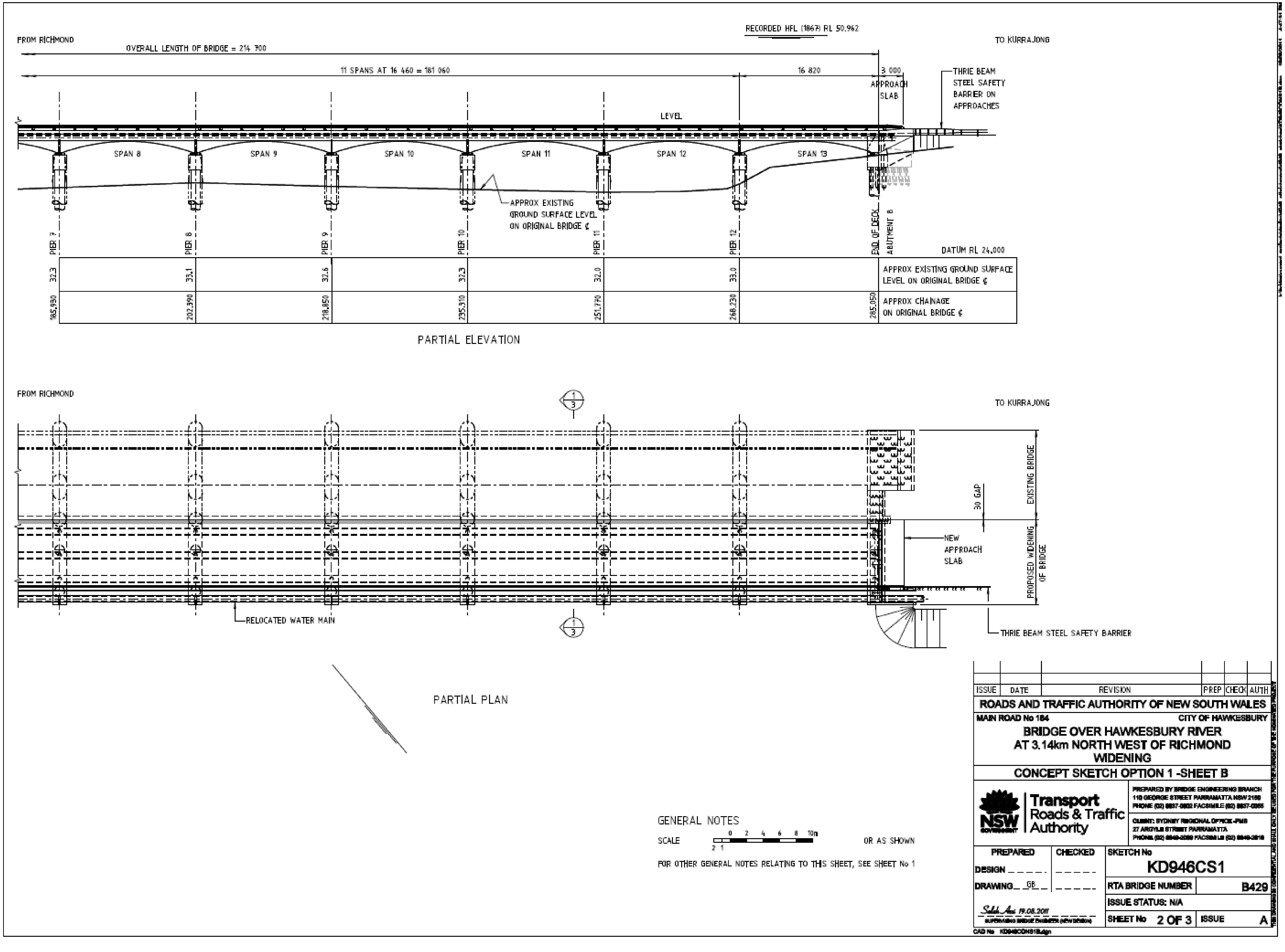
Option 2 of three lanes with provision for contraflow appears to be the least expensive option without consideration of the ongoing cost of managing the contraflow, but provides a significantly inferior functionality to Option 1. The shoulder widths are narrower and the new carriageway would not be able to accommodate two traffic lanes when replacement of the aging existing structure is due. Stage 2 of these investigations will consider the identified issues in detail in finalising the preferred option to reserve a future road corridor.

Lindsay Brown
Project Engineer
Bridge New Design

Salah Assi
Supervising Bridge Engineer,
Bridge New Design

CONCEPT SKETCHES


FROM RICHMOND
RECORDED HFL (1867) RL 50.962
OVERALL LENGTH OF BRIDGE = 214 700
TO KURRAJONG
THRIE BEAM STEEL SAFETY BARRIER ON APPROACHES
3 000
APPROACH SLAB
16 820
11 SPANS AT 16 460 = 181 060
LEVEL
SPAN 1
SPAN 2
SPAN 3
SPAN 4
SPAN 5
SPAN 6
SPAN 7
SPAN 8
WATER LEVEL RL 32.010
APPROX EXISTING GROUND SURFACE LEVEL ON ORIGINAL BRIDGE ℄
DATUM RL 24.000
ABUTMENT A
END OF DECK
PIER 1
PIER 2
PIER 3
PIER 4
PIER 5
PIER 6
PIER 7
APPROX EXISTING GROUND SURFACE LEVEL ON ORIGINAL BRIDGE ℄
33.3
32.2
31.7
29.3
31.3
31.9
32.3
APPROX CHAINAGE ON ORIGINAL BRIDGE ℄
70.350
87.170
103.630
120.090
136.550
153.010
169.470
185.930
PARTIAL ELEVATION
FROM RICHMOND
TO KURRAJONG
EDGE OF BANK APPROX
EXISTING BRIDGE
30 GAP
PROPOSED WIDENING OF BRIDGE
NEW APPROACH SLAB
RELOCATED WATER MAIN
PARTIAL PLAN
HAWKESBURY RIVER
EDGE OF BANK APPROX
THRIE BEAM STEEL SAFETY BARRIER
BRIDGE SITE
LOCALITY PLAN
THE BRIDGE SITE IS APPROXIMATELY 69 km BY ROAD FROM SYDNEY
GENERAL NOTES
SCALE 0 2 4 6 8 10m OR AS SHOWN.
DIMENSIONS ARE IN MILLIMETRES.
CHAINAGES AND REDUCED LEVELS ARE IN METRES AND ARE BASED ON INFORMATION OBTAINED FROM EXISTING BRIDGE DRAWINGS REGISTRATION No 0184 492 BC 0110.
CONCRETE BRIDGE DECK WATERPROOFING MEMBRANE SHALL CONFORM TO RTA SPECIFICATION B344 OR BPC2005/02.
WATERPROOFING MEMBRANE SHALL BE OVERLAYED WITH 75mm THICK ASPHALT.
ISSUE DATE REVISION PREP CHECK AUTH
ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES
MAIN ROAD No 184
CITY OF HAWKESBURY
BRIDGE OVER HAWKESBURY RIVER
AT 3.14km NORTH WEST OF RICHMOND
WIDENING
CONCEPT SKETCH OPTION 1 -SHEET A
Transport Roads & Traffic Authority
PREPARED BY BRIDGE ENGINEERING BRANCH
PREPARED
CHECKED
SKETCH No
KD946CS1
DESIGN
DRAWING GB
RTA BRIDGE NUMBER
B429
ISSUE STATUS: N/A
19.08.2011
SHEET No 1 OF 3
ISSUE A



FROM RICHMOND
RECORDED HFL (1867) RL 50.962
TO KURRAJONG
OVERALL LENGTH OF BRIDGE = 214 700
11 SPANS AT 16 460 = 181 060
16 820
3 000
APPROACH SLAB
THRIE BEAM STEEL SAFETY BARRIER ON APPROACHES
LEVEL
SPAN 8
SPAN 9
SPAN 10
SPAN 11
SPAN 12
SPAN 13
APPROX EXISTING GROUND SURFACE LEVEL ON ORIGINAL BRIDGE ¢
PIER 7
PIER 8
PIER 9
PIER 10
PIER 11
PIER 12
END OF DECK
ABUTMENT B
DATUM RL 24.000
32.3
33.1
32.6
32.3
32.0
33.0
APPROX EXISTING GROUND SURFACE LEVEL ON ORIGINAL BRIDGE ¢
185,930
202,390
218,850
235,310
251,770
268,230
285,050
APPROX CHAINAGE ON ORIGINAL BRIDGE ¢
PARTIAL ELEVATION
FROM RICHMOND
TO KURRAJONG
1 / 3
EXISTING BRIDGE
30 GAP
NEW APPROACH SLAB
PROPOSED WIDENING OF BRIDGE
RELOCATED WATER MAIN
THRIE BEAM STEEL SAFETY BARRIER
PARTIAL PLAN
GENERAL NOTES
SCALE 0 2 4 6 8 10m
OR AS SHOWN
FOR OTHER GENERAL NOTES RELATING TO THIS SHEET, SEE SHEET No 1
ISSUE | DATE | REVISION | PREP | CHECK | AUTH
ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES
MAIN ROAD No 184
CITY OF HAWKESBURY
BRIDGE OVER HAWKESBURY RIVER
AT 3.14km NORTH WEST OF RICHMOND
WIDENING
CONCEPT SKETCH OPTION 1 -SHEET B
NSW GOVERNMENT
Transport
Roads & Traffic Authority
PREPARED BY BRIDGE ENGINEERING BRANCH
PREPARED
CHECKED
SKETCH No
KD946CS1
DESIGN
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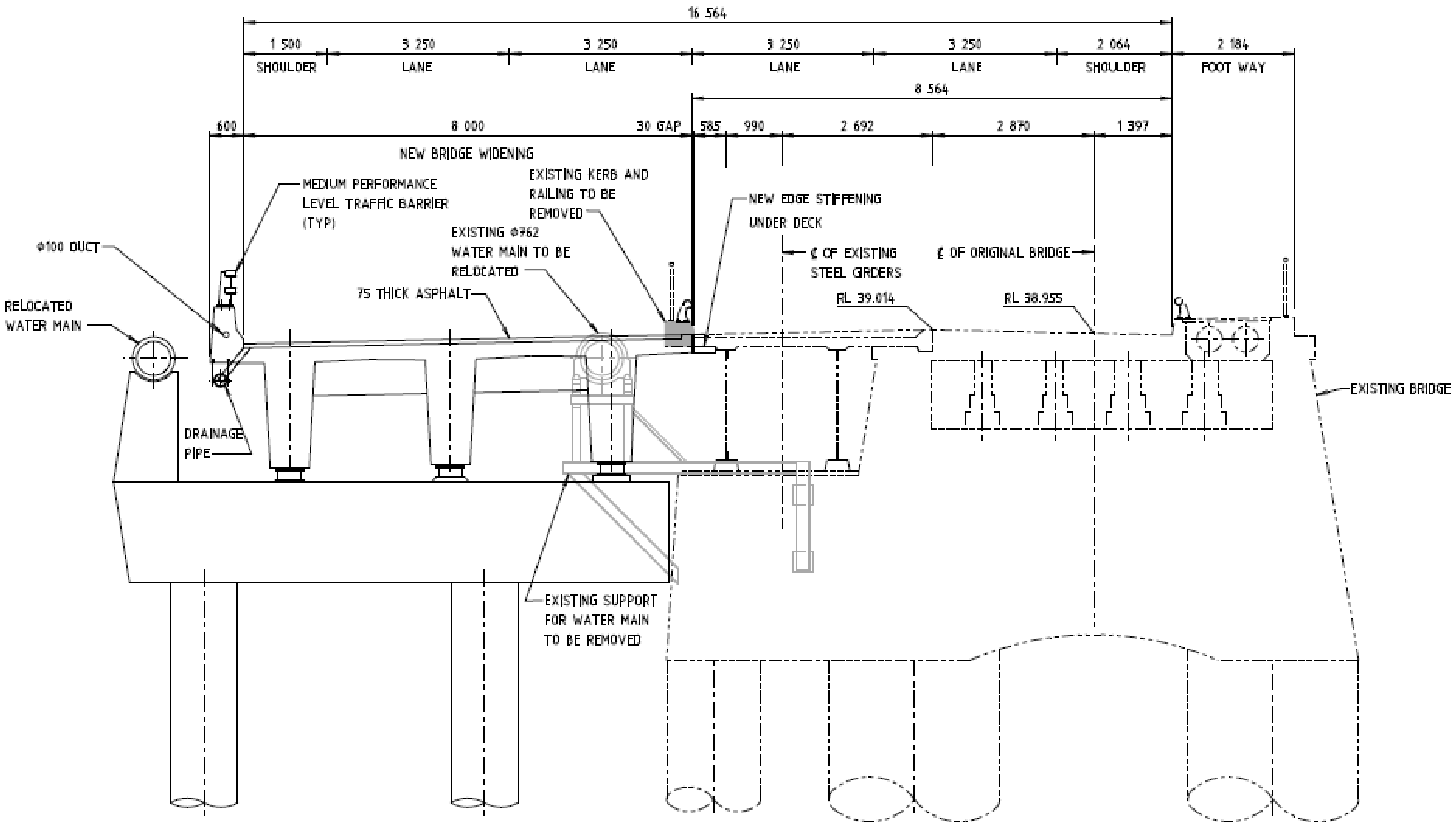
19.08.2011
SHEET No 2 OF 3
ISSUE A



TYPICAL CROSS SECTION AT PIER
4 LANE OPTION

SECTION 1/1,2

GENERAL NOTES

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FOR OTHER GENERAL NOTES RELATING TO THIS SHEET, SEE SHEET No 1

ISSUE	DATE	REVISION	PREP	CHECK	AUTH

ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES

MAIN ROAD No 184 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER
AT 3.14km NORTH WEST OF RICHMOND
WIDENING

CONCEPT SKETCH OPTION 1 - SHEET C

NSW GOVERNMENT | Transport Roads & Traffic Authority

PREPARED BY BRIDGE ENGINEERING BRANCH
110 GEORGE STREET PARRAMATTA NSW 2150
PHONE (02) 8837-0802 FACSIMILE (02) 8837-0055

CLIENT: SYDNEY REGIONAL OFFICE -PMS
27 ARGYLE STREET PARRAMATTA
PHONE (02) 8849-2090 FACSIMILE (02) 8849-2819

PREPARED	CHECKED	SKETCH No
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DRAWING _ GB _	_ _ _ _	RTA BRIDGE NUMBER B429
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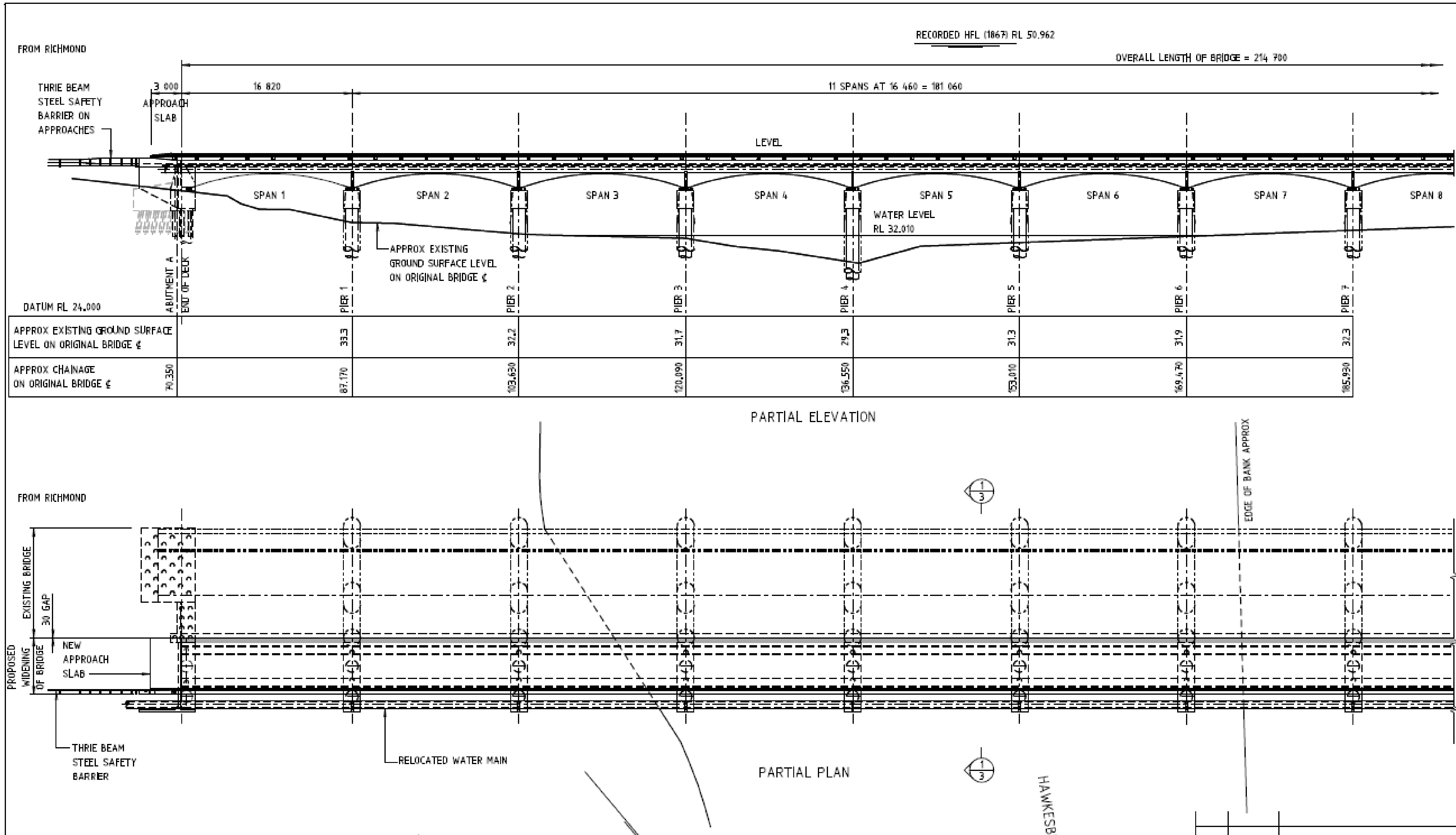
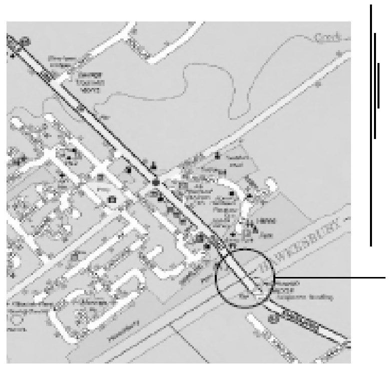


APPROX EXISTING GROUND SURFACE LEVEL ON ORIGINAL BRIDGE ¢		33.3	32.2	31.7	29.3	31.3	31.9	32.3
APPROX CHAINAGE ON ORIGINAL BRIDGE ¢	79.350	87.170	103.630	120.090	136.550	153.010	169.470	185.930



LOCALITY PLAN

THE BRIDGE SITE IS APPROXIMATELY 69 km BY ROAD FROM SYDNEY

GENERAL NOTES

SCALE 0 2 4 6 8 10m OR AS SHOWN.

DIMENSIONS ARE IN MILLIMETRES.
CHAINAGES AND REDUCED LEVELS ARE IN METRES AND ARE BASED ON INFORMATION OBTAINED FROM EXISTING BRIDGE DRAWINGS REGISTRATION No 0184 492 BC 0110
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ISSUE	DATE	REVISION	PREP	CHECK	AUTH

ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES

MAIN ROAD No 184 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT 3.14km NORTH WEST OF RICHMOND WIDENING

CONCEPT SKETCH OPTION 2 -SHEET A

NSW GOVERNMENT | Transport Roads & Traffic Authority

PREPARED BY BRIDGE ENGINEERING BRANCH 110 GEORGE STREET PARRAMATTA NSW 2150 PHONE (02) 8837-0802 FACSIMILE (02) 8837-0055

CLIENT: SYDNEY REGIONAL OFFICE -PMS 27 ARGYLE STREET PARRAMATTA PHONE (02) 8849-2080 FACSIMILE (02) 8849-2818

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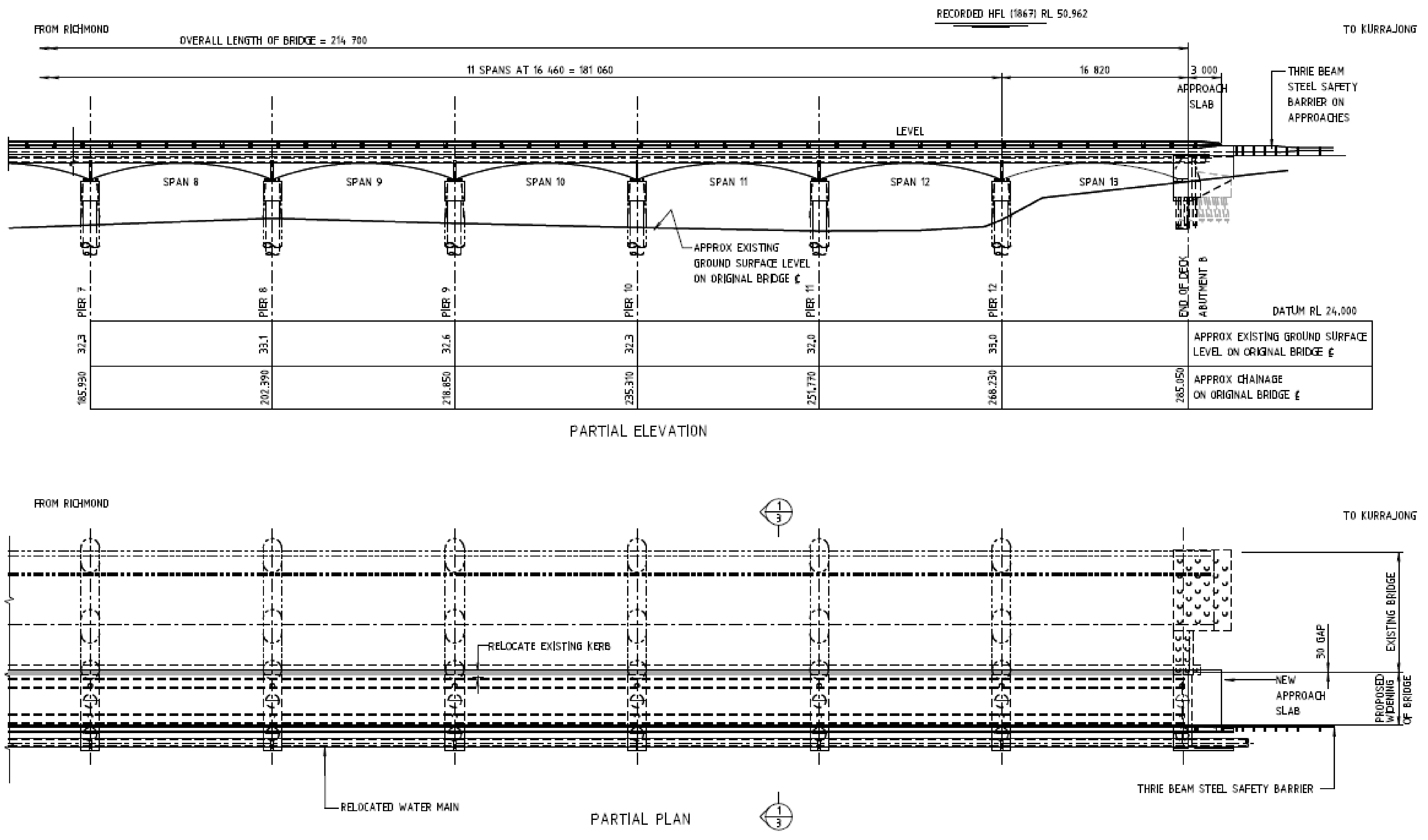
CAD No KD946CONS2A.dgn



GENERAL NOTES

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ISSUE	DATE	REVISION	PREP	CHECK	AUTH

ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES

MAIN ROAD No 184 CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT 3.14km NORTH WEST OF RICHMOND WIDENING

CONCEPT SKETCH OPTION 2 -SHEET B

NSW GOVERNMENT | Transport Roads & Traffic Authority

PREPARED BY BRIDGE ENGINEERING BRANCH
110 GEORGE STREET PARRAMATTA NSW 2150

CLIENT: SYDNEY REGIONAL OFFICE -PMS
27 ARGYLE STREET PARRAMATTA

PREPARED	CHECKED	
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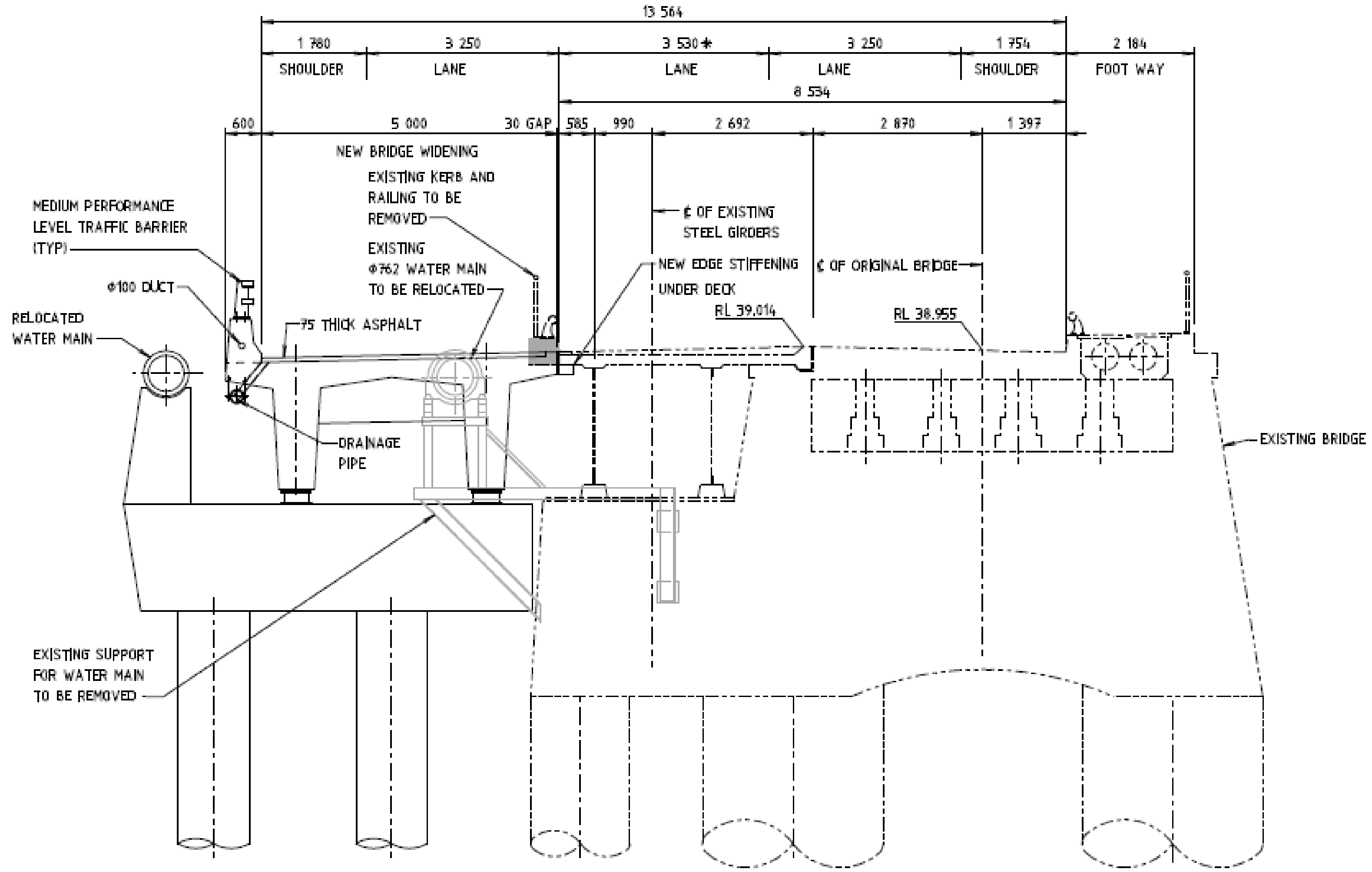

TYPICAL CROSS SECTION AT PIER
3 LANE OPTION

SECTION 1 / 1,2

GENERAL NOTES

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FOR OTHER GENERAL NOTES RELATING TO THIS SHEET, SEE SHEET No 1.
✻ WIDER LANE TO ACCOMMODATE MOVABLE MEDIAN FOR TRAFFIC CONTRAFLOW.

ISSUE	DATE	REVISION	PREP	CHECK	AUTH

ROADS AND TRAFFIC AUTHORITY OF NEW SOUTH WALES

MAIN ROAD No 184 — CITY OF HAWKESBURY

BRIDGE OVER HAWKESBURY RIVER AT 3.14km NORTH WEST OF RICHMOND WIDENING

CONCEPT SKETCH OPTION 2 - SHEET C

NSW GOVERNMENT | Transport Roads & Traffic Authority

PREPARED BY BRIDGE ENGINEERING BRANCH
110 GEORGE STREET PARRAMATTA NSW 2150
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CLIENT: SYDNEY REGIONAL OFFICE -PMS
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PHONE (02) 8849-2090 FACSIMILE (02) 8849-2818

PREPARED	CHECKED	SKETCH No KD946CS2
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