Attachment 2

City of Edmonton

Southeast to West LRT
North Saskatchewan River Bridge
Bridge Options Report

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60222337

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Executive Summary

As part of the SE-W LRT project in the City of Edmonton a new LRT bridge is required across the North Saskatchewan River south-east of the downtown area. Based on the horizontal alignment set for the LRT during the Concept Study the proposed LRT river bridge will be on the same alignment as the existing Cloverdale Pedestrian Bridge. As a result the new LRT Bridge will replace the existing Cloverdale Pedestrian Bridge and be required to carry pedestrian/bicyclist traffic as well as LRT traffic. The following eight bridge options were considered for the LRT Bridge:

-a three span variable depth girder bridge;
-a three span constant depth girder bridge;
-a three span delta frame bridge;
-a three span twin tower extradosed bridge;
-a three span single tower extradosed bridge;
-a three span tied arch bridge;
-a three span through arch bridge; and
-a two span single tower cable stayed bridge.

The eight bridge options noted above were subjectively evaluated based on Engineering and Sustainable Urban Integration (SUI) criteria with the exception of the two arch options. The arch options were not pursued further for the following reasons.

- they received a low ranking from the public during the PI process;
- they offered no advantages over the other bridge options; and
- They were two of the higher priced options.

Based on the evaluation matrix the single tower extradosed bridge option received the highest evaluation with 34 points followed by the cable stayed bridge option with 32 points and the variable depth box girder bridge option with 30 points. The next highest ranked bridge option was the twin tower extradosed bridge option with 27 points.

Based on the above evaluations it is recommended that preliminary design continue on the variable depth box girder, single tower extradosed and cable stayed bridge options. The variable depth box girder bridge option is recommended because it is one of the three lowest cost options and received the most evaluation points of the lowest cost options. The single tower extradosed and cable stayed bridge options are recommended because they received more evaluation points than the variable depth box girder bridge option. However, it should be noted that the single tower extradosed and cable stayed bridge options cost approximately 35% and 100% more respectively than the variable depth box girder bridge option.

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Appendices

1. Introduction

As part of the SE-W LRT project in the City of Edmonton a new LRT bridge is required across the North Saskatchewan River south-east of the downtown area. Based on the horizontal alignment set for the LRT during the Concept Study the proposed LRT river bridge will be on the same alignment as the existing Cloverdale Pedestrian Bridge. As a result the new LRT Bridge will replace the existing Cloverdale Pedestrian Bridge and be required to carry pedestrian/bicyclist traffic as well as LRT traffic.

The vertical profile for the LRT river bridge is controlled by the requirement that the LRT tracks pass over top of 98th Avenue immediately south of the river. As a result the LRT vertical profile at the south bank of the river is approximately 7 m above grade. Therefore the most practical location for the shared use pathway (SUP), a trail intended for both pedestrian and bicyclist use, is considered to be beneath the LRT bridge rather than on top of or beside it. This location will place the SUP at approximately the same elevation as the existing Cloverdale Pedestrian Bridge and allow it to tie in with the existing river trail system without large elevation differences. The required vertical clearance between the SUP and LRT bridge is 3.6 m although this vertical clearance may be reduced to 2.5 m at the piers.

The vertical profile for the LRT river bridge also needs to provide adequate navigational vertical clearance for the Edmonton Queen to pass beneath the bridge. The required vertical clearance, estimated from first principles, is approximately 10 meters above normal high water. Information obtained from the Edmonton Queen indicates that the height of the craft above water is slightly less than 10 meters. Normal high water corresponds to a flow of 1000 cubic meters per second. For operation the Edmonton Queen requires flows below this. This estimated clearance is very nearly equal to that provided by the existing Cloverdale Pedestrian Bridge.

The north river bank at the location of the proposed LRT river bridge has a history of instability and a potential for future instability. The instability is a result of slippage along bentonite seams at various depths. The lower slopes are part of a historic slide that stretches west of the proposed alignment. This slide was the result of slipping on one of the lower bentonite seams. The upper slopes, although not part of the historic slide, show evidence of superficial raveling that may be accelerated by construction activity. They also have the potential for a more deep-seated movement along existing upper bentonite seams that have not previously failed. Slope stabilization works will therefore be required as part of the SE-W LRT project.

Slope stabilization involves the installation of an upper and a lower pile wall to restrain movement along the potential slip planes. The upper wall will form part of the tunnel portal structure and can be tied back with prestressed anchors if necessary. The lower wall pins the toe of the slope where tie-backs will be impractical. The largest potential long-term movements are expected at this location.

Because it benefits from the support of additional structure associated with the tunnel and because it can be provided with pre-stressed tie-backs, the tunnel portal is considered to be the location least vulnerable to long-term movement. Long-term movements are expected to be largest at the lower pile wall, near the river bank at the toe of the slope.

For the proposed LRT river bridge the only location considered suitable for a pier on the north side of the river is the location of the existing north pier of the Cloverdale Pedestrian Bridge. This is due to concerns that the excavation required for pier construction will further destabilize the north riverbank if it is placed closer to the riverbank and that the pier will infringe on the horizontal navigational clearance box required for the Edmonton Queen if it is placed farther from the riverbank. Additional LRT river bridge piers can be placed on the south side of the river provided they are a minimum of 70 m south of the proposed north river bridge pier location, thus maintaining the current width of the existing navigational clearance box.

Preliminary engineering for the North Saskatchewan River Bridge is currently ongoing and is expected to be completed in February, 2013. A number of bridge options have been put forward as part of this process and the purpose of this report is to summarize the options identified and to reduce to two or three options the number of bridge options for more detailed consideration.

2. Bridge Options Considered

Six bridge options were presented to the public as part of the Stage 3 Public Involvement (PI) process. Pictures of the six options are shown in Appendix A. The bridge options presented did not show the location of the SUP on the bridge. The options presented were:

-a three span variable depth girder bridge;
-a three span delta frame bridge;
-a three span twin tower extradosed bridge;
-a three span tied arch bridge;
-a three span through arch bridge; and
-a two span single tower cable stayed bridge.

An additional bridge option that was considered but not presented to the public as part of the PI process was a three span constant depth girder bridge.

All of the above noted bridge options only defined the portion of the LRT bridge located between the north and south river banks although the extent of the bridge structure associated with the river bridge extends from the LRT tunnel portal on the north river bank to the Muttart LRT stop south of the south river bank and 98th Avenue. These additional portions of bridge structure were not presented to the public as they are considered to be common to all of the bridge options.

An additional bridge option developed subsequent to the Stage 3 PI process is a three span single tower extradosed bridge spanning over the north river bank to the LRT tunnel portal. This additional bridge option was developed as an attempt to develop an option that does not need to be founded on the potentially unstable portion of the north river bank.

3. Bridge Option Descriptions

This section describes the eight LRT bridge options identified above. Drawings showing the bridge options are provided in Appendix B. The LRT bridge is assumed to have a width of 9.5 m and the SUP a width of 4.2 m, matching the existing Cloverdale Pedestrian Bridge. Note that the pier shapes shown in these drawings should be considered preliminary only.

Span arrangements were chosen largely on the basis of appearance but with some constraints. The minimum span is 70 m to match the existing pedestrian bridge. For options requiring a north river pier, the location of this pier is constrained by geotechnical considerations discussed earlier. For girder bridges, the spans were adjusted so that the superstructure depth would match that of the approach spans on the south bank of the river. The through-arch and twin tower extadosed bridges feature longer spans where it was felt that there would be an aesthetic advantage without significant cost penalty.

3.1 Variable Depth Girder Bridge Option

This bridge is a three span bridge with spans of 60 m – 90 m – 60 m as shown on Drawings SEW-2400-01-PE-1010A and 1020A. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located in the shallows on the south side of the river approximately 30 m from the south river bank. The north end of the bridge is located approximately 10 m north of the north river bank behind one of the tangent pile walls required for stabilization of the north river bank while the south end of the bridge is founded near the top of the south river bank. The north end of the bridge will need to be designed to accommodate long-term movements of the north river bank.

The bridge cross-section is supported on a single concrete box girder with a structural depth varying from 5.0 m at the piers to 2.5 m at the mid-spans and bridge ends. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP structure of approximately 9.0 m.

3.2 Constant Depth Girder Bridge Option

This bridge has the same span configuration and layout as the variable depth girder bridge option shown on Drawings SEW-2400-01-PE-1010A and 1020A. A separate drawing has therefore not been produced for this bridge option.

The bridge cross-section is supported on a single concrete box girder with a structural depth of 4.0 m. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP of approximately 8.0 m.

3.3 Delta Frame Girder Bridge Option

This bridge is a three span bridge with spans of 60 m – 90 m – 60 m as shown on Drawings SEW-2400-01-PE-1010B and 1020B. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located in the shallows on the south side of the river approximately 30 m from the south river bank. The north end of the bridge is located approximately 10 m north of the top of the north river bank behind one of the tangent pile walls required for stabilization of the north river bank while the south end of the bridge is founded near the top of the south river bank. The north end of the bridge will need to be designed to accommodate long-term movements of the north river bank.

The bridge cross-section is supported on two delta frame steel girders with a structural depth varying from 8.0 m at the piers to 2.5 m at the mid-spans and bridge ends. At the piers the SUP passes between the delta frame legs. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP of approximately 6.5 m.

3.4 Twin Tower Extradosed Bridge Option

This bridge is a three span bridge with spans of 60 m – 100 m – 60 m as shown on Drawings SEW-2400-01-PE-1010C and 1020C. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located in the shallows on the south side of the river approximately 20 m from the south river bank. The north end of the bridge is located approximately 10 m north of the top of the north river bank behind one of the tangent pile walls required for stabilization of the north river bank while the south end of the bridge is founded at the top of the south river bank. The north end of the bridge will need to be designed to accommodate movements of the north river bank. The two towers at the piers rise approximately 14 m above the LRT deck level.

The bridge cross-section is supported on a three cell concrete box girder with a structural depth of 2.7 m. Fourteen cables in the centre span and seven cables in each end span run from the towers on each side of the box girder to provide support to the box girder. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinth) to the bottom of the SUP of approximately 6.5 m.

3.5 Through Arch Bridge

This bridge is a three span bridge with spans of 65 m – 100 m – 65 m as shown on Drawing SEW-2400-01-PE-1010D. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located in the shallows on the south side of the river approximately 20 m from the south river bank. The north end of the bridge is located approximately 15 m north of the top of the north river bank behind one of the tangent pile walls required for stabilization of the north river bank while the south end of the bridge is founded approximately 10 m south of the top of the south river bank. The north end of the bridge will need to be designed to accommodate movements of the north river bank. The through arch rises approximately 11 m above the LRT deck level and approximately 8 m below it.

The bridge cross-section is supported on the arches with a structural depth of 2.0 m. At the piers the SUP passes between the arches. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP of approximately 6.0 m.

3.6 Tied Arch Bridge

This bridge is a three span bridge with spans of 70 m – 70 m – 70 m as shown on Drawing SEW-2400-01-PE-1010E. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located at the same location as the centre pier of the existing Cloverdale Pedestrian Bridge. The north end of the bridge is located approximately 20 m north of the top of the north river bank behind one of the tangent pile walls required for stabilization of the north river bank while the south end of the bridge is located midway up the south river bank. The north end of the bridge will need to be designed to accommodate any movements of the tangent pile wall resulting from movements of the north river bank. The through arches rise approximately 11 m above the LRT deck level.

The bridge cross-section is supported on the arches with a structural depth of 1.0 m. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP of approximately 5.0 m.

3.7 Cable Stayed Bridge

This bridge is a two span bridge with spans of 170 m – 90 m as shown on Drawings SEW-2400-01-PE-1010F and 1020F. The pier is located on the south side of the navigational clearance box approximately 50 m from the south river bank. The north end of the bridge is located at the north river tunnel portal while the south end of the bridge is located approximately 5 m south of the top of the south river bank. The tower at the pier rises approximately 65 m above the LRT deck level.

The pier is located as far north as possible without encroaching on the existing navigation clearance. The main span clears the least stable region of the north bank. The back span and the sloping pier balance the main span.

The bridge cross-section is 1.8 m deep and is supported by fourteen cables in each span and on each side of the deck that run to the tower. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinths) to the bottom of the SUP of approximately 6.0 m.

3.8 Single Tower Extradosed

This bridge is a three span bridge with spans of 100 m – 100 m – 50 m as shown on Drawings SEW-2400-01-PE-1010G and 1020G. The north pier is located at the same location as the north pier of the existing Cloverdale Pedestrian Bridge while the south pier is located in the shallows on the south side of the river approximately 20 m from the south river bank. The north end of the bridge is located at the north tunnel portal while the south end of the bridge is located near the top of the south river bank. The tower rises approximately 18 m above the LRT deck level.

The 100-meter north span is needed to clear the least stable region of the north bank. The south 100-meter span provides navigation clearance and balances the north span.

The bridge cross-section is supported on a three cell concrete box girder with a structural depth of 3.0 m. Nine cables run from the tower on each side of the box girder to provide support to the box girder. This results in a total structural depth from the top of the LRT river bridge deck (not including track and plinth) to the bottom of the SUP of approximately 7.0 m.

4. Bridge Options Evaluation Criteria

The eight bridge options noted above are subjectively evaluated based on Engineering and Sustainable Urban Integration (SUI) criteria with the exception of the two arch options. The arch options were discussed at length during the 60% review by the design team, the City’s LRT Design and Construction group and the City’s bridge engineer. The consensus opinion at that time it was that the arch options should not be pursued further because:

- they received a low ranking from the public during the PI process;
- they offered no advantages with respect to SUI or Engineering criteria over the other bridge options; and
- they were two of the higher priced options.

Also a constant depth steel girder option was not considered in the evaluation because it was considered to be equivalent in cost to a constant depth concrete girder option and, with the shared use pathway (SUP) beneath the bridge and anticipated concrete approach spans at each end of the bridge, less appealing with regard to SUI criteria.

This section describes the criteria that were used to evaluate the six remaining bridge options as well as the pros and cons of each bridge option relative to each criterion.

4.1 Geometrical Accommodation of Pedestrian Bridge

The LRT bridge options need to be able to geometrically accommodate the required width of the pedestrian bridge as well as of any required features such as lookouts. They also need to be able to accommodate geometrically the vertical and horizontal clearances required for the pedestrian bridge as well as the required vertical navigational clearance required beneath the pedestrian bridge.

Bridge options are evaluated based on how well they can accommodate the above noted geometric requirements of the pedestrian bridge.

The variable depth and constant depth box girder bridge options require total structural depths (including SUP) of 9.0 m and 8.0 m respectively while the delta frame, extradosed and cable stayed bridge options require total structural depths (including SUP) between 7.0 m and 6.0 m. The shallower total structural depths allow for more flexibility in setting the LRT gradeline, i.e. a straight gradeline rather than one with a hogging vertical curve, while meeting the vertical navigational clearance requirements.

The delta frame bridge option may restrict the available width of the pedestrian bridge as it passes between the legs of the delta frames at the piers while the proposed 4.5 m widths of the box girders required for the girder and extradosed bridge options may restrict the available width of the pedestrian bridge to 4.0 m.

Based on this evaluation criterion the cable stayed bridge option is ranked the highest followed by the two extradosed bridge options, the constant depth box girder bridge option, the variable depth box girder bridge option and the delta frame bridge option.

4.2 Geotechnical Considerations

The north river bank at the proposed bridge site has a history of geotechnical instability. Long term slope movements are expected despite slope stabilization measures planned as part of the project. Also the target factor of safety against failure for the slope stabilization measures is likely to be lower than the target factor of safety against failure for the bridge options.

Bridge options are evaluated based on their ability to accommodate or span over the expected north river bank movements and their susceptibility to failure of the north river bank.

The cable stayed and single tower extradosed bridge options span over the unstable portion of the north river bank, while the box girder, delta frame and twin tower extradosed bridge options all have end spans supported on the north river bank.

Based on this evaluation criterion the cable stayed and single tower extradosed bridge options are ranked the highest. The other bridge options are ranked similarly below the cable stayed and single tower extradosed bridge options.

4.3 Design Considerations

As the SE-W LRT project is currently in the preliminary engineering phase there is a possibility that the quantities and costs assumed for each bridge option could increase during detailed design. This risk is considered to be greater for bridge options that have less accumulated design experience for their design basis. Also restrictions need to be placed on the allowable magnitude of pedestrian bridge accelerations in order to maintain pedestrian comfort levels. Traditionally LRT bridges have been restricted to having a minimum natural frequency in the range of 2.5 to 3.0 Hz to minimize bridge accelerations due to interaction between the bridge and LRT trains. However this is generally not possible for longer span bridges and as a result maximum acceleration limits can be harder to control. As a result there is an increased risk in longer span bridges that additional quantities and costs will be required to meet maximum acceleration limits.

Bridge options are evaluated based on the risk that design criteria will not be able to be met without an increase in assumed bridge material quantities and costs.

The extradosed and cable stayed bridge options are the bridge options which have the greatest structural flexibility and for which there is less accumulated experience for their design basis. The box girder and delta frame bridge options have greater structural stiffnesses and more accumulated experience for their design basis.

Based on this evaluation criterion the extradosed and cable stayed bridge options are ranked the lowest and the box girder and delta frame bridge options the highest.

4.4 Environmental Considerations

Construction of the LRT bridge options as well as dismantling of the existing Cloverdale Pedestrian Bridge will require in-stream work in the North Saskatchewan River. The amount of environmental disturbance created will depend on the extent and duration of the in-stream work.

Bridge options are evaluated based on the extent and duration of the in-stream work required for construction.

A minimum base level of in-stream work is required for all of the bridge options due to the need to dismantle the existing Cloverdale Pedestrian Bridge. The cable stayed bridge option is expected to require the least amount of additional in-stream work as it does not require a pier on the north side of the river. All of the other bridge options require two piers in the river including a pier on the north side of the river.

Also all of the bridge options, except for the delta frame bridge option, require concrete segmental construction for the bridge girders which means that access will need to be maintained to the in-stream piers during construction of the bridge superstructure.

Based on this evaluation criterion the cable stayed bridge option is ranked the highest and the delta frame bridge the second highest. The remaining bridge options are given similar but lower rankings.

4.5 Operations and Maintenance

Operations and maintenance requirements need to be considered in the evaluation of the bridge options. These considerations include consideration of the accessibility provided to maintenance items such as utilities, catenaries, and track as well as consideration of the separation of the main bridge load carrying members from the LRT tracks. Increased separation reduces the potential for damage to the main load carrying members from a LRT train derailment and also allows maintenance/rehabilitation work to occur on the main load carrying members without directly affecting LRT traffic.

Bridge options are evaluated based on the accessibility they provide to items requiring maintenance as well as on the effect that required bridge maintenance/rehabilitation would have on LRT traffic.

The extradosed and cable stayed bridge options are expected to have additional maintenance requirements due to the requirements for future cable maintenance and possible replacement. Any future cable replacements would be expected to affect LRT operations both because the bridge capacity would be affected and also because the work would need to take place adjacent to the LRT tracks. The box girder and delta frame bridge options have the advantage that their main load carrying members are below the deck and it can therefore be expected that their maintenance will have less effect on LRT operations. Finally access to utilities placed within a box girder will be more accessible for operations and maintenance than utilities attached to the bottom of an open bridge cross-section.

Based on this evaluation criterion the box girder bridge options are ranked the highest followed by the delta framed bridge option. The extradosed bridge options receive the next highest rankings with the cable stayed bridge option ranked last.

4.6 Context and Architecture

The proposed LRT river bridge is located in a prominent location in the river valley and will be highly visible to the public. Viewpoints include views from downtown, from adjacent parks and from adjacent residences. Based on the PI process there appears to be a desire to create a structure that is a piece of public art yet compliments and does not detract from the river valley.

Bridge options are evaluated based on their aesthetics as well as on how well they complement their river valley setting, both components of SUI.

The cable stayed and single tower extradosed bridges are considered to be the most elegant bridge options with no need of enhancement. However the cable stayed bridge option would give a greater opportunity to create a unique “postcard” structure that could become a symbol of Edmonton. This must be balanced against the imposing nature of the cable-stayed tower, a structure extending 65 m to 70 m above the bridge deck, The twin towered extradosed bridge option is perhaps less elegant although its design proportions could possibly be improved. The remaining three bridge options are considered to be more utilitarian and functional with the variable depth concrete box girder bridge option being the most elegant of the three.

Based on this evaluation criterion the single tower extradosed bridge option was ranked the highest followed by the cable stayed, twin tower extradosed, variable depth box girder, delta frame and constant depth box girder bridge options.

4.7 River Valley Impact

The river valley is considered to be the jewel in the heart of Edmonton and is highly used by those seeking to enjoy the natural setting and the amenities available. It is therefore considered desirable that the selected bridge option be integrated with the existing grades, trails and landscape and not detract from the river valley experience. Bridge features that could detract from the experience of river valley users include the locations of piers and overhead superstructures that crowd in on the river valley trail network, the dominance of the bridge from the perspective of a user of the river valley trails and the visual continuity provided between the river bridge and its approaches. Note that the approach spans to the main river bridge are expected to be concrete spans that are approximately 2.5 m deep.

Bridge options are evaluated based on how well they will enhance the experience of users of the river valley.

On the south river bank bridge the superstructure depths and span arrangements are similar for all the different bridge options except for the constant depth box girder bridge option which requires a deeper superstructure. On the north river bank all of the bridge options have similar superstructure depths and span arrangements except for the constant depth box girder bridge option which requires a deeper superstructure and the cable stayed and single tower extradosed bridge options which clear span over the north river bank. All of the bridge options have two piers in the river with the exception of the cable stayed bridge option which has only one pier in the river near the south river bank.

Based on this evaluation criterion the cable stayed bridge option was ranked the highest followed by the single tower extradosed, twin tower extradosed, variable depth box girder, constant depth box girder and delta frame bridge options.

The high rating of the cable stayed option notwithstanding, it must be pointed out that the pylon of the cable stayed bridge will be a dominating feature in the river valley. This pylon will roughly match the height of a 25 story building.

4.8 User Experience

The pedestrian bridge is intended to enhance the experience of river valley users not only in allowing them access from one side of the river to the other but also in providing them with a positive experience as they cross the bridge. Bridge features that could make the experience of pedestrian bridge users more positive include the views from the bridge, opportunities for overlooks and seating areas and views of the LRT bridge from the pedestrian bridge.

Bridge options are evaluated based on how well they will enhance the experience of users of the pedestrian bridge.

The extradosed and box girder bridge options use box girders that provide a smooth concrete soffit above the pedestrian bridge as opposed to a steel or concrete floor system with cable trays to support utilities. The delta frame bridge option imposes a dark tunnel like experience on the users at the piers. Also the steel delta frame bridge option is expected to be less effective in suppressing noise from LRT traffic at the level of the pedestrian bridge.

Based on this evaluation criterion the single tower extradosed bridge was ranked the highest followed by the variable depth box girder, twin tower extradosed, constant depth box girder, cable stayed and delta frame bridge options.

5. Bridge Options Evaluation Results

The results from the bridge options evaluation matrix are as follows. The detailed evaluation matrix is provided in Appendix C.

Criteria	Variable Depth Box Girder	Constant Depth Box Girder	Delta Frame	Twin Tower Extradosed	Cable Stayed	Single Tower Extradosed
Engineering	20	21	16	13	19	17
SUI	11	6	4	12	13	17
Summary	31	27	20	25	32	34

6. Bridge Options Costs

Relative bridge construction costs have been estimated for the different bridge options based on historical data for the different bridge types. The constant depth box girder, variable depth box girder and delta frame bridge options are all estimated to have the same construction cost within 10% of each other which will be referred to as the base cost. The extradosed bridge options are estimated to have a construction cost premium of approximately 40% over the base cost while the cable stayed bridge option is estimated to have a construction cost premium of approximately 80% over the base cost.

7. Discussion and Recommendation

Based on the evaluation matrix the single tower extradosed bridge option received the highest evaluation with 34 points followed by the cable stayed bridge option with 32 points and the variable depth box girder bridge option with 31 points. The next highest ranked bridge option was the twin tower extradosed bridge option with 27 points.

Based on the above evaluations and costs it is recommended that preliminary design continue on the variable depth box girder, single tower extradosed and cable stayed bridge options. The variable depth box girder bridge option is recommended because it is one of the three lowest cost options and received the most evaluation points of the lowest cost options. The single tower extradosed and cable stayed bridge options are recommended because they received more evaluation points than the variable depth box girder bridge option. However, it should be noted that the single tower extradosed and cable stayed bridge options cost approximately 40% and 80% more respectively than the variable depth box girder bridge option.

Option A
Variable Depth Concrete Box or Steel I Girder Bridge

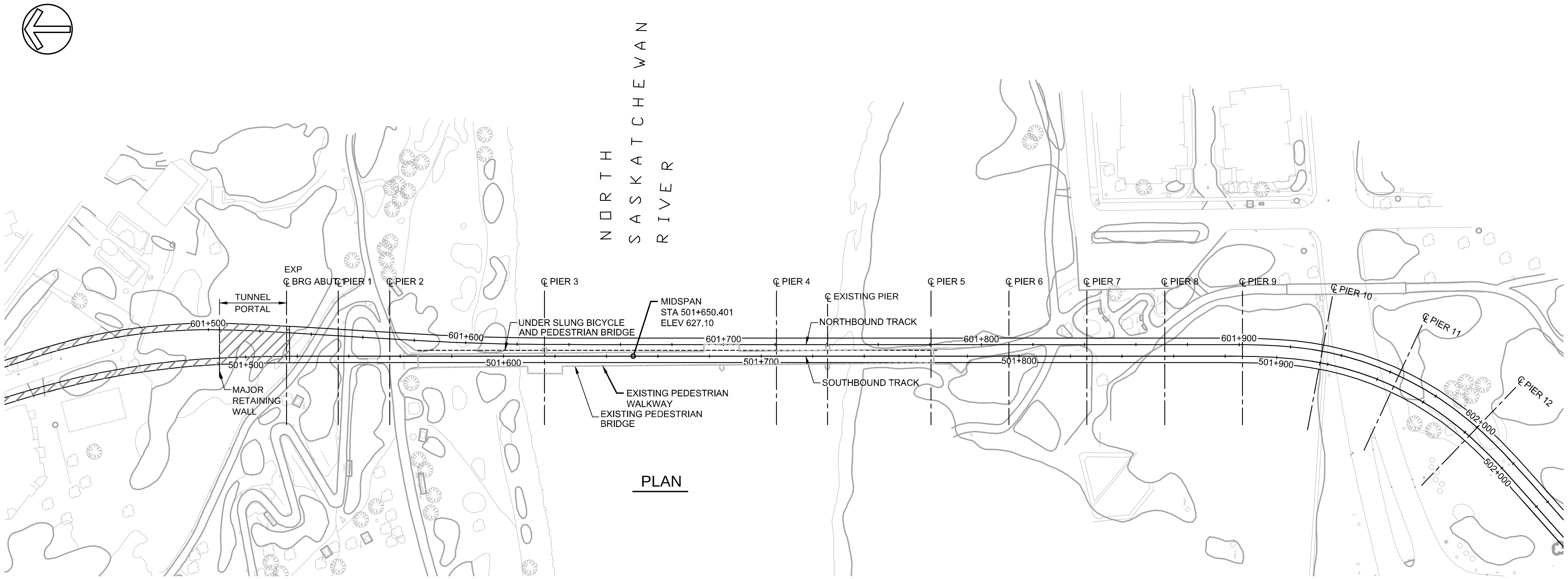
Option B
Delta Frame Steel Girder Bridge

Option C
Extradose Bridge

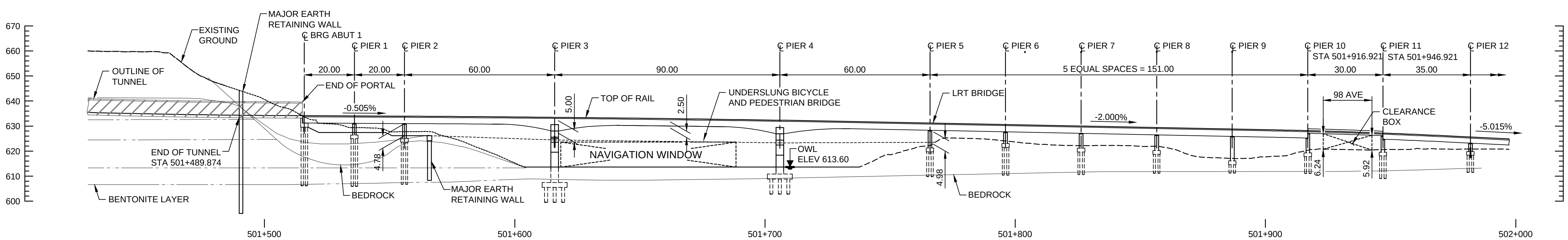
Option D
Tied Arch Bridge

Option E
Through-Arch
Bridge

Option F
Cable Stay Bridge



PLAN



ELEVATION

NOTE:
1. ALL DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE
2. TOP OF RAIL TO DECK = 0.441
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4. SUPERSTRUCTURE DEPTH IS MEASURED FROM TOP OF DECK

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A1 bar scale 1:1000m 0 10 30 50m

drawn by D. KROEKER

designed by R. MARZAN

checked by N. SAN PEDRO

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LRT STRUCTURES
OPTION 1
VARIABLE DEPTH CONCRETE BOX GIRDER BIRDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE
TO
LEWIS FARMS

drawing no. SEW-2400-01-PE-1010A

REV

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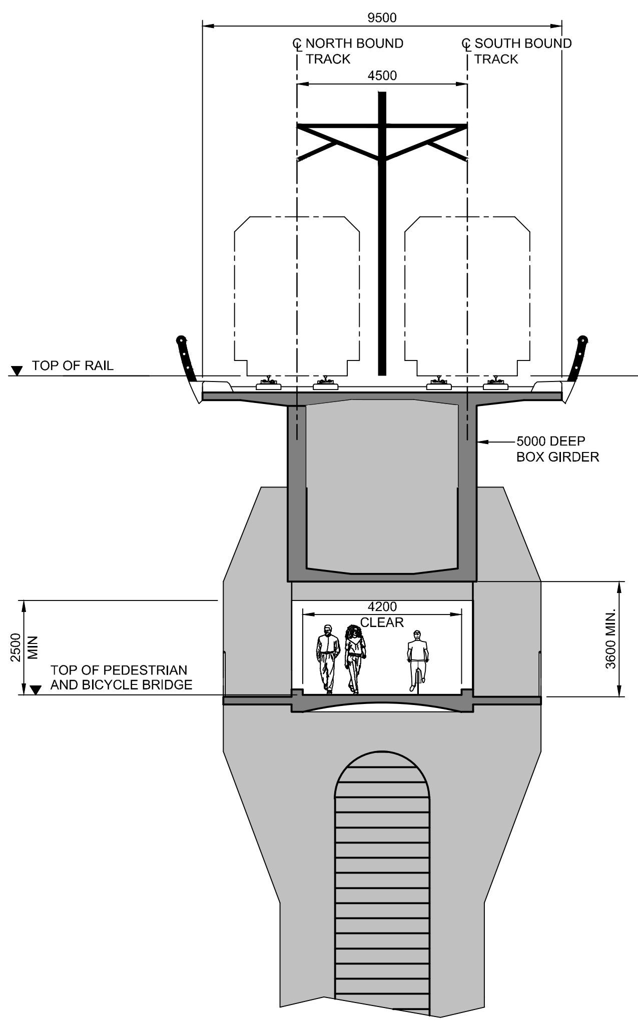

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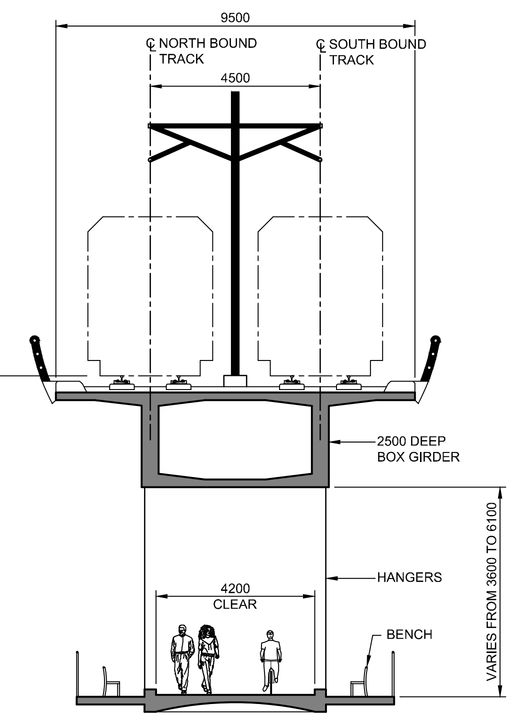

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LRT STRUCTURES

OPTION 1

VARIABLE DEPTH CONCRETE BOX GIRDER BRIDGE SECTIONS

SE to W LRT

MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1020A

REV

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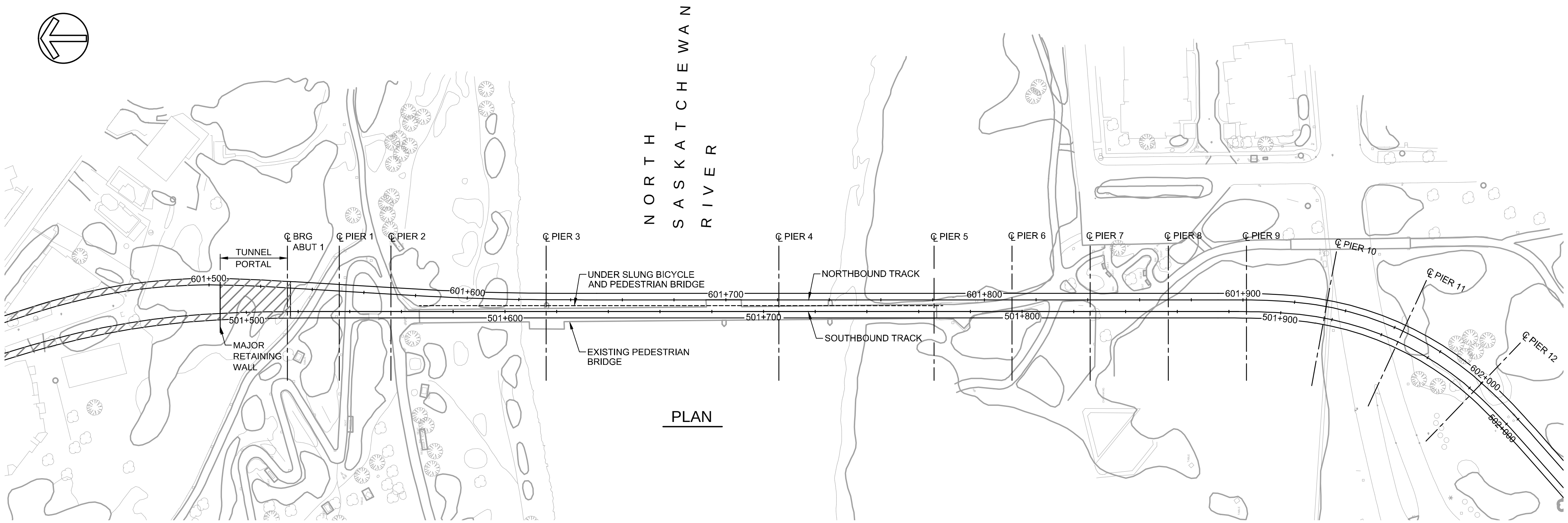

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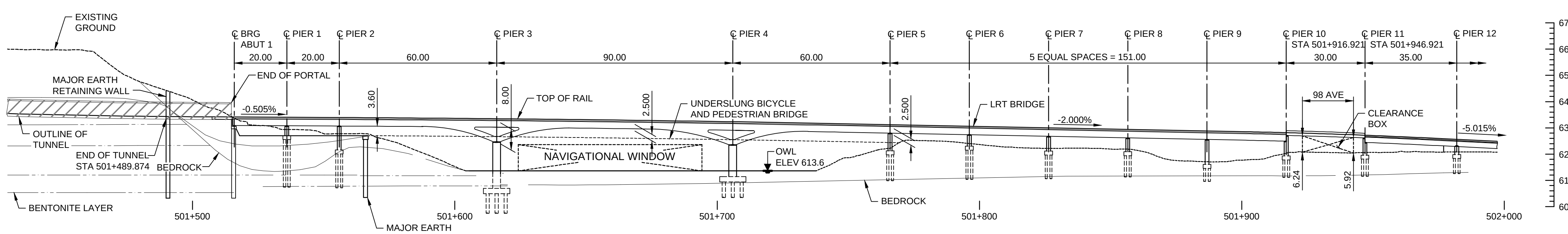

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LRT STRUCTURES

OPTION 2

DELTA FRAMED STEEL GIRDER BRIDGE

PLAN AND PROFILE

SE to W LRT

MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1010B

REV

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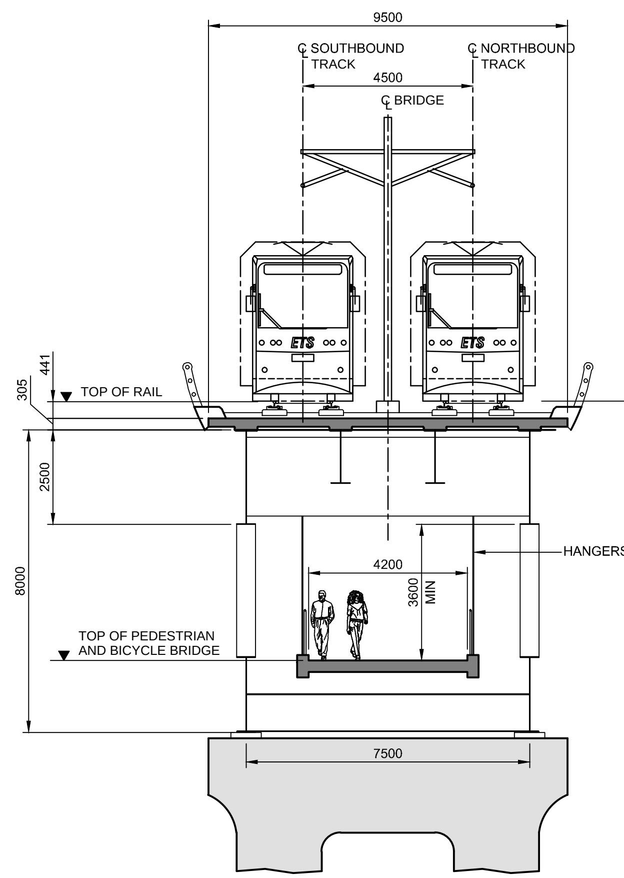

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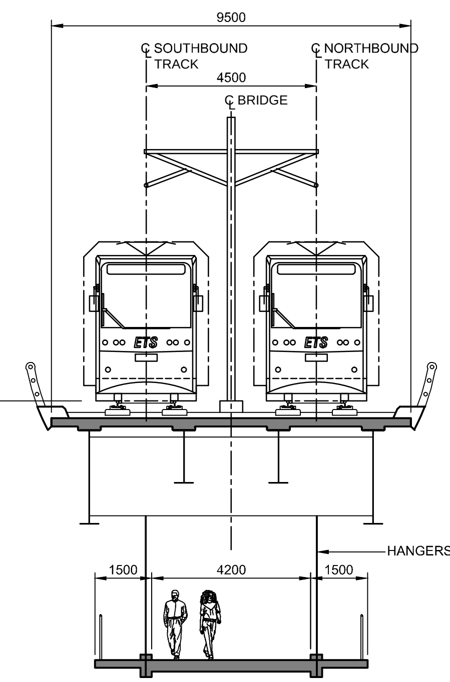

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LRT STRUCTURES

OPTION 2

DELTA FRAMED STEEL GIRDER BRIDGE

SECTIONS AND DETAILS

SE to W LRT

MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1020B

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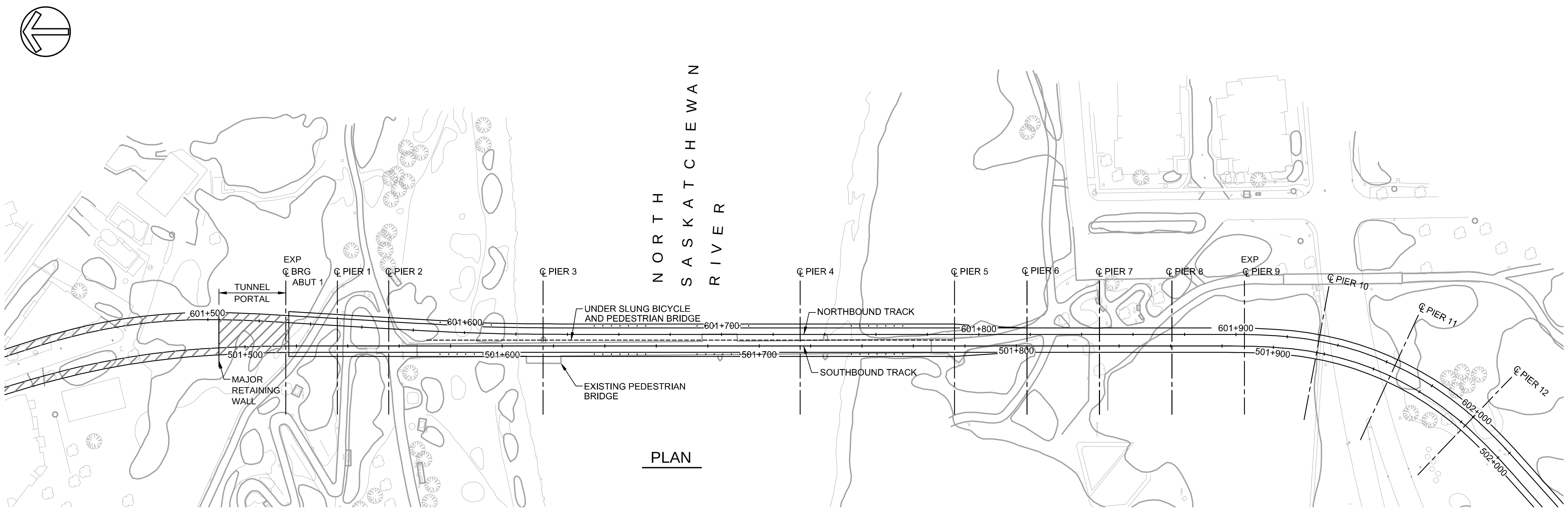

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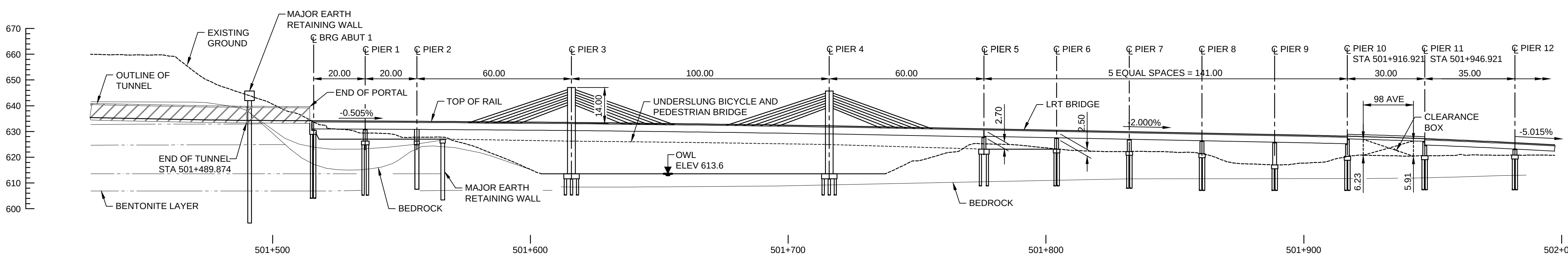

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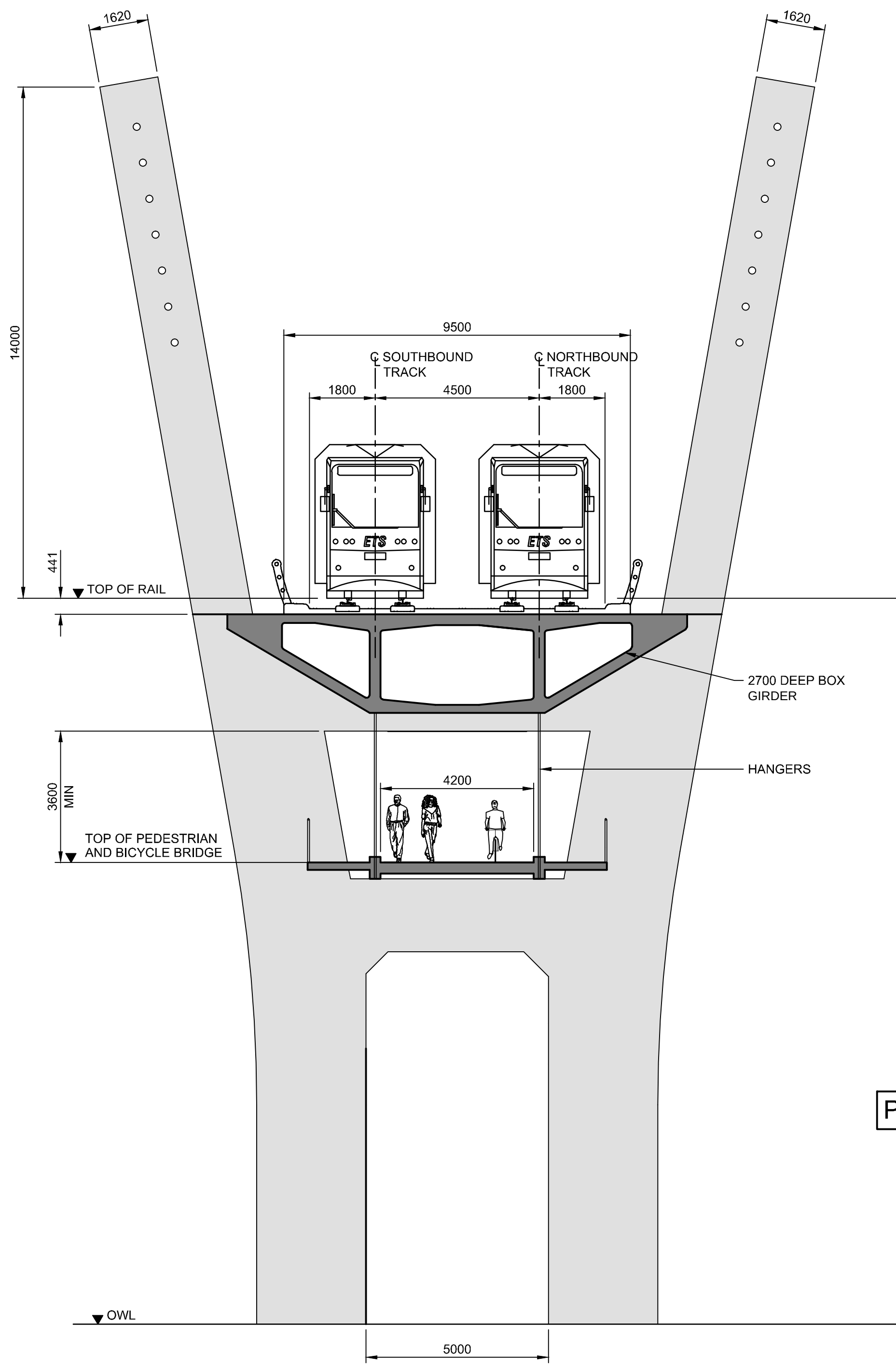
LRT STRUCTURES
OPTION 3A
TWIN TOWER EXTRADOSE BRIDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE
TO
LEWIS FARMS

drawing no. SEW-2400-01-PE-1010C | REV | SHT 009



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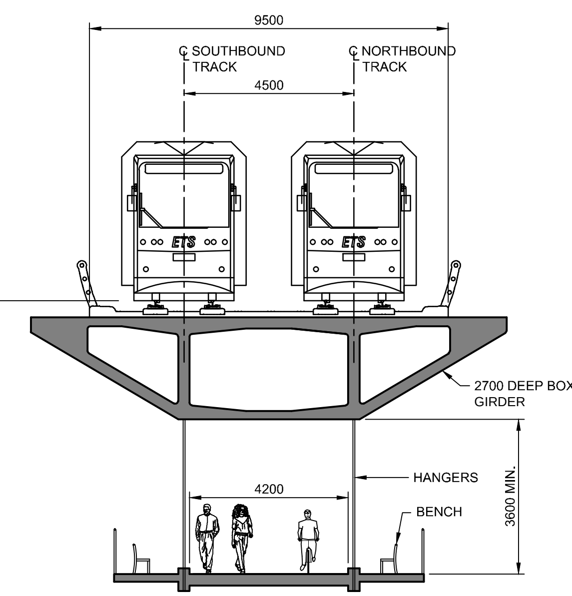

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revisions

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A1 bar scale 1:100mm 0 1000 3000 5000mm

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date 22-07-2012

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LRT STRUCTURES

OPTION 3A

TWIN TOWER EXTRADOSE BRIDGE

SECTIONS AND DETAILS

SE to W LRT

MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1020C

REV

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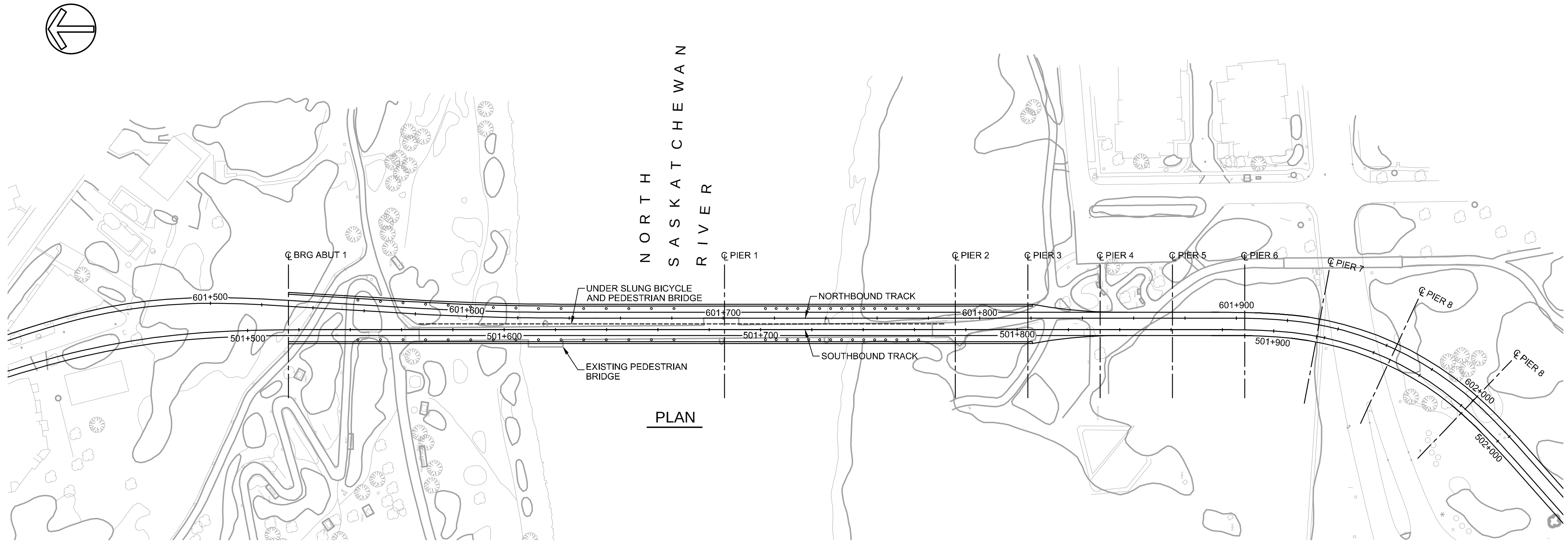

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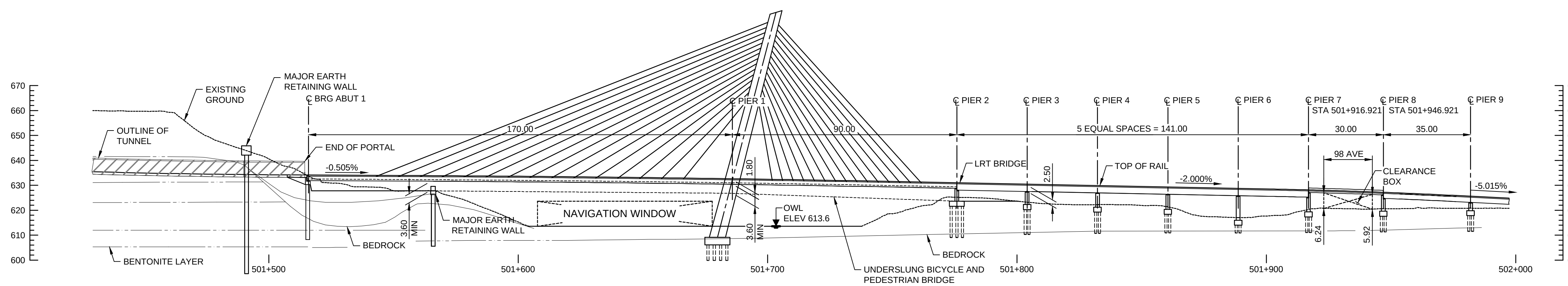

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A1 bar scale 1:1000m 0 10 30 50m

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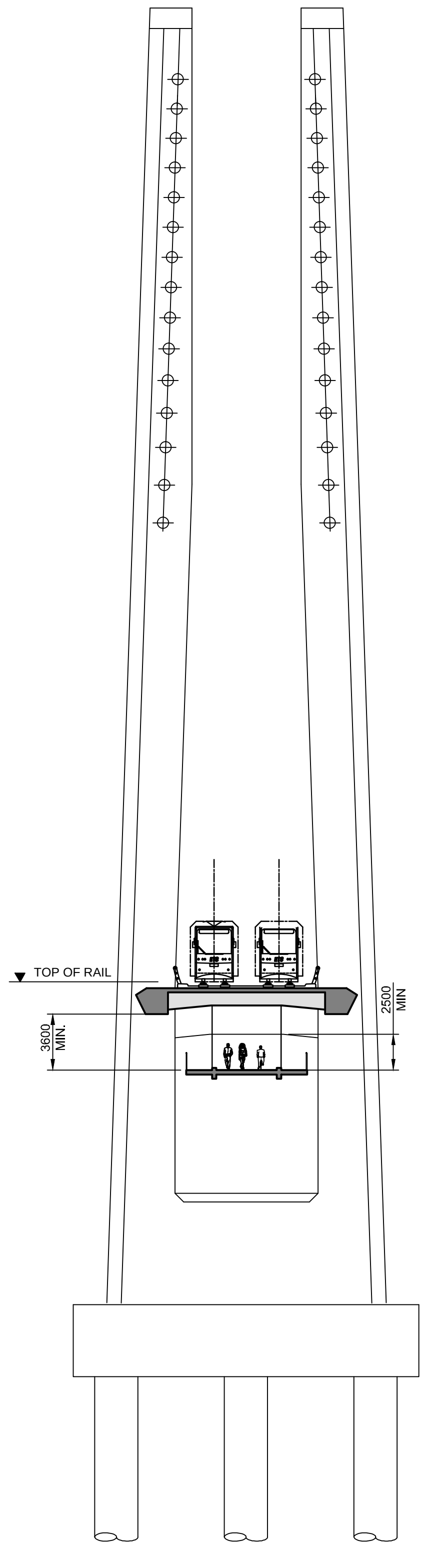
LRT STRUCTURES
OPTION 6
CABLE–STAYED BRIDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1010F | REV | SHT 015



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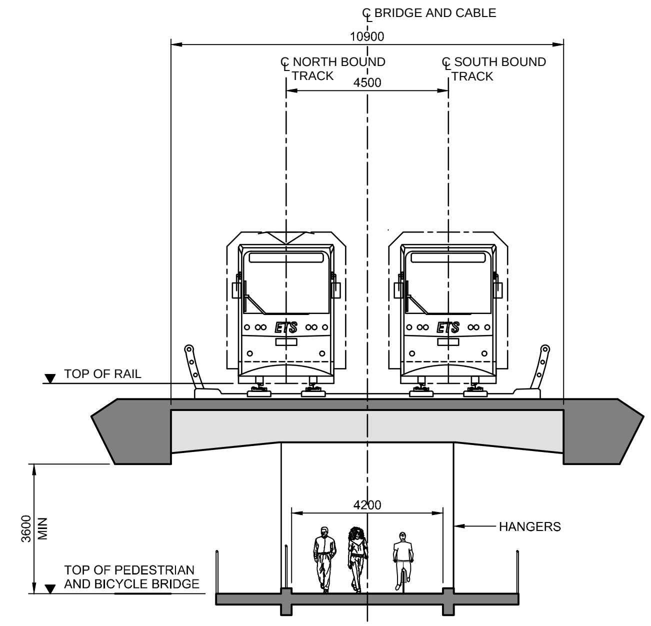

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PIER SHAPE PRELIMINARY ONLY

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no.	description	date	checked
	revisions		

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A1 bar scale 1:50mm 0 500 1500 2500mm

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drawing title

LRT STRUCTURES

OPTION 6

CABLE–STAYED BRIDGE

SECTIONS AND DETAILS

SE to W LRT

MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1020F

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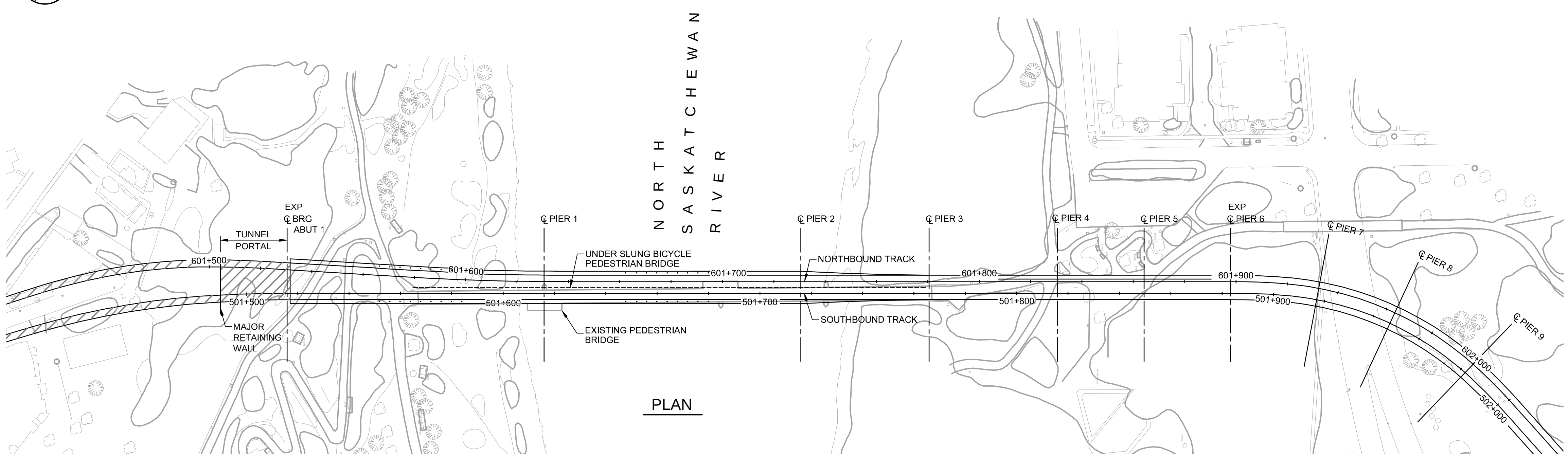

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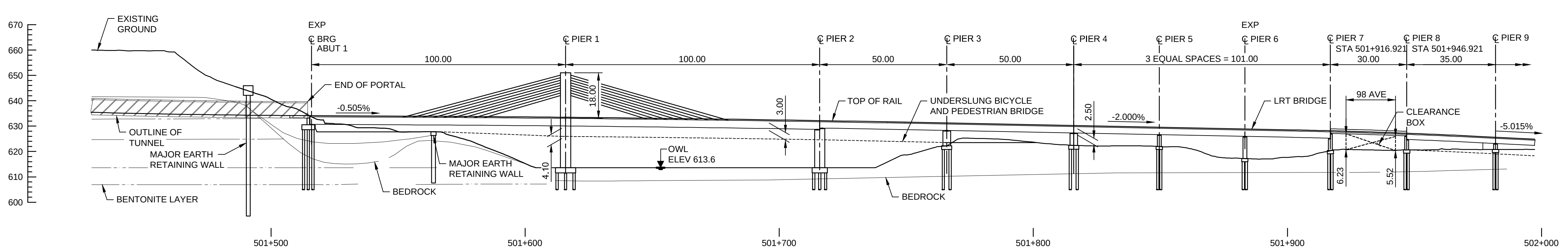

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LRT STRUCTURES

OPTION 6
SINGLE TOWER EXTRADOSE BRIDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE
TO
LEWIS FARMS

drawing no. SEW-2400-01-PE-1010G

REV

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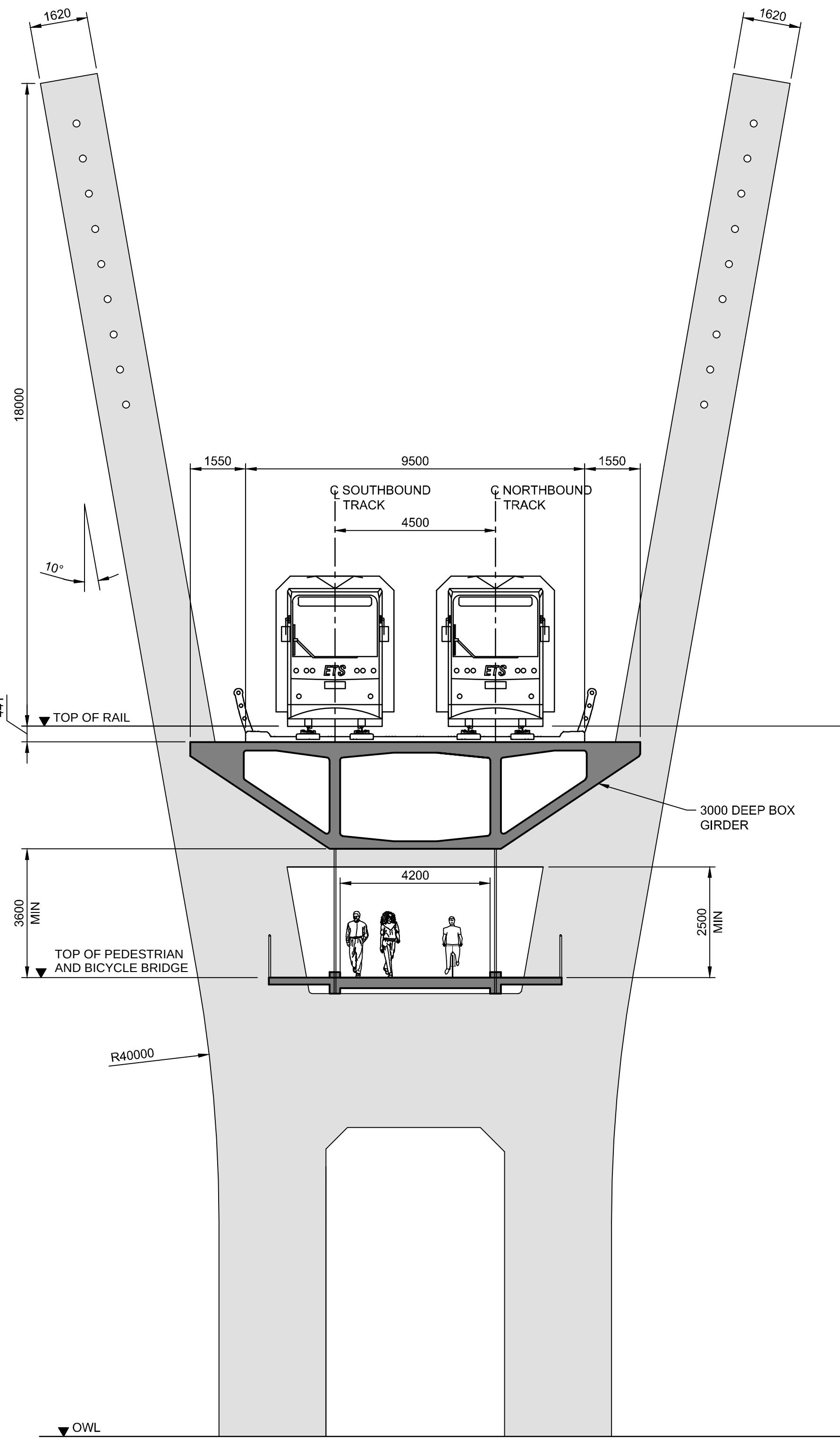

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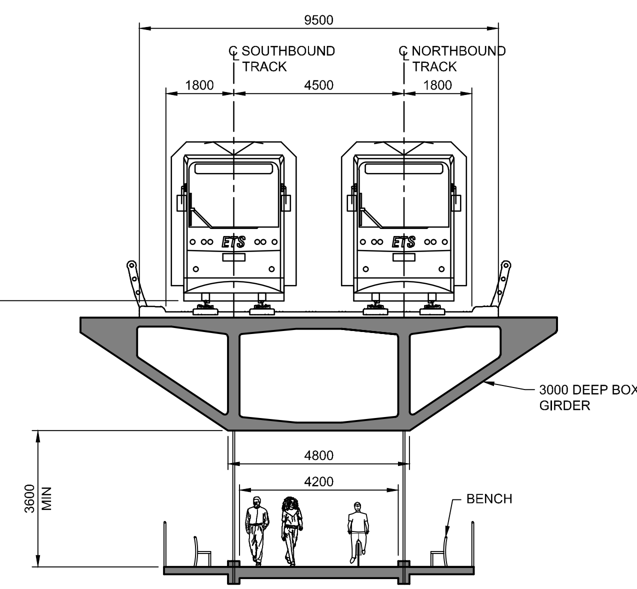

TYPICAL SECTION AT MIDSPAN

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drawing title

LRT STRUCTURES

OPTION 3B
SINGLE TOWER EXTRADOSE BRIDGE
SECTIONS AND DETAILS

SE to W LRT
MILLWOODS TOWN CENTRE
TO
LEWIS FARMS

drawing no. SEW-2400-01-PE-1020G

REV

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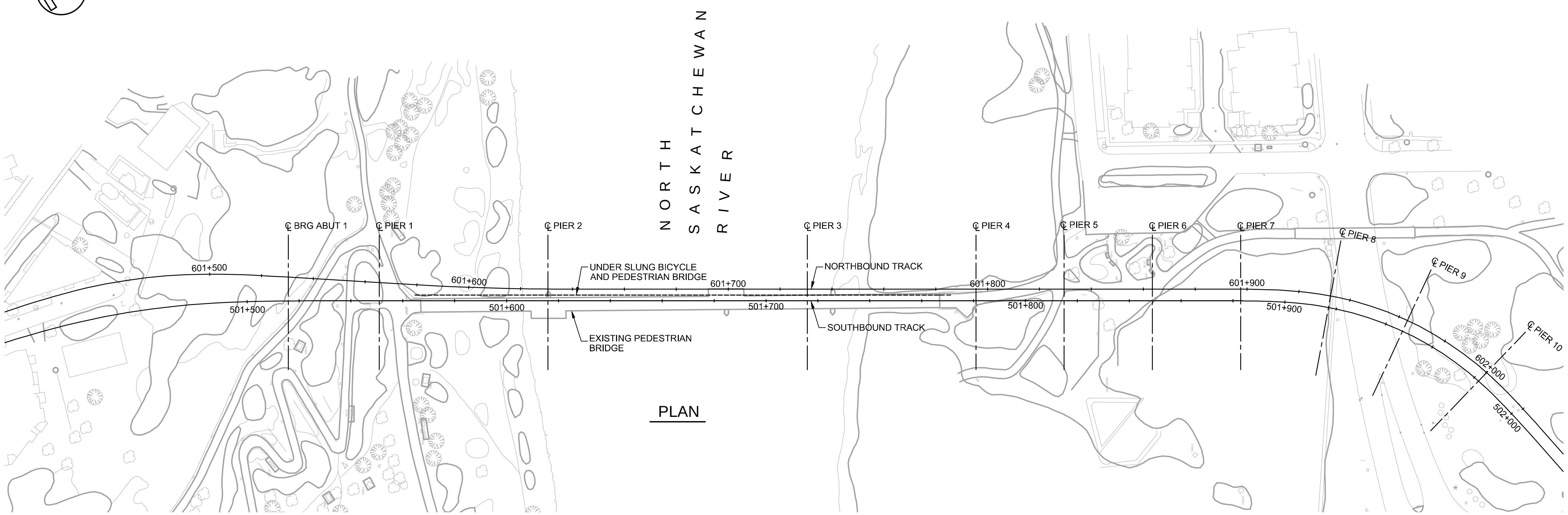

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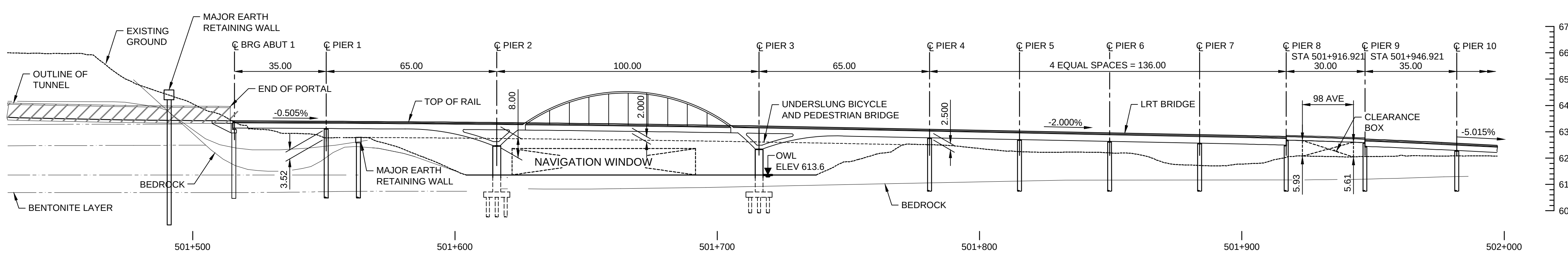

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LRT STRUCTURES

OPTION 4
THROUGH ARCH BRIDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1010D

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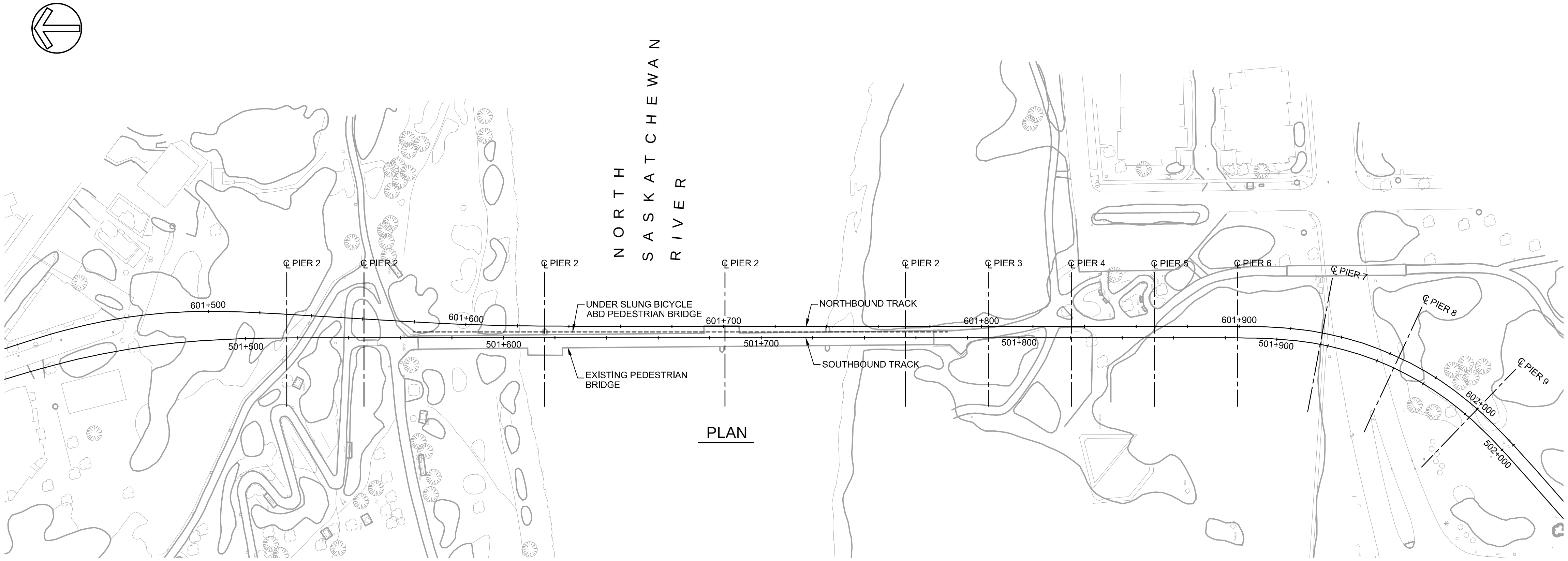

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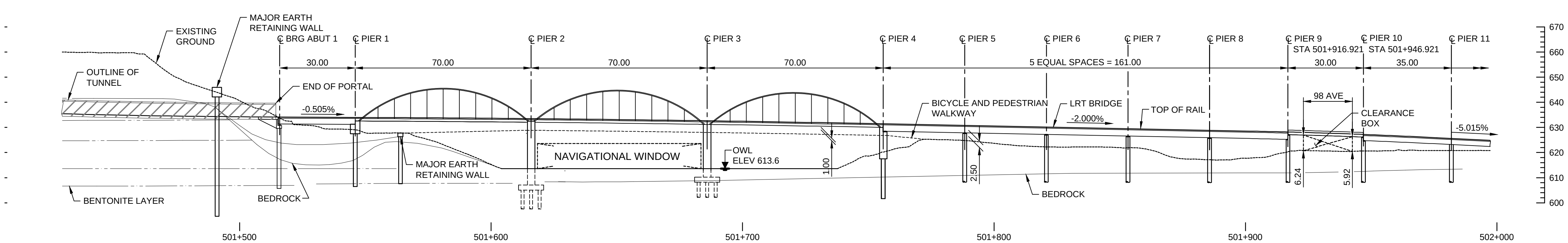

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LRT STRUCTURES

OPTION 5
TIED ARCH BRIDGE
PLAN AND PROFILE

SE to W LRT
MILLWOODS TOWN CENTRE TO LEWIS FARMS

drawing no. SEW-2400-01-PE-1010E

REV

SHT 013

Appendix C

Bridge Type Selection Matrix (draft)

September 17, 2012

Table 1 - Summary

CRITERIA		BRIDGE TYPE					
		Variable Depth Concrete Girder Bridge	Constant Depth Concrete Girder Bridge	Delta Framed Bridge	Twin Tower Extradosed bridge	Cable Stay Bridge	Single Tower Extradosed bridge
Summary	Engineering	20	21	16	12	19	17
	SUI Criteria	11	6	4	12	13	17
	Total Score	31	27	20	24	32	34

Appendix C

Bridge Type Selection Matrix (draft) September 17, 2012

Table 2 - Screening Based on Engineering Criteria

CRITERIA		BRIDGE TYPE					
		Variable Depth Concrete Girder Bridge	Constant Depth Concrete Girder Bridge	Delta Framed Bridge	Twin Tower Extradosed bridge	Cable Stay Bridge	Single Tower Extradosed bridge
Engineering Criteria	**a Geometrical Accomodation of Pedestrian Bridge** • How well does bridge option geometrically accommodate required pedestrian bridge width, clearances and features, e.g. lookouts? • Can structural depth of bridge option allow gradeline to be optimized while still meeting navigational requirements?	2	3	1	5	6	4
	b Geotechnical Considerations • Is bridge option susceptible to geotechnical instabilities at the north riverbank? • Does construction of bridge option present a risk to the stability of the north riverbank?	4	3	2	1	5	6
	c Design Considerations • Does flexibility of bridge option present risk that additional costs will be incurred to meet acceleration limits required for LRT user and pedestrian comfort? • How much historical design experience has been accumulated for each bridge option to extablish its design basis? • How forgiving is the design or each bridge option to accomodate unforseen changes?	5	6	4	3	1	2
	d Environmental Considerations •What is the extent and duration of in-stream construction required for the bridge option?	4	3	5	1	6	2
	e Operations and Maintenance • Does bridge option have its main bridge load carrying members seperated from the LRT tracks to minimize the possibility of damage to the main members and to make their maintenance easier? • How well does the bridge option accommodate utilities and their accessibility for inspection and maintenance?	5	6	4	2	1	3
Total Score		20	21	16	12	19	17

Appendix C

Bridge Type Selection Matrix (draft) September 17, 2012

Table 3 - Sustainable Urban Integration

CRITERIA			BRIDGE TYPE					
			Variable Depth Concrete Girder Bridge	Constant Depth Concrete Girder Bridge	Delta Framed Bridge	Twin Tower Extradosed Bridge	Cable Stay Bridge	Single Tower Extradosed bridge
Sustainable Urban Integra	f	**Context & Architecture** • View of the structure from adjacent park users • View of the structure from adjacent land uses-residents (both sides of river) • View of the structure from downtown and adjacent roadways • Does the structure type enhance the city context?	3	1	2	4	5	6
	g	**River Valley Impact** • View from LRT • View from pedestrians and bicyclists on approach paths • View from underhung path and lookouts • Integration of two levels within pier design • Quality of experience under superstructure: clearance, structure type, bird roosting, graffiti deterrent, CPTED • Opportunities for overlook/seating areas • Path width: does the structure provide ample width within bridge envelope for clearance of path modes (bike and pedestrian)	5	3	1	4	2	6
	h	**User Experience** • Do the approaches to the structure require retaining walls? • Integration of the approach slabs, abutments and piers into existing grade and landscape • Is the approach for ped/bike access intuitive and meet ADA grades? • Interruption to park improvements • Environmental impact and issues	3	2	1	4	6	5
Total Score			**11**	**6**	**4**	**12**	**13**	**17**