It is likely that an access road will be constructed adjacent to the structure to allow for construction of the new bridge. The site is relatively large and flat, making it suitable for positioning a crane to lift the bridge beams into place, however temporary crane foundations may be required.

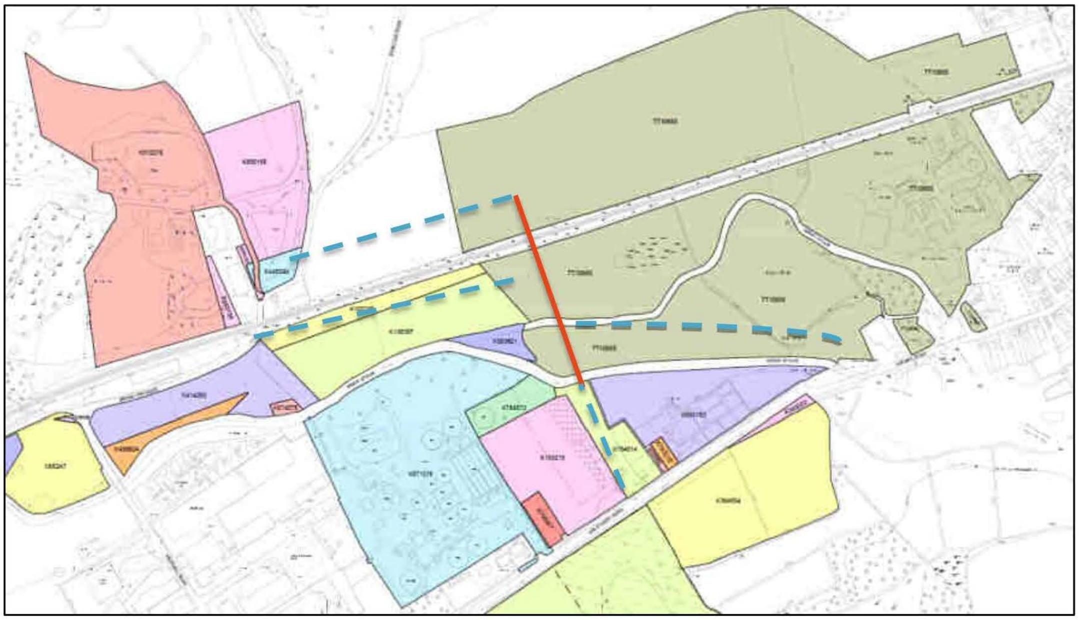

Figure 3 Land access routes

3 Bridge Design Considerations

3.1 General Requirements

3.1.1 General

Intended design life of the structure will be 120 years.

All bridge design options include provision for future statutory undertakers' plant on or within the deck. This will include up to six 150 mm diameter ducts.

The carriageway and footway widths over the bridge have been set by the highway design requirements. Headroom and lateral clearances beneath the bridge are in accordance with Network Rail and environmental Agency required minima.

3.1.2 Statutory undertakers' plant

There are no existing services to be accommodated by the structure.

All forms of bridge deck options allow for the provision of spare service ducts for future use.

3.1.3 Actions

The proposed load actions for the bridge are in accordance with BS EN 1991-2:2003 and associated UK National Annex:

- Load Model 1: Persistent actions relating to normal traffic under AW regulations and C&U regulations.
- Load Model 2: Single axle load.
- Load Model 3: SV100 – Persistent actions relating to General Order Traffic under STGO regulations.

Footway loading is also considered in accordance with BS EN 1991-2:2003.

3.1.4 Parapets and vehicle restraint system

As the bridge crosses a railway line, a High Level Containment parapet, type H4a, is required on each side of the bridge deck (ref: DMRB TD19/06 cl. 4.6).

The remainder of the bridge requires an N2 type parapet, on each side of the deck (ref: DMRB TD19/06 cl. 4.4,ii,b).

Safety barriers must be provided on both sides of the approach embankments. The safety barriers are required to be connected to the bridge parapets to minimize the risk of vehicles accidentally encroaching on the railway.

3.1.5 *Network Rail Trackside Equipment*

There is one trackside service trough and a 72.25 mile post to the north of the railway. No service diversion is required to accommodate the works. However, it is necessary to confirm the contents of the trough for health and safety reasons.

3.1.6 *Design and Construction Considerations*

The vertical alignment of the structure is determined by the minimum clearance requirements defined by Network Rail and the Environment Agency.

Careful consideration will need to be given to the safety barriers at the detailed design stage to ensure that the design meets the requirements for working width.

Careful consideration should be given to carrying out piling operations, particularly for the pier/column locations within the flood plain of the Stour River and adjacent to the railway. Monitoring of the tracks may be required during construction to detect any indication of heave. Network Rail will require that sightlines are not impaired whilst all works are carried out.

The viaduct crosses two arms of the Stour River in an area that contributes to the flood storage capacity of the river. Consultation with the Environmental Agency (EA) has highlighted the following requirements:

- no piers permitted within the watercourses,
- a minimum of 8.0m lateral clearance from the top of and bank to any pier
- a minimum 2.65m headroom from the top of any bank for maintenance vehicles.

In addition, the proposed viaduct will cross part of the Network Rail high speed St Pancras - Ramsgate route, at approximate location +350yrds. The aim of the new bridge design is to avoid any physical impact on existing Network Rail infrastructure or land. This includes any temporary works during construction of the bridge.

Network Rail specify a minimum vertical clearances of 5100mm from top of high rail to the bridge deck soffit, inclusive of all bridge deflections and a minimum horizontal clearances of 1624mm laterally from the nearest running rail. However the client has requested all works to be clear of NR land therefore a 4000mm horizontal clearance from the edge of the Network Rail land has been provided.

Scope for using the railway as a method of transporting materials to site are to be considered. Further investigation with Network Rail is required

Flat areas of land are considered the most pragmatic area to position a crane for the lifting of bridge beams in situ. Temporary platforms may be required to facilitate the crane due to the Alluvium layer of deposits present at the site.

3.1.7 *Risks common to all options*

- Working alongside live railway.
- Potential impairment of railway sightlines.
- Working at height above the railway for deck construction.
- Working adjacent to a watercourse.
- Working at height above a watercourse.

3.1.8 *Considerations common to all options*

- It is considered that the vertical and horizontal clearances between the railway and the proposed structure will be agreed with Network Rail.
- It is considered that no service diversions will be required.
- It is considered that all land purchase and licence requirements will be met.

3.2 Piling

It is envisages that the bridge will be supported on piled foundation at both abutments and 5 pier locations. The pile design for each option varies as a function of loading, but typically the abutments will be supported on 14 to 15 Φ750mm x 21.5-23m long piles and the columns will be supported on 10 to 12 Φ750mm x 21.5-23m long piles.

4 Bridge Design Options

The bridge design options described below are combinations of three forms of construction.

The various forms of construction all comprise a composite in-situ concrete deck supported on either pre-stressed precast concrete beams or steel beams. A steel beam cable stayed option is also considered. All options are set at zero skew.

The basic design options are numbered accordingly:

Option 1	5 No. precast concrete beam (6 span)
Option 2	4 No. steel beam composite, flat soffit (6 span)
Option 3	4 No. steel beam composite, curved soffit (6 span)
Option 4	6 No. steel beam composite, curved soffit (6 span)
Option 5	Ladder beam composite, curved soffit (6 span)
Option 6	Twin tower cable stayed (5 span)

There are two variations of the carriageway layout. These are:

Width 1	with bus lane
Width 2	without bus lane

Note: based on economic design Options 1, 2, 3, 4 and 6 are viable options for the carriageway with bus lane. The ladder beam construction is only considered viable for the narrower deck, therefore Options 1,5 and 6 have been compared for the carriageway without bus-lane. All option comparisons have been based on the design with wing walls perpendicular to abutment face and unpainted weathering steel where appropriate.

Therefore examples of option numbering are given below:

- Option 3.1 refers to the 4 No. steel beam composite, curved soffit with bus lane, wing walls perpendicular to abutment face and unpainted weathering steel beams.
- Option 6.2 refers to the twin tower cable stayed option without bus lane, wing walls perpendicular to abutment face and unpainted weathering steel.

In addition to the options, variations on the abutment type and steel beam type have been separately assessed.

There are four abutment design options numbered:

Abutment 1	wing walls perpendicular to abutment face
Abutment 2	splayed wing walls with inspection gallery
Abutment 3	splayed wing walls without inspection gallery
Abutment 4	bank seat on reinforced soil

The steel beam options may be either:

Beam 1	unpainted weathering steel (Corten)
Beam 2	painted carbon steel

The clear spans for Options 1 to 5 are 40.3 m (end spans) & 42.0 m (internal spans), at a skew angle of 0°.

The span arrangements for Option 6 are 40.3 m (end spans) with a 42.0 m, 84.0 m, 42.0 m (stayed spans).

The following Key risks are common to all options:

- Working alongside the railway
- Potential impairment of railway sightlines
- Working at height
- Working adjacent to a watercourse
- Potential heave of railway embankment

All options are based on the following premises:

- That the vertical and horizontal clearances between the railway and the proposed structure can be agreed with Network Rail
- That no service diversions are required
- That all necessary land purchase and licence requirements can't be met

4.1 Other Options Considered

4.1.1 In situ reinforced concrete deck

Construction of an in-situ reinforced concrete beam and deck would require extensive temporary works over the railway and to maintain a working railway whilst the bridge deck is being constructed would require the deck false-work to be constructed at a level above the minimum headroom and similar issues crossing the Stour River. This would result in the finished deck being at a level higher than required which in turn would affect the vertical alignment of the highway resulting in significantly increased embankments and temporary propping. Construction time would also be considerably longer. For these reasons a bridge deck of this form has not been considered as a feasible option.

4.2 Option 1: Precast Concrete Beam

4.2.1 Description

Option 1.1 comprises a 200 thick reinforced concrete deck slab on 5 No. pre-stressed precast simply supported W-beams, acting compositely.

Option 1.2 comprises a 200 thick reinforced concrete deck slab on 4 No. pre-stressed precast simply supported W-beams, acting compositely

The spans are 40.3 m (end spans) & 42.0 m (internal spans), at a skew angle of 0°. The beams would be individually transported to site and lifted into position prior to casting the deck on permanent non-participating formwork panels.

Refer to drawing 4300392/1700/101 in Appendix A.

4.2.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.2.3 Whole life costs

Whole Life Costs have been calculated over a period of 120 years. See Appendix B.

4.2.4 Key risks particular to this option

None

4.2.5 Assumptions particular to this option

None

4.2.6 Departures from standards particular to this option

None

4.2.7 Benefits and Dis-benefits

Benefits

- Deflections are small.
- Low maintenance requirements for precast concrete beams.
- No bracing required to support beams during deck casting.
- Soffit relatively simple to inspect and maintain.
- Edge cantilevers can be precast and lifted into position
- Deck thickness is 200mm thick.

Dis-benefits

- Pre-stressed concrete beams are heavier than the steel beam options, requiring increased foundations.
- The beams will be placed in thirty lifts, including five lifts over the railway.
- For Option 1.2 the beams will be placed in twenty-four lifts, including four lifts over the railway.
- Beams cannot be spliced within the spans, such that 42.0 m long sections of beams have to be delivered to site, abnormal load confirmation pending.
- Large overall construction depth at the abutment and mid-span sections because the beams do not act continuously over supports.
- Joints between beams are required over each pier, increasing potential maintenance liability.
- Simply supported beam spans are less structurally efficient than continuous spans.
- Deck voids within the beams are not accessible for inspection.
- Double bearings are required at each pier/column location, totalling 60 bearings for option 1.1 and 48 for option1.2.
- Edge cantilever false-work will need to be installed after lifting of beams

4.3 Option 2: 4 No. Steel Beam Composite, Flat Soffit

4.3.1 Description

Option 2.1 comprises a 250mm thick reinforced concrete deck slab on 4 No. continuous steel beams acting compositely.

The spans are 40.3 m (end spans) & 42.0 m (internal spans). The beams are transported to site in convenient lengths, where they are bolted and lifted into position in braced pairs of lengths varying from 20.4m (pier section) to 30.1m (abutment sections), The deck is then cast on permanent participating or non-participating formwork panels.

Refer to drawing 4300392/1700/102 in Appendix A.

4.3.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.3.3 Whole life costs

Whole Life Cost has been calculated over a period of 120 years. See Appendix B.

4.3.4 Key risks particular to this option

None

4.3.5 Assumptions particular to this option

None

4.3.6 Departures from standards particular to this option

None.

4.3.7 Benefits and Dis-benefits

Benefits

- Beams are spaced such that easy access can be made to all parts of the deck for maintenance purposes.
- The steel composite deck on steel beams is a relatively light form of construction.
- The beams are placed in twenty-two lifts, including four lifts over the railway.
- The option of utilizing weathering steel provides a minimal maintenance requirement.
- Flat beam soffits are marginally simpler to fabricate and transport to site.
- Reduced overall construction depth at the abutment and mid-span sections.
- Steel beams can be spliced and transported to site in convenient lengths, reducing the abnormal load constraints.
- Steel beams are bolted together at low level and lifted in braced pairs with edge cantilever false-work and most deck formwork already in place.
- Continuous beam construction allows a single bearing for each beam at each column location, totalling 28 bearings.

Dis-benefits

- Open soffit may encourage nesting of birds. The resulting debris and excreta may cause issues in the longer term, and these areas will be difficult to clean, inspect or maintain.
- The flat soffit gives an overall construction depth at the pinch point requiring slightly taller abutments, wing walls and associated earthworks than curved soffit options.
- Aesthetically, flat beams can give the appearance of sagging, particularly when spans are long, although this effect is reduced for multi-span structures.
- Some beam and bracing needs to be installed by working at height.

4.4 Option 3: 4 No. Steel Beam Composite, Curved Soffit

4.4.1 Description

Option 3.1 comprises a 250mm thick reinforced concrete deck slab on 4 No. continuous steel beams with curved soffit, acting compositely.

The spans are 40.3 m (end spans) & 42.0 m (internal spans) The beams are transported to site in convenient lengths, where they are bolted and lifted into position in braced pairs of lengths varying from 20.4m (pier section) to 30.1m (abutment sections), The deck is then cast on permanent participating or non-participating formwork panels.

Refer to drawing 4300392/1700/103 in Appendix A.

4.4.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.4.3 Whole life costs

Whole Life Cost has been calculated over a period of 120 years. See Appendix B.

4.4.4 Key risks particular to this option

None

4.4.5 Assumptions particular to this option

None.

4.4.6 Departures from standards particular to this option

None.

4.4.7 Benefits and Dis-benefits

Benefits

- The beams are spaced such that easy access can be made to all parts of the beams and deck soffit for maintenance purposes.
- The steel composite deck is a relatively light form of construction.
- Beams are placed in twenty-two lifts, including four lifts over the railway.
- The option of weathering steel beams offers minimal maintenance requirement.
- Relatively shallow construction depth at clearance pinch points allows reduced height of abutments, wing walls and associated earthworks.
- Steel beams can be spliced and transported to site in convenient lengths, reducing the abnormal load constraints.
- Steel beams are bolted together at low level and lifted in braced pairs with edge cantilever false-work and most deck formwork already in place.
- Continuous beam construction allows a single bearing for each beam at each column location, totalling 28 bearings.
- The curved soffit provides an aesthetically pleasing profile.

Dis-benefits

- Open soffit may encourage nesting of birds. The resulting debris and excreta may cause issues in the longer term, and these areas are more difficult to clean, inspect and maintain.
- Some beam and bracing assembly requires working at height.
- The curved soffit beams are marginally more complex to transport.

4.5 Option 4: 6 No. Steel Beam Composite, Curved Soffit

4.5.1 Description

Option 4.1 comprises is a 225mm thick reinforced concrete deck slab on 6No. continuous steel beams with curved soffit, acting compositely.

The spans are 40.3 m (end spans) & 42.0 m (internal spans). The beams are transported to site in convenient lengths, where they are bolted and lifted into position in braced pairs of lengths varying from 20.4m (pier section) to 30.1m (abutment sections), The deck is then cast on permanent participating or non-participating formwork panels.

Refer to drawing 4300392/1700/104 in Appendix A.

4.5.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.5.3 Whole life costs

Whole Life Cost has been calculated over a period of 120 years. See Appendix B.

4.5.4 Key risks particular to this option

None

4.5.5 Assumptions particular to this option

None

4.5.6 Departures from standards particular to this option

None.

4.5.7 Benefits and Dis-benefits

Benefits

- Closer spaced beans permit a slightly thinner deck slab
- The steel composite deck is a relatively light form of construction.
- The option of weathering steel beams offers minimal maintenance requirements.
- The overall construction depth at the clearance pinch points gives the most shallow construction depth of all options.
- Steel beams are bolted together at low level and lifted in braced pairs with edge cantilever false-work and most deck formwork already in place.
- Continuous beam construction allows a single bearing for each beam at each column location, totalling 28 bearings.
- The curved soffit provides an aesthetically pleasing profile.

Dis-benefits

- The six beams are positioned closer together, reducing access to the beams and deck soffit for inspection and maintenance.
- Relatively large number of beams to inspect and maintain.
- Open soffit may encourage nesting of birds. The resulting debris and excreta may cause issues in the longer term, and these areas will be difficult to clean, inspect and maintain.
- The beams will be placed in thirty-three lifts, including six lifts over the railway.
- Some beam and bracing assembly requires working at height.
- The curved soffit beams are marginally more complex to transport.

4.6 Option 5: Ladder Beam Composite, Curved Soffit

4.6.1 Description

Option 5.2 comprises a 250mm thick reinforced concrete deck slab on secondary transverse beams on 2No. main girders , acting compositely. This form of construction is generally best suited to narrower decks.

The spans are 40.3 m (end spans) & 42.0 m (internal spans). The main girders and transverse beams are transported to site in convenient lengths, assembled on the ground with edge cantilever false-work and all deck formwork in place prior to lifting into position. Lift lengths are 20.4m (pier section) to 30.1m (abutment sections). Each lift is bolted to adjoining sections prior to casting the deck on permanent participating or non-participating formwork panels.

Refer to drawing 4300392/1700/105 in Appendix A.

4.6.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.6.3 Whole life costs

Whole Life Cost has been calculated over a period of 120 years. See Appendix B.

4.6.4 Key risks particular to this option

None.

4.6.5 Assumptions particular to this option

None.

4.6.6 Departures from standards particular to this option

None.

4.6.7 Benefits and Dis-benefits

Benefits

- Option 5.2 comprises two primary plate girder beams with ladder transverse beams at 2.8m spacing allowing for easy access to all parts of the deck for maintenance purposes.
- Steel bracing between longitudinal beams is not required
- The steel composite construction is a relatively light form of construction.
- The beams can be placed in eleven lifts, including two lifts over the railway
- The option of weathering steel beams offers minimal maintenance requirement.
- Steel beams are bolted together at low level and lifted with edge cantilever false-work and all deck formwork already in place.
- Continuous beam construction allows a single bearing for each beam at each column location, totalling 28 bearings.
- The curved soffit provides an aesthetically pleasing profile.

Dis-benefits

- Each construction lift is heavier than for the multi steel beam options, requiring a heavier crane.
- Open soffit may encourage nesting of birds. The resulting debris and excreta may cause issues in the longer term, and these areas will be difficult to clean, inspect and maintain.
- Some beam and bracing assembly requires working at height.
- The curved soffit beams are marginally more complex to transport.
- The two main girders give a deeper overall construction depth at the clearance pinch points than other steel beam options, requiring taller abutments, wing walls and associated earthworks.

4.7 Option 6: 5 Span Cable Stayed

4.7.1 Description

Option 6 is a 5 span structure, three of which are cable stayed, with a 250mm in-situ composite deck on steel beams. The two end spans are as Option 4 whilst the cable-stayed spans comprise 6 No. 533x210 UB's supported on 914x419UB transverse beams at 4.0m centres. The proximity to the ground along the full length of the stayed spans allows for a simpler form of erection than is conventional for cable-stayed structures. This structure is designed such that the 6No. longitudinal beams are self-supporting when initially spanning between piers and temporary support at mid-span. Each transverse beam can then be offered up in turn from the ground and the cables attached prior to the reinforced deck being cast. The towers are constructed as hollow steel box sections.

The span arrangements are 40.3 m (end spans) with a 42.0 m, 84.0 m, 42.0 m (stayed spans).

Refer to drawing 4300392/1700/106 in Appendix A.

4.7.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

4.7.3 Whole life costs

Whole Life Costs have been calculated over a period of 120 years. See Appendix B.

4.7.4 Key risks particular to this option

None.

4.7.5 Assumptions particular to this option

None.

4.7.6 Departures from standards particular to this option

The deck is not designed as an aerodynamic box for reasons of economy. Wind flutter is not expected to be an issue, although wind tunnel tests may be required to prove the design.

4.7.7 Benefits and Dis-benefits

Benefits

- The cable stayed bridge would be a gateway structure, which may bring economic benefits in the longer term
- Aesthetically pleasing
- Reduced footprint within the flood plain
- Relatively simple to construct in this location compared to more conventional cable-stayed construction for this type of highway bridge.

Disadvantages

- The erection of pylons and deck is more complex and un-practiced compared to the other more conventional.
- The construction sequence will require significantly more lifts and working at height than all other options.
- The steel towers and elevated cables will be awkward to inspect and maintain.
- The cables preclude the use of maintenance access from above. Inspection and maintenance will necessitate access to the underside via a maintenance access road and stairs within the towers to view the cable ends.
- Open soffit may encourage nesting of birds.

5 Abutment Options

5.1 Abutment 1: Wing Walls Perpendicular to Abutment Face

5.1.1 Description

Abutment 1 offers in-line wing walls that are cantilevered off the abutment foundations and a viewing gallery behind the bearings for inspection and maintenance.

Refer to drawing 4300392/1700/101-106 in Appendix A.

5.1.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

5.1.3 Whole life costs

Whole Life Costs have been calculated over a period of 120 years. See Appendix B.

5.1.4 Key risks

None.

5.1.5 Assumptions

None.

5.1.6 Departures from standards

None.

5.1.7 Benefits and Dis-benefits

Benefits

- Inspection and maintenance of abutment bearings can be achieved without requirement of a temporary platform.
- The wing walls are cast integral with the abutment; therefore do not requir separate foundations.
- Parapets can be mounted directly onto the wingwalls

Dis-benefits

- The foundations require marginally deeper piles to accommodate the additional weight and loading of the wingwalls.

5.2 Abutment 2: Splayed Wing Walls with Inspection Gallery

5.2.1 Description

Abutment 2 is a reinforced concrete abutment with access from the footway into an inspection gallery. Independent wingwalls splayed at 45° from the abutment and founded on piles retain the embankment.

Refer to drawing 4300392/1700/107 in Appendix A.

5.2.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

5.2.3 Whole life costs

Whole Life Costs have been calculated over a period of 120 years. See Appendix B.

5.2.4 Key risks

None.

5.2.5 Assumptions

None.

5.2.6 Departures from standards

None.

5.2.7 Benefits and Dis-benefits

Benefits

- Inspection and maintenance of abutment bearings can be achieved without requirement of a temporary platform.

Dis-benefits

- Abutment 2 requires additional concrete works compared to Abutments 1 and 3.
- The stand-alone wing walls require discreet piled foundations.

5.3 Abutment 3: Splayed Wing Walls

5.3.1 Description

Abutment 3 is a reinforced concrete abutment with no bearing inspection gallery. Independent wingwalls splayed at 45° from the abutment and founded on piles retain the embankment.

Refer to drawing 4300392/1700/107 in Appendix A.

5.3.2 Estimated initial budget works estimate of carrying out the works

See Appendix B.

5.3.3 Whole life costs

Whole Life Costs have been calculated over a period of 120 years. See Appendix B.

5.3.4 Key risks

None.

5.3.5 Assumptions

None.

5.3.6 Departures from standards

None.

5.3.7 Benefits and Dis-benefits

Benefits

- Simplest abutment type for detailing and construction.

Dis-benefits

- Abutment 3 requires additional concrete works compared to Abutment 1,.
- The stand-alone wing walls require discreet piled.