CHAPTER 3

SELECTION OF OPTIMUM SOLUTION TO CROSS RIVER NILE AT JINJA

3. SELECTION OF OPTIMUM SOLUTION TO CROSS THE RIVER NILE AT JINJA

3.1 Overall Method of Selecting the Optimum Solution

3.1.1 Base Alignment Alternatives of the Project

The primary objective of the study is to examine the viability of the selected optimum solution for the development of the proposed Project. Several alternative schemes were therefore identified and evaluated from the viewpoint of engineering, economic/financial and natural/social environment studies.

In order to identify possible alternatives, reference has been made to previous studies conducted including the "Pre-investment Study for Nile Bridge at Jinja Uganda" by the World Bank (WB) and the "Study on Jinja Bridge Construction" by Japan International Development Institute (IDI). WB compared two alignment alternatives (A and B) and eventually recommended Alignment A. The IDI study identified alignment (C) at the downstream of the Nalubaale Dam Bridge as the most appropriate. These three alignment alternatives are outlined as shown in Table 3.1.1 and they have been adopted as the basis for elaborating other alternative alignments.

Table 3.1.1 Outline of Base Alignment and Bridge Location Alternatives

Name of Alignment	Name of Bridge Location	Description of Bridge Location
Alignment A	Bridge Location A	500 m upstream of Nalubaale Dam with river width of 300 m
Alignment B	Bridge Location B	1,200 m upstream of Nalubaale Dam, very close to Nile Bridge, with river width of 170 m
Alignment C	Bridge Location C	1800 m downstream of Nalubaale Dam with river width of 250 m

Source: JICA Study Team

The proposed project consists of a bridge portion and approach roads at both sides of the river banks. The two components were studied based on differing criteria but the planning and construction of the facility will have to be carried out appropriately so that they will eventually be connected to form a single alignment. For instance, the bridge should be located at the narrowest possible river width which would bring about the most economical construction cost. The alignment of the approach road on the other is concerned about natural/social environment, land use and engineering aspects. The selected alignment has to satisfy these requirements to avoid primary and/or secondary control points including public facilities, factories and residential houses, to the extent practicable.

In order to illustrate the optimum solution to cross the River Nile at Jinja, the definitions of a number of terminologies are described as follows:

3.1.2 Definition of Key Terms

In order to avoid confusion or ambiguity concerning the selection of alternatives, several of the key terms are defined hereunder.

- **[Route]** : This term delineates the general location of the bridge and the approach roads as a combined stretch drawn with some margin to allow possible adjustments of alignments within the space provided for the route.
- **[Bridge Location]** : This term refers to a place where the bridge crosses the River Nile.
- **[Alignment]** : This term defines the centreline of the approach road drawn on the basis of the adopted design standard, existing land use, environmental conditions along the route, and connecting a point along the bridge location.
- **[Bridge Type]** : This term is used to discuss the structural types of the bridge to be constructed along the bridge location.

The alternatives used for the discussions in selecting the optimum solution are presented in Table 3.1.2 and the conceptual diagram to illustrate the foregoing terms are exhibited in Figure 3.1.1.

Table 3.1.2 Definition of Key Terms

Study Report by	Route	Alignment (Alternative)	Bridge Location (Alternative)	Bridge Type
WB*	A	A	A	-
	B	B	B	-
IDI**	C	C	C	-
JICA Study Team	A	A1	A1	AA1, AA2, AA3, AA4, AA5
		A2	A2	
		A3	A3	
	B	B	B	BB1,BB2
	C	C1	C1	CC1, CC2, CC3, CC4
		C2	C2	

Notes: *"Pre-Investment Study" by the World Bank
**"Study on Jinja Bridge Construction" by IDI

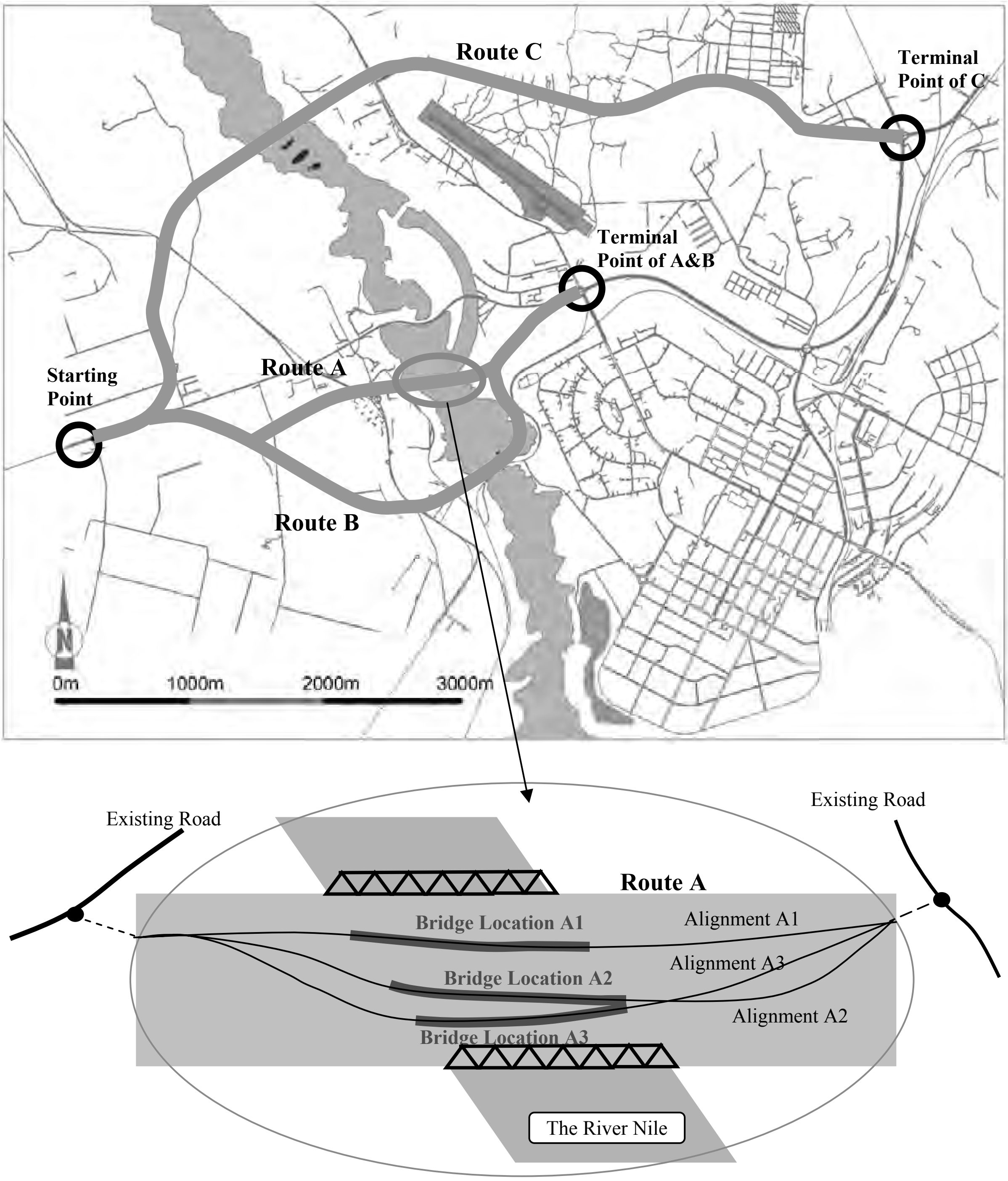


Figure 3.1.1 Conceptual Diagram of Key Terms for Selecting the Optimum Alignment

3.1.3 Methodology Flow in Selecting the Optimum Solution

Four (4) major steps were considered to realize the selection of optimum solution for the proposed Project.

<u>First Step:</u>

The three (3) base alignments proposed in the previous two studies were reviewed, and the alignments were identified at site and supplemented and confirmed with field investigations.

Second Step:

Additional alignments (composing of bridge locations and approach road alignments) were identified within the vicinity of the base alignments, and designated by routes, namely, Routes A, B and C.

Based on the field survey and engineering studies, Route A was provided with three (3) alignment alternatives, Route B one (1) and Route C two (2).

The study compared the above-mentioned alignment alternatives within the respective routes and selected the optimum solution as a representative alignment of the route.

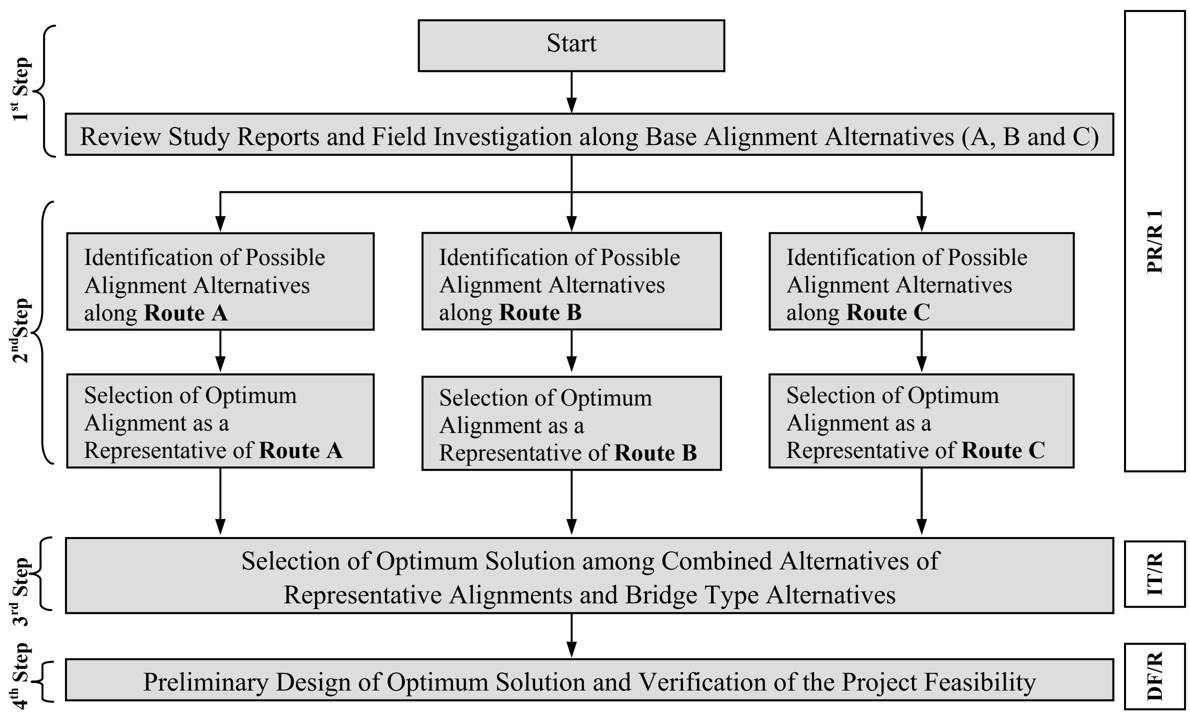
Third Step:

The representative alignment for each route was then combined with numerous possible bridge type options. Each representative alignment was provided with a minimum of two structural type options. Consequently, ten alternatives were compared to select the optimum bridge solution to cross the River Nile at Jinja.

Fourth Step:

Based on the optimum solution, preliminary design was conducted to estimate the total project cost to determine the viability of the proposed project.

Figure 3.1.2 shows the study procedure for the selection of the optimum alignment and bridge location.



Note: PR/R 1 (Progress Report 1), IT/R (Interim Report), DF/R (Draft Final Report)

Figure 3.1.2 Methodology Flow in Selecting the Optimum Solution

3.2 Review of Base Alignment Alternatives

3.2.1 Base Alignment Alternatives

Base Alignments A, B and C were derived from previous study reports namely, "Pre-Investment Study" and "Study on Jinja Bridge Construction". These three alignments are shown in Figure 3.2.1 and their features are described in the following sections.

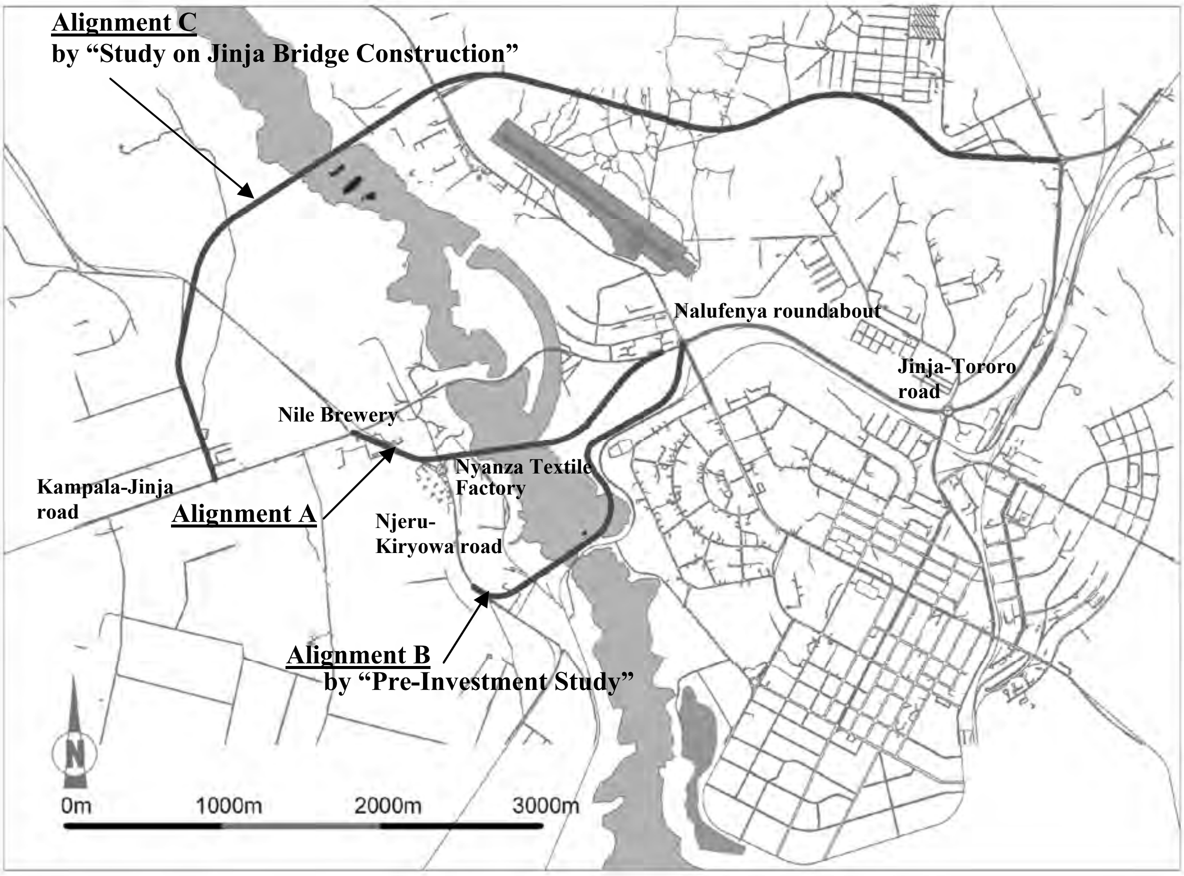


Figure 3.2.1 Base Alignment Alternatives

3.2.2 Description of Base Alignment A and Its Adjacent Area

The bridge Location for Alignment A is one of the places where the river width is relatively narrow along the section between Nalubaale Dam and the Nile (Railway) Bridge. The bridge crosses the River Nile upstream 500m from Nalubaale Dam. Nyanza Textile Factory is located in the left bank of the river where the width is approximately 300 m.

An excerpt from the "Pre-Investment Study (PIS)" Report conducted by the World Bank, for Alignment A is quoted as follows:

"The alignment commences at the roundabout of the Kampala–Jinja road and Njeru–Kiryowa road adjacent to the Nile Brewery. At a point 400m along the minor road, the alignment bears to the east and passes the north of the main building to come across the new office building of the former Nyanza Textile Factory complex before the river. Then, it crosses over the river towards the island near the Nalufenya (right) bank of the river. The alignment takes a slow bend before running between the Former Engineer's housing

and the Nalufenya Police Station. After passing this, the alignment bears north to intersect the Jinja–Tororo road to the west of the Nalufenya roundabout."(Unquote)

Based on the field survey conducted by the Study Team, it is noted that the PIS did not notice the presence of a warehouse and administration building located in the northern part of Nyanza Textile Complex. Although the Textile Factory itself was not affected, the two (2) facilities as mentioned above were affected.

3.2.3 Description of Base Alignment B and the Adjacent Area

The Bridge Location of Alternative B lies closely to the downstream of the Nile Bridge, located upstream, 1.2km from Nalubaale Dam, where the narrowest width of the river at 170m can be found.

Other possible river crossings are located further upstream of the Nile Bridge but are considered inappropriate in view of the following:

- the river width thereat ranges from 400m to 500m bringing about higher bridge development cost than Bridge Locations A and B,
- land acquisition would be difficult due to the presence of high class residential area and resort hotel close to the shore of the right bank of the river, and
- crossing the existing railway at both sides of the river bank would not be avoided.

Moreover, the river width downstream of Location B becomes very wide and the substation which is located on the left bank of the river would be difficult to relocate. In order to avoid the substation, an alignment has to be chosen in a location where the width of the river is wider and where the horizontal curve radius of curvature can be provided only for a design speed of 80 km/hr. Consequently, only one possible Bridge Location was selected as originally proposed in the Pre-Investment Study.

3.2.4 Description of Base Alignment C and Its Adjacent Area

Bridge location C is downstream of Nalubaale Dam near the Nile Resort Hotel at the right bank where the river is 450 m wide.

After the approach road crosses the bridge it bears to the existing road (Kimaka Bypass) passing north of Jinja Airfield and the Army Academy and ending up at Kamuli roundabout. Along this alignment, the most appropriate Bridge Location is found in a place where the river is about 450m wide. The left bank will require a new alignment setting considering the absence of existing road for connection with the location of the proposed bridge.

3.3 Selection of Alternative Alignments and Evaluation Method

3.3.1 Selection of Terminal Points for Alignment Alternative

The alignment alternatives have different terminals at both ends of each alignment and the bridges are located in-between. Since the geometrical alignment is heavily dependent on fixed points such as the bridge location and alignment terminals, the intersection of the alignment with existing roads are crucial.

The following should be considered in the selection of the most suitable location of the alignment terminal:

- The terminal point should be considered in conjunction with adjacent road network and the functional class of the road
- The terminal point should be located to avoid unnecessary engineering adjustments regarding linkage with the existing local road network and/or intersections.
- The terminal point should be selected taking into account adjacent land use plans and avoid areas where various types and shapes of intersections will have to be formed to connect the existing roads, and which are likely to lower the expected service level of the proposed alignment.

Initially, the western terminal of the Alternative Alignments for Routes A, B and C was generally set at a location of approximately 2,300 m west from the Nalubaale Dam along the Kampala–Jinja Road, while the eastern terminal of the Alignment Alternatives for Routes A and B was set at a location of about 1,300 m east from the Nalubaale Dam near the existing Nalufenya roundabout. The eastern terminal of the Alignment Alternatives for Route C was set near the existing Kamuli Roundabout.

Considering the above, the terminals of the Alignment Alternatives for Routes A, B and C were proposed tentatively as shown in Figure 3.3.1.

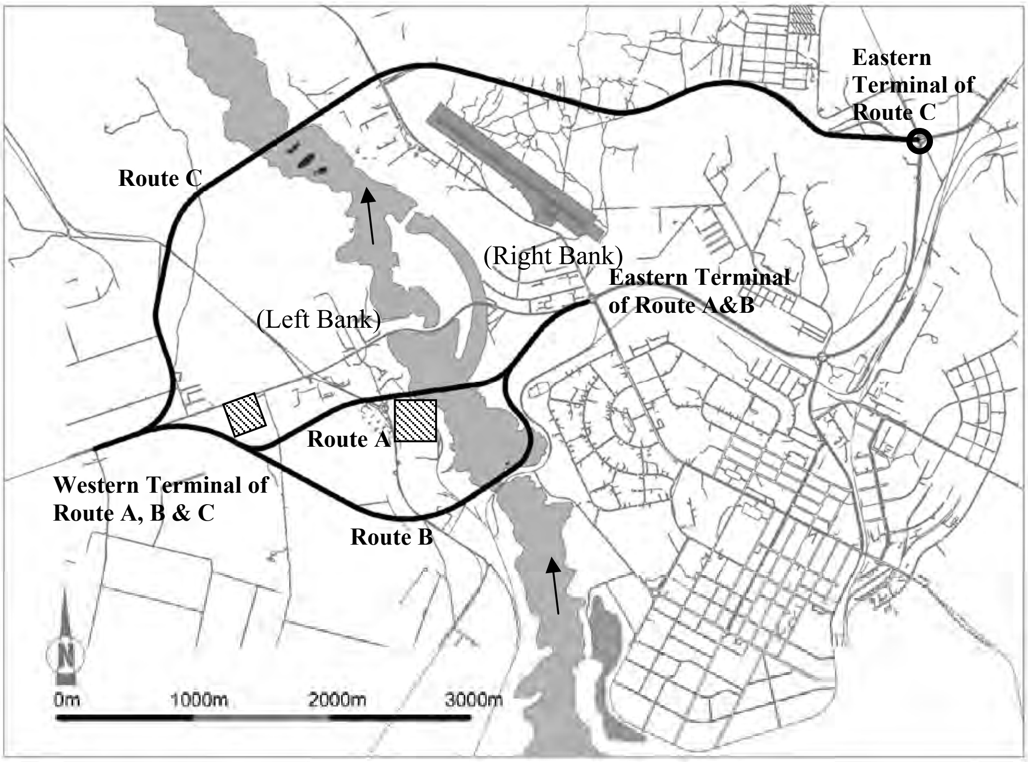


Figure 3.3.1 Proposed Terminal Locations of Route A, B and C

3.3.2 Selection of Possible Alignment Alternatives

Among the three (3) proposed Alignments A, B and C, Bridge Locations A and C have some possible bridge location alternatives taking into account the current land use conditions on both sides of the river and the planning of the bridge for length and span layout. The critical points to consider for the identification of possible bridge location alternatives for Bridge Locations A and C are listed as follows:

Bridge Location A

- Effect to Nyanza Textile Factory on the left bank of the river
- Effect to the Resort Facilities on the right bank of the river
- Construction cost relative to bridge length and span layout
- Aesthetic view

Bridge Location C

- Effect to the resort facilities both on the left and right banks (Nile Resort Hotel, Mto Moyoni) of the river
- Dam failure risk
- Construction cost relative to bridge length and span layout
- Aesthetic view

Comprehensive evaluation was made on a qualitative basis at this stage.

3.3.3 Evaluation Method

The following criteria were adopted for the evaluation of the alternative alignments:

Criterion I: Engineering (Weight: 20)

Achievement of the engineering level varies depending on the country or implementing agency due to diverse historical background, experience, regional condition, maintenance capability among other conditions. In this connection, it is noted that construction of long span bridge has never been done in Uganda thus posing enormous challenge. Given these conditions, the design and construction methodologies to be adopted should be evaluated from the engineering point of views in determining the optimum alignment and bridge type.

Criterion II: Social and Natural Environmental Considerations (Weight: 40)

The social and natural environment issues are always critical to infrastructure development and mitigation measures against possible adverse environmental concerns should be seriously dealt with. Resettlement and land acquisition issues are crucial factors to be reckoned with in determining the viability of the project that would have a bearing on the time frame for the implementation of the project. For project that requires immediate implementation such as the proposed construction of a second bridge across the River Nile, this criterion must be given heavier weight among any other criteria.

Criterion III: Financial (Weight: 40)

The construction of all infrastructure projects are subject to financial restrictions, and for this reason utmost priority should be given to financial considerations to establish a viable project at a reasonable cost.

The criteria for financial evaluation are allocated with distinctive weights (scale ratio) as mentioned above, with due consideration to the importance of the viability of the project and each criteria are allocated with sub-criteria to assess its merits by index (+++, ++, + i.e. Good, Moderate, Poor). The evaluation results by the index method are summarised at each criterion level and each of the results are weighed based on the aforesaid factors.

3.4 Selection of Optimum Alignment by Route

3.4.1 Selection of Optimum Alignment for Route A

(1) Preliminary Horizontal Alignment

The alignments, in general, run parallel to the existing road. There are no substantially sensitive or large scale private or public facilities to be affected should the development be pursued along the route except for certain minor facilities. Given these conditions, the alignments were designed for shorter stretches and smoother approach from the terminal points to the bridge. Sketches of the Alignment Alternatives are exhibited in Figure 3.4.1.

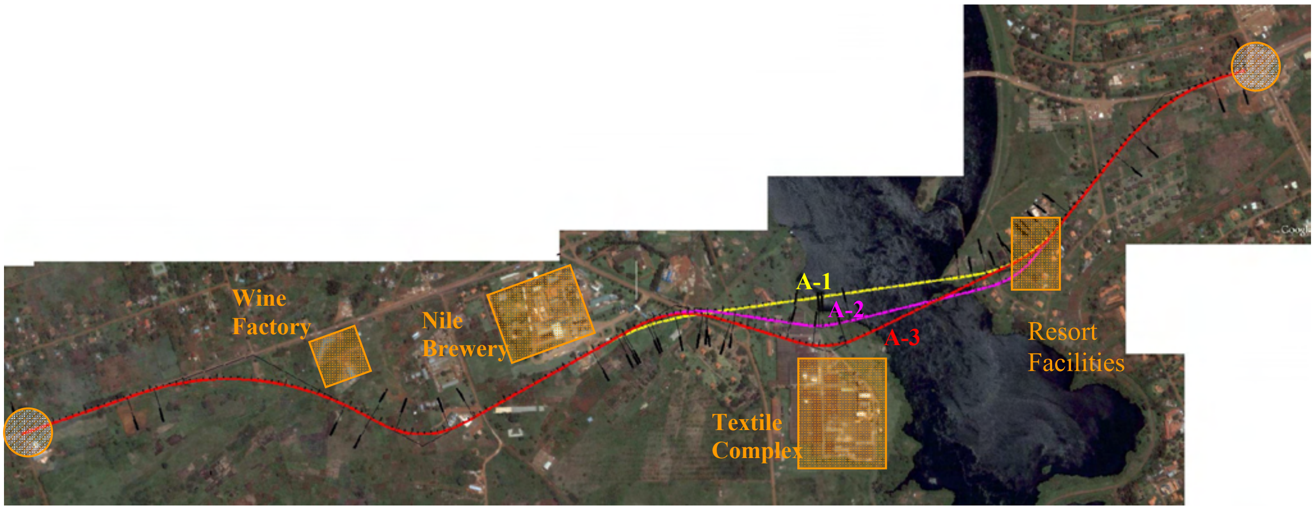


Figure 3.4.1 Outlines of Alignment Alternatives A-1, A-2 and A-3

As can be seen in the above figure, the alignment has been established to avoid Nyanza Textile Factory, considering the type of bridge and span as basis in determining the viability of the following three (3) Bridge Locations.

Bridge Location A-1: This alternative was chosen to minimize Nyanza Textile Factory from being affected by the development with the exception of a canteen and an accommodation building being affected. For this case, based on tolerable geometric requirements, the use of the island at the right bank of the river is not viable because the recreational facilities thereat would wholly be affected. The length and span of the bridge for this alternative would be the longest among the three alternatives (A-1, A -2 and A-3).

Bridge Location A-2: Compared to Bridge Location A-3, the development of Location A-2 will have a lesser impact to Nyanza Textile Factory as an agreement made with the owner for the relocation of affected facilities. Consequently, this alternative will provide limited adverse impacts to Nyanza Textile Factory, particularly for the warehouse and administration building. A bridge pier will be constructed on the island near the right bank of the river.

Bridge Location A-3: The bridge will cross the River Nile with the shortest distance. The bridge pier will be constructed on the island near the right bank of the river. This Bridge Location will provide the least bridge construction cost but certain facilities of Nyanza Textile Factory producing substantial production capacity would have to be demolished.

These three (3) Bridge Locations are shown in Figure 3.4.2.

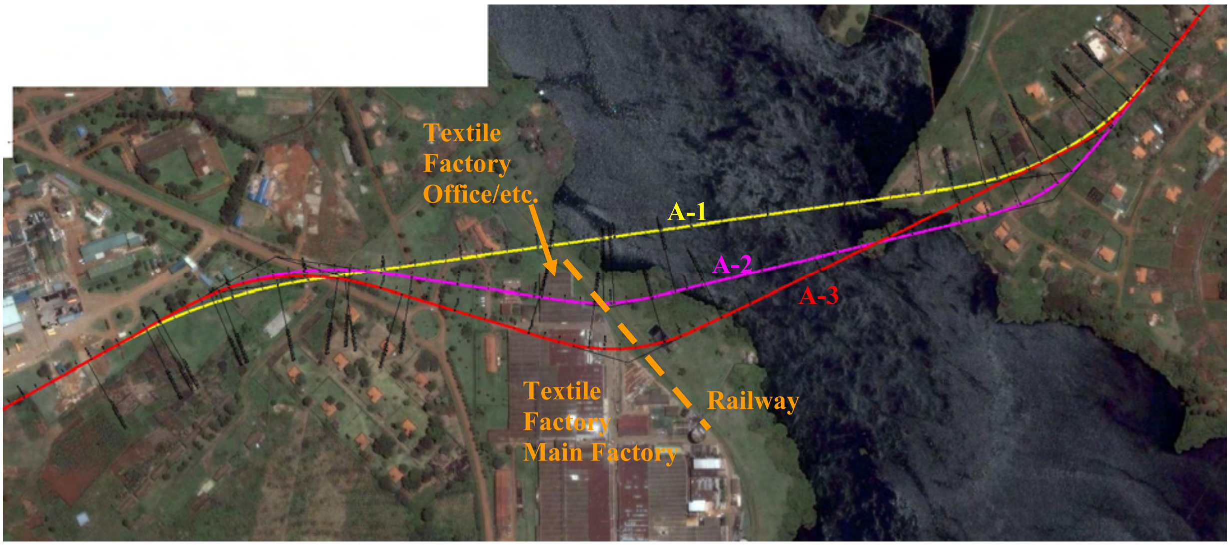


Figure 3.4.2 Alignment and Bridge Location Alternatives A-1, A-2 and A-3

Based on ideal alignment design, Alignment A-1 will relatively use a small radius of curvature ranging from 400m to 420m for the bridge approach. This horizontal alignment is acceptable provided that the design speed is restricted to 80 km/hr. Alignments A-2 and A-3 will use a minimum radius of curvature of 240 m which is the absolute horizontal alignment for a design speed of 80 km/hr.

For social environmental aspect, resettlement of facilities to be affected by the development of alternatives is listed as follows:

- Alignment A-1 : 11 units.
- Alignment A-2 : 11 units
- Alignment A-3 : 13 units

(2) Preliminary Vertical Alignment

Considering that the proposed project site is located in an urban area with potential for further urbanization in the future, the vertical alignments should be designed to maintain the existing ground level, to ensure a levelled access to adjacent plots.

Additionally, the design should minimize the vertical change points which are a normal practice in vertical setting for road of high design speed.

(3) Bridge Type

For Alignment A, a cable-stayed bridge with an approximate main span of 300 m, 194 m and 194 m, and side span of 125 m, 145 m and 130 m for Bridge Locations A-1, A-2 and A-3, respectively is deemed most appropriate. The cable-stayed bridge is planned based on the conditions that no piers/foundations will be constructed in the river except in shallow depths.

Construction of piers/foundations in the river would entail the erection of huge temporary cofferdam and construction of a jetty when the water depth is approximately 20m or the use of special technique such as caisson foundation which would need casting yard and tug boats. Excavation on foundation rock would also require the use of advanced techniques and costly method of construction. A cable-stayed bridge with centre and side spans is considered as the most economical.

(4) Optimum Alignment and Bridge Location for Route A

Tables 3.4.1-1, 2, 3 summarises the evaluation made based on the concepts described above.

Based on the result of the evaluation, Bridge Location A-2 is recommended having achieved the highest score among the three (3) alternatives.

Table 3.4.1-1 Evaluation of Bridge Location in Alignment A

Bridge Location	**Bridge Location A-1**
Probable Bridge Type	3 Span Cable Stay Bridge with Prestressed Concrete Deck
Bridge Length	550 m
Span Arrangement	125 m + 300 m + 125 m
Bridge Profile	
Outline	• Road alignment was established for minimum impact on the Textile factory, total length of the Alignment is 3,974 m. • Probable cost-effective bridge is a 3-span cable stay bridge with prestressed concrete deck and reinforced concrete pylons, • Number of piers in the river is minimal considering costly foundations, temporary cofferdam and jetty, • One pylon is expected to be constructed in shallow depth near the left bank, and the other at the right bank, • Foundations of pylons may be the caisson type bearing on rock, which will need a flat base. Abutment foundation will be spread foundation on rock.
I. Engineering (20)	
Constructability Issue	• Dynamite and/or non-explosives demolition agent may be required for rock excavation, • Concrete pylon would use jumpform techniques with cable stay anchorages cast into defined locations. • Two pylon foundations should be constructed in deep water.
	++
Construction Risk	• This bridge type and size have never been constructed in Uganda. To ensure good quality and completion schedule, local contractors & workers will have to be trained otherwise international contractors may have to be engaged • Future maintenance work might be required for the stay cables and anchorages.
	++
Road Alignment	• Total length of the Alignment is 3,974 m which is shortest among the three alternatives • Relatively small radius of curvature (R=400, 420) will be applied to the approach of the Bridge which is a tolerable horizontal alignment for design speed of 80 km/hr.
	+++
Maintenance	• Periodic inspection work will be required for the stay cables and anchorages. • Maintenance work might be required for the stay cables and anchorages for possible corrosion and cable cut if found.
	++
Sub-Total	9
Modified Sub Total	9/12x20=15.0
II. Social Environment (40)	
Land-use Issues	• Minor facility of the Textile factory will be affected
(Textile Factory)	+++
Nos. of Facility to be Affected	• 11 facilities will be affected.
	+++
Sub-Total	6
Modified Sub Total	6/6x40=40
III. Cost Effectiveness (40)	• Most costly due to the longest bridge length.
	+
Sub Total	1
Modified Sub Total	1/3x40=13.3
Total Score	**68.3**

Table 3.4.1-2 Evaluation of Bridge Location in Alignment A

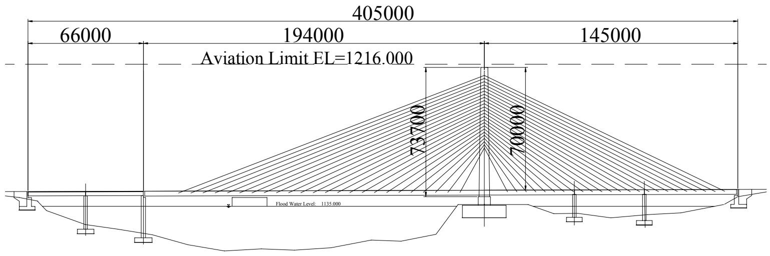
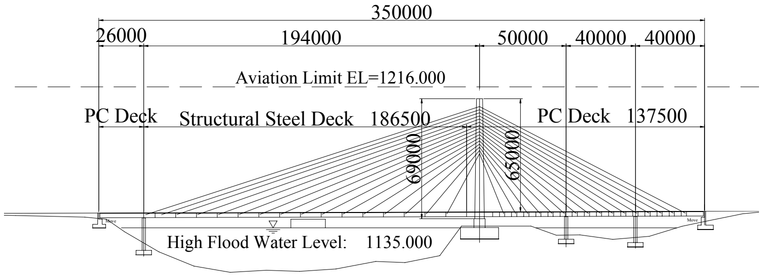
Bridge Location	**Bridge Location A-2**
Probable Bridge Type	4 Span Hybrid Cable Stay Bridge with Structural Steel & Prestressed Concrete Deck
Bridge Length	405 m
Span Arrangement	260 m + 65 m + 2 x 40 m
Bridge Profile	
Outline	• Road Alignment was set to provide medium impact on the Textile factory, the total length of the Alignment is 4,015m • Probable cost-effective bridge is 4-span cable stay bridge with prestressed concrete deck and reinforced concrete pylon, • Number of piers in the river is minimal i considering the costly foundation works, temporary cofferdam and jetty, • The pylon will be constructed on the island in the river, • Intermediate piers will be required to resist uplift pressure for the short span, • Foundations of pylons and intermediate piers may be of caisson bearing on rock, which need flat base. Foundations of abutments will be spread foundation on rock.
I. Engineering (20)	
Constructability Issue	• Dynamite and/or non-explosives demolition agent may be required for rock excavation. • Concrete pylon would use jumpform techniques with cable stay anchorages cast into defined locations. • Four pier foundations should be constructed in the river.
	++
Construction Risk	• This bridge type and size have never been constructed in Uganda. To ensure good quality and completion schedule, local contractors & workers would have to be trained otherwise reputable international contractors may have to be engaged • Future maintenance work might be required on stay cables and anchorages.
	++
Road Alignment	• Total length of the Alignment is 4,015 m which is the 2nd shortest among the three alternatives • The alignment of the approach to the bridge will be consists of an abrupt reverse curve (R=240,400m) which is an absolute horizontal alignment for a design speed of 80km/hr
	++
Maintenance	• Periodic inspection work is required for the structural steel deck, stay cables and anchorages. • Maintenance work might be required for stay cables and anchorages for any defects such as corrosion and cable cut if found.
	++
Sub-Total	8
Modified Sub Total	8/12x20=13.3
II. Social Environment (40)	
Land-use Issues (Textile Factory)	• Attached facility (Office building, Store) to the Textile factory will be affected
	++
Nos. of Facility to be Affected	• 11 facilities will be affected.
	+++
Sub-Total	5
Modified Sub Total	5/6x40=33.3
III. Cost Effectiveness (40)	• Estimated cost is moderate due to the 2nd longest bridge length.
	++
Sub Total	2
Modified Sub Total	2/3x40=26.7
Total Score	**73.3**

Table 3.4.1-3 Evaluation of Bridge Location in Alignment A

Bridge Location	**Bridge Location A-3**
Probable Bridge Type	4 Span Hybrid Cable Stay Bridge with Structural Steel & Prestressed Concrete Deck
Bridge Length	350 m
Span Arrangement	220 m + 50 m + 2 x 40 m
Bridge Profile	
Outline	• Road alignment and bridge location were determined to obtain shortest bridge length, total length of the Alignment is 4,032m • Probable cost-effective bridge is 4-span cable stay bridge with prestressed concrete deck and reinforced concrete pylon, • Number of piers to be constructed in the river will be minimal to avoid costly foundations, temporary cofferdam and jetty, • The pylon will be constructed in an island in the river, • Intermediate piers will be required to resist uplift forces in the short span direction • Foundations of the pylons and intermediate piers may be constructed of caissons bearing on rock, with flat base. Foundations of abutments will be spread foundation on rocky layer.
I. Engineering (20)	
Constructability Issue	• Dynamite and/or non-explosives demolition agent may be required for rock excavation. • Concrete pylon would use jumpform techniques with cable stay anchorages cast into defined locations. • Three pier foundations will be constructed in the river.
	++
Construction Risk	• This bridge type and size have never been constructed in Uganda. To ensure good quality and completion time, local contractors & workers needs to be trained otherwise reputable international contractors may have to be involved • Future maintenance work will be required for the stay cables and anchorages.
	++
Road Alignment	• Total length of the Alignment is 4,032 m which is the longest among the three alternatives • The alignment of the approach to the bridge will form an abrupt reverse curvature (R=240,300m) which is an absolute horizontal alignment for design speed of 80km/hr
	+
Maintenance	• Periodic inspection work will be required for the structural steel deck, stay cables and anchorages. • Maintenance work may be required for stay cables and anchorages for any defects such as corrosion and cable cut if found.
	++
Sub-Total	7
Modified Sub Total	7/12x20=11.7
II. Social Environment (40)	
Land-use Issues (Textile Factory)	• The main facility of the Textile factory will be affected
	+
Nos. of Facility to be Affected	• 13 facilities will be affected.
	+
Sub-Total	2
Modified Sub Total	2/6x40=13.3
III. Cost Effectiveness (40)	• The estimated cost is moderate because the bridge length is the shortest
	+++
Sub Total	3
Modified Sub Total	3/3x40=40
Total Score	**65.0**

3.4.2 Selection of Optimum Alignment for Route B

(1) Preliminary Horizontal Alignment

The critical factor for setting a horizontal alignment for Route B is the presence of an existing railway. The alignment should be designed so as not to cross the railway and to provide some distance from the railway.

The alignment traverses a swampy area where few facilities exist along the left side of the river bank. At the approach to the right bank of the river a minimum radius of curvature of 240m, (R=240m), will be provided as an absolute requirement for a design speed of 80km/hr. After crossing the river, the alignment will pass through the resort area that will require relatively expensive resettlements and compensations cost.

For social environmental aspect, the houses to be affected by the development are 17.

Figure 3.4.3.shows the outline of Alignment B.

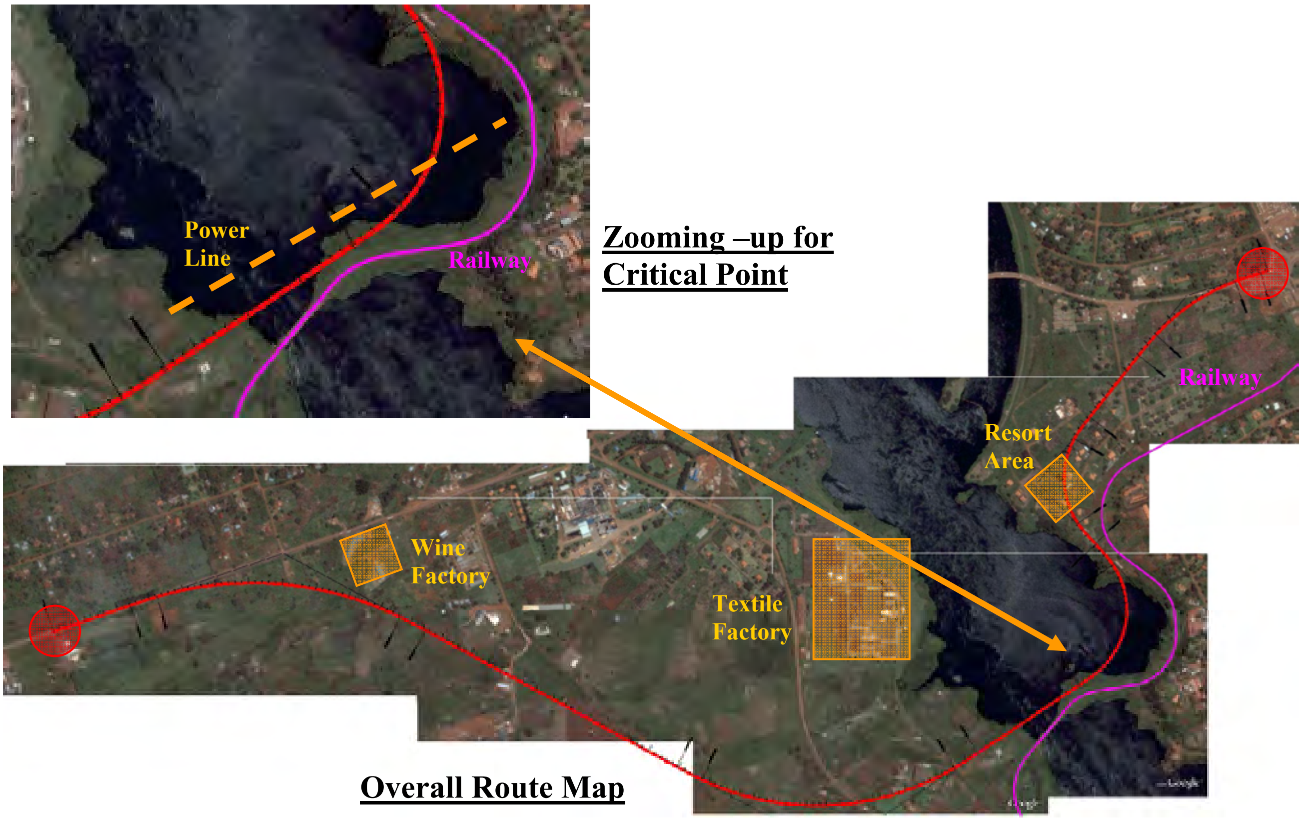


Figure 3.4.3 Outline of Alignment for B and Bridge Location B

(2) Preliminary Vertical Alignment

No particular control point (level) exists for the vertical alignment design. Since the difference in level between the river bank and water level at the bridge location is observed to be adequate, the vertical alignment was established as low as possible to minimize the size of the substructures of the bridge for economy.

(3) Bridge Type

The only possible alignment for Bridge Location B will run parallel to the existing Nile Bridge and the proposed bridge type is steel arch with steel truss girders at both sides over the navigable waterway with an approximate span of 80m. The total required span is estimated at 200m.

For aesthetics, the proposed bridge that will run parallel with the existing steel arch bridge, should also to be an RC arch bridge.

A side span over the small bay will be formed when the Nalubaale Dam is impounded and for this reason multi-span beams should be adopted for the most economical cost. Moreover, the water depth in the bay is observed to be shallow entailing lower cost for the construction of temporary cofferdam.

3.4.3 Selection of Optimum Alignment for Route C

(1) Preliminary Horizontal Alignment

The alignment alternatives were established in the northern part of the study area to form a bypass of the existing national road. The control points for the alignment setting are listed as follows:

(From starting point to ending point)

- Development of residential areas in Njeru : **a**
- Retreat Centre (Muto Muyoni): **b**
- Nile Resort Hotel: **c**
- Jinja Airfield: **d**
- Military Academy: **e**
- Development of residential areas in Jinja: **f**

The radius of curvature for the eastern section of Kimaka Bypass near Kamuli roundabout is rather small thereby not meeting the geometric requirements for a design speed of 80 km/hr. Therefore, the alignment for this section is recommended, for the proposed approach road, to divert the existing road to form a straight line up to Kumali roundabout. The alignment of the remaining road section is generally assessed as appropriate in satisfying the geometric requirements for a design speed of 80 km/hr.

The effects of the bridge crossing, bridge length and span were taken into account in setting the alignment for which the following two (2) alternative Bridge Locations were considered viable.

Bridge Location C-1: Bridge location for the narrowest section of the river of 230m, which is designated as Bridge Location C-1, is regarded as the most appropriate for Alignment C. However, this alignment will necessitate the removal of a part of the Nile Resort Hotel at the right bank of the river and totally violate the rights for the resort facilities on the left bank of the river.

Bridge Location C-2: Bridge Location C-2, is selected 200m upstream of Bridge Location C-1, passing through the island for the pier/foundation construction, so that the resort facilities at both the left and right sides of the river bank will not be affected

Figure 3.4.4 shows the location of the two bridges.

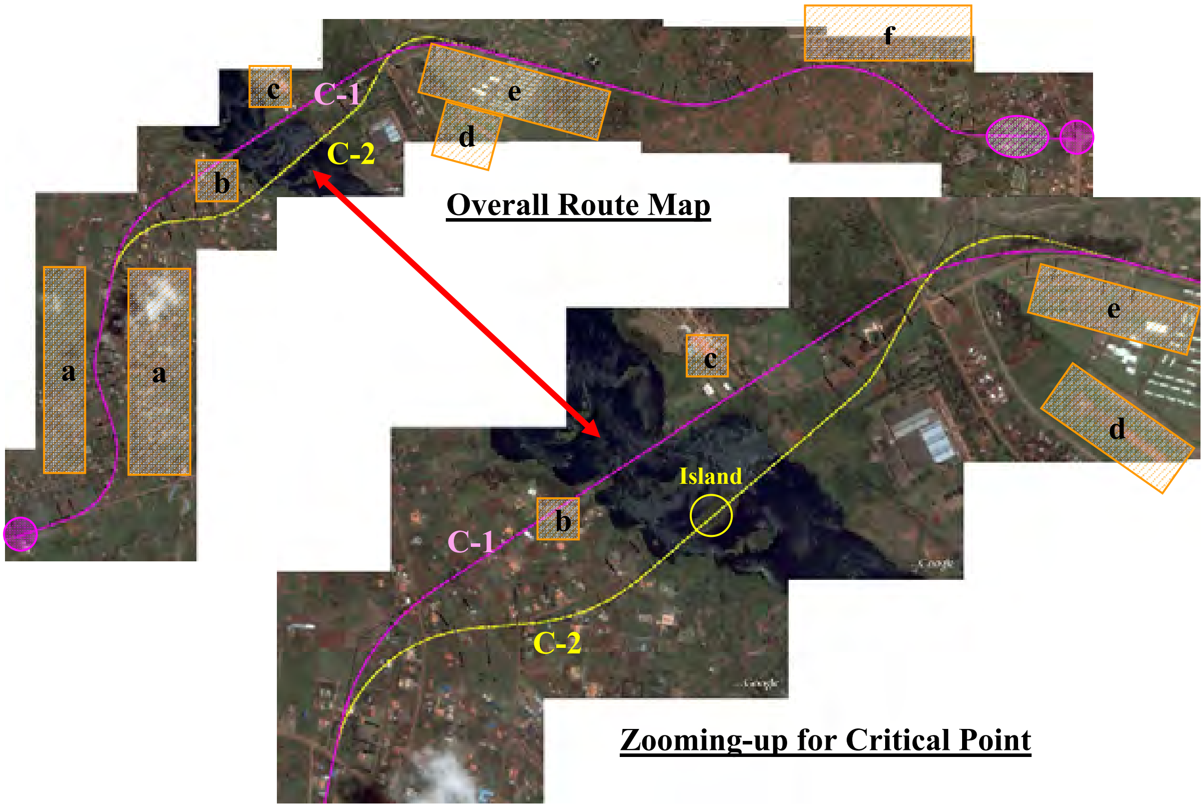


Figure 3.4.4 Outline of Alignment C and Bridge Location C

For the design of the horizontal alignment, Alignment C-1 was established to pass through the small peninsula at the right side of the river bank with minimum numbers of curvatures for crossing the river for the optimum alignment. Alignment C-1 will use a moderate radius of curvature of 600m for the bridge approach.

Alignment C-2 on the other hand will use the smallest radius of curvature of 240m and thereafter forming an abrupt short and smaller reverse curves making drivers feel uncomfortable, thereby lowering the degree of safety to certain extent. The only remedy is the imposition of a speed limit.

For social environmental aspects, Alignment C-2 will require the relocation of 56 existing facilities which is more than Alignment C-1. The difference between the two is at the bridge approach on the left side of the river bank where small houses exist. Relocation of facilities affected by these alternatives is listed as follows:

- Alignment C-1 : 45 units.
- Alignment C-2 : 56 units

(2) Preliminary Vertical Alignment

The existing terrain is hilly so that the vertical alignment of existing road shows significant undulation. The presence of poor soil and hard rock were not observed suggesting that difficulties for earthworks constructions will not be encountered.

The vertical alignment was designed to maintain the existing ground levels as much as practicable. In order to minimize vertical change points, fill and cut were given less priority than satisfying the required optimum vertical alignment.

The traces of slope failures seen at the both bridge locations suggest the need to design the vertical alignments without cutting the slopes.

(3) Bridge Type

The bridge to be adopted should be of the reinforced concrete arch type without any piers/foundations in the river. The arch span will be 235 m and 180 m long respectively for Bridge Locations C-1 and C-2. Among the numerous bridges, the RC arch type is considered economical since they do not require piers that necessitate the construction of expensive temporary cofferdam and jetty in the river.

Cable-stayed bridges with main span of 270 m and 250 m for Bridge Location C-1 and C-2 respectively are not viable due to the restrictions of the CAA for obstruction limitation for Jinja Airfield. This type of bridge would require about 65m and 60m high pylons from road top respectively.

For the approach spans, considering that the piers and foundations will be constructed on land without the need of constructing expensive cofferdam and jetty, the short -span beams will be provided with many substructures such as the multi-span pre-stressed concrete girders which are considered economical and therefore are recommended.

Consequently, the bridge types, for purposes of illustrating the optimum bridge location for Alignment C are described as follows:

Bridge Location C-1 : Single Reinforced Concrete Arch Bridge with Prestressed Concrete Precast Girders;

Bridge Location C-2 : Double Reinforced Concrete Arch Bridge with Prestressed Concrete Precast Girders.

These two (2) bridge types were chosen for discussion purposes for the optimum bridge location will be affected by possible damage should dam failure occurs. It is estimated that at the time of dam failure, water level will rise to approximately 4.5m above normal water level. Both abutments of the arch bridge for both Locations should therefore be constructed above flood water level for safety in the event of dam failure.

(4) Optimum Alignment and Bridge Location for Route C

Based on the above design descriptions for each Bridge Location, the evaluation was conducted as shown in Table 3.4.2-1, 2.

On the basis of the result of the evaluation, Bridge Location C-1 obtained a higher score than Bridge Location C-2.

Bridge Location C-1 was accepted as the optimum alignment for Route C in accordance with the result of the discussions with the Steering Committee. Nile Resort Hotel has also concurred with Bridge Location C-1.

Table 3.4.2-1 Evaluation of Bridge Location in Alignment C

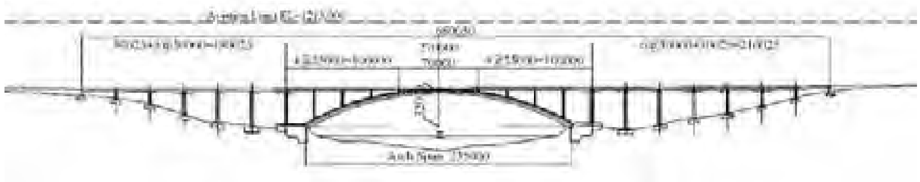
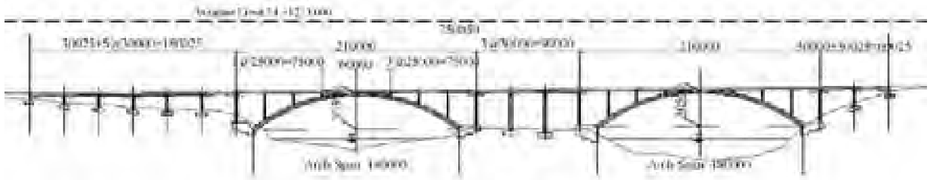
Bridge Location	**Bridge Location C-1**
Probable Bridge Type	Reinforced Concrete Arch Bridge + Prestressed Concrete Precast Girders
Bridge Length	660.05 m
Span Arrangement	30.025 m + 5 x 30 m + 270 m + 6 x 30 m + 30.025 m
Bridge Profile	
Outline	• Road alignment was established to achieve the optimum bridge location and alignment to be adopted for river crossing. The total length of the Alignment is 8,005 m. • Probable cost-effective bridge type is reinforced concrete arch with prestressed concrete precast girders for the approach. • No pier/foundation will be constructed in the river. • All structural elements will be above the flood water level should dam failure occur (estimated at 4.5m above normal water level).
I. Engineering (20)	
Constructability Issue	• Dynamite and/or non-explosive demolition agent may be required for rock excavation, • Arch member will be casted with cantilever method by supporting the arch with temporary stay cables anchored to temporary pylon anchored on the arch abutment. • Subsequently, the vertical members and concrete deck structure will be constructed on the arch member.
	+++
Construction Risk	• This bridge type and dimensions have never been constructed in Uganda. To ensure good quality and construction schedule, local contractors & workers would have to be trained otherwise reputable international contractors may have to be engaged • Basically the proposed structure is maintenance free except in special cases of dam failure.
	+++
Road Alignment	• Total length of the road is 8,005 m which is shorter than Alignment C-2. • Medium curvature of 600m (R=600) will be adopted for the approach to the bridge which is a moderate horizontal alignment design for the design speed of 80 km/hr.
	+++
Maintenance	• Periodic inspection will be required to ensure the realization of the design life period.
	+++
Sub-Total	12
Modified Sub Total	12/12x20=20
II. Social Environment (40)	
Land-use Issues	• The resort facility (Muto Muyoni) will be affected by the proposed development
(Textile Factory)	+
Nos. of Facility to be Affected	• 45 facilities will be affected by the development
	+++
Sub-Total	4
Modified Sub Total	4/6x40=26.7
III. Cost Effectiveness (40)	+++
Sub Total	3
Modified Sub Total	3/3x40=40
Total Score	**86.7**

Table 3.4.2-2 Evaluation of Bridge Location in Alignment C

Bridge Location	**Bridge Location C-2**
Probable Bridge Type	Reinforced Concrete Arch Bridge + Prestressed Concrete Precast Girders
Bridge Length	750.05 m
Span Arrangement	30.025 m + 5 x 30 m +210 m + 3 x 30 m + 210 m + 30 m + 30.025 m
Bridge Profile	
Outline	• Road alignment was established to minimize the effect on the resort facilities, to be brought about by the development. The Alignment is 8,079 m long in total • Probable cost-effective type of bridge is reinforced concrete arch over the river and prestressed concrete precast girders for the approach. • No pier/foundation will be constructed in the river. • All structural elements will be above the flood water level (estimated at 4.5m above normal water level) should dam failure occur
I. Engineering (20)	
Constructability Issue	• Dynamite and/or non-explosive demolition agent may be required for rock excavation, • Arch member will be casted with cantilever method and the arch will be supported by temporary stay cables anchored to the temporary pylon anchored on the arch abutment. • Subsequently, the vertical members and concrete deck will be constructed on the arch member.
	+++
Construction Risk	• This bridge type and dimensions have never been constructed in Uganda. To ensure good quality and construction completion time, local contractors & workers would have to be trained otherwise reputable international contractors may have to be engaged. • Basically maintenance free except in the special cases should dam failure occur
	+++
Road Alignment	• The road is 8,079 m long in total which is longer than Alignment C-1 • Since the alignment of approach to the bridge forms abrupt reverse curvature, making driver uncomfortable. Remedial measure is to reduce speed limit. • Minimum radius of curvature of 240m (R=240) will be adopted to the approach of the bridge, remedial measure by reducing speed limit may be required.
	+
Maintenance	• Periodic inspection work is required to ensure the realization of the design life period.
	+++
Sub-Total	10
Modified Sub Total	10/12x20=16.7
II. Social Environment (40)	
Land-use Issues (Textile Factory)	• The resort facilities will not be affected
	+++
Nos. of Facility to be Affected	• 56 facilities will be affected.
	++
Sub-Total	5
Modified Sub Total	5/6x40=33.3
III. Cost Effectiveness (40)	++
Sub Total	2
Modified Sub Total	2/3x40=26.7
Total Score	**76.7**

Consequently, the optimum alignments and bridge locations for Routes A, B and C were considered, based on the result of the evaluation scores shown in Tables 3.4.1-1 to 3.4.1-3 and Tables 3.4.2-1 to 3.4.2-2 and summarized in Table 3.4.3. The Steering Committee Meeting, held at UNRA Office on February 18, 2009, agreed on the chosen alignments/bridge locations based on the recommendation of the Study Team.

Table 3.4.3 Optimum Alignments for Routes A, B and C

	Route A	Route B	Route C
Optimum Alignment	A2	B	C1

Since A2, B and C1 terminologies are confusing for use in discussion of bridge type alternatives, Alignments A (or Bridge Location A), B (or Bridge Location B) and C (or Bridge Location C) were used in the succeeding sections in lieu of A2, B, and C1 respectively.

3.5 Selection of Optimum Bridge Type by Location

3.5.1 Selection Method

The optimum bridge design concepts for the three bridge locations are discussed hereunder. The technical problems and issues for the construction of the bridge will provide the critical information on the cost to determine the viability of the proposed project.

Figure 3.5.1 shows the selection process in determining the optimum bridge type and the optimum alignment/bridge location, based on the steps discussed in the following sections.

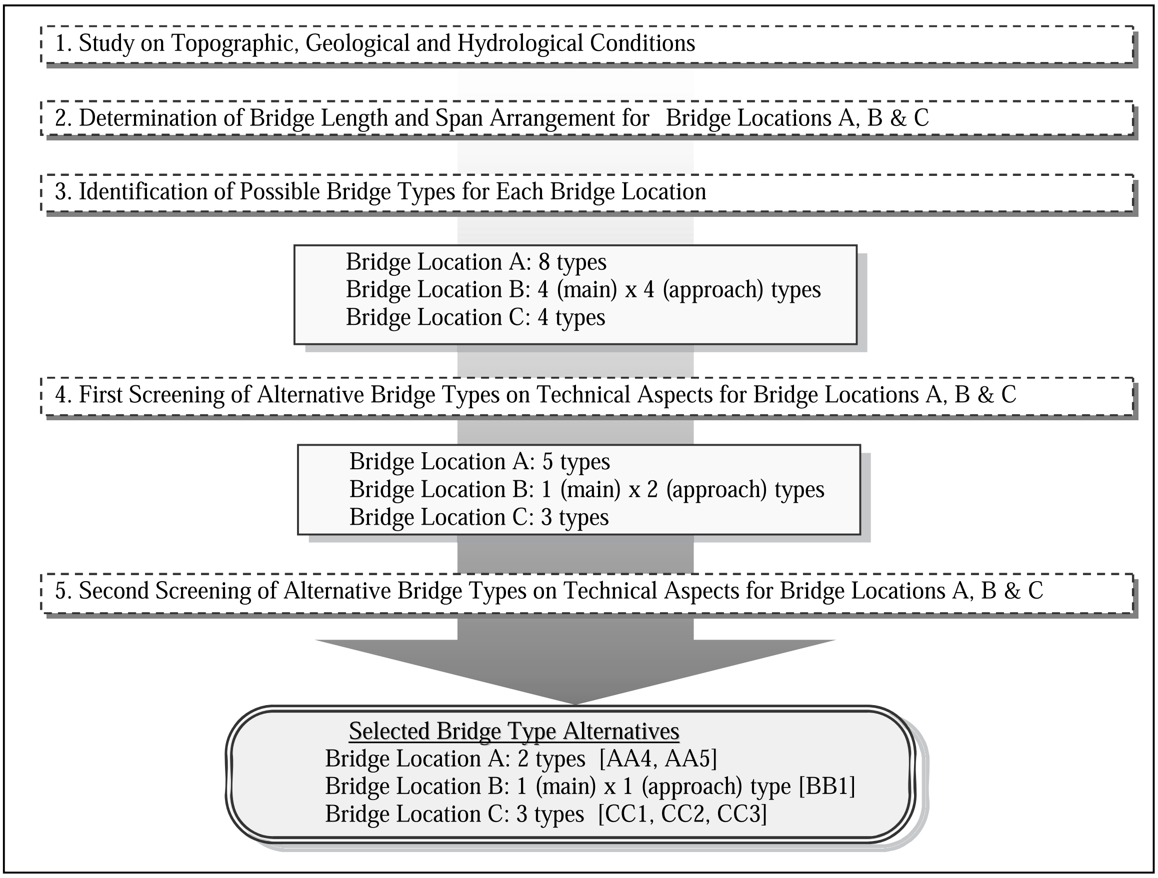


Figure 3.5.1 Flow Chart for Selecting the Optimum Bridge Types for Bridge Locations A, B & C

3.5.2 Topographic, Geological and Hydrological Conditions

Topographic, geological and hydrological conditions for each Bridge Location are described briefly as follows:

Bridge Location A

Bridge Location A is located 500 m upstream of Nalubaale Dam. The adjacent terrain is relatively flat with scattered houses and resort facilities exist on the right bank. Nyanza Textile Factory with production facilities, warehouse and administration office, accommodation building and canteen lies on the left bank. A small island with weathered rock exposure exists in the river close to the right bank.

A geological investigation was carried out based on two exploratory holes located on the left and right banks of the river. Boring was not conducted in water (river). Based on the boring investigation, the subsoil formation consists of gravel/boulder/cobble with sandy clay from ground level under laid by weathered, fragile and sound amphibolite rock with gneiss. The weathered conditions of rock strata were assumed to be stratified approximately horizontally without sharp undulation. The weathered rock may be adequate for use as base rock for the foundation of the bridge.

This location is between the Nalubaale Dam and the Nile Bridge where the river section is rather narrow, approximately 390 m wide. The average current speed was measured at 0.4 m/s, and the speed at flood is estimated at 1.0 m/s. The deepest depth is approximately 25 m. The river was muddy with low transparency.

Bridge Location B

Bridge location B lies downstream close to the Nile Bridge, some 1,200 m upstream from Nalubaale Dam. The narrowest part of the river is 170 m wide in the locality. The right bank is relatively flat, while the left bank is steep with an elevation difference of about 20 m. There is a small bay which forms at the right bank when the Nalubaale Dam is impounded.

Boring investigations carried out in one location on the right bank of the river indicated that the surface consists of sandy clay layer under laid by highly weathered, weathered and sound amphibolite rock. Boring was not made in water (river). The weathered conditions of rock strata were therefore assumed as stratified approximately horizontally without sharp undulation. The weathered rock may be adequate for use as base rock for the bridge foundation.

The average current speed was measured at 1.1 m/s, and the current speed at flood was estimated at 2.6 m/s. The deepest part of the river is approximately 22 m deep. The river was muddy with low transparency.

Bridge Location C

Bridge Location C is located 1,800 m downstream of Nalubaale Dam. The narrowest part of the river is in the downstream of the dam. The Nile Resort Hotel is located on the right bank while the Retreat Centre (Mto Muyoni) is on the left bank. The terrain is relatively steep with an elevation difference of approximately 40 m. Jinja Airfield at elevation of 1,171.671 m and an Aerodrome Surface Limitation are located to the east of the proposed Bridge Location. As part of the design criteria for the proposed Bridge Location, a restriction elevation of about 1216.000 m was imposed for the height of the structural members of the bridge particularly for the pylons of a cable-stayed bridge.

Geological investigation results obtained from a boring investigation at the right bank of the river revealed that the strata composed of residual lateritic soil with intervening sapprolite on the surface under laid by highly weathered, weathered and sound amphibolite rock. The SPT blow counts of the residual layer ranged from 10 to 20 without sapprolite and 50 or more with sapprolite. Sampling shows the presence of highly weathered rock consisting of small rock pieces. Boring investigation was not conducted in water (river). The weathered conditions of rock strata were assumed to be stratified approximately horizontally without sharp undulation. The weathered rock may be adequate for use as base rock for the bridge foundation.

Average current speed was measured at 1.2 m/s before Bujagali Dam was completed, with the flood current speed estimated at 2.4 m/s. The depth of the river is approximately 10 m at the deepest. The River was muddy with low transparency.

3.5.3 Determination of Bridge Length and Span Arrangement for Bridge Locations A, B & C

(1) Bridge Length

The bridge length was determined based on the following:

1. River width

2. Vertical alignment and Gradient of the approach road.

3. Navigation clearance.

4. Geological condition.

5. Balanced ratios of the centre span to side span for continuous deck, and of the tower height to centre / side spans for cable-stayed bridge.

6. Method of construction (considering the construction of the abutment on land).

The abutment should be 12 m high or less considering economical cost and applicable method of construction.

With the above in consideration, the shortest approximate bridge length appropriate to the respective bridge locations was established as follows:

- Bridge Location A : Approximately 405 m
- Bridge Location B : Approximately 620 m
- Bridge Location C : Approximately 660 m.

(2) Span Arrangement of the Bridge

The span of the bridge was determined as follows:

1. The navigation clearance was established at 20 m horizontal and 5 m vertical for Bridge Locations A and B above design high water level of EL.1135 m. Bridge Location C did not require navigation clearance.

2. The depth of the river of around 20 m or more for Bridge Locations A & B would require expensive construction of the piers/foundations and therefore short span bridges will not be economical.

3. The subsoil investigation results for Bridge Locations A & B showed the presence of extremely hard rock (sound amphibolites) spread over the riverbed at EL. around 1110 m.

Excavation of hard rock in deep waters will be impractical. Based on this condition, the minimum span of the bridge was determined by the location of foundations that will be installed on the upper layer of weathered rock. The water depth for Bridge Location C is comparatively shallow and this limitation will not apply.

Based on the above, the minimum span of the bridge was estimated at 145 m or greater (Figure 3.5.2).

Moreover, in the case of a long span bridge such as a Cable-stayed Bridge of more than 200 m long, the height of the pylon will be limited by the aerodrome surface limitation (Figure 3.5.3), and for this reason the span for all Bridge Locations will have to be limited.

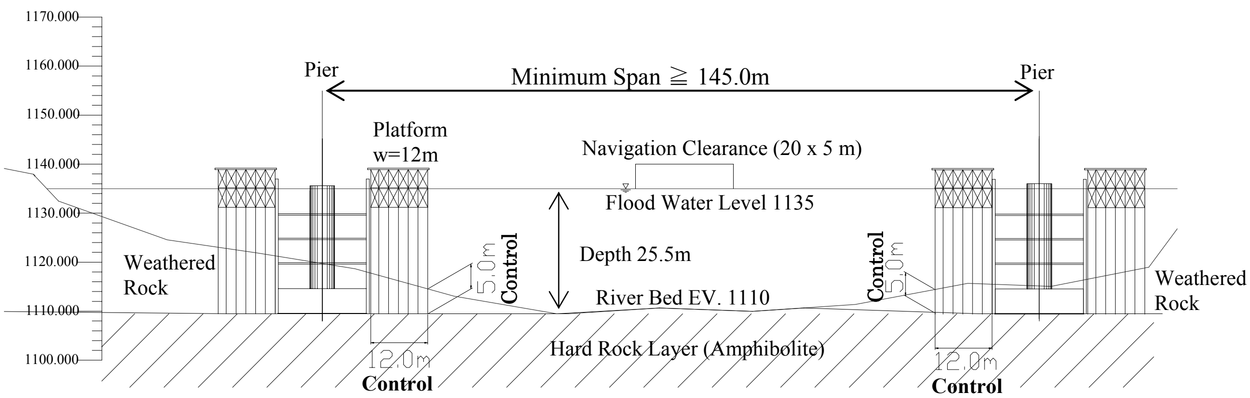
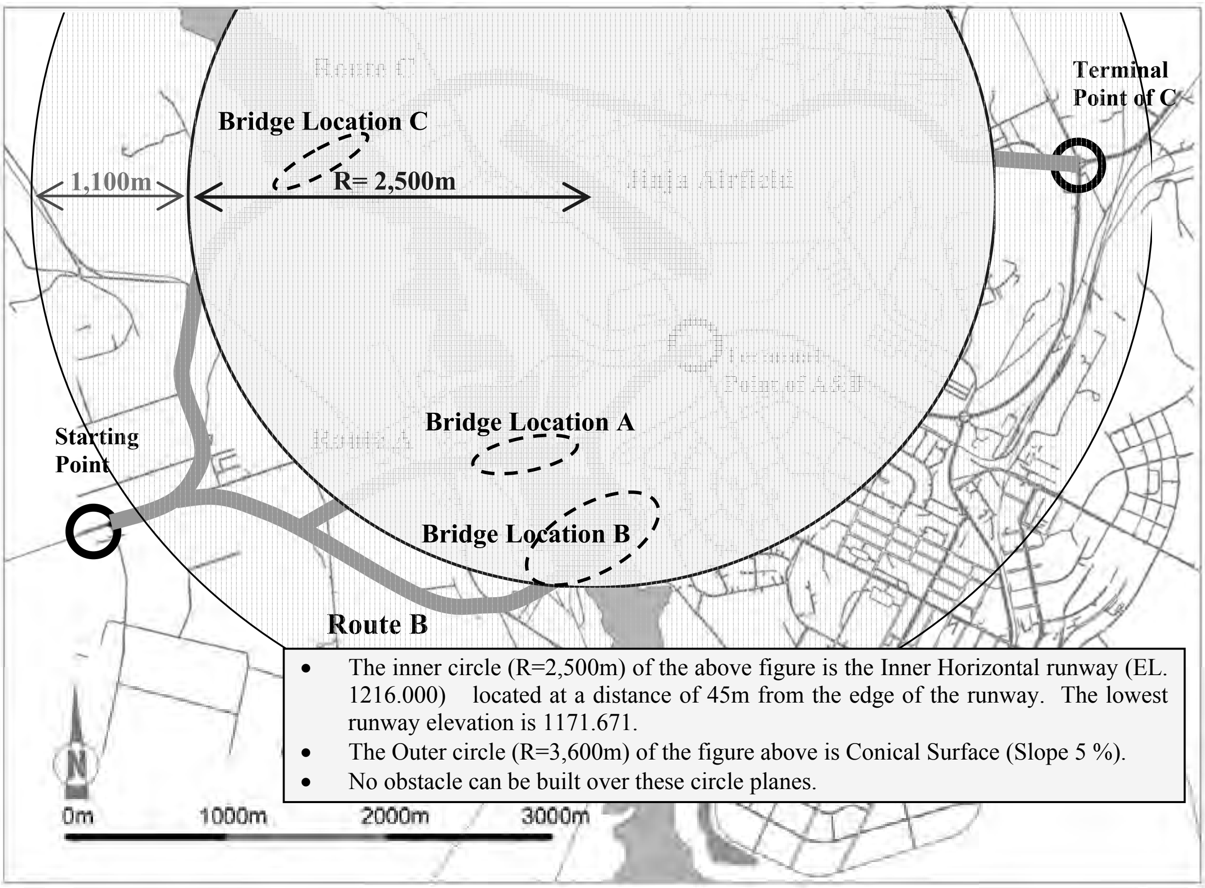


Figure 3.5.2 Method of Determining the Minimum Bridge Span (Ex. Bridge Location A)



- The inner circle (R=2,500m) of the above figure is the Inner Horizontal runway (EL. 1216.000) located at a distance of 45m from the edge of the runway. The lowest runway elevation is 1171.671.
- The Outer circle (R=3,600m) of the figure above is Conical Surface (Slope 5 %).
- No obstacle can be built over these circle planes.

Figure 3.5.3 Aerodrome Limitation of Jinja Airfield

3.5.4 First Screening of Alternative Bridge Types for Bridge Locations A, B and C

(1) Bridge Location A

There are various structural forms available for bridge spans ranging from 145 m or more. The method for the first screening of bridges is summarized in Table 3.5.1 below.

Table 3.5.1 First Screening of Bridge Type for Bridge Location A

	Bridge Type	Description	Evaluation
Steel Bridge	Continuous Box Girder	Steel plate deck was adopted for this type of bridge. Many bridges with span of 145 m exist in Japan. All steel girders must be imported from other countries. Construction and maintenance cost will be high.	Not applicable
	Continuous Truss	This type of bridge can accommodate long span bridges; however the structure is complicated, and the construction and maintenance costs will be high. Most of the steel members of the superstructure must be imported from other countries.	Not applicable
	Arch	Some difficulties will be encountered in assembling, transporting and erecting the superstructure in Uganda. Most of the members of the superstructure must be imported from other countries. The construction and maintenance cost will be high.	Not applicable
	Cable-stayed	Although the construction period is shorter, the construction and maintenance costs will be very expensive. Based on rough estimation, the direct cost for steel girders is about twice that of concrete. Most of the members of the superstructure must be imported from other countries.	Not applicable
Concrete Bridge	**PC Box Cantilever**	This type is commonly used worldwide for span as that required for the proposed project (ex. New Niari Bridge L=150 m and Kirifi Bridge L=185 m in Kenya). No major technical problems will be encountered in adopting this type of superstructure. However, some difficulties will be encountered for the construction of the foundations in deep water to be laid on shallow hard rock layer.	**Nominated to 2^{nd} screening**
	PC Extra-dosed	This type is commonly used worldwide for the span (ex. Abai Bridge L=145 m in Ethiopia). No major technical problems will be encountered in adopting this type of superstructure. Periodic inspection work is required for stay cables and anchorages. Several technical problems will be encountered for the construction of the foundations in the deep water that will be installed on shallow hard rock layer.	**Nominated to 2^{nd} screening**
	PC Cable-stayed	This type is commonly used worldwide for the span (ex. Arakawa Bridge L=260 m in Japan and My Tuan Bridge L=350 m in Vietnam). No major technical problems are encountered in adopting this type of superstructure. Periodical inspection work is required for stay cables and anchorages.	**Nominated to 2^{nd} screening**
	Cable-stayed (Composite)	The type of super structure considered is steel girders and concrete girders. The choice is rational considering the light weight advantage of steel girder (ex. Rama 8^{th} Bridge L=300 m + 175 m in Thailand). Preliminary calculations indicated the thickness of the lower flanges at 100 mm. Maintenance work (painting of the steel girders) will be required. Periodic inspection work is required for stay cables and anchorages. Construction of piers in deep waters will not be needed.	**Nominated to 2^{nd} screening**

As described in Table 3.5.1 above, four bridge types (PC Box Cantilever Bridge, PC Extra-dosed Bridge, PC Cable-stayed Bridge and Cable-stayed (Composite) Bridge) were considered as alternative bridge types for Bridge Location A. A more detailed comparison among the foregoing bridge types were carried out for the second screening process.

(2) Bridge Location B

Bridge Location B can be classified into the main bridge portion and the approach bridge portion. The main bridge portion will cross the main river at a relatively narrow section around 180 m wide. Being narrow, the current thereat is strong rendering it difficult to build a mid-stream foundation and pier. Therefore, the minimum span was set at 180 m.

The approach bridge portion crosses a small bay on the right bank. Since the radius of curvature of 240m is relatively short, possible bridge type is limited.

The first screenings for the main and approach bridge portions are shown in Table 3.5.2 and Table 3.5.3 respectively. The steel bridges were excluded due to the high construction and maintenance costs.

Table 3.5.2 First Screening for the Main Bridge Type for Bridge Location B

	Bridge Type	Description	Evaluation
Concrete Bridge	Cantilever PC Box	This type of bridges is commonly used worldwide for this span. The left side span of the main span however will be very short, and are unfavourable. The ratio of the centre span and side span of continuous girders must be balanced. The aesthetics of these bridge types would not blend with the adjacent Nile Bridge (Arch Truss Type).	Not applicable
	PC Extra-dosed		
	PC Cable-stayed		
	Arch	This type is commonly used worldwide for this span (ex. Bloukrans Bridge L=272 m in South Africa and Beppu Myoban Bridge L=235 m in Japan). No major technical problems will be encountered in adopting this type of superstructure. Periodic inspection work is required for the hanger cables and anchorages. This type will blend with the Nile Arch Bridge.	**Nominated for 2nd screening**

Table 3.5.3 First Screening of Approach Bridge Type for Bridge Location B

	Bridge Type	Description	Evaluation
Concrete Bridge	**Cantilever PC Box**	This type can support the load of a radius of curvature of 240m alignment structure. Some technical problems however, will be encountered for the construction of the foundations in deep water of more than 15 m.	**Nominated to 2nd screening**
	PC Extra-dosed	These types will be quite difficult to construct and costly to sustain the load of a radius of curvature of 240m alignment structure. Certain problems will be encountered for the cable structures.	Not applicable
	PC Cable-stayed		
	PC I-Girder	This type can support a radius of curvature of 240 m alignment structure. No major technical problems will be encountered for this type of superstructure. Certain technical problems will be encountered for the construction of the foundations in deep water of more than 15m..	**Nominated for 2nd screening**

As described in Tables 3.5.2 and 3.5.3, two bridge types (RC Arch Bridge with Cantilever PC Box Bridge and RC Arch Bridge with PC I-Girder Bridge) are the proposed alternative bridge types for Bridge Location B. In order to determine their precise viability, more detailed comparison among the bridge types was carried out for the second screening process.

(3) Bridge Location C

As mentioned earlier, the strong current is generated at the narrowest section of the river of approximately 200 m. Based on this condition, the building of foundation and pier at the mid stream will pose extreme difficulties. The river depths near both banks however are less than 7.0m deep which is rather shallow to allow the construction of foundation and pier.

Various structural forms will be listed for bridges spanning the range from 100 to 200 m. The bridge types were screened firstly as shown in Table 3.5.4. As stated previously, the Study did not consider the use of steel bridges due to the high construction and maintenance costs.

As described in Table 3.5.4, the Study proposed three bridge types (RC Arch Bridge, PC Extra-dosed Bridge, and Cantilever PC Box Bridge) as possible alternative bridge types for Bridge Location C for further screening.

Table 3.5.4 First Screening of Bridge Type for Bridge Location C

	Bridge Type	Description	Evaluation
Concrete Bridge	**Arch**	This type is commonly used for span of this extent worldwide, (ex. Bloukrans Bridge L=272 m in South Africa and Beppu Myoban Bridge L=235 m in Japan). No major technical problems will be encountered in adopting this type of superstructure. The construction of the arch rib however would be difficult and rather costly. PC I-Girder bridge will be adopted for both sides of the span.	**Nominated to 2nd screening**
	PC Extra-dosed	The maximum span for this type is 200 m (ex. Sannohe Boukyou Bridge L=200 m in Japan). No major technical problems will be encountered in adopting this type of superstructure. Periodic inspection work will be required for the stay cables and anchorages.	**Nominated to 2nd screening**
	PC Box Cantilever	This type is commonly used for the span worldwide (ex. New Niari Bridge L=150 m and Kirifi Bridge L=185 m in Kenya). No major technical problems will be encountered for adopting this type of superstructure.	**Nominated to 2nd screening**
	PC Cable-stayed	This type is generally applied for longer span bridges of more than 200m. For span of less than 200 m, the construction cost will remarkably increase compared to other bridge types. Periodic inspection work is required for the stay cables and anchorages.	Not applicable

(4) Conclusion

The following ten alternative bridge types were considered based on the result of the first screening for each bridge location.

Bridge Location A

- Bridge Type AA1 : Balanced Cantilever PC Box Girder Bridge
- Bridge Type AA2 : Extra-dosed PC Box Girder Bridge with PC I-Girder Bridge
- Bridge Type AA3 : 2-Spans PC Cable-stayed Bridge with PC I-Girder Bridge
- Bridge Type AA4 : 3-Spans PC Cable-stayed Bridge
- Bridge Type AA5 : 4-Spans Hybrid (Structural Steel & PC Deck) Cable-stayed Bridge

It should be noted that 2 types of span arrangements were considered for prestressed concrete cable-stayed bridge, i.e.,AA3 and AA4 for Bridge Location A.

Bridge Location B

- Bridge Type BB1 : RC Arch Bridge with 3-Span Balanced Cantilever PC Box Girder Bridge with PC I-Girders.
- Bridge Type BB2 : RC Arch Bridge with PC I-Girders

Bridge Location C

- Bridge Type CC1 : RC Arch Bridge with PC I-Girders
- Bridge Type CC2 : 3-Span Extra-dosed PC Bridge with PC I-Girders
- Bridge Type CC3 : 7-Span Balanced Cantilever PC Box Girder Bridge

3.5.5 Second Screening of Alternative Bridge Types for Bridge Locations A, B & C

This section describes the second screening made based on the above 10 bridge types.

(1) General

The main evaluation items for the second screening are based on technical and economical considerations as listed hereunder.

- Structural Properties of the bridge
- Method of Construction and Construction Period
- Construction Costs
- Maintenance

(2) Aesthetics Structural Properties

The properties and characteristics for each bridge type were compared with the previous descriptions in Section 3.5.4 (4), First Screening for Alternative Bridge Types for Bridge Locations A, B & C.

(3) Method of Construction and Construction Period

1) Foundations

The pier foundations for the main river were assumed to be resting directly on rock strata for which the most appropriate construction method would be caisson type. Piers and abutments constructed on land at Bridge Locations A and B were proposed to be founded on rock layer in shallow depth by spread foundations. For the approach piers and abutments at Bridge Location C however, appropriate bearing strata exist at approximately 30 m deep from the slope shoulder for which deep foundation is considered suitable. Considering economical cost and adverse impacts due to noise and vibration in the surrounding environment, cast-in-place concrete piles would be used.

The foundation costs for the second screening of alternative bridge types are estimated based on the above alternative types. Mid-stream foundation entails caissons constructed in the very deep depth with very hard riverbed. Considering this condition, the construction of the foundations may take long with considerably high cost. Table 3.5.5 shows the method of caisson fabrication and laying.

Table 3.5.5 Construction Method of Casting & Laying of Caissons

	Works for the Main River Pier	Works at the Caisson Yard	Remarks
1	Setting out the locations of the proposed works. (Select location with more than 20 m depth and 0.6 m/s current speed	Construct dry docking (assumed to be along the shoreline of Lake Victoria, east of Jinja Pier).	Requires independent environmental study and EIA for the construction of the dry dock. (Ramsar Convention restricts construction works within 100m from the River Nile and Lake Victoria
2	Construct temporary trestle structure	Construct concrete caisson (i.e. steel framework) for the installation of grouting pipes for filling of mortar (?) at the bottom of the caisson,, provide rubber protection to prevent the leakage of grouting and outlet pipe to drain water from the caisson bottom.	
3	Construct temporary working stage around the proposed pier.	Drag and tow the caisson to the wet dock. (Temporary working dock to be located downstream of the existing railway bridge where water current is low)	Requires the acquisition of tug boats
4	Blasting in water (or static blasting) of the foundation rocks for bridge pier work and excavate, disposing the excavated materials (repeated).	Construct temporary trestle structure and working stage around the proposed wet dock.	-Divers' work is difficult and slow. Divers with helmet and gears would be working under water in poor visibility conditions. -Blasting activities in water might adversely affect the intake water facilities of nearby factories and the fishery industry in the dam lake.
5	Trim and adjust the excavated bed to provide smooth surface for laying the caissons.	Construct temporary cofferdam for the caissons (i.e. steel framework for the caisson) at the wet dock.	Divers with protective helmets and gears will be working under water with low visibility
6	Towing of the caisson by tugboats.		-
7	Positioning the caisson at the proposed location. (By cable winch adjustment from anchoring points provided at both banks).		Positioning works is expected to pose difficulty since the adjustment of position would be made using anchoring points provided at both banks of the river. (Japan usually use anchoring concrete/steel blocks installed onto the riverbed to ensure precision adjustment by floating crane. Floating crane in Jinja however, is not available.)
8	Submerge and set the caisson in place (by filling water into the caisson)	Restoration of the dry dock and wet dock for the caissons.	-
9	Install preventive works around the bottom of the caisson to prevent leakage of underwater concrete.	-	Divers provided with helmet and protective gears will be working under water of more than 20m deep with low visibility.
10	Grouting by non-shrinkage concrete mortar beneath the bottom of the caisson	-	-
11	Placing of concrete blocks as counterweight and drying up of the inner caisson (i.e. removal of water in caisson).	-	-
12	Construction of foundation and pier structure in the caisson under the dry condition (supplying re-bars, erection, concrete supply and pouring)	-	-
13	Removal of the counter weight concrete blocks.	-	Disposal of concrete blocks weighing several hundreds of tons could cause .difficulties
14	Dismantling and removal of the temporary cofferdam	-	-
15	Commence superstructure works		

2) Substructures

The substructure would be constructed of reinforced concrete. “Jumpform” techniques will be used for construction of high piers.

3) Superstructures

A construction method which does not require temporary jetties or false works in the river will be adopted.

Balanced Cantilever PC Box Girder Bridge

The girders would be constructed on a pier. After the concrete placing for each block of approximately 2.0 – 4.0 m long, the top flange will be prestressed with the pier head of the other cantilever symmetrical blocks. After construction of the cantilevers have been completed and linked with the other cantilevers, prestressing of the bottom flange will be conducted for the final completion of the bridge.

The execution cycle for the construction of 1 block is about 14 days thereby the shortening of the construction period cannot be expected.

PC Cable-stayed Bridge

For the two spans, the side span on the Jinja side could be constructed by temporary false work. The main span from the pylon will be cantilevered and after the casting of concrete for each block, the associated cable stays at side span and main span will be stressed. This cycle will be repeated continuously until the completion of the main span.

Similarly for the three spans, the main and 2 side spans from the pylon will be cantilevered and after each block has been cast, the associated cable stays will be stressed.

The execution cycle for one block is about 16 days thereby the shortening of the construction period cannot be expected.

‘“Jumpform” techniques will be used for the casting of concrete for the cable-stayed anchorages into their allocated locations.

PC Extra-dosed Bridge

The erection work for this type of bridge can be executed in the same way as that of the PC Cable-stayed Bridge. The main and side spans from the pylons will be cantilevered and after the casting of each block, the associated cable stays will be stressed. This cycle will be repeated until the main span is completed.

The execution cycle for one block is about 16 days thereby the shortening of the construction period cannot be expected.

Arch Bridge

The reinforced concrete arch rib will be constructed at both sides of the riverbanks with extensive temporary works to ensure stability until the completion of the arch rib. Pylons using the Meran erection method for arch rib would be adopted for the 200 m span. The construction period would be shortened because most of the work will be on land, not in or over the water.

(4) Construction Cost

The construction costs of the various bridge alternatives for Bridge Locations A, B and C, consist of the following components:

- Bridge construction cost
- Approach road construction cost
- Maintenance Cost (considering a one hundred-year design life)
- Compensation cost (land acquisition, resettlement of houses and other buildings, and relocation of utilities).

(5) Maintenance

Bridge maintenance will be undertaken to ensure the service life of the structures and to guarantee that the facility will function as conceived, thereby ensuring public safety.

Life cycle costs have been estimated based on the following conditions:

- General Inspection: Few inspectors will be deployed for routine inspection.
- Primary Inspection: Detailed visual inspections will be undertaken every five or six years.
- Maintenance work: The different types of structure would necessitate separate maintenance method.

For instance, a steel bridge would require repainting, usually at every 20 – 30 years interval while 30 to 40% of the anchors for the cables in bridges by stay-cables or hanger-cables may require replacement once in one hundred years. Therefore, the maintenance cost of steel bridges and cable bridges would be higher during the service life (one hundred years) of the structure. Concrete bridges on the other hand will have the advantage of a lower maintenance cost than steel.

Maintenance tasks will be indentified through the inspections of the structures.

(6) Aesthetics

The new bridge would be Uganda's first long bridge located along the main international route (Northern Corridor) famous for its sight- seeing spots around the vicinity of the bridge locations. Excellent aesthetics is therefore an important aspect of the new bridge that must be considered.

The following aspects on aesthetics were considered::

- Expression of function
- Structural beauty (proportion, scale, and so on)
- Harmony with the surrounding environment

(7) Results of Second Screening

1) Comparative Analysis for Bridge Type Alternatives

Considering the foregoing conditions, the results of the second screening for each Bridge Location are shown in Tables 3.5.6 to Table3.5.8 and Figure 3.5.4.

Table 3.5.6 Technical Evaluation of Alternative Bridge Types in Bridge Location A

Bridge Type	AA1	AA2	AA3	AA4	AA5
Bridge Type	4-Span Balanced Cantilever PC Box Girder	Extra-dosed PC Box Girder with PC I-Girders	4-Span PC Cable-stayed with PC I-Girders	3-Span PC Cable-stayed	4-Span Hybrid Cable-stayed
Bridge Length	415.0 m	413.5 m	406.0 m	525.0 m	405.0 m
Span Arrangement	73.5m + 146.5m + 115m + 80m	73.5m + 146.5m + 73.5m + 4 x 30m	3 x 33m + 195m + 145m	100m + 290m + 135m	260m + 145m
1. Property of Structure	• Girder depth is 8.2m at the support. • Counterweight may be required to resist uplift forces at left abutment. • 2 piers will be constructed in deep water, which would require costly foundations, temporary cofferdam and jetty. • All bridge structures will be made of concrete, and major materials are available in Uganda.	• Depth of PC deck is about 4.0m, and pylon height is about 14.5m. • 2 piers will be constructed in deep water, which need costly foundations, temporary cofferdam and jetty. • PC Extra-dosed bridge will be used in deep water, and multi-span PC I-Girder is used in shallow water. • All bridge structures will be made of RC, and major materials except for cable systems are locally available.	• Girder depth is about 2.5m. • Since there is aerodrome air limitation, pylon height is limited to 70.0m. Due to this, cable-stayed bridge deck length is limited to 195.0m. Multi-span PC I-Girder bridge will be used for the left side. • 2 piers will be constructed in deep water, which would require costly foundations, temporary cofferdam and jetty works. • Intermediate piers will be required to resist uplift forces in the short span. direction • All bridge structures will be made of RC and major materials except for cable systems are available in Uganda.	• Girder depth is about 2.5m, and pylon height is 70.0m. • No piers will be constructed in deep water. • Left side span will be on land. • All bridge structures will be made of RC concrete, and major materials except for cable systems are available in Uganda.	• Girder depth is about 2.5m, and pylon height is 100.0m. • No piers are in deep water. • Structural steel and concrete are used respectively for long span deck and short span deck to alleviate unbalanced moment at base of pylon and to reduce uplift load. • Top of pylon is above aerodrome surface limitation. • Structural steel and cable systems are imported from overseas.
2. Constructability	• High Risk for the Construction of Foundation bearing on hard rock in Deep Water, which may cause expensive construction cost and longer construction period due to hard rock excavation. • Rock excavation will require dynamite and/or non-explosive demolition agent. • Bridge deck will be constructed of cast-in-placed RC balanced cantilever method from each pier with deck block length of 2.5 - 4.0m.	• High Risk and costly for the Construction of the Foundation bearing on hard rock in Deep Water, which may cause longer construction period due to hard rock excavation. • Rock excavation needs dynamite and/or non-explosive demolition agent. • Bridge deck for main span bridge is constructed by cast-in-place balanced cantilever method from each pier with deck block length of 3.5m.	• High Risk for Construction of the Foundation bearing on hard rock in Deep Water. Construction cost and longer construction period may be encountered due to hard rock excavation. • Rock excavation will require the use of dynamite and/or non-explosive demolition agent. • Bridge deck for the main span bridge will be constructed of cast-in-place RC concrete balanced cantilever method from each pier with deck block length of 3.0-4.0m. • Concrete pylon construction will use jump-form techniques.	• No Risk for Construction of Foundation • Bridge deck for the main span of the bridge will be constructed by cast-in-place RC concrete balanced cantilever method from each pier with deck block length of 3.0-4.0m. • Jump-form techniques will be used for the construction of the pylons	• Less Risk for Construction of Foundation bearing on hard rock in Shallow Water. • Bridge deck for short span is constructed by cast-in-place prestressed concrete on temporary platform. Using prestressed concrete deck as counterweight, steel girder is erected by cantilevered method. • Concrete pylon uses jump-form techniques.
3. Construction Period (Year)	3.1	3.3	3.7	3.5	3.3
4. Construction Cost					
A. Construction Cost (mil.US$)	65.1	69.3	72.8	67.7	66.6
- Bridge Portion	54.5	58.7	62.2	57.1	56.0
- Approach Road Portion	10.6	10.6	10.6	10.6	10.6
B. Compensation Cost (mil.US$)	2.3	2.3	2.3	2.3	2.3
Total (A+B)	**67.4 (1.00)**	**71.6 (1.06)**	**75.1 (1.11)**	**70.0 (1.04)**	**68.9 (1.02)**
C. Maintenance (100 years) Cost (US$), with 12% discount rate [without discount rate]	7,100 [335,000]	10,800 [741,000]	51,500 [4,317,000]	55,000 [4,472,000]	289,000 [10,907,000]
5. Maintenance	• Compared to other types of bridge, maintenance work will be minimal, except for the bridge bearings, expansion joints and drainage system.	• Maintenance work will be minimal except for the bridge bearings, expansion joints and drainage system. • Normal inspection for the cable systems will be required; however actual maintenance work will hardly be encountered.	• Less maintenance work except for the bridge bearings, expansion joints and drainage system. • Normal inspection for the cable systems will be required; but actual maintenance work will be hardly encountered.	• Less maintenance work except for the bridge bearings, expansion joints and drainage system. • Normal inspection for the cable systems will be required; but actual maintenance work will be hardly encountered.	• Maintenance work such as re-painting is necessary for structural steel deck. • Normal inspection for the cable systems will be required; but actual maintenance work will be hardly encountered.
6. Bridge Aesthetics	• Common bridge. Not very impressive as a symbol or landmark.	• Not very impressive due to the short pylon; but it can be a symbol landmark in the region.	• It can be a symbol and landmark.	• It can be a symbol and landmark.	• It can be a symbol and landmark.
Evaluation	**Not Recommended** (Although construction cost is the cheapest, there are high risks for foundation construction in deep water)	**Not Recommended** (Although construction cost is cheaper than Bridge Type AA4, there are high risks for foundation construction in deep water)	**Not Recommended** (Construction cost is higher than Bridge Type AA4, and there are high risks for foundation construction in deep water)	**Recommended** (Although construction cost is not the cheapest, there is no risk in construction)	**Recommended only if the aviation limit is lifted** (Although construction cost is almost equal to Bridge Type AA4, the pylon infringes aerodrome surface limitation. It needs skilled maintenance works.)

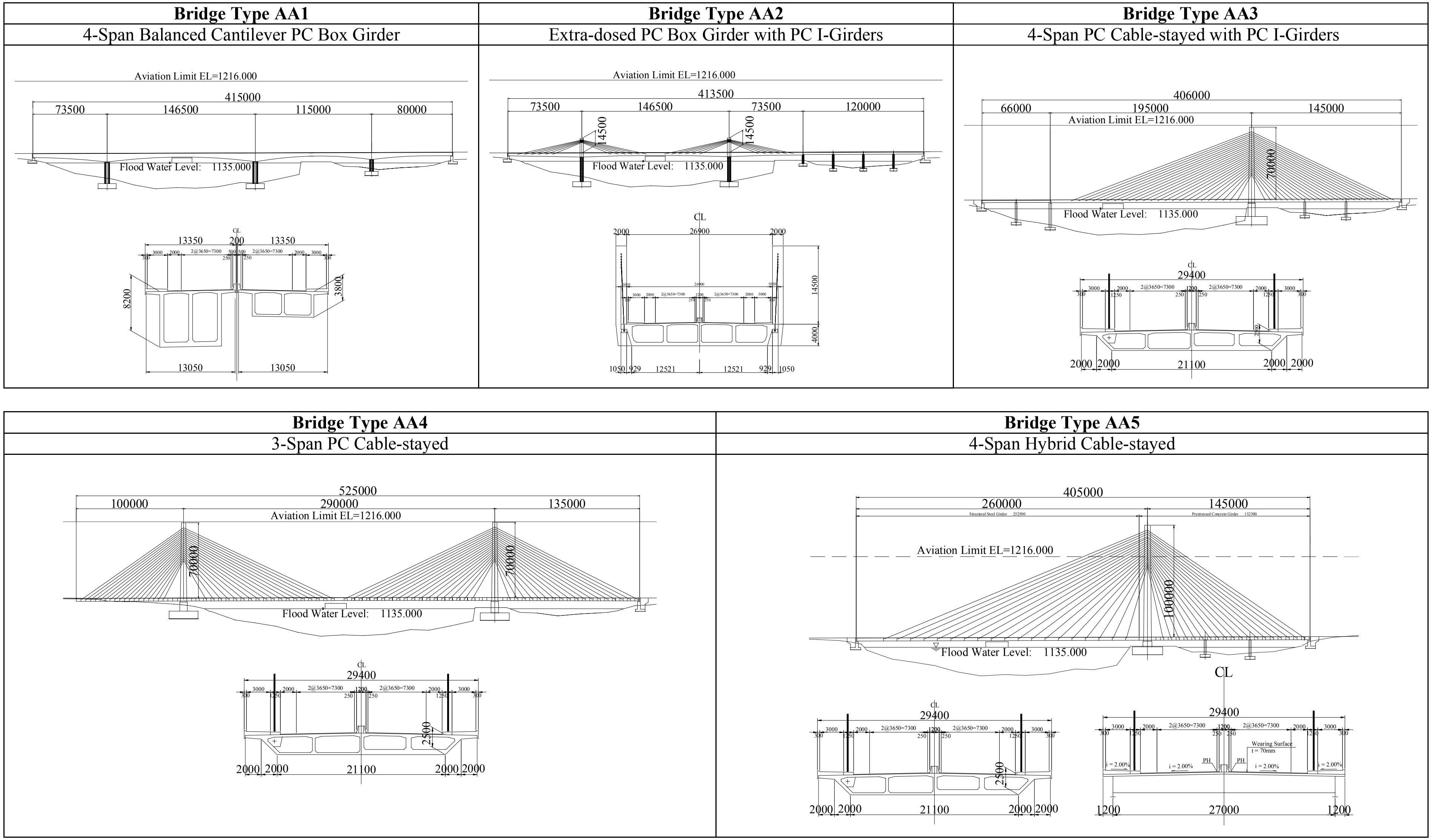


Figure 3.5.4 Bridge Profile and Section for Alternative Bridge Types in Bridge Location A

Table 3.5.7 Technical Evaluation of Alternative Bridge Types in Bridge Location B

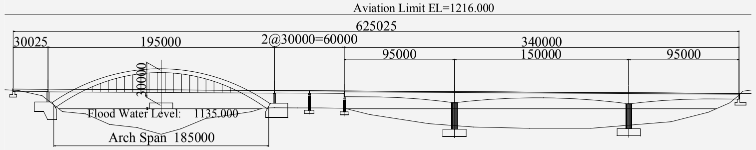
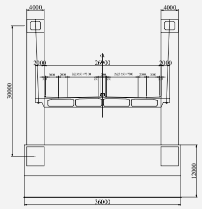
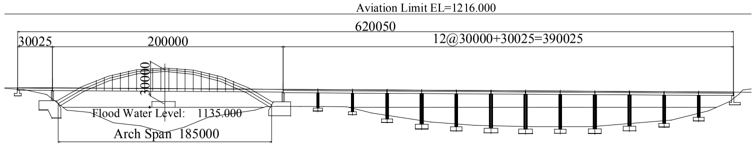
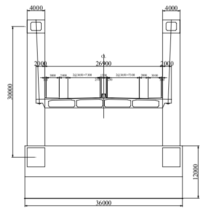
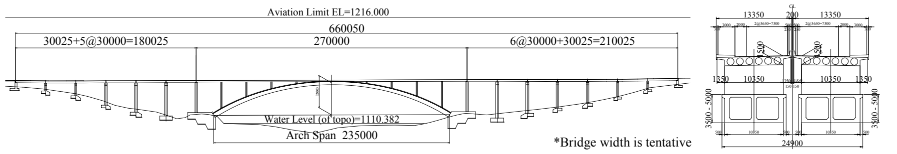
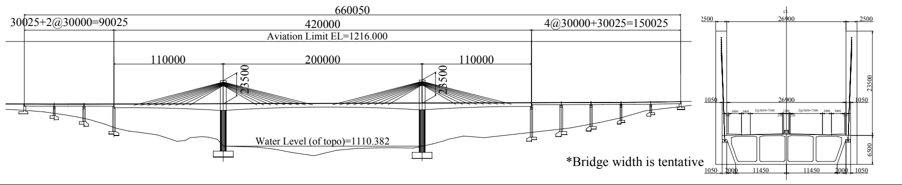
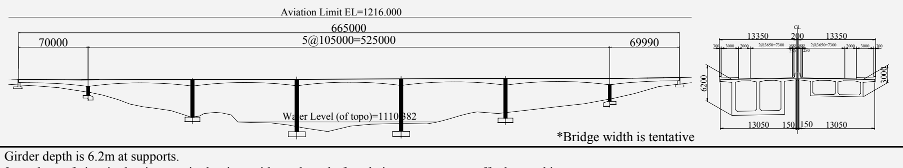
Bridge Type	BB1	BB2
Bridge Type	RC Arch Bridge with 3-Span Balanced Cantilever PC Box Girder + PC I-Girders	RC Arch Bridge with PC I-Girders
Bridge Length	625.025 m	620.050 m
Span Arrangement	30.025m + 195m + 2@30m + 95m + 150m + 95m	30.025m + 200m + 12@30m + 30.025m
Bridge Profile / Cross Section	  *Bridge width is tentative	  *Bridge width is tentative
1. Property of Structure	• Deck depth of Arch Bridge is 2.0m, and Arch rib depth varies from 3.0 to 5.0 m. • Girder depth of PC Box Girder is about 8.5 m at support. • Number of piers to be constructed in the river is lesser than those of Bridge Type B2 reducing costly foundations, temporary cofferdam and jetty. • All bridge structures will be made of concrete, and major materials except for hunger cables are available in Uganda.	• Deck depth of Arch Bridge is 2.0m, and Arch rib depth varies from 3.0 to5.0 m. • Girder depth of PC I-Girder is 1.9 m. • Numerous piers will constructed in the river, needs costly temporary cofferdam and jetty for the construction of the foundations • All bridge structures will be made of RC concrete and major materials except for hunger cables are available in Uganda.
2. Constructability	• High Risk for Construction of Foundation bearing on hard rock in Deep Water, which may cause expensive construction cost and longer construction period due to hard rock excavation. • The reinforced concrete arch will be constructed from both river banks with extensive temporary works to ensure stability until arch rib is closed at the centre. • Pylon with Meran election method will be used for the arch rib construction, with 200m span. • Bridge deck for the PC box girder will be constructed by cast-in-place RC concrete balanced cantilever method from each pier with deck block length of 2.5 -4.0m.	• High Risk for Construction of Foundation bearing on hard rock in Deep Water, which may cause expensive construction cost and longer construction period due to hard rock excavation. • The reinforced concrete arch will be constructed from both river banks with extensive temporary works to ensure stability until arch rib is closed at the centre. • Pylon with Meran election method will be used for the arch rib construction, with 200m span. • This type will need plenty of excavation of hard rock riverbed due to the numerous piers in the river. Construction will be costly and construction period will take longer.
3. Construction Period (year)	3.5	4.3
4. Construction Cost **A. Construction Cost (mil. USD)** - Bridge Portion - Approach Road Portion	 90.0 78.3 11.7	 105.8 94.1 11.7
B. Compensation Cost (mil. USD)	2.7	2.7
Total (A+B)	**92.7**	**108.5** (Cost ratio for Bridge Type B1 is 1.17)
C. Maintenance (100 years) Cost (USD) **with 12% discount rate** **[without discount rate]**	18,500 [971,000]	26,000 [1,375,000]
5. Maintenance	• Less maintenance work except for the bridge bearings, expansion joints and drainage system. • Normal inspection for the hunger cables will be required; but actual maintenance work will be hardly encountered.	• Less maintenance work except for the bridge bearings, expansion joints and drainage system. Normal inspection for the hunger cables will be required; but actual maintenance work will be hardly encountered.
6. Aesthetic Viewpoint	• It can be a symbol and landmark.	• It can be a symbol and landmark.
Evaluation	**Recommended** (The construction cost is cheaper than Bridge Type BB2. BB1 and fewer risks in foundation construction bearing on hard rock in deep water than Bridge Type BB2 due to lesser number of foundations/piers in the river.)	**Not Recommended** (The construction cost is higher than Bridge Type BB1. Numerous foundations/piers will be constructed in deep water, many risks will be encountered during construction, cost will be expensive, and construction period will be longer)

Table 3.5.8 Technical Evaluation of Alternative Bridge Types in Bridge Location C

Bridge Type	CC1
Bridge Type	RC Arch Bridge with PC I-Girders
Bridge Length	660.050 m
Span Arrangement	30.025m + 5@30.0 m + 270m + 6@30m + 30.025m
Bridge Profile / Cross Section	

1. Property of Structure	• Deck depth of Arch Bridge is 1.5 m, and Arch rib depth varies from 3.5 to 5.0 m. • Arch span is 235.0 m. This is the greatest scale of RC Arch Bridge in the world. • Girder depth of PC I-Girder is 1.9 m. • All bridge structures are made of concrete, and major materials are available in Uganda. • No risk will be encountered in case of dam failure. Abutments and piers will be constructed above floodwater level.
2. Constructability	• No Risk will be encountered for the Construction of Foundation • The reinforced concrete arch will be constructed from both river banks with extensive temporary works to ensure stability until arch rib is closed at centre. • Pylon with Meran election method will be used for the rib construction.
3. Construction Period (year)	3.4
4. Construction Cost A. Construction Cost (mil. USD) - Bridge Portion - Approach Road Portion	 83.0 56.1 26.9
B. Compensation Cost (mil. USD)	4.3
Total (A+B)	**87.3** (Cost ratio for Bridge Type CC3 is 1.08)
C. Maintenance (100 years) Cost (USD) with 12% discount rate [without discount rate]	 23,000 [1,129,000]
5. Maintenance	• Maintenance will be less, except for bridge bearings, expansion joints and drainage system.
6. Aesthetic Viewpoint	• Harmonize with surroundings environment.
Evaluation	**Recommended** (The construction cost is higher than Bridge Type CC3.)
Bridge Type	**CC2**
Bridge Type	3-Span Extra-dosed PC Bridge with PC I-Girders
Bridge Length	650.050 m
Span Arrangement	30.025m + 2@30.0m + 110m + 200m + 110m + 4@30.0m + 30.025m
Bridge Profile / Cross Section	

1. Property of Structure	• Depth of PC deck is about 6.5m, and pylon height is about 23.5m. • No pier/foundation will be constructed in the river. • Main span is 200.0 m. This is the longest span for PC Extra-dosed bridge in the world. • All bridge structures are made of concrete, and major materials except for stay cables are available in Uganda.
2. Constructability	• No Risk for Construction of Foundation • PC deck for extra-dosed bridge to be constructed by cast-in-place balanced cantilever method from the pylon with deck block length of 3.5m.
3. Construction Period (year)	3.0
4. Construction Cost A. Construction Cost (mil. USD) - Bridge Portion - Approach Road Portion	 85.2 58.3 26.9
B. Compensation Cost (mil. USD)	4.3
Total (A+B)	**89.5** (Cost ratio for Bridge Type CC3 is 1.10)
C. Maintenance (100 years) Cost (USD) with 12% discount rate [without discount rate]	 22,000 [1,450,000]
5. Maintenance	• Less maintenance work except for the bridge bearings, expansion joints and drainage system. Normal inspection for the cable system will be required; but actual maintenance work will be hardly encountered.
6. Aesthetic Viewpoint	• Low profile of pylon gives less impression; however it can be a symbol or landmark of the region. • Harmonize with surroundings environment.
Evaluation	**Recommended** (The construction cost is higher than Bridge type CC3.)
Bridge Type	**CC3**
Bridge Type	7-Span Balanced Cantilever PC Box Girder
Bridge Length	665 m
Span Arrangement	70m + 5@105m +70m
Bridge Profile / Cross Section	

1. Property of Structure	• Girder depth is 6.2m at supports. • 2 numbers of piers in the river are in the river with need costly foundations, temporary cofferdam and jetty. • All bridge structures are made of concrete, and major materials stay cables are available in Uganda.
2. Constructability	• Low Risk for Construction of Foundation in Shallow Water, which may cause a little longer construction period and a little higher construction cost. • PC deck is constructed by cast-in-place balanced cantilever method from the piers with deck block length of 2.5m – 4.0m.
3. Construction Period (year)	3.0
4. Construction Cost A. Construction Cost (mil. USD) - Bridge Portion - Approach Road Portion	 76.9 50.0 26.9
B. Compensation Cost (mil. USD)	4.3
Total (A+B)	**81.2**
C. Maintenance (100 years) Cost (USD) with 12% discount rate [without discount rate]	 7,000 [327,000]
5. Maintenance	• Compared to other types of bridges, maintenance is not much required, except for bridge bearings, expansion joints and drainage system.
6. Aesthetic Viewpoint	• Not so much impressive as a symbol or landmark.
Evaluation	**Recommended** (The construction cost is the cheapest. Although there is risk for construction of foundation in water, it is an enough surmountable risk.)

2) Summary of Definitive Bridge Type Alternatives for Comprehensive Evaluation

Based on comparative analysis I in the previous section, the following bridge type alternatives were selected for further comprehensive evaluation of alternatives to select the optimum solution for crossing the River Nile at Jinja.

The following alternatives by bridge type were selected for further comparison analysis:

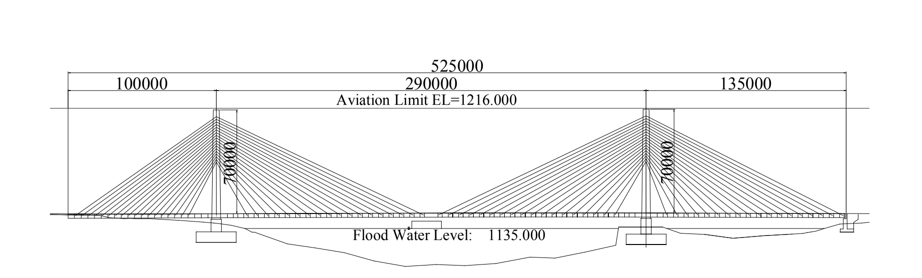
Table 3.5.9 Definitive Bridge Type Alternatives

Bridge Type		Remarks
AA4	3-Span PC cable-stayed	A plan to avoid the risk of setting the foundations on the river bed of hard rock in deep water and to satisfy aviation limit. Most recommendable.
AA5	4-Span Hybrid Cable-stayed	A plan to avoid the risk of setting the foundations on the river bed of hard rock in deep water. In case aviation limit is relaxed, this option is also recommendable.
BB1	RC Arch with 3-Span Balanced Cantilever PC Box Girder and PC I-Girders	Recommendable. Only BB1 was selected as BB2 has higher risk for construction of foundations bearing on hard rock in deep water.
CC1	RC Arch with PC I-Girders	While the cost is high there is no risk for construction of foundations, CC1 is selected for further comparison.
CC2	3-Span Extra-dosed PC Girder with PC I-Girders	Since the cost difference is not much when compared with CC1, CC2 this option is selected for further comparison.
CC3	7-Span Balanced Cantilever PC Box Girders	Since there is low risk for the construction of the foundations and considering the cost is the lowest, CC3 is also recommendable.

Figure 3.5.5 shows the additional details for the selection of bridge type alternatives.

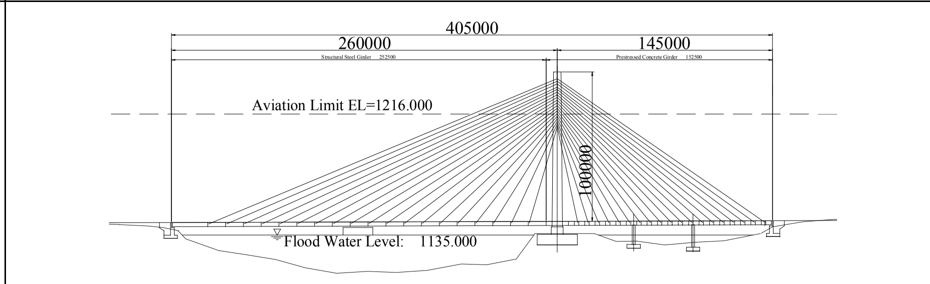
Bridge Type AA4

3-Span PC Cable-stayed



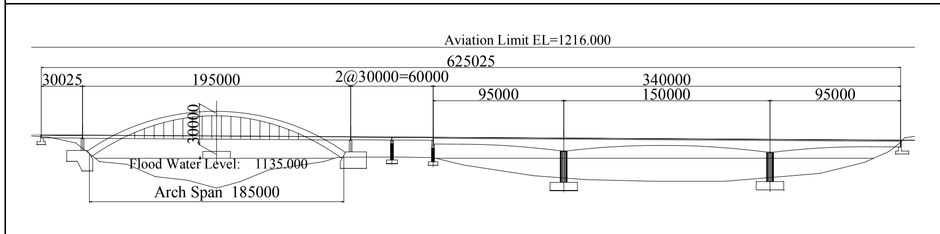
Bridge Type AA5

4-Span Hybrid Cable-stayed



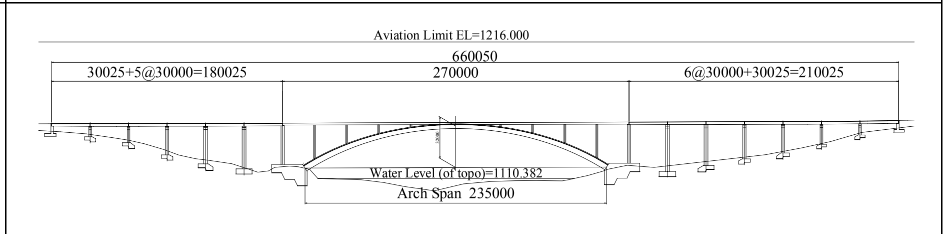
Bridge Type BB1

RC Arch Bridge with 3-SpanBalanced Cantilever PC Box Girder + PC I-Girders



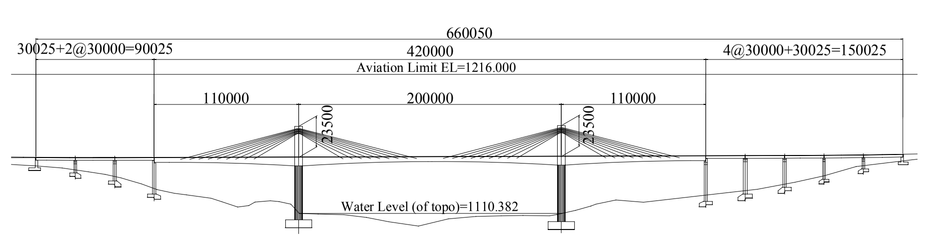
Bridge Type CC1

RC Arch Bridge with PC I-Girders



Bridge Type CC2

3-Span Extra-dosed PC Girder with PC I-Girders



Bridge Type CC3

7-Span Balanced Cantilever PC Box Girder

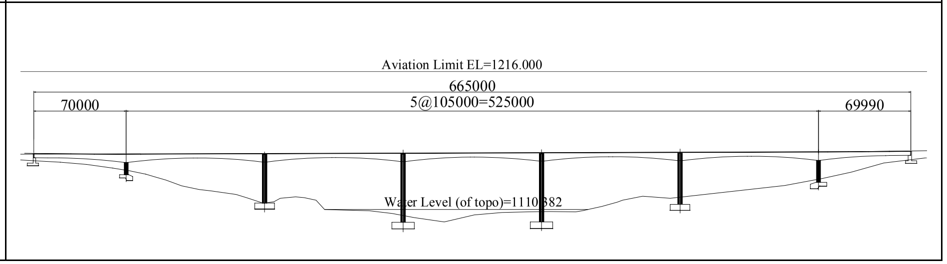


Figure 3.5.5 Profiles of Proposed Bridges

3.6 Comprehensive Evaluation

3.6.1 Evaluation Method

(1) Evaluation Step

The six (6) alternatives, considered in the previous sections, were initially evaluated by the Study Team based on the results of the questionnaire submitted by the stakeholders for the scoring and weighing method used for the evaluation. Subsequent evaluation was also conducted by the Ugandan side based on the results of the initial evaluation, which the Study Team undertook.

As previously mentioned however, the evaluation for Alternative AA5 will be pursued only if the current aviation restriction is relaxed otherwise, AA5 will have to be abandoned.

(2) Evaluation Items

Numerous evaluation items were considered for the optimum solution and classified into five (5) major items and ten (10) sub-items as shown in Table 3.6.1.

Table 3.6.1 Major Evaluation Items

Major Category		Sub-item
1	Local Development	1.1 Contribution to Local Development
2	Social Environment	2.1 Social Environmental Impact
3	Natural Environment	3.1 Natural Environmental Impact
4	Engineering Aspect	4.1 Impact to Airfield Expansion Plan
		4.2 Construction Cost
		4.3 Risk to Construction Works
		4.4 Maintenance Works
		4.5 Aesthetics of the Bridge Type
5	Economic Benefit	5.1 Transit Traffic and Through Traffic
		5.2 Accessibility to Kampala Road from Jinja

(3) Evaluation Process

1) Scoring of Sub-items by the Study Team

The alternative alignments including the bridge types were initially evaluated by detailed items, constituting the sub-items mentioned above. The evaluation results based on the detailed items eventually became the basis of the scoring system of the alternatives by sub-items as summarized in the table above.

2) Composite Scoring System for Major Evaluation Categories

The scores of the sub-items for the alternatives were weighed taking advantage of their relative importance as pointed out by the stakeholders and then integrated into the composite scores of major evaluation categories.

3) Overall Evaluations

Based on the Focus Group Discussion (FGD), held on 6 March 2009, the Study Team issued questionnaires to ascertain the opinions of stakeholders as reference in selecting the optimum solution. Figure 3.6.1 shows the comprehensive evaluation process used in selecting the optimum solution to cross the River Nile at Jinja.

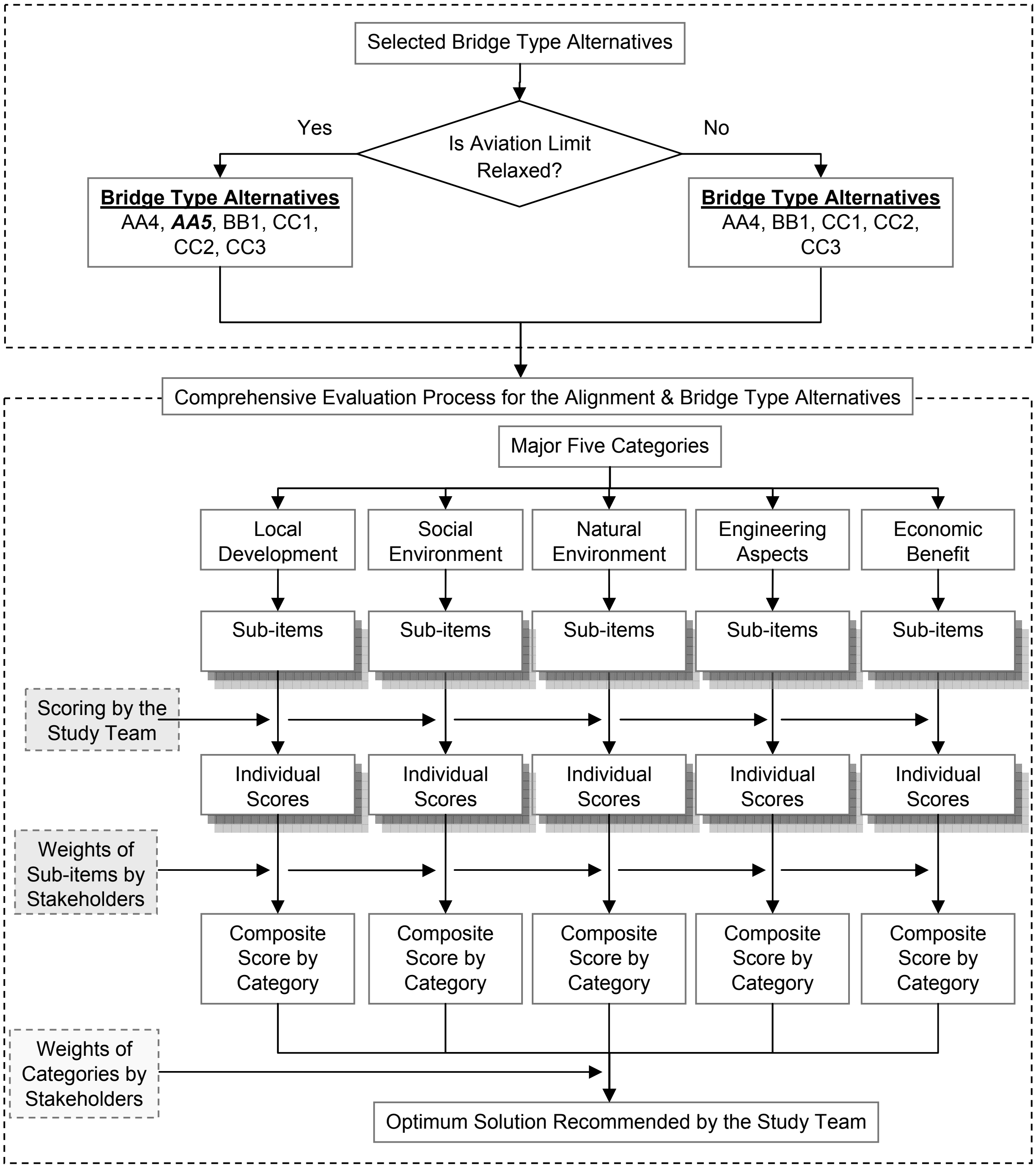


Figure 3.6.1 Evaluation Process

3.6.2 Characteristics of Selected Alignment and Bridge Type Alternatives

The characteristics of the alternatives are summarized in Table 3.6.2.

Table 3.6.2 Characteristics of Alternatives

<table>
<tr><th>No.</th><th>Item</th><th colspan="2">Alignment A</th><th>Alignment B</th><th colspan="3">Alignment C</th></tr>
<tr><td rowspan="2">1</td><td colspan="7">Local Development</td></tr>
<tr><td>1.1 Contribution to Local Development</td><td colspan="2">Considering future local development in integration of Jinja conurbation, the development in the east side of Njeru will be expected.</td><td>Since the route passes through south east of Njeru, local development is not expected.</td><td colspan="3">Although vast empty land exists, the land is owned by the military. Large urban development is not expected.</td></tr>
<tr><td rowspan="2">2</td><td colspan="7">Social Environment</td></tr>
<tr><td>2.1 Social Environmental Impact</td><td colspan="2">Large-scale involuntary resettlement is not required. Note that warehouse of textile factory and relevant facilities are affected as well as the water intake. There is expansion plan for the beer factory.</td><td>Large-scale involuntary resettlement is not required. Note that the impacts to the existing infrastructures such as transmission line exist.</td><td colspan="3">Large-scale involuntary resettlement including private retreat centre is required. Note that the impact to water usages is minimal as compared to Alignment A and B.</td></tr>
<tr><td rowspan="2">3</td><td colspan="7">Natural Environment</td></tr>
<tr><td>3.1 Natural Environmental Impact</td><td colspan="2">Temporary water quality degradation. Worsened roadside noise and air quality during/after construction phase. Temporary minor impact on flora/fauna of the River Nile.</td><td>Temporary water quality degradation. Worsened roadside noise and air quality during/after construction phase. Temporary minor impact on flora/fauna of River Nile.
Much negative impact on water quality since many bridge piers are to be constructed inside the River Nile.</td><td colspan="3">Temporary water quality degradation. Worsened roadside noise and air quality during/after construction phase. Temporary minor impact on flora/fauna of the River Nile.
Largest impacts on regional drainage. Largest amount of construction wastes due to construction of longest approach roads.
Enhanced river bank erosion during construction
Potential risk of dam failure.</td></tr>
<tr><td rowspan="7">4</td><td colspan="7">Engineering Aspects</td></tr>
<tr><td></td><td>AA4</td><td>AA5</td><td>BB1</td><td>CC1</td><td>CC2</td><td>CC3</td></tr>
<tr><td>4.1 Impact to the Airfield Expansion Plan</td><td colspan="2">No influence</td><td>No influence</td><td colspan="3">The expansion plan will delay the decision of approach road alignment.</td></tr>
<tr><td>4.2 Construction Cost</td><td>Lower than C</td><td>Lower than C</td><td>Higher than C</td><td>Moderate</td><td>Moderate</td><td>Moderate</td></tr>
<tr><td>4.3 Risk of Construction Works</td><td>Moderate(one foundation in shallow water)</td><td>A little higher (three foundations in shallow water)</td><td>High (two foundations in deep water)</td><td colspan="2">Very low (no foundations in the water)</td><td>Low (two foundations in shallow water)</td></tr>
<tr><td>4.4 Maintenance Works</td><td>Little higher than B & C (for cable)</td><td>Very high (for cable and steel girder)</td><td>Moderate</td><td>Moderate</td><td>Moderate</td><td>Very little</td></tr>
<tr><td>4.5 Aesthetics of Bridge Type</td><td colspan="2">Symbolic landmark</td><td>Old type and slightly poor in bridge combination</td><td colspan="2">Harmonization to environment and symbolic landmark</td><td>Simple and Balanced</td></tr>
<tr><td rowspan="3">5</td><td colspan="7">Economic Benefits</td></tr>
<tr><td>5.1 Transit Traffic & Through Traffic</td><td colspan="2">Travelling distance is almost similar to the existing bridge.</td><td>Travelling distance is slightly longer than the existing bridge.</td><td colspan="3">Travelling distance is slightly longer than the existing bridge.</td></tr>
<tr><td>5.2 Accessibility to Kampala Rd. from Jinja</td><td colspan="2">Travelling time and distance is similar to the existing bridge.</td><td>Travelling time and distance will increase by around 20% compared to Alignment A.</td><td colspan="3">Travelling time and distance will increase by around 60% compared to Alignment A.</td></tr>
</table>

Note: In terms of detailed characteristics of the alternatives, please refer to respective chapter or section.

3.6.3 Evaluation Results by Item

The evaluation of individual sub-items was graded according to merit by the Study Team as follows: 1 (inferior to other alternatives), 3 (average) to 5 (superior to other alternatives). After the evaluation of individual sub-items, all the scores were then merged by the Study Team.

With respect to environmental considerations, the scoring system was generally designated by "A", "B" and "C", for which "A" indicates the magnitude of considerable adverse impact, "B" indicates moderate impact and "C" indicates minimal impact. The report also adopted the scoring system in digits from "1" to "5" to be consistent with the other mode of evaluation for alternatives.

(1) Contribution to Local Development

1) Integrated Development

Integrated development between Jinja Municipality and Njeru Town is a key issue for local development based on efficient urban development management. The integrated development plan would prevent the unwarranted excessive sprawling of development and suburbanization of Jinja conurbation that would cause unnecessary inefficient public investment for social services. Moreover, dense urbanization will contribute to improvement of the standard of living for Jinja conurbation in facilitating the provision of social services. From this viewpoint, the establishment of robust and stable access between Jinja Municipality and Njeru Town should be given utmost priority.

2) Land Availability for Urban Development

Redevelopment of existing populated areas would pose extreme difficulties. Land availability will become an important issue for future urban development. Although vacant lands still exist along the boundary of Jinja Municipality, most are owned by the military. In Njeru on the other hand, vacant land in the east is available for future urban development, located within 5km from the centre of Jinja, although the current land use is agriculture.

3) Evaluation

On the basis of the above analysis and comparison, Alignment A provided the greatest advantage followed by B and C considering connectivity between Jinja and Njeru. Alignments A and B on the other hand will pass through an area with high potential for development. In light of the foregoing, Alignments A, B and C were provided with scores of "5", "4" and "3" respectively.

(2) Social Environmental Impact

1) General

Based on the preliminary examination of social conditions for the project area and project components, the proposed development is considered to provide minimal adverse social environmental impacts. The following six (6) social environmental parameters were considered as the most likely causes of adverse impacts to be brought by the proposed development of the Project based on the studies after considering the scoping checklists contained in the JICA Environmental Consideration Guidelines. .

- Mandatory Resettlement
- Local Economy including employment opportunities and livelihood, etc
- Land Use and Utilization of Local Resources

- Existing Social Infrastructures and Services
- Water Usage or Water Rights and Rights of the Common
- Hazards (Risk), due to the spread of Venereal diseases such as HIV/AIDS

Mandatory resettlement is one of the most critical issues, as this involves an adverse impact to the local economy; such as the loss of employment and livelihood, caused by ROW acquisition of the warehouse and relevant facilities of the textile factory and also the existing resort facilities. Moreover, the beer factory near Alignment A has an expansion plans. As such, the negative impacts to be brought about by the development of the proposed Project to existing land use plans, social infrastructures and water use should also be paid with special attention. The risk of hazards for the spread of infectious diseases such as HIV/AIDS by the influx and concentration of labourers from outside into Jinja for the construction of the proposed project are common issues worldwide which could be mitigated by appropriate countermeasures in accordance with the JICA Guidelines.

2) Evaluation

Among the proposed alternatives, Alignment C is the most disadvantageous with regards to the local economy and land use plans. Alignment A on the other hand will produce the greatest adverse impact to the existing textile factory and water intake, in comparison to Alignments B and C.

Based on the foregoing, Alignments A, B and C were provided with scores of “3”, “4” and “2” respectively.

(3) Natural Environmental Impact

Both sides of the River Nile are provided with Environmental Protection Zones (which is 100 m from the high water level of the River Nile). Alignments A, B and C however will be passing through the protected areas which were found to be the habitat of several IUCN-CR (critically Endangered), EN (Endangered), VL (Vulnerable), NT (Near Threatened) and LC (Less Concerned) species.

The approach roads on both sides of the river for Alignment C are the longest and the construction thereof will produce the largest volume of waste compared to Alignments A and B. By the same token, the adverse impacts on the regional drainage would be more significant than Alignments A and B.

Alignment B will be provided with many bridge piers to cross the River Nile, thereby producing greater water quality degradation during the construction of the bridges as compared with Alignments A and C.

The risk of riverbank erosion during the construction of Alignment C would be more significant than Alignments A and B.

The bridge section for Alignment C which is located downstream of Owen Falls Dam Complex is a potential risk and is in violation against dam regulations which should not be ignored.

Based on the foregoing premises, Alignments A, B and C were provided with scores of “4”, “3” and “2” respectively.

(4) Adverse Impact to Airfield Expansion Plan

1) Airfield Expansion Plan

CAA (Civil Aviation Authority, MOWT) has planned to expand the existing Jinja Airfield. The preparation of the blue print of the plan is still ongoing and at this stage, adjustments of the plan are still possible. CAA has conceived a minimum extension of 600m for the runway towards the north-west following the existing runway. A re-orientation of the runway is also possible depending on the result of the engineering analysis. All possible expansion plans, however, would hinder the approach road of Alignment C. Therefore, until such time that the expansion plan of the airfield is finalized, the approach road of Alignment C cannot be settled. It is noted that the other two alternative Alignments (A& B) will not affect the said expansion plans.

2) Evaluation

As mentioned above, the expansion plan of the airfield will be affected by Alignment C. Therefore, Alignment C has been placed on a disadvantageous position because of the need to provide longer approach road otherwise a segment of the approach road would have to pass under the runway which would entail additional cost and time for the coordination with CAA and other agencies concerned. Based on this context, Alignment A, B and C were given scores of “5”, “5” and “2” respectively.

(5) Estimated Construction Cost of the Alternate Bridges including the Approach Road

1) Outline

The estimated construction costs of both the cable-stayed bridge alternatives (AA4 and AA5) for Alignment A are almost equal and are the lowest among all the alternatives. The estimated cost of a PC box girder bridge (CC3) for Alignment C is moderate. The estimated costs for an arch bridge (CC1) and an extra-dosed bridge (CC2) are higher than a PC box girder bridge (CC3). An arch bridge with PC box girder bridge (BB1) for Alignment B is estimated to be the highest among all alternate routes because the bridge section is the longest among all the alternative alignments.

2) Evaluation

Based on this context, Alternative AA4/AA5 is given a score of “5”; BB1 is “1”, CC1/CC2 are both “2” and CC3 is “3”.

(6) Risk of Construction Works

1) Outline

The risk is evaluated as moderate for the construction of one of the foundation of both the cable-stayed bridge alternatives (AA4 & AA5) for Alignment A on an island with shallow water depth close to the right bank of the river. Three of the foundations of the cable-stayed bridge (AA5) will be located in shallow water depth for which the risk is assessed as a little higher than AA4. The two foundations of the PC box girder bridge (BB1) on Alignment B are built in deep water with hard rock river bed, risk is high. As two foundations for the PC box girder bridge (CC3) for Alignment C will be in shallow water depth therefore the risk is evaluated as moderate. The risk for the arch bridge (CC1) and extra-dosed bridges (CC2) for Alignment C, is considered as low.

2) Evaluation

On the basis of this context, Alternative AA4 is given a score of “3”, AA5 is “2”, BB1 is “1”, CC1/CC2 are both “5”, and CC3 is “4”.

(7) Maintenance Works

1) Outline

Not much maintenance work will be required for a concrete bridge except for the bearings, expansion joints, and drainage system, and appurtenant parts. The maintenance cost for a PC box girder bridge (CC3) for Alignment C is therefore the lowest among all the alternatives. Larger number of bearings and expansion joints will be required for an arch bridge (CC1) as compared with PC box girder bridge (CC3), and as such the maintenance cost will be higher. Similarly, inspections for the hanger cables of an arch bridge (BB1) for Alignment B and the cable system of an extra-dosed bridge (CC2) for Alignment C would in general be required and maintenance cost is at same level as for an arch type bridge (CC1) for Alignment C. Normal inspection of the cable system of a 3 span PC cable-stayed bridge (AA4) for Alignment A would be required, although in actual use modest maintenance will not be needed, thus, the maintenance cost would be moderate. Since the main span of the composite cable-stayed bridge (AA5) for Alignment A will be constructed of steel girder, periodic repainting would be required. As such the maintenance cost for this type is the highest among all the alternatives.

2) Evaluation

Based on this context, Alternative AA4 is given a score of“3”; AA5 is “1”; BB1/CC1/CC2 are both “4”, and CC3 is “5”.

(8) Aesthetics for the Bridge Types

1) Outline

Both the cable-stayed bridges (AA4, AA5) for Alignment A can be symbolic landmarks. The arch type bridge (CC1) and extra-dosed bridge (CC2) for Alignment C would blend with the surrounding environment and can also be a symbolic landmark. The Arch-type bridge and PC box girder bridge (BB1) for Alignment B appears to be antiquated and the combination of two different types of bridges is not recommended based on aesthetics viewpoints. The PC box girder bridge (CC3) for Alignment C is a moderate design, simple and well-proportioned.

2) Evaluation

Based on this context, Alternatives AA4/AA5 is given a score of “4”; BB1 is “2”; CC1/CC2 are both “5”; and CC3 is “4”.

(9) Benefits to Transit Traffic and Through Traffic

As observed in the OD traffic survey, numerous large trucks are crossing the border with Kenya. The transit and long distance traffics currently use the Nalubaale Dam Bridge. Diverging and merging of the traffic take place in Nalufenya Roundabout and Kamuli Roundabout. There is not much difference in distances among Alignments A, B and C. On this basis, Alignments A (AA4, AA5), B (BB1) and C (CC1, CC2, CC3) were given a score of “5”, “4” and “4” respectively.

(10) Accessibility to Kampala Road from Jinja

All local traffic would need to use the new bridge in the event that Nalubaale Dam Bridge is closed due to the expiration of its service life. Should that occur, most of the local traffic between Jinja and Kampala will have to detour should Alignment C be adopted. The travel time and distance for Alignment A however will be similar to the existing route and that for Alignment B will increase by 20%.

Taking these conditions into account, Alignment A is more advantageous followed by Alignment B when compared to Alignment C. In this context, Alignment A (AA4, AA5), B (BB1) and C (CC1, CC2, CC3) were given a score of “5”, “4” and “1” respectively.

3.6.4 Weight on Five Major Evaluation Categories

After the scoring of the individual evaluation items by the Study Team, composite scores for major categories were also carried out based on the scoring merits from the stakeholders.

(1) Weighting by Local Stakeholders

The Study Team administered questionnaires during the Focus Group Discussion (FGD), held on 6 March 2009 in Jinja with a view to determining the evaluation priorities by local stakeholders among 5 major evaluation categories in selecting the optimum solution (refer to Table 3.6.3).

1) Features of the Participating Stakeholders for the Questionnaire Survey

Table 3.6.3 Attributes of Participants

Sex		Address		Age		Occupation		Bridge construction	
Male	31	Jinja M	20	Under 20	0	Agriculture	1	Yes	48
Female	7	Njeru	6	20-29	5	Industrial	6	No	0
		Jinja District	0	30-39	14	Private service/shop	7	No comment	0
		Mukono	7	40-49	16	Local Gov. Services	23		
		Kampala	7	50-59	10	MOWT/UNRA	3		
		Others	1	60+	1	Others	9		
Total Responses	38		41		46		49		48

Source: Questionnaire Survey during the FGD

2) Methodology of Weighing

Priority weighing among the evaluation items/categories was obtained through the results of questionnaire surveys that were issued to the stakeholders during the FGD. Expression of the importance of their priorities on the evaluation of sub-items however had posed difficulties because some items involved technical matters. Based on this point of view, only simple questions on the evaluation of sub-items were issued for the stakeholders to reply in a short period of time.

The correlation between the evaluation of sub-items by category and the questionnaires relative to priority weights are summarized in Table 3.6.4.

Table 3.6.4 Evaluation Items, Questions and Weight Priority

Major Category		Sub-item	Questionnaire	Weights of Sub-items	Weights of Major Categories*	% Weight of Major Categories
1	Local Development	1.1 Contribution to Local Development	Contribution to the local development	4.17	4.17	0.21
2	Social Environment	2.1 Social Environmental Impact	Mandatory resettlement	3.39	3.39	0.17
			Impact on major factories			
			Impact to resort/ recreational/ hotel facilities			
3	Natural Environment	3.1 Natural Environmental Impact	Segregation of traffic (particularly for heavy vehicles) from the Town	3.82	3.82	0.20
			Natural environmental preservation			
			Road safety			
4	Engineering Aspects	4.1 Impact to Airfield Expansion Plans	Construction cost including maintenance cost	4.37	4.18	0.22
		4.2 Construction Cost		4.37		
		4.3 Risk of Construction Works		4.37		
		4.4 Maintenance Works		4.37		
		4.5 Aesthetics of Bridge Type	Bridge aesthetics	3.40		
5	Economic Benefits	5.1 Transit Traffic & Through Traffic	Time savings and vehicle operating cost savings	3.80	3.93	0.20
		5.2 Accessibility to Kampala Road from Jinja	Accessibility to facilities related to daily life	4.06		

Note: Weight of categories is an average weight derived from weights of sub-items by category.

(2) Weighing by the Study Team

The same questionnaire forms were filled up by the Study Team and the results are shown in Table 3.6.5. The results indicate that there was no significant variation between the reply of local stakeholders with that of the Study Team.

Table 3.6.5 Weight Results by the Study Team

No.	Major Categories	% byWeight of Categories
1	Local Development	0.22
2	Social Environment	0.19
3	Natural Environment	0.20
4	Engineering Aspects	0.19
5	Economic Benefits	0.20

Source: Questionnaires by JICA Study Team

(3) Definitive Weight on Major Items

Considering the above two results by the local stakeholders and by the Study Team, the results of priority weighing on major categories by the local stakeholders were applied in selecting the optimum solution from among the alternatives, because the two results show practically the same priority weights.

3.6.5 Overall Evaluation and Sensitivity Analysis

Based on the above weights as assessed by the local stakeholders, Table 3.6.6 shows the overall evaluation results.

Table 3.6.6 Definitive Scoring on the Alternatives

No.	Sub-item	A		B	C			Weight	
		AA4	AA5	BB1	CC1	CC2	CC3		
Alignment Length (km)		2.4		5.1	8.1			Weight of Sub-items by Stakeholders	Weight of Categories by Stakeholders in ratio
Construction Cost (US$ M)		67.7	66.0	90.0	83.0	85.2	76.9		
	Bridge	57.1	56.0	78.3	56.1	58.3	50.0		
	Road	10.6		11.7	26.9				
	Maintenance Cost (Present value US$1,000)	5.6	289.0	19.0	23.0	22.0	7.0		
	Construction Period (Year)	3.5	3.3	3.5	3.4	3.0	3.0		
1	1.1 Contribution to local development	5	5	4	3	3	3	4.17	0.21
2	2.1 Social environmental impact	4	3	4	2	2	2	3.39	0.17
3	3.1 Natural environmental impact	4	4	3	2	2	2	3.82	0.20
4	Engineering Aspects								
	4.1 Impact by airfield expansion plan	5	5	5	2	2	2	4.37	
	4.2 Construction cost	5	5	1	2	2	3	4.37	
	4.3 Risk of construction works	3	2	1	5	5	4	4.37	
	4.4 Maintenance	3	1	4	4	4	5	4.37	
	4.5 Bridge aesthetics	4	4	2	5	5	4	3.40	
	Composite score	4.00	3.37	2.63	3.53	3.53	3.58	4.18	0.21
5	Economic Benefits								
	5.1 Transit traffic & Through traffic	5	5	4	4	4	4	3.80	
	5.2 Accessibility to Kampala Road to/from Jinja	5	5	4	1	1	1	4.06	
	Composite Score	5.00	5.00	4.00	2.45	2.45	2.45	3.93	0.20
Overall Evaluation		**4.25**	4.11	3.51	2.64	2.64	2.64	19.49	1.00

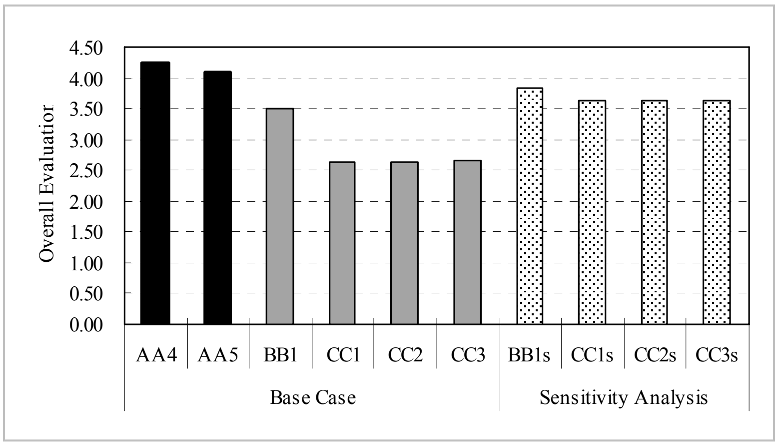
The scoring method is widely recognized. The various values were then combined into one. There is however, no fixed and definite method in evaluating the different items and for this reason a sensitivity analysis was conducted with the objective of determining marginal evaluation. This method can determine whether or not the evaluation results will change under certain conditions.

Figure 3.6.2 shows the overall evaluation scores of the alternatives. As shown AA4 and AA5 were given high scores and they are dominantly more advantageous than all the other alternatives. Table 3.6.7 shows the result of the sensitivity analysis. In scoring, the individual sub-items of Alternatives BB1, CC1, CC2, and CC3 were intentionally increased within its rationale for comparison with Alternative AA4. The results of the analysis has ensured that Alternative A with Bridge Type AA4 is most likely the most advantageous scheme as the optimum solution to cross the River Nile at Jinja.

Table 3.6.7 Results of Sensitivity Analysis

No.	Sub-item	A		B	C			Score for Sensitivity				Weight of Sub-items by Stakeholders	% Weight of Major Categories by Stakeholders in ratio
		AA4	AA5	BB1	CC1	CC2	CC3	BB1s	CC1s	CC2s	CC3s		
Alignment Length (km)		2.4		5.1	8.1								
Construction cost ($US M)		67.7	66.0	90.0	83.0	85.2	76.9						
	Bridge	57.1	56	78.3	56.1	58.3	50						
	Road	10.6		11.7	26.9								
	Maintenance cost present value $US1000)	5.6	289.0	19.0	23.0	22.0	7.0						
	Construction period (Year)	3.5	3.3	3.5	3.4	3.0	3.0						
1	1.1 Contribution to local development	5	5	4	3	3	3	5	4	4	4	4.17	0.21
2	2.1 Social environmental impact	3	3	4	2	2	2	4	3	3	3	3.39	0.17
3	3.1 Natural environmental impact	4	4	3	2	2	2	3	3	3	3	3.82	0.20
4	Engineering Aspects												
	4.1 Impact by airfield expansion Plan	5	5	5	2	2	2	5	4	4	4	4.37	
	4.2 Construction cost	5	5	1	2	2	3	1	2	2	3	4.37	
	4.3 Risk of construction works	3	2	1	5	5	4	1	5	5	4	4.37	
	4.4 Maintenance works	3	1	4	4	4	5	4	4	4	5	4.37	
	4.5 Bridge aesthetics	4	4	2	5	5	4	3	5	5	4	3.40	
	Composite score	4.00	3.37	2.63	3.53	3.53	3.58	2.79	3.95	3.95	4.00	4.18	0.22
5	Economic Benefits												
	5.1 Transit traffic & Through Traffic	5	5	4	4	4	4	5	4	4	4	3.80	
	5.2 Accessibility to Kampala Road to/from Jinja	5	5	4	1	1	1	4	4	4	4	4.06	
	Composite Score	5.00	5.00	4.00	2.45	2.45	2.45	4.48	4.00	4.00	4.00	3.93	0.20
Overall Evaluation		**4.24**	**4.10**	3.50	2.64	2.64	2.65	3.84	3.62	3.62	3.63	19.49	1.00

Source: JICA Study Team
Note: Highlighted column shows the scores that were intentionally increased within its rationality as compared to Alternative AA4.



Source: JICA Study Team

Figure 3.6.2 Results of the Overall Scoring based on Sensitivity Analysis

3.6.6 Conclusion and Recommendation

(1) Arrangement of Alternatives

The alternatives consist of road alignments and bridge types. The six alternatives were selected in discussing the optimum solution to traverse the River Nile, by any of the following alternatives: AA4, AA5, BB1, CC1, CC2 and CC3.

(2) Conclusion and Recommendation

1) Recommendation of the Study Team

The Alternatives were evaluated based on the scoring of individual sub-items and composite major items. The Stakeholders provided their opinion as regards to prioritization among the evaluation items issued during the Focus Group Discussion held in Jinja on 6 March 2009. The priority weights for scoring for evaluation of items was resorted to obtain comprehensive evaluation of the alternatives.

The result of the comprehensive evaluation disclosed that Alternative AA4 is the most recommendable solution to cross the River Nile at Jinja. Although the overall evaluation score for Alternative AA5 is close to AA4, it was ultimately decided that it be excluded from the list of alternatives. The primary reason is that the Civil Aviation Authority has officially informed the Study Team that the aviation limit for the Jinja Airfield could not be relaxed based on their letter of 26 March 2009 (as appended in Appendix 2).

The sensitivity analysis that was conducted also ensured that Alternative AA4 has garnered the highest priority among the alternatives even if the conditions for the other Alternatives were intentionally made with advantageous scores.

In light of the foregoing analyses, the Study Team has concluded and is recommending that Alternative AA4 be adopted as the optimum solution to cross the River Nile at Jinja.

2) Agreement by Ugandan Stakeholders

Based on the recommendations of the Study Team, the 3rd Steering Committee meeting was held on 1 April, 2009 for which the Ugandan side agreed with the recommendations of the Study Team to adopt Alignment A with Bridge Type AA4 as the optimum solution to cross the River Nile at Jinja.

Finally, the chosen optimum plan was accepted by the Ugandan Side during the 2nd Public Consultation Meeting held in Kampala on 3 April 2009.