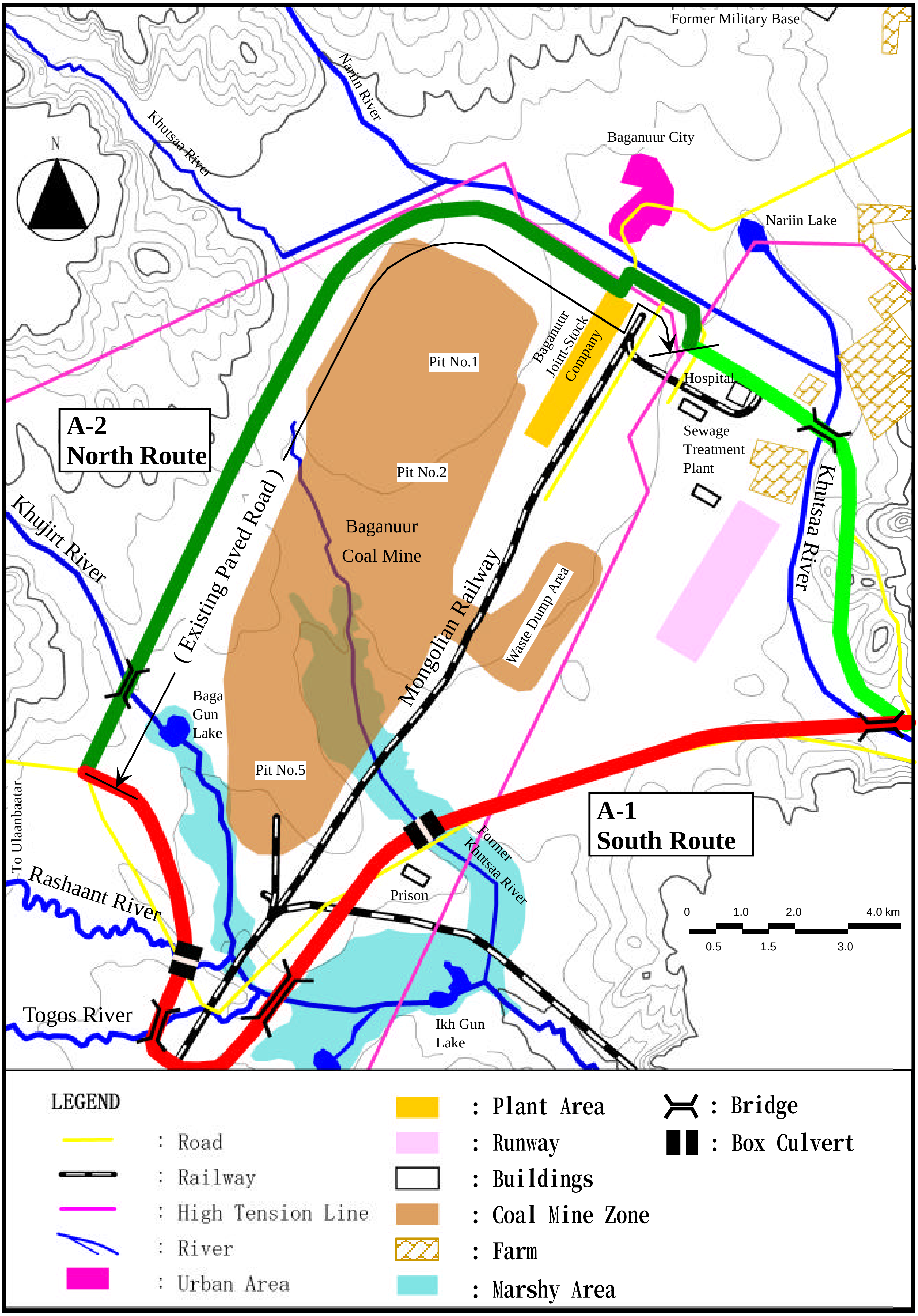


Figure 9-2-6 Detailed Location of Alternatives at Section A

2) Alternative Route A-1 (South Route: Railway Crossing)

The marshy area widely spread in the south of Baganuur Coal Mine where the Khujirt River, the Rashaant River and the Togos River exist together with flood prone area including the Baga Gun Lake and the Ikh Gun Lake. This route (A-1) will manage to pass these marshy areas by bridges/box culverts and high embankment with soft ground treatment. The Route A-1 is planned to have two railway crossings, totaling 25.576 km in length.

The A-1 starts from Baganuur T-shape intersection. This intersection is the starting point of the approach road to Baganuur City (STA. 113+117.720). The A-1 curves southward from the starting point and goes through plane pasture to railway crossing point (STA. 120+313). The A-1 crosses the Rashaant River by box culvert, the Togos River by bridge, the merged Togos River/Rashaant River/Khujirt River by bridge and the Former Khutsaa River by box culvert as shown in Figure 9-2-7.

The location to cross the railway was discussed with Mongolian Railways. It was decided to set at the point which is approximately 1.5km south to the existing Togos River railway bridge to avoid coal handling facilities, points/switches with signals. This point has sufficient sight for the safety for both railway and vehicles according to the memorandum with Mongolian Railway. The road requires a new embankment, since the railway is set on the existing embankment.

The A-1 crosses the railway siding by grade crossing (STA. 126+430) after the merged Togos River/Rashaant River/Khujirt River Bridge. The railway has already exiting grade crossing and permission of Mongolian Railway is obtained.

The A-1 goes through pasture and up gentle hill after the grade crossing. It also curves eastward keeping a distance to the jail. The downward slope of the hill is steep with 16m-height difference. The 270m long slope of 6% grade is planned with partially cutting.

There is the Former Khutsaa River crossing the route after the hill and a box culvert is planned to cross it. The Khutsaa River was made a detour at upstream to exploit the Baganuur Coal Mine when it was developed. Remaining river channel still drains storm water and forms river.

It also utilizes the 4km gravel road that was constructed before the coalmine was exploited and goes through plane pasture. It crosses the diverted Khutsaa River by bridge (STA. 138+600) and joints with the alternative route A-2.

This point is wide marsh area where the Khutsaa River merges to the Kherlen River and it will require sufficient countermeasures such as soft ground treatment, control of frost action, etc. There is the checkpoint of the Kherlen River Bridge with a restaurant near the ending point (STA. 139+264).

3) Alternative Route A-2 (North Route; Baganuur City)

This route (A-2) goes northward from the starting point (STA. 112+127), utilizing the existing paved road to Baganuur City and passes besides the residential area of the city. The paved road is of 18.7km long and many cracks are found on the surface of pavement. The A-2 is planned to make full use of such existing road, totaling 29.136 km in length.

There is an existing RC bridge over the Khujirt River (STA. 113+840) that was constructed more than 30 years ago and has a lack of discharge capacity and poor structural soundness.

The A-2 passes between residential area and coal mining area. The existing coal mining area will be used for some industry in the future plan. The staggered intersection is located in front of the entrance gate of Baganuur Joint-stock Company (STA. 128+388) and it is about 700m away from the residential area of the city. The A-2 passes eastward in the north of the hospital and sewage disposal facility pertaining to Baganuur Joint-stock Company and goes towards the crossing point of the diverted Khutsaa River. The pavement from the staggered intersection is badly deteriorated and an improvement work will be required.

The A-2 crosses the Khutsaa River by wooden bridge and turns southward after crossing the river. The A-2 runs parallel to Khutsaa River averting the marshy area along the river. It merges the alternative route A-1 before the checkpoint of the Kherlen River Bridge (STA. 141+263).

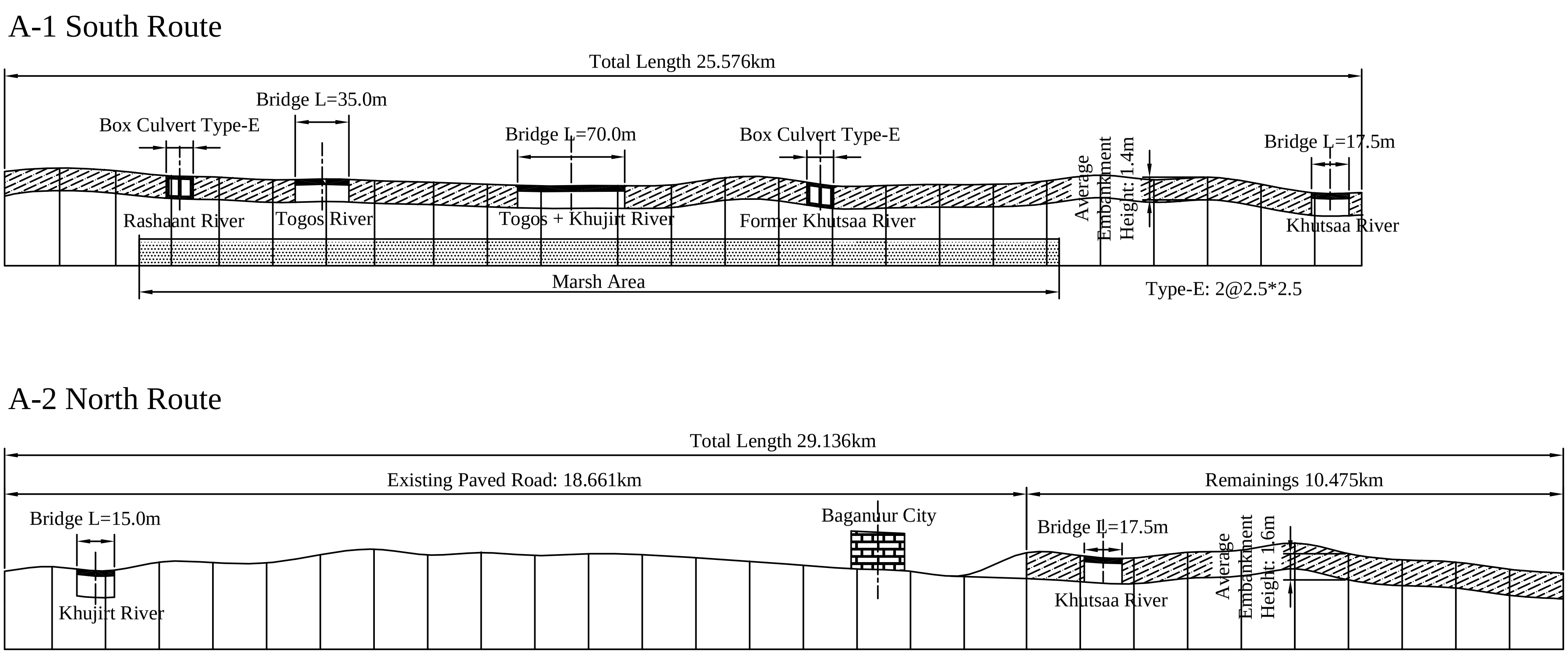


Figure 9-2-7 Profile and Location of Main Structures of the Alternatives

(2) Evaluation

Table 9-3-1 summarizes the comparison of salient features and differences revealed in association with route alternatives of which route location will bring about impacts physically, technically, socially and economically.

It is concluded that the alternative Route A-2 is selected in Baganuur Section where the comprehensive evaluation reveals the superiority of Alternative Route A-2 quantitatively and qualitatively. The demerits of A-1 and the merits of A-2 is summarized as follows:

1) Demerits of the A-1: South Route

a) Issues related to Railway

This route cannot pass directly to the east because it is needed to avoid coal loading facilities, points/switches with signals and it is forced to make detour about 3 km to the southward according to the understanding of Mongolian Railway.

A grade separation structure will be required at the point of railway crossing in case that the route should keep on going eastward. The high embankment of railway will make a large-scale flyover, while the scheme of underpass will necessitate large-scale diversion of railway during construction and will incur difficulties against storm water drainage due to flood level.

b) Physical Constraints in Marshy Area

The marshy area widely spread in the south of Baganuur Coal Mine where the Khujirt River and the Togos River exist together with flood prone area including the Baga Gun Lake and the Ikh Gun Lake. It is true this route will manage to pass these marshy areas by bridges/box culverts and high embankment with soft ground treatment, but it will be far from practical solution.

c) Scale of Structures

Three bridges totaling 122.5 m in length and two box culverts will be required in the South Route, while only two bridges totaling 32.5 m in length will be in the North Route.

d) Costs of Construction and Maintenance

The costs of construction will be 1.75 times as high as that of the North Route. Furthermore, the cost of maintenance will surely become higher because of passing two railway crossings and flood prone area.

2) Merits of the A-2: North Route

a) Shorter Period of Construction

Although the road length of North Route is 29.1 km that is 3.5 km longer than that of the South Route, the new construction of road is only 10.5 km long because there is 18.7 km long existing paved road in the North Route. The construction period is surely shorter not only compared with 25.6 km of the South Route but also scale of structures.

b) Costs of Construction and Maintenance

The costs of construction will be 57% of the South Route, and the maintenance will be cheaper due to neither railway crossing nor flood prone area.

c) Road User's Benefits

The South Route will bring VOC saving on traffic through Baganuur due to shorter road length. However, the traffic access to and egress from Baganuur will be imposed higher VOC in case of the South Route because the origin/destination of traffic is the CBD of Baganuur where the North Route is planned to pass nearby the city.

Although the policy of "the Millennium Road Plan" is to pass in the outskirts of city to keep traffic safety and avert adverse environmental impacts, the North Route is planned to pass 500m away from the city and appropriate countermeasures will be able to cope with these issues.

d) Development Impacts

The North Route is planned to pass in between residential area and coal mining area, and the existing coal mining area will be used for some industrial use according to the future plan. The production of Baganuur Coal Mine has reached to their peak at the year 1994 and the production as well as its profit decreases gradually. It is desirable to develop some industries in Baganuur stemmed from two transport means of railway and road.

Table 9-2-1 Comparison of Salient Features of Alternatives in Baganuur

Section A : Baganuur

(BP : Baganuur T-Shape Paved Intersection, EP : Check Point at Kherlen Bridge)

Items	**Alternative A-1 (South Route: Railway Crossing Route)**	**Alternative A-2 (North Route: Baganuur City Passing Route)**
Outline of Alternative		
Route Description	1) The route has two railway crossings. 2) Open spaces such as pastureland and wasteland spread widely expect Baganuur Coal Mine. 3) Marshy areas spread widely along rivers, lakes and surrroundings, especially Togos River, Khutsaa River and Ikh Gun Lake. 4) Existing embankment of former gravel road will be used in the east of railway approximately 4 km in length.	1) The route pass through Baganuur City. 2) Open spaces such as pastureland and wasteland spread widely expect Baganuur City and Baganuur Coal Mine. 3) Marshy areas are located along Khutsaa River. 4) From beginning point, the exsiting paved road can be reused for 18.7 km by rehabilitating (including DBST, 2.1 km).
Road Length	25.576 km Through : Nuga Steppe	29.136 km (Including Exsiting Paved Road L=18.661 km) Through : Baganuur City
Major Structures	Bridge : 3 Bridges (L=35m and L=70m over the Togos River and L=17.5m over the Khutsaa River, totaling 122.5 m long) Box Culvert : 2 locations	Bridge : 2 Bridges (L=17.5m over Khutsaa River and 15m replacement over the Khujirt River, totaling 32.5 m long) Box Culvert : Nil
Project Cost Index	1.75	1.00
1. Construction Economy	1) **Poor** because of new constructed road of totaling 25.6 km in length, including three bridges, two box culverts, high embankment with soft ground treatment and two railway crossings.	1) **Good** because of new construced road of 10.5 km in length, including two bridges and overlaying exsiting paved road of 18.7 km in length.
2. Road User's Benefit	1) **High** for through-traffic in summer because the VOC is lower than Alternative A-2 due to shorter route. 2) **No Difference** in winter because all wehicles prefer to passing Baganuur and even through-traffic cross the frozen Kherlen River through Baganuur.	1) **Modest** because the VOC for through-traffic in is higher than that of the A-1 due to 3.5 km detour but the traffic access to and egress from Baganuur will be imposed higher VOC in case of the A-1. 2) **High** because drivers will secure traffic safety against severe winter travelling.
3. Adverse Social Impact	1) **Some Extent** because the route will have two railway crossing where 7-8 trains are operatede a day at present. 2) The route will pass nearby the prison that the location is isolated.	1) **Low** because the route is located between residential area and coal mine facilities where low traffic volume is forecasted and wide open space along the road exists.
4. Adverse Environmental Impact	1) **Considerable** because new construction road is longer than Alternative A-2, and affected marshry area is long.	1) **Low** because the route is mostly used the existing paved road.
5. Development Impact	1) **Low** because the marshry area is spread widely, and the route pass beside the prison.	1) **Higher** because the routes pass through Baganuur City, and there is open space at the periphery of the city widely. 2) It will go a long way toward promoting industries, utilizing road and railway.
Evaluation	**Not Acceptable**	**Acceptable**

9.2.6 Route Description and Evaluation in Kherlen East (Section B)

(1) Route Description

1) General

There are two routes to pass Nogoon Modot Mountain, namely Jargalant Valley and Ust Valley. The route passing Ust Valley is shorter but steeper. It will encounter at the eastern end of mountain pass the area where permafrost exists. On the other hand, the route passing Jargalant Valley is longer but flatter. However, numbers of wadi exist along the Kherlen River and the route passes wadi-laden river terrace in the vicinity of Sogoot Valley to avert swampy area.

Figure 9-2-8 shows the location of alternative route.

2) Alternative B-1 (South Route)

This route passes Ust Valley, and total length of the route 30.634 km. Accordingly, this route is shorter than Alternative B-2.

The starting point locates eastern end of the Kherlen Bridge where exists a petrol station and gel type restaurants (STA. 143+223).

The route goes through the southern bank of Ust Valley and turns towards north-east from STA. 147+000. The Ust Valley forms pasture of gentle slope and marsh area at the bottom.

The route crosses the valley at the STA. 158+265 and a box culvert is planned. It starts to run north-eastward on the north bank after crossing the valley and changes the direction to east at the STA. 166+700. It also reaches the origin of the Ust valley's flow. This alignment is set not to cross marsh area at the bottom of the valley. The route gets up to the pass where ovoo exist (H=1,638m, STA. 169+800). The route avoids the ovoo.

The downhill is located on the very steep slope. A 670m slope of 7.0% incline are planned to get to the ending point or alternative route.

The ending point is designated at Jargalant Crossroads, which is starting point of Alternatives C-1 and C-2 at STA. 173+857.

3) Alternative B-2 (North Route)

This route passes Jargalant Valley, and the total length of the route 32.798 km at STA. 1+113.493.

The route goes northward from the starting point for 7km after crossing the Ust Valley by 15m RC bridge planned to be constructed (STA. 1+511.5). It crosses numerous wadis that are originated at Mt. Nogon Modot to the Kherlen River and each wadi requires pipe culvert (STA. 2+400 to STA. 6+400). This section of the road will be approximately 4km of length.

There will be a curve towards north-eastward after the section mentioned in the previous paragraph and runs through the Jargalant Valley (STA. 8+200). This valley is wide, forms pasture on the slope and wide marsh area with a few ponds made by springs at the bottom.

The route will curve to south-eastward near the juncture with Sogoot Valley (STA. 22+000). It will start passing the river terrace for 6km (STA. 22+000 to STA. 28+000). The most difficult terrace to pass is Olon Burd where ovoo exists (STA. 24+000). It is necessary to move the ovoo to roadside of new road because this part requires cutting partially. The reasons of it will be listed as follow. (1) This terrace forms steep slope and has a spring at the bottom. (2) It is probable to have underground stream. (3) It is better to pass this terrace by constructing embankment on the natural environmental and road maintenance point of view, but the highest part will be 24m of height.

The alternative route ends at STA. 33+911.769 after passing fairly plane pasture with 2 steep slopes.

(2) Evaluation

Table 9-2-2 summarizes the comparison of salient features and differences revealed in association with route alternatives of which route location will bring about impacts physically, technically, socially and economically.

The comprehensive evaluation reveals the superiority of Alternative B-1 quantitatively and qualitatively. The superiority is summarized as follows:

- It is more realizable to be constructed due to fewer spots of construction difficulties, for instance wadi and river terrace. This aspect also leads to easier maintenance after finishing the construction.
- The construction cost will be lower and benefit of road user will be higher due to the short length road construction.
- It affects less in natural environmental aspects due to fewer countermeasures to natural conditions.

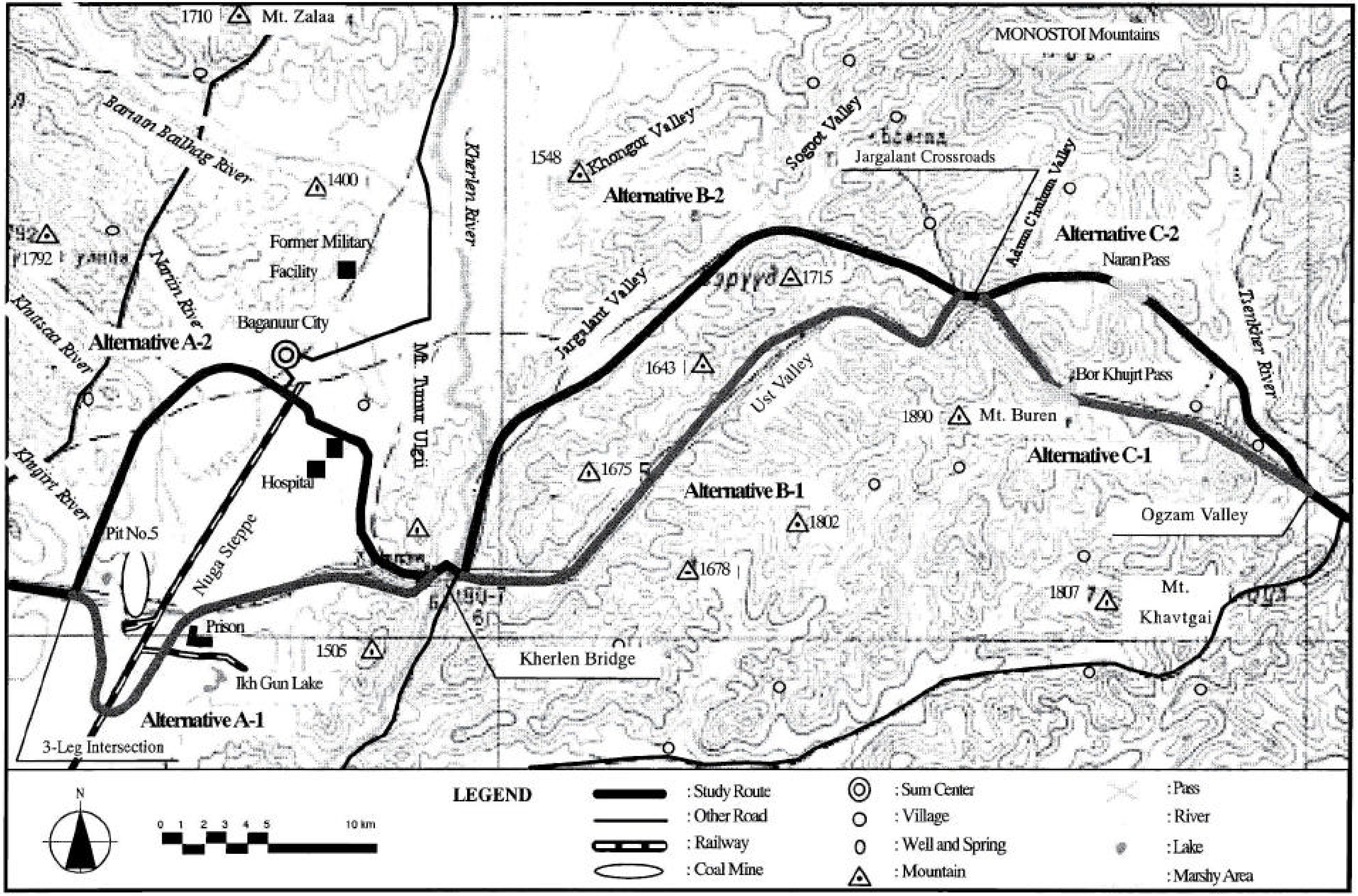


Figure 9-2-8 Location of Each Alternative Route

Table 9-2-2 Comparison of Salient Features of Alternatives in Kherlen East

Section B : Kherlen East

(BP : East bank of Kherlen River, EP : Jargalant Crossroads)

Items	Alternative B-1 (South Route)	Alternative B-2 (North Route)
Outline of Alternative		
Route Description	1) Open spaces such as pastureland and wasteland spread widely. 2) Ust Valley is gently-sloping, and the upstream side is flat. 3) A high mountain pass is located at the source of valley. 4) Marshy areas spread along the bottom of valley.	1) Open spaces such as pastureland and wasteland spread widely. 2) Jargalant Valley is flat, and many river terrace are locatted at the source of valley. 3) The section along Khelren River is innumerable steep wadi. 4) Marshy areas spread along valley widely, and some pond with spring are scattered about the bottome of valley.
Road Length	30.634 km Through : Ust Valley	32.798 km Through : Jargalant Valley
Major Structures	Bridge : Nothing Box Culvert : 7 pieces	Bridge : 1 Bridge Box Culvert : 6 pieces
Project Cost Index	1.00	1.19
1. Construction Practicability	1) **Higher** because there is only high embankment at east side of pass.	1) **Lower** because of the routes have to pass through river terrace in long distance and cross innumerable waji. 2) There is the possibility that the cutting of river terrace strilkes a water vein because there is some pond with spring under river terrace.
2. Ease of Maintenance	1) **Simple** because the road is scarcely feared to suffer damage.	1) **Hard** because maintenance is required form river terrace zone and waji zone in long distance.
3. Construction Economy	1) **Higher** because of road of totaling 30.6 km in length. 2) Maintenance is simple.	1) **Lower** because of road of totaling 32.8 km in length. 2) Maintenance cost is inclined to increase.
4. Environmental Impact	1) **Less** because deep cut and high embankment is limited, especially at east side of pass.	1) **Considerable** because deep cut and hight embankment is required along the terrace in long distance.
5. Road User's Benefit	1) **High** because the VOC is lower than Alternative B-2 due to short traveling.	1) **Low** because the VOC is higher than Alternative B-1 due to long traveling.
Evaluation	**Superior**	**Inferior**

9.2.7 Route Description and Evaluation in Tsenkhermandal West (Section C)

(1) Route Description

1) General

There are two routes to bypass Khunkh Mountain, namely passing Naran Pass and Bor Khujirt Pass. The road length is almost the same. The route passing Bor Khujirt Pass passes hilly terrain but it is flatter. It will encounter at the end of this section the area where two swampy areas and permafrost exist. On the other hand, the route passing Naran Pass is steeper and to pass the area where there are some stretches traversing seeping or boggy ground at Aduun Chuluun Valley where permafrost exist widely and some swampy area at the Tsenkher river crossing.

Figure 9-2-8 shows the location of alternative route.

2) Alternative C-1 (South Route)

This route passes Bor Khujirt Pass, and the total length of the route 19.518 km. Accordingly, this route is shorter than Alternative C-2.

The starting point is designated at Jargalant Crossroads, which is ending point of Alternatives B-1 and B-2 at STA. 173+857.

The route runs through gentle slope of valley at the beginning. The planned incline goes up to 7% at the approach of the Bor Khujirt Pass (H=1,644m, STA. 179+200). This slope will continue for 390m through pasture and reaches the ovoo at the top of the pass. It is necessary to move the ovoo to roadside of new road. Because, the pass is narrow but the ovoo is located at center of pass.

The downhill from Bor Khujirt Pass requires a slope of 7.0% for 580m at first. It turns to pasture with gentle hills and the route heads eastward towards Zuun Shar Bul Valley -1 (STA. 187+215).

This Valley includes wide area of frost susceptible soils of freeze-thaw cycle. It is incapable to make a detour to the area for at least 150m. The route reaches to Zuun Shar Bul Valley -2 (STA. 190+521) after passing 2 small hills.

This Valley has also wide area of frost susceptible soils of freeze-thaw cycle. The route has to cross the area at least for 250m in spite of crossing narrow section where exiting road locates.

The alternative route ends at the Ogzam Valley (STA. 193+375) after passing fairly plane pasture with a small pass of 38m-height difference. There is a petrol station and a few restaurants, which supplies safety rest area for drivers.

3) Alternative C-2 (North Route)

This route passes Naran Pass, and the total length of the route 21.221 km at STA. 1+911.769.

The route enters the Aduun Chulun Valley from the starting point. It crosses at least 2km of marsh area due to existence of wide marsh area in the valley.

The planned incline of 400m slope rises up to 5.6% to reach the Naran Pass (H=1,594m, STA. 7+900). The pass has an ovoo with a good view. The route keeps distance from the ovoo.

The downward slope will be 6.9% of incline with 400m of length. The route will reach to a wide valley of a tributary of the Tsenkher River (STA. 11+000) after passing through the pasture.

The pasture of poor ground forms this valley. The route has to go through the frost susceptible soils of freeze-thaw cycle for nearly 1,000m around the juncture with the Bor Khujirt Bul Valley -1 (STA. 12+800 to STA. 13+800).

The route reaches the Bor Khujirt Bul Valley-2. A bridge of 15m is planned to cross the flow of the valley.

The alternative route gets to the end at the Ogzam Valley (STA. 23+132.706) after running along the Tsenkher River on its southern bank.

(2) Evaluation

Table 9-2-3 summarizes the comparison of salient features and differences revealed in association with route alternatives of which route location will bring about impacts physically, technically, socially and economically.

The comprehensive evaluation reveals the superiority of Alternative C-1 quantitatively and qualitatively. The superiority is summarized as follows:

- It is more realizable to be constructed due to smaller area of frost susceptible soils of freeze-thaw cycle to be passed through. This aspect also leads to less effect in natural conditions.
- The construction cost will be lower and benefit of road user will be higher due to the short length road construction.

Table 9-2-3 Comparison of Salient Features of Alternatives in Tsenkhermandal West

Section C : Tsenkhermandal West

(BP : Jargalant Crossroads, EP : Ogzam Valley)

Items	Alternative C-1 (South Route)	Alternative C-2 (North Route)
Outline of Alternative		
Route Description	1) Open spaces such as pastureland and wasteland spread widely. 2) There are one high mountain pass and three low mountain passes. 3) The route pass through narrouw valleys and foot of mountains. 4) Affected marshy including frost susceptible soil of freeze-thaw cycle, are limited and short crossing.	1) Open spaces such as marshy, pastureland and wasteland spread widely. 2) There is one high mountain pass only, and flatter. 3) At both side of mountain pass, spacious valley extend. 4) Affected marshy areas including frost susceptible soil of freeze-thaw cycle, spread widely, especially on low land at east side of Naran Pass.
Road Length	19.518 km Through : Bor Khujrt Pass	21.221 km Through : Naran Pass
Major Structures	Bridge : Nothing Box Culvert : 5 pieces	Bridge : 1 Bridge Box Culvert : 5 pieces
Project Cost Index	1.00	1.23
1. Construction Practicability	1) **Higher** because affected frost susceptible soil zone of freeze-thaw cycle is limited.	1) **Lower** because the route have to pass in frost susceptible soil zone of freeze-thaw cycle in long distance.
2. Environmental Impact	1) **Lesser Degree** because mitigated countermesure is in shorter, and minimized against frost susceptible soil of freeze-thaw cycle. 2) Domestic animal crossing occurs frequently due to vast pastureland.	1) **Considerable** because mitigated countermesure is required in longer against frost susceptible soil of freeze-thaw cycle. 2) Domestic animal crossing scarcely occurs due to vast marshy.
3. Construction Economy	1) **Higher** because of road of totaling 19.5 km in length. 2) Maintenance is easy because mitigated countermeasure is limited for environment.	1) **Lower** because of road of totaling 21.2 km in length with one bridge. 2) Maintenance is required from a bridge and mitigated countermesure for environment in long distance.
4. Road User's Benefit	1) **High** because the VOC is lower than Alternative C-2 due to short traveling.	1) **Low** because the VOC is higher than Alternative C-1 due to long traveling.
5. Land Availability	1) **Higher** because marshy areas are limited, yet the route have to cross four mountain passes.	1) **Lower** because Narangin Pass is suitable for scenic overlooks due to getting a fine views. On the other hand, the routes have to pass through marshy areas in long distance.
Evaluation	**Superior**	**Inferior**

9.3 Consideration of Alternative Route Crossing Kherlen River

9.3.1 Alternative South Route Crossing Kherlen River

To select the appropriate South C- route crossing the Kherlen River in connection to Millennium International Road, utilization of existing Kherlen Bridge (total length 268.8m) will be important question. Three routes crossing the Kherlen River can be selected from topographic condition of river and dike, location of branched river as follows:

- **First Route** (here in after "**C-1 Route**"): Existing Bridge Route (Use of existing bridge)
- **Second Route** (here in after "**C-2 Route**"): New Route (1 km down stream form existing bridge)
- **Third Route** (here in after "**C-3 Route**"): Existing Bridge Route (use of existing bridge with limited Heavy Vehicles & New Route (beside existing bridge, minimum width)

The most appropriate South C-route shall be determined considering scale of approach road, bridge and river training, possibility of technical methods of reinforcement and/or repair, construction cost, period and maintenance, etc.

The outline for the above South three routes in area of Kherlen River is illustrated as shown below Figure 9-3-1.

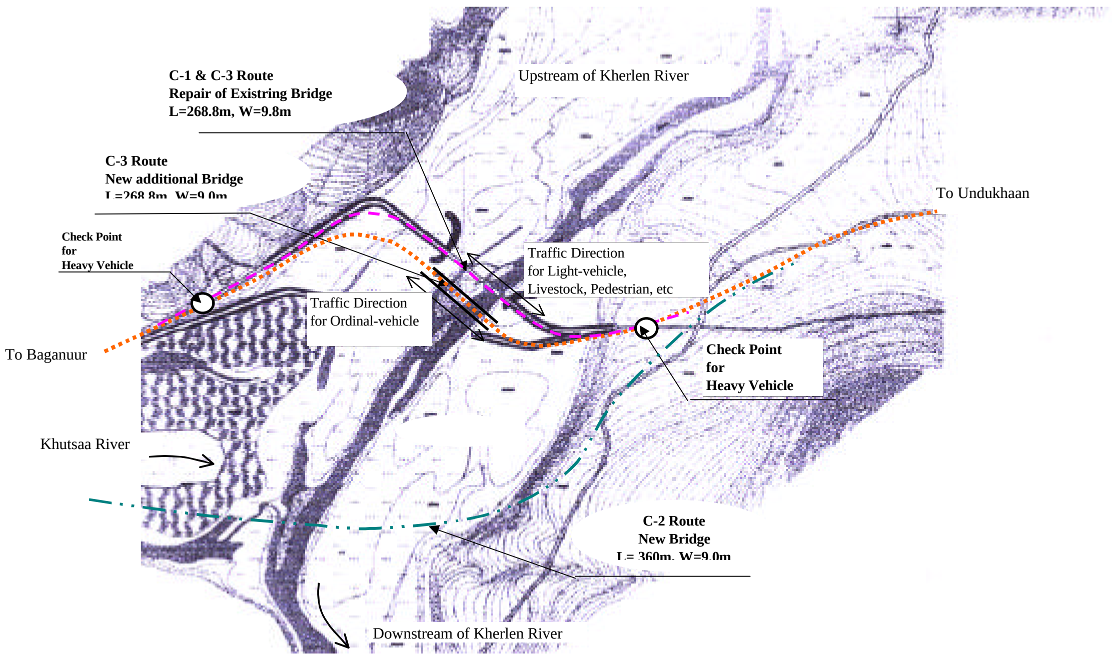


Figure 9-3-1 South Routes Crossing Kherlen River

9.3.2 Characteristics of the Routes

- C-1 Route:

  The characteristic of this route shall utilize the existing bridge.

  The Kherlen Bridge are not stabled from the results of investigation and examination applying International Design Standard based on American AASHTO/ JAPAN for Millennium Arterial Road. Therefore, the existing bridge shall be reinforced, and/or partly replaced to have the stability by design loading system. The temporary bridge during improvement of the existing bridge shall be required for ordinal traffic transportation.

  These examinations are Case C1-1 and Case C1-2 according to degree of stability for members of bridge as flowchart of Figure 9-3-2.

- C-2 Route:

  This intended new bridge is South route toward 1 km down stream side from existing Kherlen Bridge. This new bridge is scaled with 360m length for two lanes (carriage way width 8m). The existing bridge shall demolish after construction of new bridge.

  The new bridge shall be designed based on American AASHTO/ Japanese International Standard.

- C-3 Route:

  This route is compromised of above C-1 and C-2 alternatives. The reinforcement or repair of existing bridge is to be minimized, and to be utilized light vehicles, livestock and pedestrian. Therefore, new bridge for carriage way with 8m width of Millennium Arterial Road Standard shall be constructed beside existing bridge at down stream side with 30-50m distance in parallel. The proposed total bridge length is 268.8m in the same scale with existing bridge. In case that the existing bridge is occurred big damages and/or broken, the new bridge shall be extended to 360m long corresponding to designed river conditions in future stage.

  Regarding to this C-3 route, the examination methods of the existing bridge are two cases of C3-1 and C3-2 as flowchart of Figure 9-3-2.

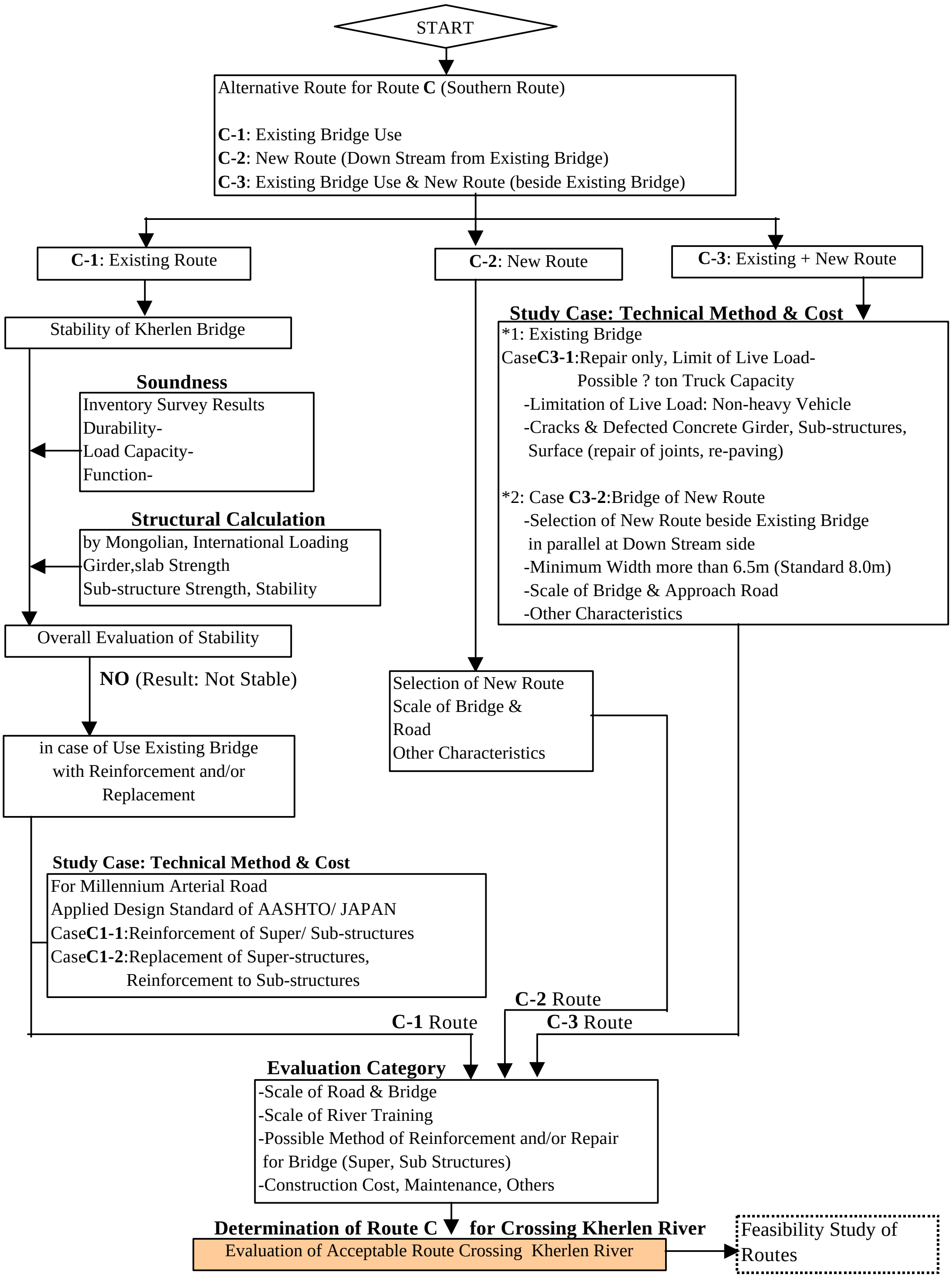
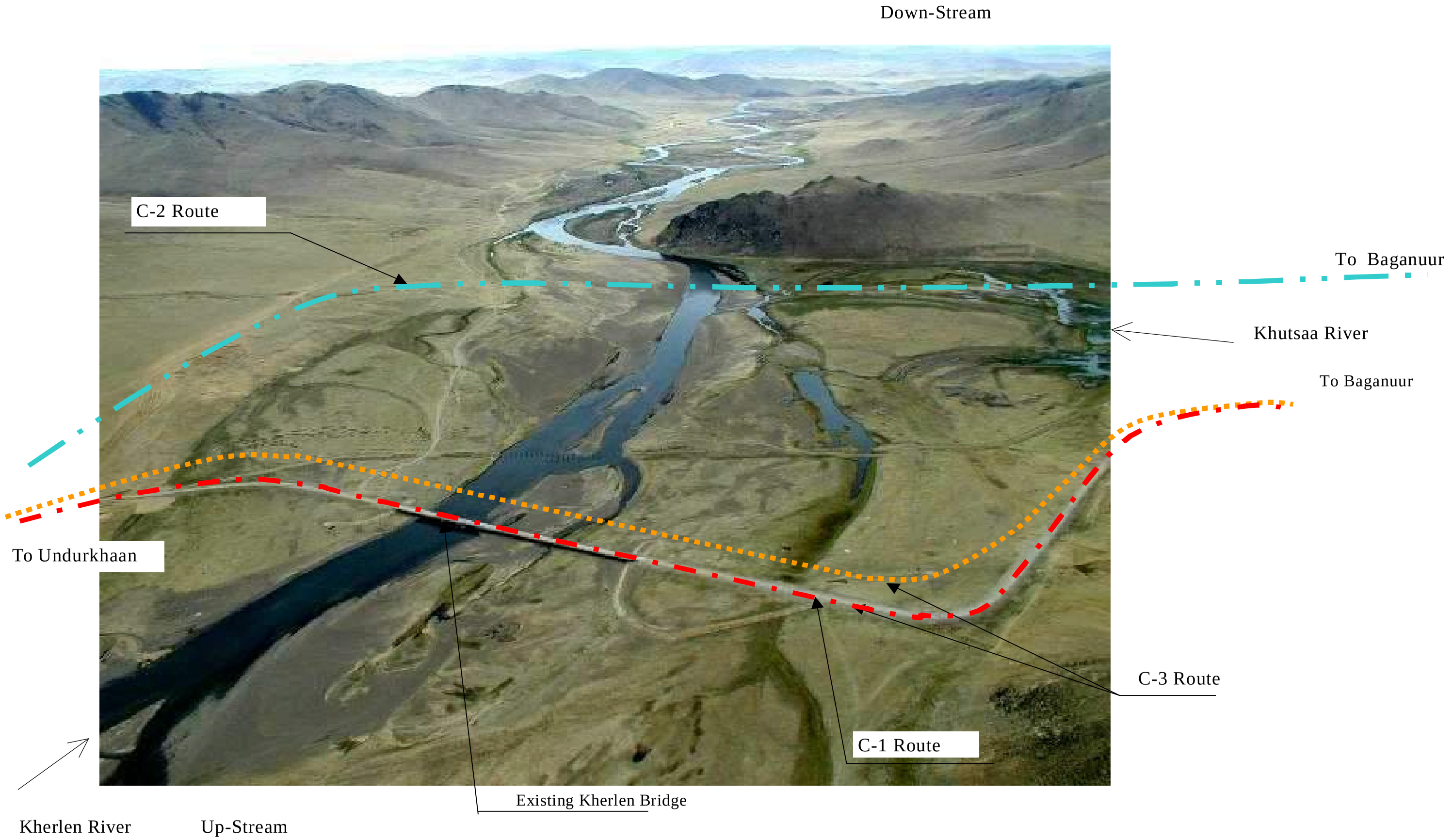


Figure 9-3-2 Flowchart of Selection of South Route Crossing Kherlen River

These locations of each route are shown in photograph 9-3-1.

South C Route Crossing Kherlen River



Photograph 9-3-1 View of C Route Crossing Kherlen River

9.3.3 Loading Capacity and Improvement Method for Existing Bridge

(1) Improvement Method

There are two kinds of improvement, “**repair**” and “**reinforcement**”.

Improvement, Betterment

- **Repair, Mending** **: Not expected strengths after repair/ mending**
  Concrete/mortar into cracks and/or defected parts,
  Replace or overlay of bridge surface,
  Expansion joints, handrail, etc
- **Reinforcement** **: Expected strengths after reinforcement**
  Reinforcing steel-bars and concrete,
  Steel plates
  Partly replace such as girder, pier

The “**repair**” does not means to reinforce the structure. It is to put mortar into cracks/broken places, and replace surface pavement and expansion joints.

On the other hand, the “**reinforcement**” means to expect increase of strength with reinforcing concrete (RC), steel plate, and partly replacement, etc.

Example for Repair:

Case C3-1: Possible live load (equivalent to truck weight) within allowable strength for super/ sub-structures without reinforcement

Example for Reinforcement:

Case C1-1: Working Strength using A-live load of Japanese Standard and/or American AASHTO (heavy loading system conforming to Millennium International Road) with/without reinforcement

(2) Present Conditions of Kherlen Bridge

From the results of examinations in both soundness and structural calculations, Kherlen Bridge is not stable enough to apply International Design Standard for Millennium Arterial Road.

Though, existing Kherlen Bridge is large scale with 268.8m length (16 @ 16.8m span), and the location of the bridge is stabilized in view of characteristics of Kherlen River.

Therefore, it shall be studied whether existing Kherlen Bridge is available to use considering limitation of live load, and/or improving method such as repairs, reinforcement.

(3) Results of Stability for Existing Bridge and General Method of Improvement

To calculate to the strength and capacity of the bridge members (slab, girder, of super-structures and substructures), live loading cases (TL-14 ton, and A-live load) of Japanese standard were applied.

From the computed the above live loading cases, the degree of strength in the members is listed below Table 9-3-1.

Table 9-3-1 Application of Live Load and Strength of Members for Existing Bridge

<table>
<tr><td rowspan="2">Capacity
Load Case</td><td colspan="2">Super-structure</td><td colspan="3">Sub-structure</td><td rowspan="2">Comment</td></tr>
<tr><td>Slab
(D13mm-10)
Strength</td><td>Girder
(D29mm-10)
Strength</td><td>Pier beam
(D29mm-15)
Strength</td><td>Shoe-bed
Strength</td><td>Caisson
Stability</td></tr>
<tr><td>Case C3-1
(C3-2)
Japan
TL-14</td><td>M=1.55tfm
Working σ s
1302kg/cm²<
Allowable σ sa
1400kg/cm²

Stabled</td><td>M=85.83tfm
Working σ s
1763kg/cm²<
Allowable σ sa
1800kg/cm²

Stabled</td><td>M=150.7tfm
Working σ s
1751kg/cm²<
Allowable σ sa
1800kg/cm²

Stabled</td><td>S=3.6tf
Working τ
3.3kg/cm²<
Allowable τ a
8.5kg/cm²

Stabled</td><td>Fifth Pier
Working Q
27.9 tf/m²<
Allowable Q
58.8 tf/m²

Stabled</td><td>Evaluation;
Existing Br.
Capacity:
Truck 14 ton
Maximum</td></tr>
<tr><td>Case C1-1
Japan
A-Load
And/or
American
AASHTO</td><td>M=2.62tfm
Working σ s
2200kg/cm²>
Allowable σ sa
1400kg/cm²

<u>Not stabled</u></td><td>M=102.76tfm
Working σ s
2111kg/cm²>
Allowable σ sa
1800kg/cm²

<u>Not stabled</u></td><td>M=178.9tfm
Working σ s
2078kg/cm²>
Allowable σ sa
1800kg/cm²

<u>Not stabled</u></td><td>S=4.4tf
Working τ
4.1kg/cm²<
Allowable τ a
8.5kg/cm²

Stabled</td><td>Fifth Pier
Working Q
32.5 tf/m²<
Allowable Q
58.8 tf/m²

Stabled</td><td>Evaluation;
Applied
International
Live-Loading

Existing Br.
Totally,
Over strength
Not stabled</td></tr>
</table>

Based on the above for **Case C3-1**, limited live loading weight for existing bridge without reinforcement is 14 ton. This live loading system is previous Japanese second class, TL-14 as shown in below Figure 9-3-3.

However, in **Case C1-1** applying International Load (Japan A-live load and/or American AASHTO), working strengths of existing bridge are exceeded against allowable strengths. Therefore, **the Case C1-1** shall be reinforced with concrete including steel bars or additional steel plates as calculated in next clause.

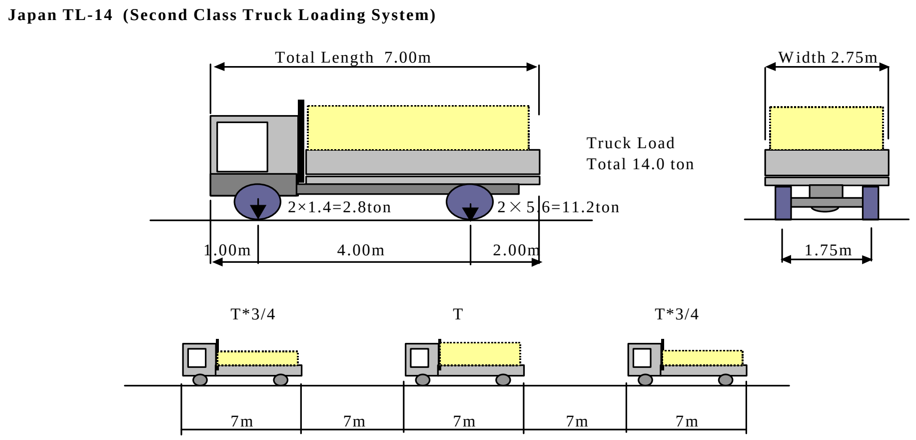


Figure 9-3-3 Limited Live Loading System, 14 ton Truck, for Existing Bridge

(4) Reinforcing Method of Existing Bridge for **Case C1-1** and **Case C1-2**

Depending on the above in case of **C1-1** applied of International Live Loading System, the existing bridge shall be required to reinforce against slab, RC -T girders and pier beams. There are two kinds of reinforcing method, reinforced concrete (steel bars and concrete) and steel plates. The method of reinforced concrete is extremely long period due to chipped out and bonding on slab and girder surface before pouring concrete. Also, adhesion/bond between new concrete/steel plate and overage concrete are difficult. Therefore, the life of bridge after reinforced concrete is very short term.

On the other hand, the method of steel plate bond is inadequate because the steel plate is not produced in this country. These materials of special bond, steel plates and anchors, etc. shall be imported from other country, such as Japan, Korea and Thailand.

As shown in Figure 9-3-4 (case-1), the computed results of the reinforcement for slab, girder and pier-beam are shown in below Table 9-3-2.

Table 9-3-2 Results of Reinforcement for Each Members

Applied Live Load	Slab **Plus 5cm RC surface** **Total 20cm thickness**	Girder **Plus 20cm RC web** **Total 36cm width** **Of girder web**	Pier-beam **Plus 2×30cm RC** **Beam width** **Total 1.8m width** **of pier beam**
Japan A-Live Load And/or American AASHTO	M=2.47tfm D13mm-10 Working σs 1369kg/cm^2 < Allowable σsa 1400kg/cm^2	M=121.03tfm D29-14 (added 4 no) Working σs 1656kg/cm^2 < Allowable σsa 1800kg/cm^2	M=220.02tfm D29-23(added 8 no) Working σs 1670kg/cm^2 < Allowable σsa 1800kg/cm^2
After Reinforcement	**Stabled**	**Stabled**	**Stabled**

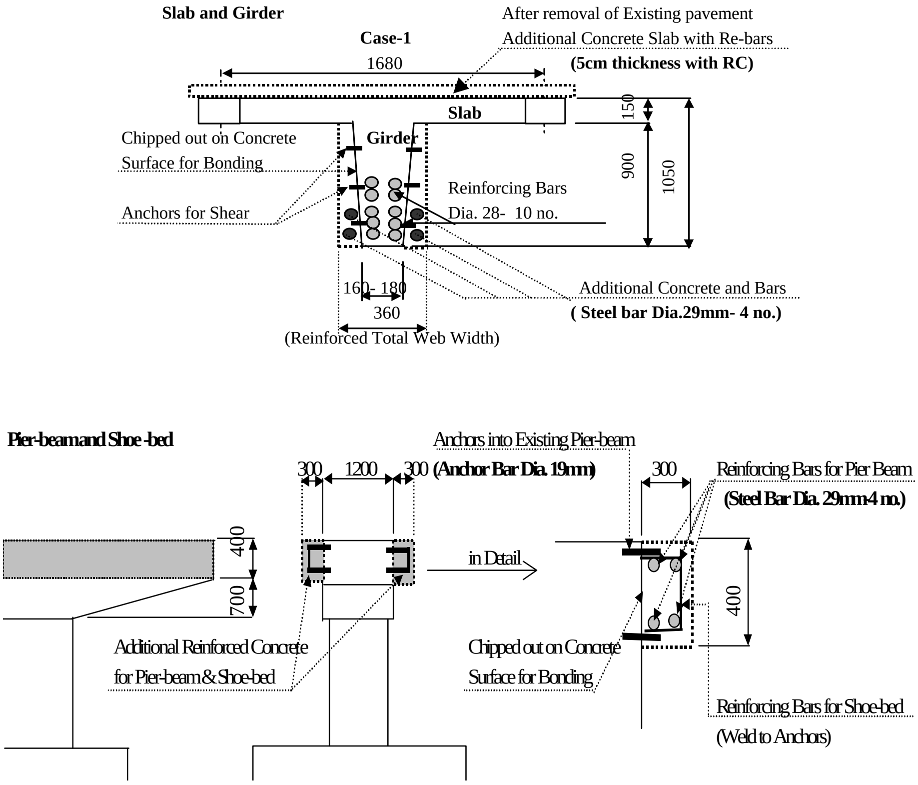


Figure 9-3-4 Details of Repair in Case C1-1

In case of difficulties of reinforcement for existing bridge, replacement with new girders in Case **C1-2** shall be considered to apply steel or RC types. The scale of Case C1-2 for replacement of super-structure is as follows.

- Bridge Length : 268.8m (16 @ span length 16.8m)
- Bridge width : 9.0m in total (carriage way 8.0m)- refer to next clause
- Type : RC- T Girder or Steel H-beam Girder conforming to International Standard Load

(5) New Bridge Construction in **Case C-2** and **Case C3-2**

The width and scale of bridge of new bridge for **Case C-2** crossing Kherlen River at 1 km down stream from existing bridge are shown as below Figure 9-3-5.

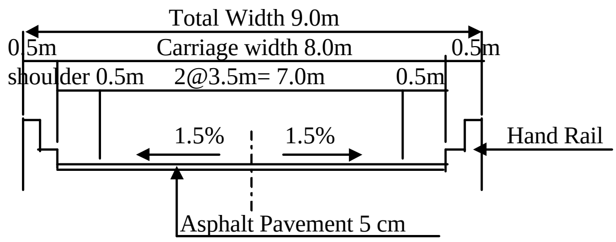


Figure 9-3-5 Bridge Width for Case C-2 and Case C-3-2

Bridge Length: 360m (18 @ span length 20m for RC-T, 12 @ span length 30m for PC-Girder) crossing Kherlen River

Bridge Type: RC-T Girder or PC-Girder for Super-structure

RC Reversed-T for Sub-structure and Spread Foundation

On the other hand, the width and scale of bridge of new bridge for Case C3-2 crossing Kherlen River at 30-50m down stream from existing bridge are follows.

The carriage way for Millennium Arterial Road is defined 8.0m of width in this stage (Figure 9-3-5). In Department of Roads, width of bridge to apply National Road is also defined as 4.5 m for one lane, 6.5m and 8.0m for two lanes.

- Bridge Length: 268.8m (16 @ span length 16.8m for RC-T, 8 @ span length 33.6m for PC-Girder)
- Crossing Kherlen River, total bridge width 6.5m
- Bridge Type: RC-T Girder or PC- Girder for Super-structure
- RC Reversed T for Sub-structure and Spread foundation

9.3.4 Evaluation of South Route Crossing Kherlen River

(1) Evaluation of South route crossing Kherlen River

From the results of above mentioned study cases, the selected route C1, C2, and C3 was evaluated in viewpoints of technical method, construction cost, period and river training, etc. as shown in Table 9-3-3. Especially, cost estimation is referred comparison table of bridge type for large scaled bridge (Table 9-3-4 and 9-3-5).

Also, evaluation for selection of South route was discussed between Mongolian Technical/ Steering Committee and Study Team held on September 21, and December 4, 2001.

(2) Recommendation of South Route Case

Recommendation to apply South Route of Case C3-1 plus C3-2.

- Existing Kherlen bridge (268.8m length, total width 9.8m (7.0m carriage-way and 2@ 1.0m pedestrian-way) shall effectively utilize with repairs and limited light vehicles (up to 14 ton truck), live stock and pedestrian.

  C3-1: Repair/ Mending of Existing Bridge

  - Over-lay with asphalt on surface for carriage-way
  - Set new expansion joints
  - Repair of hand rail
  - Repair of girders and piers for defected parts

- New bridge construction shall locate 30m down stream of existing bridge corresponding to international criteria with 8.0m width of carriage-way. The length of bridge is same length of existing bridge (268.8m) because of stabilized river features, and shall be able to expand to 360m length to meet design river discharge in future stage.

  C3-2: Scale of New Bridge

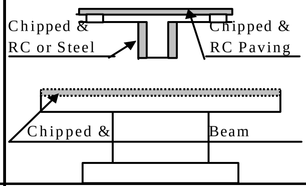
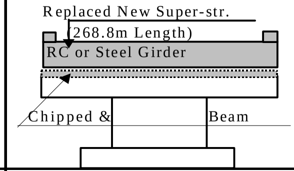
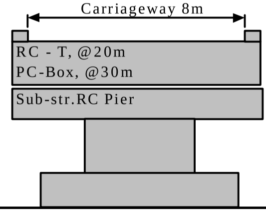
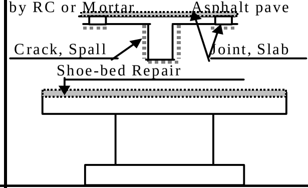
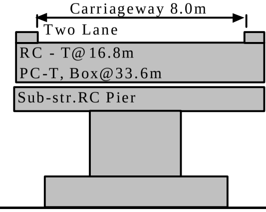
  - Superstructure Type- PC girder L= 268.8m (span 8@ 33.6m)
  - Substructure Type- RC wall and spread foundation

Reasons:

- Construction period is most short, compared other alternative.
- Construction cost for new bridge and minimum repair cost for existing bridge are fairly economy.
- Existing bridge can be utilized with limitation of live loading up to 14 ton truck (equivalent) traffic lane, livestock and pedestrian.
- Repair of existing bridge can be done after construction of new bridge.
- The carriage-way of new bridge is utilized for heavy vehicles to pass each other, Millennium Arterial Road.
- Temporary bridge for ordinal traffic transportation is not required.
- The length of new bridge can be expanded to meet design river section (360m) in future stage.
- It is estimated to finish the future stage construction before 2024. This estimation comes from the durability of existing bridge (50 years, constructed in 1974). The time of construction would be sooner if fatal damage was found in periodic inspection.

The relationship between existing bridge and construction new bridge for selected C-3 South route is illustrated as shown in Figure 9-3-6.

Table 9-3-3 Evaluation of Selected South Route and Type of Kherlen Bridge

Route / Category	C-1: Existing Bridge Route				C-2: New Route		C-3: Existing Bridge + New Route			
	C1-1: Reinforcement of super/sub-structures		C1-2:Partial replacement & Reinforcement		C2:New Bridge with Carriage Way (8m)		C3-1:Repair only Limitation of Live-Load		C3-2:New Bridge with Carriage Way (8m)	
1. Method 1.1 Reinforcement & Repair 1.2 New Bridge	*Slab(paving), Girder with RC *Pier-beam, Shoe-bed with RC 		*Replacement of Super-str. *Reinforcement to Sub-str. (Pier-beam, Shoe-bed with RC) 		*Length 360m 		* Repairs to Defected parts (Joint, Crack, Broken, Spall) by RC or Mortar 		*Length 268.8m 	
2. Requirement	Design Standard: AASHTO or JAPAN for Millennium Road		Design Standard: AASHTO or JAPAN for Millennium Road		Design Standard: AASHTO or JAPAN for Millennium Road		Limitation of Live-Load 14 Ton Truck		Design Standard: AASHTO or JAPAN for Millennium Road	
3. Quantity, Cost	(Q)	(US$)	(Q)	(US$)	(Q)		(Q)	(US$)	(Q)	(US$)
3.1 Bridge	Exi.268.8*9.8m RC-T (Steel Plate)	 $147,700 ($2,380,800)	RC-T 268.8*9m (Steel-H 268.8*9m) Exi. Pier [RC-T]	$456,000 ($772,700) $5,600	New 360*9m RC-T (PC-Box)	 $1,466,100 ($1,775,500)	Exi.268.8*9.8m	$18,400	New 268.8*7.5m RC-T (PC-Box) (PC-T)	 $1,122,700 ($1,359,700) ($1,349,000)
3.2 River Training	L=100m	$10,000	L=100m	$10,000	L=550m	$55,000	-		L=200m	$20,000
3.3 Temporary Bridge & Road	200*7.0m	$215,700	200*7.0m	$215,700	(No Bridge required)	$1,900	-		(No Bridge required)	$1,900
3.4 Others	-		Demolition952m3 (Super-str.)	$43,400	Demolition1259m3 (Super,Sub-str.)	$57,400	-		-	
3.5 Indirect Cost	RC-T (Steel Plate)	$350,200 ($882,000)	RC-T (Steel-H)	$508,800 ($567,000)	RC-T (PC-Box)	$936,800 ($1,184,900)	-		RC-T (PC-Box) (PC-T)	$582,900 ($768,300) ($550,405)
3.6 Total Cost Case A Case B Case C	 With RC (2@) With Steel Plate -	 $723,500 $3,488,500 -	 With RC-T With Steel-H -	 $1,239,400 $1,608,800 -	 With RC-T With PC-Box -	 $2,517,100 $3,074,800 -	 With RC-T With PC-Box With PC-T			 $1,745,900 $2,168,300 $1,939,705
Cost Index	1.80		0.83		1.30		1.00			
4. Construction Period	C1-1: Middle (App. 29 month)		C1-2: Very long (App. 33 month)		C2: Very Long(App. 35 month)		C3-1+ C3-2: Short(App. 22 month)			
5. Other Evaluation	**B**ond/adhesion between new concrete/steel plate and overage concrete, and pouring concrete with equipment are extremely difficult.(C1-1) **C**hipping out 96 girders/slab and demolition takes long period. **D**emolition is required.Life span is different of Super/Sub str.(C1-2) **T**emporary bridge for ordinal traffic transportation is required. **B**ridge length does not satisfy design river section (350m). **A**fter reinforcement, life of bridge is too short. (app. 10 years period)				**A**fter construction of new bridge, demolition of existing bridge is required, and takes long period. **T**emporary bridge is not required. **B**ridge length satisfies design river section.(350m)		**E**xisting bridge can be utilized for limitation of live load up to 14ton truck (equivalent) traffic, livestock and pedestrian. **R**epair of existing bridge can be done after construction of new bridge. **C**arriage-way is two vehicles to pass each other for Millennium Road. **T**emporary bridge is not required. **N**ew bridge can be expanded to satisfy design river section (360m) in future stage.			
Recommendation							**Recommend (New Bridge: PC Girder Type)**			
Construction Work Period (month)	Preparation(1), Chipping of concrete(8,4), and Concreting (18,6), Temporary bridge(2), Demolition of bridge(13,16), Construction of new girder(7), Construction of new bridge (18), Repairing existing bridge(3)									

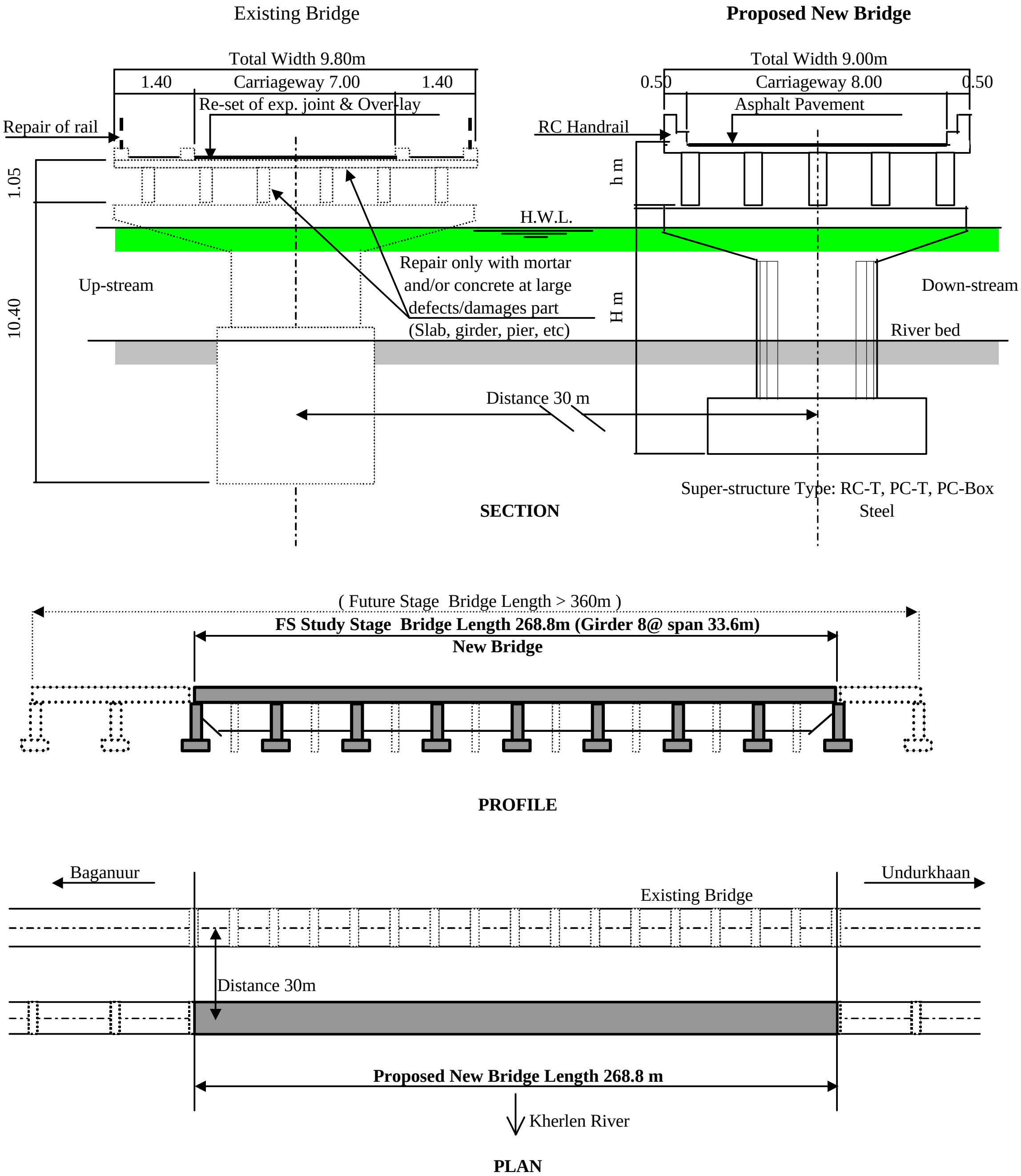


Figure 9-3-6 Relationship between Existing Bridge and Construction New Bridge for South Route