13.1.8 Countermeasures for Environmental Impacts

(1) Countermeasure for permafrost

The study route is planned to cross permafrost. In this area, box culvert are to installed where road embankment interrupt water flow on frozen layer. Therefore, box culvert is planned to install for equalizing difference between potential head of upstream and of downstream. Moreover, embankment height is planned to be two or three meter in order to absorb heaving of ground.

(2) Approach slopes for domestic animal crossing

The slope of embankment is designed to be of 1 to 2, and it is so steep that domestic animals could not cross the road in case of high embankment. Domestic animals will cross the road where a box culvert is installed in the vicinity of high embankment. An approach slope, however, will be required for domestic animals to cross the road where embankment is enough high and no box culvert is found in its surrounding.

(3) Tree planting for environmental protection of inhabitants beside road

The study route is planned to pass beside some village and settlement. There is the possibility that circumstances are deteriorated by car fumes and noise. It is necessary to plant trees at intervals of ten meters between road and village or settlement.

(4) Reinstate of hauling road

Hauling road is necessary for road construction. Heavy dump truck, water sprinkler and other construction equipments go and return in many times through hauling road and it is used in long period. During construction, hauling road is hardened day by day. After construction, ground under hauling road have been damaged and obstacles to grow up of vegetation. It is necessary that the hard ground soil is churned up by ripper and other equipment and soft ground is reinstated.

(5) Recovery measure after excavation at borrow pit and quarry site

Borrow pits and quarry sites left after construction are unsightly and destroy the scenery. After construction, there are sloped the wall with 1 to 5 and made rounding the edge of ground surface due to recover of harmony with the surroundings. Especially, it is necessary to pay attention to command a view from road user.

13.2 Design of Pavement

13.2.1 Design of Asphalt Concrete Pavement

There are many pavement design methods in the world and some of them prevail in actual practices. In Mongolia, Japanese Pavement Manual method, TRL method from England and Asphalt Institute method from USA were used before. However, for the Study, AASHTO design method is selected because of progression method based on pavement performance or road test.

(1) Consideration of Cold Weather

The following salient features induced by extreme climatic conditions have been discussed repeatedly in Mongolia.

- Cold weather-induced cracking
- Frost upheaval or Freeze-thaw cycle

As for the former, theoretically there is no solution to prevent it due to the property of asphalt. Ordinary asphalt has broken at subzero temperate by brittleness. On the other hand, approximately more than 60 degree Celsius (generally black color asphalt pavement is absorbing sunshine and surface temperature of asphalt pavement reaches up to 60 degree Celsius in hot summer) asphalt will start melting. Therefore, it is no way to solve cold weather-induced crack in asphalt pavement.

In addition, modified asphalt such as polymer asphalt was once used in Mongolia, however the result was not satisfactory because cracks appeared in the asphalt pavement. Besides, it was very costly.

Generally, high-grade penetration asphalt is used in cold weather country such as northern European countries; however there is not hot summer like Mongolia. There temperature range is approximately from - 5 to 30 degree Celsius, while the temperature in Mongolia ranges from - 40 to 40 degree Celsius. Therefore, it is impossible to prevent this phenomenon in Mongolia because of extreme climatic conditions.

In Mongolia, crack sealing after winter is one of the appropriate measures to cope with such cold weather-induced cracking considering the very dry climate with limited rainfall.

The latter usually happens on embankment section in valley and cutting section in hilly areas where alligator cracks appear on surface of asphalt pavement. Mostly, this problem is brought on by inadequate materials for base course and subbase course or poor drainage. "Active Subgrade Layer" is specified in Mongolian Highway Standards (2000) as the provision that the upper portion of roadbed designated as 2/3 of the frost penetration depth or 1.5 m deep from the pavement surface which is bigger. The layer should be located above the highest level of estimated ground water table or be replaced by material other than frost susceptible soil.

The study area is designated as Climatic Zone IV, and the standard specifies that the pavement surface should be designed higher than 1.8 m from estimated highest ground water level in case that Active Subgrade Layer contains heavy silty loam. The preliminary design has incorporated fully such provisions of the standard related to cold weather.

(2) Traffic Volume by Section

The Study route was divided into four sections, Erdene - Baganuur, Baganuur - Jargaltkhaan, Jargaltkhaan - Murun and Murun – Undurkhaan. And among the four sections, Erdene - Baganuur section has been started to construct by DOR. Therefore, this section was deleted from further study based on discussion with DOR.

Future traffic volume is estimated up to year 2025 as shown in following table.

Table 13-2-1 Future Traffic Demand for Five-Vehicle Composition

Baganuur - Jargaltkhaan

Year	ALL	Growth Rates (%)	Car	Growth Rates (%)	Bus	Growth Rates (%)	S-Truck	Growth Rates (%)	M-Truck	Growth Rates (%)	L-Truck	Growth Rates (%)
2000	426	-	218	-	71	-	10	-	91	-	36	-
2005	630	1.081	313	1.075	112	1.095	18	1.125	133	1.079	54	1.087
2010	907	1.076	448	1.074	168	1.084	27	1.084	189	1.073	75	1.067
2015	1,352	1.083	659	1.080	260	1.091	37	1.065	288	1.088	108	1.076
2020	1,966	1.078	958	1.078	378	1.078	54	1.079	419	1.078	157	1.078
2025	2,858	1.078	1,393	1.078	549	1.077	79	1.079	609	1.078	228	1.077

Jargaltkhaan – Murun

Year	ALL	Growth Rates (%)	Car	Growth Rates (%)	Bus	Growth Rates (%)	S-Truck	Growth Rates (%)	M-Truck	Growth Rates (%)	L-Truck	Growth Rates (%)
2000	316	-	144	-	57	-	9	-	82	-	24	-
2005	453	1.075	201	1.069	84	1.081	14	1.092	119	1.077	35	1.078
2010	656	1.077	286	1.073	127	1.086	21	1.084	174	1.079	48	1.065
2015	994	1.087	428	1.084	192	1.086	30	1.074	275	1.096	69	1.075
2020	1,445	1.078	622	1.078	279	1.078	43	1.075	399	1.077	102	1.081
2025	2,102	1.078	905	1.078	406	1.078	63	1.079	581	1.078	147	1.076

Murun – Undurkhaan

Year	ALL	Growth Rates (%)	Car	Growth Rates (%)	Bus	Growth Rates (%)	S-Truck	Growth Rates (%)	M-Truck	Growth Rates (%)	L-Truck	Growth Rates (%)
2000	330	-	153	-	57	-	9	-	85	-	26	-
2005	478	1.077	216	1.071	85	1.083	14	1.092	125	1.080	38	1.079
2010	702	1.080	313	1.077	131	1.090	21	1.084	185	1.082	52	1.065
2015	1,076	1.089	477	1.088	201	1.089	31	1.081	294	1.097	73	1.070
2020	1,565	1.078	693	1.078	292	1.078	45	1.077	427	1.077	108	1.081
2025	2,275	1.078	1,008	1.078	425	1.078	66	1.080	621	1.078	155	1.075

(3) Cumulative ESAL for Four Vehicle Categories

Cumulative ESAL is calculated to year 2025 based on extended future traffic volume. Half of future traffic volume (On-way direction) is used for the computation of ESAL, if drivers will keep their lane after the road is developed.

Table 13-2-2 shows cumulative ESAL for four vehicle categories by section.

Table 13-2-2 Cumulative ESAL for Four Vehicle Categories

Baganuur – Jargaltkhaan

Year	**Bus**	Cumulative ESAL	**Ordinal Truck**	Cumulative ESAL	**Heavy Truck**	Cumulative ESAL	**Trailer**	Cumulative ESAL	ESAL for the section
2000	71	11,040	101	13,345	25	9,554	11	30,743	32,300
2005	112	71,137	151	83,242	37	59,234	17	195,636	204,600
2010	168	108,843	216	121,229	52	85,029	23	279,481	501,800
2015	260	166,374	325	178,706	75	121,334	33	391,273	**930,600**
2020	378	248,007	473	263,599	109	175,791	48	565,948	1,557,200
2025	549	360,348	688	383,507	159	256,044	69	817,480	**2,465,800**

Jargaltkhaan – Murun

Year	**Bus**	Cumulative ESAL	**Ordinal Truck**	Cumulative ESAL	**Heavy Truck**	Cumulative ESAL	**Trailer**	Cumulative ESAL	ESAL for the section
2000	57	8,863	91	12,024	16	6,114	8	22,358	24,600
2005	84	54,810	133	73,993	24	38,216	11	132,753	149,800
2010	127	82,021	195	108,347	33	54,457	15	181,662	363,000
2015	192	124,003	305	165,163	48	77,386	21	251,532	**672,000**
2020	279	183,089	442	246,753	71	113,691	31	363,325	1,125,400
2025	406	266,277	644	358,733	102	165,282	45	531,013	**1,786,000**

Murun – Undurkhaan

Year	**Bus**	Cumulative ESAL	**Ordinal Truck**	Cumulative ESAL	**Heavy Truck**	Cumulative ESAL	**Trailer**	Cumulative ESAL	ESAL for the section
2000	57	8,863	95	12,552	18	6,879	8	22,358	25,300
2005	85	55,199	139	77,296	26	42,037	12	139,740	157,100
2010	131	83,965	206	113,962	36	59,234	16	195,636	383,400
2015	201	129,057	325	175,403	51	83,119	22	265,506	**709,900**
2020	292	191,641	472	263,269	75	120,379	33	384,286	1,189,600
2025	425	278,716	687	382,847	108	174,836	47	558,961	**1,887,200**

Two sections, Jargaltkhaan - Murun and Murun - Undurkhaan, have almost the same cumulative ESALs. Therefore, the latter cumulative ESAL is adopted for both sections to determine the pavement structure.

(4) Representative Design CBR values, Design Life Cycle and Pavement Structures.

The study route is grouped into two sections, Baganuur - Jargaltkhaan and Jargaltkhaan - Undurkhaan. These two sections have CBR values of existing ground ranging from 4 to 15. To make the design of pavement structures simple and to adopt realistic design CBR values referred to CBR values of existing ground and materials from presumed borrow pits, following assumptions are made:

a) CBR < 4 or 5, then embankment height is at least 1.0m and pavement structure is about 50cm.
b) CBR > 10, then pavement structure sits on existing subgrade and minimum embankment is 50cm.
c) CBR = 7 or 8, then embankment height is 70 to 80 cm and pavement structure is about 50cm.
d) CBR > 15 for embankment material. (This value is based on soil investigation)

In case of assumption a), design CBR is calculated as follow.

CBR = ((50cm x 4 ^1/3 +50cm x 15 ^1/3) / 100cm) ^3 = 8.3 say **design CBR = 8**

In case of assumption c), design CBR is calculated as follows.

CBR = ((80cm x 7 ^1/3 +20cm x 15 ^1/3) / 100cm)^ 3 = 8.3 say **design CBR = 8**

As a result, minimum design CBR value is computed as 8 in sections.

As for the designed life period, 20-year life period together with overlay at 10 years interval was proposed in the Interim Report. However, to examine the optimum design life cycle in detail, the following cases of design life cycle are assumed and pavement structures are computed based on those cases.

Case-1: first overlay at 7 years and second overlay at 14 years from year 2005

Case-2: first overlay at 10 years and second overlay at 16 years from year 2005

Case-3: overlay at 13 years from year 2005

Case-4: overlay at 15 years from year 2005.

ESALs for each section based on above cases are shown in Table 13-2-3.

Table 13-2-3 Cumulative ESAL for Design Life Cycles

Baganuur - Jargaltkhaan:

Case 1: 7-14-20 years		Case 2: 10-16-20 years		Case 2: 10-16-20 years		Case 4: 15-20 years	
7 years	433,300	10 years	707,100	13 years	1,054,900	15 years	1,337,500
14 years	1,190,500	16 years	1,496,600	-	-	-	-
20 years	2,276,700	20 years	2,276,700	20 years	2,276,700	20 years	2,276,700

Jargaltkhaan - Undurkhaan:

Case 1: 7-14-20 years		Case 2: 10-16-20 years		Case 3: 13-20 years		Case 4: 15-20 years	
7 years	334,200	10 years	543,500	13 years	808,000	15 years	1,021,900
14 years	910,800	16 years	1,142,000	-	-	-	-
20 years	1,728,000	20 years	1,728,000	20 years	1,728,000	20 years	1,728,000

*Note: assuming construction will start at 2005

In each case, pavement structures are computed using design CBR values of 8, 10, 12 and 14 respectively.

Computed pavement structures (Structure Number) are shown in Table 13-2-4.

Table 13-2-4 Computed SN for Design Period by Section

Baganuur - Jargaltkhaan

	CBR = 8	**CBR = 10**	**CBR = 12**	**CBR = 14**
Case 1: **7** years design period	2.41	2.21	2.05	1.93 (1.99)
Case 2: **10** years design period	2.61	2.39	2.23	2.10
Case-3: **13** years design period	2.79	2.56	2.39	2.25
Case-4: **15** years design period	2.90	2.66	2.48	2.34

Jargaltkhaan - Undurkhaan

	CBR = 8	**CBR = 10**	**CBR = 12**	**CBR = 14**
Case 1: **7** years design period	2.30	2.11	1.97 (1.99)	1.85 (1.99)
Case 2: **10** years design period	2.50	2.29	2.13	2.01
Case-3: **13** years design period	2.67	2.45	2.28	2.15
Case-4: **15** years design period	2.77	2.54	2.37	2.23

As for the SN value, coefficient of Relative Strength for each layer of pavement structure is as follows.

a= 0.45 for asphalt concrete surface

a= 0.14 for granular base course (CBR>80)

a= 0.08 for granular subbase (20<CBR<30)

In addition, minimum thickness requirement of each layer is as follows.

5cm for asphalt concrete surface

10 cm for base course (in case of 40mm top size of aggregate)

20cm for subbase

Therefore, **minimum pavement thickness is 35cm** and minimum Structure Number is **SN=1.99**.

From Table 13-2-4, SN values of CBR=14 in Case 1 at Baganuur – Jargaltkhaan section and CBR=12 and 14 in Case 1 at Jargaltkhaan – Undurkhaan section are lower than the minimum SN value and already satisfies required SN value.

In addition, from Table 13-2-4, significant difference of SN values among each design CBR is found between Case 1 and 2. Therefore, case 1 (7 years design period) is the most effective in construction cost. Also considering about maintenance cost, both case 1 and 2 has overlay two times in 20 years analysis period and both overlay thickness is approximately 5cm. Therefore, Case 1 is most effective. Table13-2-4 is summarized as follows.

Table 13-2-5 Optimum Computed SN by Sections

Case 1: 7 years design period

	CBR = 8	**CBR = 10**	**CBR = 12**	**CBR = 14**
Baganuur - Jargaltkhaan	2.41	2.21	2.05	1.99
Jargaltkhaan - Undurkhaan	2.30	2.11	1.99	1.99

Furthermore, there are not much difference in SN values between CBR=12 and 14. Therefore, design CBR values of 8, 10 and 12 are selected as representative and the pavement structures are determined as follows.

Table 13-2-6 Representative CBR and Pavement Structure by Sections

Baganuur - Jargaltkhaan

	CBR = 8	**CBR = 10**	**CBR = 12**
Asphalt Concrete Surface	5	5	5
Granular Base Course	15	15	10
Granular Subbase	26	20	22
Total	**46**	**40**	**37**

Jargaltkhaan - Undurkhaan

	CBR = 8	**CBR = 10**	**CBR = 12**
Asphalt Concrete Surface	5	5	5
Granular Base Course	15	10	10
Granular Subbase	23	24	20
Total	**43**	**39**	**35**

13.2.2 Consideration of Bituminous Surface Treatment

Bituminous Surface Treatment (hereinafter referred to as “BST”) is very common in Southeast Asian and some African countries because it is reported that initial investment is low compared to asphalt concrete pavement in case of small work volume.

However, BST has following disadvantages:

a) There is less bearing capacity so that it is suitable only for light traffic load.
b) Low durability requires frequent maintenance (mostly 2 to 3 years).
c) A practical design method has not yet been developed.

For the analysis of BST having uncertain factors, BST surface of 2.5cm is adopted empirically, and base and subbase course are assumed to be the same thickness as asphalt pavement. Periodic maintenance is assumed every three years for life cycle cost analysis to keep the same serviceability of asphalt concrete pavement.

13.2.3 Consideration of Cement Treated Base

Low cost pavement with cement treated base course has been continuously studied between Mongolian and Japanese Universities. In addition, the trial base course was constructed in 1997, and much data are being collected.

It is reported that a cement treated base course is useful for sandy soil in case neither granular borrow pit nor quarry site is available near the project site. However, in the study area, there are many granular borrow pits and quarries, and it is revealed by the Study that required cost and construction period of cement treated base course are much bigger than that of mechanical stabilized base course.

Furthermore, for the following reasons, a cement treated base course is not adopted in the Study.

- Quality control becomes to be difficult unless mixing plant is mobilized.
- It requires more severe quality controls such as mixing, placing compacting and curing.
- It is not cost-effective method on condition that granular materials for base course and subbase are easily obtained.
- Construction speed decrease because curing is required at site.

13.2.4 Evaluation of DOR Paving Section between Erdene and Baganuur

At the beginning of the study, this section was included in the study. While investigating the site, it was recognized that the section had been started construction by DOR and will be completed in year 2004.

However, it is necessary to evaluate the pavement structure for the Life Cycle Cost Analysis (for future AC overlay).

The pavement was designed based on Russian Standard (SNIP) in 1992. Due to absence of traffic data, it was assumed minimum traffic volume category of 70 pcu.

As a result, pavement structure was designed as follows.

AC surface:	6 cm
Base Course:	10 cm at Dutluur pass and 15 cm for embankment section
Subbase:	variable thickness

To evaluate the pavement structure (SN values) based on AASHTO method, following assumptions are made.

a) At Dutluur pass, base course is 10cm. On the other hand, existing ground is mostly gravel and referring to the soil and material investigations, CBR 14 is expected at least. Therefore, part of existing ground can be expected as a base course.

b) At embankment section, average embankment height is more than 60 cm. Therefore, average subbase thickness is 39 cm and becomes more than 30 cm.

Therefore, computed SN value is as follow.

Asphalt concrete surface	6 cm	=	2.36 inch
	SN_1	=	1.06
Base Course	15 cm	=	5.91 inch
	SN_2	=	0.59
Subbase	30 cm	=	11.81 inch
	SN_3	=	0.94
	SN	**=**	**2.59**

On the other hand, required pavement structure was computed based on future traffic demand. As a result, SN value became 2.60 as shown in following Table.

log10W18=ZR*S0+9.36*log10(SN+1)-0.20+log10(ΔPSI/(4.2-1.5))/((0.40+1094/(SN+1)5.19)+2.32*log10MR-8.07

*Effective Resilient Modulus of Subgrade (psi)	MR=	1,500*CBR
*Reliability: 90% (middle range of Local Area)	ZR =	-1.282
*Standard Deviation:		0.35
*Initial Pavement Serviceability Index for the Asphalt Pavement:		4.2
*Terminal Serviceability Index:		2.5
*ΔPSI = 4.2 - 2.5 =		1.7

*Cumulative traffic (ESAL) Erdene-Baganuur: 44,800 * ((1+g) t-1) / g g = 5.9 %

ESAL for **10 years**: 44,800*((1.059)13-1) / 0.059 - 44,800*((1.059)3-1) / 0.059= 698,000

Table 13-2-7 Required Pavement Structure in DOR Paving Section

Input Data for SN

W18	ZR	S0	ΔPSI	CBR	MR	log10W18	ZR*S0	log10(ΔPSI /(4.2-1.5))	log10MR
6.98E+05	-1.282	0.35	1.7	**8**	12,000	**5.844**	-0.449	-0.201	4.079

Y=ZR*S0+9.36*log10(SN+1)-0.20+log10(ΔPSI/(4.2-1.5))/((0.40+1094/(SN+1)5.19)+2.32*log10MR-8.07

Computed SN

CBR = 8		
SN0	Y	log10W18
2.59	5.831	**5.844**
2.60	5.842	
2.61	5.852	

Pavement Layer	a	**CBR =8**	
		Thickness (D)	SN
Asphalt Concrete Surface	0.45	2.36	1.06
Granular Base Course (CBR>30)	0.10	7.87	0.79
Road bed (10<CBR<20)	0.06	12.50	0.75
Total	-	**22.73**	**2.60**

Evaluated pavement structure and required pavement structure were almost same value. Therefore, evaluated pavement structure has enough durability for 10 years design period.

13.2.5 Evaluation of Existing Paved Section

Exiting AC and BST pavement sections exist in the section between Baganuur and Kherlen Bridge East. To evaluate the structure, site investigation and road inventory were carried out.

These pavements have been used more than 20 years and it is evaluated as poor condition because pavement surfaces are oxidized and deteriorated. However, pavement structure itself is still in good condition and any distortion or disintegration such as rutting and pothole are not found. Therefore, it is concluded that only AC overlay is enough and it is not necessary to reconstruct the pavement structure.

Followings are assumptions and result of computation.

a) Pavement structure for AC section is

AC surface:	12 cm (from Road Inventory sheet)
Base Course:	20 cm (from Road Inventory sheet)
Subbase:	30 cm (from visual observation at site: minimum)

b) Pavement structure for BST section is

BST surface:	7 cm (from Road Inventory sheet)
Base Course:	20 cm (from Road Inventory sheet)
Subbase:	25 cm (from visual observation at site: minimum)

c) Existing SN values for AC pavement is

AC surface:	4.72 inch x 0.45 / 4	=	0.53
Base Course:	7.87 inch x 0.10	=	0.79
Subbase:	12 inch x 0.06	=	0.72
			2.04

d) Pavement structure for BST section is

BST surface:	2.76 inch x 0.3 / 3	=	0.28
Base Course:	7.87 inch x 0.10	=	0.79
Subbase:	10 inch x 0.06	=	0.60
			1.66

e) Overlay will be completed by year 2005 in both section and it will last out until year 2012.

f) ESAL is computed by following formula.

ESAL = 44,800 x ((1 + g) t – 1) / g
Where: g = growth rate and t = target year

Computed overlay thickness is as follows.

AC surface section:	4 cm AC overlay
BST section:	6 cm AC overlay

13.2.6 Computation of Periodic Maintenance

As described in Chapter 13.2.1 (4), initial design period of 7 years was adopted and then overlay thickness was computed for AC pavement. And, overlay was planned to implement at 7 and 14 years, which are year 2012 and 2019 after completion of the construction.

Table 13-2-8 is in case of all AC pavements with overlay on whole stretch. Moreover, Table 13-2-9 is in case of Bituminous Surface Treatment adopted in the latter sections.

Table 13-2-8 Computed Pavement Structures in Initial and Maintenance Stages (AC)

	Erdene - Baganuur	**Section 1**	**Section 2**		**Section 3 - 12**			**Section 13-21**		
Station	-	STA. 112+127 ~STA.121+448	STA. 121+448 ~STA.128+388	STA. 128+678 ~STA.130+769	STA.130+769 ~STA.237+100			STA.237+100 ~STA.333+949		
Section Length	-	8,866 m	6,940 m	2,091 m	62,131 m	16,000 m	28,200 m	17,600 m	33,749 m	45,500 m
Existing condition	New Construction	Asphalt Pavement	Asphalt Pavement	Surface Treatment	New Construction			New Construction		
					CBR = 8	CBR = 10	CBR = 12	CBR = 8	CBR = 10	CBR = 12

Unit: cm

Initial Pavement by year 2005										
	-	Asphalt overlay			-	-	-	-	-	-
AC concrete	6	4	4	6	5	5	5	5	5	5
Base course	10-16	-	-	-	15	15	10	15	10	10
Subbase	Variable	-	-	-	26	20	22	23	24	20
Total	--	**4**	**4**	**6**	**46**	**40**	**37**	**43**	**39**	**35**

1st overlay at year 2012										
AC concrete	**5**	**4**	**4**	**5**	**4**	**4**	**5**	**4**	**4**	**5**

2nd overlay at year 2019										
AC concrete	**5**	**5**	**5**	**4**	**5**	**4**	**5**	**4**	**4**	**5**

Table 13-2-9 Computed Pavement Structures in Initial and Maintenance Stages (BST)

Section 13-21			
STA.237+100~STA.333+949			
Existing condition	L= 17,600 m	L= 33,749 m	L= 45,500 m
	New Construction		
	CBR = 8	CBR = 10	CBR = 12

Unit: cm

Initial Pavement by year 2005			
Bituminous Surface Treatment	2.5	2.5	2.5
Base course	15	10.	10
Subbase	23	24	20
Total	**40.5**	**36.5**	**32.5**

1st periodic maintenance at year 2008 (Bituminous Surface Treatment)	2	2	2
2nd periodic maintenance at year 2011 (Bituminous Surface Treatment)	2	2	2
3rd periodic maintenance at year 2014 (Bituminous Surface Treatment)	2	2	2
4th periodic maintenance at year 2017 (Bituminous Surface Treatment)	2	2	2
5th periodic maintenance at year 2020 (Bituminous Surface Treatment)	2	2	2
6th periodic maintenance at year 2023 (Bituminous Surface Treatment)	2	2	2

For the cost estimate of the periodic maintenance, following assumptions were made.

1) As for the AC pavement, first overlay is carried out 7 years after completion of the construction. However, half of the area within all sections is assumed to be still in good condition. Therefore, overlay is applied on half of the area within all sections.

   This is based on the reports for the pavement management system in Japan. In the report, it is described that low traffic volume road such as a road related to basic life lasts more than 15 years without maintenance. This is beyond far away from 10 years design period.

   This type of road has a thin pavement structure, however, because of low traffic volume, the rutting is not appeared in the pavement surface and this is maintaining better riding comfort and extending life period.

   Eastern arterial road in Mongolia has similar characteristics with this type of road. Therefore it has 7 years design period, however it is predicted that some section lasts more than the design period.

   Moreover, routine maintenance is carried out annually and deteriorated area is repaired at the time, so even passed 7 years, it is considered some areas are still in good condition.

2) For the second overlay, same assumption was made, so the maintenance cost is applied on half of the section within all sections. Therefore, all the section is overlaid one time.

3) As for the BST section, it is said that the pavement will last from 4 to 6 years. Therefore every 3-year periodic maintenance before suffering big loss was adopted. The frequency of the maintenance is higher than AC pavement and the routine maintenance is carried parallel with the periodic maintenance. However, BST thickness itself is thinner than AC surface, each periodic maintenance was applied to 50 percent of all sections. Therefore, 6-time periodic maintenance is carried out within 20 years analysis period and totally all the section is overlaid three times.

The cost estimate for the periodic maintenance is shown in as follows.

Table 13-2-10 Periodic Maintenance Cost (All Asphalt Concrete)

(in US$) 1US$ =1,100 Tg.

Year	Cumulative	Erdene-Baganuur	Section 1	Section 2		Section 3 -12			Section 13 -21			Total
				Ac Surface	BST	CBR=8	CBR=10	CBR=12	CBR=8	CBR=10	CBR=12	
Section Length (m)		36,800	9,321	6,940	2,091	62,131	16,000	28,200	17,600	33,749	45,500	258,332
Bridge Length (m)		103	15	0	0	286	53	15	0	53	0	525
Pavement length (m)		36,697	9,306	6,940	2,091	61,845	15,947	28,185	17,600	33,696	45,500	257,807
Maintenance Cost	4cm	-	34,340	34,340	34,340	36,548	36,548	-	36,548	36,548	-	
	5cm	39,660	39,660	39,660	39,660	42,324	-	42,324	-	-	42,324	
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	1	0	0	0	0	0	0	0	0	0	0	0
2007	2	0	0	0	0	0	0	0	0	0	0	0
2008	3	0	0	0	0	0	0	0	0	0	0	0
2009	4	0	0	0	0	0	0	0	0	0	0	0
2010	5	0	0	0	0	0	0	0	0	0	0	0
2011	6	0	0	0	0	0	0	0	0	0	0	0
2012	7	661,547	145,258	108,327	37,695	1,027,414	264,923	542,228	292,384	559,782	875,337	4,514,896
2013	8	0	0	0	0	0	0	0	0	0	0	0
2014	9	0	0	0	0	0	0	0	0	0	0	0
2015	10	0	0	0	0	0	0	0	0	0	0	0
2016	11	0	0	0	0	0	0	0	0	0	0	0
2017	12	0	0	0	0	0	0	0	0	0	0	0
2018	13	0	0	0	0	0	0	0	0	0	0	0
2019	14	661,547	167,762	125,109	32,639	1,189,785	264,923	542,228	292,384	559,782	875,337	4,711,497
2020	15	0	0	0	0	0	0	0	0	0	0	0
2021	16	0	0	0	0	0	0	0	0	0	0	0
2022	17	0	0	0	0	0	0	0	0	0	0	0
2023	18	0	0	0	0	0	0	0	0	0	0	0
2024	19	0	0	0	0	0	0	0	0	0	0	0
2025	20	0	0	0	0	0	0	0	0	0	0	0
Total		1,323,094	313,020	233,436	70,334	2,217,199	529,846	1,084,456	584,768	1,119,565	1,750,675	9,226,393

Table 13-2-11 Periodic Maintenance Cost (Asphalt Concrete + BST)

(in US$) 1US$=1,100 Tg.

year	Cumulative	Erdene -Baganuur	Section 1	Section 2		Section 3 -12			Section 13 -21			Total
				Ac Surface	BST	CBR=8	CBR=10	CBR=12	CBR=8	CBR=10	CBR=12	
Section Length (m)		36,800	9,321	6,940	2,091	62,131	16,000	28,200	17,600	33,749	45,500	258,332
Bridge Length (m)		103	15	0	0	286	53	15	0	53	0	525
Pavement length (m)		36,697	9,306	6,940	2,091	61,845	15,947	28,185	17,600	33,696	45,500	257,807
Maintenance Cost	4cm	-	34,340	34,340	34,340	36,548	36,548	-	17,668	17,668	17,668	
	5cm	39,660	39,660	39,660	39,660	42,324	-	42,324	-	-	-	
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	1	0	0	0	0	0	0	0	0	0	0	0
2007	2	0	0	0	0	0	0	0	0	0	0	0
2008	3	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2009	4	0	0	0	0	0	0	0	0	0	0	0
2010	5	0	0	0	0	0	0	0	0	0	0	0
2011	6	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2012	7	661,547	145,258	108,327	37,695	1,027,414	264,923	542,228	0	0	0	2,787,393
2013	8	0	0	0	0	0	0	0	0	0	0	0
2014	9	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2015	10	0	0	0	0	0	0	0	0	0	0	0
2016	11	0	0	0	0	0	0	0	0	0	0	0
2017	12	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2018	13	0	0	0	0	0	0	0	0	0	0	0
2019	14	661,547	167,762	125,109	32,639	1,189,785	264,923	542,228	0	0	0	2,983,993
2020	15	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2021	16	0	0	0	0	0	0	0	0	0	0	0
2022	17	0	0	0	0	0	0	0	0	0	0	0
2023	18	0	0	0	0	0	0	0	141,344	270,610	365,406	777,360
2024	19	0	0	0	0	0	0	0	0	0	0	0
2025	20	0	0	0	0	0	0	0	0	0	0	0
Total		1,323,094	313,020	233,436	70,334	2,217,199	529,846	1,084,456	848,064	1,623,657	2,192,438	10,435,545

13.2.7 Comparison of All AC Surface Section and Combination of AC/BST Surface

The EAR has salient features from engineering aspects such as relatively low traffic, extreme climatic conditions and freeze-thaw cycle phenomenon where empiricism still plays an important role even up to the present day. One of such features is inevitable thermal cracking that is induced by low-temperature constriction and thermal fatigue on the flexible pavement. For the purpose of LCC analysis, the following assumptions are taken even though the pavement design procedure is adopted to perform averting failure criteria during design life:

(1) Routine maintenance including thermal cracks filled with asphalt emulsion slurry for both AC pavement and BST pavement.
(2) Periodic maintenance for AC pavement with overlay at 7 years interval.
(3) Surface dressing at 3 years interval on BST pavement due to keeping similar roughness of AC pavement and avoiding particular surface treatment problems.

LCC analysis is conducted at two sections of the EAR, namely Erdene to Baganuur and Murun to Undurkhaan. The former is a representative section of relatively heavy traffic volume and high embankment, and the latter is of low embankment with small traffic.

The principal economic benefits are savings in vehicle operating costs. With the new paved road the average IRI is expected to be about 3.0, compared with 14.0 for the without case. With good standard routine maintenance and surface dressing every three years, it is considered that an IRI of about 3.0 could be sustained throughout the period 2006 to 2025. The traffic details used in the economic analysis are based on the analyses in Chapter 3. An only benefit attributable to normal traffic is considered and even modest amount of generated traffic that the paved road would lead to is ignored. Travel time savings have not been included in the economic analysis as described in Chapter 16. This conservative approach reflects the inherent difficulty of putting a value on travel time.

Vehicle operating costs in 2001 economic prices are shown below, based on the RED (roads economic decision) VOC model developed by the World Bank.

Table 13-2-12 Vehicle Operating Costs in $ per Vehicle km

Vehicle Type	IRI 14 without project	IRI 3 with project	VOC saving
Car	0.234	0.100	0.134
Bus (medium)	0.654	0.504	0.150
Small Truck	0.222	0.095	0.127
Medium Truck	0.723	0.445	0.278
Large Truck	0.770	0.498	0.272

Table 13-2-13 Results of LCC Analysis

Section		Type	Initial Investment* (M. $)	NPV (Thousand $)	EIRR
Erdene - Baganuur	L= 33 km	AC	9,310	4,239	17.6%
		BST	8,619	4,610	18.4%
Murun - Undurkhaan	L= 67 km	AC	7,834	11,895	26.7%
		BST	6,691	12,833	29.4%

Note: * shows estimated costs of pavement and embankment only on the assumption that the former is 4m high on average and the latter is 2 m. Costs of bridges and structures are excluded for the sake of analysis.

The LCC analysis shows both pavement types are expected to have sufficient economic return. However, BST pavement is superior to AC pavement in the section of Murun to Undurkhaan, while it can be seen that both are almost equal in the section of Erdene to Baganuur.

Table 13-2-14 shows each salient feature of AC pavement and BST pavement.

Table 13-2-14 Salient Feature of Each Pavement

	AC Pavement	BST Pavement
Strength	Large : For heavy vehicles	Medium : For light to medium vehicles
Durability	High : Generally 10 years life expectancy	Low : Surface dressing is necessary at 2 or 3 years intervals
Riding Comfort	Excellent : Generally IRI is low	Fair : Generally IRI is high
Ease of Construction	Hard : The construction area is limited by hauling distance of asphalt concrete.	Simple : This construction method can be applied anywhere with materials and maintenance equipments
Initial Cost	Large : Installation of asphalt plant and procurement of paving equipment	Low : Not necessary special equipment
Maintenance Cost	Low : interval of maintenance works is low	Large : maintenance at frequent intervals is necessary

The existing Asphalt Plant that was procured by Japan's grant aid is located at Erdene and it can supply asphalt concrete to a construction site along National Highway No.A0501. In Mongolia, asphalt concrete can deliver 100 km at most, providing that a dump truck can haul it on paved road. It is also pointed out that some maintenance and repair works require asphalt concrete after the road is open to public.

AC pavement will be practical in Murun to Undurkhaan, on condition that a new Asphalt Plant at Murun or Undurkhaan is set and hot-mixed asphalt concrete becomes available. On the contrary, BST pavement requires in-situ techniques at the stage of both construction and maintenance, using the same construction equipment.

The following two alternative schemes are examined, considering results of LCC analysis, equipment availability and ease of maintenance.

Table 13-2-15 Proposed Alternative Pavement Structures

Section	Type of Pavement	
	Alternative - 1	Alternative - 2
Erdene - Tsenkhermandal	AC Pavement	AC Pavement
Tsenkhermandal - Undurkhaan	AC Pavement	BST Pavement

13.2.8 Construction Cost Estimate

As described in Interim Report, particular attention should be paid to reality of unit prices, considering the characteristics of civil work such as material availability, hauling distance and volume of work. Therefore, followings describe about subbase and base course materials, and for the cost estimation of other item such as AC surface etc. is described in Chapter 13.4.

(1) Confirmation of Sections

The study road is split into 21 sections, and road length of each section varies ranging from 9.3 to 13.3 km long as shown in Table 13-2-16.

Table 13-2-16 Proposed Section for Eastern Arterial Road

	Starting Point		Ending Point	Section Length (m)	Remarks
1	112 + 127.000	～	121 + 448.000	9,321	Starting point of existing AC pavement, AC overlay and replacement of Khujirt River bridge
2	121 + 448.000	～	130 + 769.000	9,321	Ending point of existing AC pavement, AC overlay
3	130 + 769.000	～	142 + 700.000	11,931	From ending point of existing pavement to diverging point at east side of Kherlen River. New construction of Kherlen Bridge (L=268.8m)
4	142 + 700.000	～	152 + 700.000	10,000	
5	152 + 700.000	～	162 + 700.000	10,000	
6	162 + 700.000	～	172 + 700.000	10,000	
7	172 + 700.000	～	182 + 700.000	10,000	
8	182 + 700.000	～	192 + 400.000	9,700	Tsenkhermandal diverging point
9	192 + 400.000	～	203 + 400.000	11,000	
10	203 + 400.000	～	214 + 400.000	11,000	New construction of Tsenkher bridge (L=52.2m)
11	214 + 400.000	～	225 + 400.000	11,000	
12	225 + 400.000	～	237 + 100.000	11,700	Jargaltkhaan diverging point
13	237 + 100.000	～	247 + 100.000	10,000	
14	247 + 100.000	～	257 + 100.000	10,000	
15	257 + 100.000	～	267 + 100.000	10,000	Duut pass clunk portion
16	267 + 100.000	～	277 + 100.000	10,000	
17	277 + 100.000	～	287 + 100.000	10,000	Chandgana coal mine
18	287 + 100.000	～	297 + 100.000	10,000	Murun diverging point
19	297 + 100.000	～	307 + 400.000	10,300	
20	307 + 400.000	～	320 + 600.000	13,200	
21	320 + 600.000	～	333 + 949.000	13,349	Ending point of Undurkhaan
			Total	221,822	

(2) Material Availability

According to material investigation, borrow pit and possible quarry locations are shown in following figures.

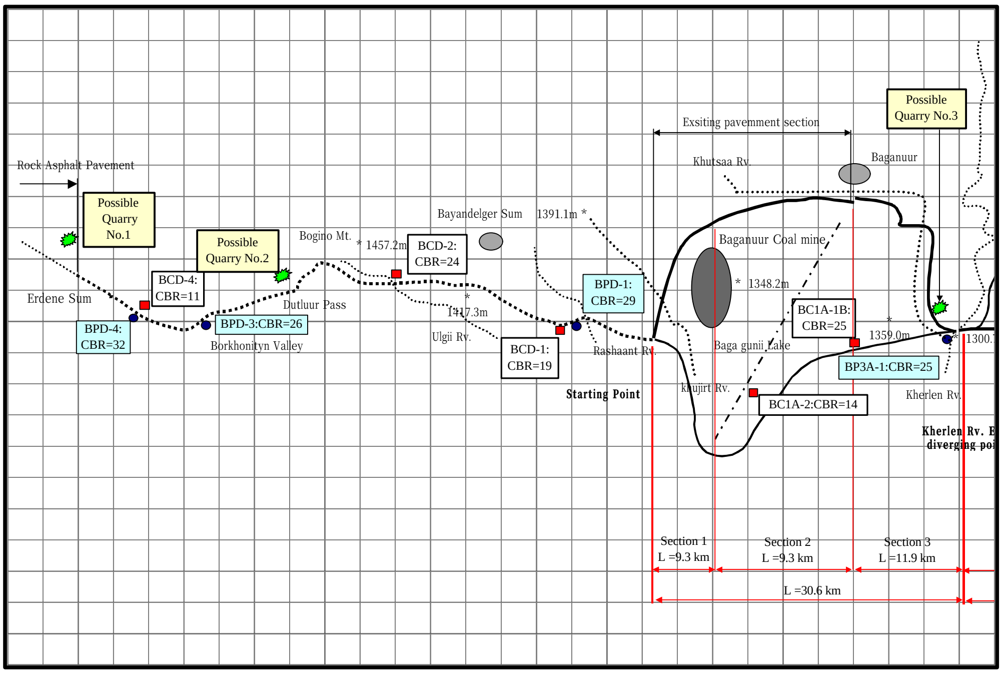


Figure 13-2-1 Borrow Pit and Possible Quarry Locations (1)

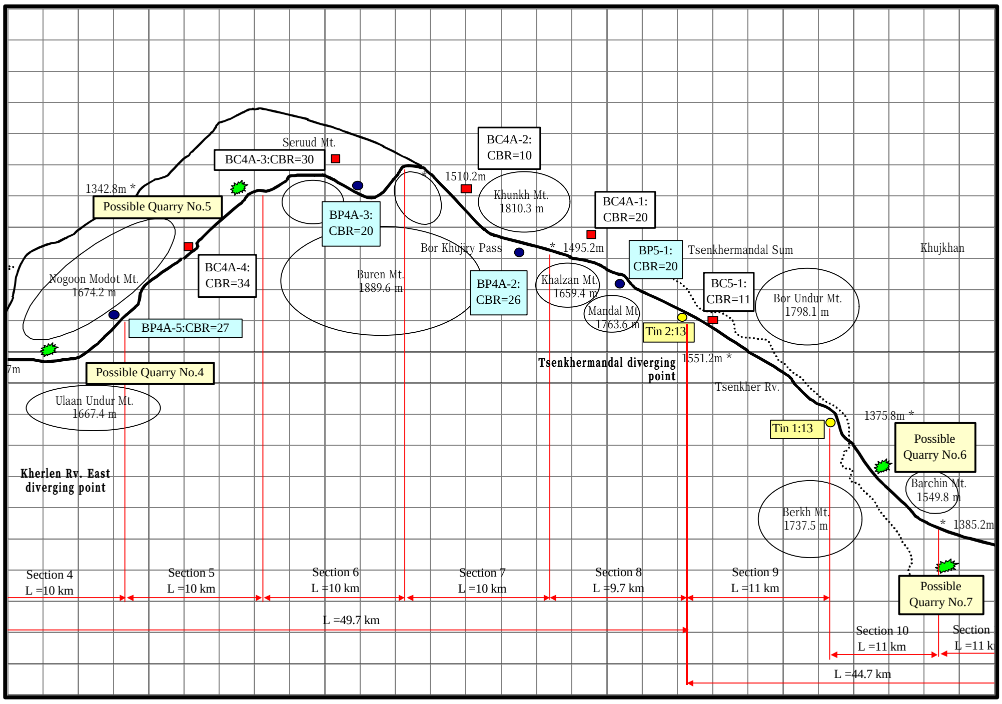


Figure 13-2-2 Borrow Pit and Possible Quarry Locations (2)

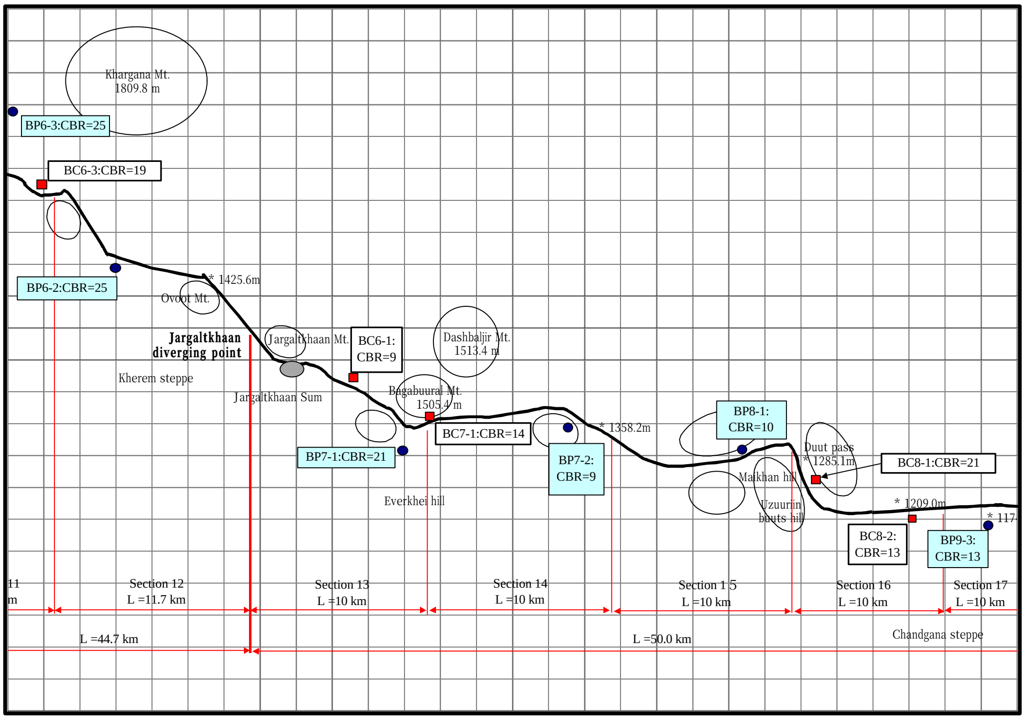


Figure 13-2-3 Borrow Pit and Possible Quarry Locations (3)

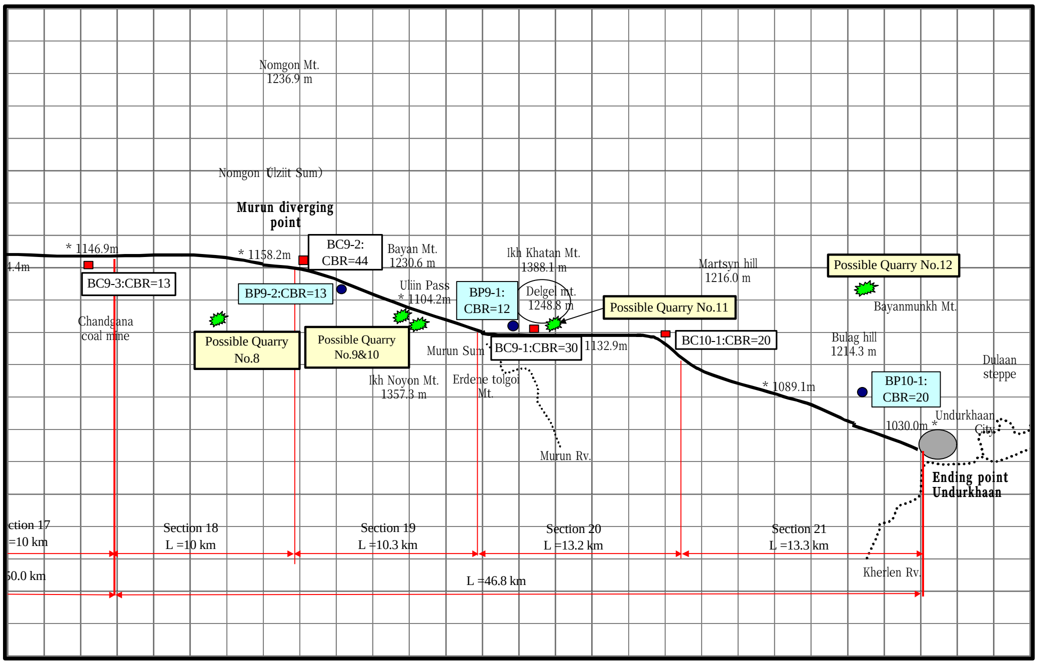


Figure 13-2-4 Borrow Pit and Possible Quarry Locations (4)

(3) Hauling Distance

From location of each borrow pit and possible quarry, hauling distances of base course and subbase materials are estimated as shown in Table 13-2-17.

Table 13-2-17 Hauling Distances of Base Course / Subbase Materials in Each Section

Section	Length	Subbase Borrow	Average Hauling Distance	Base Course Material (Quarry)	Average Hauling Distance
1	9.32 km	-	-	-	-
2	9.32 km	-	-	-	-
3	11.93 km	BP3A-1	5.0 km	P.Q. No.3	6.0 km
4	10.00 km	BP4A-5	5.0 km	P.Q. No.4	4.0 km
5	10.00 km	BP4A-5/BC4A-4	4.0 km	P.Q.No.5	5.0 km
6	10.00 km	BC4A-3	4.0 km	P.Q. No.5	7.0 km
7	10.00 km	BP4A-2	5.0 km	P.Q. No.5	17.0 km
8	9.70 km	BP5-1	3.0 km	P.Q. No.5	22.0 km
9	11.00 km	BC5-1	6.0 km	P.Q. No.6	10.0 km
10	11.00 km	BP6-3	17.0 km	P.Q. No.6	6.0 km
11	11.00 km	BP6-3	6.0 km	P.Q.No.7	8.0 km
12	11.70 km	BP6-2	6.0 km	P.Q. No.7	19.0 km
13	10.00 km	BP7-1	6.0 km	P.Q. No.7	31.0 km
14	10.00 km	BC7-1	5.0 km	P.Q. No.7	51.0 km
15	10.00 km	BC7-1	15.0 km	P.Q. No.8	35.0 km
16	10.00 km	BC8-1	5.0 km	P.Q. No.8	25.0 km
17	10.00 km	BP9-3	6.0 km	P.Q. No.8	15.0 km
18	10.00 km	BC9-2	6.0 km	P.Q. No.8	8.0 km
19	10.30 km	BC9-2	4.0 km	P.Q. No.9 & 10	4.0 km
20	13.20 km	BC9-1	6.0 km	P.Q. No.11	7.0 km
21	13.35 km	BP10-1	8.0 km	P.Q. No.12	15.0 km
Total	221.82 km	-	-	-	-

(4) Computation of Hauling Cycle

To compute hauling cycle of dump trucks, following assumption is made.

a) Hauling speed is 30 km/h for short distance (3 to 10 km).
b) Hauling speed is 40 km/h for longer distance (15 to 51 km)
c) 8 hours working per day.
d) Loading time is 4 minutes and unloading time is 1 minute respectively.

Following cycle time is calculated from the assumption, and hauling cycle is computed as shown in Table 13-2-18.

Table 13-2-18 Hauling Times and Cycles Based on Hauling Distance

	Average Hauling Distance	Hauling Time	Loading Time	Unloading Time	Total Cycle Time	Hauling Cycles per Day
V= 30 km/h	3.0 km	12.0 min	4 min	1 min	17.0 min	28
	4.0 km	16.0 min	4 min	1 min	21.0 min	22
	5.0 km	20.0 min	4 min	1 min	25.0 min	19
	6.0 km	24.0 min	4 min	1 min	29.0 min	16
	7.0 km	28.0 min	4 min	1 min	33.0 min	14
	8.0 km	32.0 min	4 min	1 min	37.0 min	12
	10.0 km	40.0 min	4 min	1 min	45.0 min	10
V= 40 km/h	15.0 km	45.0 min	4 min	1 min	50.0 min	9
	17.0 km	51.0 min	4 min	1 min	56.0 min	8
	19.0 km	57.0 min	4 min	1 min	62.0 min	7
	22.0 km	66.0 min	4 min	1 min	71.0 min	6
	25.0 km	75.0 min	4 min	1 min	80.0 min	6
	31.0 km	93.0 min	4 min	1 min	98.0 min	4
	35.0 km	105.0 min	4 min	1 min	110.0 min	4
	51.0 km	153.0 min	4 min	1 min	158.0 min	3

(5) Computation of Work Volume

Daily base work volume is calculated as follows.

1) Subbase material

- Daily basic progress is 200 m. This is roughly 20 km progress in a year.
- Volume of excavation is **1,300 m^3/day** (=200 m x 1/2 x (12+14) m x 0.5 m)

(Computed subbase thickness is from 20 to 26 cm, however, as stated in Pavement Design, CBR value for embankment will be more than 15, therefore, embankment and subbase materials are assumed as similar.)

2) Base Course material

- Daily progress is 200 m. This value is same as subbase material.
- Volume of excavation is **245 m^3/day** (=200 m x 1/2 x (8.0+8.3) m x 0.15 m)

(6) Unit Price for Subbase and Base Course

From hauling distances of materials and work volumes, unit prices for subbase and base course materials are computed as shown in Table 13-2-19.

As a result, unit price for subbase is from 2,110 Tg to 4,560 Tg, and base course is from 8,810 Tg to 17,860 Tg.

Table 13-2-19 Unit Prices for Subbase and Base Course for Each Section

Section	Length	Unit Price for Subbase	Unit Price for Base Course
Unit	(km)	(Tg / m^3)	(Tg / m^3)
1	9.32		
2	9.32		
3	11.93	2,650	9,310
4	10.00	2,650	8,810
5	10.00	2,380	9,030
6	10.00	2,380	9,570
7	10.00	2,650	11,310
8	9.70	2,110	12,530
9	11.00	2,910	10,380
10	11.00	4,980	9,310
11	11.00	2,910	9,890
12	11.70	2,910	11,820
13	10.00	2,910	14,910
14	10.00	2,650	17,860
15	10.00	4,560	15,120
16	10.00	2,650	12,680
17	10.00	2,910	10,890
18	10.00	2,910	9,890
19	10.30	2,380	8,810
20	13.20	2,910	9,570
21	13.35	3,560	10,890
Average		2,946	11,188

*The price does not include paving price but include hauling to the site.

13.3 Design of Bridges and Structures

13.3.1 Design Concept

Based on adopted appropriate Project route in Chapter 9, the length of proposed Project Route between Baganuur and Undurkhaan is approximately 222km. In previous Chapter 5,7 and 9, the design criteria, appropriate type and scale of structures were studied and established by the Study Team associated DOR, Infrastructure.

Therefore, preliminary design for bridges and box culverts shall be studied by following flowchart of procedures.

Flowchart of Procedure to Preliminary Design for Structures

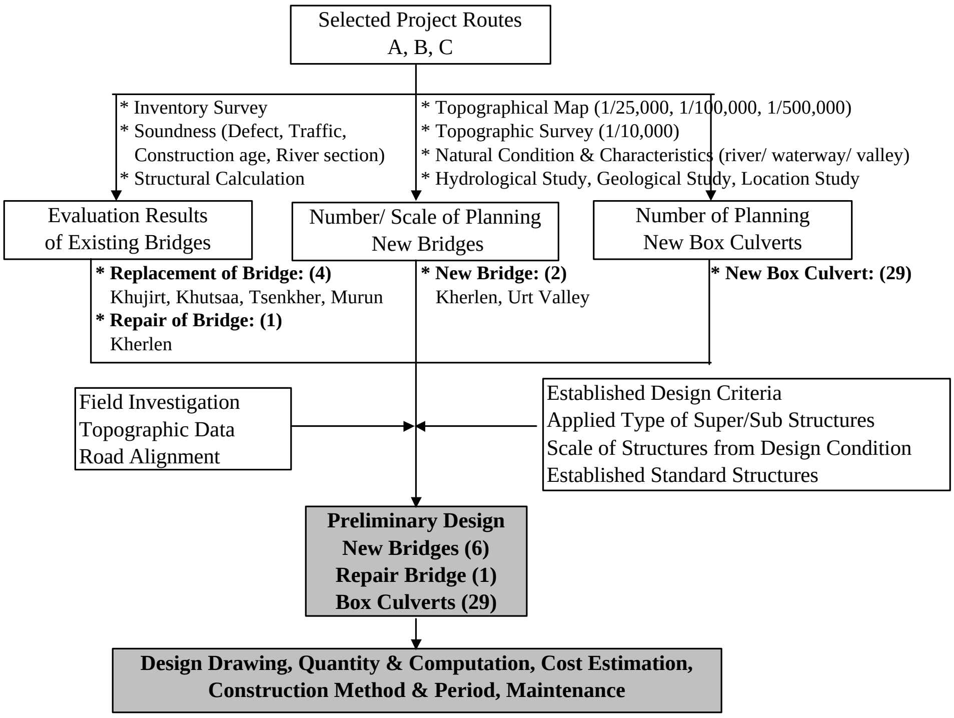


Figure 13-3-1 Procedure of Preliminary Design Stage

The contents of preliminary design are comprised in design by computing, quantities, drawings, construction method and time schedule, and maintenance method for the planned structures.

13.3.2 Design of Bridges and Main Culverts

(1) Location and Type of Structures

The location, scale and type for six (6) bridges and twenty-nine (29) main box culverts are determined according to hydrological study of Chapter 5, design conditions of Chapter 9 and below Figure 13-3-2.

These designing structures are shown in below Table 13-3-1 with station numbers based on topographic survey and road alignment between Baganuur and Undurkhaan.

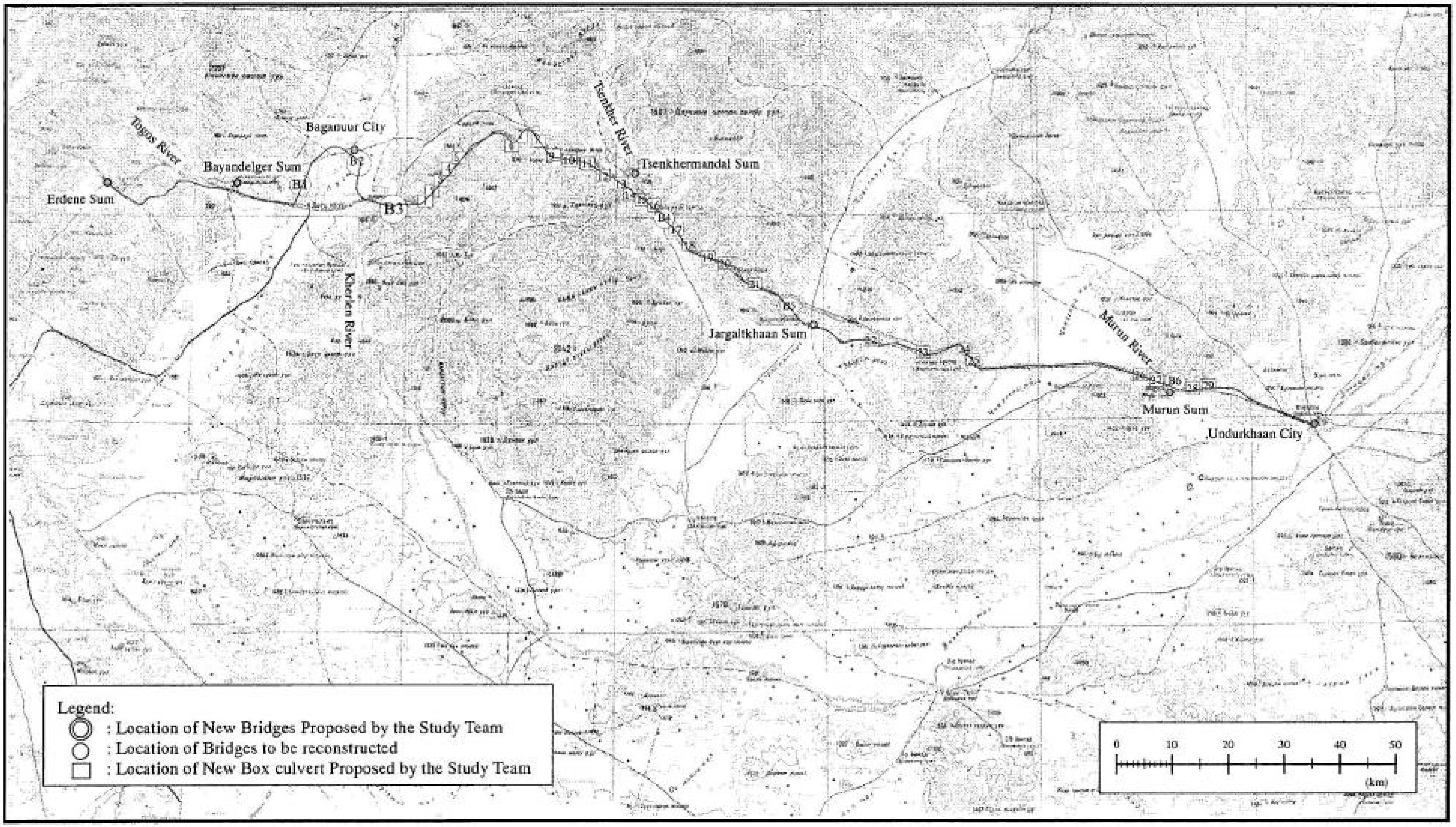


Figure 13-3-2 Location Map for Project Bridges and Box Culverts

Table 13-3-1 List of Designing Structures for the Project

No.	Structure	Station (Centre)		Type	Length	Span (m)	Width	Name of River (Valley)
B1	RC-T	113	+ 840	1	15.0 m	15.0	9.0 m	Khujirt
B2	RC-T	134	+ 036	2	17.5 m	17.5	9.0 m	Khutsaa, Nariin
B3	RC-T	142	+ 242	6	268.8 m	8@33.6	9.0 m	Kherlen
BC1	Box	150	+ 773	D	2.5 m	2.5	-	(Kharzat)
BC2	Box	151	+ 770	D	2.5 m	2.5	-	(Yumt)
BC3	Box	154	+ 885	D	2.5 m	2.5	-	(Dund Bulag)
BC4	Box	157	+ 770	E	5.0 m	2@2.5	-	(Shoboi)
BC5	Box	158	+ 265	F	7.5 m	3@2.5	-	(Ust)
BC6	Box	171	+ 313	D	2.5 m	2.5	-	-
BC7	Box	171	+ 963	D	2.5 m	2.5	-	-
BC8	Box	176	+ 367	E	5.0 m	2@2.5	-	-
BC9	Box	181	+ 171	D	2.5 m	2.5	-	-
BC10	Box	184	+ 370	E	5.0 m	2@2.5	-	-
BC11	Box	187	+ 215	E	5.0 m	2@2.5	-	(Bor Khujir)
BC12	Box	190	+ 521	E	5.0 m	2@2.5	-	(Ulaan Chuluun)
BC13	Box	192	+ 570	D	2.5 m	2.5	-	-
BC14	Box	194	+ 970	F	7.5 m	3@2.5	-	(Bogin)
BC15	Box	196	+ 370	D	2.5 m	2.5	-	(Toson)
BC16	Box	198	+ 921	E	5.0 m	2@2.5	-	(Byatskhan Bulag)
B4	RC-T	205	+ 072	4	52.5 m	3@17.5	9.0 m	Tsenkher
BC17	Box	207	+ 020	F	7.5 m	3@2.5	-	(Urgun)
BC18	Box	210	+ 677	E	5.0 m	2@2.5	-	-
BC19	Box	214	+ 577	F	7.5 m	3@2.5	-	(Ar Khadagtai)
BC20	Box	216	+ 274	E	5.0 m	2@2.5	-	Uvur Khadagtai
BC21	Box	224	+ 577	D	2.5 m	2.5	-	(Zuulun)
B5	RC-T	231	+ 896	1	15.0 m	15.0	9.0 m	(Urt)
BC22	Box	250	+ 377	E	5.0 m	2@2.5	-	(Ulaan Khudag)
BC23	Box	259	+ 077	D	2.5 m	2.5	-	-
BC24	Box	268	+ 777	F	7.5 m	3@2.5	-	Duut
BC25	Box	270	+ 730	E	5.0 m	2@2.5	-	(Duut)
BC26	Box	301	+ 177	E	5.0 m	2@2.5	-	(Tsagaan Morit)
BC27	Box	305	+ 377	D	2.5 m	2.5	-	(Del)
B6	RC-T	307	+ 834	4	52.5 m	3@17.5	9.0	Murun
BC28	Box	309	+ 877	D	2.5 m	2.5	-	-
BC29	Box	313	+ 427	E	5.0 m	2@2.5	-	(Khatan Uul)
Total					541.3 m			

Note: B1- B6 for Bridges, BC1- BC29 for box culverts

The detailed scale and type for Project bridges are listed in below Table 13-3-2.

Table 13-3-2 List of Preliminary Designing Bridges

No.	Name of Bridge	Station	Type of Bridge		
			Super-structure	Sub-structure	Foundation
B1	Khujirt	113k+847.50	RC T Girder	RC Wall	Spread Footing
B2	Khutsaa, Nariin	134k+044.75	RC T Girder	RC Wall	Spread Footing
B3	Kherlen	142k+376.40	PC T Girder	RC Wall	Spread Footing
B4	Tsenkher	205k+098.25	RC T Girder	RC Wall	Spread Footing
B5	Urt Valley	231k+903.50	RC T Girder	RC Wall	RC Pile
B6	Murun	307k+860.25	RC T Girder	RC Wall	Spread Footing

The existing Kherlen Bridge is to repair for defected and damaged parts investigating the conditions (referred in Appendix-C).

The each type of box culvert is pre-casting reinforced concrete segments fabricated in the camp/casting yards because of scattered locations between Baganuur and Undurkhaan, easier quality control of concrete materials in yard, and shorter period of construction. These types and the scales of RC box culverts are shown in Table 13-3-3.

Table 13-3-3 List of Preliminary Designing Box Culverts

Type of Box Culvert		
Type	Scale (m)	Reinforced Method
D	1@2.5x2.5	Pre-cast Segment
E	2@2.5x2.5	Pre-cast Segment
F	3@2.5x2.5	Pre-cast Segment
G	3@3.0x3.0	Pre-cast Segment

(2) Control Point of Structures for Road Longitudinal Alignment

The proposed elevation height of road surface at the location of bridges shall be measured more than below height in Table 13-3-4, illustrated in Figure 13-3-3.

Table 13-3-4 List of Proposed Height at the Bridge Points

Name of Bridges	Design River Bed: ELG	Added Height (Meter)	Proposed Height: ELB **(more than this ELB)**
B1: Khujirt	1,352.0	3.7	1,355.7 → **(1,356.2)**
B2: Khutsaa, Nariin	1,327.5	3.9	1,331.4 → **(1,331.9)**
B3: Kherlen	1,297.6	4.9	1,302.5 → **(1,303.0)**
B4: Tsenkher	1,366.3	3.9	1,370.2 → **(1,370.7)**
B5: Urt Valley	1,383.2	3.7	1,386.9 → **(1,387.4)**
B6: Murun	1,090.3	3.9	1,094.2 → **(1,094.7)**

Also, the proposed elevation height of road surface at the location of box culverts shall be measured more than 3.0m from existing ground height as shown in illustrated Figure 13-3-4. Therefore, cover of box culverts is required at least 0.30m considering pavement on culverts.

For the setting of small pipe culverts along the Project Road, the height of embankment shall also consider to reduce as much as possible, as illustrated Figure 13-3-4.

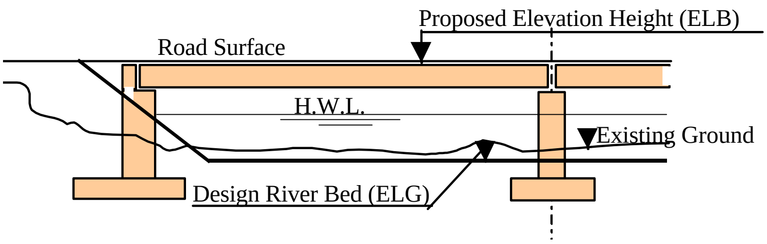
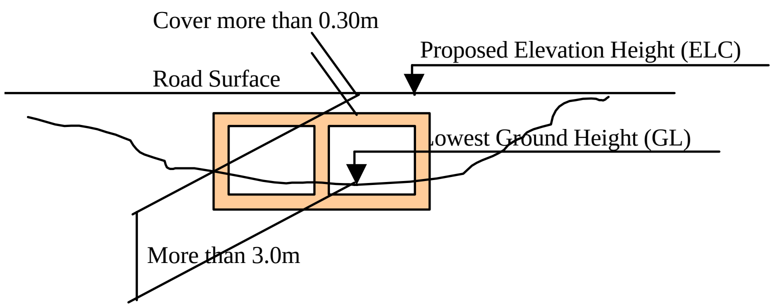


Figure 13-3-3 Control Point of Proposed Elevation Height for Bridges



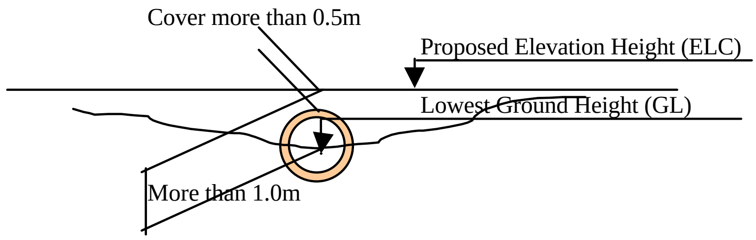


Figure 13-3-4 Control Point of Proposed Height for Culverts

(3) Design of Bridges

In accordance with design criteria in previous Chapter 7, the structures of bridges and box culverts were computed, drawn, and reported in attached Volume III, "**DRAWINGS**" corresponding to the Millennium Arterial Road.

The design standards shall apply Japanese specification and American AASHTO, referring Mongolian standards.

From the design of structures, the drawings including quantities for the Project were executed as shown in below Table 13-3-5.

The design drawings of standardized structures of bridges and culverts are also executed for Millennium Arterial Road in future construction as shown in Table 13-3-6.

These structural design drawings show with scaled 1 to 200.

Table 13-3-5 Design Drawings of Structures for the Project

1	**GENERAL VIEW OF KHUJIRT RIVER BRIDGE (NO.1- B1)**
2	**GENERAL VIEW OF KHUTSAA, NARIIN RIVER BRIDGE (NO.2- B2)**
3	**GENERAL VIEW OF KHERLEN RIVER BRIDGE (NO.3- B3)**
4	**GENERAL VIEW OF TSENKHER RIVER BRIDGE (NO.4- B4)**
5	**GENERAL VIEW OF URT VALLEY BRIDGE (NO.5- B5)**
6	**GENERAL VIEW OF MURUN RIVER BRIDGE (NO.6- B6)**
7	**GENERAL VIEW OF PIPE CULVERT (NO.7- C1)**
8	**GENERAL VIEW OF BOX CULVERT (NO.8- C2)**

Table 13-3-6 Design Drawings of Standardized Structures for the Millennium Arterial Road

1	**STANDARD RC-T GIRDER BRIDGE NO.1 (BRIDGE LENGTH 15M)**
2	**STANDARD RC-T GIRDER BRIDGE NO.2 (BRIDGE LENGTH 17.5M)**
3	**STANDARD RC-T GIRDER BRIDGE NO.3 (BRIDGE LENGTH 35M)**
4	**STANDARD RC-T GIRDER BRIDGE NO.4 (BRIDGE LENGTH 52.5M)**
5	**STANDARD RC-T GIRDER BRIDGE NO.5 (BRIDGE LENGTH 70M)**
6	**STANDARD PC-T GIRDER BRIDGE NO.6 (BRIDGE LENGTH 100M)**
7	**STANDARD PC-T GIRDER BRIDGE NO.7 (BRIDGE LENGTH 120M)**
8	**STANDARD PIPE CULVERT NO.8**
9	**STANDARD BOX CULVERT NO.9**

13.3.3 Construction Cost Estimates

(1) Unit Cost Estimates of Structures for the Project

Basic policy for unit cost estimates is described Zone 1, 2 and 3 (refer to Figure 13-3-2) between Baganuur and Undurkhaan depending on the difference of transportation cost for materials, units and equipment, etc, up to 222km long distance.

Zone 1: Baganuur city to 10km West of Tsenkhermandal (Bor Khujirt)
Zone 2: 10km West of Tsenkhermandal (Bor Khujirt) to
20km East of Jargaltkhaan Sum (Gichgene)
Zone 3: 20km East of Jargaltkhaan Sum (Gichgene) to Undurkhaan city

Based on the drawings and quantities of structures in Attached Volume III "**DRAWINGS**", unit costs of work items are summarized in Table 13-3-7.

Table 13-3-7 Unit Cost of Structures of Each Items

・Unit Cost of Labor (Structure)

Classification	Unit Cost			Remarks
	Foreign Portion (US$/Day)	Local Portion (Tg./Day)	Total (US$/Day)	
Senior Field Engineer	0	21,000	19.09	Domestic
Skilled Labor	0	15,000	13.64	Domestic
Unskilled Labor	0	10,000	9.09	Domestic
Mason/Carpenter	0	18,000	16.36	Domestic
Equipment Operator	0	13,000	11.82	Domestic
Crane Operator	0	17,000	15.45	Domestic
Skilled Operator	0	15,000	13.64	Domestic
Driver	0	10,000	9.09	Domestic
Re-bar Specialist	0	12,000	10.91	Domestic
Electrician	0	13,000	11.82	Domestic
Welder	0	13,000	11.82	Domestic
Steeplejack	0	13,000	11.82	Domestic
Painter	0	19,000	17.27	Domestic
Guardman	0	13,000	11.82	Domestic

・Unit Cost of Major Materials (Structure)

Materials	Unit	Unit Cost			Remarks
		Foreign Portion (US$)	Local Portion (Tg.)	Total (US$)	
Portland Cement	kg	0.00	75,000	68.18	Domestic
Sand (for concrete)	m^3	0.00	13,000	11.82	Domestic
Pea-gravel (for Concrete)	m^3	0.00	21,000	19.09	Domestic
Admixture (for Concrete)*	kg	5.60	0	5.60	Imported
Sand (for Asphalt)	m^3	0.00	13,000	11.82	Domestic
Aggregate (for Asphalt)	m^3	0.00	21,000	19.09	Domestic
Straight Asphalt*	ton	61.53	0	61.53	Imported
Embankment Material	m^3	0.00	12,700	11.55	Domestic
Reinforcing Steel (SD 30)	ton	0.00	497,310	452.10	Domestic
Plywood (12.5mm)	m^2	0.00	17,000	15.45	Domestic
Timber Plank	m^3	0.00	113,000	102.73	Domestic
Diesel Fuel	liter	0.00	725	0.66	Domestic
Gasoline	liter	0.00	751	0.68	Domestic
Lubricant	liter	0.00	1,943	1.77	Domestic
Paint	kg	0.00	2,152	1.96	Domestic
Rubber Shoe*	each	177.60	0	177.60	Imported
Expansion Joint*	m	539.20	0	539.20	Imported
PC Strand (12T12.7)*	kg	1.89	0	1.89	Imported

Notes : 1. Unit Costs of imported goods (marked *) are based on CIF price, i.e. including port handing and clearance costs, plus Mongolian tax and duty.
2. Mongolian value added tax (VAT) is not included.

・Unit Cost of Major Equipments (Structure)

Item	Spec./ Capacity	Unit	Unit Cost			Remarks
			Foreign Portion	Local Portion	Total	
			(US$)	(Tg.)	(US$)	
Bulldozer	15 ton	hr.	0.00	35,437.50	32.22	Domestic
Excavator	Backhoe 0.6m^3	hr.	0.00	35,625.00	32.39	Domestic
Tractor Shovel	1.2 m^3	hr.	0.00	28,125.00	25.57	Domestic
Trailer	32t	hr.	0.00	34,312.50	31.19	Domestic
Cargo Truck	11 ton	hr.	0.00	21,984.38	19.99	Domestic
Cargo Truck	2 ton	hr.	0.00	21,600.00	19.64	Domestic
Asphalt Finisher	3.5 m	hr.	0.00	73,950.00	67.23	Domestic
Dump Truck	10 ton	hr.	0.00	21,600.00	19.64	Domestic
Dump Truck	2 ton	hr.	0.00	19,031.25	17.30	Domestic
Water Tanker	5,500 - 6,000 l	hr.	0.00	18,750.00	17.05	Domestic
Truck Crane	15 ton	hr.	0.00	37,996.88	34.54	Domestic
Truck Crane	20 ton	hr.	0.00	39,375.00	35.80	Domestic
Truck Crane	40 ton	hr.	0.00	76,920.88	69.93	Domestic
Crawler Crane	40 ton	hr.	0.00	70,350.00	63.95	Domestic
Line Marker	10cm, hand guide	hr.	0.00	5,700.00	5.18	Domestic
Truck Mixer	4.5 m^3	hr.	0.00	28,200.00	25.64	Domestic
Generator	150 kVA	hr.	0.00	18,937.50	17.22	Domestic
Generator	2000 kVA	hr.	0.00	23,625.00	21.48	Domestic
Air Compressor	17.0m^3/min	hr.	0.00	13,425.00	12.20	Domestic
Concrete Plant	30 m^3/hr.	m^3	32.08	0.00	32.08	Imported
Asphalt Plant	60 ton/hr.	hr.	40.00	28,000.00	65.45	Domestic
Erection Girder		each	0.00	121,277.40	110.25	Imported
Portal Frame		each	0.00	80,851.60	73.50	Imported

(2) Estimated Total Cost of Structures for the Project

Based on the unit costs for structures, the total construction cost for the structures along the Project road was estimated as shown in below Table 13-3-8.

The construction cost for the alternative routes shall also be estimated.

Table 13-3-8 Estimated Construction Cost of Bridges and Culverts

Culvert Type		Section (m)	Cost/piece ($)	Cost (Thousand Tg)	Total Cost / piece ($)	remarks
Pipe	A	ö1.0	770	5,110	5,500	122 no.
	B	ö1.5	1,370	7,810	8,600	57 no.
	C	2@ö1.5	1,970	11,370	12,500	18 no.
Box	D	2.5*2.5	3,170	16,020	18,000	12 no.
	E	2@2.5*2.5	4,970	22,710	26,000	12 no.
	F	3@2.5*2.5	6,580	28,540	33,000	5 no.
	G	3@3.0*3.0	8,770	36,970	43,000	0 mo.

Bridge	Length (m)	Cost ($)	Cost (Thousand Tg)	Total Cost ($)	remarks
Type-1S	15	38,050	59,350	93,000	Khujirt Br.(B-1)
Type-1P	15	42,210	64,580	102,000	Urt Valley Br.(B-5)
Type-2	17.5	43,030	65,840	104,000	Khutsaa Br.(B-2)
Type-3	35	86,070	131,690	208,000	0 Br.
Type-4	52.5	129,100	197,530	312,000	Tsenkher, Murun Br.(B-4,B-6)
Type-5	70	172,140	263,370	416,000	0 Br.
Type-6	268.8	655,890	1,234,560	1,799,000	Kherlen Br.(B-3)

13.3.4 Construction Method and Time Schedule

(1) Construction Type and the Volume

The construction for the Project road shall be implemented considering long distance with 222km between Baganuur and Undurkhaan.

The kind of construction for the structures in the Project is classified to 3 category as bridge, box culvert and pipe culvert.

Due to location and scale (number and volume) of the structures in Project area, the construction method shall be studied to meet the construction sequence, period, economy and safety aspects.

The construction scale and volume for the structures are shown in below Table 13-3-9.

Table 13-3-9 Construction Scale for the Structures

Kind of Structure	Name of Bridge Type of Culvert	Number	Remark
Bridge	B1:khujirt B2:Khutsaa B3:Kherlen B4:Tsenkher B5:Urt Valley B6:Murun	RC-T RC-T PC-T RC-T RC-T RC-T	Total Structural Concrete Volume 5,110m^3 Total Reinforced Steel Bar Weight 290ton Total PC cable Weight 70ton Total Excavation Volume 14,350m^3 Total Guide Bank Length 1,200m
Total		6 Bridges	
Culvert (Box Type)	Type D (2.5m @ 1) Type E (2.5m @2) Type F (3.0m @3)	12 nos. 12 nos. 5 nos.	Total Structural Concrete Volume 2,760m^3 Total Reinforced Steel Bar Weight 140ton Total Excavation Volume 4,930m^3
Total		29 Box Culverts	
Culvert (Pipe Type)	Type A (Φ1m@1) Type B (Φ1.5m@1) Type C (Φ1.5m@2)	122 nos. 57 nos. 18 nos.	Total Structural Concrete Volume 4,170m^3 Total Reinforced Steel Bar Weight 190ton Total Excavation Volume 13,280m^3
Total		197 Pipe Culverts	

(2) Key Points for the Construction

Following items shall be taken into consideration for the construction of bridges and culverts.

- Construction period for the whole work on the Project site is limited annually from May to October due to the prevailing severe weather conditions.
- From viewpoint of the long length of the Project road, the location/place of plant and base camp yard shall be considered for the construction materials, equipment, concrete and asphalt work, etc.
- In the range of each Project area, the borrow pit and quarry site shall be obtained to utilize the construction work.
- The construction in the river shall be taken measures to avoid flood in the rainy season.
- During the construction work for the structures, ordinal traffic flow shall not be disturbed, even for inhabitants in the Project area.
- The concrete and reinforcing steel works shall be carried out securely, such as exact position of reinforcing bars, utilization of vibrators for the pouring concrete and curing after placed concrete, etc.

- The check/test for materials, concrete, reinforcing bar and asphalt shall be completely executed at prepared laboratory.
- Erection method by crane or launching for girders shall be selected considering existing land access, weight of girders and availability of the equipment.

(3) Construction method

The construction method for the structures of bridges and culverts is to be separately intended as follows:

Bridge over larger/smaller River (Khujirt, Khutsaa, Kherlen, Tsenkher, Ult-valley, Murun,)	**Temporary Work** Temporary construction road crossing river will require for the construction of sub structures. **Pile Foundation Work** Before pile driving at the position, temporary road for equipment into river shall be prepared. The piling method is earth drilling or with diesel hammer considering technical experience/ equipment type. **Substructure Work** During foundation works, embankment with soils/sheets at the position of footing will be made to avoid from water flow with changing river way. The designated bottom of footing shall ensure to meet with bearing hard layer at excavated time. Regarding to the pouring concrete for substructures, transportation of agitator truck from plant shall ensure the travelling time and interval. The curing method after poured concrete will be required, case by case. **Superstructure Work** The fabrication works (form-work, steel bar-arrangement, pouring concrete, curing, etc.) of RC and PC girder in base camp/casting yard shall carry out with technical force by skilled Engineer, especially prestressing procedure. Transportation of the girders by trailer to bridge site from base camp/casting yard is to be taken the safety of road. The reinforced concrete girders shall fabricate in base camp/casting yard. And their qualities shall ensure by testing at laboratory. Prior to the girder erection, the approach road shall be constructed for the transportation and setting of their girders. Two kinds of erection method by crane and launched girder for the Project bridges will be proposed. Heavy truck crane shall be imported because Mongolian contractors have 25 ton size maximum. On the other hand, the launched girder erection method shall be made a temporary steel girder/portal frame and the launching equipment. The launching method has advantage and lower cost rather than heavy truck crane due to a lot of girders in their Project bridges. (refer to figures and photos) **Revetment, Dike Works** To avoid the scouring of floods, protection with revetment and dike (guide bank) at bridge site shall be constructed by stone pitching/concrete block on embankment. These bank slope shall keep appropriate value, as 1(vertical): 1.5(horizontal).
Improvement for Existing Bridge (for Kherlen Bridge)	Improvement of existing bridge shall ensure to smooth traffic for light weigh vehicles. The carriage way surface shall over lay with asphalt pavement after repairing of uneven surface, and replacement of expansion joints. Broken hand railing shall replace. Broken and/or defected parts of girder/pier shall repair with mortar injection or concrete/steel plate.

Box Culverts Crossing Road (for water way or small river)	Before set the segments of box culvert, bearing layer shall be confirmed to meet with designated value. And, gravel and leveling concrete will be laid at the location. In order to shortly set in the waterway and keep the good quality, the reinforced concrete box type culvert will be fabricated in the base camp for pre-cast type, and transport to located site. These lengths of segments of box culvert are 1 to 2m to meet the easier transportation and construction. After setting the pre-cast blocks, joints parts between segments shall place with concrete. The works of retaining walls and inlet/outlet shall be completely carried out to protect the road embankment and waterway. To avoid settlement the embankment on and approach of culverts, certain compaction of back fill shall require.
Pipe Culverts Crossing Road (for waterway)	The pipe culvert of reinforced concrete type shall be fabricated in base camp for the length with 1 m segments. Before set the pipe culverts, the bearing layer will be examined by the Engineer. The set of pipe culvert with lining concrete base shall arrange at correct position. To avoid settlement the embankment on and approach of culverts, certain compaction of back fill shall require. The works of retaining walls and inlet/outlet shall be completely carried out to protect the road embankment and waterway.

(4) Materials

* Reinforcing Steel Bar and Angle:

  Production at "Darkhan Metallurgical Kombinat"
  Reinforcing Bar- SD390 Dia.10, 13, 16, 19, 22, 25, 29, 32mm conforming to JIS of Japan
  Steel L- angle- SS400 45mm, max.65mm
  Productivity- Reinforcing Bar 6,000 to 8,000 tons per year

* Cement:

  Production at "Darkhan EREL CEMENT" and Erdenet
  EREL Cement Factory: Production 75,000 tons per year (past 3 years)
  Almost quality, strength 400 kg/cm^2 (4 cm cube, water, sand, cement) conforming to AASHTO

* Asphalt:

  Production at Erdene (under paving construction, as of September, 2001)
  Purchase from Russia, Angarsk, Ural

* Sand /Aggregate:

  Production at Baganuur (also Darkhan, Ulaanbaatar)
  Other Quarry Site:
  Zoomond Sand Pit, Kherlen River, Ex-Tsenkhermandal Tine Mine, Gold mine at Tsenkher, Murun, Undurkhaan Sand Pit

* Plant(asphalt, concrete) and Base Camp:

  No concrete plant from Erdene to Undurkhaan
  One asphalt plant at Erdene sum (no plant along the Project area)
  Candidate Base Camp- Baganuur, Undurkhaan, Jargaltkhaan

As shown in Figure 13-3-5, three (3) camp/casting yards for the stock of materials, fabrication of concrete and the offices shall plan because of long distance of works at Project sites.

And, there are more than 8 locations of sand/aggregate pits in the Project area. These are available to product the concrete and asphalt, etc.

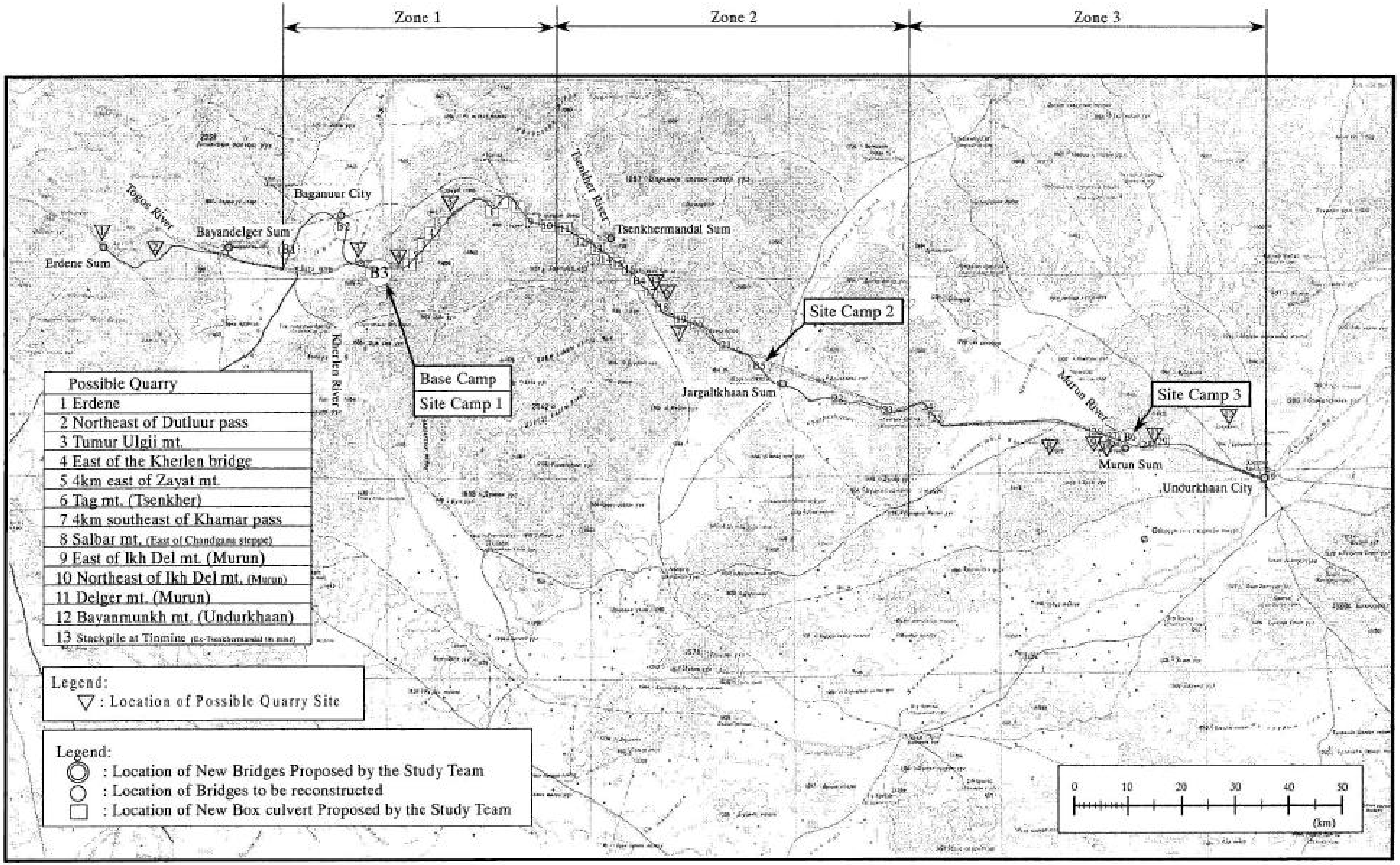


Figure 13-3-5 Location Map for Camp Yard and Quarry Site along the Project Area