STUDY ROUTE NO. 31

Rt. 1016 (B. Kiu Phrao)
– Rt. 1174 (B. Kaen Tai)
L = 55.0 Km
Changwat : Chiang Rai

1. GENERAL

1-1 Location of Route

The study route locates close to northern end of Changwat Chiang Rai. It lies generally east-west direction originating at B.Kin Phrao on the Rt.1016 and ends at B.Kaen Tai on the Rt.1174 in the east side. (see Figure 31-1-1)

The route of 55 Km long passes flat to rolling terrain in the origin side but mountainous terrain in the destination side. Major agricultural products are rice, maize and cassava.

At the 19 Km from the starting point, the permanent bridge across the Kok river is under construction by MDU.

For 20 Km of latter half of the route is winding steep alignment, some section of which is now under construction by DOH.

Population mostly concentrated along the route is about 33 thousand within the area of influence of the road.

Geologically, the route is located on the alluvial basin of the Kok in the west side but Rataburi formation and carboniferous igneous rocks are dominant in the east side.

1-2 Conditions of Existing Road

Condition of the existing route are mentioned dividing it into 3 segments in Table 31-1-1.

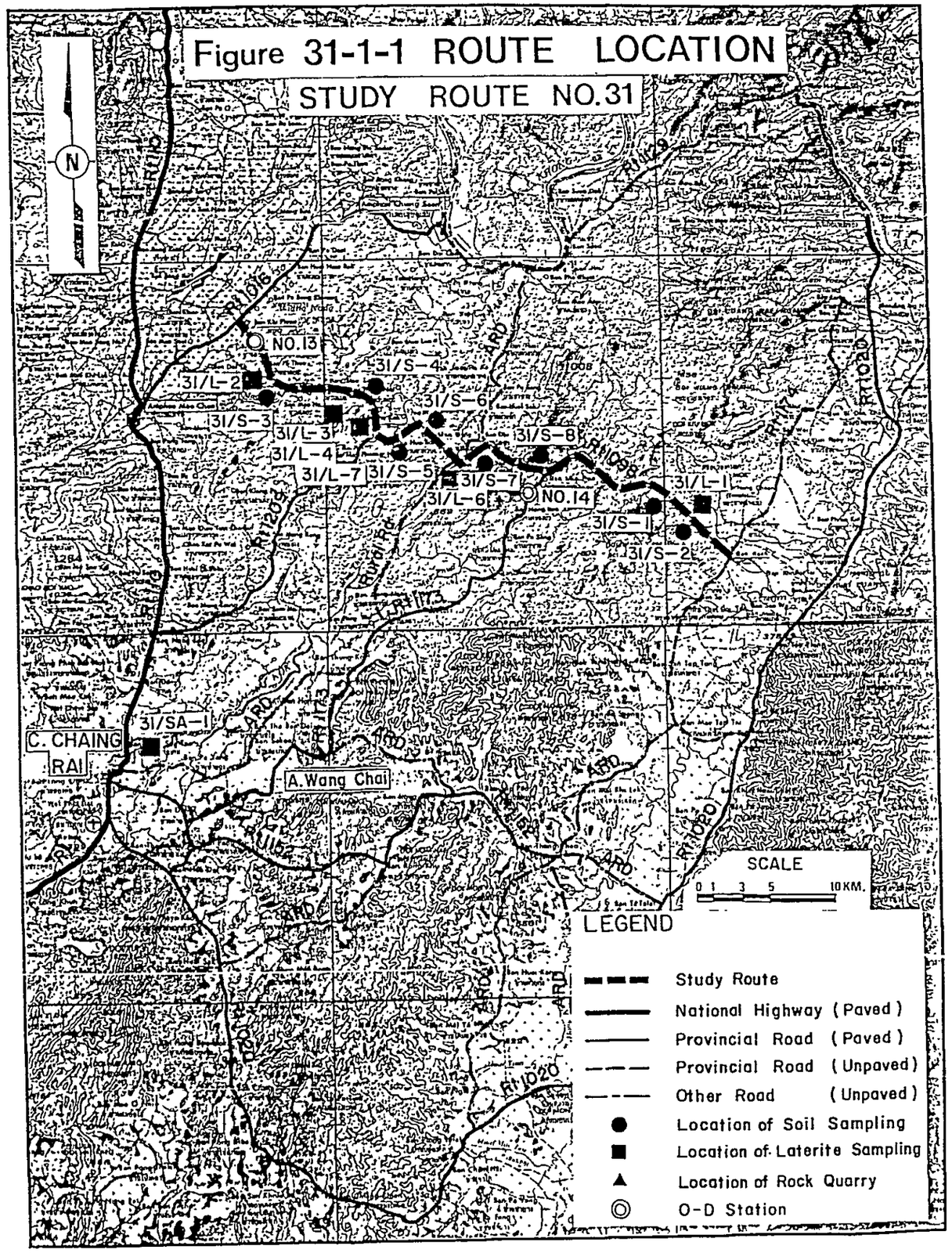


Table 31-1-1 SUMMARY OF ROAD INVENTORY

Segment	Changwat	Route Name	Route Section: Origin	Route Section: Destination	Length (km)	Terrain	Roadway Condition: Surface: Earth/Lat./S.T.	Surface: Length (km)	Surface: Condition	Alignment: Horizontal	Alignment: Vertical	Road Cross Section: Width (m)	Road Cross Section: Emb. H. (m)	Road Cross Section: Cut D. (m)	Bridge: Nos.	Bridge: Width (m)	Bridge: ACC. Length (m)	Land Use	Overflow: Height X Length (m)
Seg-ⓐ	Chaing Rai	R.1098	R.1016 B.Kiu Phrao	B.Kopang	17.7	Flat	E	2.7	Fair	Fair		5.0	0.5	0	3	4.0		Paddy	-
						⟩	L	13.0	⟩		Fair	⟩	⟩	⟩		⟩	29.0		
						Rolling	S.T.	2.0	Bad			7.0	2.0	1.5	Timber	4.5		Maize	
Seg-ⓑ	Chaing Rai	R.1098	B.Kopang	B.Mae Liob	16.8	Flat	E	16.0		Fair	Fair	4.0	0.5	0	1	7.0	200.0	Maize	
						⟩			Bad	⟩	⟩	⟩	⟩	⟩	Con-			Paddy	0.5x2,700
						Rolling	L	0.8		Bad	Bad	8.0	2.5	6.0	cret 8 Timber	4.5~5.5	77.5	Cassava	1:2x290
Seg-ⓒ	Chaing Rai	R.1098	B.Mae Liob	R.1174 B.Kaen Tai	20.5	Flat Rolling Mountain-ous	L	20.5	Fair ⟩ Bad	Fair ⟩ Bad	Fair ⟩ Bad	4.0 ⟩ 8.0	0.5 ⟩ 1.5	0 ⟩ 2.0	8 Timber	4.0 ⟩ 4.5	126.4	Maize Paddy	0.5x700 0.5~1.0x700

2. TRAFFIC

2-1 Traffic Zone and Road Links

Traffic zoning was made as shown in Figure 31-2-1

The area of influence was divided into 5 traffic zones, and total population in the area amounts approximately to 33200. The density in terms of population per unit Km of the proposed road length is 600. Annual rate of population increase in the area is 0.9% in the past 3 years, which is lower than the average of 2.2% in the Northern Region.

As the major destinations of transport demands originated in the area, three Amphoe of Muang Chiang Rai, Mae Chan and Wiang Chai were chosen based on the O/D survey. Characteristics of the traffic zones are shown in Table 31-2-1.

The existing and proposed roads in the area together with surrounding roads concerned were divided into totaling 22 road links, 5 links in the proposed roads and 17 links in the surrounding roads. The details are shown in Table 31-2-2.

2-2 Transportation Demands

a) Passenger

Passenger transportation demands by O/D pair in the opening year of the project were estimated in both cases of with and without projects as follows:

Passenger O/D (without project)-1987

(trip/day)

	1	2	3	4	5	11	12	21	22
1	0	299	97	81	28	149	0	0	0
2	0	0	85	47	23	47	80	196	269
3	0	0	0	252	56	214	120	217	124
4	0	0	0	0	118	0	0	0	145
5	0	0	0	0	0	78	58	109	48
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0

Passenger O/D (with project)-1987

(trip/day)

	1	2	3	4	5	11	12	21	22
1	0	348	257	240	72	183	0	0	0
2	0	0	287	173	64	92	92	230	373
3	0	0	0	525	141	266	134	262	276
4	0	0	0	0	231	0	0	0	280
5	0	0	0	0	0	119	76	140	92
11	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0

b) Agricultural Freight

The major destinations of agricultural freight originated in the influencial area were selected at A. Muang Chiang Rai and A. Mae Chan, basing on the agro-economic survey results.

The estimated agricultural freight O/D volumes in 1987 for the both cases of with and without projects are as follows:

Agri. Freight O/D (without project)-1987

(1,000 ton/year)

	1	2	3	4	5	11	12	21	22
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	11.1
3	0.0	4.6	0.0	1.0	0.0	0.0	0.0	0.0	12.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.3
5	0.0	0.0	0.0	1.4	0.0	0.0	0.0	6.3	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 31-2-1 ZONING AND ROAD NETWORK

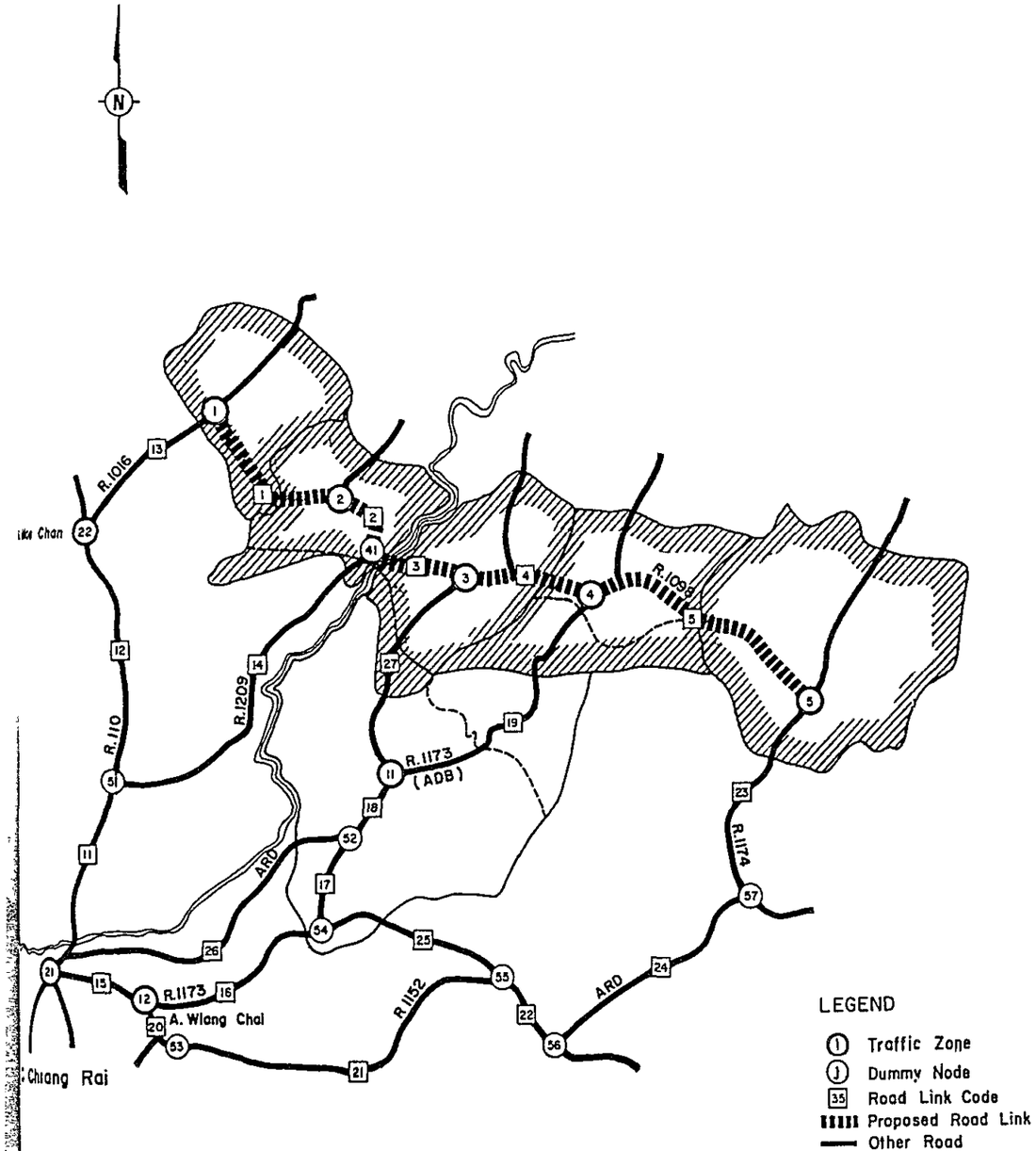


Table 31-2-1 ZONE CHARACTERISTICS

Traf. Zone	Relative Administrat. Div. Changwat	Amphoe	Tambon Code	% of Popul. in Traf. Zone	Popul. in 1981 (10^3)	Past Trend of Popul. Increase	Annual Rate of Increase 1981-1987	Projected Population in 1987 Generation	Attraction
1	C.R	Mae Chang	090502(1)	8	1.4				
			090502(2)	92	16.3				
			Total	-	17.7	-0.2	0.0	17.7	17.7
2	C.R	M.Chiang Rai	090105	8	1.1				
		Mae Chan	091101	100	5.3				
			Total	-	6.3	0.5	0.7	6.6	6.6
3	C.R	Mae Chan	090507	48	9.1				
		Wiang Chai	091101	6	1.0				
			Total	-	10.1	0.5	0.7	10.5	10.5
4	C.R	Mae Chan	090507	48	9.1				
		Wiang Chai	091105	60	4.5				
			Total	-	13.6	0.7	0.7	14.2	14.2
5	C.R	Chiang Khong	090405(1)	25	1.8				
			090405(2)	75	5.5				
			Total	-	7.3	4.5	2.4	8.1	8.1
11	C.R	Wiang Chai	091101	78	19.9				
			091105						
			Total	-	19.9	1.4	1.3	21.7	21.7
12	C.R	Wiang Chai	0911024	100	42.6	1.1	1.1	-	46.0
21	C.R	-	090000	100	926.2	0.9	0.9	-	977.4
22	C.R	Mae Chan	090500	100	103.3	0.7	0.7	-	107.8

Table 31-2-2 ROAD LINK CHARACTERISTICS

NO	SN	EN	LO	GOD	GOR	LW	GWD	GWR	TO	TW	REMARKS
1	1	2	11.2	8	11	11.2	5	5	16.8	11.2	R.1098
2	2	41	7.2	9	12	7.2	5	5	14.5	7.2	R.1098
3	3	41	8.6	13	15	8.6	5	5	25.7	8.6	R.1098
4	3	4	8.8	13	15	8.8	5	5	26.3	8.8	R.1098
5	4	5	19.2	9	12	19.2	6	6	38.6	23.0	R.1098
11	21	51	12.0	1	1	12.0	1	1	9.2	9.2	R.110
12	22	51	18.0	1	1	18.0	1	1	13.8	13.8	R.110
13	1	22	10.0	4	4	10.0	4	4	8.6	8.6	R.1016
14	41	51	25.0	8	11	25.0	8	11	37.5	37.5	R.1209(IBRD)
15	12	21	7.5	4	4	7.5	4	4	6.4	6.4	R.1173
16	12	54	14.0	5	5	14.0	5	5	14.0	14.0	R.1173
17	52	54	7.0	5	5	7.0	5	5	7.0	7.0	R.1173
18	11	52	4.5	5	5	4.5	5	5	4.5	4.5	R.1173
19	4	11	18.5	5	5	18.5	5	5	18.5	18.5	R.1173
20	12	53	2.0	5	5	2.0	5	5	2.0	2.0	R.1173
21	53	55	25.0	5	5	25.0	5	5	25.0	25.0	R.1152(IBRD)
22	55	56	10.0	5	5	10.0	5	5	10.0	10.0	R.1152(IBRD)
23	5	57	11.9	8	11	11.9	8	11	17.9	17.9	R.1174
24	56	57	15.0	9	12	15.0	9	12	30.2	30.2	ARD
25	54	55	12.0	9	12	12.0	9	12	24.1	24.1	ARD
26	21	52	24.0	8	11	24.0	8	11	36.0	36.0	ARD
27	3	11	16.0	9	12	16.0	9	12	32.2	32.2	Rural

Note SN. Start Node, EN. End Node, LO Link Length (W), GOD Road Grade in Dry Season (W), GOR. Road Grade in Rainy Season (W), LW. Link Length (W), GWD. Road Grade in Dry Season (W), GWR. Road Grade in Rainy Season (W), TO. Time (W), TW Time (W)

Agri. Freight O/D (with project)-1987

(1,000 ton/year)

	1	2	3	4	5	11	12	21	22
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	11.8
3	0.0	4.6	0.0	1.0	0.0	0.0	0.0	0.0	14.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	4.3
5	0.0	0.0	0.0	1.4	0.0	0.0	0.0	6.3	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

c) Non-agricultural Freight

The non-agricultural freight transportation demands are estimated based on the model described in 3-3-3 in the Summary Report. Their movements on each road link were obtained relating with the passenger movements which were derived from the assignment of the passenger O/D volumes shown in the above a).

2-3 Traffic Composition, Occupancy and Loading Ratio

a) Traffic Composition

In accordance with the examination of the classified traffic counts in the Phase I and II studies and DOH's traffic records, the traffic composition on the existing roads of the project area was estimated as follows:

Existing Traffic Composition

Survey Points and Source	Passenger Traffic						Freight Traffic				
	P/C	P/P	L/B	M/B	H/B	Total	P/T	4/T	6/T	10/T	Total
No.3(Phase II)	.16	.37	.47	.00	.00	1.00	.25	.25	.50	.00	1.00
No.14(PhaseII)	.00	.26	.20	.54	.00	1.00	.65	.00	.29	.06	1.00
R. 1098 (DOH)	.28	.14	.47		.11	1.00	.52		.35	.13	1.00
Estimated	.08	.31	.35	.25	.01	1.00	.35	.15	.46	.04	1.00

Changes in traffic composition due to income growth and road surface condition were predicted for the both cases of with and without projects as shown in the following tables:

Passenger Traffic Composition

Year	Without Project					With Project				
	P/C	P/P	L/B	M/B	H/B	P/C	P/P	L/B	M/B	H/B
1981	.08	.31	.35	.25	.01	.08	.31	.35	.25	.01
1987	.09	.35	.32	.23	.01	.12	.33	.28	.21	.06
1993	.10	.41	.28	.20	.01	.15	.35	.21	.17	.11
2001	.12	.46	.24	.17	.01	.20	.38	.12	.12	.18

Freight Traffic Composition

Year	Without Project				With Project			
	P/T	4/T	6/T	10/T	P/T	4/T	6/T	10/T
1981-2001	.35	.15	.35	.15	.40	.03	.40	.17

b) Occupancy

Occupancy by vehicle type and the average were determined as follows:

Occupancy

Vehicle Type	Person per Vehicle
P/C	3.1
P/P	4.4
L/B	10.9
M/B	16.2
H/B	38.3
Ave. (1993, $\overline{W}$)	8.8
(1993, W)	11.3

c) Loading Ratio

Loading ratio by vehicle type and the average were determined as follows:

Loading Ratio

Vehicle Type	Ave. Load of Loaded Truck	Rate of Loaded Trucks	Loading Ratio (ton)
P/T	0.65	.45	0.3
4/T	2.0	.50	1.0
6/T	4.1	.55	2.3
10/T	12.6	.60	7.6
Ave.($\overline{W}$)	-	-	2.2
(W)	-	-	2.4

2-4 Growth Rates of Transportation Demands

The growth rates of passenger, agricultural freight and non-agricultural freight transport demands for the periods of 1987-1993 and 1993-2001 were projected. The basis for the estimation of growth rate for passenger, and the projected rates are shown in the following tables:

The Basis for Estimation of Passenger Demands Growth

Indicator	Annual Growth Rate (%) 1987 - 1993	1993 - 2001	Elasticity
Per capita Income	5.7	5.5	1.08
Transportation price	3.6	3.6	-0.24
Population	0.9	1.1	1.00

Growth Rate of Transportation Demands

Type of Demand	Annual Growth Rate (%) 1987 - 1993	1993 - 2001	Index 1987=100 1993	2001
Passenger	6.2	6.2	144	233
Agri. Freight	0.6	0.5	103.4	117.7
Non-Agri. Freight	7.4	7.4	153	272

2-5 Forecasted Traffic

a) Forecasted Traffic by Vehicle Type

The forecasted traffic is summarized in the following table:

Forecasted Traffic

Year	P/C	L/B	M/B	H/B	P/P P/T	4/T	6/T	10/T	ADT	M/C
1987	20	48	36	10	84	2	28	12	239	321
1993	35	48	39	25	119	3	38	16	324	347
2001	68	41	41	61	191	5	62	26	495	350

b) Forecasted Traffic by Road Link

Details of the forecasted traffic by road link by traffic type are shown in the following table, taking a sample of the case of 1993:

Forecasted Traffic by Road Link

TRAFFIC VOLUME ON ROUTE 31 (1993)

LINK		1	2	3	4	5	AVR.
P/C	N+D	29	17	21	23	10	18
	I	18	22	23	20	8	16
	DV	0	0	0	0	0	0
	TOTAL	47	39	44	43	18	35
L/B	N+D	41	23	29	32	14	26
	I	25	31	32	28	11	22
	DV	0	0	0	0	0	0
	TOTAL	65	54	61	61	25	48
M/B	N+D	33	19	24	26	11	21
	I	20	25	26	23	9	18
	DV	0	0	0	0	0	0
	TOTAL	53	44	49	49	20	39
H/B	N+D	21	12	15	17	7	14
	I	13	16	17	15	6	12
	DV	0	0	0	0	0	0
	TOTAL	34	28	32	32	13	25
P/P&T	N+D	106	61	75	75	33	65
	I	60	73	76	68	26	53
	DV	1	1	1	0	0	1
	TOTAL	167	135	152	143	59	119
4/T	N+D	3	2	2	2	1	2
	I	1	2	2	2	1	1
	DV	0	0	0	0	0	0
	TOTAL	4	3	4	3	1	3
6/T	N+D	38	22	26	21	10	22
	I	19	22	23	21	7	16
	DV	1	1	1	0	0	1
	TOTAL	58	45	50	42	17	39
10/T	N+D	16	9	11	9	4	9
	I	8	9	10	9	3	7
	DV	1	0	0	0	0	0
	TOTAL	25	19	21	18	7	16
ADT	N+D	287	166	203	205	91	177
	I	164	198	208	184	70	146
	DV	3	3	3	0	0	1
	TOTAL	454	367	413	390	161	324
M/C	N+D	311	199	237	251	126	211
	I	139	186	187	167	79	136
	DV	1	1	1	0	0	0
	TOTAL	451	386	425	418	204	347
TOTAL	N+D	598	365	440	456	217	397
	I	303	384	395	351	149	282
	DV	4	3	3	0	0	2
	TOTAL	905	753	838	808	365	671

NOTE
N : NORMAL TRAFFIC D : DIVERTED TRAFFIC
DV : DEVELOPED TRAFFIC I : INDUCED TRAFFIC

3. AGRICULTURAL DEVELOPMENT

3-1 Crop Production

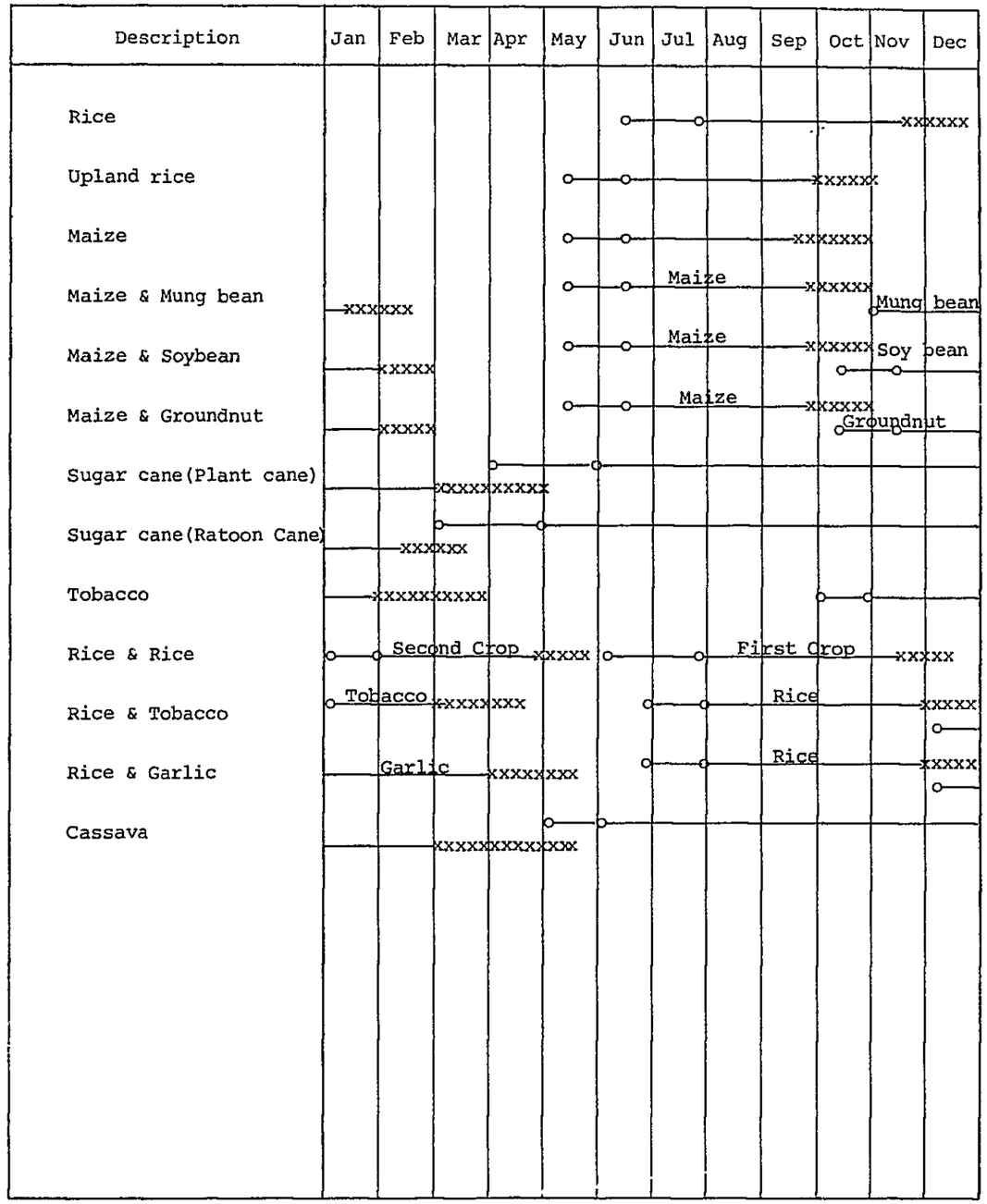
The area of influence is extended mostly in the hilly area. More than 65% of cultivated area is for upland crops such as maize, fruits, cassava, vegetables, tobacco and beans. At present most of the production in the area are assembled at Mae Chan where markets and factories exist.

Land use and capability in the area of influence is illustrated in Figure 31-3-2. Typical cropping calendar in Chiang Rai area is also shown in Figure 31-3-1. Based on the estimated planted area and yields, the future crop production in the area of influence after opening of the proposed road is given in the following Table 31-3-1.

3-2 Net Value Added

In accordance with the concept discussed in Chapter 4 of Summary Report, net value added was calculated for both cases, with project and without project. The agricultural development benefit, indicated by the increment of net value added of crop production in the with project case, attributable to the project is estimated at 11.8,13.1 and 14.8 in million Baht for 1987, 1993 and 2001 respectively.

Figure 31-3-1 TYPICAL CROPPING CALENDAR - Route 31



NOTE: ○——○——xxxxxxxxxxxxx

Sawing Season — Growing Season — Harvesting Season

Figure 31-3-2 LAND USE AND CAPABILITY OF INFLUENCE AREA STUDY ROUTE NO.31

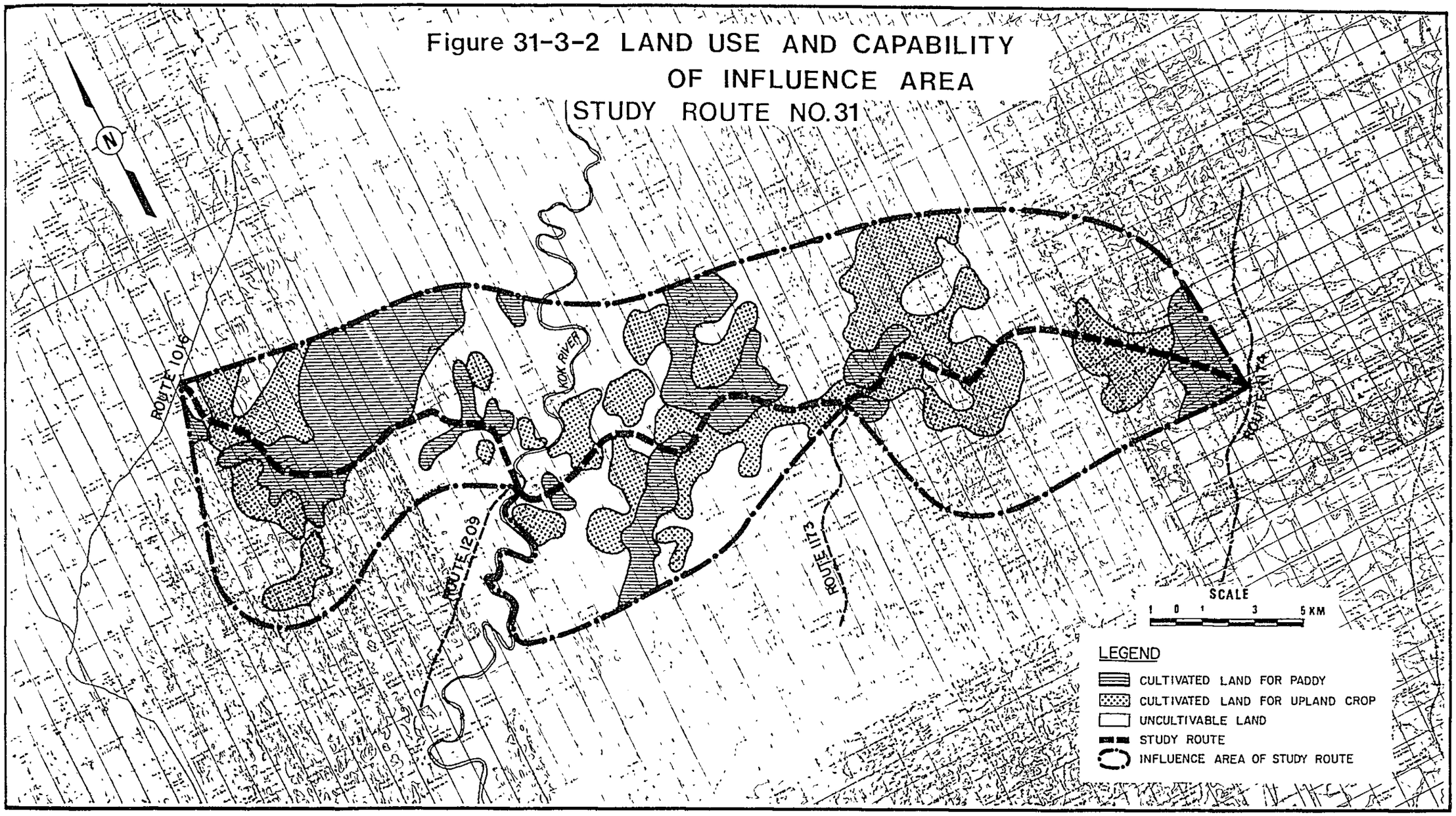


Table 31-3-1 CROP PRODUCTION - Route 31

(1000 TON)

CROP	1987		1993		2001	
	W/O	W	W/O	W	W/O	W
PADDY	14.8	14.9	14.9	15.2	15.1	15.8
MAIZE	0.3	0.3	0.3	0.4	0.3	0.4
MUNG BEAN	0.1	0.1	0.1	0.2	0.1	0.2
SOY BEAN	0.0	0.0	0.0	0.0	0.0	0.0
GROUND NUTS	0.0	0.0	0.0	0.0	0.0	0.0
SORGHUM	0.0	0.0	0.0	0.0	0.0	0.0
CASSAVA	0.0	0.0	0.0	0.0	0.0	0.0
SUGAR CANE	0.0	0.0	0.0	0.0	0.0	0.0
TOBACCO	0.0	0.0	0.0	0.0	0.0	0.0
COTTON	0.0	0.0	0.0	0.0	0.0	0.0
GARLIC	0.0	0.0	0.0	0.0	0.0	0.0
CHILLI	0.0	0.0	0.0	0.0	0.0	0.0
SESAME	0.0	0.0	0.0	0.0	0.0	0.0
VEGETABLES	0.1	0.1	0.1	0.1	0.1	0.1
FRUITS	0.1	0.1	0.1	0.1	0.1	0.1
OTHERS	0.2	0.2	0.2	0.2	0.2	0.2

4. ROAD USERS COST SAVINGS

In accordance with the concept and basic data described in Chapter 5 of Summary Report, sums of VOC on each road link concerned were calculated in both cases of with project and without project.

Road users cost savings, defined as the difference of total link VOC in the case of with project and that in the without project case, were estimated at 18.0, 28.6 and 51.9 in million Baht for 1987, 1993 and 2001 respectively.

5. ENGINEERING

5-1 Soils and Materials

Test results of subgrade soil, materials for subbase and shoulders and crushed rocks along the route or in the vicinity of the project area are shown in Table 31-5-1.

Location of samplings for the soil test done in this study are shown in the Location Map of Figure 31-1-1.

5-1-1 Subgrade Soils

Subgrade soils along the study route consist mainly of clayey soil of medium plasicity-index ranging from 11.0 to 25.0%. They were classified as A-4 and A-7-5 in the AASHTO Classification. CBR values were from 3.0 to 6.0%.

5-1-2 Subbase and Shoulder Materials

Test results of laterite sampled along the study route indicated that of the plasticity index in the portion passing No. 4 sieve was from N.P to 30.0% and the soaked CBR was from 20.0 to 50.0%.

Most of laterites along the study route are not suitable for use in subbase and shoulder layer because of their high plasticity-index. To reduce the plasticity, the river sand obtained in adjacent river was mixed with the laterite of high plasticity. This mixture has less than 10.0% in plasticity and are suitable for subbase and shoulder materials.

5-1-3 Rock Material

The rock quarry available for the proposed road is the source 29/R-1, the quality of which is described in the previous section.

5-2 Preliminary Design

Engineering studies on the proposed road are described, dividing the route into three Segments ((a), (b) and (c)), due to its topographic differences.

Segment-(a) :	Rt. 1016, B. Kiu Phrao	- B. Kopang	(17.7 km, rolling)
Segment-(b) :	B. Kopang	- B. Mae Liob	(16.8 km, rolling)
Segment-(c) :	B. Mae Liob	- Rt.1174, B. Kaen Tai	(20.5 km, mountainous)

Design speeds employed in the studies are 60 and 45 km/hr for Segment (a), (b) and Segment (c) respectively according to F4 class of DOH Design Standard.

5-2-1 Alignment and Earthwork

Segment (a) and (b) include some gradients steeper than 10% and sharp horizontal curves. They were improved in accordance with the geometric design criteria. As the result, the cutting depth of 1.0 m to 3.0 m in an accumulated length of 2.5 km arise. The widening width and the rising height respectively vary from 1.0 m to 5.0 m and 0.5 m to 2.0 m.

In Segment (c), the section between STA. 38+400 and STA. 48 is now under improvement by DOH in accordance with the design criteria of class F5, therefore no improvement of the alignment is required. The widening width and the raising height vary from 1.0 m to 5.0 m and 0.5 m to 2.0 m respectively through the remaining length.

5-2-2 Pavement Design (F4 Class)

Forecasted ADT is very low in 35.8 km long section passing trough mountainous area comparing other sections. The pavement thickness was therefore calculated dividing into two sections, mountainous and other sections.

Table 31-5-1 TEST RESULTS OF SOILS AND MATERIALS

Description	Sample No.	Location of Source (KM)	Depth (m)	Description of Sample	AASHO Classification	Sieve Analysis (% Passing)								Plasticity		Compaction DH-T STD.		Lab.CBR		Moisture Content (After Soaked) (%)	Abrasion (%)
						50.0	25.0	19.0	9.5	#4	#10	#40	#200	LL (%)	PI (%)	Opt. Mc.(%)	γd gm/cc.	CBR (%)	Swell (%)		
	31/S-1	KM.48+500 (R.3m)	0.3-0.7	clayey soils	A-6	-	-	100	99.4	98.8	98.4	95.8	84.6	36.8	12.8	22.8	1.581	3.5	2.10	27.8	
	31/S-2	KM.51+450 (R.4m)	0.3-0.7	clayey silt	A-4	-	-	100	98.8	94.6	89.0	76.2	63.6	30.8	8.8	18.2	1.730	10.0	1.40	18.5	
	31/S-3	KM. 5+00 (R.7)			A-7-5	-	-	100	78.2	-	36.2	32.2	31.6	75.0	24.5	22.5	1.830	6.3	0.22	25.9	
Subgrade Soil	31/S-4	KM 15+00 (L.9)			A-4	-	-		100	-	99.4	82.0	56.8	34.1	11.7	30.5	1.480	3.1	-	33.3	
	31/S-5	KM 20+00		clayey soil	A-7-6	-	-		100	98.6	73.8	54.8	46.6	51.5	21.6	17.4	1.710	6.4	0.44	21.2	
	31/S-6	KM 25+00 (R.6)		clayey soil	A-7-5	-	-	-	-	100	99.8	76.8	65.6	59.2	20.5	26.5	1.485	5.9	1.1	34.5	
	31/S-7	KM 30+00 (L.8)		clayey soil	A-6	-	-	-	-	100	99.6	99.2	88.8	36.6	11.4	16.7	1.790	4.0	1.08	22.1	
	31/S-8	KM 3F+00 (L.7)		clayey soil	A-7-5	-	-	-	100	99.8	99.6	95.8	83.6	43.8	22.0	20.9	1.635	3.8	1.03	27.8	
	31/L-1	KM 51+229		laterite	A-2-6	100	88.9	81.5	57.3	36.8	22.4	11.1	7.1	36.1	11.6	9.7*	1.996*	51.0	0.88		41.2
	31/L-2	KM 4+400		laterite		-	100	89.9	63.9	-	23.6	21.5	20.7	70.1	21.3						41.8
	31/SA-1	KM830+700 (KoK Rv.)		sand	A-3	-	-	-	100	-	99.8	78.5	0.9	N - P							
Subbase/ Shoulder Material		31/L-2 mixed with 31/SA-1 in 7:3				-	100	92.9	74.7	-	46.5	38.1	14.7	35.0	10.5	12.5*	2.205*	85.5	0.11		
	31/L-3	KM 11+750			A-7-5	-	100	95.7	82.9	-	51.8	44.4	40.8	63.0	19.0	18.0*	1.909*	49.2	0.62		58.4
	31/L-4	KM 11+400 (R.100)			A-2-7	-	100	-	92.7	-	46.3	34.5	31.3	72.8	31.3	24.2*	1.670*	28.5	1.10		56.8
	31/L-5	KM 17+750			A-2-7	-	100	87.5	59.2	-	16.5	14.3	13.1	52.5	19.4						60.8
		31/L-5 mixed with 31/SA-1 in 4:1				-	100	90.0	67.4	-	33.2	27.1	10.7	23.0	8.5	11.2*	2.292*	53.0			
	31/L-6	KM 28+000			A-7-5	-	100	96.5	81.5	-	59.9	48.2	44.3	53.6	22.7	19.6*	1.736*	21.2	0.88		55.8

Table 31-5-1 TEST RESULTS OF SOILS AND MATERIALS (Cont'd)

Description	Sample No.	Location of Source (KM)	Depth (m)	Description of Sample	AASHO Classi-fication	Sieve Analysis (% Passing)								Plasticity		Compaction DH-T STD.		Lab.CBR		Moisture Content (After Soaked) (%)	Abrasion (%)
						50.0	25.0	19.0	9.5	#4	#10	#40	#200	LL (%)	PI (%)	Opt. Mc.(%)	γd gm/cc.	CBR (%)	Swell (%)		
	31/L-7	KM 17+750			A-2-7	-	100	95.3	69.1	-	29.7	27.2	26.4	70.1	16.7						71.4
		31/L 7 mixed with 31/SA-1 in 7:3				-	100	46.7	78.4	-	50.7	42.6	18.7	32.0	7.5	13.6*	2.080*	51.0	0.24		
	31/L-8	KM886+000 (L.600m)			A-7-6	-	-	100	93.4	-	57.8	52.2	49.4	53.5	33.7	23.1*	1.824*	22.3	0.45		68.4
	31/L-9	KM854+150			A-4	-	-		100	-	83.1	62.1	42.4	N - P		18.6*	1.700*	21.0	1.10		62.0

Note: * Compaction by DH-T-MOD

A) Mountainous Section

1) Design Traffic Number (DTN)

The basic data on traffic volume for DTN calculation are as follows:

	Heavy Truck	Medium Truck	Heavy Bus	Total	Remarks
Average Number of Heavy Vehicles	5	12	5	22	ADT in 1987

Using the traffic analysis chart, DTN obtained for DTN7 (7 years design period) and DTN15 (15 years) were 1.5 and 3.5, respectively.

2) Design CBR

Design CBR of 30 percentile value was calculated at 3.9 percent from the following testing results.

Sample No.	1	2	3	4	5	6	Design CBR
CBR Testing Value	6.3	3.1	5.9	4.0	(10.0)*		3.9

* CBR 10 was neglected.

3) Thickness of Pavement

Thicknesses of full-depth asphaltic concrete were obtained from the Thickness Design Chart as 145 mm and 165 mm for TA7 (7 years design period) and TA15 (15 years), respectively.

Thickness of pavement structures of SBST was determined from calculated TA7 145 mm full-depth asphaltic concrete as follows:

SBST		12 mm
Crushed stone base	CBR $\geq$ 80	150 mm
Soil aggregate subbase	CBR $\geq$ 20	190 mm

Thickness of overlay required at 7th year is 20 mm (TA15 - TA7) in case of asphaltic concrete. If it is planned with SBST, the layer composition is as follows:

SBST		12 mm
Crushed stone base	CBR $\geq$ 80	40 mm

B) Other Sections

1) Design Traffic Number (DTN)

The basic data on traffic volume for DTN calculation are as follows:

	Heavy Truck	Medium Truck	Heavy Bus	Total	Remarks
Average Number of Heavy Vehicles	15	36	13	64	ADT in 1987

Using the traffic analysis chart, DTN obtained for DTN7 (7 years design period) and DTN15 (15 years) were 3.5 and 9.5 respectively.

2) Design CBR

The same value of design CBR used in mountainous section was applied.

3) Thickness of Pavement

Thicknesses of full-depth asphaltic concrete were obtained from the Thickness Design Chart as 165 mm and 190 mm for TA7 (7 years design period) and TA15 (15 years), respectively.

Thickness of pavement structures of SBST was determined from calculated TA7 165 mm full-depth asphaltic concrete as follows:

SBST		12 mm
Crushed stone base	CBR $\geq$ 80	150 mm
Soil aggregate subbase	CBR $\geq$ 20	250 mm

Thickness of overlay required at 7th year is 25 mm (TA15 - TA7) in case of asphaltic concrete. If it is planned with SBST, the layer composition is as follows:

SBST		12 mm
Crushed stone base	CBR $\geq$ 80	50 mm

5-2-3 Drainage

1) Pipe Culvert

Segment - (a)

Pipe culverts (ϕ 1.0 m) were installed at intervals of 200 m for the sections where the land is used for paddy fields, 7.4 km long in total and at every sag points for the remainder of Seg. (a).

Segment - (b)

Pipe culverts (ϕ 1.0 m) were installed at every sag points for a distance about 9.0 km and at intervals of 200 m or 500 m for the remainder.

Segment - (c)

No pipe culvert was not installed for the section between STA. 38 + 400 and STA. 48.

Pipe culverts (ϕ 1.0 m) were installed at every sag points for a distance of about 7.0 km and at intervals of 500 m for the remainder.

2) Box Culvert

Box culvert (2.4 m x 2.4 m) was planned at the water course having small catchment area. The number of cells of culvert was determined by comparing discharge with flow capacity as shown in following table.

List of Box Culvert

Station	Existing Structure	Catchment Area (km^2)	Intensity (mm/h)	Discharge (m^3/sec)	Proposed Structure 1/	Capacity (m^3/sec)
16+750	-	3	108	49	C-B 2(2.4x2.4)	50
23+600	BR-T (1.5x8.0)	3	100	45	C-B 2(2.4x2.4)	50
32+500	(5.0x5.5)	3	92	41	C-B 2(2.4x2.4)	50

Note: 1/ Length of Culvert is 10.0 m.

5-2-4 Bridge

Short span concrete bridges was planned where the river is relatively narrow and shallow. The length of bridges was determined by comparing discharge with flow capacity of bridge opening.

List of Bridge

Station	Existing Structure	Catchment Area (km^3)	Intensity (mm/h)	Discharge (m^3/sec)	Proposed Structure 1/	Capacity (m^3/sec)	
7+200	BR-T (4.5x8.0)	20	46	128	BR-C-12.0	63	139
7+450	BR-T (4.5x9.0)				BR-C-14.0	76	
11+750	BR-T (4.0x12.0)	6	87	78	BR-C-12.0	81	
21+700	BR-T (4.5x5.0)	5	76	54	BR-C-10.0	63	
26+450	BR-T (4.5x6.5)	34	34	154	BR-C-12.0	81	162
26+650	BR-T (4.5x8.0)				BR-C-12.0	81	
28+700	BR-T (4.5x6.5)	3	115	55	BR-C-10.0	63	
30+200	BR-T (5.5x4.2)	136	32	568	BR-C-16.0	116	570
30+550	BR-T (4.0x22.0)				BR-C-30.0	454	
32+050	BR-T (4.0x11.0)	6	87	77	BR-C-12.0	81	
35+500	BR-T (4.0x11.8)	3	135	65	BR-C-12.0	81	
37+050	BR-T (4.5x34.0)	100	38	496	BR-C-40.0	330	
38+050	BR-T (4.5x18.5)				BR-C-24.0	186	
41+150	-	13	80	153	BR-C-24.0	186	
41+500	-	13	80	141	BR-C-20.0	151	
41+600	-	13	80	141	BR-C-20.0	151	
42+100	-	8	100	102	BR-C-16.0	115	
42+300	-	8	100	102	BR-C-16.0	115	
42+350	-	8	100	102	BR-C-16.0	115	
42+600	-	7	100	89	BR-C-14.0	98	
42+650	-	7	100	89	BR-C-14.0	98	
42+750	-	7	100	89	BR-C-14.0	98	
42+800	-	7	100	89	BR-C-14.0	98	
43+400	-	6	100	77	BR-C-12.0	81	
43+500	-	6	100	77	BR-C-12.0	81	
43+700	-	6	100	77	BR-C-12.0	81	

Note: 1/ Carriageway width of bridge is 7.0 m.

List of Bridge (Cont'd)

Station	Existing Structure	Catchment Area (km^3)	Intensity (mm/h)	Discharge (m^3/sec)	Proposed Structure 1/	Capacity (m^3/sec)
43+900	-	6	100	77	BR-C-12.0	81
44+400	-	3	125	59	BR-C-10.0	63
44+700	-	3	125	59	BR-C-10.0	63
44+750	-	3	125	59	BR-C-10.0	63
44+950	-	3	125	59	BR-C-10.0	63
46+700	-	3	125	59	BR-C-10.0	63
47+150	-	3	125	59	BR-C-10.0	63
47+700	-	6	120	114	BR-C-16.0	115
49+850	BR-T (4.5x8.5)	7	100	107	BR-C-20.0	117
49+800	BR-T (4.5x18.0)	7	100	107	BR-C-20.0	117
49+900	BR-T (4.5x10.0)	6	70	60	BR-C-12.0	63
50+800	BR-T (4.0x11.0)	7	55	58	BR-C-12.0	63

Total length = 572.0 m

Note: 1/ Carriageway width of bridge is 7.0 m.

6. CONSTRUCTION COST

Construction costs were obtained by applying the unit rates to the respective work quantities calculated on the basis of the engineering studies.

Rock materials used for SBST, base course and structure works were supposed to be transported from rock quarry 29/R-1 with a hauling distance of 56 km. The transportation cost for this hauling distance was reflected to each unit rate.

The construction cost together with land acquisition cost are given in in Table 31-6-1.

The construction period for the proposed road was estimated to be 3 years. Yearly disbursements of construction cost together with price contingency are shown in the following table.

YEARLY COST DISBURSEMENT - Route 31

(Million Baht)

	1984		1985		1986		Total		
	L/C[1/]	F/C[2/]	L/C	F/C	L/C	F/C	L/C	F/C	Total
Construction Cost	13.7	12.6	34.1	31.5	20.5	18.9	68.3	63.0	131.3
Price Contingency[3/]	4.4	2.0	15.5	7.3	12.3	5.9	32.2	15.2	47.4
Total	18.1	14.6	49.6	38.8	32.8	24.8	100.5	78.2	178.7
							(4.38)	(3.41)	(7.79)

Note: 1/ Local Currency

2/ Foreign Currency

3/ At assumed annual escalation rates as follows (% p.a.):

	Local C.	Foreign C.
1981 - 1983	15	7.5
1983 - 1987	10	6.5

( ) Million US$ Equivalent (1US$ = 22.63 Baht)

Table 31-6-1 CONSTRUCTION COST - Route 31 (F-4 / 55.0 Km)

Description	Unit of Quantity	Financial Unit Rate (Baht)	Quantity	Economic Cost (10^3 ฿)
Clearing & Grubbing	ha	17,000	93	1,439
Roadway Excavation-Classified Earth	m^3	36	166,500	5,395
Roadway Excavation-Classified Soft Rock	m^3	80	0	0
Embankment-Side Borrow	m^3	45	277,600	11,368
Embankment-Borrow Pit	m^3	60	0	0
Embankment-Selected Material	m^3	80	0	0
Subbase-Soil Aggregate	m^3	106	126,900	11,972
Base-Crushed Rock	m^3	344	53,600	16,963
Shoulder-Soil Aggregate	m^3	170	23,100	3,495
Asphaltic Prime Coat	m^2	11.3	357,500	3,717
Single Bituminous Surface Treatment	m^2	28.0	302,500	7,623
R.C. Pipe Culvert	m	2,700	1,840	4,571
R.C. Box Culvert	m	18,700	60	1,010
R.C. Bridge-Short Span	m	41,400	572	21,076
P.C. Bridge-Long Span	m	71,600	0	0
Sub-Total				88,629
Miscellaneous Works[1/]				6,204
Total Direct Construction Cost				94,833
PHYSICAL CONTINGENCY[2/]				14,225
DESIGN AND CONSTRUCTION SUPERVISION[3/]				9,483
Total				118,541
Land Acquisition				
Highly Devel'd Land	ha	50,000	0	0
Less Devel'd Land	ha	15,000	0	0
Grand Total				118,541
FINANCIAL COST (10^3 Baht)				(131,294)

NOTE: 1/ 7% Of direct construction cost of major work items.

2/ 15% Of direct construction cost.

3/ 10% Of direct construction cost.

7. EVALUATION

In accordance with the basic conditions of economic evaluation discussed in Chapter 8 of Summary Report and economic costs and benefits estimated as in the foregoing sections, internal rate of return of the proposed road project was calculated at 20.3%. This implies that the proposed project is economically viable, assuming that the opportunity cost of capital is 12%.

Details of costs and benefits stream are given in Table 31-7-1.

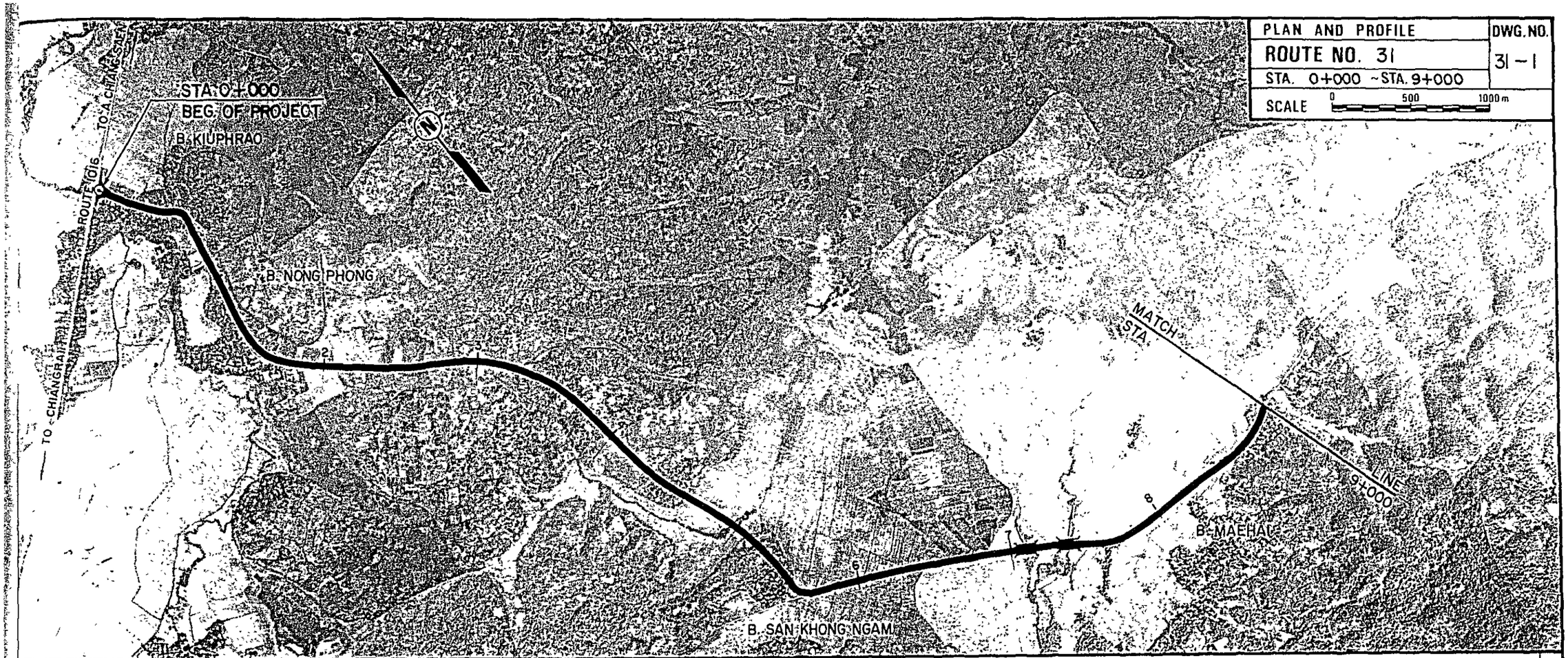
Table 31-7-1 COSTS AND BENEFITS - Route 31

(1000 BAHT)

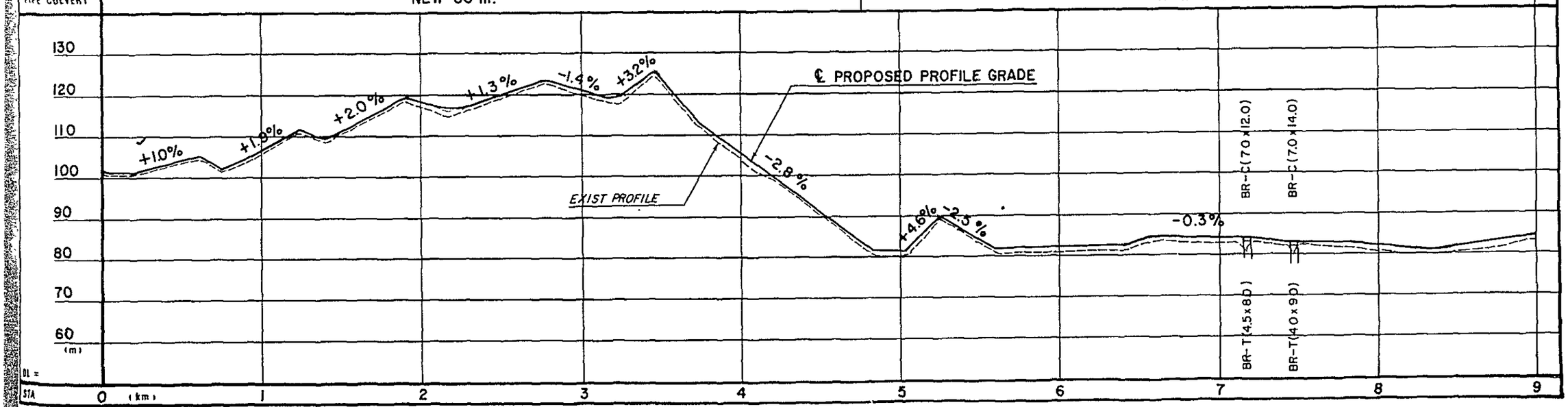
	COST	BENEFITS				DISCOUNTED(12%)	
YEAR	CONST. COST	AGRI. BENEFIT	VOC SAVING	RMC SAVING	TOTAL	COST	BENEFIT
1983	0	0	0	0	0	0	0
1984	23,710	0	0	0	0	33,311	0
1985	59,270	0	0	0	0	74,348	0
1986	35,561	0	0	0	0	39,828	0
1987	0	11,772	17,962	-244	29,490	0	26,330
1988	0	11,986	19,731	-220	31,497	0	25,109
1989	0	12,200	21,500	-196	33,504	0	23,848
1990	0	12,415	23,269	-171	35,512	0	22,568
1991	0	12,629	25,038	-147	37,519	0	21,289
1992	0	12,843	26,807	-123	39,526	0	20,025
1993	0	13,057	28,576	-99	41,533	0	18,788
1994	36,580	13,271	31,492	-58	44,705	16,547	18,056
1995	0	13,486	34,408	-18	47,876	0	17,265
1996	0	13,700	37,325	23	51,048	0	16,436
1997	0	13,914	40,241	63	54,219	0	15,587
1998	0	14,128	43,158	104	57,390	0	14,731
1999	0	14,343	46,074	145	60,562	0	13,879
2000	0	14,557	48,991	185	63,733	0	13,041
2001	-54,529	14,771	51,907	226	66,904	-9,962	12,223
TOTAL	100,592	199,071	496,477	-530	595,017	154,072	279,174

DISCOUNTED ECONOMIC COSTS :	154,072
DISCOUNTED ECONOMIC BENEFITS :	279,174
AGRICULTURAL DEVELOPMENT BENEFIT	87,443
VOC SAVING	192,428
RMC SAVING	-697
NET PRESENT VALUE :	125,102
BENEFIT COST RATIO :	1.81
INTERNAL RATE OF RETURN :	20.3 %

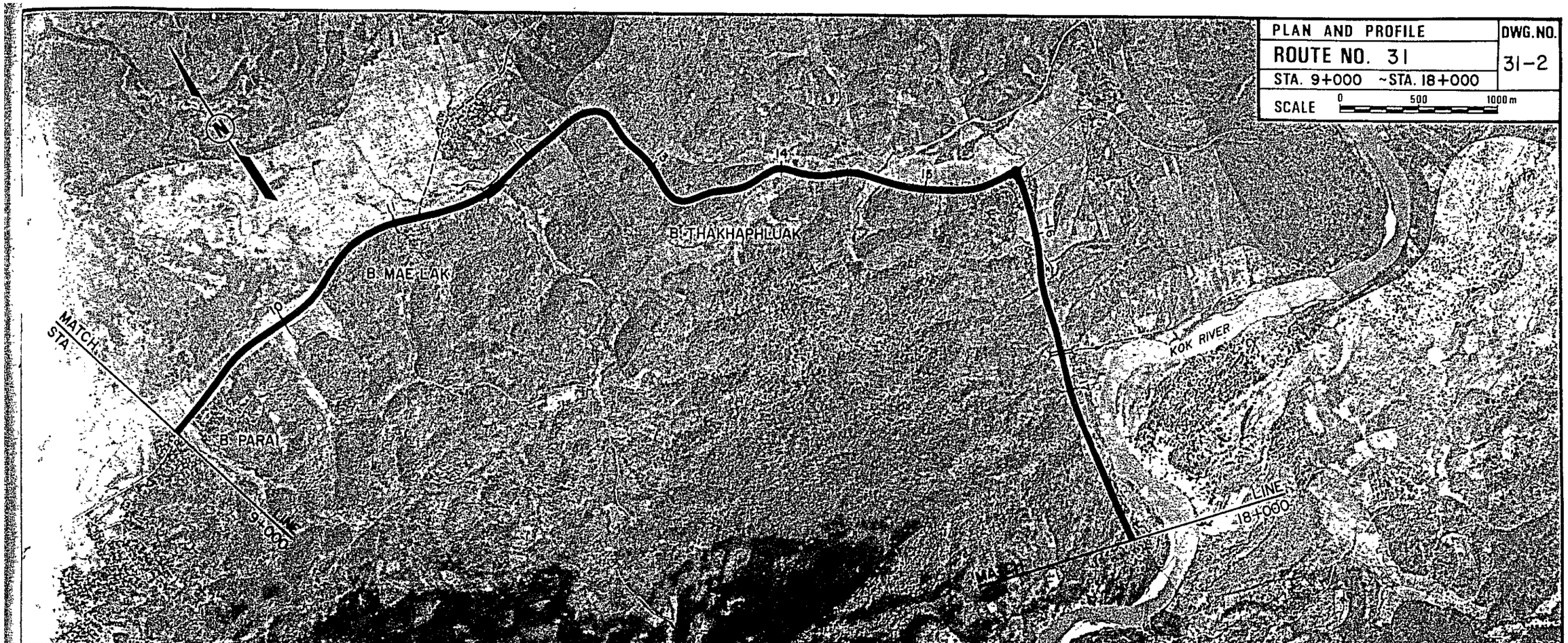
PLAN AND PROFILE	DWG. NO.
ROUTE NO. 31	31 – 1
STA. 0+000 ~ STA. 9+000	
SCALE 0 500 1000 m	



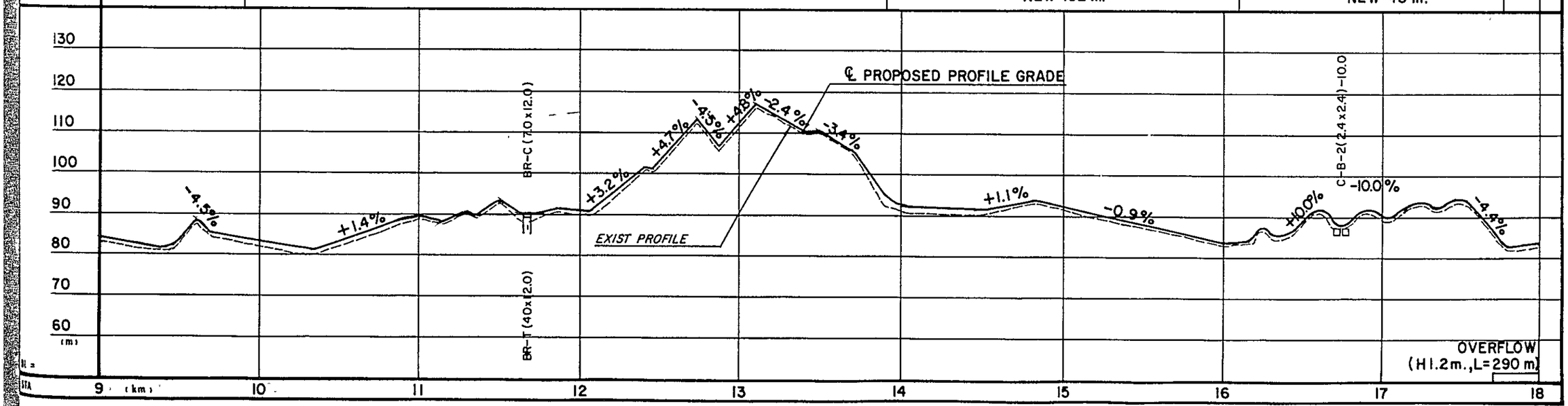
CONSTRUCTION		IMPROVEMENT (F4)							
FORMATION (m)	UP	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
	DOWN								
PIPE CULVERT		NEW 60 m.					NEW 312 m.		



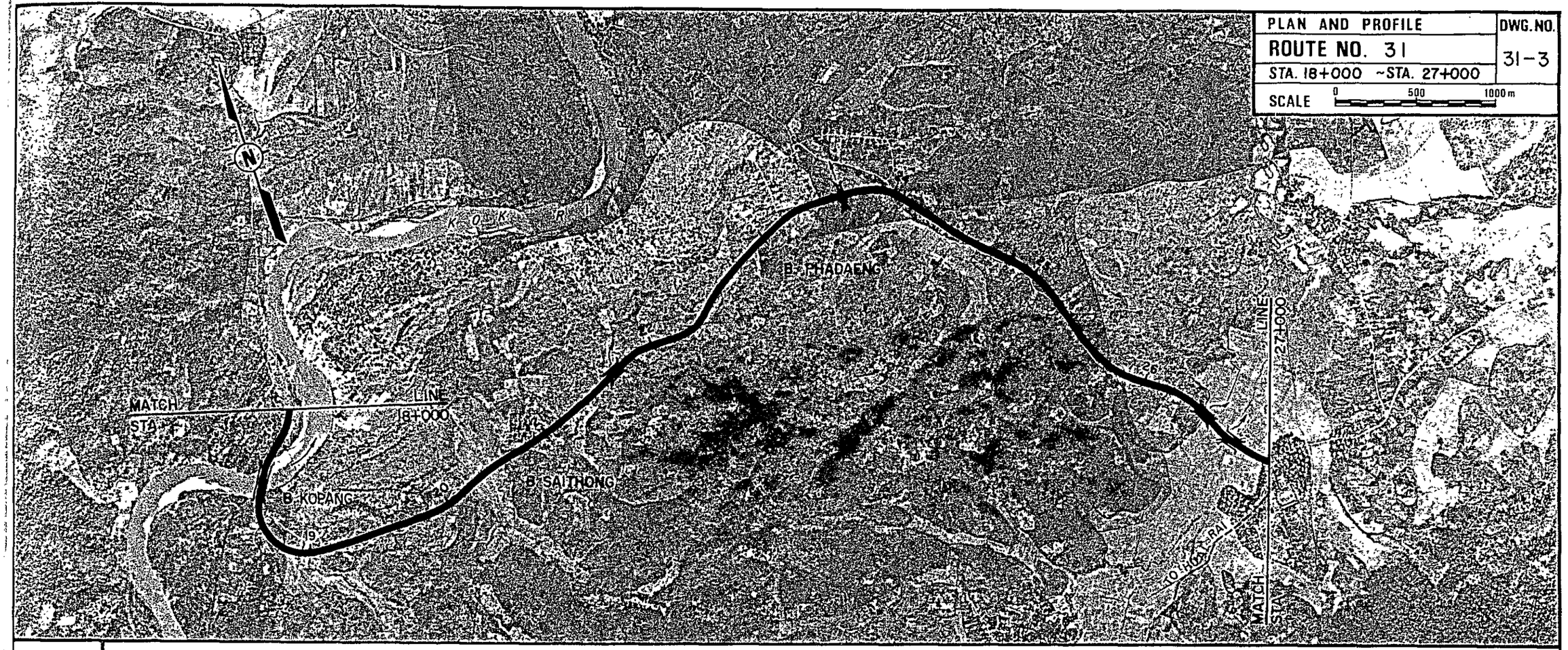
PLAN AND PROFILE	DWG.NO.
ROUTE NO. 31	31-2
STA. 9+000 ~STA. 18+000	
SCALE 0 500 1000 m	



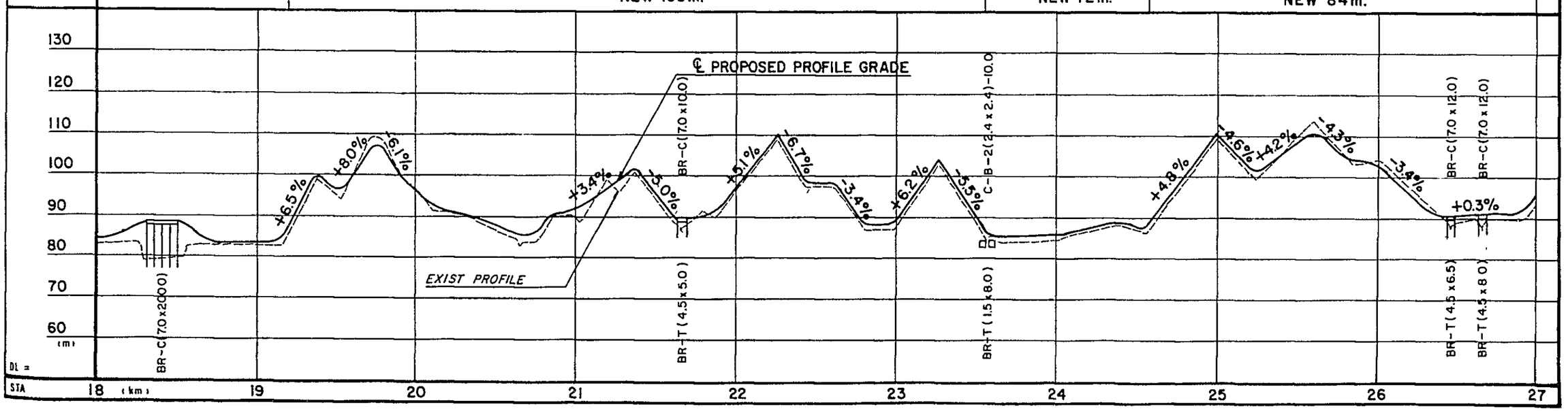
CONSTRUCTION		IMPROVEMENT (F4)											
FORMATION (m)	UP	1.0	0.5	1.0	0.5	2.0	0.5	1.0	0.5	1.0	0.5		1.0
	DOWN												
PIPE CULVERT			NEW 84 m.							NEW 132 m.		NEW 48 m.	



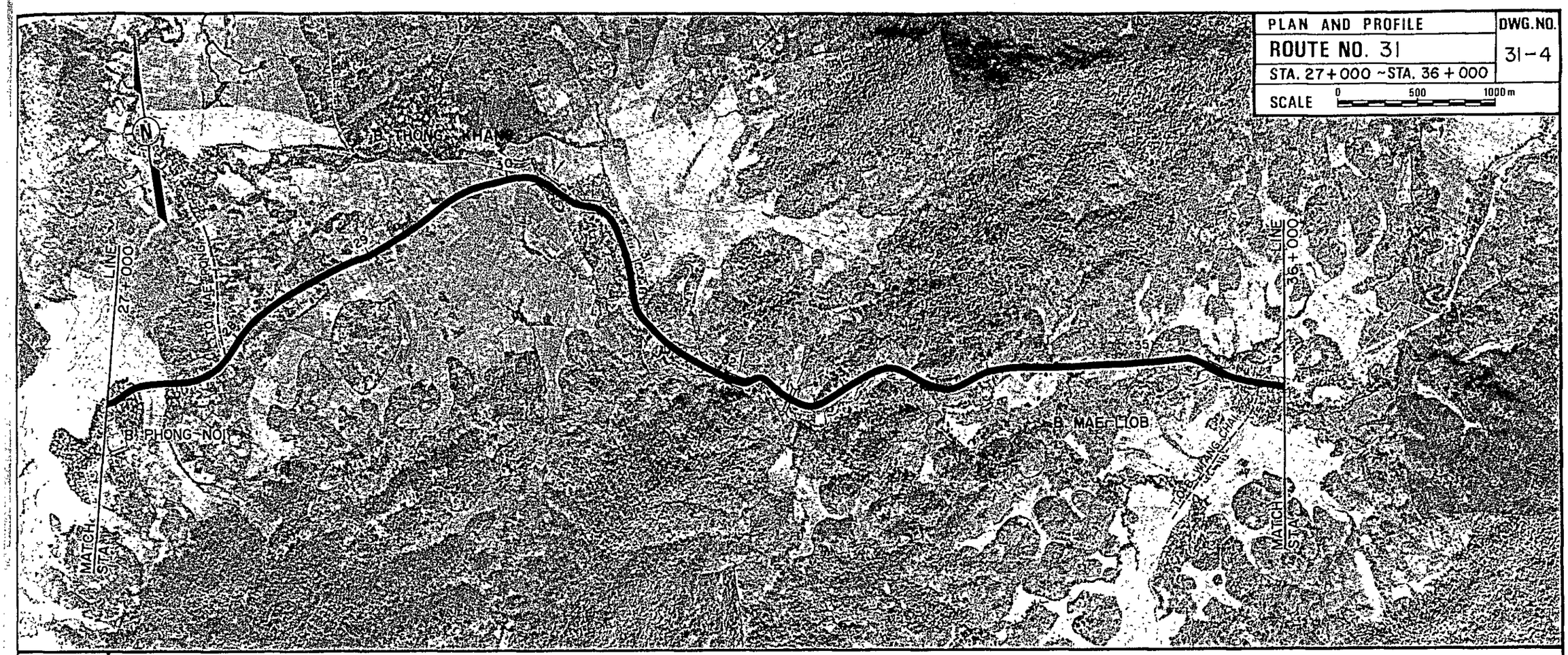
PLAN AND PROFILE	DWG.NO.
ROUTE NO. 31	31-3
STA. 18+000 ~STA. 27+000	
SCALE 0 500 1000 m	



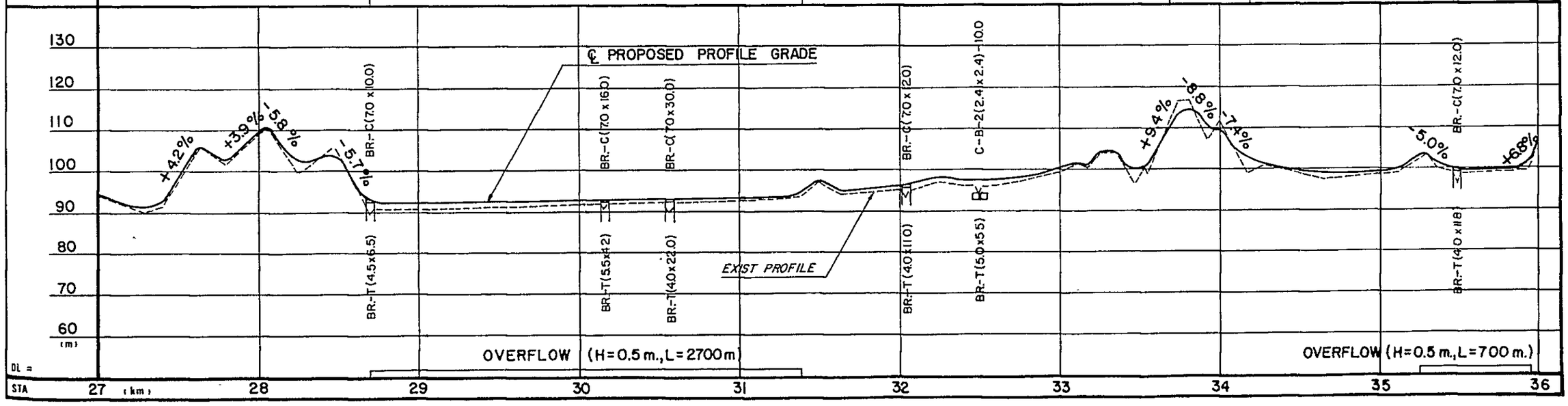
CONSTRUCTION		IMPROVEMENT (F4)																												
FORMATION (m)	UP	1.0	BRIDGE	1.0	0.5	1.5		0.5	1.0	0.5	1.5		1.5	0.5	1.0		0.5	1.0	0.5	1.0	0.5	1.0			1.0					
	DOWN						1.0					1.0				2.0								1.0						
PIPE CULVERT		NEW 12 m.						NEW 108 m.													NEW 72 m.					NEW 84 m.				



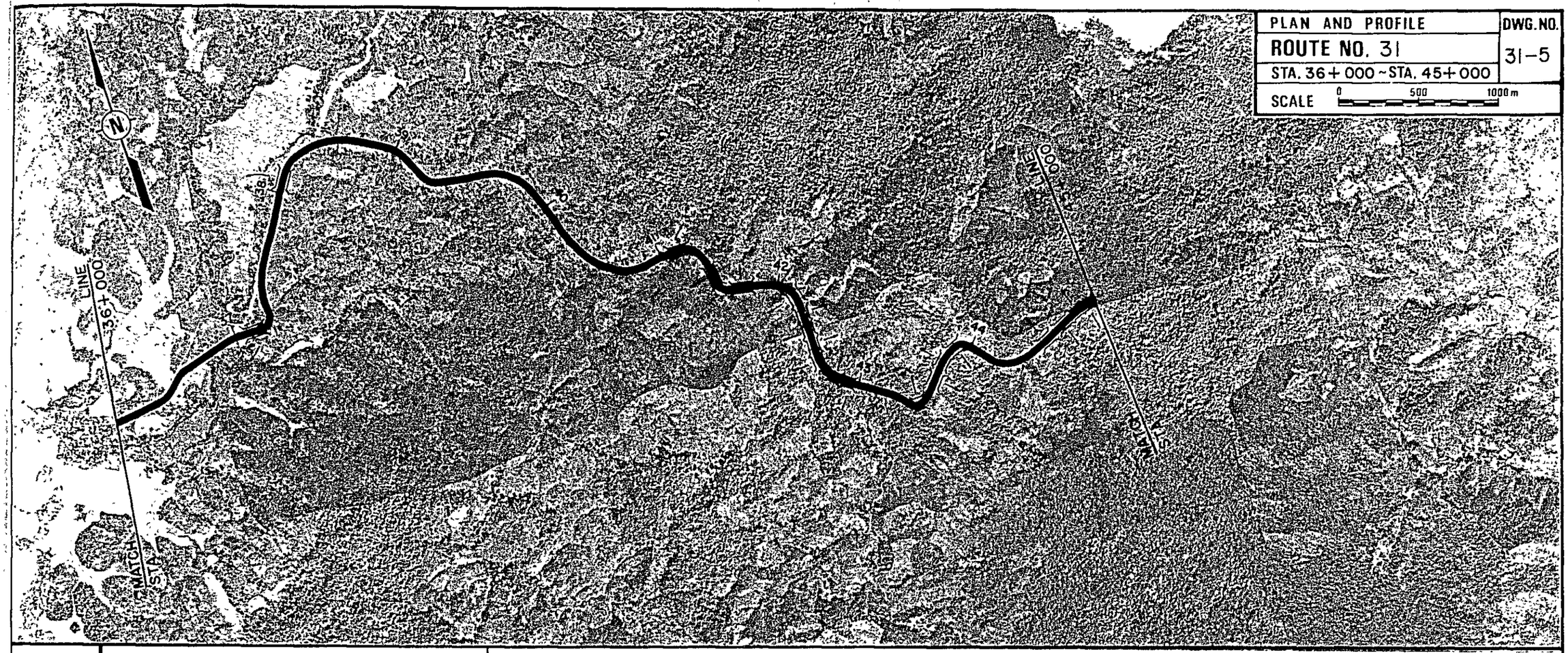
PLAN AND PROFILE	DWG.NO.
ROUTE NO. 31	31-4
STA. 27+000 ~STA. 36+000	
SCALE 0 500 1000 m	



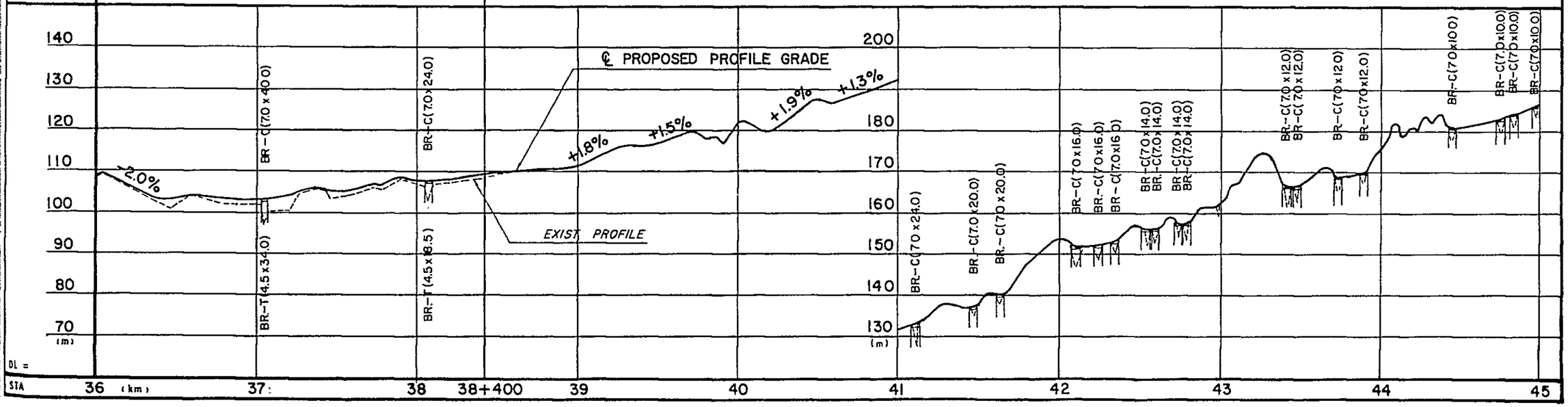
CONSTRUCTION		IMPROVEMENT (F 4)																								
FORMATION (m)	UP	0.5	1.0	0.5	2.0		2.0	1.5			1.0	0.5	1.0	2.0		0.5	1.5		2.0	0.5	1.0		0.5	1.5		0.5
	DOWN					1.0												3.0								
PIPE CULVERT		NEW = 96 m.						NEW = 60 m.										NEW=12 m.		NEW = 108 m.						



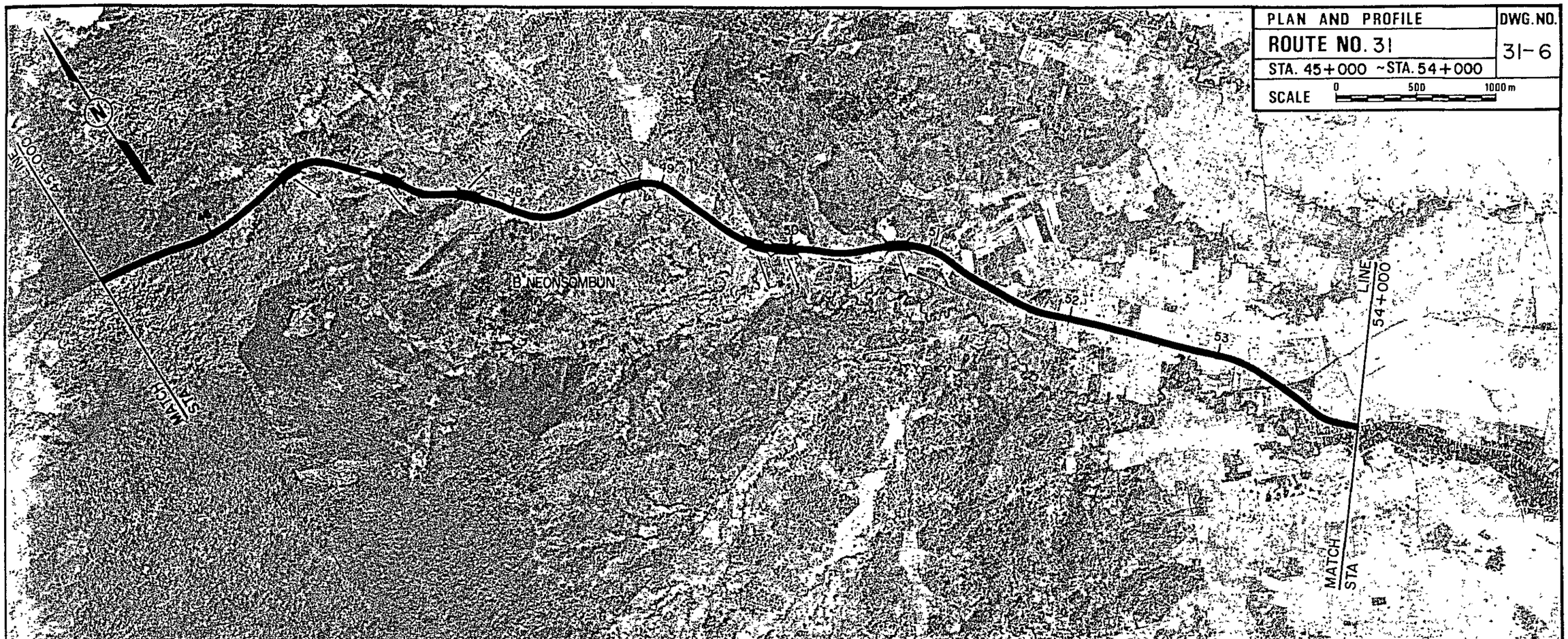
PLAN AND PROFILE	DWG. NO.
ROUTE NO. 31	31-5
STA. 36+000 ~ STA. 45+000	
SCALE 0 500 1000 m	



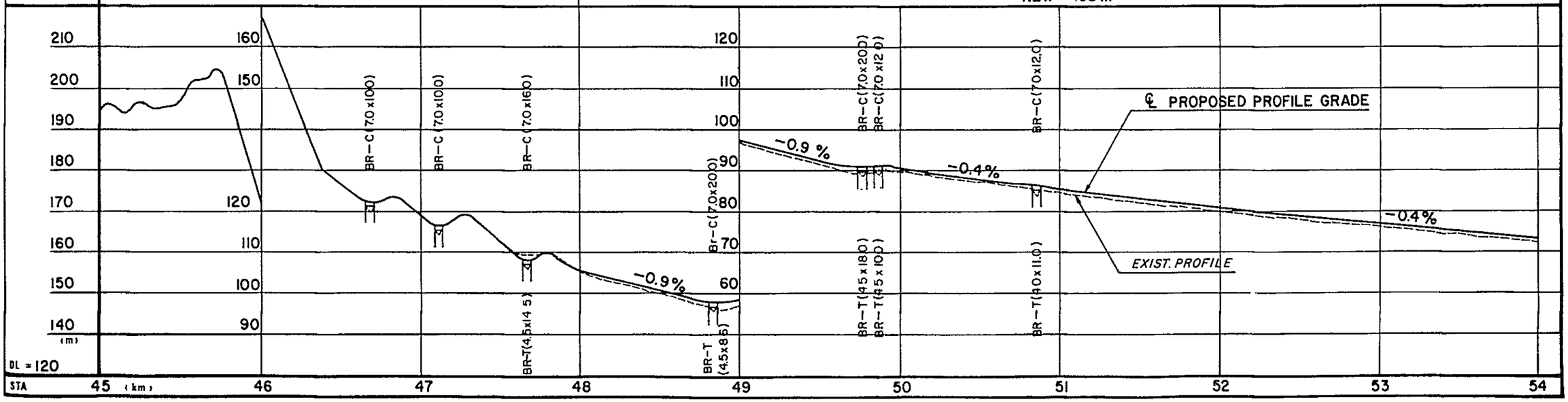
CONSTRUCTION		IMPROVEMENT (F4)							BRIDGE CONSTRUCTION ONLY
FORMATION (m)	UP	0.5	1.0	0.5	1.0	1.0	0.5	1.0	
	DOWN								
PIPE CULVERT									



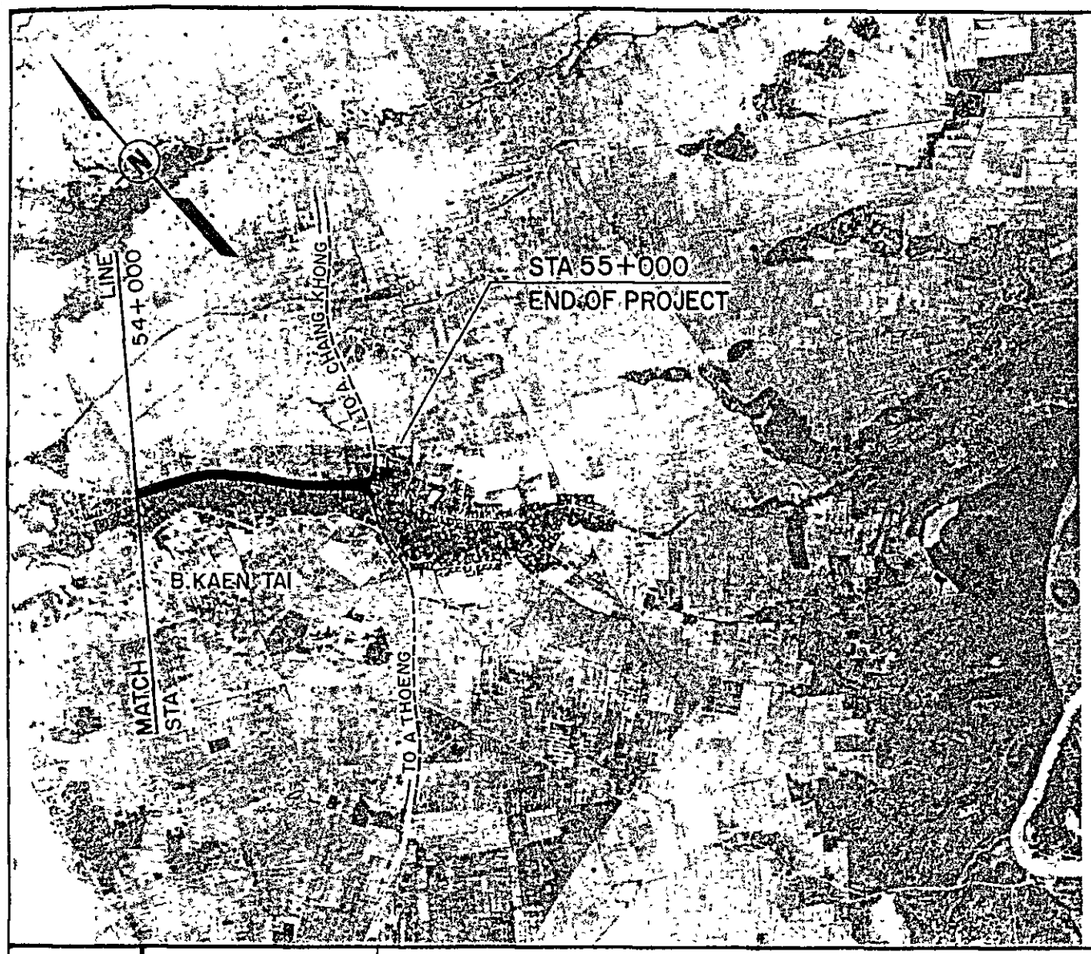
PLAN AND PROFILE	DWG.NO.
ROUTE NO. 31	31-6
STA. 45+000 ~STA. 54+000	
SCALE 0 500 1000 m	



CONSTRUCTION		BRIDGE CONSTRUCTION ONLY	IMPROVEMENT (F4)				
FORMATION (m)	UP		0.5	1.5	0.5	2.0	0.5
	DOWN						
PIPE CULVERT			NEW = 108 m				



PLAN AND PROFILE	DWG NO
ROUTE NO. 31	31-7
STA 54+000 ~STA 55+000	
SCALE 0 500 1000 m	



CONSTRUCTION		IMPROVEMENT(F4)	
FORMATION (m)	UP	0.5	1.5
	DOWN		
PIPE CULVERT			NEW=48m