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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF SURFACE TRANSPORT
GOVERNMENT OF INDIA

THE FEASIBILITY STUDY ON NATIONAL HIGHWAY BYPASSES IN INDIA

FINAL REPORT

SUMMARY

AUGUST 1998

NIPPON KOEI CO., LTD.
YACHIYO ENGINEERING CO., LTD.

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Note

Following exchange rates were applied in this report:

US$1.00=Rs. 39.15
Yen 100=Rs. 30.58
(as of February 1998)

PREFACE

In response to the request from the Government of India, the Government of Japan decided to conduct the Feasibility Study on National Highway Bypasses in India and entrusted the study to the Japan International Cooperation Agency (JICA).

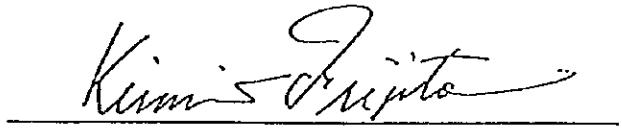
JICA sent to India a study team headed by Mr. Eiichi Yokota and composed of the members of Nippon Koei Co., Ltd. And Yachiyo Engineering Co., Ltd., three times between April 1997 and July 1998.

The team held discussions with the officials concerned of the Government of India, and conducted field surveys at the study areas. The team carried out the Pre-Feasibility Study of the proposed 10 bypasses during Phase 1, and the Feasibility Study of Bareilly Bypass and Gwalior Bypass during Phase 2. Then the present report was prepared.

I hope that this report will contribute to the promotion of the projects and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of India for their close co-operation extended to the team.

August 1998



Kimio Fujita

President
Japan International Cooperation Agency

OUTLINE OF THE PROJECT

1. The Feasibility Study on the National Highway Bypasses in India was carried out with the following work schedule:

Phase 1 : Pre-Feasibility Study

Preparatory work in Japan	: 23/03/1997 ~ 06/04/1997
Pre-Feasibility Study in India	: 07/04/1997 ~ 04/08/1997
Finalisation of the Pre-Feasibility Study in Japan	: 05/08/1997 ~ 19/08/1997

Phase 2 : Feasibility Study

Feasibility Study in India	: 16/10/1997 ~ 27/03/1998

Phase 3 : Finalisation of the Feasibility Study

Preparation of the Draft Final Report in Japan	: 06/06/1998 ~ 20/06/1998
Submission of the Draft Final Report in India	: 21/06/1998 ~ 03/07/1998
Preparation of the Final Report in Japan	: 18/07/1998 ~ 01/08/1998

2. The objectives of the Study were to:

1) conduct a pre-feasibility study on proposed highway bypasses projects (target year for the completion of the construction; 2012), and

2) conduct a feasibility study on high priority projects (target year for the completion of the construction; 2002) selected through the previous phase of the Study.

3. The Study covered the following 10 cities and their peripheral areas where the proposed highway bypasses are located:

	Name	State
1	Bareilly	Uttar Pradesh
2	Patna	Bihar
3	Keonjhar	Orissa
4	Balugaon	Orissa
5	Vijayawada	Andhra Pradesh
6	Kannur	Kerala
7	Nandura	Maharashtra
8	Khamgaon	Maharashtra
9	Bhopal	Madhya Pradesh
10	Gwalior	Madhya Pradesh

4. During the Phase 1 : Pre-Feasibility Study, the following field studies were carried out:

1) Traffic Survey
2) Initial Environmental Examination
3) Social Environmental Study

5. The design condition of the proposed bypasses was proposed as listed below:

1) Road classification	: National Highways	
2) Terrain classification at study area	: Level plains or Rolling plains	
3) Design speed	: 100 km/hrs	
4) Road land width	: 80 m	
5) Carriageway width	: 2@3.5=7.0 m (Dual two lane)	
6) Shoulder width	: Paved (outer) shoulder	2.50 m
	: Earthen shoulder	1.00 m
	: Paved (median) shoulder	0.70 m
7) Median width	: 5.00 m	

6. The preliminary design of the bypasses for the Pre-Feasibility Study was carried out based on the findings obtained by the field investigations and available topographic maps of scale 1/50,000 and/or 250,000, published by the Survey of India. As for the horizontal alignment design, the alignment previously proposed by the respective State PWDs was referred as the basis.

7. As the subject of the Study was the National Highway Bypass, it was understood that the beneficiaries (driver) of the bypass ought to share the expenses for the bypass. Therefore, the concept of toll charged bypass was assumed as the basis of future traffic demand forecast, and financial analysis. The followings show the toll rates in 1997 price, applied to the Study:

Car/Jeep/Van	Rs. 1.00 per km
Light Commercial Vehicle	Rs. 1.75 per km
Truck and Bus	Rs. 3.50 per km
Heavy construction machinery	Rs. 7.50 per km
Two wheeler (50% of cars)	Rs. 0.50 per km

8. Table 1 shows the estimated project cost, and the results of economic/financial analysis of the proposed 10 bypasses by the Pre-Feasibility Study. Based on the results obtained by the Study, the priority of each bypass was assessed. Then, Bareilly Bypass and Gwalior Bypass were selected as high priority projects for the further study, Phase 2 : Feasibility Study.

9. During the Phase 2 : Feasibility Study, the following field studies were carried out:

1) Supplemental Traffic Survey
2) Geotechnical Survey
3) Geodetic Survey
4) Hydrological Survey

Table 1 Study Results of Pre-Feasibility Study

Bypass Name	Length (km)	Estimated Project Cost (Rs.)	EIRR (%)		FIRR (%)
			VOC saving only	with Travel Time saving	
1. Bareilly	31.1	1,879,362,000	46.8%	112.1%	25.9%
2. Patna	49.9	4,923,724,000	27.9%	49.7%	14.2%
3. Keonjhar	8.5	453,253,000	2.9%	11.6%	Negative
4. Balugaon	15.4	552,559,000	11.7%	23.0%	13.0%
5. Vijayawada	28.1	2,054,426,000	23.7%	43.2%	18.6%
6. Kannur	11.1	1,464,531,000	18.8%	57.4%	7.4%
7. Nandura	6.4	359,483,000	28.6%	50.2%	19.0%
8. Khamgaon	10.9	711,891,000	20.0%	36.8%	20.1%
9. Bhopal	40.3	2,175,863,000	21.6%	56.9%	20.9%
10. Gwalior	26.0	2,121,407,000	19.7%	34.5%	16.9%

Remarks, EIRR : Economic Internal Rate of Return
VOC : Vehicle Operating Cost
FIRR : Financial Internal Rate of Return

5) Environmental Impact Assessment (Natural Environmental Aspects)
6) Environmental Impact Assessment (Social Environmental Aspects)

10. The Geodetic Survey for the project areas was carried out including 1) Control Points Survey, 2) Centreline Survey, 3) Longitudinal Profile Survey, 4) Cross-sectional Survey, and 5) Topographical Survey of the proposed bypasses. The Control Points Survey was initially executed by applying Global Positioning System (GPS). Cement concrete pillars were embedded on the ground at the position of the Control Points.

11. Then, after the establishment of control points by GPS, the survey centreline was established based on the Universal Transverse Mercator (UTM) co-ordinates system. Based on the survey centreline, Centre Line Survey, Longitudinal Profile Survey, Cross-sectional Survey and Topographical Survey were carried out with the said co-ordinate system.

12. Based on the further site investigation, the geodetic survey outputs, and the utilisation of satellite images of concerned area, the horizontal/vertical alignment of the proposed bypasses was finalised. As Bareilly Bypass has two crossing points with the existing State Highways, SH37 and SH33, interchanges, the Y-shape type with at-grade intersection, were proposed at each crossing point, to enable the access from the existing SH to the bypass.

13. The construction costs of the proposed bypasses were estimated on the basis of "MoST Standard Data Book For Analysis of Rates". In order to establish the unit cost for the Study, the latest information of labour cost, machinery and equipment cost, and material cost was obtained from the concerned State PWD and local contractors/ manufacturer/importers, and analysed. Then the schedule of rates for each proposed bypass were established.

14. Based on the updated data of future traffic demand forecast, civil work construction cost/project cost, and reviewed VOC, etc. the economic/financial analysis was carried out. Table 2 shows the study result of Feasibility Study.

Table 2 Study Results of Feasibility Study

Bypass Name	Length (km)	Estimated		EIRR (%)		FIRR (%)
		Construction Cost (Rs.)	Project Cost (Rs.)	VOC saving only	with Travel Time saving	
Bareilly	29.98	1,060,628,900	1,583,000,000	45.3%	100.3%	22.0%
Gwalior	26.50	799,305,600	1,140,198,000	45.9%	85.4%	21.2%

Note : FIRR represents the financial internal rate of return on total investment (ROI).

15. This Study assumed the project implementation by private investors. Then the financial viability of SPV (Project implementation entity : Special Purpose Vehicle) was assessed with the condition of 30 years concession for operation. Table 3 shows the estimated value of FIRR-ROE (Financial Internal Rate of Return on Equity), one of the financial viability indicators.

Table 3 Summary of estimated FIRR-ROE

Bypass Name	Base Case*	Sensitivity Analysis			
		GOI/NHAI Grant	Interest of Long-term Loan		Toll Rate
		40%	15%	10%	+20%
Bareilly Bypass	20.0%	26.1%	22.3%	25.1%	23.2%
Gwalior Bypass	18.0%	23.6%	20.5%	23.1%	21.5%

Note : * Base Case : No government grant, 20% of interest on long-term loan and original toll rates shown in the above clause No.7.

16. In addition to the above assessment, the minimum requirement of the followings were analysed:

Option 1 : Minimum requirement of GOI/NHAI Capital Grant to the SPV with the 20 years concession period, in order to attain 20% of FIRR-ROE.

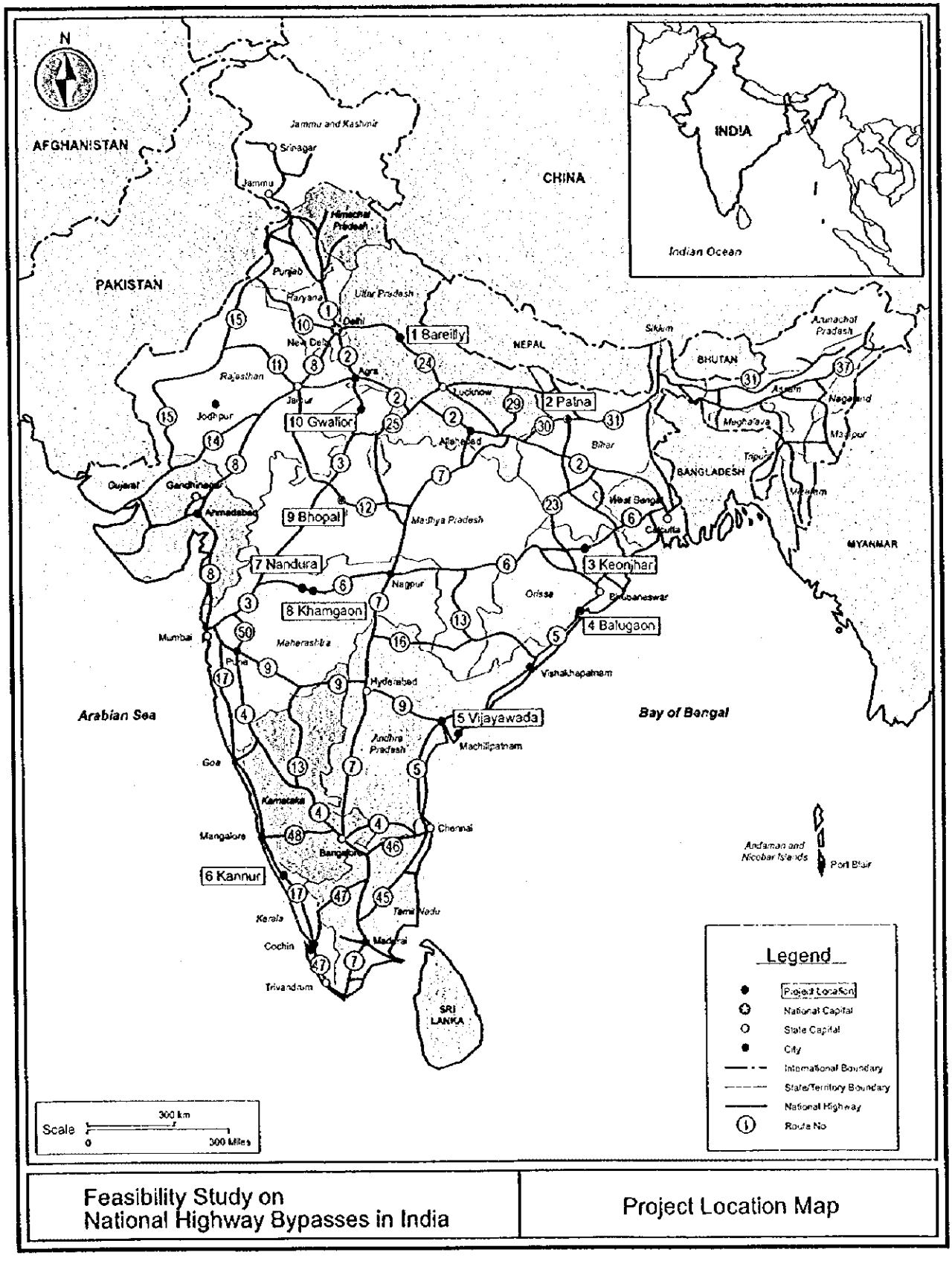
Option 2 : Minimum requirement of concession years with 40% of GOI/NHAI Capital Grant to the SPV, in order to attain 20% of FIRR-ROE.

17. Table 4 shows the result of this analysis.

Table 4 Minimum Requirement to attain 20% of FIRR-ROE

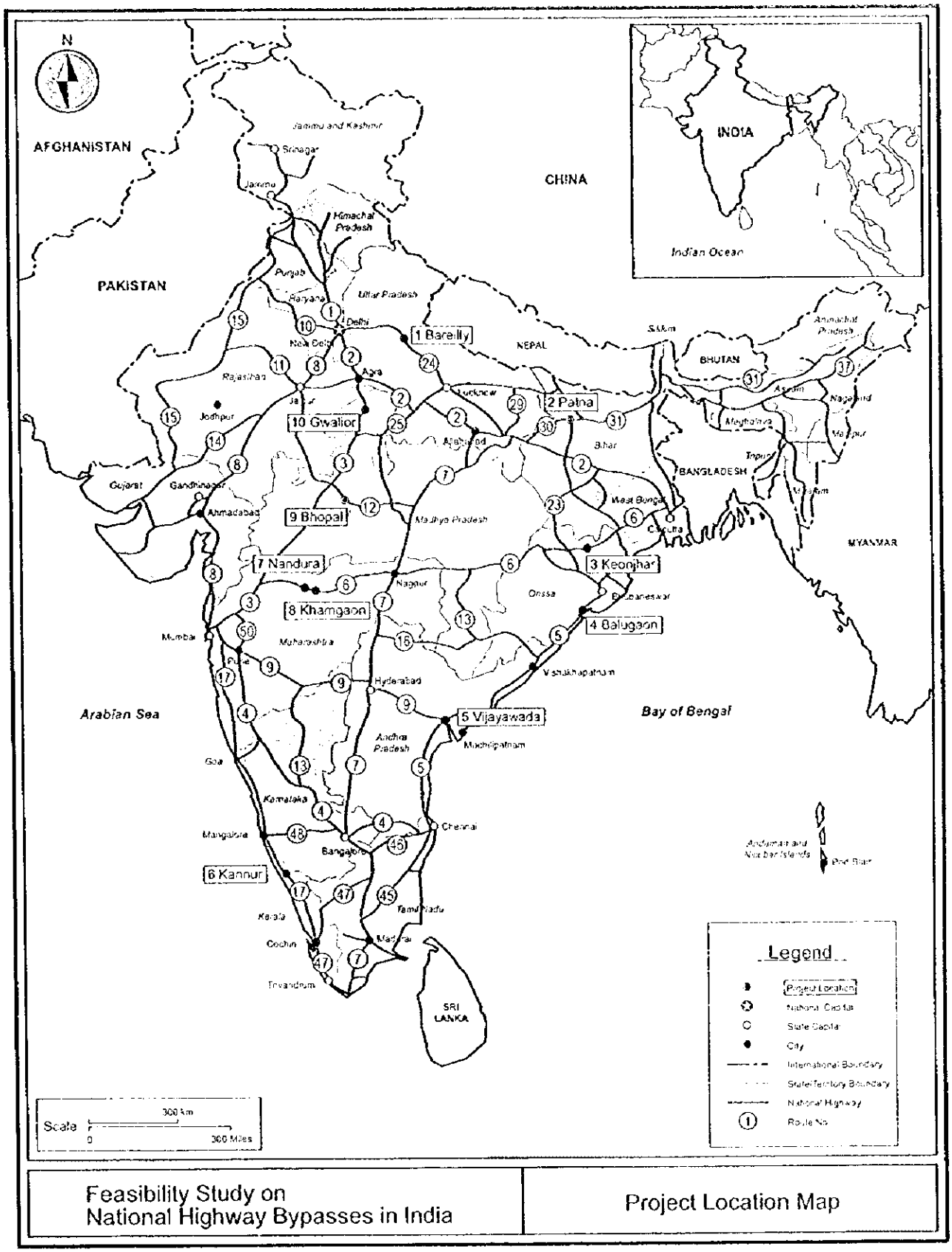
Bypass Name	Option 1 Required Capital Grant Ratio (Amount)	Option 2 Required Concession Period
Bareilly Bypass	13.5% (Rs. 246.4×10^6)	12 years
Gwalior Bypass	29.0% (Rs. 399.7×10^6)	15 years

18. Judging from the above financial indicators obtained, it was recommended to realise the proposed Bareilly Bypass and Gwalior Bypass by BOT basis, with the kind grant of offering the governmental concession as much as possible.



Feasibility Study on
National Highway Bypasses in India

Project Location Map



Feasibility Study on
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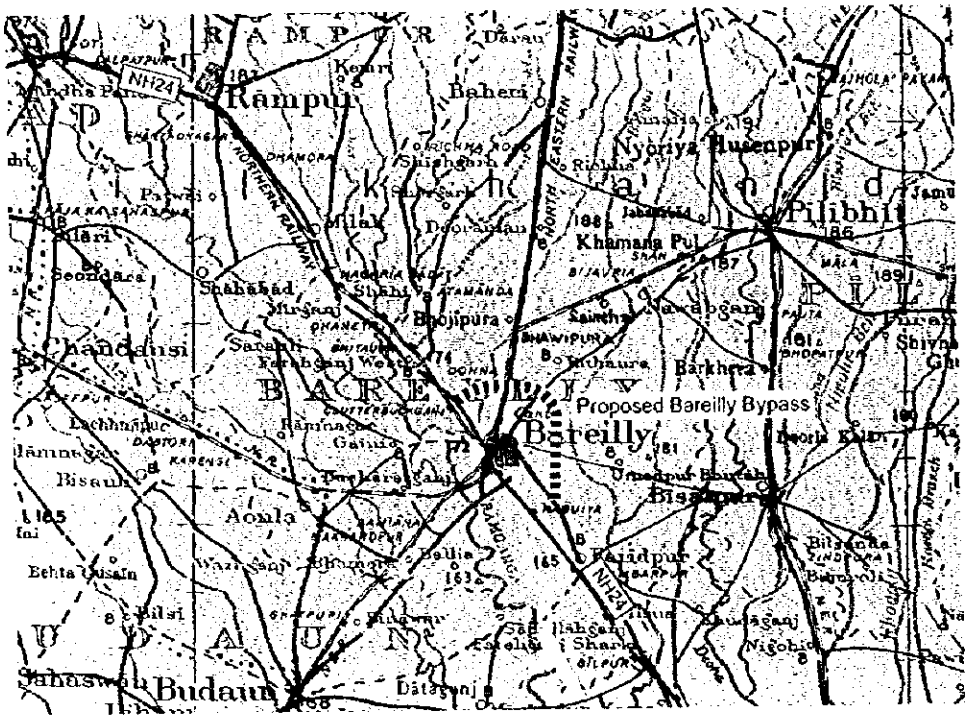
Project Location Map



Location Map of Proposed Bypass (1/9)	Uttar Pradesh Bareilly Bypass (L=30.0 km)

Scale 1:1,000,000

0 10 20 30 40 50 km

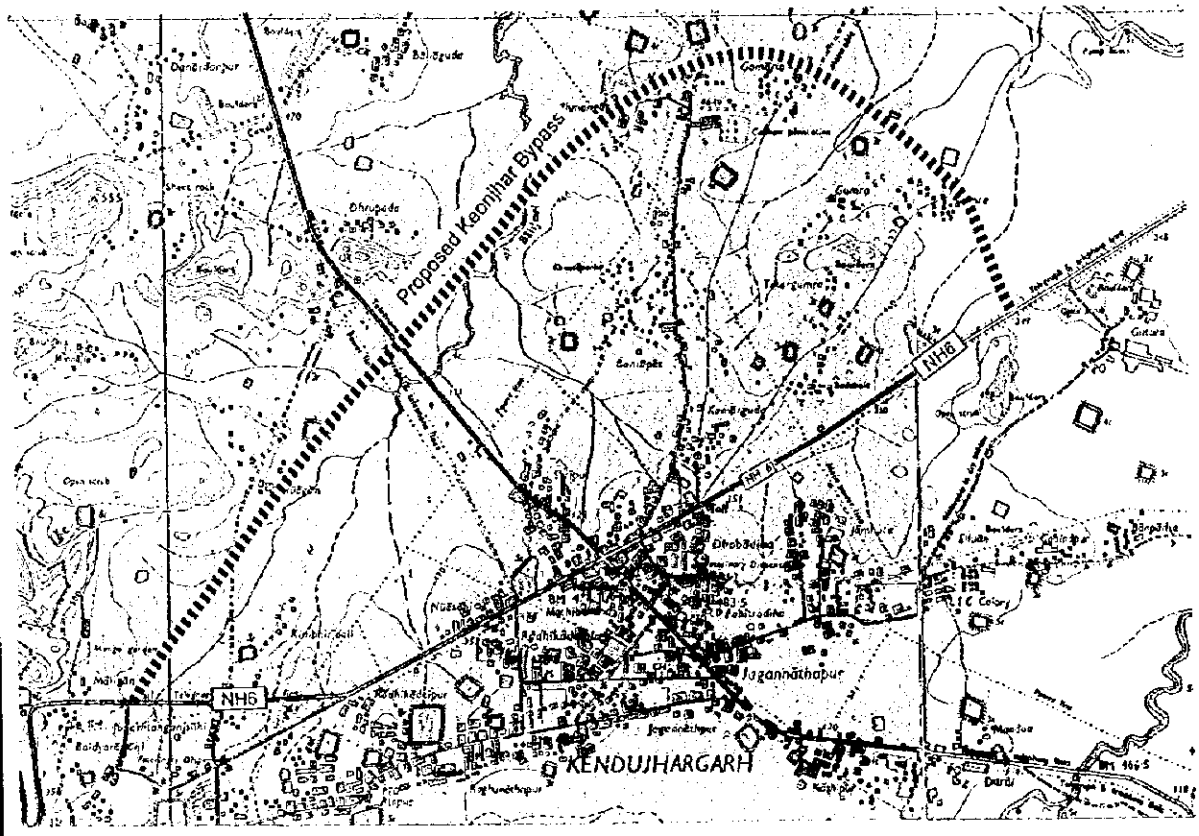
LEGEND

Proposed Route of Bypass

NH30 Route number of National Highway

Location Map of Proposed Bypass (2/9)

Bihar
Patna Bypass (L=49.8 km)



LEGEND

Proposed Route of Bypass

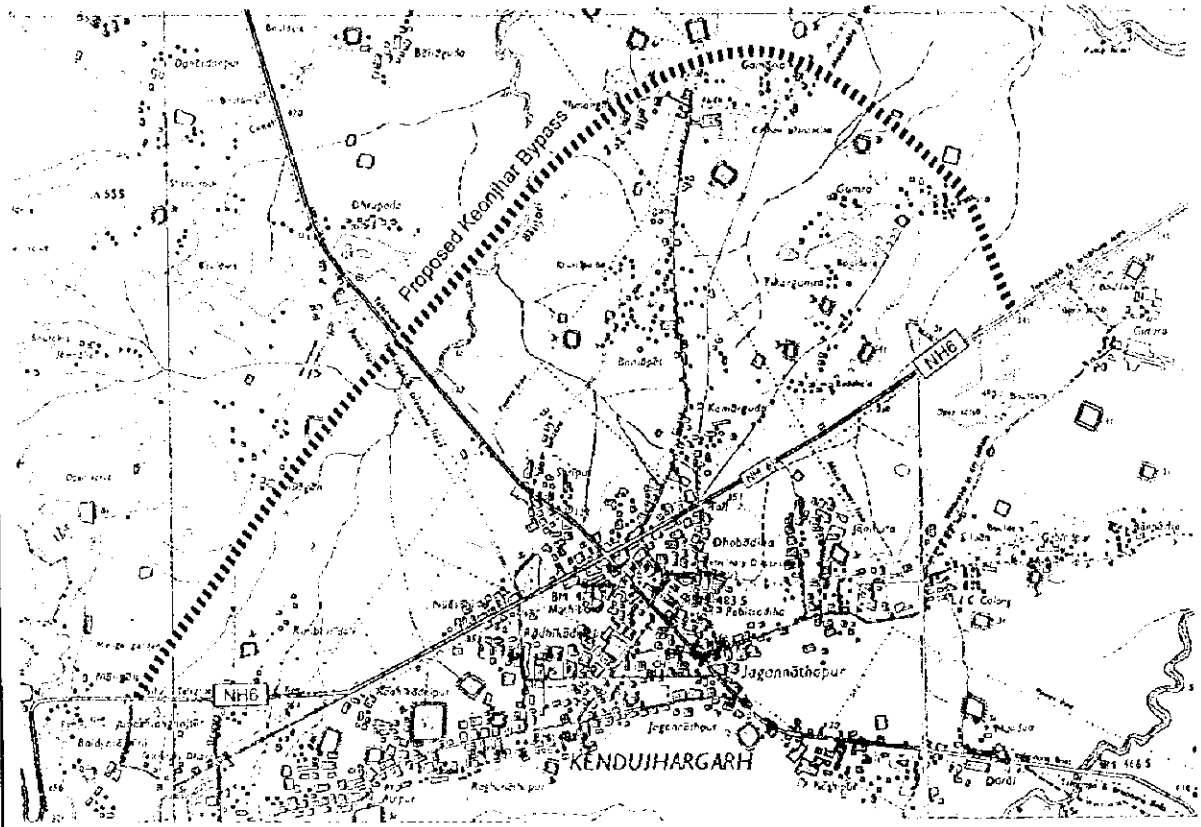
NH6 Route number of National Highway

Scale 1:25,000

0 0.5 1.0 1.5 2.0 km

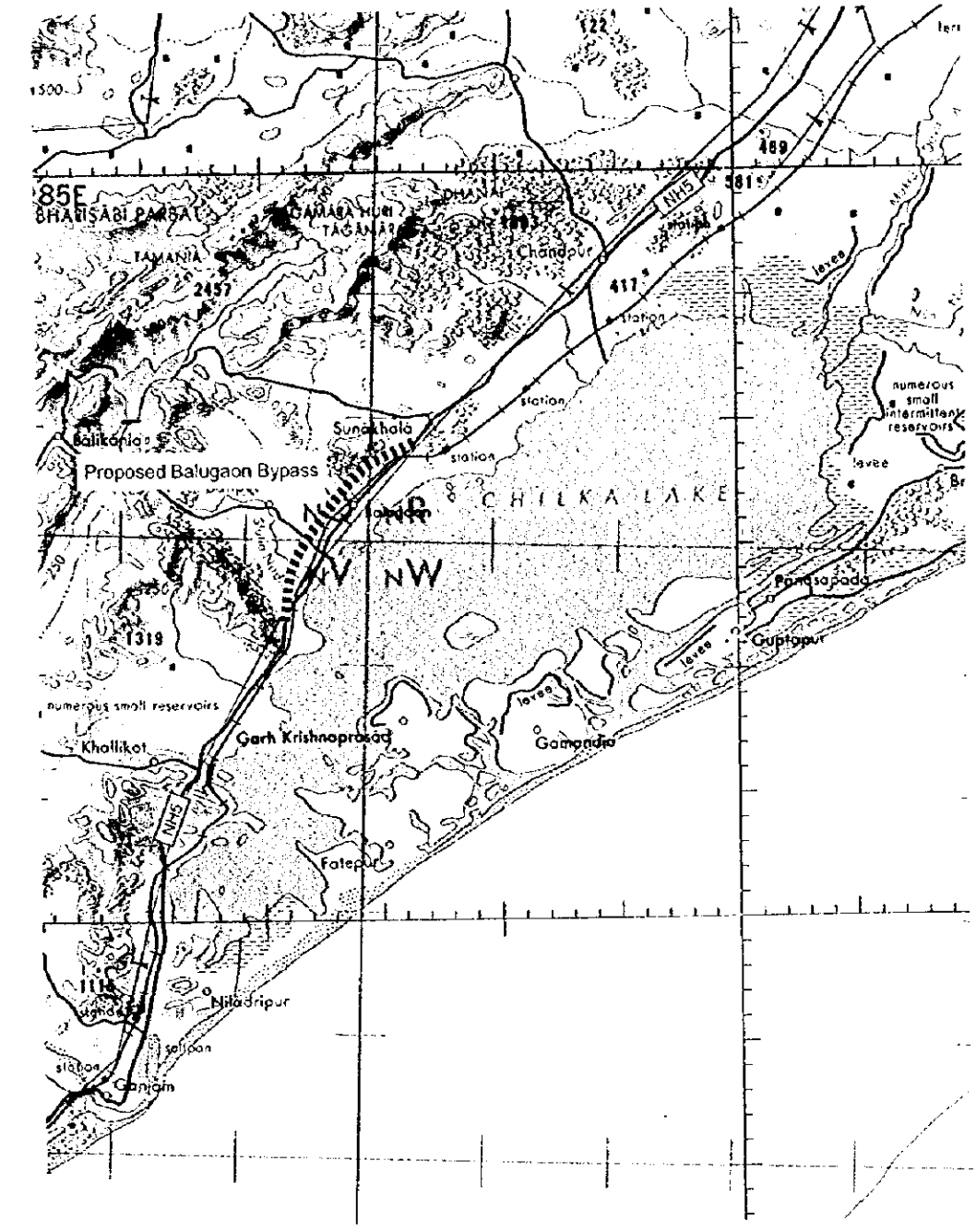
Location Map of Proposed Bypass (3/9)

Orissa
Keonjhar Bypass (L=8.5 km)

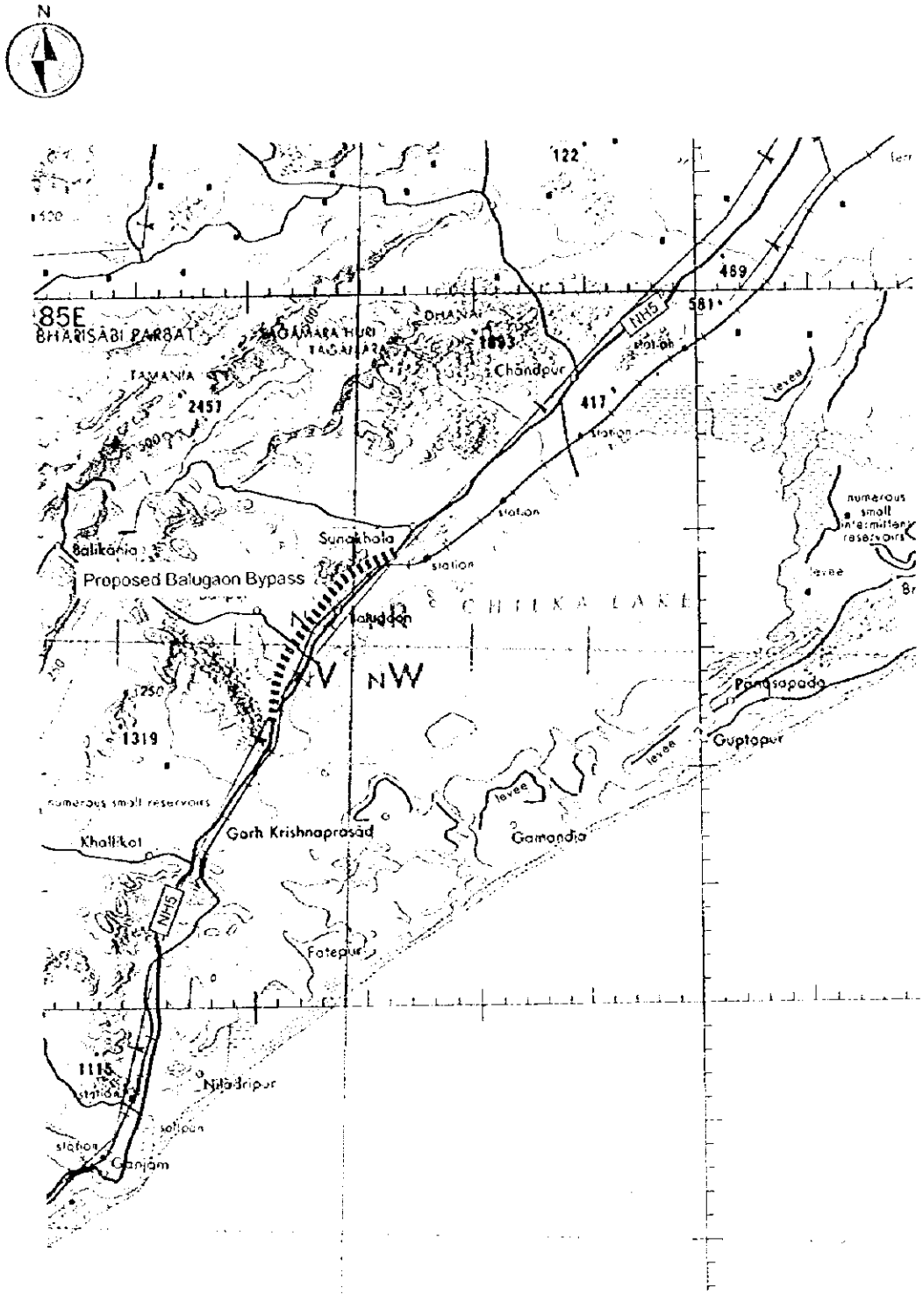


Location Map of Proposed Bypass (3/9)

Orissa
Keonjhar Bypass (L=8.5 km)



Location Map of Proposed Bypass (4/9)	Orissa Balugaon Bypass (L=15.4 km)



LEGEND

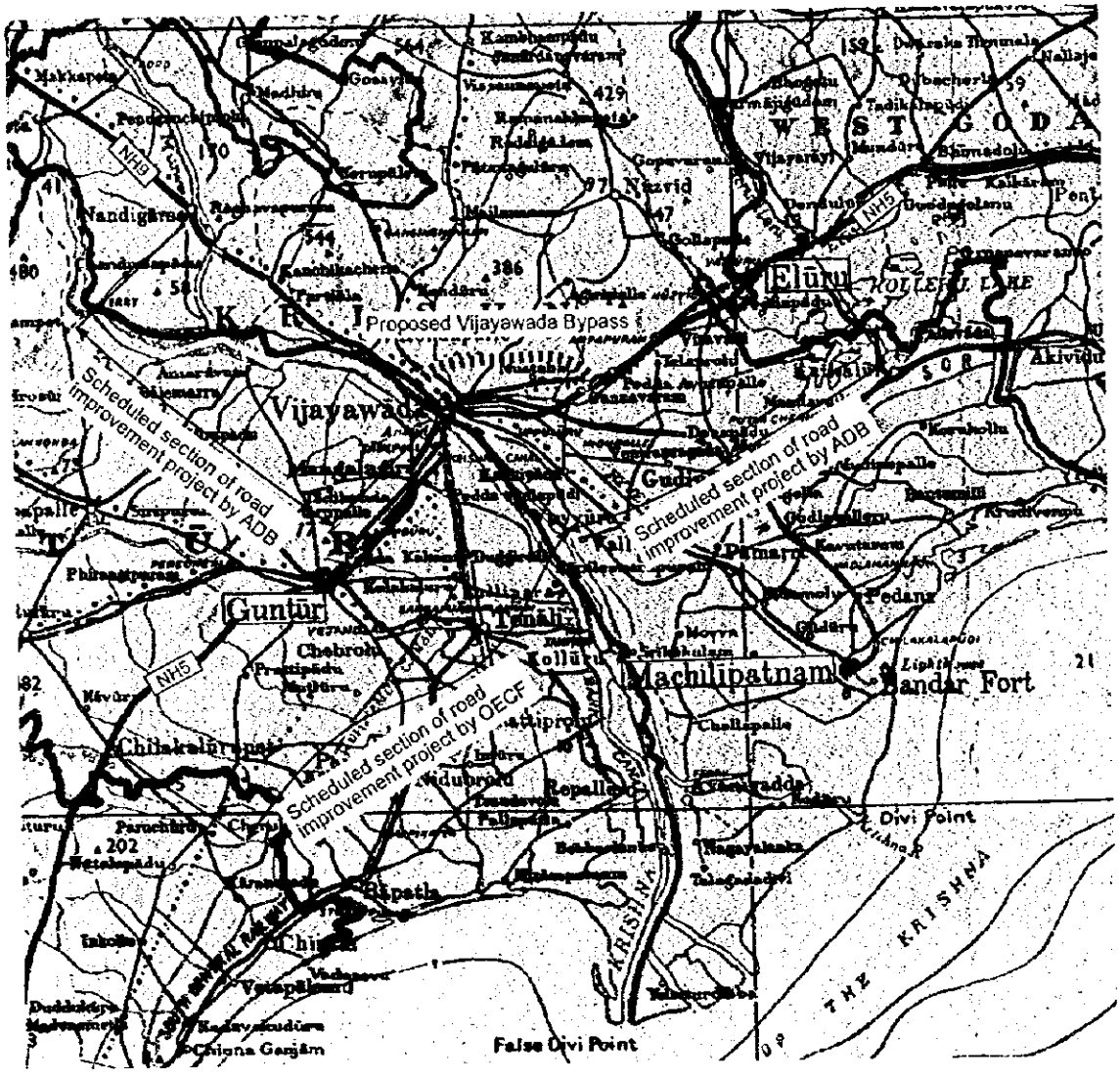
Proposed Route of Bypass

NH5 Route number of National Highway

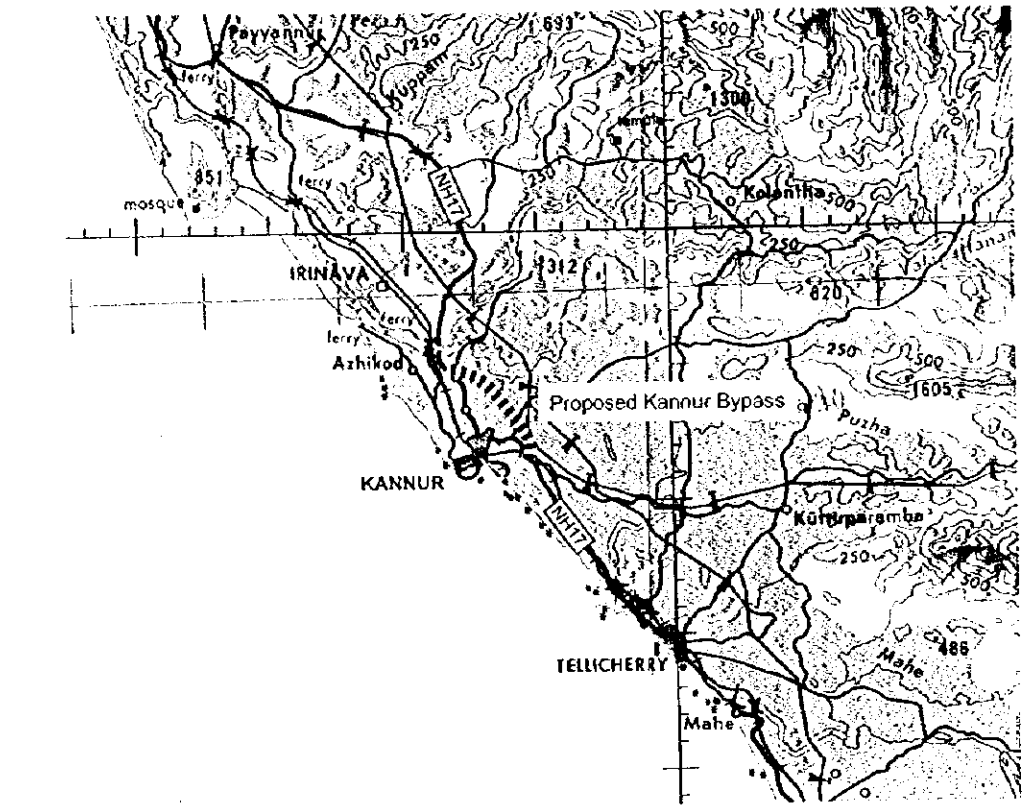
Scale 1:500,000

0 5 10 15 20 25 km

Location Map of Proposed Bypass (4/9)	Orissa Balugaon Bypass (L=15.4 km)



Location Map of Proposed Bypass (5/9)	Andhra Pradesh Vijayawada Bypass (L=28.1 km)



LEGEND

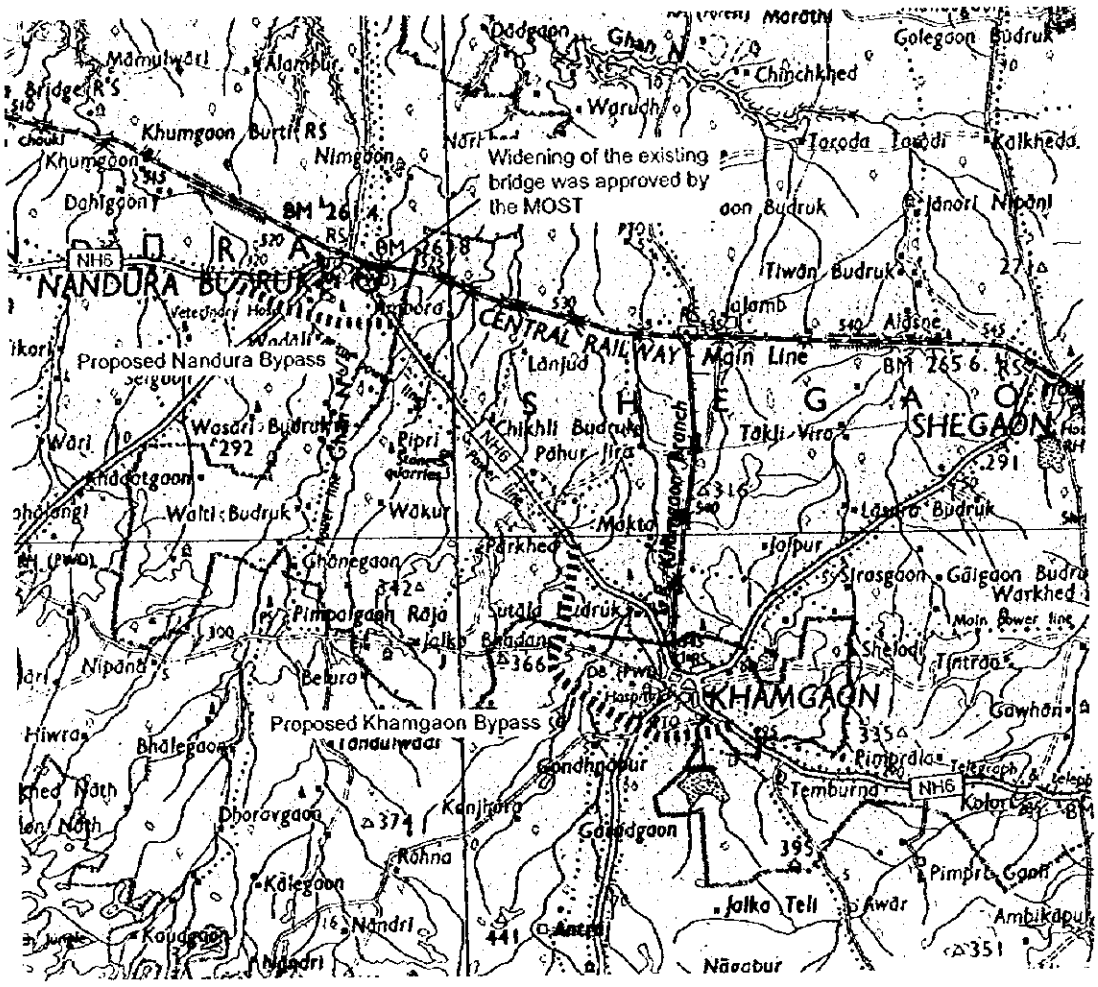
Proposed Route of Bypass

NH17 Route number of National Highway

Scale 1:500,000

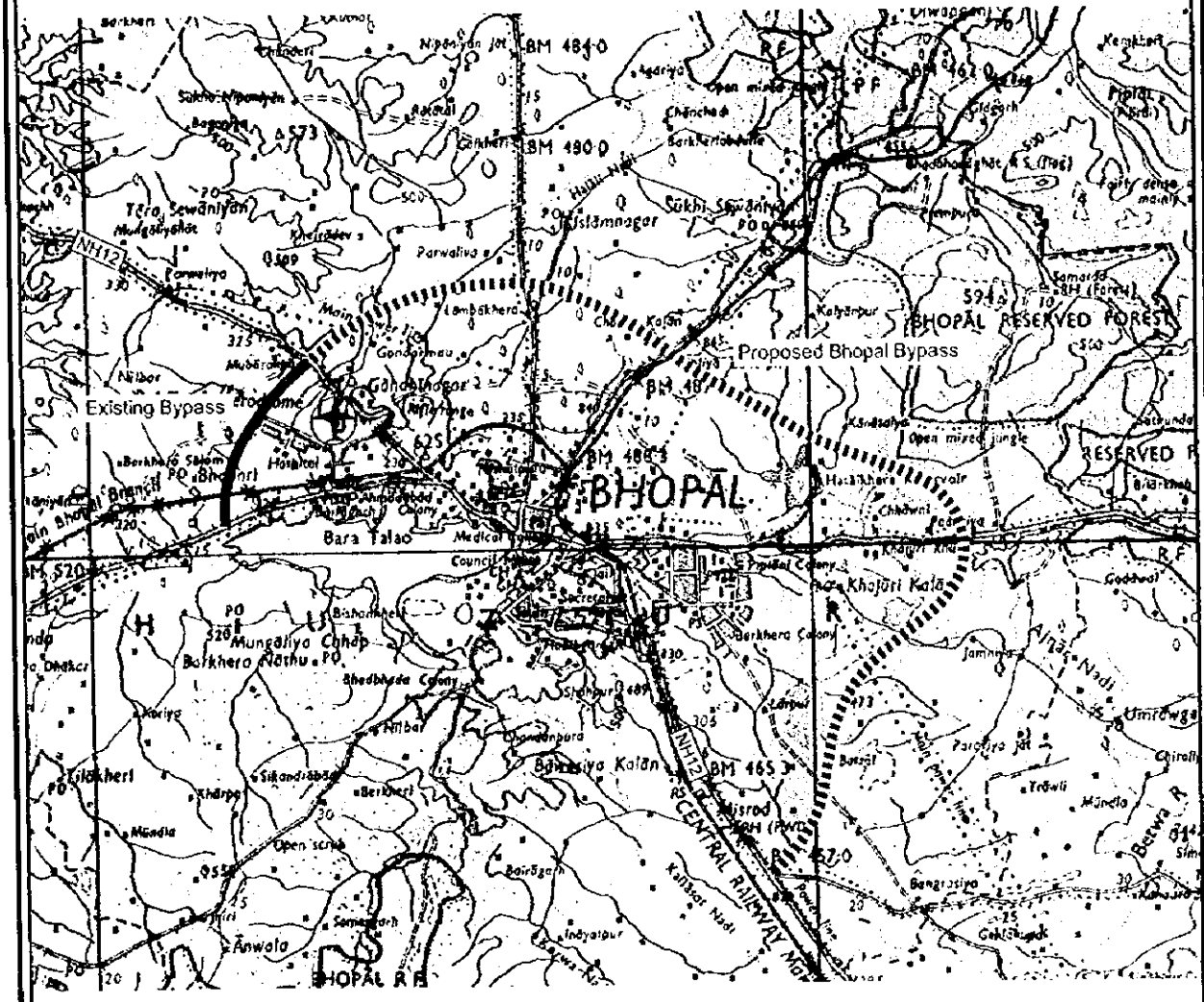
0 5 10 15 20 25 km

Location Map of Proposed Bypass (6/9)	Kerala Kannur Bypass (L=11.1 km)

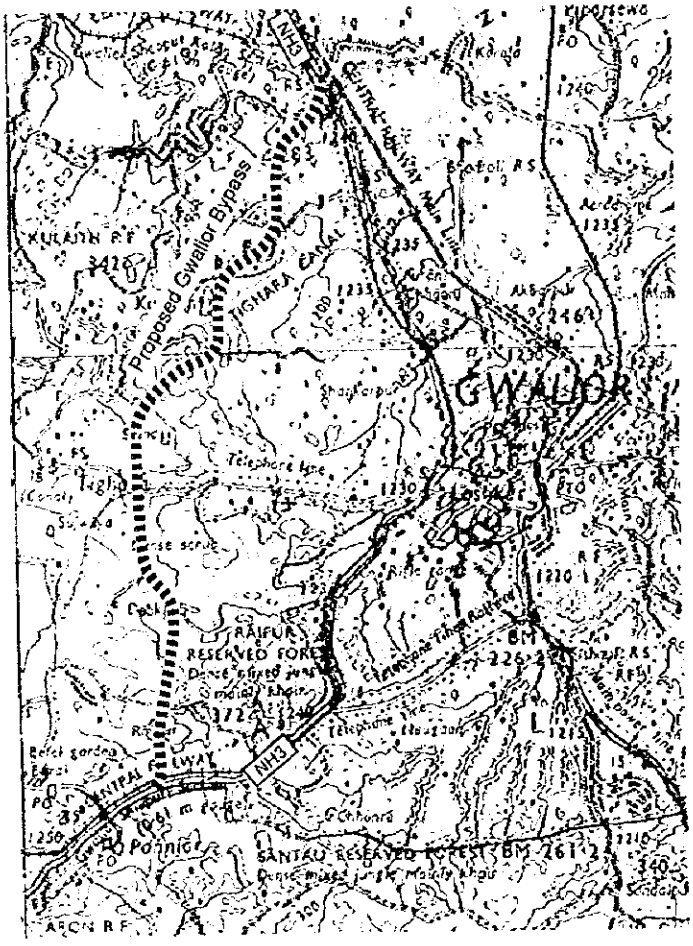


Location Map of Proposed Bypass (7/9)

Maharashtra
Nandura Bypass (L=6.4 km) and
Khamgaon Bypass (L=10.9 km)



Location Map of Proposed Bypass (8/9)	Madhya Pradesh Bhopal Bypass (L=40.3 km)



LEGEND

Proposed Route of Bypass

NH3 Route number of National Highway

Scale 1:250,000

0 5 10 15 km

Location Map of Proposed Bypass (9/9)

Madhya Pradesh
Gwalior Bypass (L=26.5 km)

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Summary of Pre-Feasibility Study

1. Socio-economic Conditions

1.1 National Economy

1.1.1 Economic Growth

The Indian economy has grown with an average annual rate of 6.2% over the past ten years (1985/86-1995/96). The Seventh Five Year Plan (1985-90) aimed at a 5.0% of growth rate against the actual achievement of 6.0% per annum. Furthermore, the Eighth Plan (1992-97) is expected to end with an average growth of 6.5% per annum, 0.9% point higher than the target rate of 5.6%, and 0.5% point higher than the actual achievement of the Seventh Plan.

The Indian economy, however, has experienced a severe stagnation in 1991/92. Growth of real GDP at factor cost had fallen to a mere 0.8% in the crisis year of 1991/992. Under the circumstance, the new reforms had initiated in 1991, by introducing the stabilisation and liberalisation of the economy. The situation has changed dramatically since then. The full dimensions of the recovery produced by the reforms are becoming clear. Although there was slow down in the pace of reforms, economic growth in 1996/97 is estimated to be around 6.8%.

The percentage share of agriculture sector in real GDP has been declining progressively from 40 % in 1980/81 to 29% in 1995/96. At present, the same share is dominated by the manufacturing sector. Transport sector including communication and trade has contributed 20% of GDP in 1995/96.

Table 1-1 Gross Domestic Product by Industrial Origin
(at 1980/81 constant prices)

(Rs. Crore)

No.	Sector \ Year	1980~81		1985~86		1990~91		1995~96 (Q)	
1	Agriculture, forestry and logging, fishing, mining and quarrying	48,536	40%	56,841	36%	69,860	33%	78,838	29%
2	Manufacturing, construction, electricity, gas and water supply	29,828	24%	40,602	26%	59,493	28%	80,180	29%
3	Transport, communication and trade	20,437	17%	27,600	18%	37,744	18%	54,972	20%
4	Banking & insurance, real estate and ownership of dwellings & business services	10,791	9%	14,708	9%	21,700	10%	30,866	11%
5	Public administration and defence and other services	12,835	10%	16,815	11%	23,456	11%	29,353	11%
	Total	122,427	100%	156,566	100%	212,253	100%	274,209	100%

Source : "Economic Survey 1996-97"
Note (Q) : Quick estimate

1.1.2 Annual Inflation

The Wholesale Price Index (WPI) of the fiscal year beginning April, 1996/97 recorded a rate of 7.4% up to February 1997. At the same time, Consumer Price Index (CPI) for industrial workers recorded the rates of 8% to 11% during the fiscal year 1996/97 up to January 1997.

1.1.3 National Development Plan (Ninth Five Year Plan : 1997~2002)

The Planning Commission has presented the following macro economic development scenarios. The economic growth rate by the Ninth Five Year Plan is expected in the range of 6.2% to 7.0% per annum during the plan period.

Table 1-2 Macro Parameters

Index		VIII Plan	IX Plan	
			Base-line Scenario	Accelerated 7% Growth
1	Domestic Saving Rate (% of GDP at market price)	23.7	25.2	26.2
2	Current Account Deficit (% of GDP at market price)	1.3	1.7	2.4
3	Investment Rate (% of GDP at market price)	25.0	26.9	28.6
4	GDP Growth Rate (% per annum)	5.9	6.2	7.0
5	Export Growth Rate (%per annum)	11.4	12.0	14.5
6	Import Growth Rate (% per annum)	13.6	11.4	15.3

Source : Approach Paper to the Ninth Five Year Plan 1997-2002

1.2 Road Sub-sector of India

The total road length grew from 0.4 million km in 1950 to 2.1 million km in 1992. The network is classified into three categories on a functional basis :

(1) The primary system of National Highways (34,300 km in 1996), mostly serving interstate long distance traffic;

(2) The secondary system, consisting of State Highways (128,000 km in 1992) and Major District Roads (216,000 km in 1992), carrying mainly intra-State traffic; and

(3) The tertiary system, comprising rural roads (1,375,000 km), including other district roads, village and local roads.

Nearly 20% of the National Highways, which are almost all surfaced with bituminous pavement, still have a single lane (3.7 meters wide) carriageway.

Although the National Highways constitute only 1.7% of the total road network in the country, they carry about 40% of the total passenger and freight traffic.

2. Traffic Survey and Future Traffic Demand Forecast

2.1 Traffic Survey

In order to analyse the present traffic characteristics and to collect the basic data for traffic demand forecasting for the proposed ten bypasses, the following traffic surveys were carried out at total 26 survey locations on National Highways :

(1) Traffic count survey (24-hour, 3 days)

(2) Roadside Origin-Destination (O-D) survey

(3) Traffic speed-delay survey

Results of traffic count survey are summarised as below :

Table 2-1 Average Daily Traffic (May 1997)

Survey Area	National Highway	Vehicles/day (all vehicles)	PCU/day (all vehicles)
Bareilly	24	12,800	22,800
Patna	30	10,100	16,400
Keonjhar	17	5,600	8,900
Balugaon	5	5,600	10,800
Vijayawada	5	13,600	29,500
Kannur	17	9,600	15,500
Nandura	6	7,300	15,600
Khamgaon	6	7,700	17,600
Bhopal	12	12,100	20,000
10. Gwalior	3	10,600	24,100

Note : PCU : Passenger Car Unit including slow vehicles.

2.2 Future Traffic Demand Forecast

2.2.1 Future Socio-economic Framework

Future growth rates of population and GDP were estimated based on the past trend and the target growth rates by the Ninth Five Year Plan (1997~2002) as shown below.

	1997-2002	2002-2007	2007-2012
Population Growth	1.78% p.a.	1.68% p.a.	1.47% p.a.
GDP Growth Rate	6.0%	5.8%	5.6%

At the same time, growth rates of Net State Domestic Product (NSDP) by each State were also estimated keeping the consistency with above macro economic growth rates.

2.2.2 Traffic Growth Rate

Future traffic growth rates were estimated based on the following formula :

$$Gri = [(1 + p/100) \times (1 + n/100) - 1] \times Ei \times 100$$
$$= [(1 + N/100) - 1] \times 100$$

where, GRi : annual growth rate of vehicle type i (%)
p : annual growth rate of State population
n : annual growth rate of per capita NSDP (%)
Ei : elasticity of traffic growth rate for vehicle type i
N : annual growth rate of NSDP (%)
NSDP : Net State Domestic Product

The estimated traffic growth rates ranged from 6% to 10%.

2.2.3 Future Traffic Demand on Proposed Bypasses

Future O-D matrices were forecast applying the above traffic growth rates to the present O-D matrices and then assigned to the future road network with proposed Bypasses. Traffic assignment was based on the capacity-constraint simulation method. Toll rates were decided through the consultation with the MOST and applied toll rates were at Rs.1.0/km for cars and Rs. 3.5/km for buses and trucks. The results of forecasting are summarised as below.

Table 2-2 Future Traffic Projection (Fast Vehicles)

Name of Bypass	2002 (PCU/day)	2012 (PCU/day)
1. Bareilly	17,200 (average)	51,500 (average)
2. Patna	18,100	26,200
3. Keonjhar	1,700	5,700
4. Balugaon	2,500	12,800
5. Vijayawada	4,300	33,000
6. Kannur	8,100	19,100
7. Nandura	13,500	24,600
8. Khamgaon	15,400 (average)	28,700 (average)
9. Bhopal	6,400 (average)	27,100 (average)
10. Gwalior	13,500	27,200

Note : PCU : Passenger Car Unit (fast vehicles only)

3. Preliminary Design of the Bypasses

3.1 Design Standard for Pre-Feasibility Study

3.1.1 Geometric Design Standards for Throughway

As the proposed bypasses were intended to build as full control of access and provide high level of service, the geometric design standards listed in Table 3-1 was

applied for the Study. In order to establish this standards, the following publications were referred.

(1) IRC: "Pocketbook for Highway Engineers (First Revision 1995)"
(2) IRC: Special Publication No. 20, "Manual for Survey, Investigation, and Preparation of Road Projects"
(3) IRC: 73-1980 "Geometric Design Standards for Rural (Non-urban) Highways"
(4) IRC: 62-1976 "Guidelines for Control of Access on Highways"
(5) AASHTO: "A Policy on Geometric Design of Highways and Streets, 1994"
(6) JRA: "Japan Road Structure Ordinance (JRSO)"
(7) JHPC: "Design Manual Vol. 4: Geometric Design Standard"

Figure 3-1 shows the typical section applied to the Study.

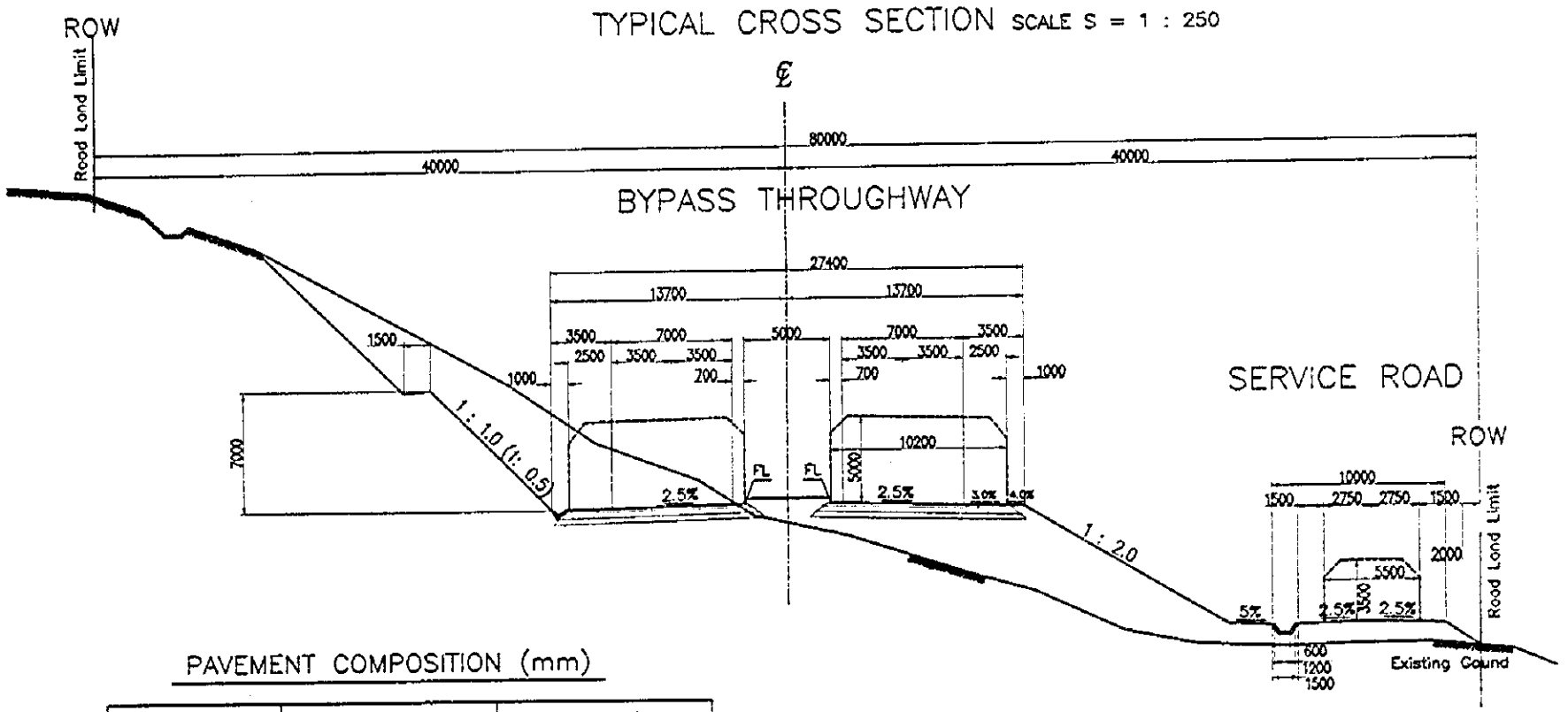
3.1.2 Design Standards for Structural Design

Referred to the following publications, design standards for the structural design was established.

(1) Specification for Highway Bridge (Japan Road Association)
(2) JIS A5313 & JIS A5319 for Pre-cast Concrete Girder
(3) IRC: 5-1985 Standard Specifications and Code of Practice for Road Bridge(Section-I, General Features of Design)
(4) IRC: 6-1966 Standard Specifications and Code of Practice for Road Bridge(Section-II, Loads and Stresses)
(5) IRC: 78-1983 Standard Specification and Code of Practice for Road Bridges(Section-VII, Foundation and Substructure)
(6) IRC: 54-1974 Lateral and Vertical Clearances at Underpasses for Vehicle Traffic
(7) IRC: 73-1980 Geometric Design Standards for Rural (Non-Urban) Highways
(8) IRC: 3-1983 Dimensions and Weights of Road Design Vehicle
(9) IRC Special Publication No.13 Guideline for the Design of Small Bridges and Culverts
(10) Pocketbook for Bridge Engineers (Published by IRC, 1995)
(11) Standard Plans for Highway Bridges (R.C.C. T-beam and slab Superstructure)
(12) Standard Plans for Highway Bridges (Pre stressed Concrete beams & R.C.C. slab type Superstructure)
(13) Addendum to Ministry's Technical Circulars and Directives on National Highways and Centrally Sponsored Road & Bridge Projects, August 1988 to December 1992

Table 3-1 Established Geometric Design Standard

		Design Elements	Type/Value	Remarks	Reference
1	Road Classification		National Highway	0~10 % slope	IRC
2	Terrain		Plain		IRC
3	Design Speed (km/h)		100		IRC
4	Design Vehicle	Dimension (WxHxL, m)	2.50x4.2x18.0		IRC
		Weight (Gross, ton)	52.2		IRC
		Weight (Axle, ton)	18.0		IRC
5	Cross-Sectional Elements	Overall Width between Control Lines (m)	150		
		Overall Width between Building Lines (m)	100		IRC modified
		Road Land Width (m)	80		IRC modified
		Roadway Width (m)	27.00	Dual 2-lane	----
		Carriageway Width(m)	7.00	2@3.5	IRC
		Outer Shoulder Paved Width (m)	2.50		AASHTO/JRSO
		Outer Shoulder Earthen Width (m)	1.00		JRSO
		Inner Shoulder Paved Width (m)	0.70		JRSO
		Median Width (m)	5.00	Raised type	AASHTO/JRSO
		Crossfall			
		Carriageway (%)	2.50		IRC
		Outer Shoulder Paved (%)	2.50		IRC
		Outer Shoulder Earthen (%)	4.00		IRC
		Inner Shoulder Paved (%)	2.50		same as
		Median (%)	3.00		carriadgeway
		Slope of Earthworks			
		Fill	V : H = 1:2		
		Cut	V : H = 1:1 (0.5)		( ) Value for Rock
6	Sight Distance	Driver's Eye Height (m)	1.20		IRC
		Height of Object for Stopping Distance (m)	0.15		IRC
		Safe Stopping Sight Distance (m)	180		IRC
		Intermediate Sight Distance (m)	360		IRC
		Overtaking Sight Distance (m)	640		IRC
7	Horizontal Alignment	Horizontal Curve			
		Minimum Radii of Horizontal Curve (m)	360		IRC
		Minimum Curve Length (m)	150		IRC
		Superelevation			
		Maximum Superelevation (%)	7.00		IRC
		Minimum Radii w/o Superelevation (m)	1800		IRC
		Maximum Slope of Superelevation	1/200		AASHTO
		Transition Curve			
		Spiral Type	Clothoid		
		Minimum Radii w/o Transition (m)	2000		IRC
8	Vertical Alignment	Gradients			
		Ruling (%)	3.3		IRC
		Limiting (%)	5.0		IRC
		Exceptional (%)	6.7		IRC
		Critical Length of Gradients			
		For 3.3 %	no limit		IRC
		For 4.0 % (m)	700		JRSO
		For 5.0 % (m)	500		JRSO
		For 6.0 % (m)	400		JRSO
		Vertical Curve			
		Minimum Length of Vertical Curve (m)	60		IRC
			10000 (6500)	( )Absolute Minimum	AASHTO/JRSO
		Minimum Radius of Vertical Curve	4500 (3000)	( )Absolute Minimum	AASHTO/JRSO
		Summit Curve (m)			
		Valley Curve (m)			
		Minimum Gradients for Drainage			
		Lined (%)	0.50		IRC
		Unlined (%)	1.00		IRC
9		Lateral Clearance (m)	10.20	all paved width	
		Vertical Clearance (m)	5.00		IRC



PAVEMENT COMPOSITION (mm)

BYPASS	BAREILLY	GWALIOR
AC	40	40
DBM	160	160
WMM	300	300
GSB	300	300
TOTAL	800	800

NOTE:
1) Cut slope is 1:0.5 in rock section in Gwalior Bypass

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DWG TITLE : Figure 3-1 Typical Cross Section of Throughway

DWG SCALE : S = 1 : 250

DWG NO. : B-1

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3.1.3 Pavement Design Criteria

Referred to the IRC Guideline, "IRC: 37-1984, Guidelines for the Design of Flexible Pavements", the design MSAL (cumulative equivalent standard axle load in million) was estimated from the future traffic projection, and applied the MSAL value of 50 for the pavement design of Pre-Feasibility Study. Based on the revised IRC: 37-1984, in 1993, the composition of pavement for the Study was decided as shown in Table 3-2.

Table 3-2 Pavement Composition

No.	Depth (mm)	Acc. Depth (mm)	Sign	Description
1	40	40	AC	Asphalt Concrete
2	150	190	DBM	Dense Bituminous
3	300	490	WMM	Wet Mix Macadam
4	300	790	GSB	Granular Sub-Base

3.2 Preliminary Design of Bareilly Bypass

The original alignment of Bareilly Bypass was drawn by State PWD in 1993. Subsequently, the MoST has approved the alignment. The district of Bareilly is located in a gentle sloping plain. There are no topographical obstructions in the proposed alignment. However, the area of the proposed bypass route encounters some villages and local manufacturers of bricks. Airforce aerodrome is located in the north east of Bareilly City. The major control points were listed in Table 3-3.

Table 3-3 Major Controls of Bareilly Bypass

No.	Approx. Sta.	Description	Requirements
1	0+000	NH24	To secure smooth connection
2	5+100	Village(Pardhauli)	To be avoided
3	7+000	Village(Ata)	To be avoided
4	7+800	Deorania River	Bridge
5	9+080	SH37	Bridge
6	9+120	Railway	Bridge
7	13+720	SH33	Bridge
8	14+240	Nakatia River	Deorania River
9	15+500	Village(Mahoranian)	To be avoided
10	23+560	MDR	Bridge
11	25+000	Village(Chainpur)	To be avoided
12	31+100	NH24	To secure smooth connection

The starting point of the bypass is Km. 235 of NH24, and the ending point is Km. 259 on NH24. The proposed alignment crosses over SH37, at around STA. 8+800, and SH33 at STA. 13+720. Major structures proposed were summarised in Table 3-4, including two viaducts for crossing SH37 and SH33, where interchanges will be allocated.

Table 3-4 Major Structures of Bareilly Bypass

No.	Approx. STA.	Description	Type	Span Arrangement (m)
1	7+800	Deorania	RC-T	4@15=60
2	8+800	SH37	RC-T	2@13=26
3	9+080	Railway, SH37	PC-Hollow	4@16=64
4	13+720	SH33	RC-T	2@119=38
5	14+240	Nakatia	RC-T	4@15=60

The proposed plan and profile of the bypass was given in Figure 3-2 and major quantities of proposed bypass in the Pre-Feasibility Study was summarised in Table 3-5.

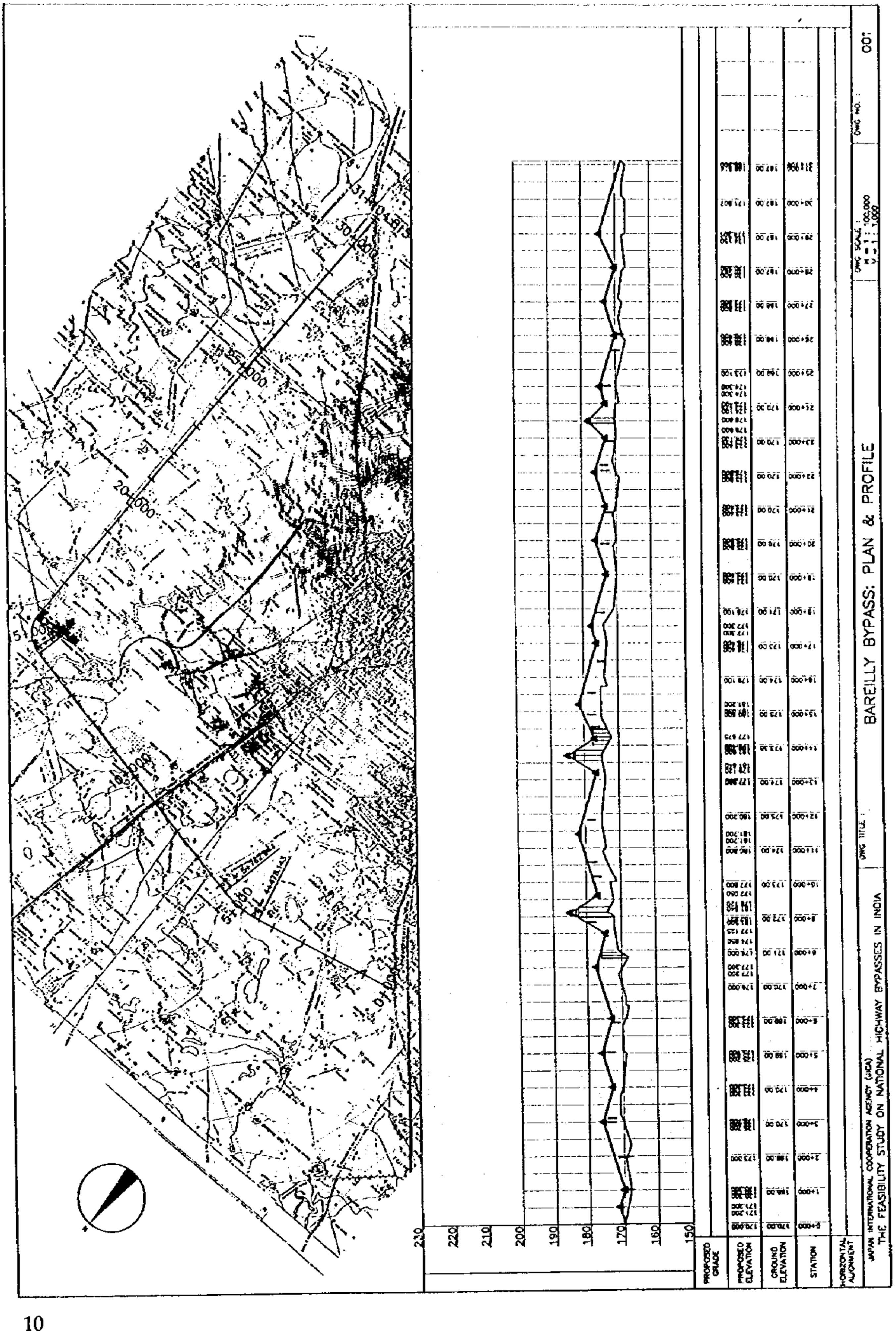
Table 3-5 Major Quantities of Bareilly Bypass

Item	Unit	Amount
Bypass Length	km	31.1
Earthwork Section	km	30.9
Structural Section	km	0.2
Earthwork Balance	m^3	-4,411,000
Fill	m^3	4,411,000
Cut	m^3	
Concrete	m^3	20,700
HYSD	ton	2,740
PC Strand	ton	24
Pavement		
AC	m^3	19,200
DBM	m^3	96,900
WMM	m^3	222,500
GSB	m^3	217,900

3.3 Preliminary Design of Patna Bypass

Patna Bypass was originally proposed by State PWD to ease the traffic congestion of NH30 which traverses the main Arrah town, Danapur Military Cantoment Area and northern part of Patna town. Eastern part of the Patna Bypass has already been built for approximately 20 km. as Phase 1 & 2 section. The balance portion, which is expected to connect Arrah and down south of Patna, was the subject of the Pre-Feasibility Study. The proposed route starts from Km. 116, Anet Junction, of NH30, passes over the Sone River at Koilwar, and ends to Km 179 of NH30, at Chitcohra Junction, the end point of existing bypass.

The project area locates on flood plain of both the Ganga and the Sone River. The project bypass starts at the elevation of 62 and ends at the elevation of 44, in distance of 50 km approximately. The Highest Food Level of the Sone River was assumed as the elevation of 59, based on the flood record of the river. Major control points along the project route was summarised in Table 3-6.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PROPOSED ELEVATION
GROUND ELEVATION
STATION
HORIZONTAL ALIGNMENT
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DWG SCALE:
DWG NO.:
001

Table 3-6 Major Controls of Patna Bypass

No.	Approx. Sta.	Description	Requirements
1	0+000	NH30, Anet JC	To secure smooth connection
2	2+400	Ara Canal	Bridge
3	9+000	NH30	Bridge
4	12+700	Village(Bahiara)	To be avoided
5	13+000 14+350	Sone River	Bridge
6	15+000	Village(Bindaul)	To be avoided
7	23+450	MDR	Bridge
8	33+000	Village(Naubatpur)	To be avoided
9	36+100	Patna Canal	Bridge
10	43+000	Villages	To be avoided
11	49+839	NH30, Chitcohra JC	To secure smooth connection

The Patna Bypass was proposed to cross the Sone River nearly 4.5 km upstream of the existing Sone Bridge. According to the information from the State PWD, Sone River has following characteristics:

River Width : 1,200 m
Average River Flow : 36,600 m^3/sec
Highest Flood Level : 58.9 m
Depth of Bearing Stratum : 30 m

In this Study, the following two alternative bridge types were studied and PC Extra-dose Bridge type was proposed.

Alternative-A
PC Extra-dosed Bridge : 98.700 m + 8 @ 148.050 m + 98.700 m = 1,381.800 m

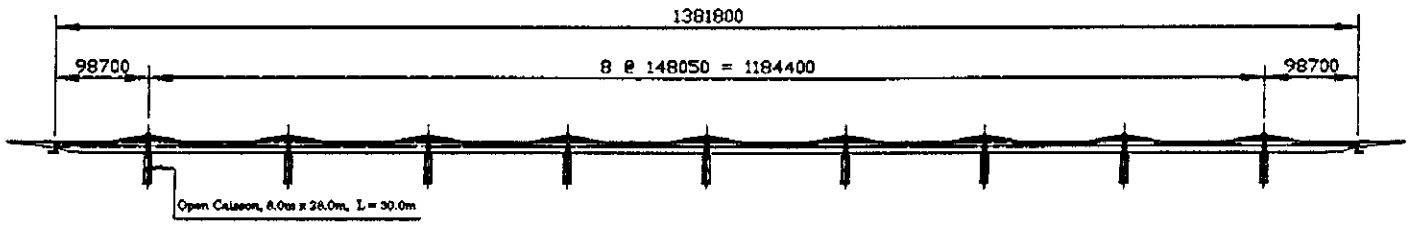
Alternative-B
PC Box Ramen Bridge : 14 @ 98.700 m = 1,381.800 m

Figure 3-3 shows the general side view and span arrangement of these two alternatives.

The proposed plan and profile of the bypass was given in Figure 3-4 and estimated major quantities was summarised in Table 3-7.

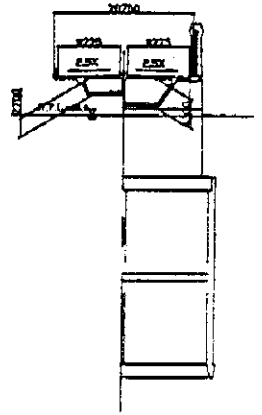
Alternative-A: PC Extra-dosed Bridge (98,700+8@148,050+98,700=1,381,800)

Side View Scale 1:5,000



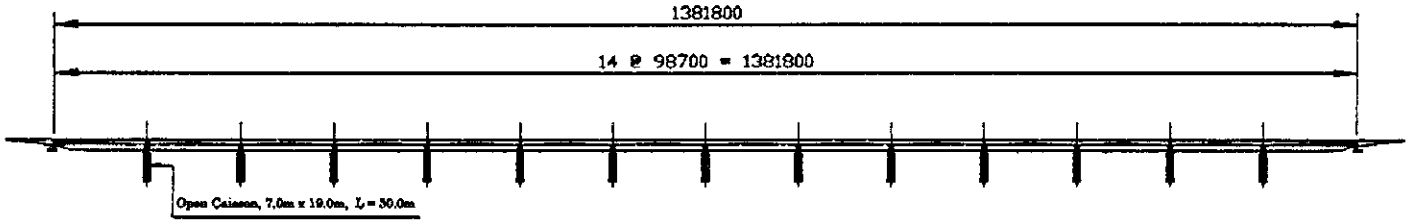
Cross Section Scale 1:700

(Center Span) (Above Pier)



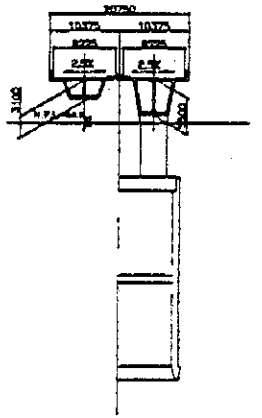
Alternative-B: PC Box Ramen Bridge (14@98,700=1,381,800)

Side View Scale 1:5,000



Cross Section Scale 1:700

(Center Span) (Above Pier)



Girder Soffit is to be 1.5m above the Highest Flood Level (H.F.L.) = 58.9m for both alternatives.

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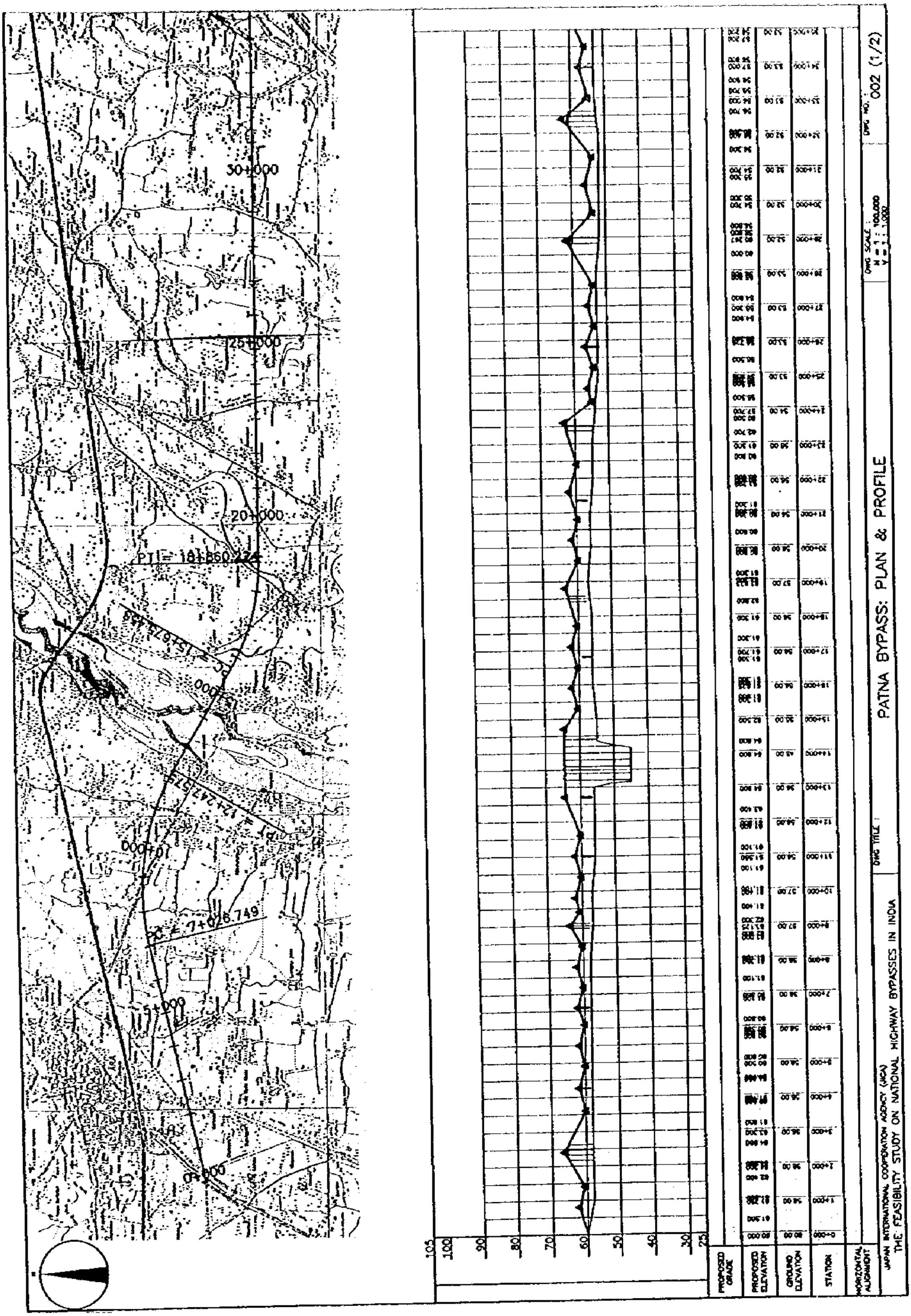
Figure 3-3 Alternatives for Proposed Bridge over Sone River



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25+000
20+000
PT = 18+860.224
PC = 7+076.749
5+000
0+000
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PROPOSED GRADE
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GROUND ELEVATION
STATION
HORIZONTAL ALIGNMENT
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
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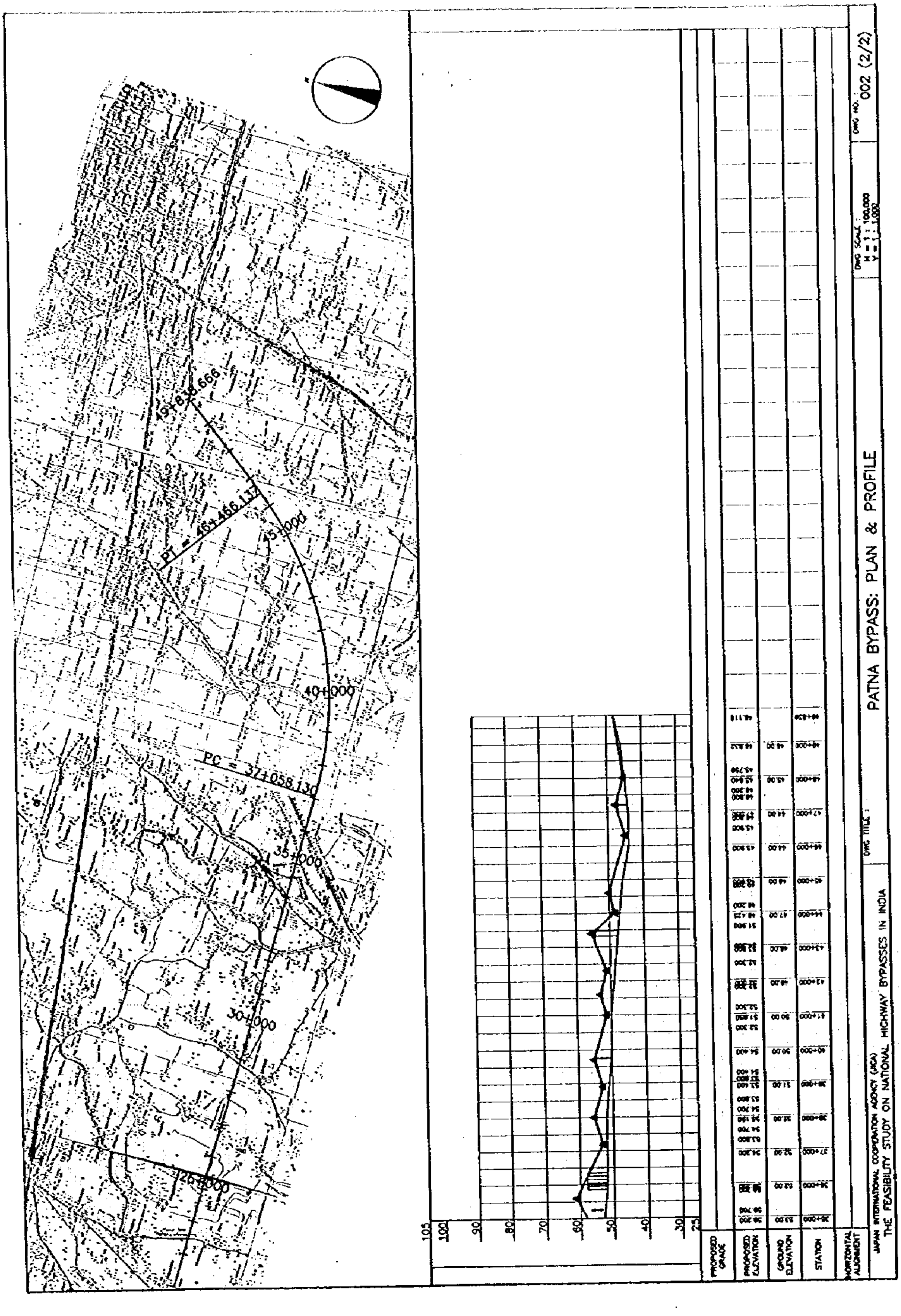
DWG TITLE
PATNA BYPASS: PLAN & PROFILE
DWG SCALE
DWG NO.
002 (1/2)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PROPOSED GRADE
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HORIZONTAL ALIGNMENT
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PATNA BYPASS: PLAN & PROFILE
002 (2/2)

Table 3-7 Major Quantities of Patna Bypass

Item	Unit	Amount
Bypass Length	km	49.9
Earthwork Section	km	48.2
Structural Section	km	1.7
Earthwork Balance	m^3	- 4,493,000
Fill	m^3	4,513,000
Cut	m^3	20,000
Concrete	m^3	76,600
HYSD	ton	11,000
PC Strand	ton	1,300
Pavement		
AC	m^3	29,900
DBM	m^3	151,100
WMM	m^3	347,000
GSB	m^3	338,400

3.4 Preliminary Design of Keonjhar Bypass

Six (6) km stretch of NH6 located in Keonjhar town, from Km. 349 to Km. 355, is very congested with problems of ribbon development of the town along the NH. It is a virtual bottleneck on NH6. To solve this problems, it was proposed to construct the Keonjhar Bypass starting at Km. 349 of NH6 and running on the right side of the existing stretch and finally meeting it at Km. 355. The maximum offset distance from NH6 is about three km.

There is no major control for the horizontal alignment except a new railway construction project near the starting point. The railway line is being laid in the North South direction with at-grade crossing on NH6. The major control points are listed in Table 3-8.

Table 3-8 Major Controls of Keonjhar Bypass

No.	Approx. Sta.	Description	Requirements
1	0+000	NH6	To secure smooth connection
2	1+000	Railway	To be avoided
3	2+800	Village(Gamaria)	To be avoided
4	4+800	River	Bridge
5	6+020	SH11	Bridge
6	8+505	NH6	To secure smooth connection

Regarding the vertical alignment, the elevation difference between the beginning point and the end point is about 15 metres with a gradually increasing slope. However, the section of Sta. 2+000 to Sta. 3+000 is at a slightly lower elevation due to some streams, and will be a fill section with 4~6 metres high. At the crossing with SH11, a viaduct bridge was proposed for a grade separation. Table 3-9 presented the

proposed major structures for the bypass.

Table 3-9 Major Structures of Keonjhar Bypass

No.	Approx. STA.	Description	Type	Span Arrangement (m)
1	4+800	River	RC-T	2@15=30
2	6+020	SH11	RC-T	2@13=26

The proposed plan and profile of the bypass was given in Figure 3-16 and estimated major quantities wer summarised in Table 3-10.

Table 3-10 Major Quantities of Keonjhar Bypass

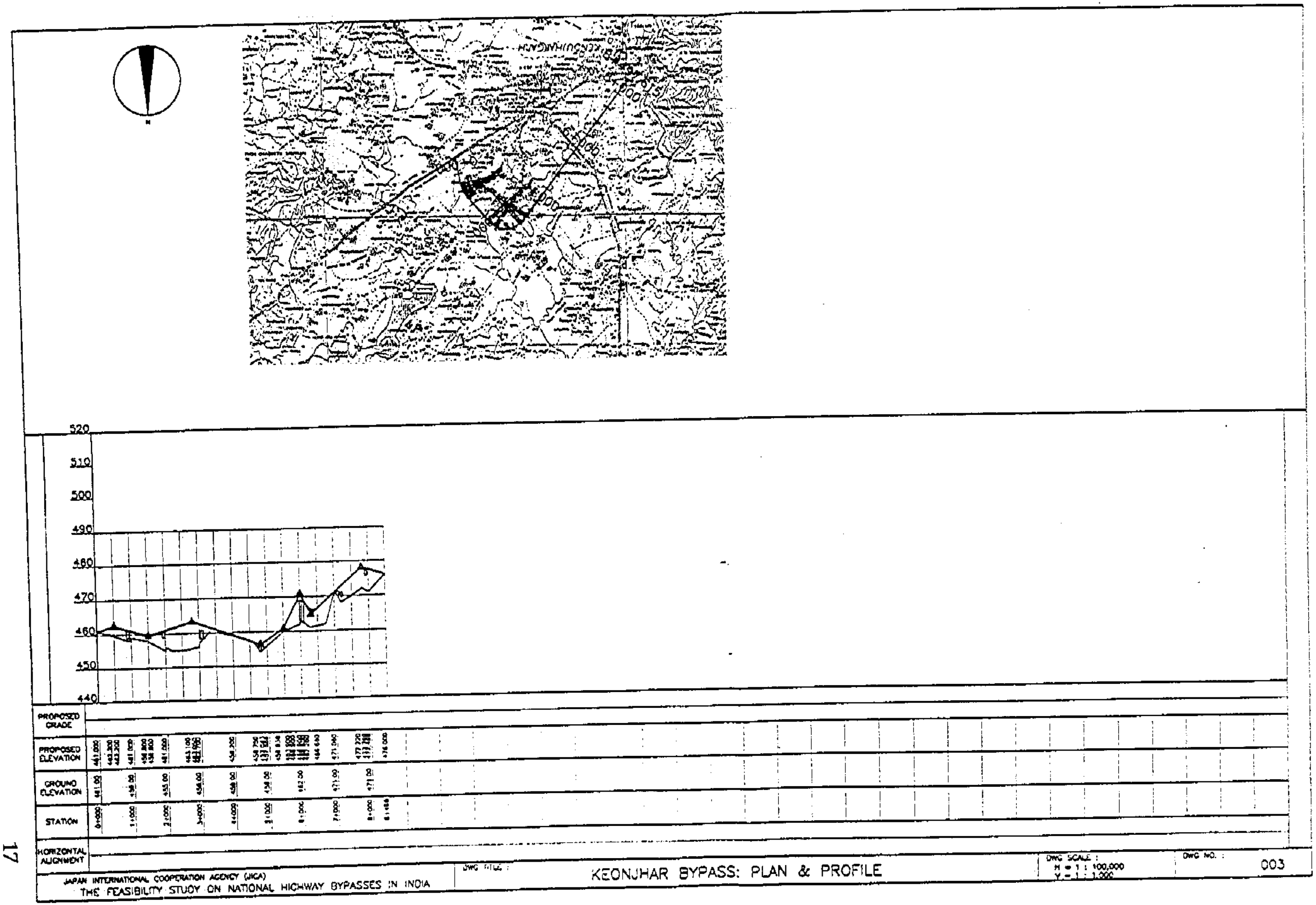
Item	Unit	Amount
Bypass Length	km	31.1
Bypass Length	km	8.5
Earthwork Section	km	8.4
Structural Section	km	0.1
Earthwork Balance	m^3	-762,000
Fill	m^3	762,000
Cut	m^3	
Concrete	m^3	6,500
HYSD	ton	800
Pavement		
AC	m^3	5,300
DBM	m^3	26,700
WMM	m^3	61,200
GSB	m^3	59,700

3.5 Preliminary Design of Balugaon Bypass

There are two level crossings of railways at Km. 323 and Km. 337 on either side of Balugaon. These crossings pose a serious influence to the traffic on NH5. To avoid to cross the railways, Balugaon Bypass was proposed to start from Km. 322 on NH5, and run on the left side of the existing railways up to Km. 337. The maximum separation distance is about two km from NH5. The major control points were listed in Table 3-11.

Table 3-11 Major Controls of Balugaon Bypass

No.	Approx. Sta.	Description	Requirements
1	0+000	NH5	To secure smooth connection
2	1+500	Village (Tutipara)	To be avoided
3	5+600	MDR	Bridge
4	8+000	Village (Bishundihi)	To be avoided
5	9+470	River	Bridge
6	15+400	NH5	To secure smooth connection



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PROPOSED ELEVATION
GROUND ELEVATION
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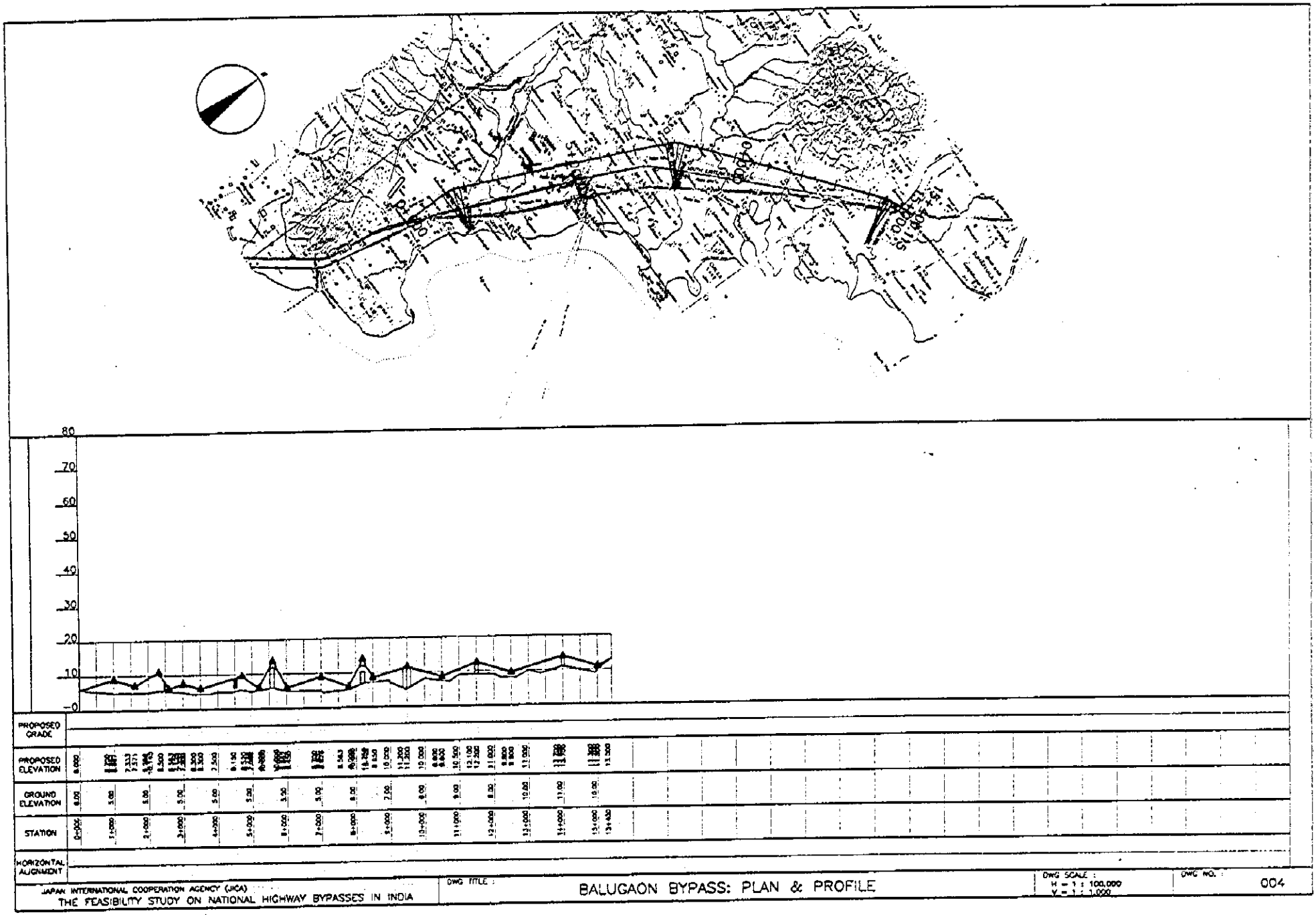
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DWG NO. :
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Major structures and estimated major quantities of proposed Balugaon Bypass were listed in Tables 3-12 and 3-13, respectively. Figure 3-6 presents the proposed plan and profile of the bypass.

Table 3-12 Major Structures of Balugaon Bypass

No.	Approx. STA.	Description	Type	Span Arrangement (m)
1	5+600	MDR	RC-T	1@11=11
2	9+470	River	RC-T	4@15=60

Table 3-13 Major Quantities of Balugaon Bypass

Item	Unit	Amount
Bypass Length	km	15.4
Earthwork Section	km	15.3
Structural Section	km	0.1
Earthwork Balance	m^3	-245,000
Fill	m^3	245,000
Cut	m^3	
Concrete	m^3	6,700
HYSD	ton	900
PC Strand	ton	
Pavement		
AC	m^3	9,500
DBM	m^3	48,000
WMM	m^3	110,000
GSB	m^3	107,400

3.6 Preliminary Design of Vijayawada Bypass

There were two separate, but similar, ring road plan prepared to ease the traffic congestion within Vijayawada City. One was propose by the State PWD and the other was proposed by Vijayawada - Guntur - Tanali Urban Development Authority (VGTUDA). The proposed alignment of ring road by VGTUDA is as follows.

Section I Starts at Gollapudi village on NH9 and joins at Chinna Avutapalli village on NH5

Section II Starts at Gollapudi village on NH9 and joins at Chinna Kakani village on NH5

Section III Starts at Gudavalli village on NH5 and joins at Mangalagiri

For this Pre-Feasibility Study, Section I of the ring road, proposed by VGTUDA, was selected as the subject bypass.

The proposed Bypass route starts at Km. 259 of NH9 at Surayapalem near Gollapudi village and joins NH5 at Km. 27 at Christlanpeta village. As Vijayawada City is situated beside the Krishna River, in sedimentary flat plains, there are no topographical obstructions along the alignment. Table 3-14 shows the major controls

identified by the site reconnaissance.

Table 3-14 Major Controls of Vijayawada Bypass

No.	Approx. Sta.	Description	Requirements
1	0+000	NH9	To secure smooth connection
2	1+450	Railway	Bridge
3	2+540	River	Bridge
4	5+000	Marshalling	To be avoided
5	6+350	Hill	To be avoided
6	16+000	Pond	To be avoided
7	17+800	ODR	Bridge
8	18+000	Village (Mustabad)	To be avoided
9	19+000	Pond	To be avoided
10	21+000	Village (Purushottapatam)	To be avoided
11	24+740	River	Bridge
12	26+220	Railway	Bridge
13	27+500	Canal	Bridge
14	28+125	NH5	To secure smooth connection

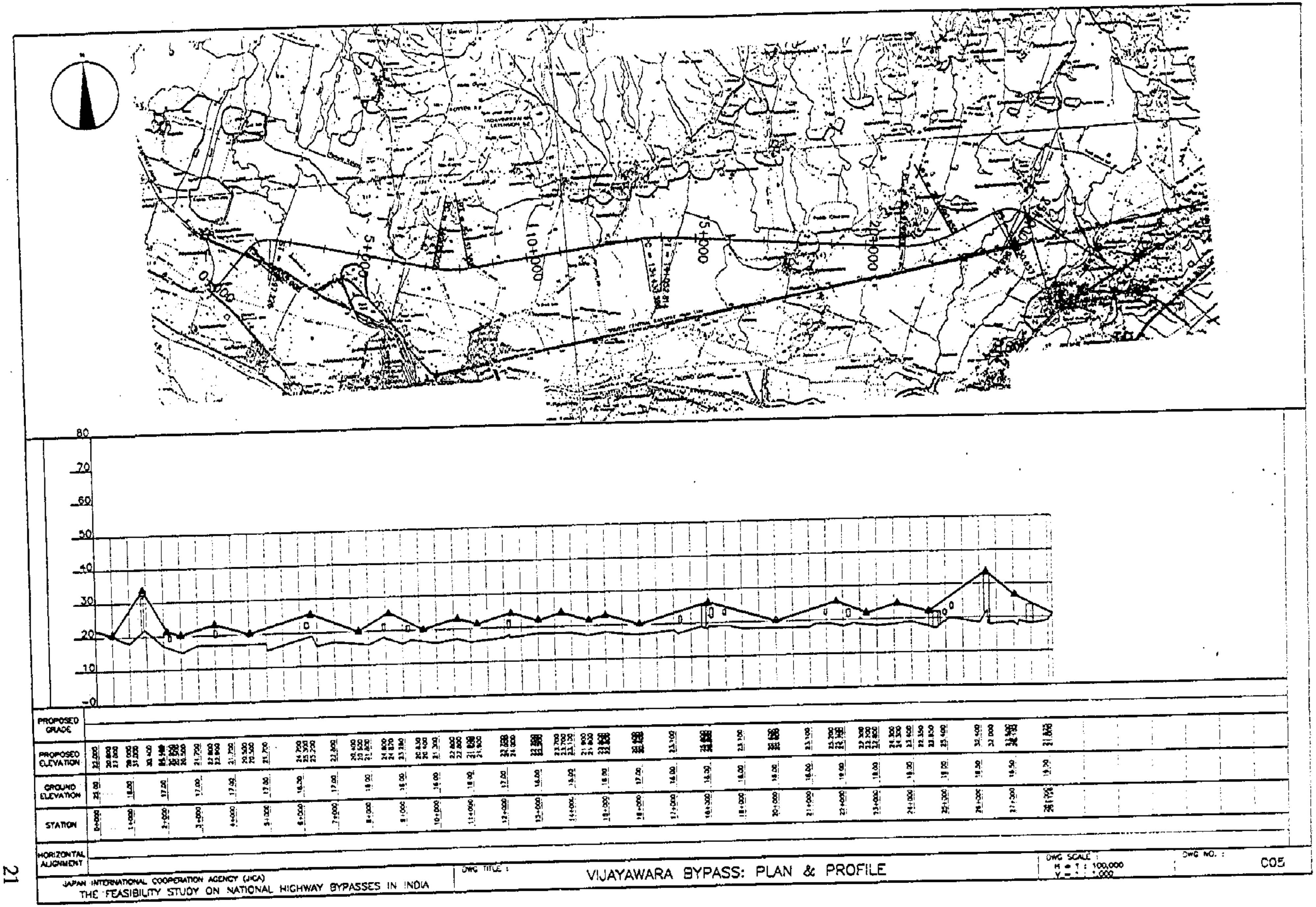
Proposed major structures and estimated major quantities of Vijayawada Bypass were listed in Tables 3-15 and 3-16, respectively. Figure 3-7 presents the proposed plan and profile of the bypass.

Table 3-15 Major Structures of Vijayawada Bypass

No.	Approx. STA.	Description	Type	Span Arrangement (m)
1	1+450	Railway	PC-Hollow	1@25=25
2	26+220	Railway	RC-I	1@36=36

Table 3-16 Major Quantities of Vijayawada Bypass

Item	Unit	Amount
Bypass Length	km	28.1
Earthwork Section	km	28.0
Structural Section	km	0.1
Earthwork Balance	m^3	-5,244,000
Fill	m^3	5,244,000
Cut	m^3	
Concrete	m^3	18,400
HYSD	ton	2,400
PC Strand	ton	43
Pavement		
AC	m^3	17,400
DBM	m^3	87,800
WMM	m^3	201,600
GSB	m^3	196,600



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GROUND ELEVATION
STATION
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