2.3 ROAD ALIGNMENT PLANNING CRITERIA AND METHOD

2.3.1 Alignment Planning Policy and Methodology

(1) Policy of Planning Alignment

Based on the basic concepts mentioned in the previous section, the alignment of the Sindhuli Road, originally determined in the Aftercare Study in 1993, was modified taking into consideration the following issues:

- The result of the site investigation of the post-disaster status of the area due to 1993 heavy rain over the planned route area.
- Socioeconomic conditions determined in the site reconnaissance conducted in April 1999
- Information contained in aerial photographs
- Information from satellite remote sensing
- Land usage, vegetation, geographic, and topographical information obtained from Geographic Information System (GIS)

The planning of the alignment was conducted incorporating the following two policies defined in the Aftercare Study and the Basic Design Study for Sindhuli Road Section IV:

- To minimize risks likely to be exposed due to slope failure, disasters and plan road earthworks that minimize influences to natural slope, and second put priority on the design of the alignment.
- Mitigate destruction of historic artifacts and religious sites, alleviate number of resettlement, reduction of forest cutting areas, and consider environmental protection measures.

2.3.2 Policy for Determining Alignment

In order to implement and realize the two policies, technology of the geographic information system was applied to determine the alignment. Specifically, the following procedures were followed:

1) Generate figures on 1:10,000 scale topographical map indicating land use distribution, hazard map, natural slope angle, and potential sediment yield based on aerial photo reading, satellite remote sensing, geographical information system technology.
2) On the basis of the geographical information obtained from 1), extract locations of saddle of ridges, forested area, slope gradient distribution, landslide hazard zones, and other information that would control the planning of the alignment. These integrated information would then be filtered through comprehensive evaluation and judgment to determine the area for alignment planning.
3) Digitize the 1:2,000 topographical map data and plan an optimal route (a tentative route) within the constraints of the alignment by trial and error process on a computer.
4) Confirm and revise the geographic information along the tentative route by incorporating data acquired through site reconnaissance and topographical

survey and generate digital terrain data.

5) Finalize the road alignment based on the digital terrain data.

Figure 2.3.1 indicates the work process to determine the alignment. Figures 2.3.2 to 2.3.5 indicate the generated land use distribution, landslide hazard zones, distribution of the slope gradient, and the potential deposit yield.

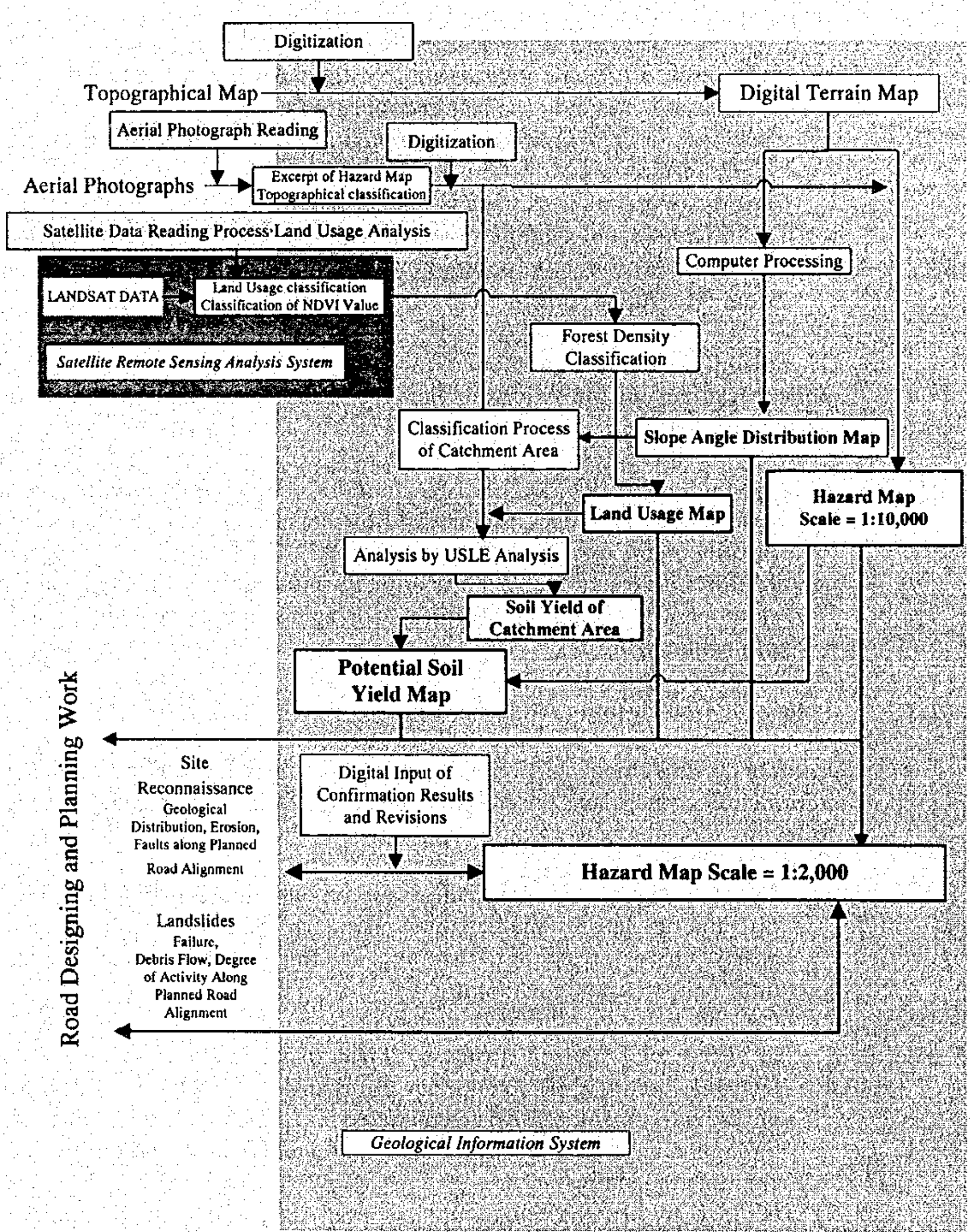
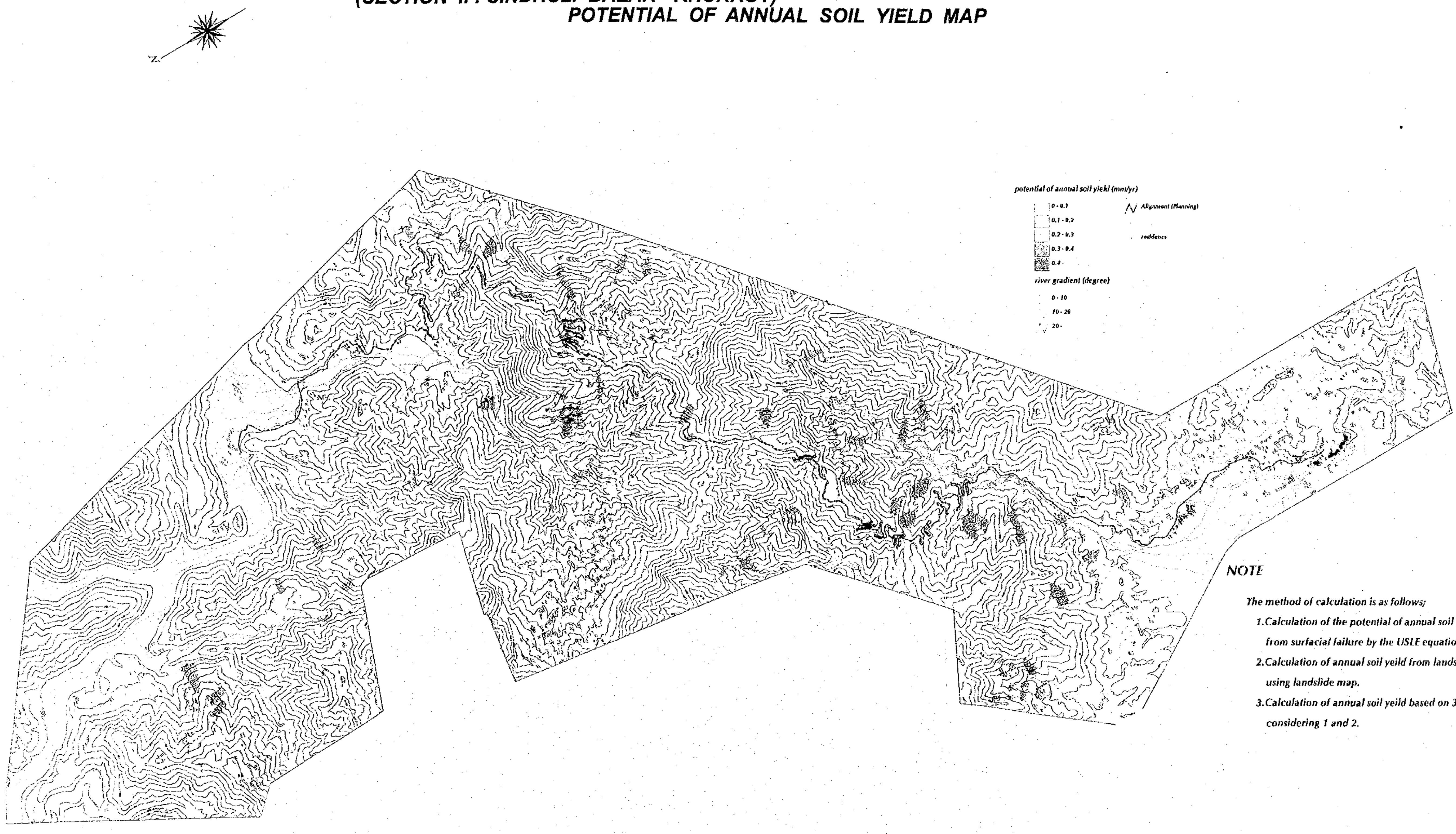


Figure 2.3.1 The Work process to Determine the Alignment

BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD (SECTION II : SINDHULI BAZAR - KHURKOT)

POTENTIAL OF ANNUAL SOIL YIELD MAP



NOTE

The method of calculation is as follows;

1. *Calculation of the potential of annual soil yeild from surfacial failure by the USLE equation.*
2. *Calculation of annual soil yeild from landslide using landslide map.*
3. *Calculation of annual soil yeild based on 30m mesh considering 1 and 2.*

SCALE 0 500 1000m

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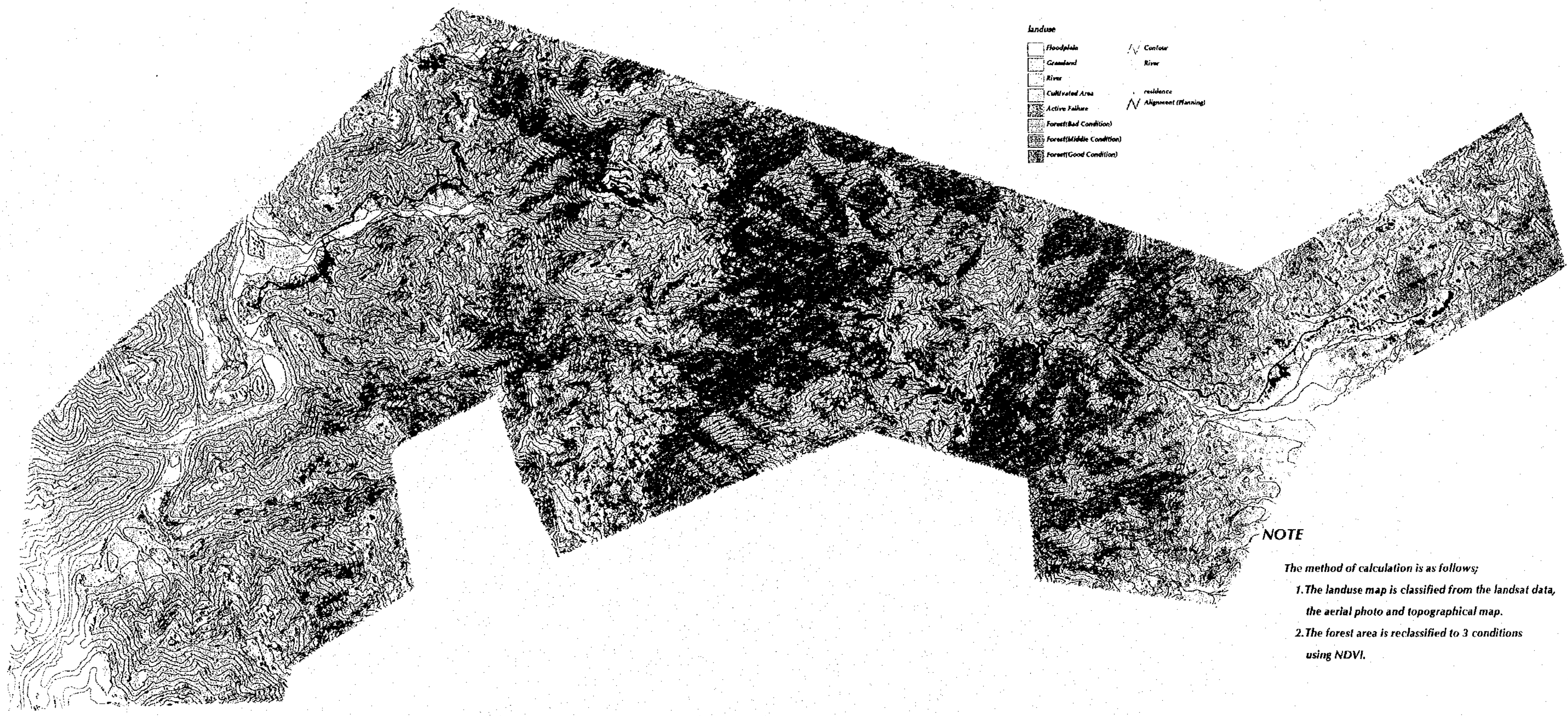
Figure 2.3.5 Soil Yield Potential Map

BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD
(SECTION II : SINDHULI BAZAR - KHURKOT)
LANDUSE MAP



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SCALE
0 500 1000 m

Figure 2.3.2 Vegetation Density Distribution Map

BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD (SECTION II : SINDHULI BAZAR - KHURKOT)

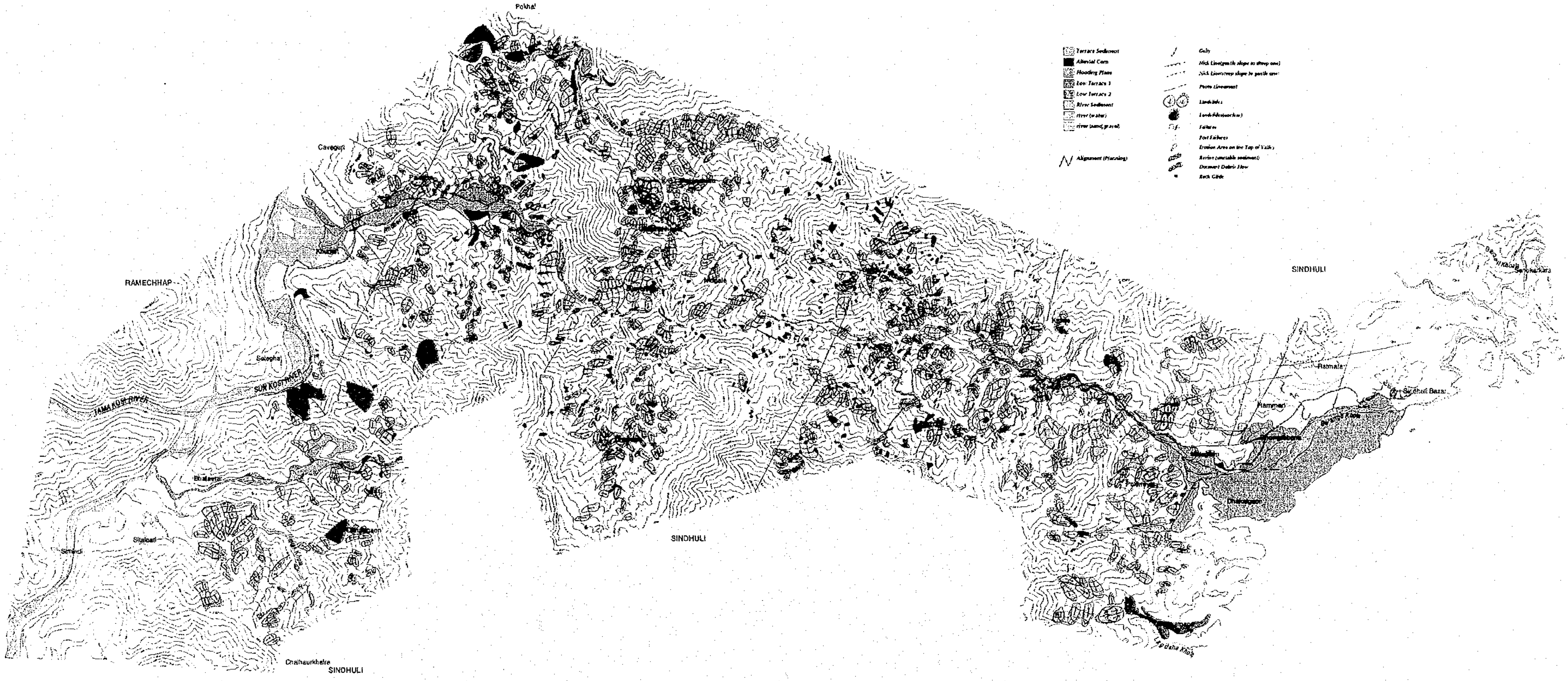

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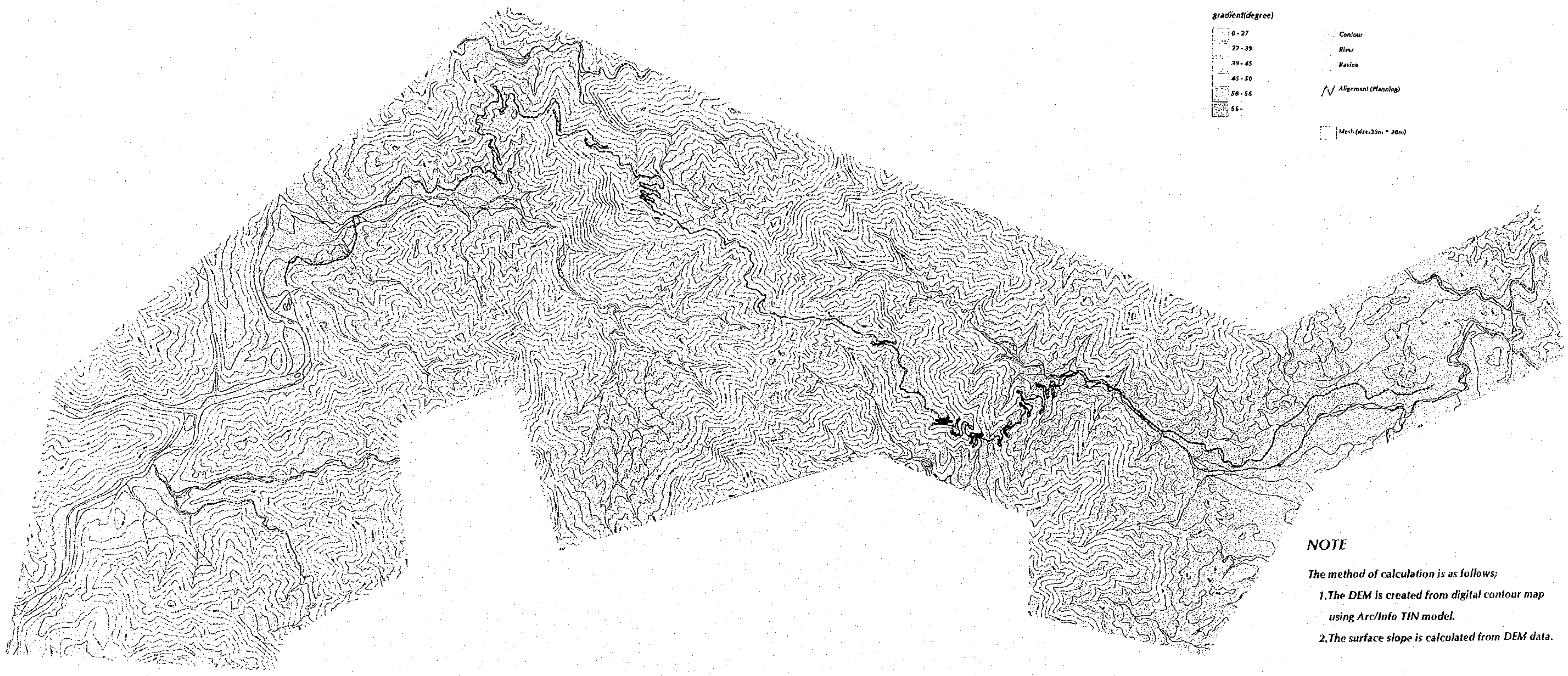
Figure 2.3.3 Geological Hazard Map

BASIC DESIGN STUDY ON THE PROJECT FOR CONSTRUCTION OF SINDHULI ROAD (SECTION II : SINDHULI BAZAR - KHURKOT)

GRADIENT MAP



NOTE

The method of calculation is as follows;

1. *The DEM is created from digital contour map using Arc/Info TIN model.*
2. *The surface slope is calculated from DEM data.*

SCALE 0 500 1000 m

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Figure 2.3.4 Slope Gradient Distribution Map

2.3.3 Social conditions, Land Usage, Vegetation, and Route Planning

The following explains the contents of the revision made to the original alignment established in the Aftercare Study, and clarifies factors that determines the route selection namely: social-demographic conditions, land usage, and vegetation. Figure 2.3.6 depicts the areas and sections where the alignment were modified taking into consideration social-demographic conditions, land usage and vegetation.

(1) Existing Road Section

There is about a 4 km road constructed by the Department of Roads, from Sindhuli Bazar, at the end of Section I. A fairly good standard of design is adopted for the alignment and some cross-drainage structures have also been constructed. In order to minimize any additional land acquisition costs and compensation for housing, and in order to reduce the construction costs, the alignment of this road is designed so as to maximize the utilization of the existing road alignment and drainage structures on site.

Photograph 2.3.1 Current Situation of Existing Roads

(2) Historic and Religious Sites

For centuries, the existing road that stretches from Sindhuli Bazar to Khurkot has played an important role connecting Ramechap and the hinterland of Sindhuli district with the Terai Plain. In the vicinity of Sindhuli Gadhi, the alignment is planned overlapping this historic road. Ruins of a mason fort exists on a strategic point of Sindhuli Gadhi. This fort has served as a stronghold for the Nepalese army to defeat the intruding forces of the East India Company 180 years ago and is considered of high historical value. Special consideration has been set for road alignment planning to preserve this fort.

Photograph 2.3.2 Sindhuli Gadhi Fort Ruins

Special care has been provided for other existing landmarks and facilities besides the ruins of the Sindhuli Gadhi fort. Since large trees, particularly the Bo tree, and small religious facilities are scattered along the route, the road alignment will be planned avoiding these items.

(3) Obstruction

In the vicinity of Sindhuli Gadhi, power transmission lines are being constructed along the historic road of which 2km from approximately STA17 to STA20 of the line is adjacent to the planned alignment. This power transmission line, currently under construction, is part of the conductor line for the micro-hydro power project, connecting Terai and Khimthi. The power line is supported by lightweight assembling type stainless steel pole, and upon completion, the line is scheduled to conduct 11KV of power.

The road alignment between STA17 to STA20 is positioned in a steep mountainous area and passes through the following three control points, or the design constraints of the vertical alignment planning: The Dhungre Bhanjyan saddle, the historic saddle of Sindhuli Gadhi, and the Sindhuli Gadhi saddle. And to be consistent with the policy of minimizing the forest cutting area, the alignment is intentionally planned to overlap with the historic pass.

Due to these design constraints and the necessity to mitigate damages to the forest and fauna environment, it is difficult to adjust the road alignment to avoid the power line currently under construction. Thus, the road alignment was planned on assumption that the supporting structures will be removed prior to the implementation of the Project Section II.

Photograph 2.3.3 Power transmission lines near Sindhuli Gadhi

(4) Land Usage/Vegetation

Since the forest area of Nepal has decreased to 29% out of the total area in the country, the protection and the management of the remaining forest of Sindhuli Gadhi has become a great concern and an immediate issue that needs to be addressed in Nepal. Thus, to reduce the cutting area of the forest along the project road, the road alignment was planned with the policy to pass through Sindhuli Gadhi area (i) along the existing foot trail, and (ii) boundary between the forest area and the cultivated /uncultivated land.

To minimize the resettlement of the inhabitants in Sindhuli Bazar and Khurkot, the road alignment is planned to avoid the residential areas and/or overlap the centerline of the existing road.

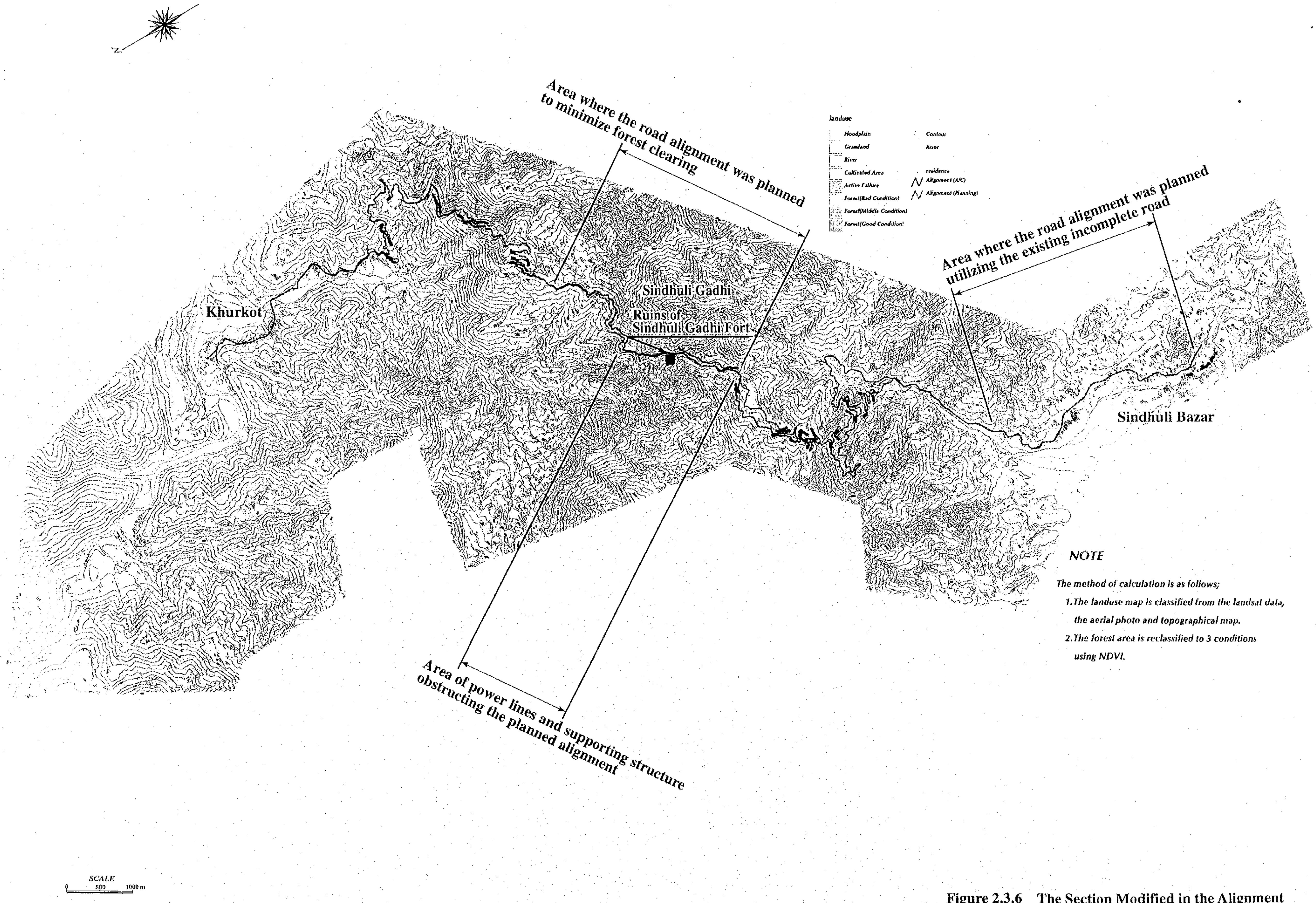

Figure 2.3.6 The Section Modified in the Alignment by Social conditions, Land Usage,Vegetation

2.3.4 Geological and Topographical Conditions and Route Planning

According to the geological information obtained through the hazard map, slope gradient distribution map, findings on the field investigation in the first field survey and recommendations in the reconnaissance report prepared by DOR after 1993 heavy rainfall, the alignment planned in the Aftercare Study was modified at three sections as shown in Figure 2.3.7 and are described below.

(1) Upper Stream Area of Gwang River

The upper stream of Gwang River basin shows progression of dissection and forms a dendrite drainage pattern. The 1993 heavy rain has caused many debris slides on the slopes along the upper stream, and hazard maps indicate that many slope failures and large-scale landslides are triggered by the active MBT and MCT faults. Boulders, with maximum diameter of 5 meters, are scattered on the flood plain that is 3m higher than the existing river bed. So the upper stream of Gwang River is an area subject to intense movements of debris. Also, the route planned in the Aftercare Study, which crosses many rivers by crossing structures including the three bridges planned over the Gwang River, is prone to risks of slope failures and debris flow. Thus, the alignment in this area was modified to cross the Gwang River prior to entering the area of intense flow movements.

(2) Pipal Bhanjyan Area

Many failures had occurred at the slopes on the upper stream area of Gwang tributary river due to the heavy rain in 1993. The upper stream area of Gwang tributary river is prone to mass movements of debris. Thus, the original alignment that passes through this area, established in the Aftercare Study, is subject to risks of slope failures and debris flow. On the other hand, the ridge in the vicinity of Pipal Bhanjyan area is formed of stable sandstone and conglomerate. Thus, the route originally planned in the Aftercare Study was modified so as to avoid passing through the area of potential intense debris movement, and the road would be safer to climb up along the ridgeline by zigzag sections.

(3) Chimin Dhanda Area

A large-scale landslide occurred on the northwest slope of the Chimin Dada area due to the 1993 heavy rain. This landslide is the partial reactivation of the massive landslide that originates near the ridge at the elevation of 1200m. The width and the length of this massive landslide is 100m and 250m, respectively. The route conceived during the Aftercare Study was to pass through the center of this huge landslide. To avoid potential landslide hazards, this route was modified so as to climb the steep slopes in Dhancheldada village by five layers of zigzag sections and raising the alignment up to the ridge, prior to coming into this section.

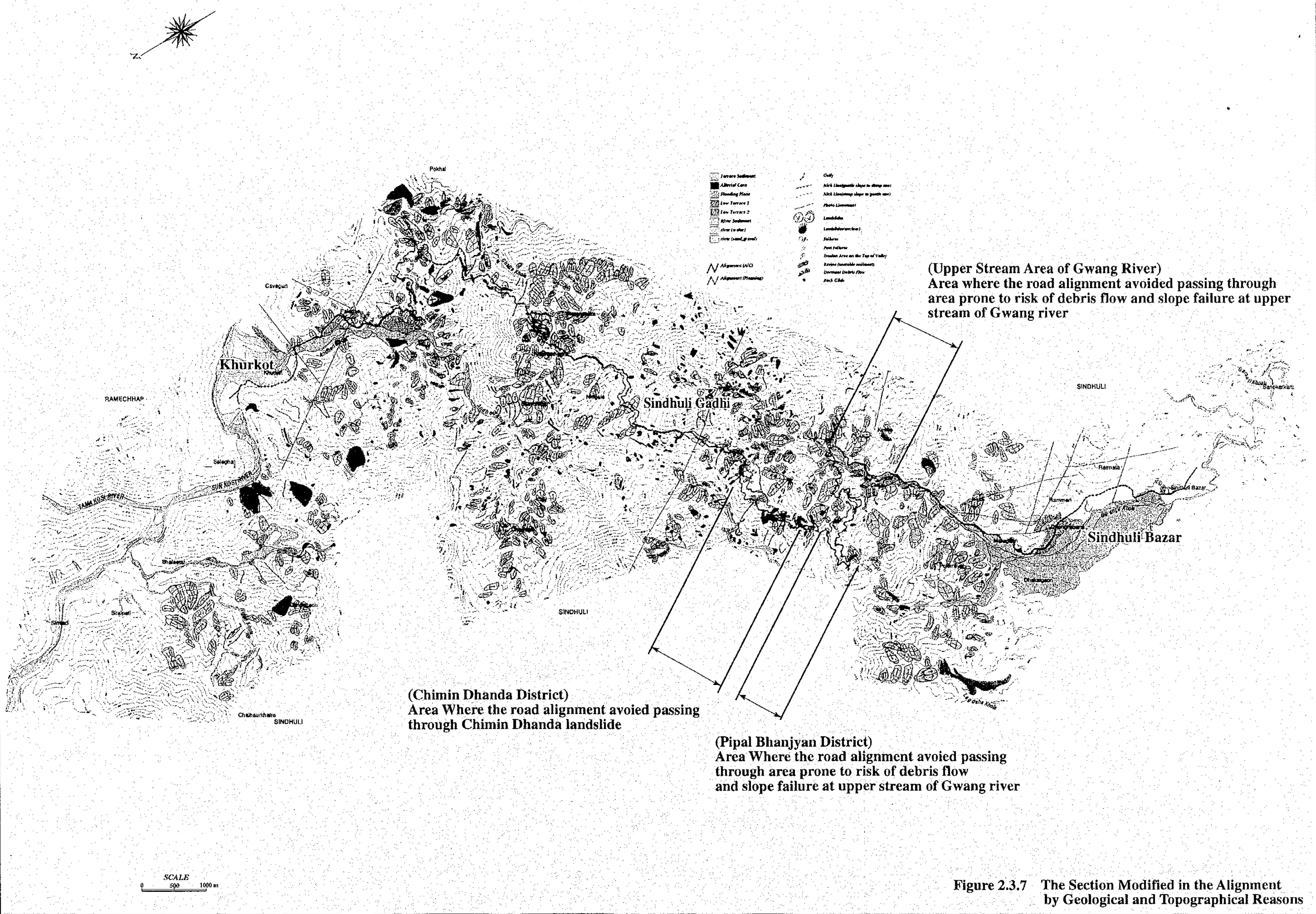

Figure 2.3.7 The Section Modified in the Alignment by Geological and Topographical Reasons