## 6.3 Engineering Study for Master Plan

### 6.3.1 Design Speed

Design speeds and road functions based on terrain are shown in Table 6.1.

**Table 6.1 Design Speed According to Road Function**

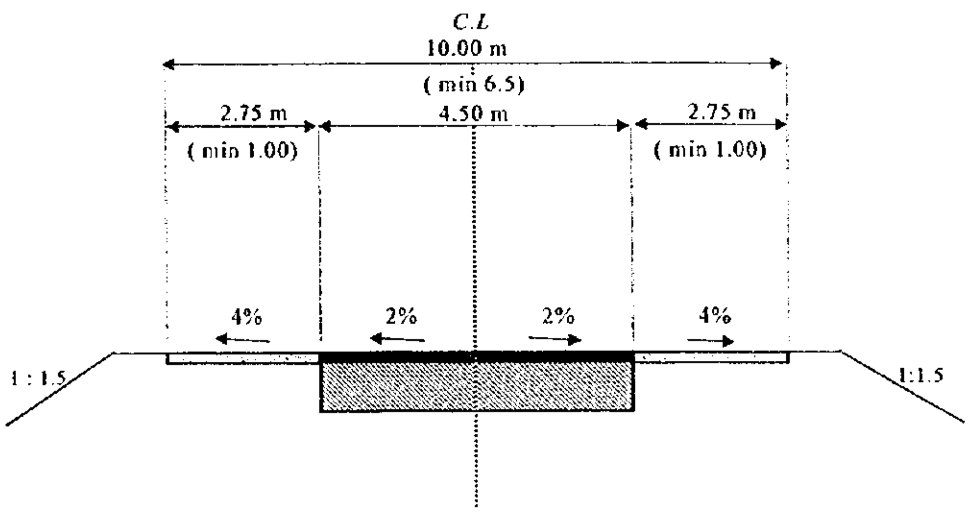
| Traffic Volume (pcu/day) | 3,000 to 20,000 | | Less than 3,000 | |
|---|---|---|---|---|
| Terrain | Flat and Rolling | Mountainous | Flat and Rolling | Mountainous |
| Pavement Width (m) | 6.0 | 6.0 | 4.5 | 4.5 |
| Design Speed (Km/h) | | | | |
| Arterial Road | 60 | 40 | 50 | 30 |
| Collector 1 | 50 | 30 | 50 | 30 (20) |
| Collector 2 | 50 | 30 (20) | 40 | 30 (20) |
| Collector 3 | 50 | 30 (20) | 40 | 20 |
| Type of Typical Cross Section | Type 2 (See Figure 6.6) | | Type 1 (See Figure 6.5) | |

*Source: Bina Marga*
Note: ( ) is special case

### 6.3.2 Typical Cross Section

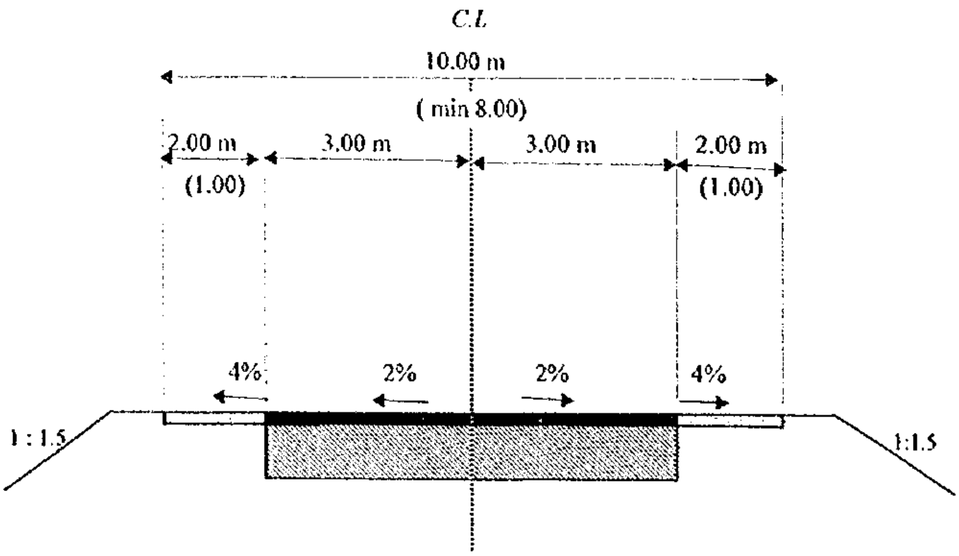
A minimum width of more than 6.5m was adopted for the road sections with a future design traffic volume of 3,000 pcu or less (Type 1). In case of a future daily traffic volume of 3,000 - 20,000 pcu, minimum. width of 8.0m (Type 2) with a carriageway of 3.0 m x 2 and shoulder of 1.0 m x 2 is needed.

Typical standards cross sections for Types 1 and 2 are shown in Figure 6.5 and 6.6.




*Source: Study Team*

**Figure 6.5 Typical Cross Section of Type 1**
(Future daily traffic volume of 3000 PCU or less)




*Source: Study Team*

**Figure 6.6 Typical Cross Section of Type 2**
(Future daily traffic volume of 3000 PCU and over)

### 6.3.3 Pavement

The pavement structure is determined from the CBR of subgrade soil and the accumulated wheel load based on the traffic demand. In this study, the structure is planned to have a 20 - 25 cm subgrade on the basis of assumption of the field CBR value of 5 - 10. The pavement design is established by assuming a design CBR value of 6%. The wheel load was calculated from the projected traffic volume per day per direction for the year 2018. For the pavement structure, four types shown in the Table 6.2 are planned on the basis of the traffic volumes of heavy vehicles (buses and trucks) in the year 2018. The pavement surface is designed as two layers by considering the overlay to be provided in the future while using an asphalt surface. The base course will be treated with buton (natural) asphalt while the subbase will be made from mechanical stabilized crushed stone.

**Table 6.2 Pavement Types for Traffic Volumes of Heavy Vehicle**

| Pavement Type | Traffic Volumes (Heavy veh./day) |
|---|---|
| AA | More than 3000 |
| A | 1000 - 3000 |
| B | 250 – 1000 |
| C | Less than 250 |

*Source: Study Team*

**Table 6.3 Pavement Structure by Type**

Unit : cm

| Item | AA | A | B | C |
|---|---|---|---|---|
| Over-lay 1* | 5 | 5 | 5 | 5 |
| Surface 2 | 5 | 5 | 5 | 5 |
| Base Course** | 20 | 15 | 10 | 0 |
| Subbase Course | 25 | 25 | 20 | 20 |
| Total | 55 | 50 | 40 | 30 |

*Source: Study Team*

*: After 10 years from operation
**: Bituminous Treatment

### 6.3.4 Bridges

There are about 2,500 existing bridges in the study area of Central and Southeast Sulawesi. Bridge capacity should be improved in accordance with the road development plan in order to ensure the safety traffic flow as most of these bridges are old, narrow or lacking in strength.

Bridge improvements will be classified into four categories.

- Replacement (bridges affected by the improvement of road alignment, seriously damaged or deteriorated bridges, bridges of narrow width or where widening is judged to be impractical);
- Rehabilitation (replacement of deck slab, repair and reinforcing of structure, protection of substructure);
- Widening; or
- No improvements necessary( use as is).

The data of existing bridge conditions was obtained from the bridge inventory of Bina Marga BMS as shown in Table 6.4. The data was examined and the bridge improvement plan was established. The concepts of bridge improvements for the Study are summarized in Figure 6.7.

### 6.3.5 Slope Protection Works

Due to the high percentage of steep terrain in the study area where road slope failures are prone to occur, the road master plan must incorporate slope protection works which will be applied that roads will be resistant to potentially hazards natural forces.

By understanding the relationship between slope protection and disaster management, one can ascertain the need of such protection.

- Classification of road damage
  Type and characteristics of road damage are clarified.

- Slope protection function and characteristics.
  These are clarified.

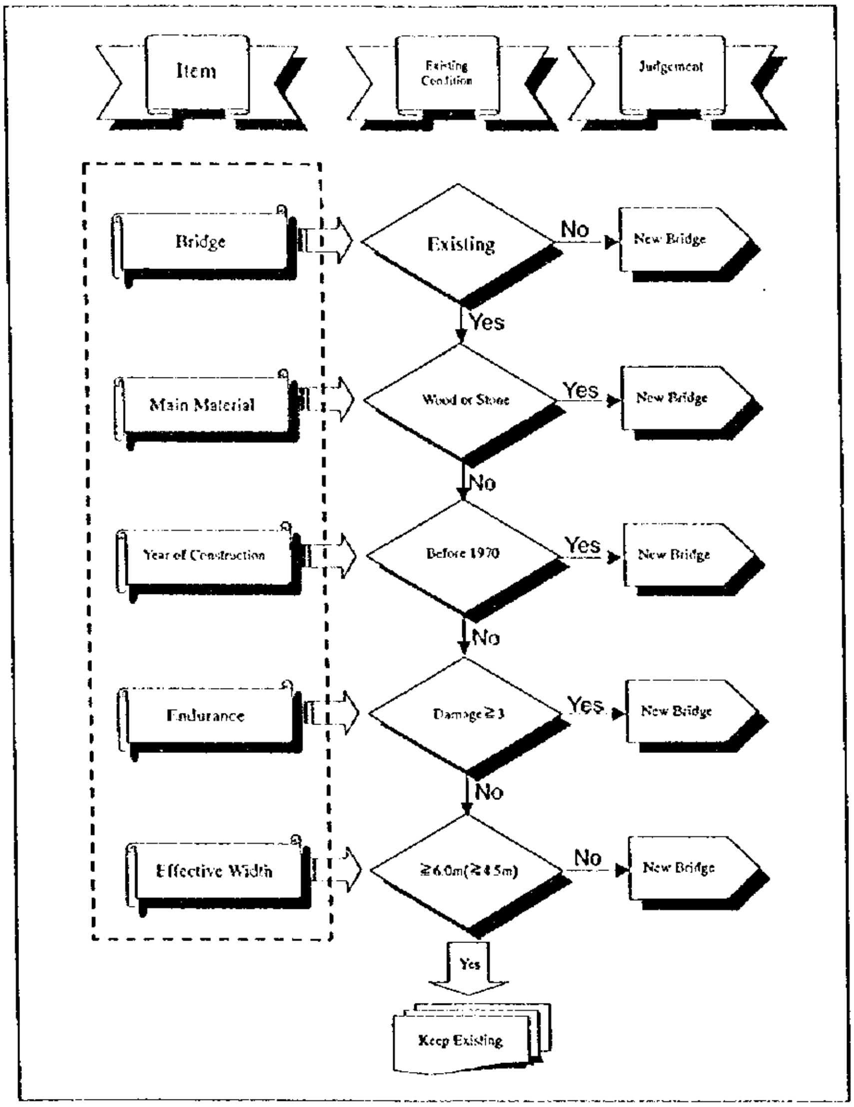
The concept of slope protection works has been established as to how to select and apply a design type, after which quantity estimate of the works will be prepared. The study flow chart is as shown in Figure 6.8.

The main purpose of the slope protection works is to prevent weathering and erosion, therefore the type of design should be selected based on geological and topographical conditions. The study team recommends the types shown in Table 6.5.

## Table 6.4 Existing Bridges along the National and Provincial Roads in the Central and Southeast Sulawesi

| Province | Central Sulawesi | | Southeast Sulawesi | |
|---|---|---|---|---|
| Road Classification | National Road | Provincial Road | National Road | Provincial Road |
| Number of Bridges | 708 | 1026 | 238 | 501 |
| | 1734 | | 739 | |
| Total Length (m) | 11904 | 14984 | 3057 | 6686 |
| | 26888 | | 9743 | |
| Width (m) | 3.0 – 9.9 | 3.0 – 9.9 | 3.0 – 12.0 | 3.0 – 7.5 |
| Road Length (m) | 1606 | 1523 | 304 | 1452 |
| | 3129 | | 1756 | |
| $\frac{BridgeLength}{RoadLength}$ (%) | 0.74 | 0.98 | 1.01 | 0.46 |
| | 0.86 | | 0.55 | |

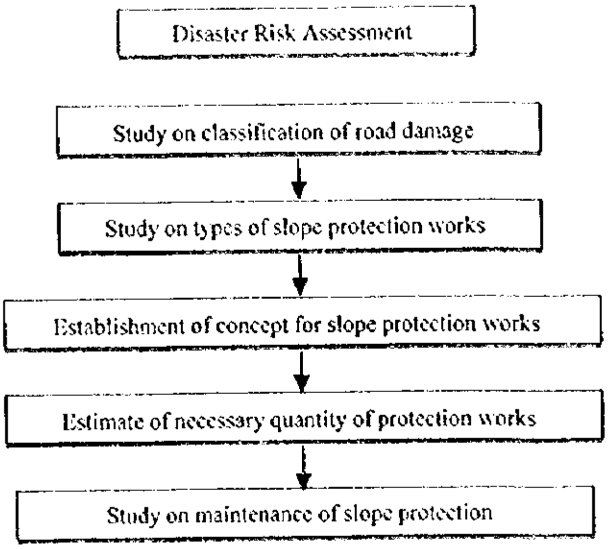
*Source: Study Team*




Notes: Damage Level 3: Damage which needs attention. (The damage may become serious within 12 months.)
Damage Level 4: Critical conditions. (Serious damage, which needs attention immediately.)
Damage Level 5: Collapsing or malfunction element.

*Source: Study Team*

## Figure 6.7 Procedure for the Decision of Bridge Improvement Plan




*Source: Study Team*

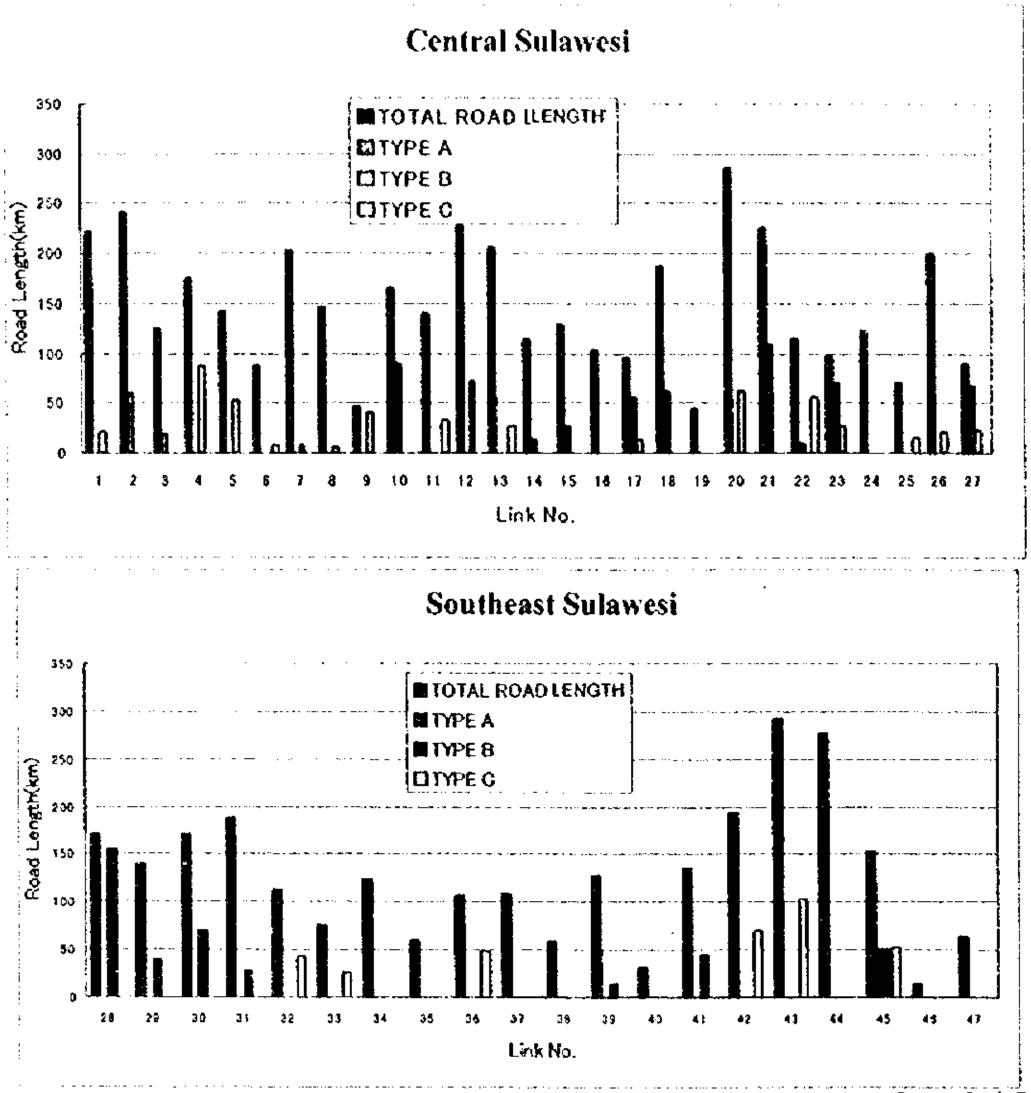
**Figure 6.8 Flow Chart of Study on Slope Protection Works**

**Table 6.5 Types of Slope Protection Works and their Purposes**

| Kind of Work | Purposes and Features |
|---|---|
| Shotcrete<br>Stone pitching<br>Block pitching | Prevention of weathering and erosion. |
| Concrete block cribworks | Prevention of erosion when filled up with sediment or gravel. |
| Concrete pitching<br>Sprayed concrete cribworks<br>Slope anchor works | Prevention of collapse of surface layer of slope, prevents separation of bedrock, and retains earth. |
| Wicker works<br>Slope gabion works | For controlling erosion of surface layer of slope and outflow of surface water. |
| Rockfall prevention nets<br>Rockfall prevention fences<br>Rockfall shed | Prevention of rockfall on to the road. |

*Source: Study Team*

Slope protection works are constructed to protect the slopes from erosion or weathering by covering them with vegetation or structures. They also stabilize the slopes by means of drainage works or retaining structures. Necessary length of slope protection works for each link is shown in Figure 6.9.




*Source: Study Team*

Note: Type of slope protection is classified by height (m).
TYPE A: More than 10m
TYPE B: From 6m up to 10m
TYPE C: Less than 6m

**Figure 6.9 Proposed Slope Protection Types**

### 6.3.6 Tunnel Design

Use of tunnels is one of the most effective means of the preventing slope failures and land slides. They protect the existing environment, and secure an efficient road alignment within the mountain range. However, there are disadvantages that have to be considered:

- Construction cost will be higher than that of roads and bridges
- Maintenance costs for ventilation systems
- Psychological problems due to enclosed space
- Potential of subsequent disaster following traffic accidents

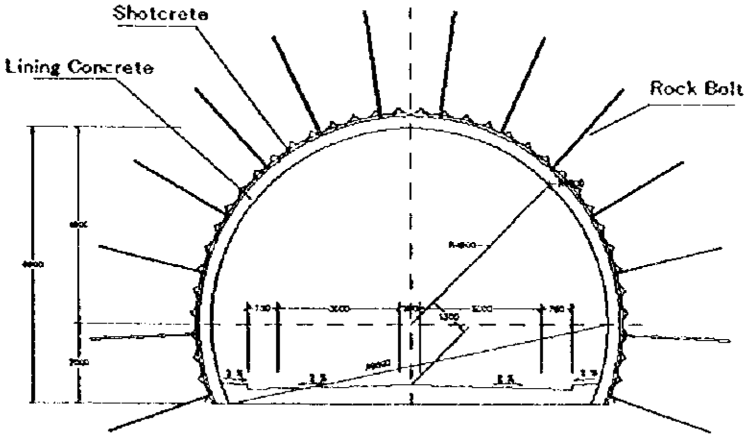
The shape and dimensions of a tunnel should be determined based on the facilities required for the tunnel interior and its structural stability.

The tunnel interior cross section must include consideration of:

- Width and construction limits in accordance with standards indicated in road structure statutes
- Construction limits to allow for inspection way and/or pedestrian way
- Variation of crossfall
- Dimensions of pavement and drainage
- Margin for ventilation facilities
- Construction tolerances

Tunnel cross-section must be determined by consideration of soil conditions, excavation methods, width of traffic lanes and type of tunnel support. Tunnel support is a vital component of tunnel structure, protecting the overall tunnel structure from failure of overlying rock mass and earth pressure which constantly bears down upon it. These tunnel supports will function to stabilize the excavated section.

A tunnel cross section for less than 1,000 m tunnel length is recommended as shown in Figure 6.10.




*Source: Study Team*

**Figure 6.10 Tunnel Cross Section**

The tunnel engineering generally requires sufficient experience but there is no experience of the road tunnel construction in Indonesia at present. The following aspects, therefore, should be well considered at stages of detailed design and construction:

- Introduction of the tunnel engineering from foreign countries in which know how of the tunnel engineering for NATM has sufficiently been experienced.
- Procurement of the special equipment for tunnel construction such as drill jumbo, shotcrete machine.
- Detailed rock investigation: Structural elements of tunnel, especially the entrance and thickness of lining concrete, are extremely affected by rock conditions
- Management and operation to prevent the secondary accident since a traffic accident in the tunnel is apt to lead to the secondary accident.

### 6.4 Cost Estimates

Unit cost of major pay items went unanalyzed and were estimated based on the labor, material and equipment cost according to local and foreign components. Then new construction, road improvement and rehabilitation costs for the period between the year 1999 and 2018 were calculated converting the unit costs into the unit cost of pavement and earthwork per kilometer, bridge per square meter, slope protection per square meter and tunnel per kilometer for each road link. Estimated cost for each road link is shown in Table 6.6.

### 6.5 Investment Schedule

Total road length for the future road network is to be about 6,500 km. The future road network will be constructed within 20 years with about 1,600 km developed over each five year period. The implementation schedule is to be determined according to regional budgets and priority of the road link. Project costs are limited by the available budget but priority of the projects is determined in consideration of total score obtained according to appraisal items such as the road hierarchy, future traffic volumes, existing road condition, progress of present road development plan and environmental aspects of each project. The implementation sequence for each package will be divided into the four terms of five (5) year plans. Table 6.7 shows the score of each appraisal items to establish the implementation schedule. The result of appraisal scores of each road link as well as construction and maintenance costs is shown in Table 6.6.

**Table 6.7 Score of Appraisal Items**

| 1 Road Classification | Points |
|---|---|
| a Gross Corridor | 4 |
| b Sub-Gross Corridor | 3 |
| c Corridor to Ports | 2 |
| d Corridor for hazard prevention | 1 |
| and permanent settlement | |
| 2 Traffic Volumes ( Vehicles /Day) | |
| a More than 3000 | 4 |
| b 3000>V>1000 | 3 |
| c 1000>V>250 | 2 |
| d Less than 250 | 1 |
| 3 Condition of Existing Road | |
| a Missing Link | 5 |
| b Pavement width < 3.0m | 3 |
| c 3.0m<Pavement width< 5.0m | 2 |
| d 5.0m<Pavement width | 1 |
| 4 Road investment | |
| a Progress of implementation | 5 |
| b Invested in past 5 years | -1 |
| 5 Environmental aspect | |
| a Affect the National Park | -5 |
| b Affect | -2 |

(Notes: Weight of points was decided by Study Team for reference.)

## Table 6.6 Total Construction Cost And Maintenance Cost for Each Road Link of Road Network

| No | Link Name | Road Length (Km) | Construction Cost Foreign (US$) | Construction Cost Local (Mill. Rp) | Construction Cost Total (Mill.Rp) | Maintenance Cost (Financial) Foreign (US$) | Maintenance Cost (Financial) Local (Mill. Rp) | Maintenance Cost (Financial) Total (Mill.Rp) | Total Cost (Financial) Total (Mill.Rp) | Total Appraisal Score |
|---|---|---|---|---|---|---|---|---|---|---|
| | **CENTRAL PROVINCE** | | | | | | | | | |
| 1 | SURUNAMA-DONGARA-PALU-KASINBAR | 223.0 | 16,996,599 | 177,957 | 358,121 | 4,678,765 | 47,650 | 97,245 | 455,366 | 9 |
| 2 | TAMBU-MALALA | 241.8 | 24,974,248 | 252,269 | 516,996 | 5,767,821 | 58,741 | 119,880 | 636,876 | 6 |
| 3 | MALALA-TORITORI,BASI-MEPANGA | 124.1 | 11,908,251 | 121,342 | 247,569 | 2,180,635 | 22,208 | 45,323 | 292,892 | 8 |
| 4 | TOLITORI-BUOL | 174.2 | 12,595,094 | 127,299 | 260,807 | 3,063,441 | 31,199 | 63,672 | 324,479 | 8 |
| 5 | BUOL-UMU | 141.0 | 11,395,620 | 116,145 | 236,939 | 2,479,594 | 25,253 | 51,537 | 288,475 | 8 |
| 6 | MEPANGA-MOLOSIPAT | 87.9 | 4,208,006 | 45,738 | 90,343 | 1,545,789 | 15,743 | 32,128 | 122,471 | 8 |
| 7 | TOBOLI-MEPANGA | 201.4 | 9,203,058 | 101,273 | 198,825 | 3,540,015 | 36,053 | 73,577 | 272,402 | 8 |
| 8 | TAWALI-POSO | 146.8 | 8,347,087 | 87,812 | 176,291 | 2,581,591 | 26,292 | 53,657 | 229,948 | 9 |
| 9 | TAWAELI - TOBOLI | 40.1 | 15,369,493 | 133,199 | 296,116 | 974,781 | 9,927 | 20,260 | 316,376 | 10 |
| 10 | POSO-TINDATANA | 151.4 | 23,382,185 | 214,322 | 462,173 | 2,662,486 | 27,116 | 55,338 | 517,511 | 9 |
| 11 | TAGOLU-AMPANA | 140.2 | 10,988,608 | 120,377 | 236,856 | 3,344,287 | 34,059 | 69,509 | 306,365 | 8 |
| 12 | AMPANA-LUWUX | 227.0 | 22,777,203 | 236,916 | 478,354 | 5,414,786 | 55,146 | 112,543 | 590,896 | 8 |
| 13 | LUWUX-BATURUBE | 206.5 | 12,011,915 | 129,546 | 256,872 | 4,220,779 | 42,986 | 87,726 | 344,598 | 5 |
| 14 | TARIPA-BETEREME, PAPE-TOMATA | 115.0 | 7,026,157 | 74,117 | 148,594 | 1,629,745 | 16,598 | 33,873 | 182,467 | 6 |
| 15 | UEKUULI-NUHA | 174.0 | 16,549,349 | 165,557 | 340,980 | 2,704,780 | 27,546 | 56,217 | 397,197 | 9 |
| 16 | TOMPIRA-BUNGKU | 103.9 | 9,907,627 | 107,253 | 212,274 | 2,833,120 | 28,853 | 58,884 | 271,158 | 9 |
| 17 | PALU-GINPU | 95.9 | 9,337,297 | 95,462 | 194,437 | 2,561,252 | 26,085 | 53,234 | 247,671 | 4 |
| 18 | TENTENA-GINTU | 186.6 | 29,002,048 | 271,114 | 578,536 | 4,983,624 | 50,755 | 103,581 | 682,118 | 2 |
| 19 | PALU-SIMORA | 45.5 | 3,481,900 | 37,251 | 74,159 | 930,002 | 9,471 | 19,329 | 93,488 | 5 |
| 20 | BIAK-SALODIK | 286.6 | 18,786,502 | 196,785 | 395,922 | 5,857,992 | 59,660 | 121,754 | 517,676 | 5 |
| 21 | PALU-KASIGUNCU, SANGGINORA-BATUNONCU | 226.5 | 29,855,265 | 283,097 | 599,563 | 4,627,528 | 47,128 | 96,180 | 695,743 | 6 |
| 22 | BUNGKU-BORDR OF PROVINCE | 115.0 | 17,252,048 | 176,727 | 359,599 | 2,414,982 | 24,595 | 50,194 | 409,793 | 11 |
| 23 | BATURUBE -TONDOYANDA | 97.4 | 23,981,321 | 225,424 | 479,626 | 2,601,313 | 26,493 | 54,067 | 533,693 | 2 |
| 24 | BUOL-BASI | 121.7 | 8,367,072 | 92,344 | 181,035 | 2,902,993 | 29,565 | 60,337 | 241,371 | 7 |
| 25 | TOLITORI-BASI | 70.5 | 3,666,542 | 41,876 | 80,741 | 1,681,685 | 17,127 | 34,953 | 115,694 | 7 |
| 26 | BANGAI ISLAND | 199.9 | 13,926,375 | 145,129 | 292,749 | 4,085,878 | 41,612 | 84,922 | 377,671 | 5 |
| 27 | BALINGARA-TOILI | 90.0 | 24,130,381 | 212,291 | 468,073 | 2,146,832 | 21,864 | 44,620 | 512,694 | 7 |
| | Total in Central Province | 4,033.9 | 399,427,251 | 3,988,622 | 8,222,551 | 84,416,496 | 859,724 | 1,754,539 | 9,977,090 | |
| | **SOUTHEAST PROVINCE** | | | | | | | | | |
| 28 | LASUSUA-BORDR OF PROVINCE | 171.0 | 31,203,069 | 296,811 | 627,564 | 3,007,167 | 30,626 | 62,502 | 690,065 | 9 |
| 29 | KOLAKA-LASUSUA | 139.0 | 15,500,140 | 157,944 | 322,245 | 2,444,422 | 24,895 | 50,806 | 373,051 | 9 |
| 30 | KUNDARI-KOLAKA | 170.4 | 19,993,147 | 202,005 | 413,932 | 2,998,374 | 30,536 | 62,319 | 476,252 | 9 |
| 31 | BARRU-KASIPUTE | 188.0 | 10,985,233 | 117,388 | 233,831 | 3,306,125 | 33,671 | 68,716 | 302,547 | 9 |
| 32 | POHARA-ASERA | 91.7 | 11,207,129 | 112,711 | 231,507 | 1,709,387 | 17,409 | 35,528 | 267,035 | 9 |
| 33 | ASERA-BORDER OF PROVINCE | 76.0 | 12,407,725 | 116,633 | 248,155 | 1,595,988 | 16,254 | 33,172 | 281,326 | 11 |
| 34 | BELALO-TINANGGEA | 124.0 | 5,004,892 | 58,804 | 111,856 | 1,768,858 | 18,015 | 36,764 | 148,621 | 6 |
| 35 | MOTAHA-TOBIMATE | 59.7 | 2,417,581 | 28,126 | 53,752 | 850,933 | 8,666 | 17,686 | 71,438 | 6 |
| 36 | NANGA NANGA-AMBESIA | 105.8 | 5,913,717 | 63,097 | 125,782 | 2,834,310 | 28,865 | 58,909 | 184,691 | 5 |
| 37 | MANDONGA-TINANGGEA | 107.7 | 4,731,833 | 54,407 | 104,564 | 2,577,851 | 26,254 | 53,579 | 158,143 | 7 |
| 38 | LATE LATE-BAULA | 57.5 | 3,681,835 | 40,809 | 79,836 | 1,376,290 | 14,017 | 28,605 | 108,441 | 7 |
| 39 | POLIPOLIA-KASIPUTE | 127.7 | 10,142,667 | 107,502 | 215,014 | 2,610,138 | 26,582 | 54,250 | 269,264 | 4 |
| 40 | ALANGGA-PUNGGALUKU | 31.2 | 1,387,052 | 15,738 | 30,441 | 442,157 | 4,503 | 9,190 | 39,631 | 5 |
| 41 | TAMPE-WARA | 136.2 | 9,228,625 | 95,125 | 192,948 | 3,226,591 | 32,861 | 67,062 | 260,011 | 8 |
| 42 | NUNA ISLAND K | 193.7 | 8,302,656 | 94,883 | 182,891 | 5,173,247 | 52,686 | 107,522 | 290,413 | 5 |
| 43 | BUTON ISLAND | 292.0 | 15,152,346 | 166,541 | 327,156 | 6,965,276 | 70,937 | 144,768 | 471,925 | 7 |
| 44 | BUTON ISLAND K | 242.9 | 26,419,373 | 254,537 | 534,582 | 4,964,781 | 50,563 | 103,190 | 637,772 | 5 |
| 45 | TRANCE PENI | 153.0 | 12,690,651 | 119,292 | 253,813 | 4,086,251 | 41,616 | 84,930 | 338,743 | 5 |
| 46 | UNAAHA-ABUKI | 13.3 | 798,838 | 8,625 | 17,093 | 271,847 | 2,769 | 5,650 | 22,743 | 6 |
| 47 | TOLUIU-MOWEWE | 37.5 | 3,408,704 | 36,138 | 72,270 | 787,494 | 8,020 | 16,368 | 88,638 | 9 |
| | Total in Southeast Province | 2,518.3 | 4,379,234 | 2,147,116 | 4,379,234 | 1,101,516 | 539,743 | 1,101,516 | 5,480,750 | |
| | Ground Total (Mill Rp) | 6,552.2 | 12,601,785 | 6,135,738 | 12,601,785 | 85,518,012 | 1,399,467 | 2,856,055 | 15,457,840 | |

*Source: Study Team*

Figure 6.11 shows the implementation schedule of each road link for five-year spans from 1999 to 2018.

## 6.6 Economic Analysis

The unit vehicle operating costs are determined by both speed and IRI (International roughness index) conditions in each road link. The data of speed and IRI for each road link in the "without" case were based on the inventory data compiled by Bina Marga and reviewed by the Study Team. Those in the "with" case were assumed from the viewpoint of the engineering study by the Study Team.

The analysis follows the conventional discounted cash flow method in determining the economic internal rate of return (EIRR), the net present value (NPV) and the benefit cost ratio (B/C). The project life is assumed to be 25 years following the year 2003.

The benefits in the intermediate years were interpolated and those beyond 2018 were assumed to be fixed. The efficiency measures were calculated and the results are as follows:

**Table 6.8 Result of Economic Analysis**

| Efficiency Measures | |
|---|---|
| EIRR | 24.3 % |
| NPV (Million Rp.) | 1,670,981 |
| B/C | 1.61 |

Discount Rate: 15 %

These results indicate that the implementation of the Project (road development master plan of the two provinces of Central Sulawesi and Southeast Sulawesi) is economically feasible.

## 6.7 Budgetary Plan

To attain budgetary guideline for the investment of the road network master plan, high annual increase of budget is required for each Five-Year Plan from year 1999 to 2018

In case of an annual increase of 10%, about 2,900 billion Rp. in the first 5-year plan (1999-2003) will be available to invest in road maintenance, rehabilitation, improvements, and new construction.

The following are the available budget covering the period of 20 years from year 1999 to 2018.

**Table 6.9 Budgetary Guideline for Central and Southeast Province**

| Covering Period | 1999 - 2003 | 2004 - 2008 | 2009 - 2013 | 2014 - 2018 |
|---|---|---|---|---|
| Annual increase of budget for investment | 10 % | 6 % | 4 % | 0 % |
| Available budget for investment for each period (Billion Rp.) | 2,900 | 4,100 | 5,200 | 5,600 |
| Accumulative (Billion Rp.) | 2,900 | 7,000 | 12,200 | 17,800 |

## 6.8 Effects of Road Network Master Plan on Industries

Development and improvements in the road network have various effects not only on roadside development and productivity but also on road users and regional society as a whole. "Direct effects" of such road development, or beneficial effects occurring without the intervention of a third party, include the following.

- Securing of emergency access to disaster-stricken areas i.e.s areas affected by storms, landslides, fires, etc.
- Improving of living standards and opportunities for cultural and economic exchange such as living standards, employment, new business
- Improvement of public services in hospitals, schools, telephone, ports, etc.
- Improved productivity in agro-industries, transmigration, mining, agriculture, etc.
- Growth in opportunities to local industries such as agriculture, tourism, agri-forest, fishery, etc.
- Businesses benefiting from road construction: construction, quarrying, cement, etc.
- Effective land use: horticulture, transmigration, agriculture, etc.

## 6.9 Selection of Road Links for Pre-Feasibility Study

Road link Nos..1, 4, 5, 6, 7, 8, 9, 10, 11, 12, 15, 16, 22, 28, 29, 30, 31, 32, 33, 41 and 47 are accorded high priority based on the appraisal score shown in Table 6.8.

However, road link Nos.. 1, 6, 7, 10, 11, 12, 28, 29, 30 and 47 were not studied under the pre-feasibility study as they have already been the object of investment at some point within the past 5 years. In addition, road link No. 9 was omitted from the pre-feasibility study as this road link had been selected for the feasibility study due to its high priority and urgent need of improvement.

Because of the above reasons, road link Nos.. 4, 5, 8, 15, 16, 22, 28, 31, 32 and 33 were selected for the pre-feasibility study for roads totalling of 1,210.6 km in length which are to serve as road links by the year 2008.

Road links for pre-feasibility study are shown in Table 6.10.

**Table 6.10 Road Links for Pre-Feasibility Study**

| Link No. | Road Length (km) | Location | Province |
|---|---|---|---|
| 4 | 174.2 | Toli Toli – Buol | Central Sulawesi |
| 5 | 141.0 | Buol – Umu | Central Sulawesi |
| 8 | 146.8 | Toboli – Poso | Central Sulawesi |
| 15 | 174.0 | Uekuli – Nuha | Central Sulawesi |
| 16 | 103.9 | Tompira – Bungku | Central Sulawesi |
| 22 | 115.0 | Bungku – Provincial Border | Central Sulawesi |
| 31 | 188.0 | Barru – Kasipute | Southeast Sulawesi |
| 32 | 91.7 | Pohara – Asera | Southeast Sulawesi |
| 33 | 76.0 | Asera – Provincial Border | Southeast Sulawesi |
| Total | 1210.6 | | |

*Source: Study Team*

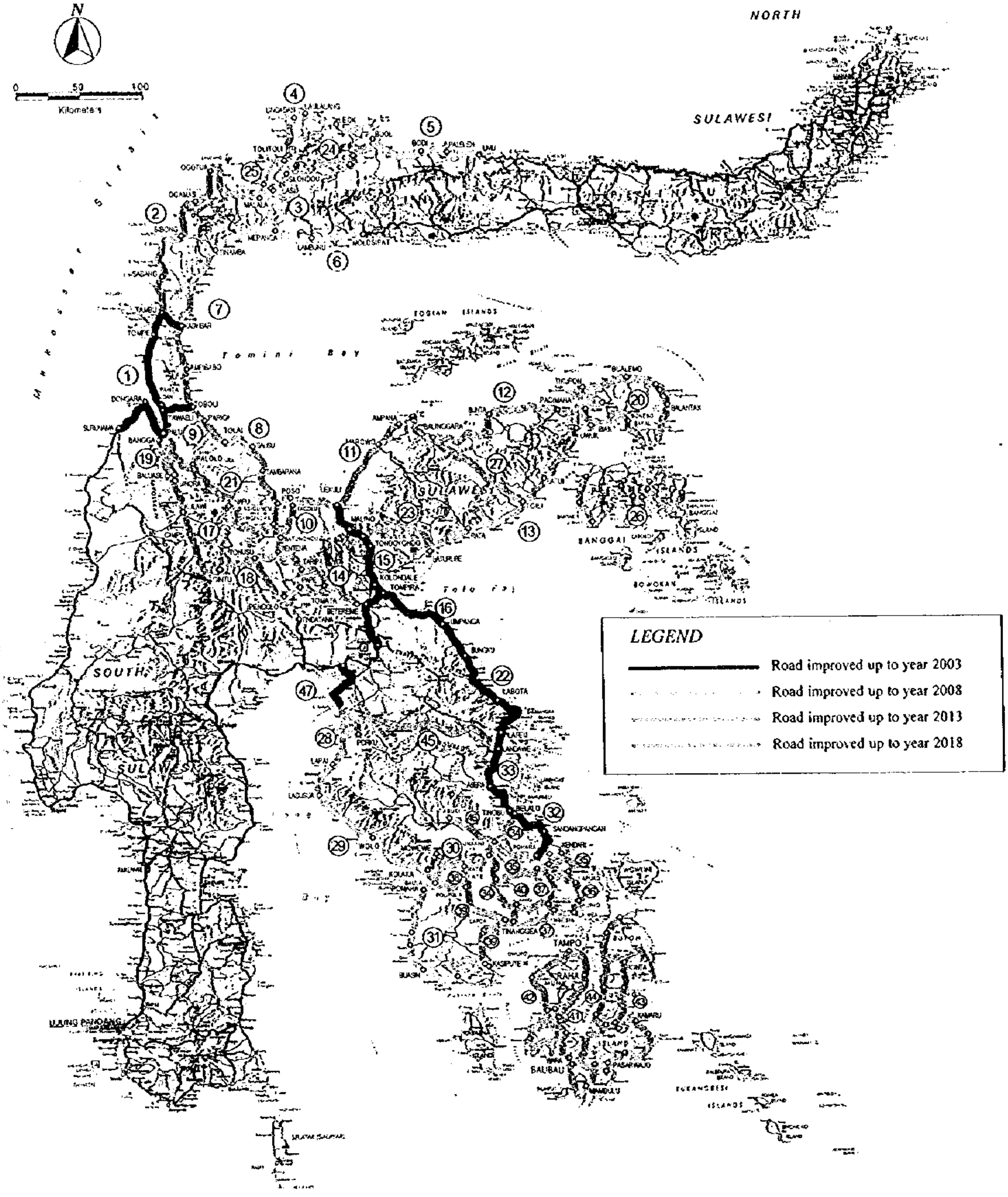



**Figure 6.11 Map of Implementation Schedule for Each Road Link**

# PART-II

# PRE-FEASIBILITY STUDY

## PART-II PRE-FEASIBILITY STUDY

## 7. DESIGN STANDARDS FOR PRE-FEASIBILITY STUDY

The pre-feasibility study for nine (9) links of 1,200.2 km has been conducted based on the recommendations of master plan study.

The geometric design uses the "Standard Specification for Geometric Design of Road" (December 1990) of Bina Marga together with AASHTO and Japanese design standards. The Bina Marga standards are of the same quality of design criteria as AASHTO, and Japanese design standards.

### 7.1 Geometric Design Standard for Pre-Feasibility Routes

Based on the above, geometric design standards have been established as shown in Table 7.1.

**Table 7.1 Geometric Design Standard**

| Terrain | | Flat, Rolling | Mountain | Mountain |
|---|---|---|---|---|
| Design Speed | Km/h | 60 | 40 | 30 |
| Lane Width | M | 3.00 x 2 | 3.00 x 2 | 3.00 x 2 |
| Shoulder Width | M | 2.0 - 1.0 | 2.0 - 1.0 | 2.0 - 1.0 |
| Crossfall of Pavement | % | 2 | 2 | 2 |
| Crossfall of Shoulder | % | 4 | 4 | 4 |
| Min. Radius Curve | M | 115 | 50 | 30 |
| Min. Curve Length | M | 100 | 70 | 50 |
| Max. Gradient | % | 5 | 7 | 8 |
| Abs. Max. Gradient | % | 9 | 11 | 12 |

*Source: Study Team*

### 7.2 Typical Cross Section

Two types of typical cross sections of road are shown in Figures 6.5 and 6.6.

### 7.3 Bridge Design Standards

The design work of the proposed bridge structures will be carried out in accordance with the "Bridge Design Code (Directorate General of Highways, Indonesia)" (hereinafter referred to as "Indonesian Bridge Design Code") as the prime design standard. Although the principal design concept is in accordance with the Indonesian Design Code, a bridge specification established by the American Association of State Highway and Transportation Officials (hereinafter referred to as "AASHTO") and a specification issued by the Japan Road Association as listed in (2) below will be applied as the need arises.

The structural calculation method for the bridge design will basically follow the "Allowable Stress Design (working stress design) Method" in accordance with the Indonesian Bridge Design Code. However, prestressed concrete structures will be designed to accommodate the ultimate loading conditions prescribed in the code.

## 8. PREPARATORY ENGINEERING DESIGN

### 8.1 Field Reconnaissance

In order to gain an understanding of the roadside topography and current road conditions, including the pavement, road slope, and bridge conditions for the 1,200-km section of the road to be examined in the pre-feasibility study, site reconnaissance was made supported with data from a 1:50000 topographic map, existing road inventory, geologic map, and current load use. Consideration was also given to the possibility of roadside land use/development.

Figure 8.1 shows the location of the routes for the pre-feasibility study, which have been selected from the road network master plan.

### 8.2 Road Traffic

Study result of traffic forecast for Pre-feasibility routes are as shown in Table 8.1. The figures will be used for pavement design and road widths.

**Table 8.1 Future Traffic Volumes of Pre-F/S Routes**

| Link No. / Vehicle Type | Link 4 (veh/day) | | Link 5 (veh/day) | | Link 8 (veh/day) | |
|---|---|---|---|---|---|---|
| | 2003 | 2018 | 2003 | 2018 | 2003 | 2018 |
| Motorcycles | 106 | 37 | 8 | 33 | 934 | 2664 |
| Passenger Cars | 5 | 17 | 7 | 22 | 318 | 1115 |
| Buses | 14 | 10 | 6 | 19 | 454 | 1593 |
| Trucks | 14 | 15 | 3 | 10 | 768 | 2788 |
| Total | 139 | 79 | 24 | 84 | 2474 | 8160 |

| Link No. / Vehicle Type | Link 15 (veh/day) | | Link 16 (veh/day) | | Link 22 (veh/day) | |
|---|---|---|---|---|---|---|
| | 2003 | 2018 | 2003 | 2018 | 2003 | 2018 |
| Motorcycles | 261 | 577 | 352 | 502 | 335 | 441 |
| Passenger Cars | 126 | 352 | 190 | 285 | 162 | 224 |
| Buses | 242 | 480 | 349 | 385 | 333 | 347 |
| Trucks | 396 | 862 | 602 | 816 | 569 | 750 |
| Total | 1025 | 2271 | 1493 | 1988 | 1399 | 1762 |

| Link No. / Vehicle Type | Link 31 (veh/day) | | Link 32 (veh/day) | | Link 33 (veh/day) | |
|---|---|---|---|---|---|---|
| | 2003 | 2018 | 2003 | 2018 | 2003 | 2018 |
| Motorcycles | 70 | 313 | 400 | 543 | 335 | 450 |
| Passenger Cars | 10 | 83 | 176 | 239 | 162 | 230 |
| Buses | 110 | 280 | 415 | 417 | 333 | 352 |
| Trucks | 142 | 464 | 601 | 775 | 569 | 769 |
| Total | 332 | 1140 | 1592 | 1974 | 1399 | 1801 |

*Source: Study Team*

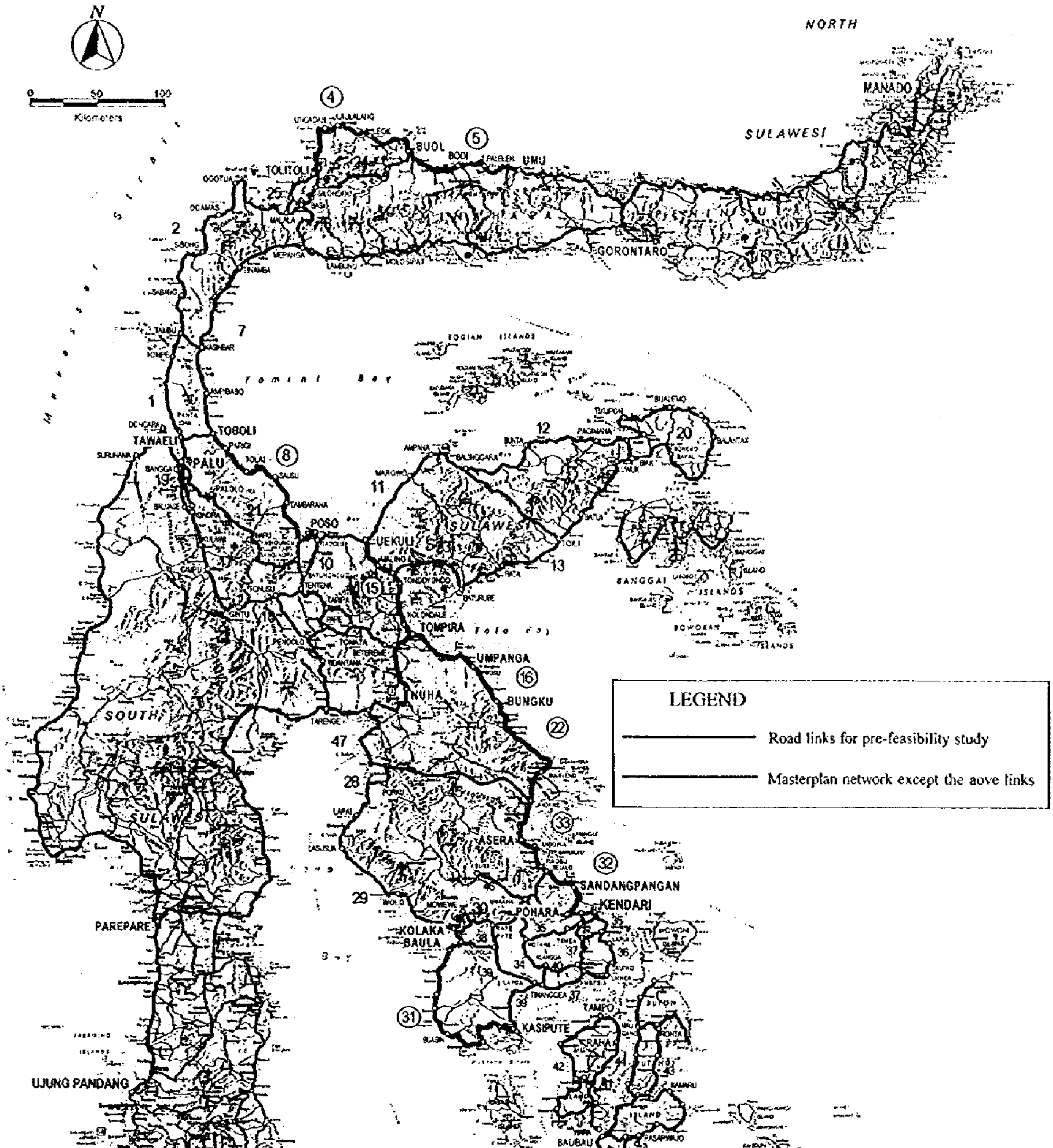



**Figure 8.1 Road Link Map of Pre-feasibility Study**

## 8.3 Preparatory Engineering for the Pavement

Design CBR of 5% to 6 % was used based on the results of the CBR Test conducted by the study team.

Design traffic volume for the pavement design is to be for a period of 20 years.

For the pavement structure, four types of design shown in Figure 8.2 are planned on the basis of the traffic volumes of heavy vehicles (buses and trucks) in the year 2018. The pavement surface is designed in two layers. The lower layer will be asphaltic cement on a bituminised base course. An upper 5-cm layer of asphaltic cement will be overlaid in the future. The base course will be treated with buton (natural) asphalt while the subbase will be made from mechanical stabilized crushed stone.

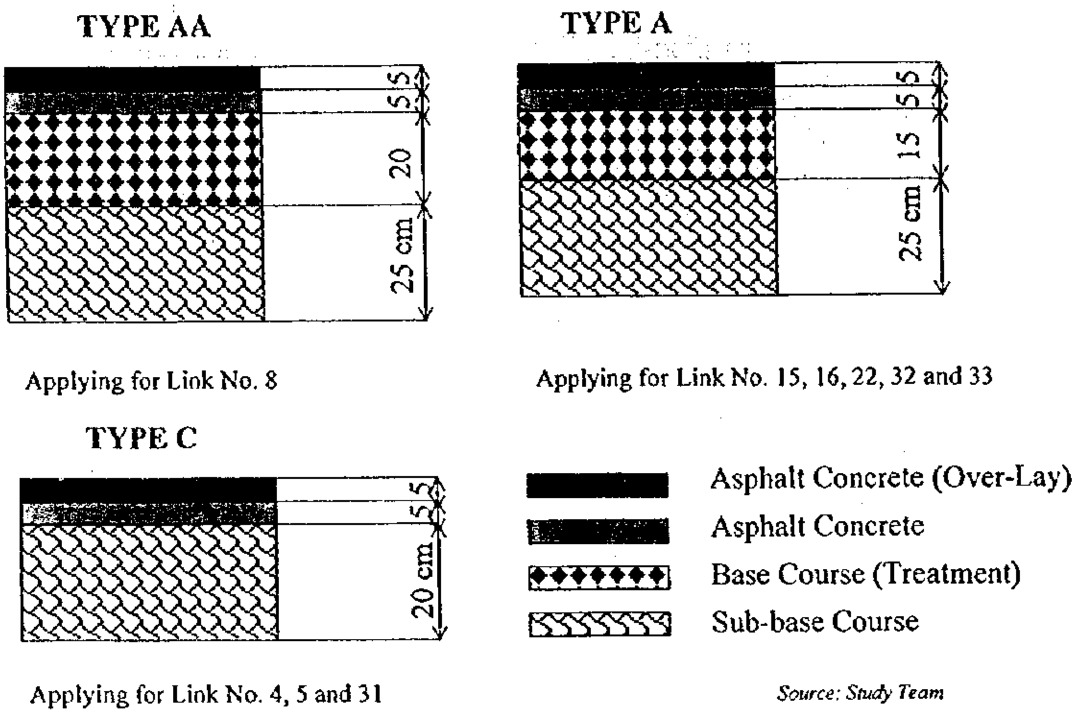


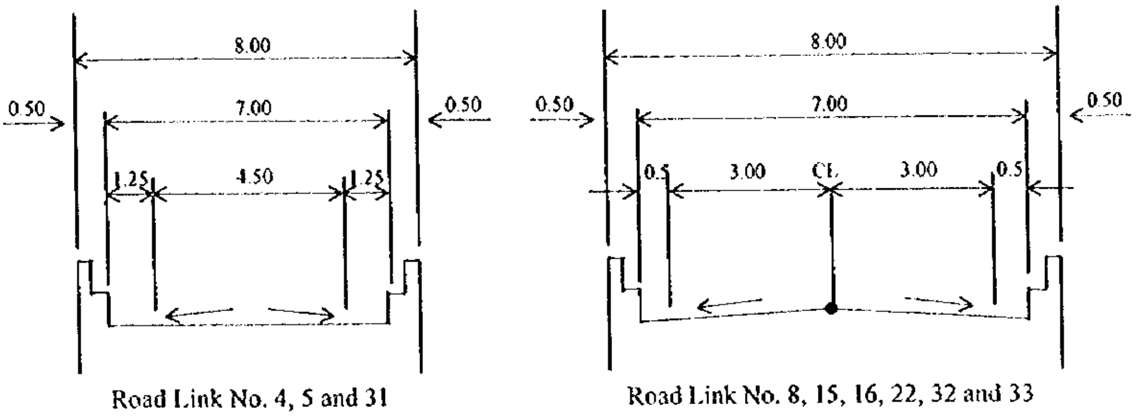

**Figure 8.2 Pavement Structure by Type**

## 8.4 Preparatory Engineering of Bridges

The minimum effective width of a bridge is defined as 7.0 m. However, in consideration of an economic improvement programme and single carriageway road, when the bridge has sufficient durability, the bridge is not improved as it is judged that traffic flow will not be affected by the narrower width.

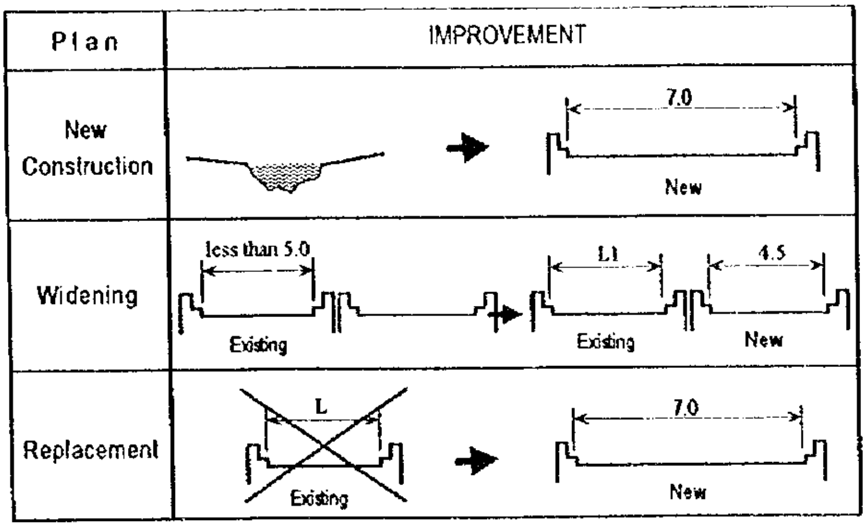
On the other hand a bridge of inadequate durability will be replaced (reconstructed) even if it is of sufficient width.

For roads of link Nos.4, 5, 8, 15, 16, 22, 31, 32 and 33, typical cross sections for bridges are shown in Figure 8.3. Figure 8.4 shows the concept of bridge improvement plan.




*Source: Study Team*

**Figure 8.3 Typical Cross Section of New Bridge for Road Link of Pre-F/S**




*Source: Study Team*

**Figure 8.4 Bridge Improvement Plan for Road Link of Pre-F/S**

Bridge improvements on the roads of F/S links is summarized in Table 8.2.

**Table 8.2 Summary of Quantity of Bridge Improvement for Road Links**

| | Link Name | Road Length (km) | Quantity of Bridge Construction (m²) Classification by Span Length: L (m) | | | |
|---|---|---|---|---|---|---|
| | | | L<=10m | 10m<L<=20m | 20m<L<=30m | L>30m |
| 4 | Toli Toli – Buol | 174.2 | 1,775 | 158 | 95 | 353 |
| 5 | Buol – Unu | 141.0 | 749 | 420 | 1,170 | 3,128 |
| 8 | Toboli – Poso | 146.8 | 83 | 0 | 0 | 2,649 |
| 15 | Uekuli – Nuha | 174.0 | 1,010 | 187 | 1,334 | 0 |
| 16 | Tompira – Bungku | 103.9 | 780 | 1,440 | 3,150 | 240 |
| 22 | Bungku – Border of Province | 115.0 | 2,540 | 1,084 | 1,558 | 1,558 |
| 31 | Barru – Kasipute | 188.0 | 2,356 | 1,058 | 826 | 482 |
| 32 | Pohara – Asera | 91.7 | 2,213 | 0 | 540 | 0 |
| 33 | Asera – Border of Province | 76.0 | 480 | 630 | 0 | 360 |

*Source: Study Team*

## 8.5 Preparatory Engineering of Slope Protection Works

Slope protection works are provided to protect the slopes from erosion or weathering by covering them with vegetation or structures and also to stabilize the slopes by means of drainage works or retaining structures. The following types of slope protection works are adopted for the pre-feasibility route considering the terrain and geology, as shown in Table 8.3. Figure 8.5 shows proposed slope protection samples for the disaster-prone areas of existing slopes.

**Table 8.3 Quantities of Slope Protection**

| Road Link No. | Cut | | | Fill |
|---|---|---|---|---|
| | Sprayed Concrete Cribwork ($m^2$) | Shortcrete ($m^2$) | Stone Masonry ($m^2$) | Mat Gabion ($m^2$) |
| 4 | 10,697 | 0 | 6,554 | 10,557 |
| 5 | 5,811 | 0 | 3,561 | 5,735 |
| 8 | 0 | 0 | 0 | 0 |
| 15 | 12,745 | 114,707 | 7,809 | 12,578 |
| 16 | 0 | 0 | 0 | 0 |
| 22 | 14,646 | 131,812 | 8,974 | 14,454 |
| 31 | 7,513 | 67,619 | 4,603 | 7,415 |
| 32 | 5,042 | 45,379 | 3,089 | 4,976 |
| 33 | 12,880 | 115,918 | 7,892 | 12,711 |

# 9. COST ESTIMATES AND ECONOMIC ANALYSIS

The cost estimates and economic analysis were conducted and summarized as shown in Table 9.1. The results of economic analysis indicate that the benefit of road link Nos... 4 and No. 5 are very small, but the others are viable.

**Table 9.1 Summary of Cost Estimates and Economic Analysis**

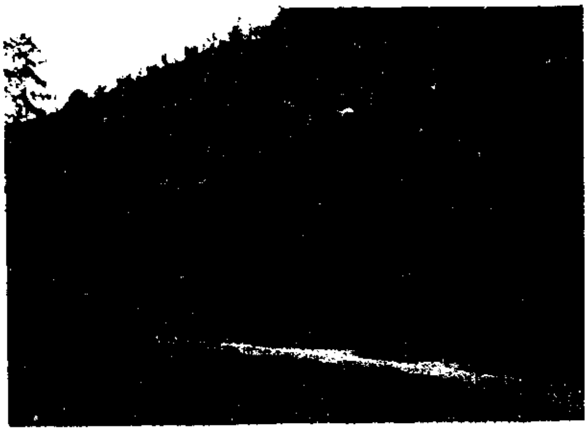
| Road Link No. | Length (km) | Construction Cost (Mill. Rp) | Unit Cost (Mill. Rp/km) | E.I.R.R. (%) | B/C |
|---|---|---|---|---|---|
| 4 | 174.2 | 223,100 | 1,280.7 | 0 | - |
| 5 | 141.0 | 169,676 | 1,394.9 | 0 | - |
| 8 | 146.8 | 216,763 | 1,476.6 | 64.7 | 7.95 |
| 15 | 174.0 * | 362,449 | 2,814.0 | 28.8 | 2.39 |
| 16 | 103.9 | 236,511 | 2,276.3 | 27.3 | 2.13 |
| 22 | 115.0 | 433,747 | 3,771.7 | 17.5 | 1.20 |
| 31 | 188.0 | 259,262 | 1,379.8 | 19.0 | 1.32 |
| 32 | 91.7 | 207,438 | 2,548.4 | 25.8 | 1.97 |
| 33 | 76.0 | 211,912 | 2,788.3 | 23.5 | 1.73 |
| Total | 1210.6 | 2,347,858 | 2,032.8 | - | - |

*Source: Study Team*

* The length of 128.8 km was estimated for the improvement out of 174.0 km of link No.15.

**Sprayed Concrete Cribwork Type**

**Existing Slope**



**Proposed Slope Protection**

**Shotcrete Type**

**Existing Slope**

**Proposed Slope Protection**

**Figure 8.5 Image of Slope Protection**

## 10. CONCLUSION AND RECOMMENDATION OF PRE-FEASIBILITY STUDY

A feasibility study section of 300 km should be selected from the pre-feasibility study of about 1,200 km by taking into account the seven items shown in Table 10.1.

Table 10.2 shows the result of counts taken for each of the above items. Road link Nos.16, 22, 33 and 32 were selected for the feasibility study based on the following reasons:

- Road link Nos. 16, 22, 32 and 33 of the east route in Central and Southeast Sulawesi should be improved for the continuity between Poso and Kendari. These links should be given priority as they are part of the Trans-Sulawesi East Route.
- Road link No. 8 has been already invested for the improvement within the past 5 years and has sufficient traffic capacity at present.
- The Tompira-Umpanga section of road link No.16 is completely improved and thus excluded from the scope of feasibility study.
- For road link No.32, the Pohara-Sandangpangan section is currently under improvement and also excluded from the feasibility study.

**Table 10.1 Criteria for Evaluation**

| Appraisal Items | Points |
|---|---|
| 1. Traffic Demand (heavy vehicles per day) | |
| a. More than 3000 | 3 |
| b. From 200 to 3000 | 2 |
| c. Less than 200 | 1 |
| 2. Existing Land Use | |
| a. Extremely high | 3 |
| b. High | 2 |
| c. Normal | 1 |
| 3. Development Possibilities | |
| a. Extremely high | 3 |
| b. High | 2 |
| c. Normal | 1 |
| 4. Hierarchy of the Road Network | |
| a. Gross Corridor | 3 |
| b. Sub-Gross Corridor | 2 |
| c. Corridor | 1 |
| 5. Direct Effect (EIRR) | |
| a. Extremely high (More than 20%) | 3 |
| b. High (From 15% up to 20%) | 2 |
| c. Normal (Less than 15%) | 1 |
| 6. Indirect Effect | |
| a. Extremely high | 3 |
| b. High | 2 |
| c. Normal | 1 |
| 7. Environmental Assessment | |
| a. No impact | 3 |
| b. Small impact | 2 |
| c. Heavy impact | 1 |

*Source: Study Team*
(Notes: Weight of points was decided by Study Team for reference)

## Table 10.2 Evaluation for Road Links of Pre-Feasibility

| Evaluation Items | Project Package Link No. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 5 | 8 | 15 | 16 | 22 | 31 | 32 | 33 |
| 1. Traffic Demand | 1 | 1 | 3 | 2 | 2 | 2 | 1 | 2 | 2 |
| 2. Existing Land Use | 1 | 1 | 3 | 1 | 2 | 1 | 2 | 1 | 1 |
| 3. Development of Possibilities | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| 4. Road Hierarchy | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| 5. Direct Effect (EIRR; %) | 1 (-) | 1 (-) | 3 (65) | 3 (29) | 3 (27) | 2 (18) | 2 (19) | 3 (26) | 3 (24) |
| 6. Indirect Effect | 3 | 3 | 1 | 3 | 2 | 3 | 2 | 2 | 3 |
| 7. Environment | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| Total | 14 | 14 | 17 | 16 | 18 | 17 | 15 | 17 | 18 |

*Source: Study Team*

A road length totalling 300 km is recommended for the Feasibility Study, as shown in Table 10.3.

## Table 10.3 Recommended Road Links for Feasibility Study

| Link No. | Road Length (km) | Location | Remarks |
|---|---|---|---|
| 16 | 51 | Umpanga-Bungku | Umpanga is located 53 km south of Tompira |
| 22 | 115 | Bungku-Border of Province | |
| 33 | 76 | Border of Province-Asera | |
| 32 | 58 | Asera-Sandangpangan | Sandangpangan is located 24 km north of Pohara |
| Total | 300 | | |

*Source: Study Team*

# PART-III

# FEASIBILITY STUDY FOR TAWAELI-TOBOLI ROAD

# PART-III FEASIBILITY STUDY FOR TAWAELI-TOBOLI ROAD

## 11. GENERAL

The road between Tawaeli and Toboli (the Tawaeli - Toboli road) is located to the north of Palu, the capital city of Central Sulawesi. This route is an important arterial road together with the Trans-Sulawesi Road, connecting with road networks of North, Central, and South Sulawesi. The total length of this route is approximately 45 km with altitudes from 3 m to 865 m above sea level. Though this road is important as an arterial road, landslides, slope failures, and other problems frequently occur at present. Such events adversely affect traffic and economic activities. Improvement of this road will contribute to the economic and social activities of all people in Sulawesi.

Since January 1997 this section has been receiving investment for the rehabilitation of pavement and removal of debris and soil caused by slope failure in order to maintain safe travelling, with a budget of 2.5 billion Rp. assisted by ADB fund.

## 12. ENGINEERING SURVEY

### (1) Aerial Photographic Survey

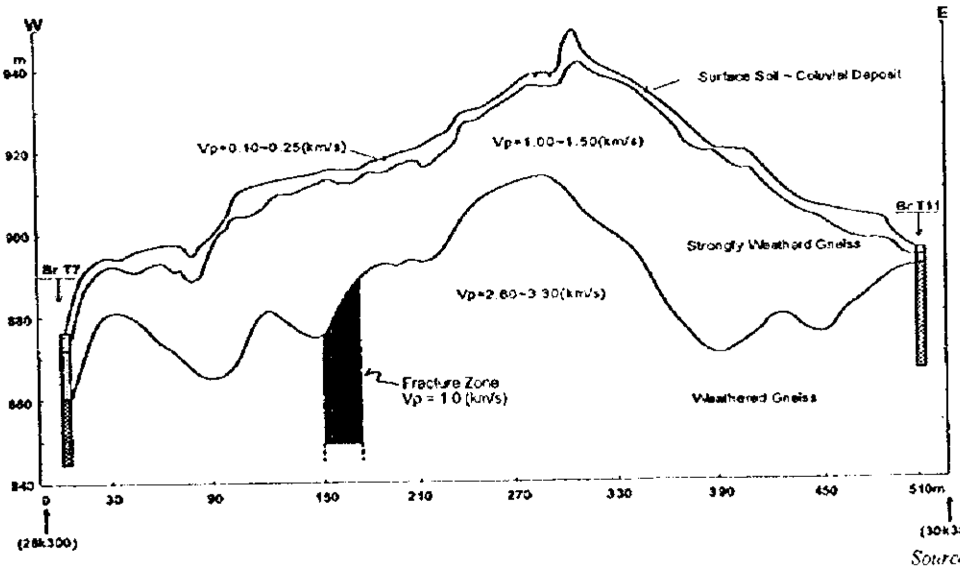
Aerial photogrammetry and ground survey were carried out in order to prepare the 1:5000 topographic map and longitudinal profile data necessary for the preliminary design of the Feasibility Study for Tawaeli-Toboli Road.

### (2) Soil and Material Survey

Boring survey was carried out between Tawaeli and Toboli. The total number of boreholes was twenty-three (23). Purpose of boring survey is to obtain information on:

a) Geological conditions of entrances and the center of planned tunnel.
b) Geological condition at sites of proposed bridges

Seismic prospecting was carried out to obtain geological information of proposed tunnel route. Seismic profile lines are shown in Figure 12.1.




*Source: Study Team*

**Figure 12.1 Seismic Profile of Proposed Tunnel Location**

## 13. DESIGN STANDARDS FOR TAWAERI-TOBOLI ROAD

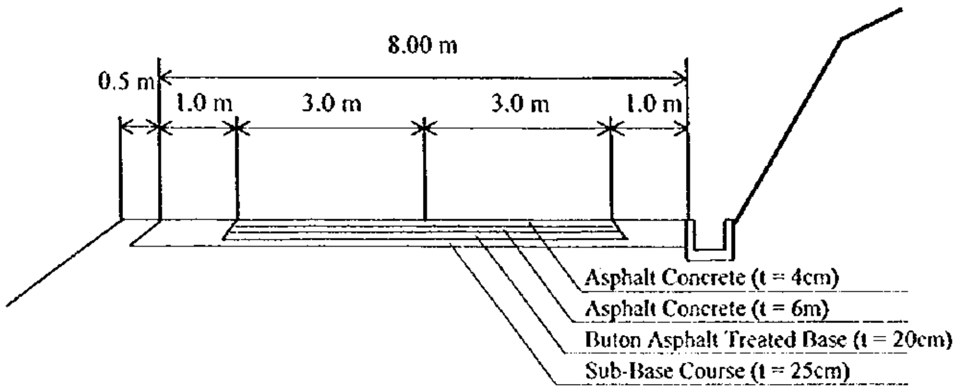
Considering the present road conditions and alignment, the service level of the Tawaeli-Toboli road is very low compared with the other primary arterial roads. Design criteria should be reconsidered to adjust to future traffic demand, and service level should be upgraded to that of primary arterial road.

The Summary of design standards is shown in Table 13.1.

**Table 13.1 Design Standards**

| Items | Design Standards |
|---|---|
| 1. Road Classification | Arterial Road |
| 2. Design Standards | 60 km/h (Flat & Rolling Terrain)<br>30 km/h (Mountainous Terrain) |
| 3. Number of Lanes | Two lanes |
| 4. Typical Cross Section | See Figure 13-1. |
| 5. Geometric Design Standards | See Table 7-1. |
| 6. Pavement | AASHTO pavement design,<br>Pavement design standards in Japan |
| 7. Bridge | Indonesian bridge design code<br>AASHTO and Japanese bridge design specification |
| 8. Tunnel | Indonesian road geometric standards,<br>Design standards for road tunnel, Japan |
| 9. Road Traffic | 1997:886 veh/day, 2018:3849 veh/day |

*Source: Study Team*




*Source: Study Team*

**Figure 13.1 Typical Cross Section for Tawaeli-Toboli Road**

## 14. SELECTION OF ROUTE LOCATION

### 14.1 Field Reconnaissance Survey of Tawaeli-Toboli Road

Field reconnaissance survey was carried out from 9th to 12th April and 20th to 24th May 1997, in which existing road, bridge, disaster areas and alternative routes were investigated.

### 14.2 Alternative Route and Selections

#### (1) Alternative Routes

The existing road is obviously in a dangerous condition. To cope with this situation, alternative routes have been studied based on the following policy.

- To avoid large cutting slopes in areas prone to landslides and slope failures including new route alignment;
- To provide counter-measure facilities against earth movements where there are cut-and-fill slopes;
- To sustain living environment of local inhabitants;
- To secure dual-lane traffic throughout the year:
- To sustain environmental conditions; and
- To up-grade service level.

Based on this policy, four alternative routes were determined through considering the design standards:

Figure 14.1 shows the comparison of alternate routes. The characteristics of each route are:

Alternative A: This is an improvement of the existing road. There is difficulty in improving vertical alignment due to the steep terrain; therefore, sight distance should be maintained. Minimum radius is 15m with a design speed of 20km/h.

Alternative B: Minimum curve radius of 30 m was applied with design speed of 30 km/h. Tunnel is provided to avoid a landslide area. Bridges are added in conjunction with improved road alignment. Other improvements are the same as alternative A.

Alternative C: A bypass is proposed to provide lower cost of disaster mitigation facilities and less traffic impact during the construction of the bypass. Other improvements are the same as alternative B except for the bypass.

Alternative D: Provides preferable service level of design speed of 40 km/h to satisfy the criteria for arterial road with 5 tunnels, bridges and 2 bypasses.

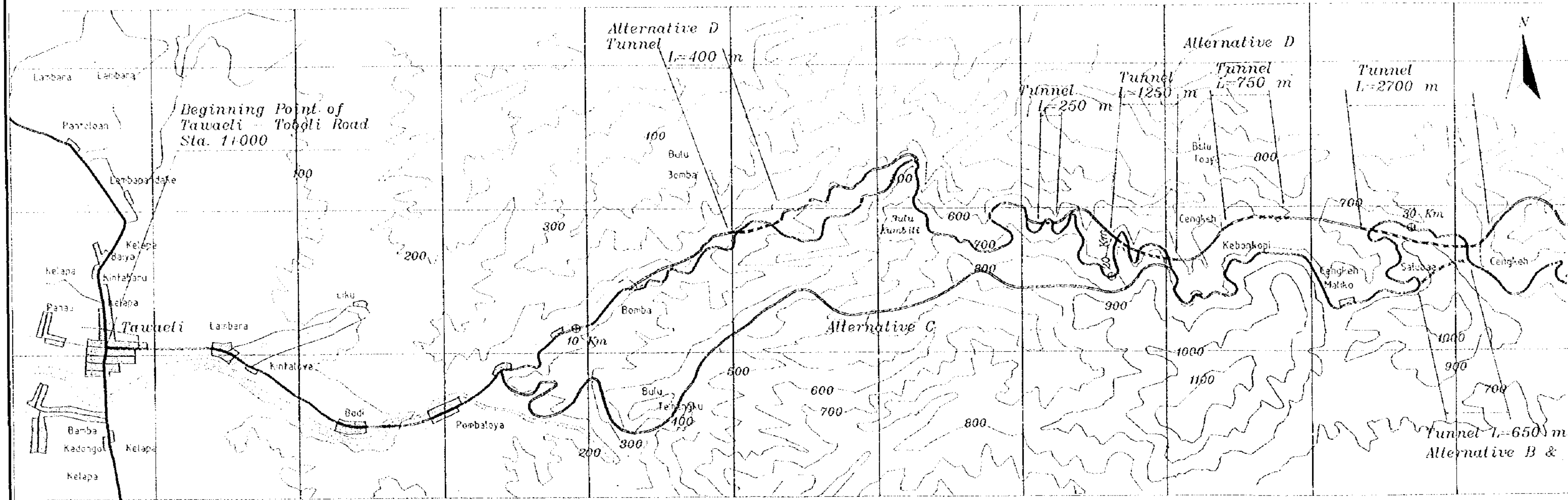
Project cost of each alternative is as shown Figure 14.2.

11 Km

25 Km

33 Km

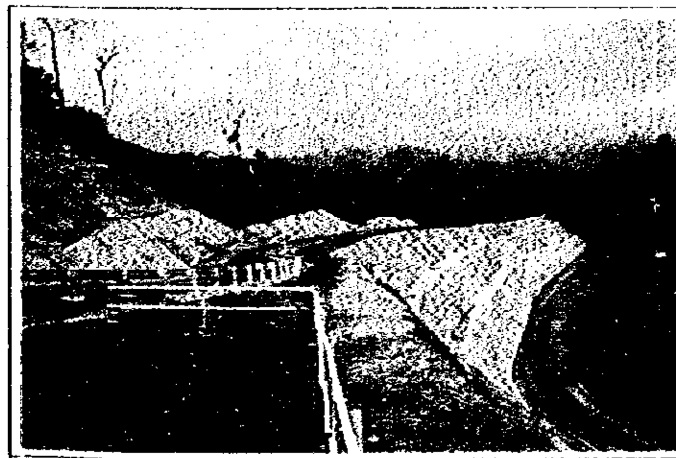
44 Km



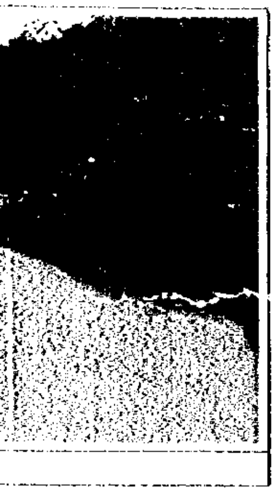

13 Km

31.5 Km

40 Km

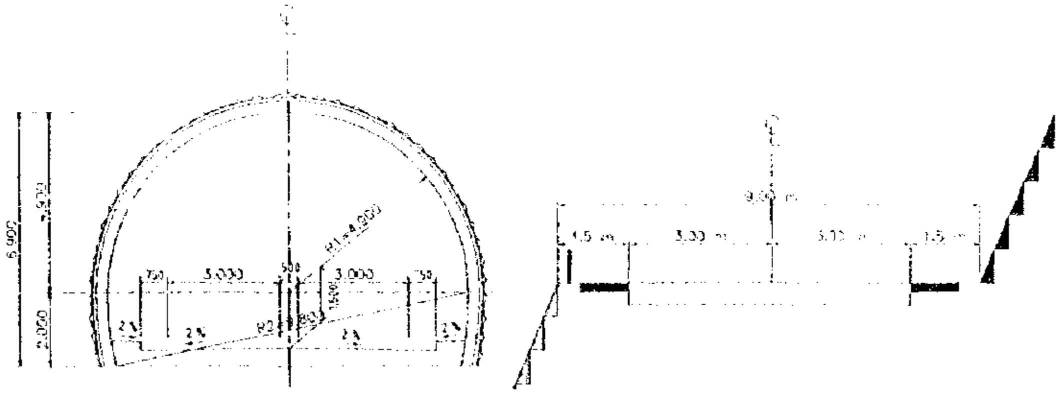


Construction Example

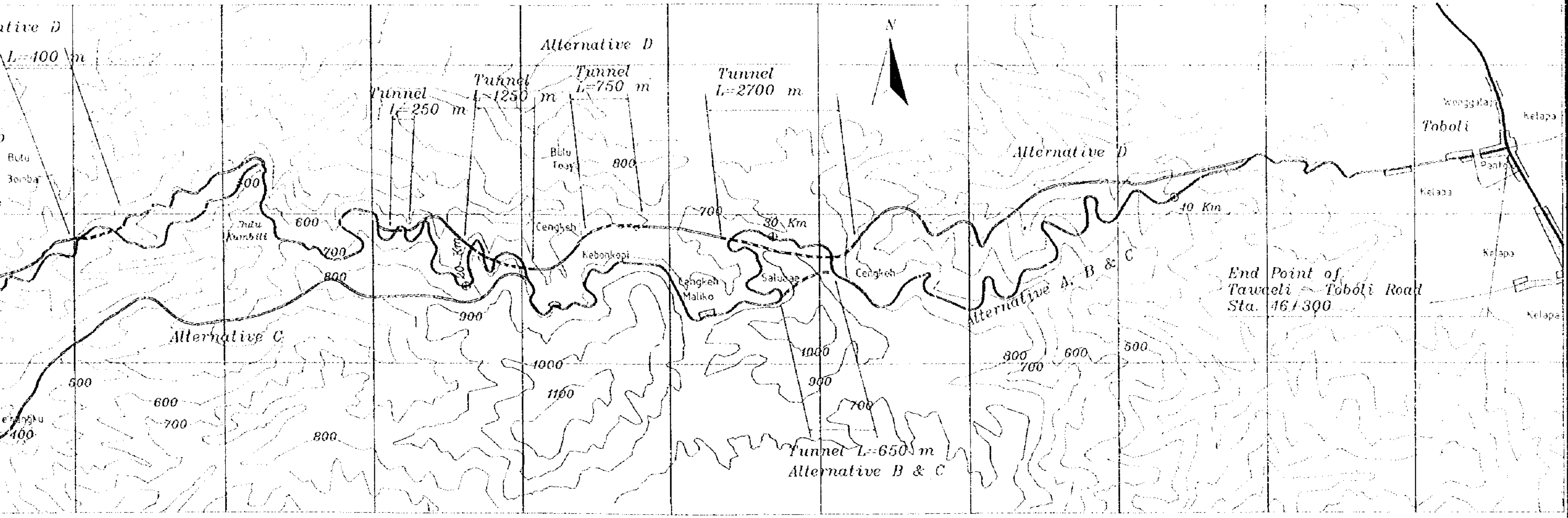


33 Km

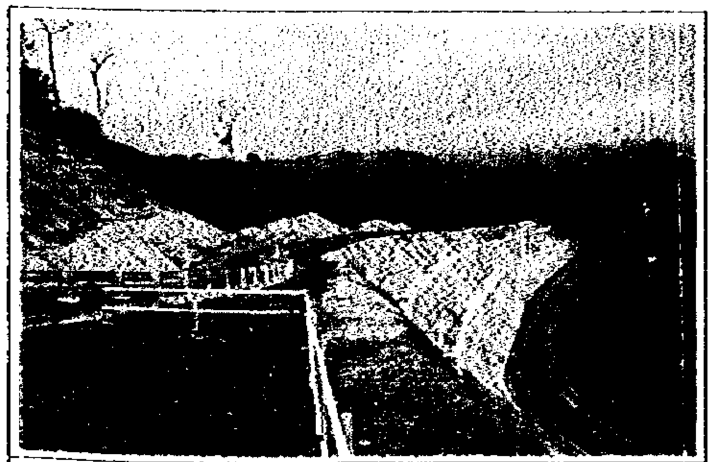
44 Km



Typical Tunnel Section and Cross Section




40 Km



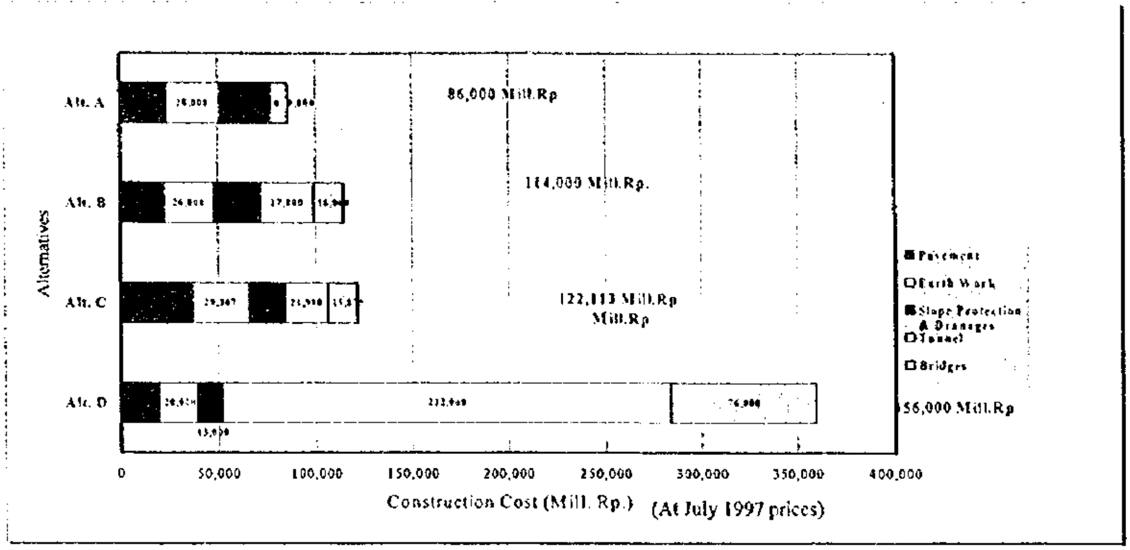
Construction Example

SCALE 1 : 50.000

0 km 1 km 2 km 4 km

| Alternative | Length Km |
|---|---|
| A (Red) | 45.30 |
| B (Red) | 42.35 |
| C (Blue) | 41.35 |
| D (Black) | 33.42 |

**Figure 14.1 Location of Alternative Routes**




*Source: Study Team*

## Figure 14.2 Comparative Construction Cost for Each Alternative

### (2) Recommendations

Alternative A has the lowest construction cost but the design speed of 20 km/h is not acceptable and the route length of 45.3 km is longer than the other alternatives. Alternative D has a preferable design speed of 40 km/h and the shortest route length, but the cost of Rp 356 billion is too great to attain economic viability.

Alternative C has the following advantageous and disadvantageous points in comparison with Alternative B:

- This route is shorter than Alternative B by 1.5 km, avoiding critical disaster-prone areas.
- There is less impact on traffic in Alternative C during construction as the existing section for improvement of Alternative C is 28.85 km, which is shorter than that of Alternative B by 13.5 km.
- The construction cost of alternative C is higher than that of Alternative B only 7%.

Alternative C was recommended based on the above comparisons though it has some disadvantagement.

### (3) Salient Features of Tawaeli-Toboli Road

## Table 14.1 Salient Features of Tawaeli-Toboli Road

| Items | Major Salient Features |
|---|---|
| 1. Existing Road Length | 45.8 km |
| 2. Planned Road Length | 41.35 km |
| 3. Bridge Length | 830 m (cumulative) |
| 4. Tunnel Length | 620 m |
| 5. Slope Protection Works | 165,700 $m^2$ |

*Source: Study Team*

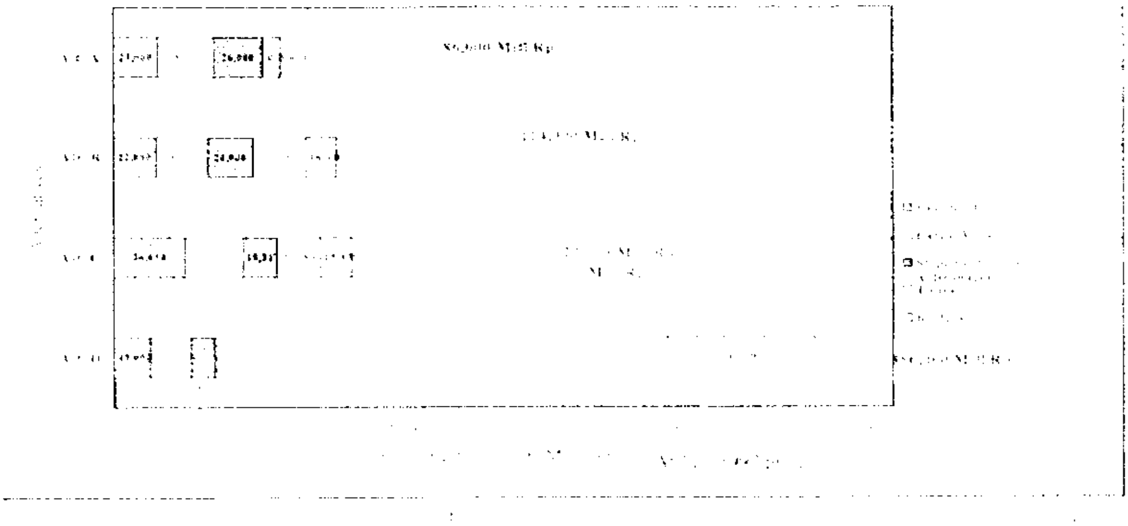


**Figure 14.2 Comparative Construction Cost for Each Alternative**

## (2) Recommendations

Alternative A has the lowest construction cost but the design speed of 20 km/h is not acceptable and the route length of 45.3 km is longer than the other alternatives. Alternative D has a preferable design speed of 40 km/h and the shortest route length but the cost of Rp 356 billion is too great to attain economic viability.

Alternative C has the following advantageous and disadvantageous points in comparison with Alternative B.

- This route is shorter than Alternative B by 1.5 km, avoiding critical disaster-prone areas.
- There is less impact on traffic in Alternative C during construction as the existing section for improvement of Alternative C is 28.85 km, which is shorter than that of Alternative B by 13.5 km.
- The construction cost of alternative C is higher than that of Alternative B only [illegible]

Alternative C was recommended based on the above comparisons though it has some disadvantagement.

## (3) Salient Features of Tawaeli-Toboli Road

**Table 14.1 Salient Features of Tawaeli-Toboli Road**

| Items | Major Salient Features |
|---|---|
| 1. Existing Road Length | 45.8 km |
| 2. Planned Road Length | 41.85 km |
| 3. Bridge Length | 830 m (cumulative) |
| 4. Tunnel Length | 620 m |
| 5. Slope Protection Works | 165,700 m |

## 15. PRELIMINARY ENGINEERING DESIGN

### 15.1 Design Policies

The following is a list of certain control points and design policies for the Tawaeli-Toboli road:

- Design speed of 30 km/h should be applied as appropriate road geometry for undulated and mountainous areas.
- Sufficient protective countermeasures should be provided in many areas suffering from hazards.
- The number of affected houses and lots of villages should be minimized to mitigate adverse environmental impact.
- Two-way traffic throughout the year should be provided.

### 15.2 Preliminary Bridge Design

The following criteria were adopted for the bridge design;

1) Superstructure

| | | |
|---|---|---|
| Type | : | Prestressed concrete simple I-girder |
| Width | : | 0.3+7.0+0.3 (m) |
| Length | : | 10 m ~ 30 m |
| Live Load | : | D loading, T loading |
| Concrete | : | Girder; Specified strength at 28 days = 400 kgf/cm$^2$<br>Cross Beam; Specified strength at 28 days = 250 kgf/cm$^2$ |
| Tendon | : | Uncoated 7 wire super strand (ASTM A-416, grade 270)<br>Diameter; 12.7 mm |

2) Substructure

| | | |
|---|---|---|
| Abutment | : | Reinforced concrete, Cantilever abutment |
| Pier | : | Reinforced concrete, Hammerhead shaped pier |
| Concrete | : | Specified strength at 28 days = 240 kgf/cm$^2$ |

3) Foundation : Spread foundation

Proposed bridge improvement is summarized in Table 15.1.

**Table 15.1 Summary of Proposed Bridges and Box Culverts on Tawaeli-Toboli Road**

| Accumulative Length of Bridges (Number) | | | Number of Box Culvert |
|---|---|---|---|
| Existing Bridge to be used as is | New Bridge under construction | New Bridge to be constructed | |
| 24.9 m (5) | 180.0 m (3) | 850.0 m (38) | 25 |

*Source: Study Team*

### 15.3 Preliminary Design of Slope Protection Works

In order to stabilize the road slope, sprayed concrete cribwork is recommended by the study team as a countermeasure in hazardous parts between Tawaeli and Toboli. Slope stabilization calculations are analyzed according to the height and features of sprayed concrete cribwork. Sprayed concrete crib of 15cm × 15cm in cross section and frame dimensions of 115cm × 115cm are adapted on the basis of similar constructed works.

The average protection height between Tawaeli and Toboli is 12.5 meters, and the gradient of cutting works is 1:0.5 (for soft rock).

It is believed that the thickness of potentially unstable stratum is 1.5 meters and suggested the internal friction angle between sprayed concrete cribwork and stratum $\phi$ be 35°, also that the diameter of the applied anchor bar be 22 millimeters and the pitch of the applied anchor bar be 1.15 meters. After strength calculation and stability analysis for anchor bar and sprayed concrete cribwork, the length of anchor bar is to be 2.49 meters, and 2.5 meters adopted for standardisation.

The quantities of slope protection works for Tawaeli-Toboli road are summarized as shown in Table 15.2.

**Table 15.2 List of Quantities**

| | Cut | | | Fill |
|---|---|---|---|---|
| | Sprayed Concrete Cribwork ($m^2$) | Shotcrete ($m^2$) | Stone Masonry ($m^2$) | Mat Gabion ($m^2$) |
| Quantity | 83,921 | 22,654 | 6,530 | 10,518 |
| Average Height | 12.5 | 13.1 | 1.7 | 5.0 |

*Source: Study Team*

### 15.4 Preliminary Tunnel Design

The design and shape of tunnel interior cross section must be technically and economically practical. The engineering design of tunnel was carried out in full consideration of topographical and geological conditions. The width and construction clearance of the proposed tunnel is shown below:

- Entire width : W = 0.75 + (0.75+3.00) x 2 + 0.50 + 0.75 = 9.50 m
- Crossfall : i = 2.00 % (upward grade from both portals)
- Inspection way : Installed on both sides (width = 0.75 m, height = 2.00 m)

## 16. ENVIRONMENTAL IMPACT ASSESSMENT

### 16.1 Existing Environmental Conditions

An observation survey was carried out for the following to understand the existing environmental conditions along Tawaeli-Toboli Road;

- Air Quality and Noise Level (4 locations)
- Water Quality (2 locations)
- Landslide (4 locations)
- Flora and Fauna (5 locations)
- Traffic (6 locations)
- Domestic Waste (1 location)
- Public Perception (5 locations)

#### (1) Flora and Fauna

The road crosses Tawaeli Settlement Area, Limited Production Forest Area, Protected Forest Area, Parigi-Binangga Nature Forest Reserve Area and Toboli Settlement Area.

Parigi-Binangga Nature Reserve is crossed by the Tawaeli-Toboli road by about 3 km in length, specifically from the 38 km to 41 km points from Tawaeli.

The total area of the Parigi-Binangga Nature Reserve is 6,000 hectares and established for the purpose of ebony (*Diospyros celebica*) protection.

At the road sides around the nature reserve, monyet jambul (*Macaca tonkeana*), rangkong (*Penelopides exaratus*), burung gagap (*Corvus euca*), elang (*Pernis celebensis*) and kum-kum (*Ducula bicolor)* have been observed. Based on interviews with the local people, it is found that quantities of babirusa (Babyrousa babirussa), babi (*Sus vitarus*), musang coklat (*Marcrogalidia musschenbroekii*), kus-kus (*Phalanger ursinus*), Anoa (*Bubalus depresicornis*) and rusa (*Cervus timorensis*) can be found in this area.

#### (2) Social Environment

The road crosses three Kecamatans; i.e., Kecamatan Palu Utara, Kecamatan Tawaeli and Kecamatan Parigi. Three villages will be affected by the road and their population is as shown in Table 16.1.

**Table 16.1 Population in the Study Area**

| No | Sub District | Area | Total Population | | | Total Household | Household Size(Ave.) | Population Density |
|---|---|---|---|---|---|---|---|---|
| | | ($km^2$) | Male | Female | Total | Family | Person | ($Pop/km^2$) |
| 1 | Kec. Palu Utara | 107.72 | 13,185 | 13,055 | 26,220 | 5,244 | 5 | 243 |
| | Lambara village | 13.86 | 1,059 | 1,088 | 2,147 | 429 | 5 | 155 |
| 2 | Keg. Tawaeli | 450.32 | 11,735 | 11,420 | 23,155 | 4,238 | 5 | 51 |
| | Nupabomba vill. | 135.28 | 1,389 | 1,236 | 2,625 | 550 | 5 | 19 |
| 3 | Kec. Parigi | 565.06 | 23,085 | 22,256 | 45,341 | 9,593 | 5 | 80 |
| | Toboli village | 120.64 | 1,281 | 1,241 | 2,522 | 452 | 5 | 21 |

*Source : Kecamatan Palu Utara in Figure, 1996, Kecamatan Parigi in Figure, 1996, Kecamatan Tawaeli in Figure, 1996*

80% of the inhabitants of three villages are farmers, 10% are civil servants and the remaining 10% work in service sectors such as commerce, carpentry workshops, etc.

The average monthly income of residents of the three villages in the study area is approx Rp 100,000 – Rp 300,000 per month. However, 62% of the people had an average monthly income of less than Rp. 100,000 as of June, 1997.

### (3) Environmental Pollution

Existing noise level was measured by a sound level meter as shown in Table 16.2.

**Table 16.2 Result of Measurement of Noise Level**

| Location | Noise Level (dB(A)) | | standard (dB(A)) |
|---|---|---|---|
| | 10:00 - 11:00 am | 2:00 - 3:00 pm | |
| Pombaloya settlement | 40 - 50 | 60 – 65 | 60 |
| 19 km | 80 - 85 | 60 – 65 | |
| 24 km | 60 - 65 | 50 – 55 | |
| Kebon Kopi Settlement | 60 - 65 | 55 – 60 | |

*Source: Study Team*

The result of measurement on the noise level shows that at the location of 19 km, the noise level of 80 - 85 dB(A), derived from the sound of an excavator in the distance of three meters from measurement point. The noise level of 60 - 65 dB(A) at the 19 km point was derived from vehicles which passed the area (four-wheel and two-wheel vehicle), two meters away from the noise measuring device.

## 16.2 Impact Analysis

Prediction and evaluation of major impacts, and mitigation measures are indicated as follows:

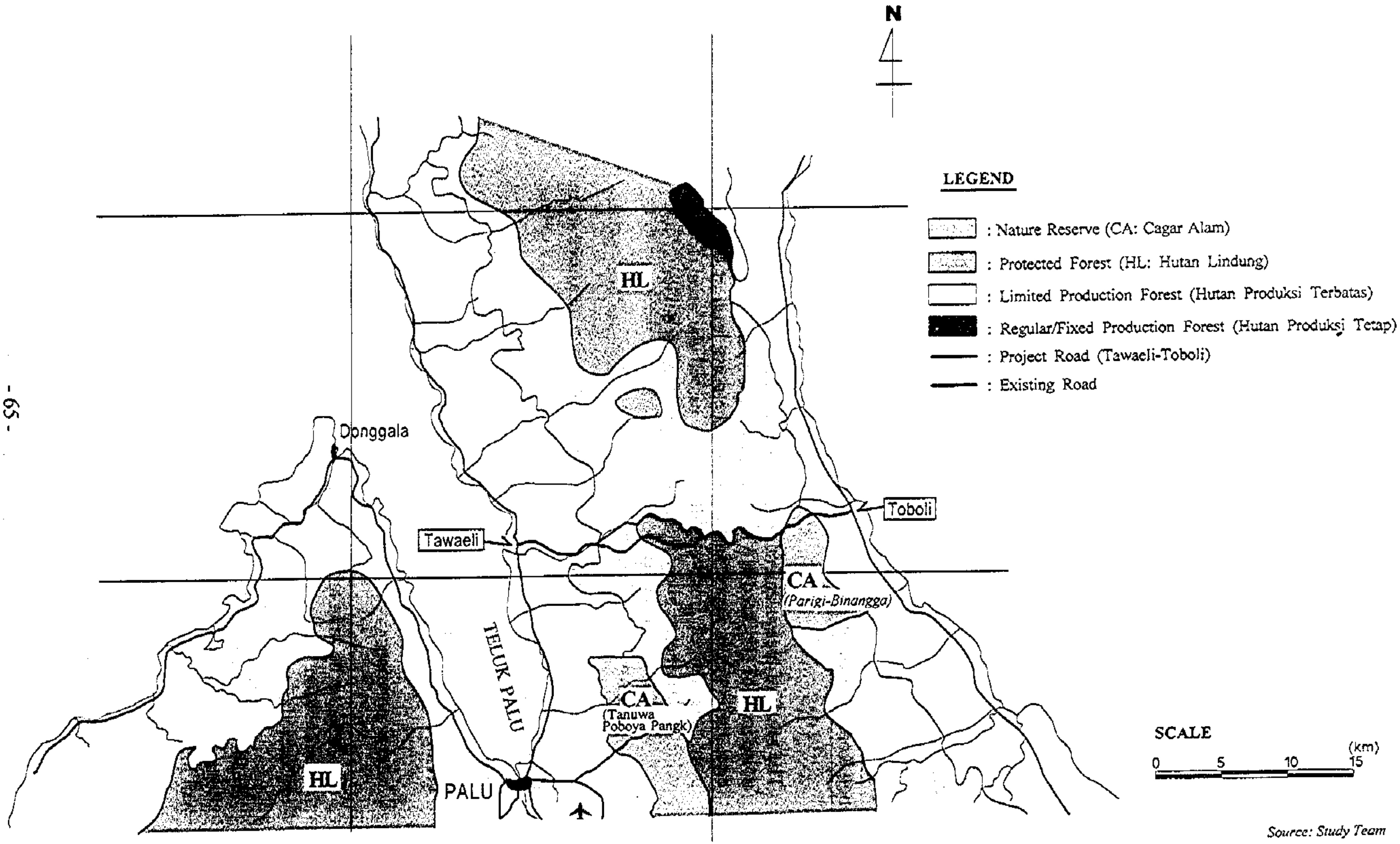
- Social unrest:

  Due to possible appearance of land speculation, disturbances could occur, which would impede or even foil survey activities. Potential social unrest may be dealt with by giving explanation to local residents concerning project activities.

- Land acquisition:

  The land to be affected by the road project is not private land, but is state land. Compensation for plants and vegetation, etc, managed and/or owned by the people is to be carried out.

  In the case that certain residents need to be relocated due to construction whether temporarily or permanently, a full explanation should be given regarding the necessity of the project and compensation program.




Source: Study Team

Figure 16.1 Tawaeli-Toboli Road and Parigi-Binangga Nature Reserve

- Labor mobilization:

  Potential unfavorable impacts are: ① People's dissatisfaction towards project activities and ② Disturbance that can impede and/or obstruct construction activities.

  The above can be dealt with by giving working opportunity with the project for the people around it conforming with required qualifications and social interaction between the incoming labor and the local communities. Operation of construction base camp should be managed as follows:

  - Selection of location that is rather far from the settlement
  - Explanations to the incoming workers

- Traffic disturbance:

  Such impact is dealt with by issuing some program for regulating traffic flows depending on time, weather and so on. Traffic congestion is expected, due to the increase in construction vehicles and equipment.

  - Traffic regulations are to be enforced and traffic signs installed.
  - Application of the traffic schedule in line with the Decree of the Governor of Central Sulawesi Number 8, 1997.

- Slope protection:

  Slope protection works such as sprayed concrete cribwork, shotcrete work, stone masonry and mat gabions for fill and cut slopes should be constructed to prevent soil erosion and landslides.

- Surface soil run-off:

  Run-off of surface soil is to be dealt with by adequate arrangement of implementation and development of drainage/culvert systems. Impact is monitored to avoid water inundation.

- Surplus soil:

  Surplus soil, of which more than 560,000 $m^3$ is estimated as disposal waste during construction stage, must be managed as follows:

  - Excavated soil should not be dumped or left "as is" in excessively rainy or dry seasons.
  - Dump sites in which exposed or graded surfaces of excavated soil can be minimized should be selected.
  - Planting or seeding of dumped soil should be undertaken immediately.
  - Proper drainage facilities should be supplied to prevent negative environmental affects such as a water contamination, siltation, muddiness, etc., downstream from the site.

- Groundwater flow:

  No ground water flow was found around the tunnel development site based on the geological and other surveys. However, water leakage can be anticipated during tunnel construction due to the existence of some faults and changes in geological strata. Therefore, some monitoring should be conducted on groundwater flow and leakage.

- Fauna and flora:

  The alignment change and widening of the existing road should be minimized to reduce impact to the Parigi-Binangga Nature Reserve.

  Impact on fauna and flora is to be mitigated by restricting the speed of vehicles, reducing the noise and vibration, prohibiting illegal cultivation and settlements in that area. Impact on fauna and flora can be slightly alleviated by the following measures:

  - Educating the people and laborers regarding the environment.
  - Construction of warning boards about protection of fauna and flora.

- Traffic accidents:

  - Installation of the traffic signs and road marking.
  - Construction of guard rails.

### 16.3 Environmental Management and Monitoring

Environmental management and monitoring are important in each stage of the Project, i.e., pre-construction stage, construction stage and post-construction stage. This includes not only the management of environmental issues related to the Project, but also those related to improvements of the environment throughout Central Sulawesi and Southeast Sulawesi. Environmental management and monitoring should consider:

- Organization for environmental management.
- Management of resettlement and land acquisition.
- Environmental surveillance of construction work.
- Forest/Coastal zone environmental management.
- Environmental education.
- Traffic volume monitoring.
- Groundwater level.
- Post resettlement survey.
- Noise and vibration monitoring.
- Land slide/soil erosion surveillance.

## 17. ROAD MANAGEMENT AND MAINTENANCE PLAN

### 17.1 Definition of Road Maintenance System

Table 17.1 shows the maintenance work items of each level of provincial, regency and site offices. Dinas PU(provincial office) should co-ordinate with national government, establishing maintenance grade of the roads within their jurisdiction, and overall management of the implementation program of the maintenance works. The main works for the regency office should be considered with provincial government and implementation planning for all other roads in the regency. Each site office should conduct the implementation of the road maintenance and operations.

**Table 17.1 Main Tasks of Road Maintenance System and Responsible Office**

| Main Tasks | Activities | Responsible Office | | |
|---|---|---|---|---|
| | | Provincial office (Dinas PU) | Maintenance Office | |
| | | | Regency office | Site office |
| 1. Planning and Programming | a) Planning | O | O | |
| | b) Implementation programming | O | O | |
| 2. Traffic Engineering and Safety | a) Road and Traffic engineering development and research | O | | |
| | b) Traffic forecasts | O | O | |
| | c) Implementation of traffic survey | | O | |
| | d) Statistical data processing | | O | O |
| 3. Maintenance and Operations | a) Setting of standards | O | O | |
| | b) Supervision and consultation works | | O | |
| | c) Maintenance and operations | | | O |
| 4. Coordination and Public Relation | a) Coordination with relevant agencies | O | O | |
| | b) Response activity | O | O | |
| 5. Administration | a) Personnel management, salary, welfare, etc | O | | |

*Source: Study Team*

## 17.2 Road Maintenance and Operations

There are three types of task in maintenance. One is routine maintenance where task volumes are not affected by road standards or traffic volumes. Another is periodic maintenance which is related to traffic volumes and lane width and is proportional to the number of lanes. The third is incidental maintenance which is basically the works to be conducted to prevent and to restore the road and related facilities to normal operating conditions after damage by road accident or natural causes.

- Routine maintenance
  - a. Patrol, inspection, removal of obstacles on road
  - b. Cleaning of surface, side ditch, canal, culvert
  - c. Vegetation control; grass cutting of slope and shoulder, take care of roadside trees
  - d. Repairing and repainting of traffic safety and management facilities
  - e. Repairing lighting facilities

- Periodic maintenance
  - f. Renewal of traffic marking
  - g. Pavement maintenance and repair
  - h. Overlay
  - i. Maintenance and repair of bridges and culverts

- Incidental maintenance
  - j. Disaster restoration

Of the above maintenance and operations, "a" through "c" can be implemented over about 250 km a year by one site office. However, maintenance operations, "d" through "j" are expected to be difficult in practical implementation due to their scale and need for additional workers and skills. In line with improved pavements in the future, operations under direct road management control, such as monitoring of the road surface, etc., may increase. It is therefore desirable to establish a maintenance system based primarily on management and the contracting of works other than those under force account.

### 17.3 Location of Offices

Each maintenance office (regency and site offices) should be conduct the direct implementation of the maintenance and operations for the national and provincial roads in the regency, and the offices should be located as follows:

- The present regency office at Palu should control about 1,000 km road length of national and provincial road with the existing office facility.
- Each site office should maintain about 250 km of national and provincial road under control of regency office.
- Tawaeli-Toboli road is maintained by one of the site offices which use the existing Tawaeli-Toboli improvement office.

### 17.4 Equipment and Workshops

The maintenance equipment are located in each site office which changes the maintenance and operation over about 250 km of national anf provincial road. Require vehicles and equipment per one site office are pick up (20 units), dump truck (1 unit), loader (1 unit) and bulldozer (1 unit).

### 17.5 Maintenance and Operation Cost

The annual operation and maintenance cost of Tawaeli-Toboli road was estimated to be Rp. 509 million with overlay cost of Rp. 5,200 million (every 7 years) by use of July 1998 prices.

## 18. COST ESTIMATES AND IMPLEMENTATION SCHEDULE

The estimated project cost (in July 1998 prices) and implementation schedule are shown in Figure 18.1.

1US$=10,600 Rp.

| Item | Unit | Quantity | 1999 | 2000 | 2001 | 2002 | 2003 | Total |
|---|---|---|---|---|---|---|---|---|
| 1. Preparation of Project | | | | | | | | |
| 2. Survey and Design | km | 40.05 | | | | | | |
| 3. Construction | | | | | | | | |
| Earth work | $m^3$ | 852,447.00 | | | | | | |
| Slope Protection | $m^2$ | 165,695.00 | | | | | | |
| Tunnel | m | 620.00 | | | | | | |
| Bridges | m | 830.00 | | | | | | |
| Pavement | km | 40.05 | | | | | | |
| Foreign Currency (Thousand US$) | | | - | 698 | 3,282 | 6,049 | 5,340 | 15,369 |
| Local Currency (Billion Rp) | | | - | 4.94 | 27.01 | 50.03 | 51.23 | 133.20 |
| **Total Cost (Billion Rp)** | | | - | 12.34 | 61.80 | 114.15 | 107.84 | 296.12 |

*Source: Study Team*

**Figure 18.1 Project Cost and Implementation Schedule for Tawaeli-Toboli Road**

## 19. ECONOMIC ANALYSIS

The result of economic analysis for Tawaeli-Toboli road is shown in Table 19.1.

### Table 19.1 Result of Economic Analysis

| EIRR | NPV (Million Rp) | B/C |
|---|---|---|
| 19.8 % | 76,555 | 1.50 |

Discount Rate: 15 % p.a.

*Source: Study Team*

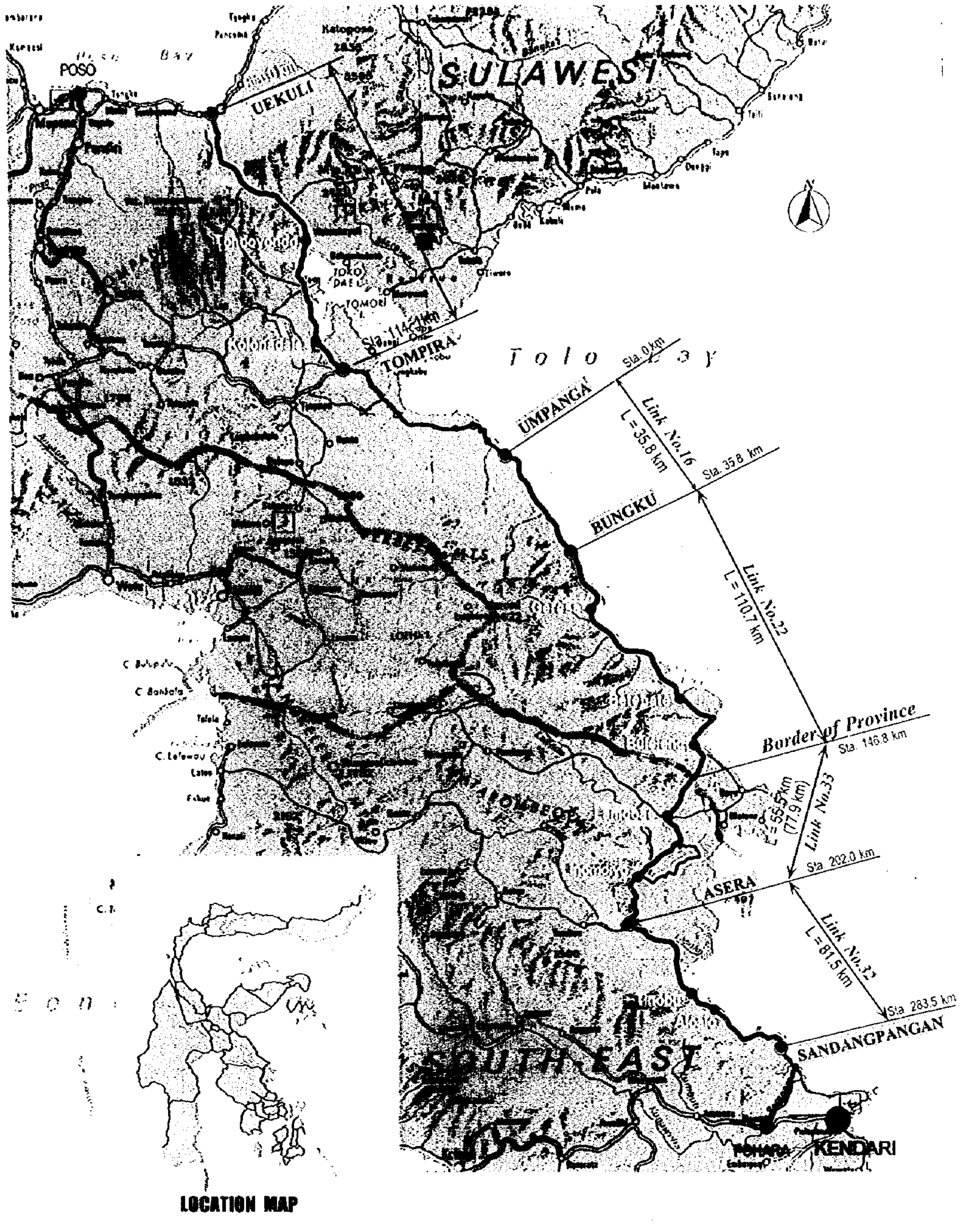
## 20. CONCLUSION AND RECOMMENDATION

Tawaeli-Toboli road is a feasible project and should be completed by year 2003 based on the following:

- The road is two lane with design speed of 30 km/h to 60 km/h;
- The construction cost is 296.12 Billion Rp.(at July 1997 prices) with a by-pass of 12.5 km, pavement works of 40.05 km, a tunnel of 620 m, 38 bridges and slope protection works of 166,000km$^2$;
- Surplus excavated soil should be dumped in properly selected sites (at intervals of 10km on the average).
- The alignment change and widening of the existing road should be minimized to reduce impact to the Parigi-Binangga Nature Reserve.
- Slope protection works such as sprayed concrete cribwork, shortcrete work, stone masonry and mat gabions for fill and cut slopes should be constructed to prevent soil erosion and landslides.
- Tunnel construction was recommended considering the following points:
    - Prevention of hazards on the road sections where the slope protection structure is not practical.
    - Ensuring of adequate road alignment by reducing sharp turns.

# PART-IV

# FEASIBILITY STUDY FOR TRANS-SULAWESI EAST ROAD


POSO
SULAWESI
UEKULI
Sta. 114.2 km
TOMPIRA
Tolo Bay
Sta. 0 km
UMPANGA
Link No.16
L = 35.8 km
Sta. 35.8 km
BUNGKU
Link No.22
L = 110.7 km
Border of Province
Sta. 146.8 km
L = 55.5 km
(77.9 km)
Link No.33
Sta. 202.0 km
ASERA
Link No.32
L = 81.5 km
Sta. 283.5 km
SANDANGPANGAN
SOUTH-EAST
POHARA
KENDARI
LOCATION MAP


LOCATION MAP

# PART-IV FEASIBILITY STUDY FOR TRANS-SULAWESI EAST ROAD

## 21. GENERAL

Road (link Nos.. 15, 16, 22, 32 and 33) of the Trans-Sulawesi East Road which are the object of the feasibility study are located from the top of east Sulawesi peninsula to the east coast of lower east Sulawesi peninsula. In addition to the priority links of the recommended 300 km of the pre-feasibility study, Link No. 15 of 114 km from Uekuli to Tompira was added to the feasibility study considering its high priority and importance in supporting regional development in the eastern part of the region (strategic area of Luwuk).

Characteristics of these links can be divided into mountainous terrain and coastal flat terrain. A mountain range is located from Uekuli to Kolonadale. Kolonadale to Sandangpangan via Tompira, Umbanga, Bungku, provincial border and Asera is located on the east coast of lower east Sulawesi peninsula. Most of the route is located along the coastal area, but some parts cross the mountain ranges.

Topographic maps of 1:5,000 in scale prepared by the study team were used for link Nos.. 16, 22, 33 and 32, but topographic maps of 1:50,000 were used for link No. 15. Therefore the accuracy of engineering design of link No. 15 is low compared with other links.

## 22. ENGINEERING SURVEY

### (1) Aerial Photographic Survey

Aerial photogrammetry and ground survey were carried out in order to prepare the 1;5,000 topographic map and longitudinal profile data necessary for the preliminary design of the Feasibility Study for the reroute from Umpanga to Sandangpangan (300 km long).

### (2) Soil and Material Investigation

Boring survey was carried out between Umpamga and Sandangpangan section. The total number of boreholes drilled was conducted for sixty (60) of geological condition of proposed bridges and embankment.

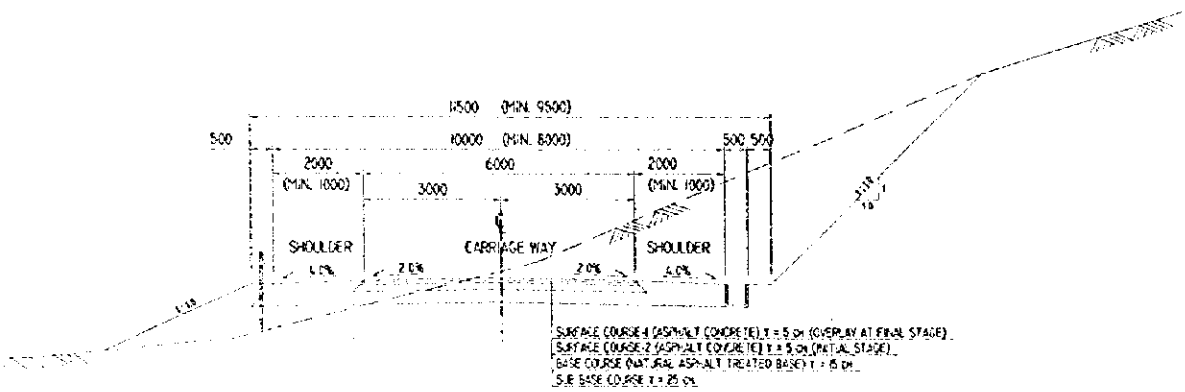
## 23. DESIGN STANDARDS FOR TRANS-SULAWESI EAST ROAD

Trans-Sulawesi East Road (link Nos... 15, 16, 22, 32 and 33) is classified as a collector road considering its road characteristics. As link No. 15 is in a mountainous area, its design speed should be limited to 30 km/hr. The summary of design standards is shown in Table 23.1.

## Table 23.1 Design Standards

| Items | Design Standards | | |
|---|---|---|---|
| 1. Road Classification | Collector Road | | |
| 2. Design Speed | 60 km/h (Flat and Rolling)<br>40 km/h (Mountainous) | Link No. 16, 22, 32 and 33 | |
| | 60 km/h (Flat and Rolling)<br>30 km/h (Mountainous) | Link No. 15 | |
| 3. Number of Lanes | Two lane | | |
| 4. | See Figure 23.1. | | |
| 5. Geometric Design Standards | See Table 7.1. | | |
| 6. Pavement | AASHTO Pavement Design,<br>Pavement Design Standard, Japan | | |
| 7. Bridge | Indonesian Bridge Design Code,<br>AASHTO and Japanese Bridge Design Specification | | |
| 8. Tunnel | Indonesian Road Geometric Standards,<br>Design Standards for Road Tunnel, Japan | | |
| 9. Road Traffic | Link No. | 1997 | 2018 |
| | 15 | 42 veh/day | 1,667 veh/day |
| | 16 | 135 | 1,486 |
| | 22 | 0 | 1,321 |
| | 33 | 0 | 1,351 |
| | 32 | 224 | 1,431 |

*Source: Study Team*




*Source: Study Team*

**Figure 23.1 Typical Cross Section of Trans-Sulawesi East Road**

## 24. PRELIMINARY ENGINEERING DESIGN

### 24.1 General

The following are control points and design policy for the Trans-Sulawesi road:

- Design speed of 30 km/h, 40 km/h and 60 km/h should be selected as appropriate road geometry based on the terrain.
- Sufficient protective countermeasures should be provided in many areas suffering from hazards .
- The number of affected houses and lots of villages should be minimized to mitigate adverse environmental impact.
- Two-way traffic should be provided based on traffic demand.

### 24.2 Description of Route Condition

**(1) Link No. 15 (Uekuli-Tompira, 114.1 km)**

Road link length totals 114.1 km, 34.7 km of which is finished by simple pavement with asbuton (natural asphalt) between Kolonadale and Beteleme. There are two missing sections of about 29 km between Malino and Kolonadale (65 km). The remaining section is a gravel road. The entire drainage system is an open earth ditch.

**(2) Link No. 16 (Umpanga-Bungku, 35.8 km)**

The beginning point starts at Umpanga and the end point is 35.8 km far from the beginning point. Of the total length of the road, a 30.8 km section is paved with 3.5 m asphalt. The remaining 5.0 km section is gravel road. Most of bridges are made from wood. At Ipi, there is no bridge at present. The width of the existing river bed is 30 m. The road alignment is satisfactory as the land is flat.

**(3) Link No. 22 (Bungku-Border of Province, 110.7 km)**

Ridges originating in the mountains run to the shoreline. Portions projecting into the sea make up a steep limestone topography, with terraces formed by the upheaval of coral reefs in the coastal area. The road winds along the base of steep limestone mountains.

A very low-level design standard has been employed for road sections in the steep topography, with the road width being less than 3 m in certain locations. Collapse of the slope faces was also observed in a few places. The road has a gravel pavement with wooden bridges crossing small rivers.

**(4) Link No. 33 (Provincial Border-Asera, 55.5 km)**

Three major bridges are currently under construction. The road is entirely a gravel or earth road without road surface drainage. There is an alternative route of short-cut new road connecting directly to Limomoiyo and Lamonal instead of the existing road passing through transmigration villages.

(5) Link No. 32 (Asera-Sandangpangan, 81.5 km)

The entire route is designated as a provincial road (see Project Location Map). The 20 km section on the Pohara side is finished by simple pavement with penetration macadam. The remaining 61.5 km section is a gravel road. The section between Sandangpangan and Pohara is presently being paved.

## 24.3 Preliminary Bridge Design

Bridge designs were conducted and the accumulative length of bridges are summarized as shown in Table 24.1, based on the category of bridge construction.

**Table 24.1 Summary of Bridge Length and its Number**

| Link No. | Road Length (km) | New Bridge Length | | Existing Bridge Length (used as it is) | Total |
|---|---|---|---|---|---|
| | | More than 50 m | Less than 50 m | | |
| 15 | 114.1 | 820 m (11) | 540 m (25) | 0 m (0) | 1,360 m (36) |
| 16 | 35.8 | 0 (0) | 440 (20) | 235 (6) | 675 (26) |
| 22 | 110.7 | 840 (12) | 2,160 (94) | 0 (0) | 3,000 (106) |
| 33 | 55.5 | 30 (3) | 570 (23) | 120 (1) | 1,050 (27) |
| 32 | 81.5 | 60 (1) | 1,300 (56) | 105 (3) | 1,464 (60) |
| Total | 397.6 | 2,080 (27) | 5,010 (218) | 460 (10) | 7,550 (255) |

Figure in parenthesis indicates the number of bridges.

*Source: Study Team*

## 24.4 Preliminary Design of Slope Protection

Protective measures to alleviate erosion or weathering of slopes conducted by covering with vegetation or use of structures. Stabilization also ensured by means of drainage works or retaining structures.

**Table 24.2 Summary of Slope Protection Works**

| Link No. | Types of Slope Protection | | |
|---|---|---|---|
| | Cut Slope | | Fill Slope |
| | Sprayed Concrete Cribwork ($m^2$) | Shotcrete ($m^2$) | Mat Gabion ($m^2$) |
| 15 | 15,621 | 126,042 | 52,699 |
| 22 | 3,360 | 36,593 | 83,289 |
| 33 | - | - | 559 |
| 32 | 9,509 | 10,068 | 7,734 |
| Total | 28,490 | 172,703 | 144,281 |

*Source: Study Team*

## 24.5 Preliminary Tunnel Design

Four tunnels are required on the steep lime stone terrain between chainages 62 km to 66 km of Link No. 15 as shown Table 24.3. The other links do not require any tunnels.

**Table 24.3 List of Tunnel of Link No. 15**

| Tunnel No. | Location of Tunnel (km from Uekuli) | Tunnel Length (m) |
|---|---|---|
| No. 1 Tunnel | 62.380 km – 63.120 km | 740 |
| No. 2 Tunnel | 63.270 km – 63.730 km | 460 |
| No. 3 Tunnel | 63.800 km – 64.090 km | 290 |
| No. 4 Tunnel | 65.240 km – 65.740 km | 500 |

*Source: Study Team*

Tunnel lighting powered by solar energy is provided.

# 25. ENVIRONMENTAL IMPACT ASSESSMENT

## 25.1 Existing Environmental Conditions

An environmental site survey for the five (5) road link of Nos.. 15, 16, 22, 33 and 32 was conducted for the feasibility study. The survey was conducted focusing on the environmental items marked (*) in Table 25.1.

**Table 25.1 Environmental Items**

| Social Environment | | Natural Environment | | Environmental Pollution | |
|---|---|---|---|---|---|
| 1 | Resettlement * | 10 | Topography and Geology * | 18 | Air Pollution |
| 2 | Economic Activities * | 11 | Soil Erosion * | 19 | Water Pollution |
| 3 | Traffic and Public Facilities | 12 | Groundwater * | 20 | Soil Contamination |
| 4 | Split of Communities | 13 | Hydrological Situation * | 21 | Noise and Vibration * |
| 5 | Cultural Property | 14 | Coastal Zone * | 22 | Land Subsidence |
| 6 | Rights of Common * | 15 | Fauna and Flora * | 23 | Offensive Odor |
| 7 | Public Health Conditions | 16 | Meteorology | | |
| 8 | Waste * | 17 | Landscape | | |
| 9 | Hazard (Risk) * | | | | |

*Source: Study Team*

Link Nos... 15, 16 and 22 are located in Kabupaten Poso and mainly situated along the coastline except for the roads between Uekuli and Lembahsumara (northern part of Link No. 15), and between Betebete and the provincial border (southern part of Link No. 22). Link Nos.. 32 and 33 are located in kabupaten Kendari. The northern part is an inland area among hills and mountains. The Environmental Map indicates the locations of coral reefs, mangrove forest, protected forest, native reserve, tourism area, transmigration site and lake as shown in Figures 25.1 to 25.4.

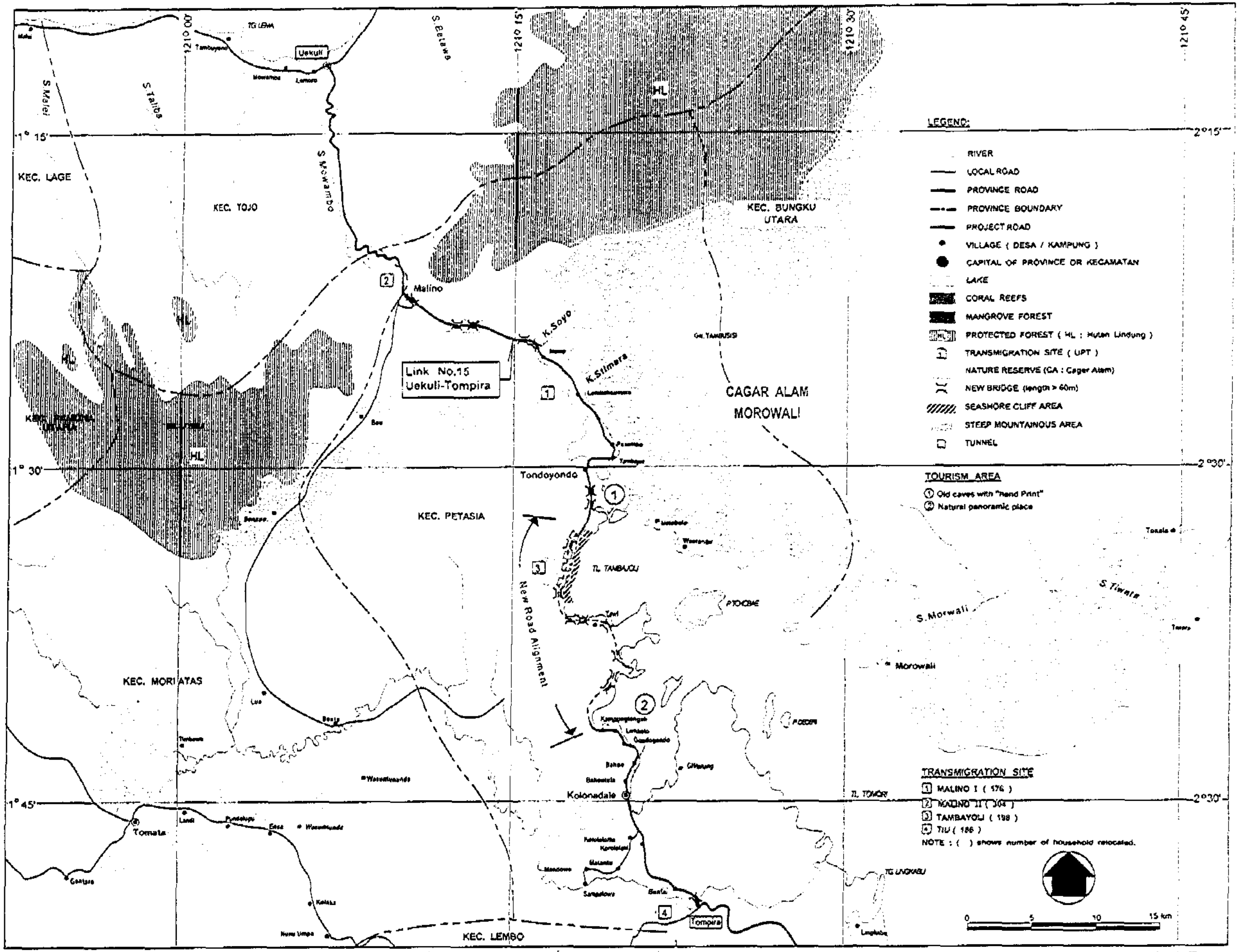



Figure 25.1 Environmental Map (1/4)

*Source: Study Team*

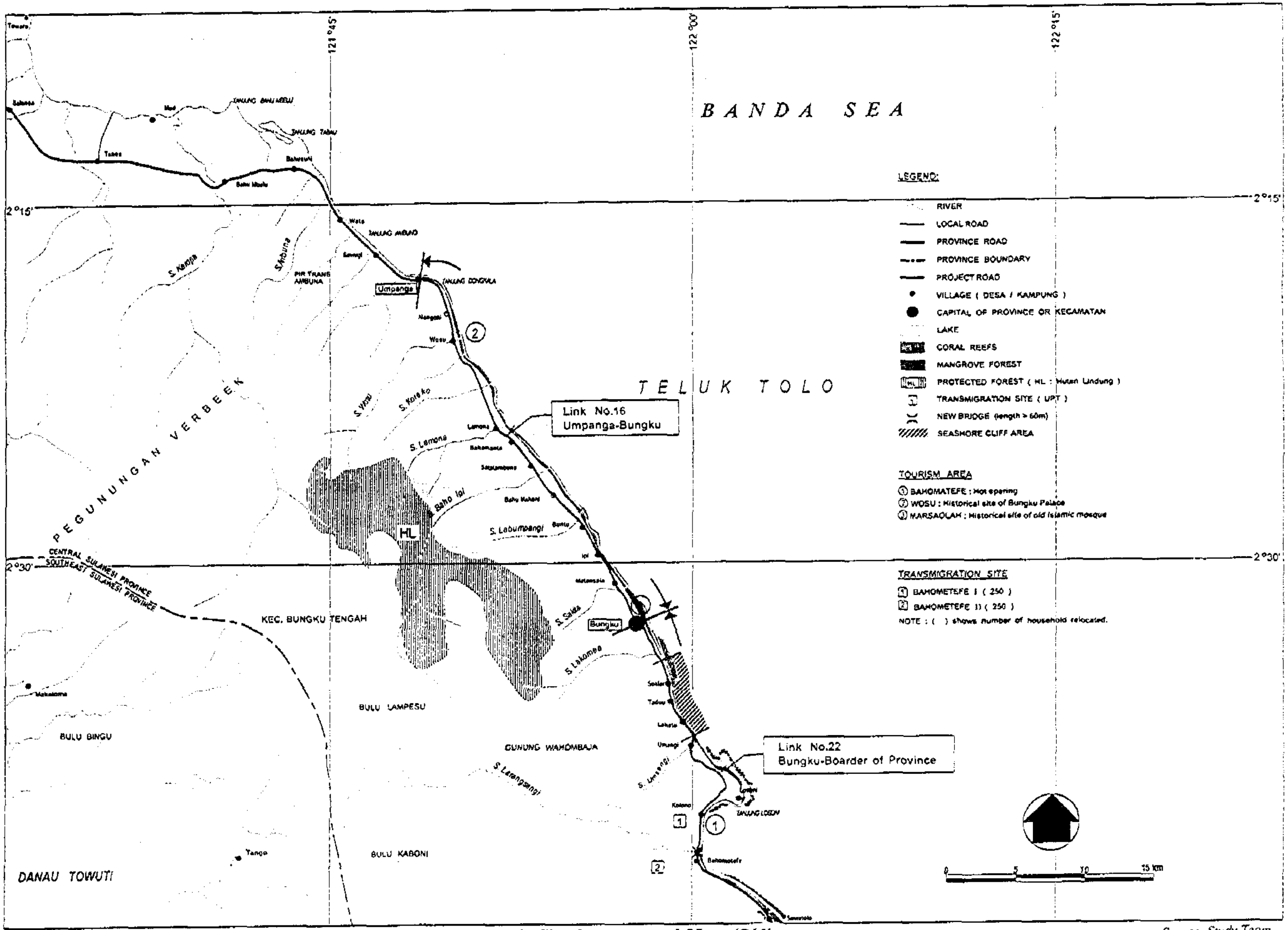


Figure 25.2 Environmental Map (2/4)

Source: Study Team

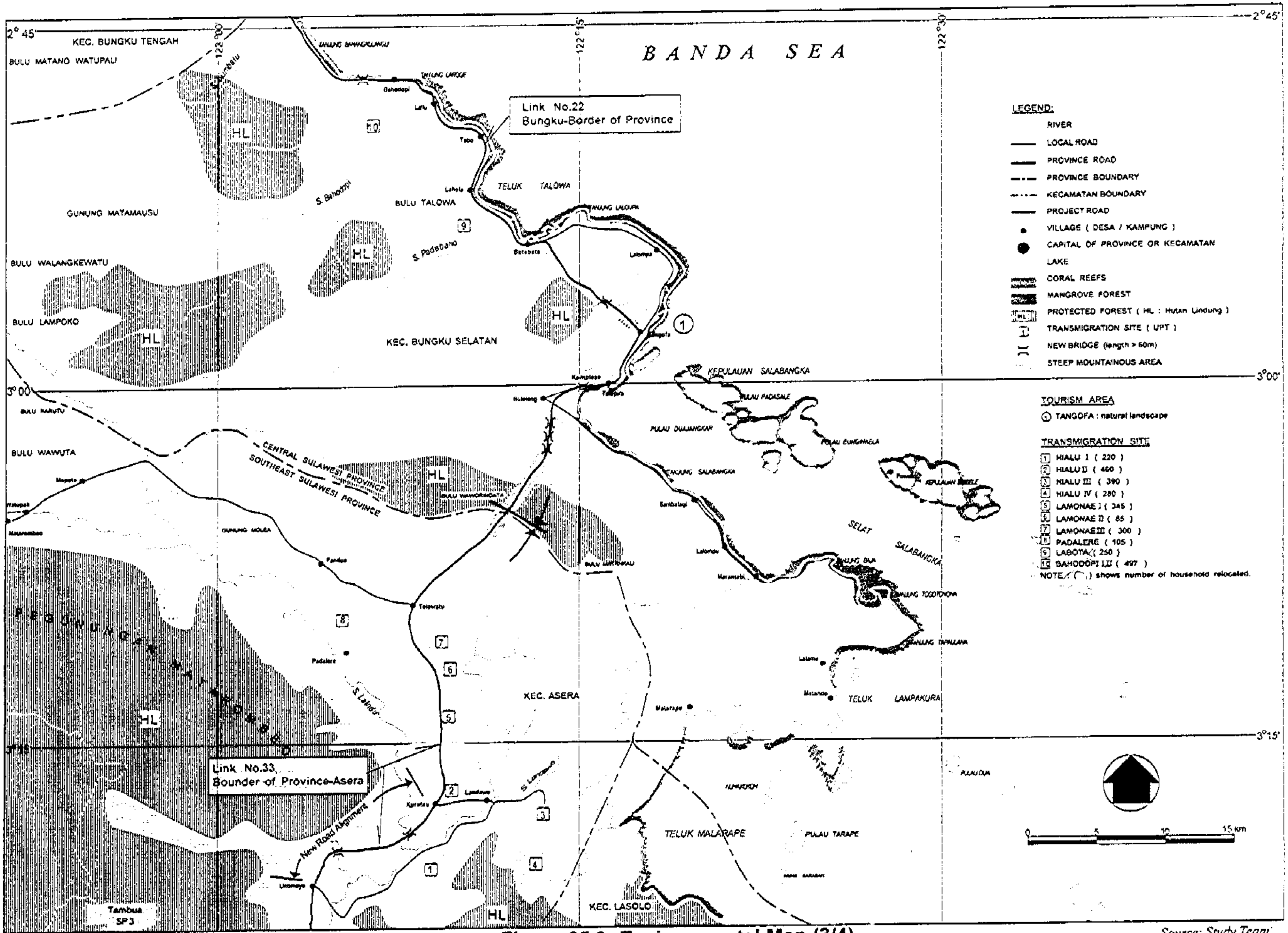



**Figure 25.3 Environmental Map (3/4)**

Source: Study Team

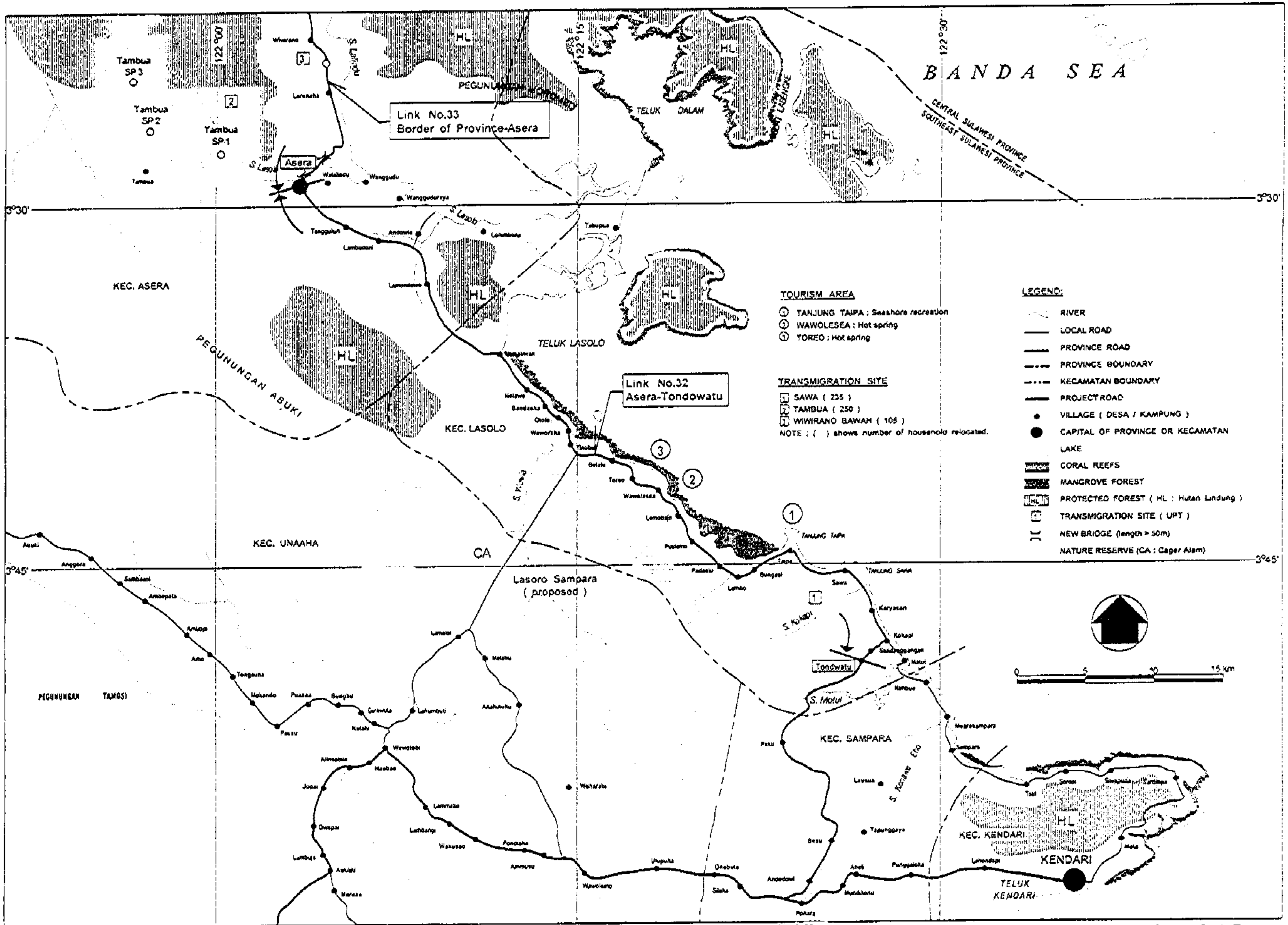



**Figure 25.4 Environmental Map (4/4)**

*Source: Study Team*

### 25.2 Impact Analysis

Prediction and evaluation of major impacts, and mitigation measures are indicated as follows:

- Resettlement and Land Acquisition

  Compensation for plantations and vegetation fields of the people, etc. shall be carried out after considering necessity of the road construction and properly estimated cost.

- Social Unrest

  Due to possible appearance of land speculation, disturbances could occur, which would impede or even foil survey activities. Potential social unrest may be dealt with by giving explanation to local residents concerning project activities.

- Nature Reserves/Fauna and Flora

  - Route alignment where the project road passing through the forest reserve shall be carefully planned taking into account the impact on the endemic fauna and flora.
  - Ecologically significant forest areas, ensuring that the area is large enough to maintain biological diversity and ecological processes.
  - With the project description and with a view of risk-benefit concepts in the development scheme, evaluation and assessment should be made on the impacts.
  - Necessary coordination between Ministry of Public Works and Ministry of Forest shall be carried out for the project implementation.
  - Impact management is conducted by restricting the speed of vehicles, reducing the noise and vibration and the regulating the solid waste, particularly surplus soil dumping in that area. Impact monitoring is conducted regarding the condition of fauna, flora and habitat.
  - In order to prevent the illegal harvesting/cultivation by slash-and-burn, the increase of forest squatters and illegal settlement, especially in the nature/forest reserves, regulations and management should be implemented.

- Hazard (Risk)

  - Route alignment shall be carefully planned taking into account the topographic and geological features of the site.
  - Proper technical alternatives (slope protection, tunnel, etc.) shall be adopted in the plan to prevent landslide and/or cave-in hazards.

- Waste Disposal (Surplus Soil)

  Surplus excavated soil has to be well managed as in the following manner:

  - Excavated soil (surplus soil) should not be dumped or left as is.
  - Dump sites of the surplus soil produced by the project excavation work shall be selected and properly operated.
  - It is recommended that planting or seeding treatment of hauled surplus soil be carried out immediately.
  - Proper drainage facilities shall be constructed to prevent negative environmental impacts; such as water contamination, loss of wetlands, health risks, etc., downstream of the site location.

- Groundwater

  - Some considerations for the impact, such as periodical monitoring, etc., during the tunnel construction shall be carried out regarding groundwater flow and leakage.

- Hydrological Situation/Coastal Zone

  Proper implementation plan/process taking into account the impact to hydrological situation of rivers and coastal zone shall be prepared and construction activities shall adopt the approved methods. Special attention shall be paid to:

  - Treatment of construction waste, including surplus soil.
  - Mining of the gravel, boulders and sand from the river.
  - Bridges construction over rivers and tunnel construction.

- Noise and Vibration

  Construction plan including daily time schedule of equipment operation shall be prepared taking into consideration the following items:

  - Construction work shall cease during the period of religious activities and school time.
  - Blasting method for cut slopes shall not be adopted where surrounding area is a nature/forest reserves in order to prevent the disturbance of fauna habitat.

- Land Slide/Soil Erosion

  - Periodical monitoring shall be carried out to prevent the landslides and soil erosion, especially in the rainy season.

### 25.3 Environmental Management and Monitoring

Environmental management and monitoring are important in each stage of the Project, i.e., pre-construction stage, construction stage and post-construction stage. These include not only the management of environmental issues related to the Project, but also those related to improvements of the environment throughout Central Sulawesi and Southeast Sulawesi. Environmental management and monitoring should consider:

- Organization for environmental management.
- Management of resettlement and land acquisition.
- Environmental surveillance of construction work.
- Forest/Coastal zone environmental management.
- Environmental education.
- Traffic volume monitoring.
- Groundwater level.
- Post-resettlement survey.
- Noise and vibration monitoring.
- Land slide/soil erosion surveillance.

## 26. ROAD MAINTENANCE

The road maintenance system of Trans-Sulawesi East road is applied to the same system of Tawaeli-Toboli road.

Site offices are to be located at Kolonadale, Bungku and Asera. Required vehicles and equipment for the road maintenance and operations to each site office are listed in Table 26.1. Table 26.2 shows the maintenance and operation cost of the Trans-Sulawesi East Road.

**Table 26.1 Vehicles and Equipment for Road Maintenance**

| Site Office | Jurisdiction | Vehicles and Equipment (unit) | | | |
|---|---|---|---|---|---|
| | | Pick up | Dump truck | Bulldozer | loader |
| Kolonadare | Link No.15 | 15 | 2 | 1 | 1 |
| Bungku | Link Nos.. 16 & 22 | 15 | 2 | 1 | 1 |
| Asera | Link Nos.. 33 &32 | 20 | 2 | 1 | 1 |

*Source: Study Team*

**Table 26.2 Maintenance and Operation Cost of Trans-Sulawesi East Road**

| Road link No. | Location | Maintenance and Operation Cost except for Overlay Cost ( Million Rp.) | Overlay Cost (Every 7 years) (Million Rp.) |
|---|---|---|---|
| 15 | Uekuli – Tompira | 194 | 22,961 |
| 16 & 22 | Umpanga – Provincial Border | 249 | 29,481 |
| 33 &32 | Provincial Border - Sandangpangan | 233 | 27,569 |

*Source: Study Team*

## 27. COST ESTIMATES AND IMPLEMENTATION SCHEDULE

The estimated project cost (in July 1998 prices) and implementation schedule for Link Nos.. 15, 16, 22, 33 and 32 are shown in Figure 27.1.

## 28. ECONOMIC ANALYSIS

The result of economic analysis of feasibility study is shown in Table 28.1.

## 29. CONCLUSION AND RECOMMENDATION

Link Nos. 16, 22, 33 and 32 are feasible with a high EIRR and will be constructed by the end of 2003, to complete the missing sections of the Trans-Sulawesi East Road:

- The road is two-lane with a design speed of 40 km/hr to 60 km/hr.
- The construction cost including ROW is 895.76 Billion Rp. with pavement work over 283.5 km, bridges totalling 6,190 m, slope protection works covering 150,752 m$^2$ and 912,000 m$^3$ of disposal soils (at intervals of 10km on the average).
- Slope protection works such as sprayed concrete cribwork, shortcrete work, stone masonry and mat gabions for fill and cut slopes should be constructed to prevent soil erosion and landslides.
- Tunnel construction was recommended considering the following points:

- Prevention of hazards on the road sections where the slope protection structure is not practical.
- Ensuring of adequate road alignment by reducing sharp turns.

Link Nos. 15 is feasible with a high EIRR and will be constructed with two-lane and a design speed of 30 km/h to 60 km/h. However, the construction cost of the Trans-Sulawesi East road (1,482 Billion Rp.). Therefore, the construction of link No.15 may be deferred by five (5) years considering the availability of Bina Marga's budget.

**Table 28.1 Result of Economic Analysis**

| Link No. | Location | EIRR (%) | NPV (Million Rp.) | B/C | Road Length (km) |
|---|---|---|---|---|---|
| 15 | Uekuli – Tompira | 20.5 | 152,563 | 1.51 | 114.1 |
| 16 | Umpanga – Bungku | 40.9 | 84,660 | 3.89 | 35.8 |
| 22 | Bungku – Provincial Border | 19.5 | 89,869 | 1.37 | 110.7 |
| 33 | Provincial Border – Asera | 33.4 | 106,586 | 2.79 | 55.5 |
| 32 | Asera - Sandangpangan | 30.4 | 163,407 | 2.47 | 81.5 |
| Total | Uekuli - Sandangpangan | 23.8 | 597,085 | 1.81 | 397.6 |

Discount Rate: 15 % p.a. *Source: Study Team*

| Link No. | Schedule and Cost | 1999 | 2000 | 2001 | 2002 | 2003 | Total |
|---|---|---|---|---|---|---|---|
| 15, 16, 22, 33, 32 | Preparation<br>Design<br>Construction | | | | | | |
| 15 | F/C (Thousand US$) | | 1,383 | 6,213 | 10,934 | 11,526 | 30,056 |
| | L/C (Billion Rp.) | | 16.03 | 56.42 | 87.11 | 108.11 | 267.67 |
| | Total (Billion Rp.) | | 30.69 | 122.27 | 203.01 | 230.29 | 586.26 |
| 16 | F/C (Thousand US$) | | 145 | 400 | 989 | 1,478 | 3,012 |
| | L/C (Billion Rp.) | | 1.43 | 4.16 | 9.06 | 15.00 | 29.65 |
| | Total (Billion Rp.) | | 2.97 | 8.40 | 19.54 | 30.67 | 61.58 |
| 22 | F/C (Thousand US$) | | 1,138 | 4,439 | 9,300 | 9,390 | 24,267 |
| | L/C (Billion Rp.) | | 10.20 | 40.95 | 81.42 | 92.74 | 225.31 |
| | Total (Billion Rp.) | | 22.26 | 88.01 | 180.00 | 192.28 | 482.55 |
| 33 | F/C (Thousand US$) | | 307 | 883 | 2,273 | 3,078 | 6,541 |
| | L/C (Billion Rp.) | | 2.92 | 8.93 | 19.00 | 30.08 | 60.93 |
| | Total (Billion Rp.) | | 6.17 | 18.30 | 43.09 | 62.71 | 130.27 |
| 32 | F/C (Thousand US$) | | 522 | 1,696 | 3,707 | 4,907 | 10,832 |
| | L/C (Billion Rp.) | | 5.64 | 17.63 | 33.59 | 49.68 | 106.54 |
| | Total (Billion Rp.) | | 11.18 | 35.61 | 72.89 | 101.69 | 221.37 |
| 15, 16, 22, 33, 32 | Grand Total F/C (Thousand US$) | | 3,495 | 13,631 | 27,203 | 30,379 | 74,708 |
| | Grand Total L/C (Billion Rp.) | | 36.22 | 128.09 | 230.18 | 295.61 | 690.10 |
| | Grand Total Total (Billion Rp.) | | 73.27 | 272.59 | 518.53 | 617.64 | 1,482.03 |

Notes: Exchange Rate: 1.0 US$ = 10,600 Rp. *Source: Study Team*

Link No. 15 was studied based on topographic map with a scale of 1:50,000 but link Nos. 16, 22, 32 and 33 were studied based on topographic map with a scale of 1:5,000.

**Figure 27.1 Project Cost and Implementation Schedule for Trans-Sulawesi East Road**

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