14.4 Hydrological Study and Analysis

14.4.1 Purpose of the Analysis

The purpose of the analysis was to clarify the hydrological characteristics of the drainage structures/facilities to cover:

- Analyzing of Probable Daily Rainfall in the project area using available hydro-meteorological data.
- Establishment of an appropriate design return period for each type of drainage structure or facility.
- Estimation of the design rainfall intensity for each type of drainage structure or facility.
- Estimation of the flood discharge of major rivers which have crossing points along the high priority project roads.

14.4.2 Review of Hydro-meteorological Data

There are five rain gauge stations around the Project area with the annual rainfall data for the past 30 years at each rain gauge station being acquired (refer to Appendix 14.10).

Out of the five rain gauge stations, the one at Dar es Salaam Airport was considered to be the most reliable for statistical analysis from the following viewpoints:

- The average annual rainfall for the past 30 years indicates the highest value of the five stations.
- The most consecutive and accumulative rainfall data are available.

14.4.3 Probable Daily Rainfall

The probable daily rainfall in the Project area was analyzed by means of the following three statistical methods using the maximum daily rainfall records from the Dar es Salaam Airport shown in Appendix 14.11.

- Hazen Method
- Gumbel Method
- Pearson Type III Method

As a result of the above analysis, the probable daily rainfall was estimated for the return period as shown in Table 14.5.

Table 14.5 Probable Daily Rainfall

Return Period (year)	Hazen Method	Gumbel Method	Pearson Type III Method
3	78.8	81.1	79.0
5	89.2	91.6	89.5
7	95.4	98.2	95.0
10	102.0	104.9	101.1
50	132.3	134.2	126.4

Of the three statistical methods, the Gumbel method indicated the highest value in each return period. Thus, the value in Gumbel Method was applied as the probable daily rainfall for further analysis.

14.4.4 Design Return Period

The design return period for each type of drainage structure was applied as shown below in Table 14.6 from the viewpoint of the importance in the roads.

Table 14.6 Design Return Period

Type of drainage Structure	Applied Design Return Period	Remarks
Bridge and Box Culvert crossing of river	50 years	Important structures for operation and maintenance of the roads
Pipe and Box Culvert for drainage on flat area	10 years	
Pipe Culvert for minor drainage	5 years	
Other Structures/facilities	3 years	

14.4.5 Design Rainfall Intensity

The design rainfall intensity by type of drainage structure was determined on the basis of estimation of probable daily rainfall and established design return period. The rainfall intensity curves are illustrated in Fig. 14.5.

14.4.6 Flood Discharge

Four major rivers which have large basins were identified in the Project area. These are the Msimbazi, Ubungo/Ruhanga, Sinza and Kijitonyama Rivers. As shown in Figure 14.6, there are four crossing points on the high priority project roads with these major rivers.

The flood discharge at the crossing points were estimated to clarify the size of the drainage structures. The Rational Formula was applied for estimation of the flood discharge (refer to Appendix-14.12). The results of this are shown in Table 14.7.

Table 14.7 Flood Discharge on Major River

Crossing Point /1	Project Road	Major River	Flood Discharge /2
(A)	New Kigogo	Msimbazi	381.4 m3/sec
(B)	New Kigogo	Ubungo/Ruhanga	73.6 m3/sec
(C)	Morocco	Sinza	65.1 m3/sec
(D)	New Bagamoyo	Kijitonyama	32.3 m3/sec

Note: /1 For each location, refers to Figure 14.6.
/2 Estimated with 50-year return period.

14.5 Topographical Survey

Supplemental plane surveys were conducted at the following sites shown in Figure 14.2 for the purpose of performing the structural design:

1) Sokoine Seashore
2) Gerezani Bridge
3) Bandari Bridge
4) First Msimbazi Culvert Box
5) Second Ubungo Culvert Box
6) Sinza Culvert Box
7) Ilala Bridge

The preliminary design including road alignment and the drainage design was based on existing topographic maps having a scale of 1 to 2,500 (edited from aerial photos taken in 1992).

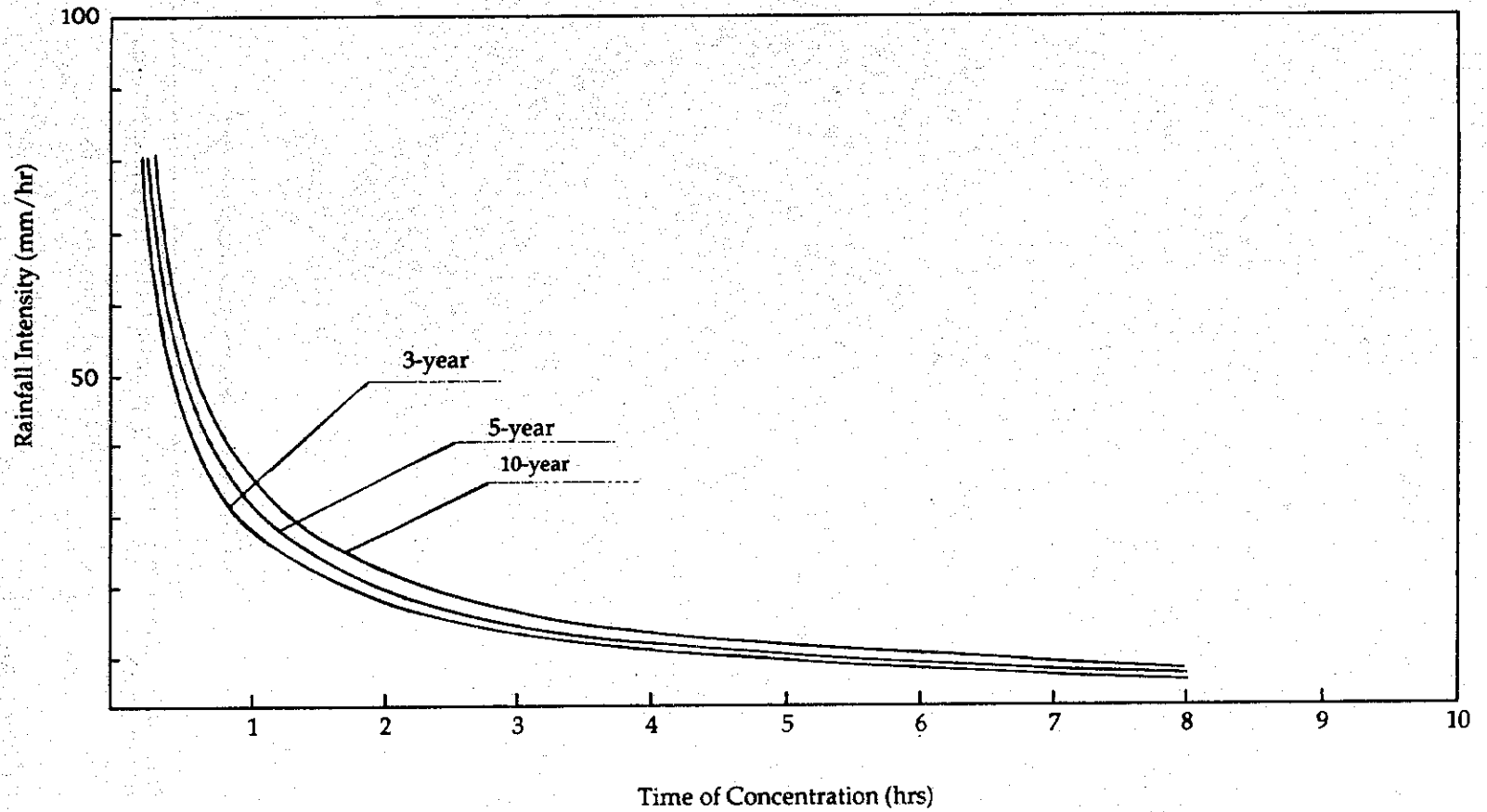
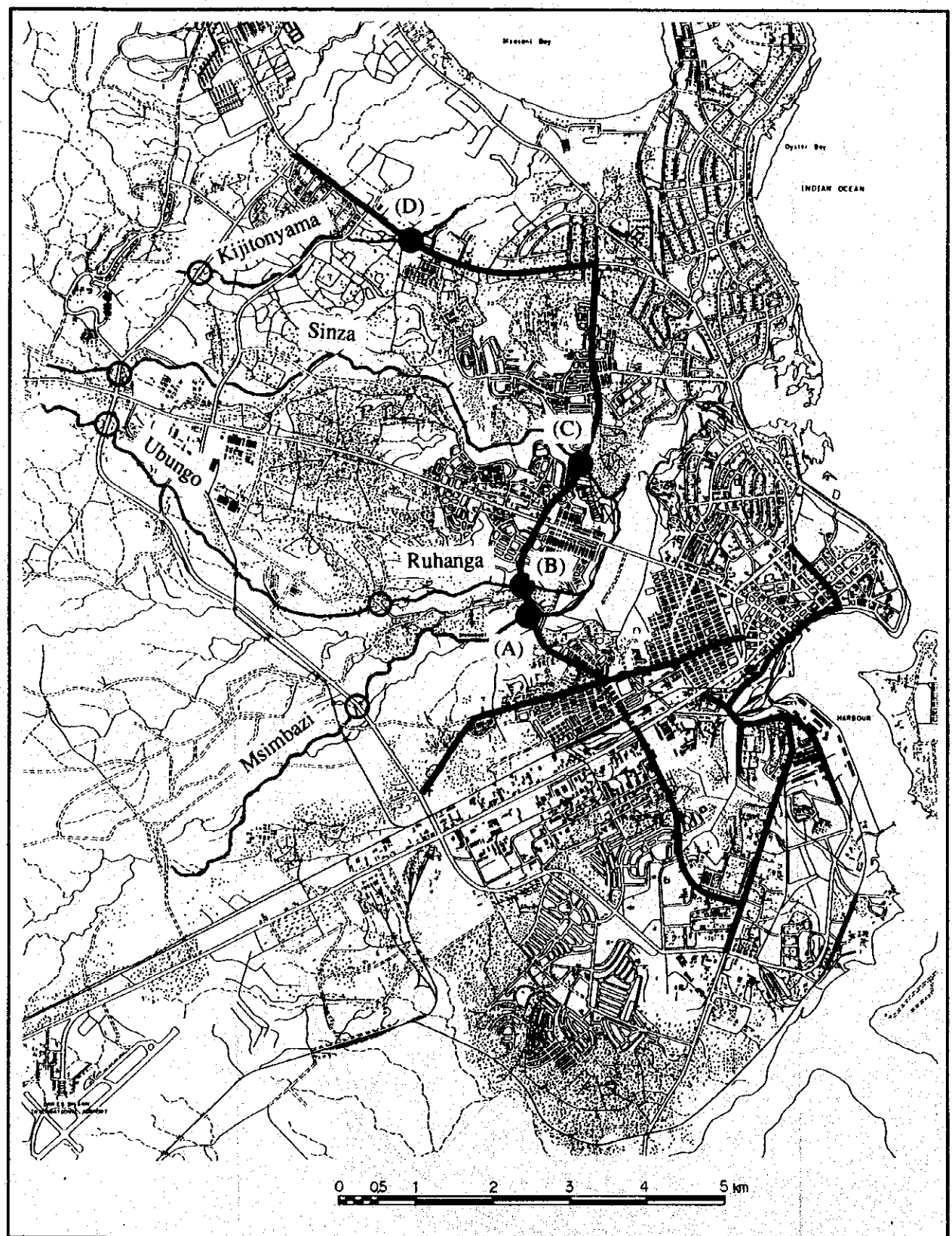


Figure 14.5 Rainfall Intensity Curve



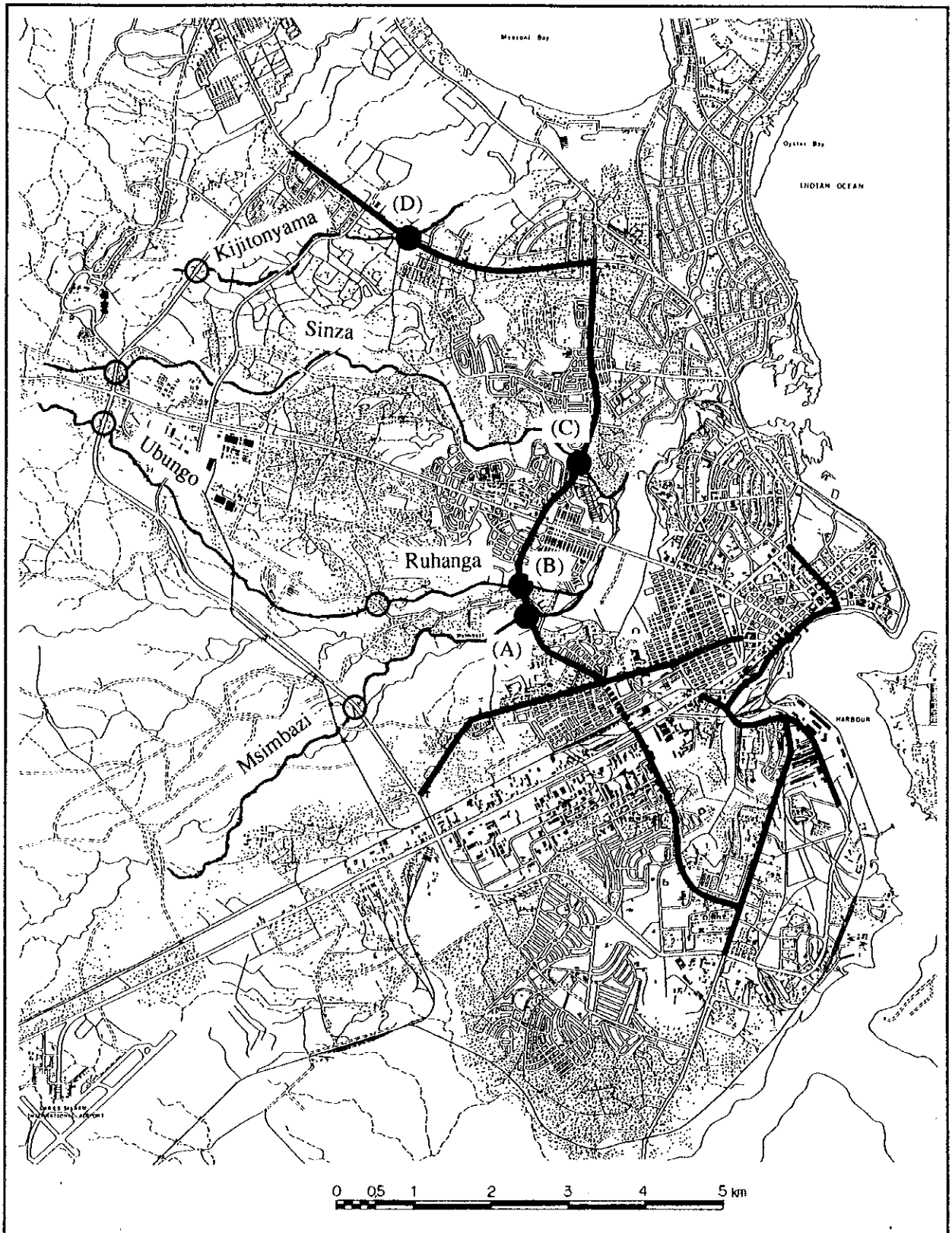
THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 14.6

Major Rivers in the Project Area

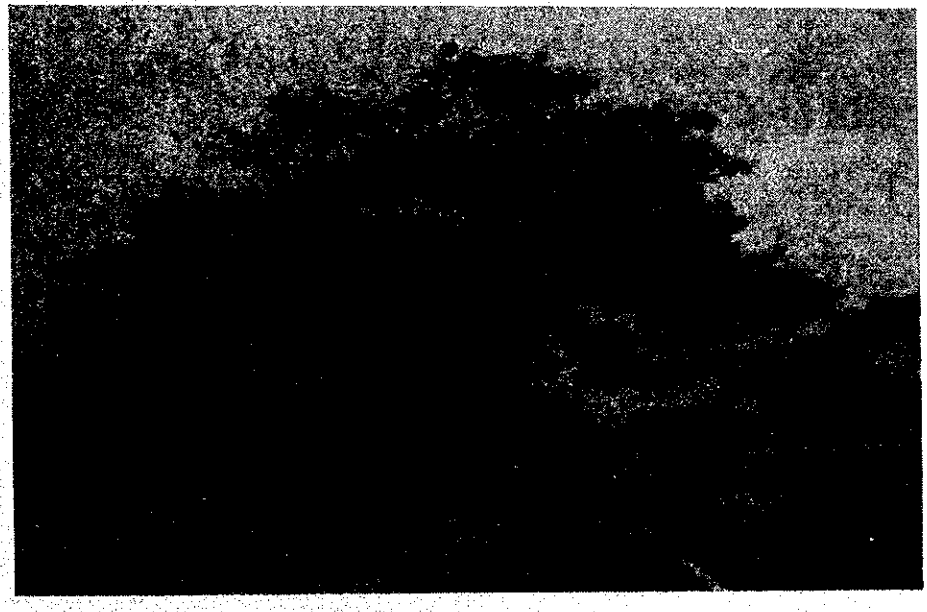
● Crossing point on high priority project roads

○ Crossing point on other trunk roads



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN	● Crossing point on high priority project roads ○ Crossing point on other trunk roads
Fig. 14.6 Major Rivers in the Project Area	

CHAPTER 15 PRELIMINARY ENGINEERING DESIGN



Chapter 15 PRELIMINARY ENGINEERING DESIGN

15.1 General

On the basis of the data and information obtained through the field surveys, the preliminary engineering design was conducted using the existing topographical maps with a scale of 1/2,500 for the road design. A supplemental topographical map with a scale of 1/500 was prepared by the Study Team for the bridge and structural design.

The preliminary engineering design was conducted for the following items of priority roads:

- Alternative Route Study
- Highway Design including Intersections
- Bridge and Structural Design
- Drainage Design
- Pavement Design
- Road Facilities Design
- Public Utilities Design
- Preliminary Right-of-way Plan

15.2 Alternative Route Study

An alternative study has been conducted for the following two sections of the proposed roads:

* Missing Link of the Middle Ring Road between New Kigogo and Chang'ombe Road (L= 750 m)

* Kariakoo Section of Uhuru Road (L= 880 m)

No alternative study was conducted for the other proposed roads because of the following reasons:

(i) The principal improvement measure proposed for the other high priority roads is a widening of the existing road, so that no remarkable alignment changes are necessary.

(ii) The land alongside the proposed road has many shops and houses, so that alignment changes would require a large amount of land and house acquisitions.

15.2.1 Missing Link of Middle Ring Road

Three alternative routes were considered for the missing link between New Kigogo and Chang'ombe Road as shown Fig.15.1. The advantages and disadvantages that were studied for each alternative are summarized below:

(1) Alternative Routes

(i) Alternative 1:

The priority for this alternative was given to the alignment taking into account that the function of the Middle Ring Road has a high design standard, but the proposed alignment is running through the center of cemetery.

This alternative plan is advantageous in terms of the safety and the streamlining of traffic because of a better alignment; however, implementation of the Project might be difficult because it may take a long time for negotiations with the owners of gravestone regarding relocation and compensation for the graves that would have to be moved.

(ii) Alternative 2:

This alignment utilizes the open space of Karume Memorial Stadium running along the fence on the boundary between Memorial Stadium and the cemetery. Although the effect on the cemetery is minimal, part of the land of Karume Memorial Stadium must be acquired.

Even so, it is advantageous since the route will not affect the cemetery.

(iii) Alternative 3:

The alignment is for this alternative is along the boundary on the western end of cemetery to avoid any effect on it as well as the Karume Memorial Stadium.

Alternative 3 will not affect the Karume Memorial Stadium and the cemetery; however, it will pass through a large number of houses including the Boma buildings and primary school located nearby which may require long negotiation and large costs for their removal and relocation.

Overall, Alternative 2 is recommended taking into consideration the ease of implementation as well as the comparatively less cost required for the compensation of land acquisition and house removal.

(2) Alternative Profile

The proposed route, however, has to cross over three railway track lines in this section. Two alternative profiles were considered as shown in Fig.15.2 for crossing these railway tracks as outlined below:

(i) Profile 2-1:

The Profile 2-1 was planned to pass over the existing railway track lines No. 1 and No. 2 (No. 3 is not affected) by provision of a 45 m long RC bridge, three box culverts (5.0 m x 4.7 m) and a 220 m long retaining wall with an average height of 6.0 m at both ends of the roadsides in the approach section. This may result in a large construction cost as listed below:

Retaining wall (H= 6.0 m ave., L= 2 x 220 m)	US$ 1.3 million
Box culvert (3 nos., WxHxL=5.0x4.7x21.0m)	US$ 1.6 million
Earthwork & Pavement (65,000 m^3 & 14,700m^2)	US$ 1.2 million
Bridge RC 3@ 15.0 W= 21m	US$ 3.3 million
Total	US$ 7.4 million

(ii) Profile 2-2:

Profile 2-2 was planned to be intersected with the main railway track at-grade/level. This plan, however, requires that the alignment of railway track No. 1 be raised by 2.5 m (maximum) up to the same level of the sidetrack (track line No. 2) as shown in Fig. 15.3. This will require an alignment change of the railway track for a total length of about 1.0 km. The estimated cost for the realignment of the railway is as follows:

- Embankment of railway track
  (HxWxL = 2.0 m x 10.0 m x 1,000 m) with gravel (t= 0.5 cm)
  US$ 0.5 million
- Installation of new railway (40 kg/m x 2 nos. x 1,000 m)
  US$ 0.2 million
- Construction of missing link (L= 700 m, W= 25 m)
  US$ 0.7 million

  Total US$ 1.4 million

Even though Profile 2-2 will interfere with the railway operation during the realignment of the track, the following advantages are expected:

(i) The estimated cost of Profile 2-2 is less than one-fifth of Profile 2-1. It should be noted that the cost required for railway realignment is included as a part of the relocation work pertaining to the road construction.

(ii) While Profile 2-2 does not separate Ilala town. Profile 2-1 parcels the town into two block by means of elevated roads.

(iii) The future development of the railway by means of Profile 2-2 will be easier and less costly than that of Profile 2-1.

Considering the advantages and disadvantages mentioned above, Profile 2-2 is recommended from the engineering and economical viewpoints, though a political decision might be required for the needed realignment of TRC's railway line.

15.2.2 Kariakoo Section of Uhuru Road

The feasibility study on Uhuru Road covers the section from the UWT Junction up to Nelson Mandela Junction in accordance with the Minutes of Discussion mutually signed by Tanzanian Government and the Study Team on 7 June 1994. For the purpose of the Study, Uhuru Road is divided into three sections as shown in Fig. 15.4.

The alternative route was considered in Section 1 (Kariakoo Section) because of the very tight ROW situation. Two options were considered as shown in

Fig. 15.5.(1) and Fig. 15.5.(2), with advantages and disadvantages of each alternative being described below:

(1) Option 1: Widening of the Existing Uhuru Road to 4 Lanes

The construction of widening to 4-lanes road will be made by extending the existing carriage way by 10.0 m including a 3.0 wide sidewalk. The additional land to be acquired along the existing road is 10 m to 15 m wide.

This proposal is advantageous in terms of streamlining the traffic; however, the implementation might be very difficult because of the fact that the area alongside the road is densely developed by multi-storyed permanent buildings, which would require large compensation costs for house removal and relocation. 38 high-storyed (max. 7 storyed) concrete buildings would have to be removed.

It is noted that the pavement overlay on the existing road in the Kariakoo section will be done in the next year under the Japanese Grant Aid Program of DRIMP - IV, which is supposed to be implemented from January 1995 to March 1996. It is assumed, therefore, that the existing carriage way will be used as it is without large pavement improvement or rehabilitation, with the exception of the minor adjustment. Construction of pavement will be done only for the carriageway where the widening will be performed.

The construction cost for the above widening work is estimated as shown below:

Widening length	= 750 m
Pavement width for widening	= 7.0 m in average
Sidewalk to be constructed (one side)	= 3.0 m
Roadside drainage to be provided (both side)	= 750 m
Nos. of houses/buildings to be removed	= 66 nos.
Estimated construction cost	= Tsh. 278 million
Estimated land/house compensation cost	= Tsh. 239 million
Total Cost	= Tsh. 517 million

(2) Option 2: Introduction of a One-way System

One-way system could be introduced using the Kipata Street which is running in parallel with the Uhuru Road behind the block. The Kipata Street shall be widened to 2-lanes road to meet the requirement of the design standard of the proposed road.

It is assumed that the existing road will be used for the traffic coming from Ilala area to the city center, while the existing road for the traffic from the city center to the outside. The existing road will be utilized as it is and no major improvement will be needed for the same reason explained for Option 1. The Kipata street shall be reconstructed totally.

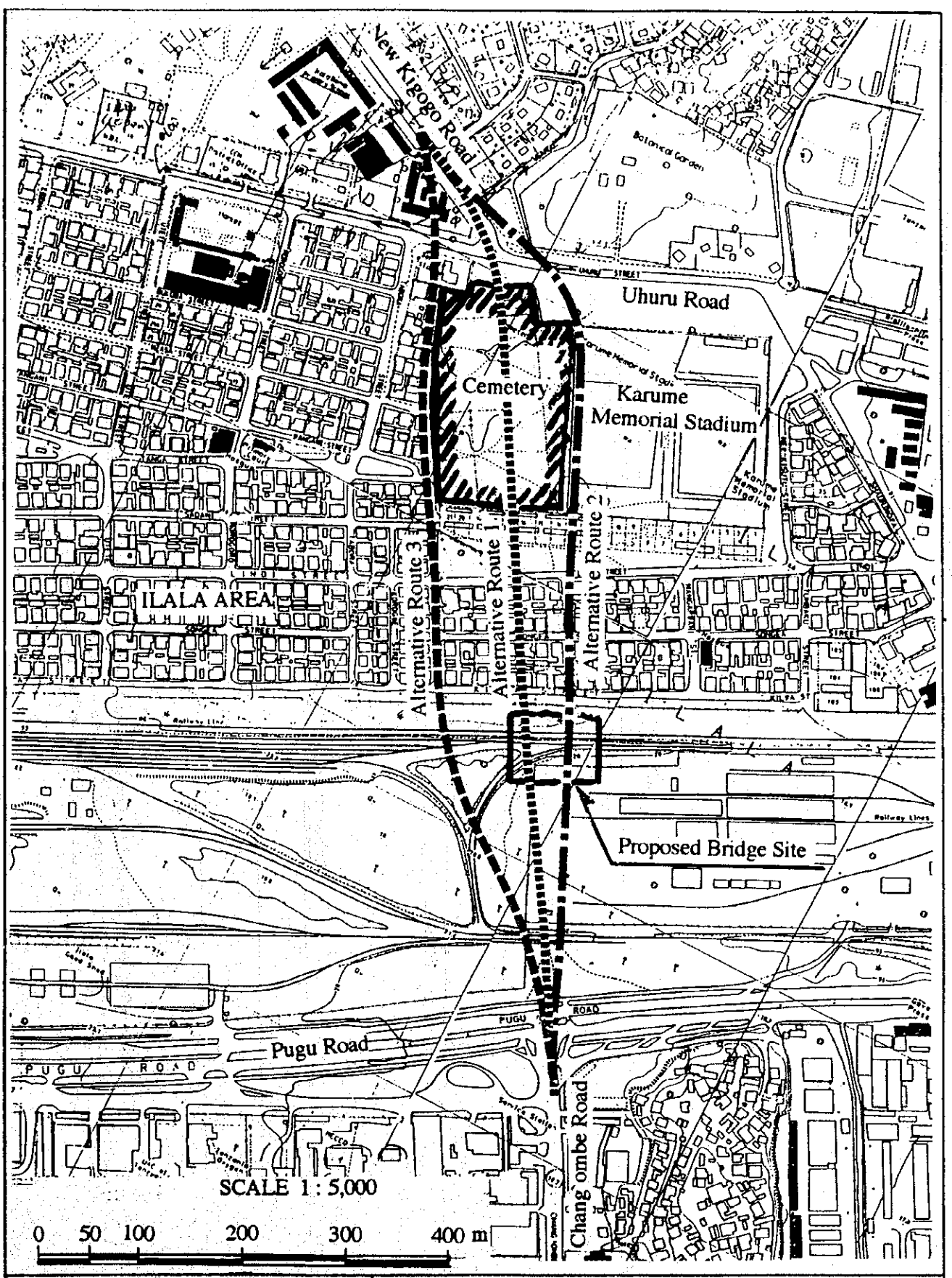
Option 2 may also require a compensation costs for removal of houses; however, those houses which have to be removed are mostly one-storied houses (max. 2 stories) so that the acquisition and compensation might not be so difficult if compared to Option 1. The houses to be removed are 29 nos. in total.

The construction cost for the Option 2 is estimated as shown below:

Reconstruction of Kipata Street	= 850 m
Pavement width for reconstruction	= 7.0 m in average
Sidewalk to be constructed (both side)	= 2.0 m
Roadside drainage to be provided (both side)	= 2 x 850 m
Nos. of houses/buildings to be removed	= 22 nos.
Estimated construction cost	= Tsh. 388 million
Estimated land/house compensation cost	= Tsh. 66 million
Total cost	= Tsh. 454 million

As seen in the above comparison, the construction cost of Option 1 (Tsh. 279 million) is smaller than that of Option 2 (Tsh. 388 million), however, total cost of Option 1 is higher than that of Option 2 due to high compensation costs for houses and buildings removal in Option 1.

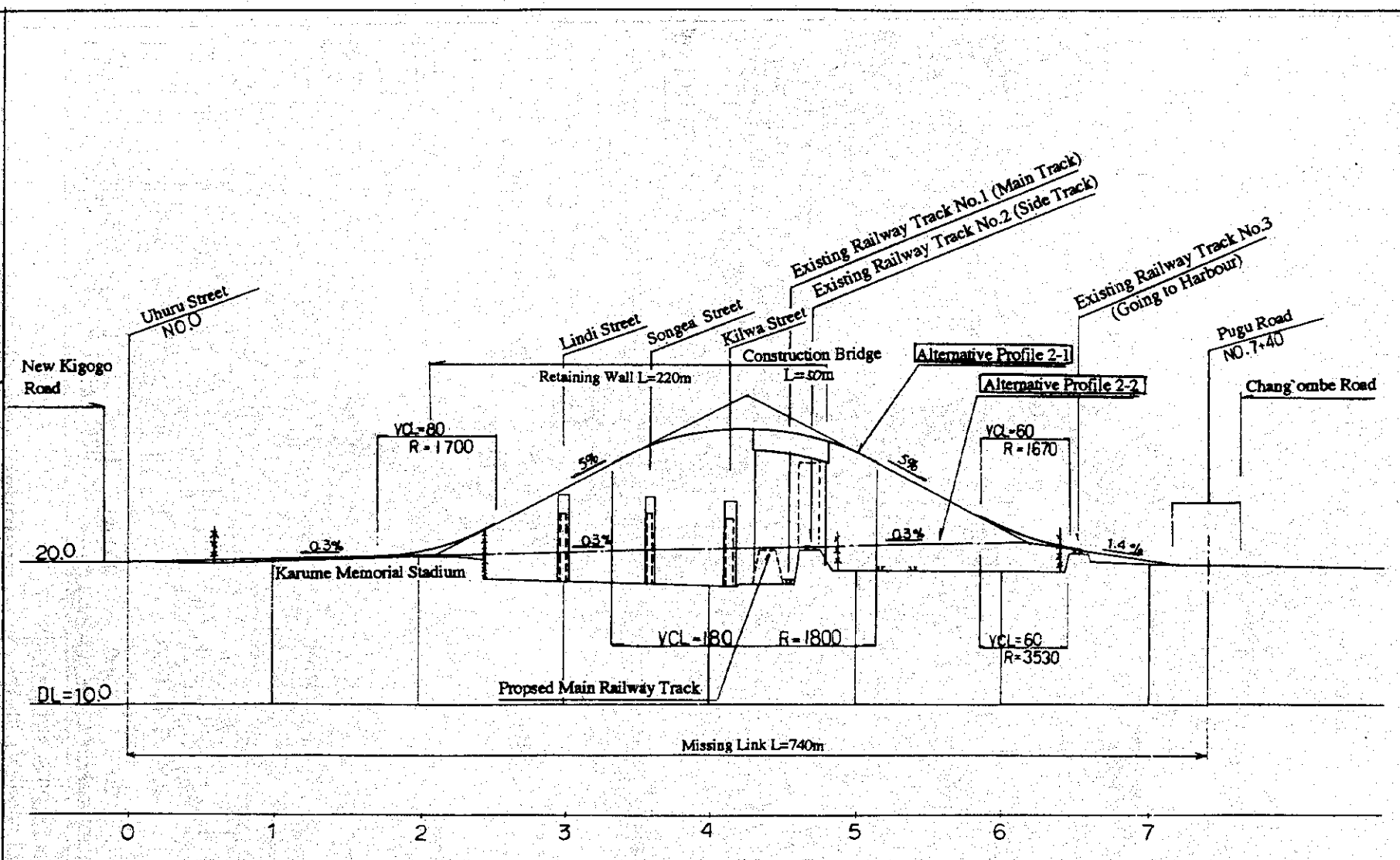
Option 1 (one-way system) is, therefore, recommended taking into consideration the ease of implementation from the view point of land/house acquisition and compensation. The calculation of construction costs for each alternative are presented in Appendix. 15.1.



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

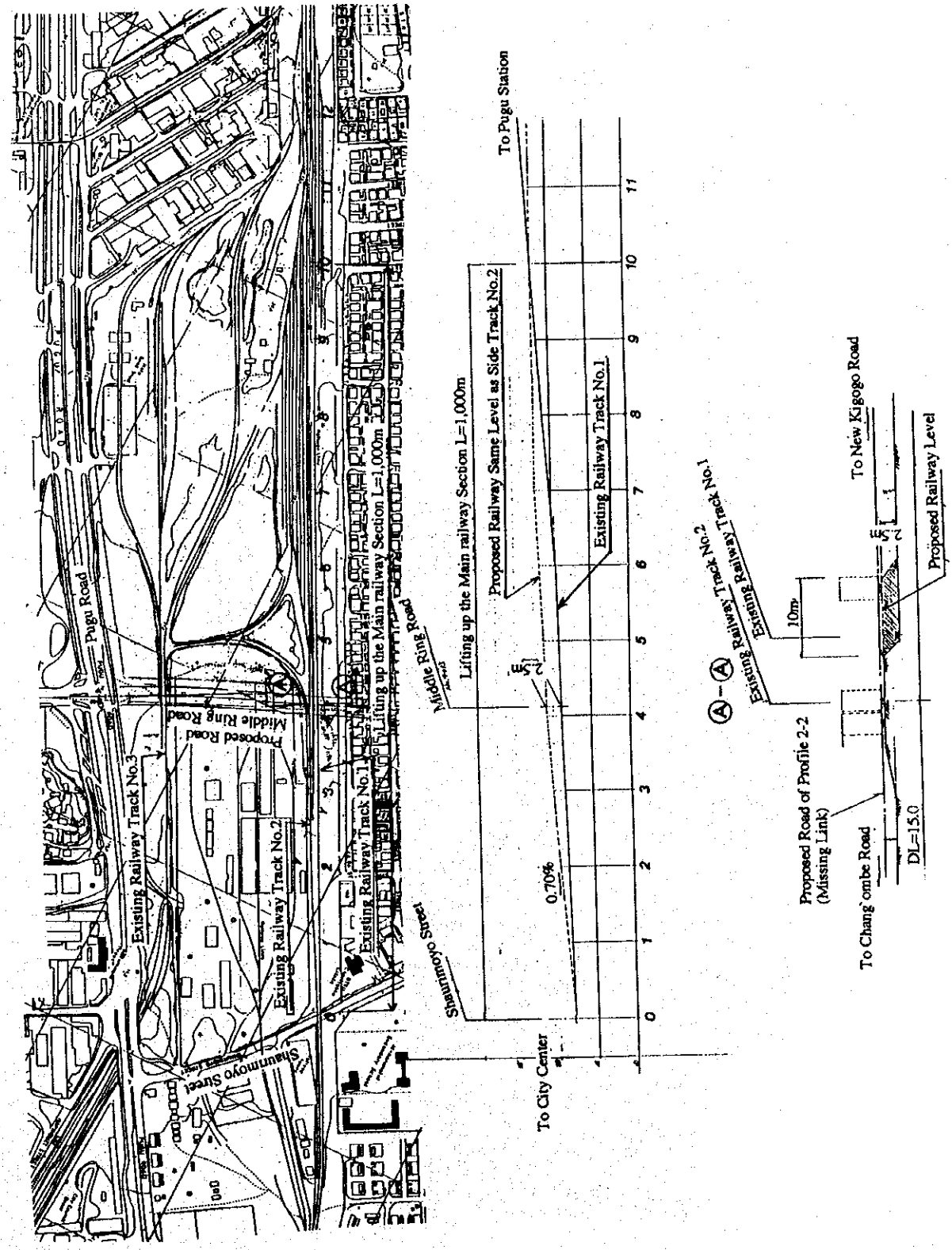
Fig.15.1
Alternative Routes on Missing Link of the Middle Ring Road

Alternative Route 1
Alternative Route 2 (Recommendation)
Alternative Route 3

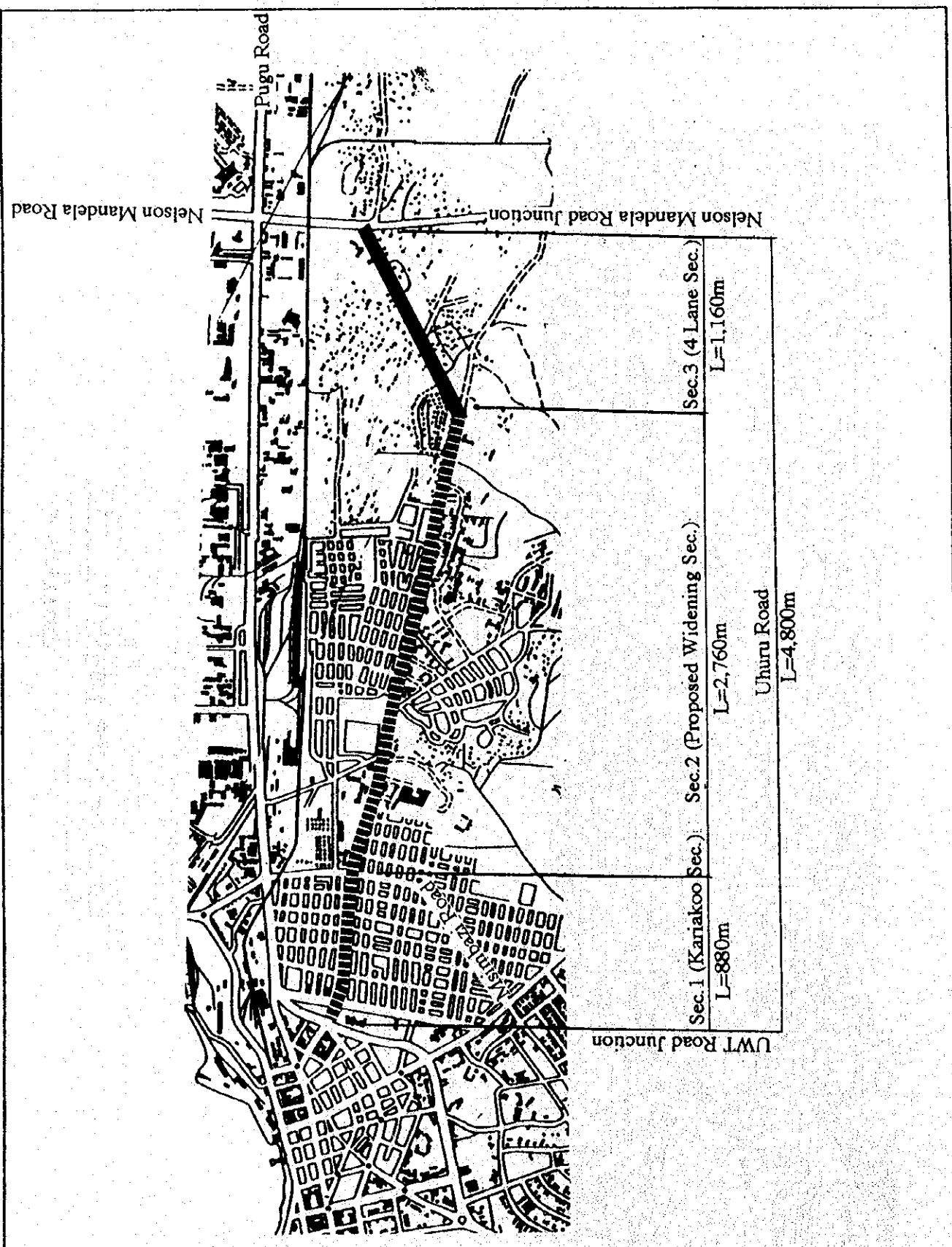


Alternative Profile 2-1 : The Proposed Road is planned flying over the railway by provision of bridge.
Alternative Profile 2-2 : The Proposed Road is planned to cross over the railway at-grade level by lifting up the Main railway up to the level of sidetracks.

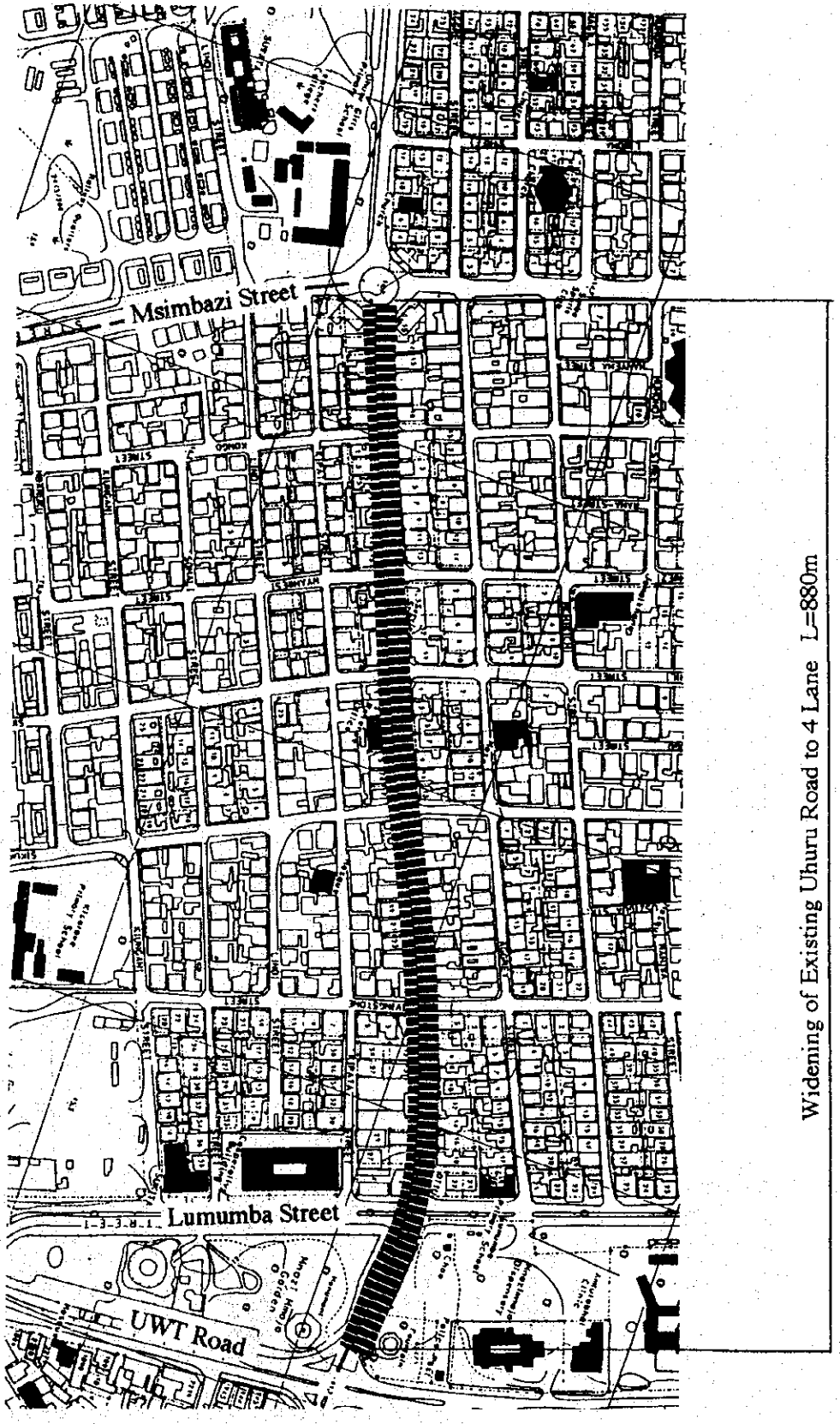
Fig. 15.2 Alternative Profile of Route No.2, Missing Link of the Middle Ring Road



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN	Fig.15.3 Proposed Re-alighnment Plan of TRC's Railway Track at Chang'ombe

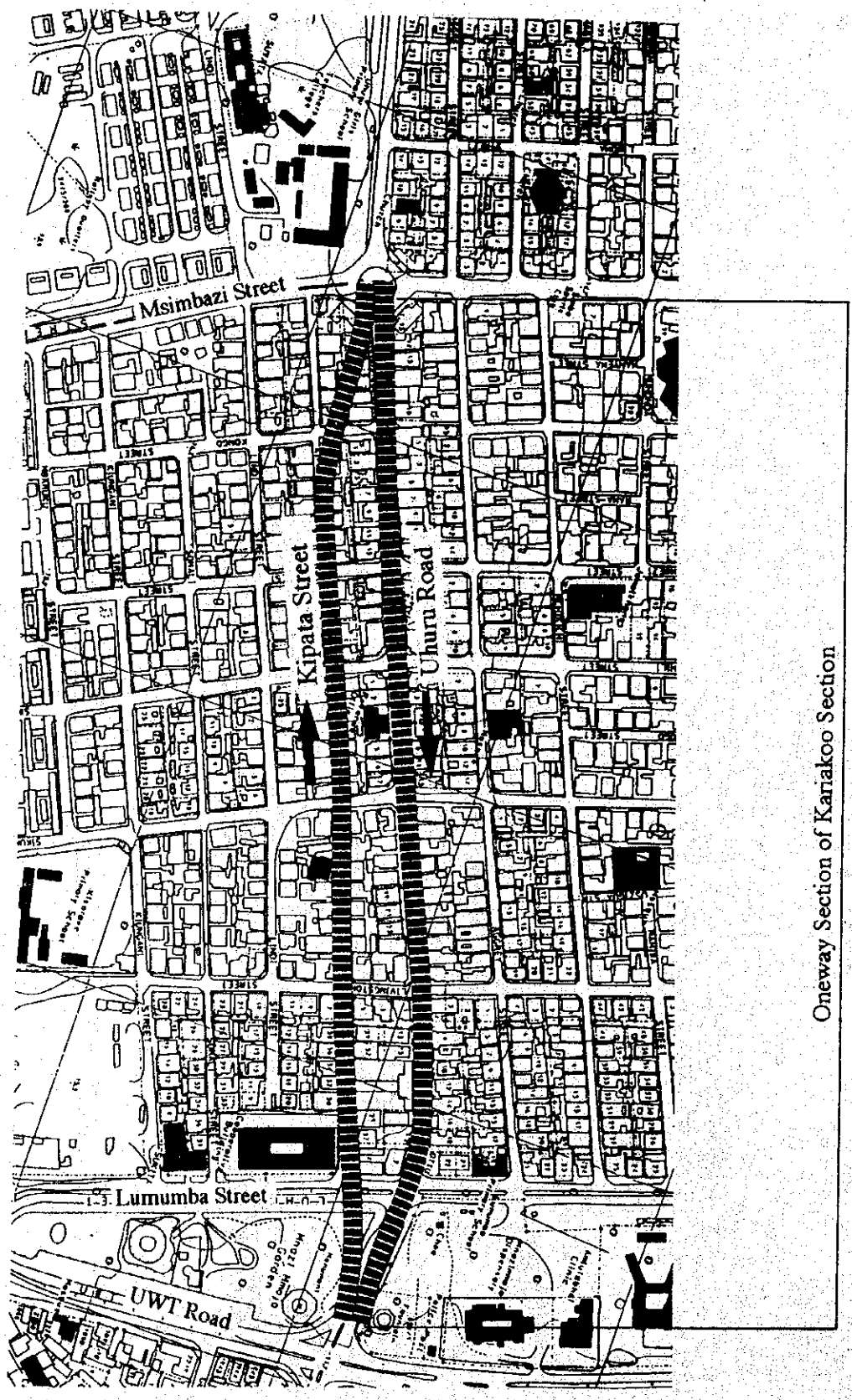


THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN	Sec.1 : UWT Road Junction - Msimbazi Road Junction Sec.2 : Msimbazi Road Junction - End Point of 4 Lane Road Sec.3 : 4 Lane Road Section
Fig. 15.4 Sub-section of Uhuru Road	Section



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 15.5(1) Alternative Widening Plan of Kariakoo Section of Uhuru Road (Option-1)



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 15.5(2) Alternative Widening Plan of Kariakoo Section of Uhuru Road (Option-2)

15.3 Highway Design

15.3.1 Basic Concept of Highway Design

Before starting the preliminary engineering design on the priority roads, the following concepts were established:

(1) The proposed roads will form a basic frame of the urban road network in Dar es Salaam, so that the geometric design including the alignment should meet the requirement of the expected function as an arterial road.

(2) The roads should be designed paying due attention to the characteristics of the traffic components and local movement in Dar es Salaam; that is, large-size heavy trucks and buses, non-motorized transport including bicycles, push carts, large numbers of pedestrians, etc.

(3) Since the proposed roads are located in the urban areas where land acquisition and property demolishing are very sensitive, the right-of-way aspects should be studied carefully. Widening of the existing road should be planned inside the present ROW strip as much as possible to minimize the removal of houses and buildings along the side of the proposed road.

(4) The road drainage should be connected to the existing storm drainage system properly, paying due attention to their functions as well as the working conditions.

(5) Public utilities including water mains, sewerage, telephone cables, electric wires/poles, etc., that are located inside the ROW strip should be thoroughly investigated. Relocation and/or protection of these utilities should be planned taking into account the ease of repair and maintenance operation which would often hinder traffic and accelerate the deterioration of the road structure.

(6) Since bus services are the main means of public transport in Dar es Salaam, so that the provision of facilities such as bus stops, terminals, bus stations and interchange points with other forms of transport should be designed properly by consideration with the agency concerned. Introduction of a bus exclusive lane or priority bus lane should be studied in the road design taking into consideration the future development of bus services.

(7) The intersection, where grade separation is ultimately proposed for the long-term plan, should be designed with sufficient capacity to accommodate the anticipated future traffic demand and be planned as far as practicable to conform to the future layout. In this regard, the ROW plan should cover the space required for grade separation at the ultimate stage.

15.3.2 Geometric Design Standards

Geometric design standards to be applied for each road are directly related to the design speed. Table 15.1 shows the proposed geometric design criteria to be applied for each road.

Table 15.1 Proposed Geometric Design Standards

Proposed Roads	Design Speed (km/hr)	Min. Radius Desirable (m)	Min. Radius Absolute (m)	Min. Radius for no Transition (m)	Maximum Gradient (%)	Normal Camber (%)	Normal Shoulder slope (%)	Stopping Sight Distance (m)	Passing Sight Distance (m)
1 Package 1: Arterial Roads in the City Center									
- Ohio Street	40	75	50	220	6.0	2.0	3.5	40	250
- Kivukoni Front	40	75	50	220	6.0	2.0	3.5	40	250
- Sokoine Drive	40	75	50	220	6.0	2.0	3.5	40	250
- Gerezani Street	40	75	50	220	6.0	2.0	3.5	40	250
- Bandari Road	40	75	50	220	6.0	2.0	3.5	40	250
2 Package 2: Middle Ring Road									
- Morocco Road	60	150	125	500	5.0	2.0	3.5	75	400
- New Kigogo Road	60	150	125	500	5.0	2.0	3.5	75	400
- Chang'ombe Road	60	150	125	500	5.0	2.0	3.5	75	400
- Missing Link	60	150	125	500	5.0	2.0	3.5	75	400
3 Package 3: Radial Trunk Roads									
- New Bagamoyo Road	80	300	230	900	4.0	2.0	3.5	115	550
- Uhuru Road	40	75	50	220	6.0	2.0	3.5	40	250
- Kilwa Road	60	150	125	500	5.0	2.0	3.5	75	400

15.3.3 Typical Cross Sections on Proposed Roads

The width and layout of a road will depend largely upon the type, volume and speed of the traffic it will carry. The various components of the road for accommodation and safety of vehicular and pedestrian traffic has been considered for each proposed road as discussed in the following sub-sections:

(1) Package 1: Arterial Roads in the City Center

Package 1 consists of widening Ohio, Kivukoni Front, Sokoine Drive, Gerezani and Bandari Roads to 4 lanes. The proposed typical cross-sections to be applied for these roads are presented in Fig. 15.6 (1) through 15.6 (5).

The proposed roads are running through the city center where the ROW situation is very tight due to limited space; therefore, no median strip will be provided.

Sidewalks with about 10 cm high raised kerbs should be provided on both sides of the road. The width of the sidewalks will vary from 2.0 m to 5.0 m, depending on the ROW situation. A turning lane for right-turn traffic will be provided at each intersection.

Reclamation of the sea-shore along the Kivukoni Front and Sokoine Drive is proposed to assure necessary space for constructing a pedestrian promenade, bus terminal and bus stop in front of the Old Post Office and parking lots for the Ferry Station. The seaside from the Kivukoni Front up to the Ferry Station is designated as a conservation area by the Tanzanian government, so that new development by private business is strictly prohibited.

The Study Team confirmed with the Ministry of Education and Culture, which is the agency concerned with the national preservation policy, that the Ministry has no objection to the proposed plan since it is expected to improve the seaside environment.

However, the Ministry pointed out that the antiquated buildings located along the Sokoine Drive including Azania Lutheran Church, St. Joseph's Cathedral, City Hall and the national conservation monuments (particularly the Old Boma), should not be affected by the construction of proposed road. The widening of Sokoine Drive is, therefore, planned to extend towards the seaside by provision of the retaining structures to minimize the effect on thesevaluable

buildings. A minor relocation of the access roads to the Ferry Station as well as to the Sea Cargo Office of Dar es Salaam Harbor Authority might be necessary.

The ROW strip along Gerezani Road is narrow and tight for widening because of the buildings located along the road. The width of the carriageway and sidewalks shall follow the minimum standard so as to minimize the effect on the land/house acquisition.

The ROW situation along Bandari Road is also tight, so the minimum standard cross section shall also apply for this section.

(2) Package 2: Widening of Middle Ring Road

Package 2 consists of widening Morocco, New Kigogo and Chang'ombe Roads to 4 lanes. New construction of the Missing Link between New Kigogo Road and Chang'ombe Road is also included in this package. The proposed typical cross-sections to be applied for these roads are presented in Fig. 15.7 (1) through 15.7 (4).

The proposed roads are running through the urban area where many residence, kiosk and factories have been built along the road. The ROW strip is widely reserved ranging from 30 to 50 m for Morocco Road and New Kigogo Road. Wide shoulders and a median strip should be adopted wherever it is possible taking into consideration future development. And an open channel should be provided in the between shoulders and the sidewalks. The space for the open channel could be utilized for bus exclusive lanes in the future, if necessary.

The construction of the Missing Link between New Kigogo Road and Chang'ombe Road is an entirely new road passing through land owned by the Tanzania Railways Corporation (TRA). No obstructions for the road design are expected.

The widening of Chang'ombe Road will not be easy because of the limited width of the ROW strip (20 m to 25 m) as well as the factories that have been built along the road. The minimum standards of 1.0 m for median strip should apply for this section and sidewalks with raised kerbs, varying from 2.0 m to 5.0 m wide, should be built on each side of the road.

A turning lane for right-turn traffic will be provided at each major intersection.

(3) Package 3: Widening of Radial Trunk Road

Package 3 consists of widening New Bagamoyo, Uhuru and Kilwa Roads to 4 lanes. The proposed typical cross-sections to be applied for these roads are presented in Fig. 15.8 (1) through 15.8 (3).

The proposed roads are running through urban and sub-urban areas; however, the present ROW strip is widely reserved with the exception of Uhuru Road. A median strip, bicycle lanes and sidewalks with the sufficient width should be provided for New Bagamoyo and Kilwa Roads.

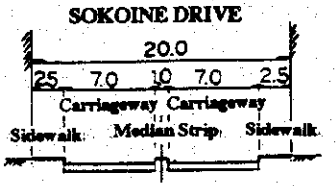


Fig. 15.6(3)

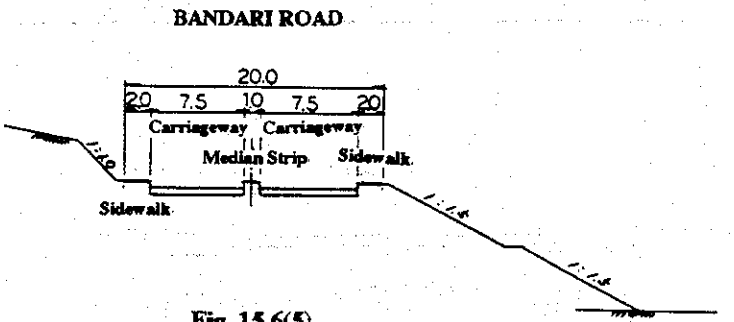


Fig. 15.6(5)

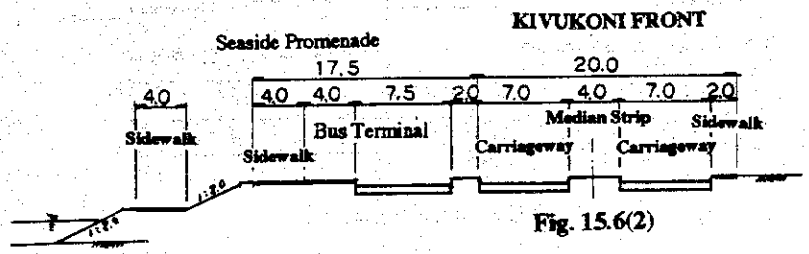


Fig. 15.6(2)

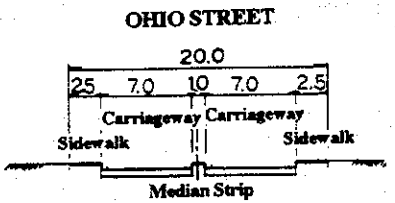


Fig. 15.6(1)

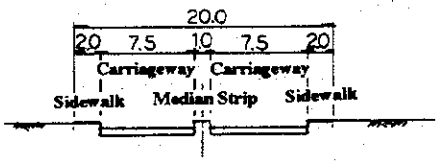


Fig. 15.6(4)

THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT STUDY	
Fig. 15. 6(1)- Fig. 15.6(5) **Typical Cross Section of Package 1**	

NEW KIGOGO ROAD

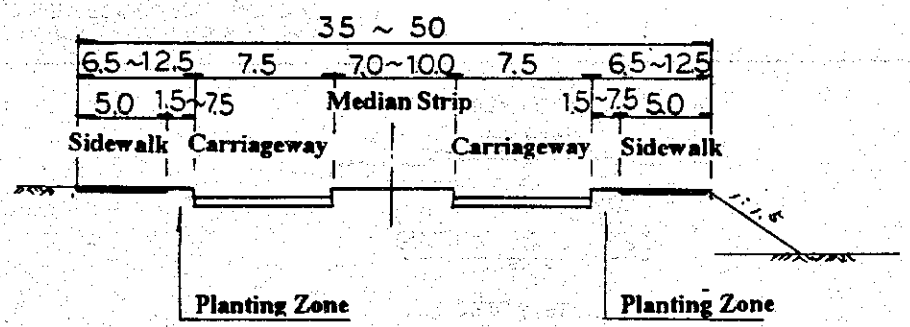


Fig. 15.7(2)

CHANG'OMBE ROAD

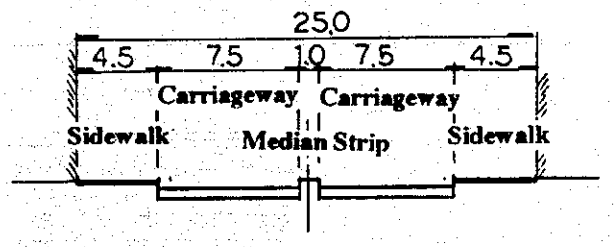


Fig. 15.7(4)

MOROCCO ROAD

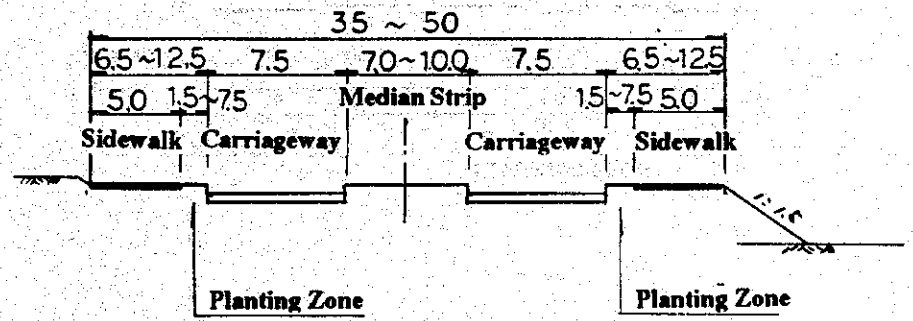


Fig. 15.7(1)

MISSING LINK

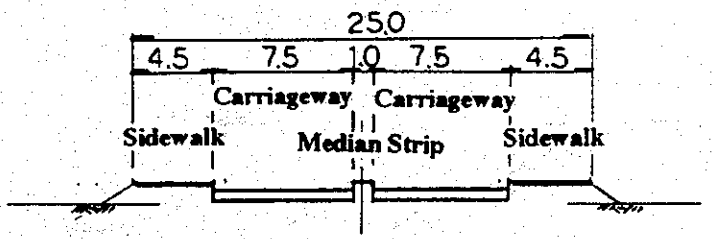


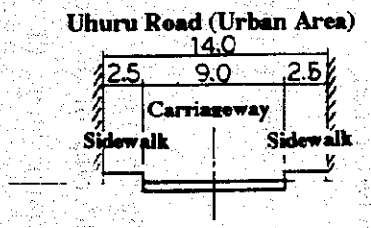
Fig. 15.7(3)

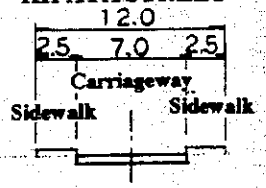
THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT STUDY

Fig. 15.7(1) - Fig.15.7(3)

Typical Cross Section of Package 2

UHURU ROAD





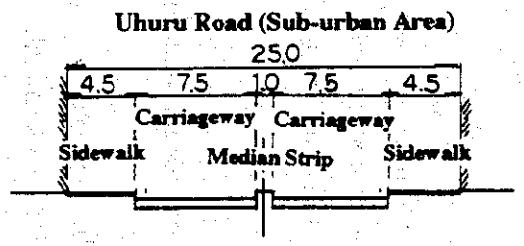
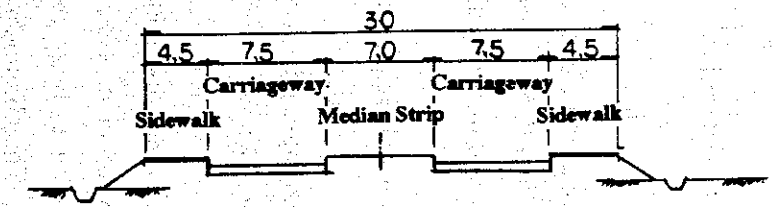


Fig. 15.8(2)

NEW BAGAMOYO ROAD



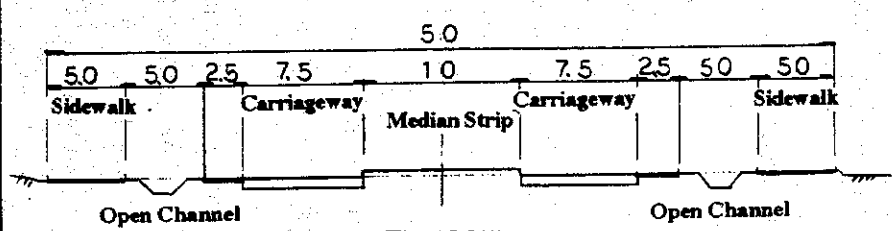
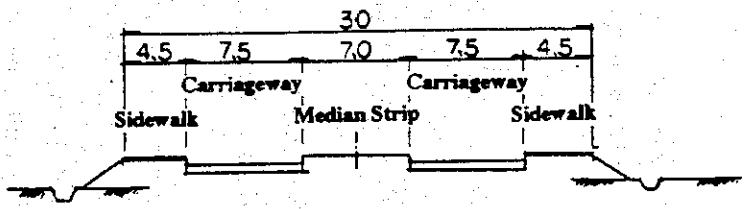


Fig. 15.8(1)

KILWA ROAD



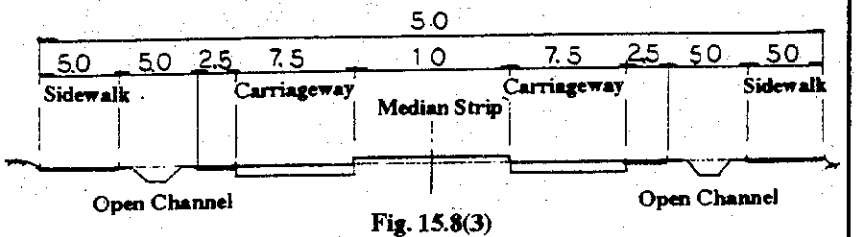


Fig. 15.8(3)

THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT STUDY	
Fig. 15.8 (1) - Fig. 15.8 (3) **Typical Cross Section of Package 3**	

15.3.4 Alignment Design

The improvement measures proposed in this Study are mainly widening of the existing road from two to four lanes so that no remarkable alignment changes are required.

Before commencing the alignment design, a reconnaissance study was conducted to find the most feasible alignment for the proposed road. The reconnaissance study was made paying attention to the following items:

- Roads to be intersected.
- Landuse situations including factories, houses and buildings to be affected.
- Historical monuments and churches to be conserved.
- Public facilities as such the railway station, sea terminal, harbor, school, hospital, etc.
- Public utilities including electric pylons, water mains, etc.

In order to minimize construction, the alignment of new roads is planned to utilize the existing road as much as possible provided that the pavement condition of the existing road is reasonably maintained in good condition.

The vertical alignment shall be determined taking into account the following items:

- Elevation of roads to be intersected.
- Minimum gradient (0.5%) is required for road side drainage.
- High water level at the flood discharges of the major rivers to be crossed,
- Required clearance height for railway to be crossed.

Design controls for the horizontal and vertical alignments of the proposed roads are summarized as shown below:

(1) Package 1: Arterial Roads in the City Center (see Fig. 15.9)

(i) The proposed improvement measures are widening of the existing roads which are running through the city center where the ROW situation is very tight. The alignment design therefore focused on the

existing roads within the ROW strip and vertical alignments were designed at a height of the existing road with minor adjustment.

(ii) The major controls for the horizontal alignment are the historical buildings located along Sokoine Drive including Azania Lutheran Church, St. Joseph's Cathedral, City Hall and the national conservation monuments, particularly the Old Boma. The ferry station, Dar es Salaam Railway Station, Harbor Authority and BP Station are also major controls on the alignment design.

(2) Package 2: Widening of Middle Ring Road (see Fig. 15.10)

(i) Package 2 consists of widening to 4 lanes Morocco, New Kigogo and Chang'ombe Roads including construction of Missing Link between New Kigogo Road and Chang'ombe Road. The horizontal alignment has been designed within the ROW strip.

(ii) The major controls for the vertical alignments in Package 2 are as outlined below:

- High Water Level of Sinza River
  The elevation of the new road should be designed properly taking into account the high water level of the Sinza River. The existing pipe culverts should be replaced by box culverts with sufficient capacity to meet the requirement for the river's discharge.

- Karume Memorial Stadium and the Cemetary
  The horizontal alignment for the Missing Link was designed utilizing the open space of Karume Memorial Stadium, by running along the fence on the boundary between the stadium and the cemetery in order to minimize the affect on these facilities.

- Railway Crossings
  There are three railway crossings in the section of the Missing Link and the proposed road has been planned to cross at the same level of these railway lines. This plan requires raising of the alignment of railway track No.1 by 2.5 m up to the same level of the side track (line No.2) and this will require an alignment change of the railway track with a total length of about 1.0 km.

(iii) Extension of the Middle Ring Road up to the Mandela Road

Tanzanian Government has placed high priority on the development of Kigamboni Area for the residential and industrial areas with 265,000 population by the year of 2000 in order to cope up with the rapid increase of population in Dar es Salaam. The construction of permanent crossing facilities across creek is essential for stimulating the development of Kigamboni area instead of present ferry system.

Kurasini bridge has been proposed as a permanent crossing facility connecting Kurasini on Mandela Road with Kigamboni. This bridge is planned to be connected with the proposed Middle Ring Road in the long-term Master Plan by extending the Middle Ring Road from the Kilwa Road Junction up to the Mandela Road (700 m approx.).

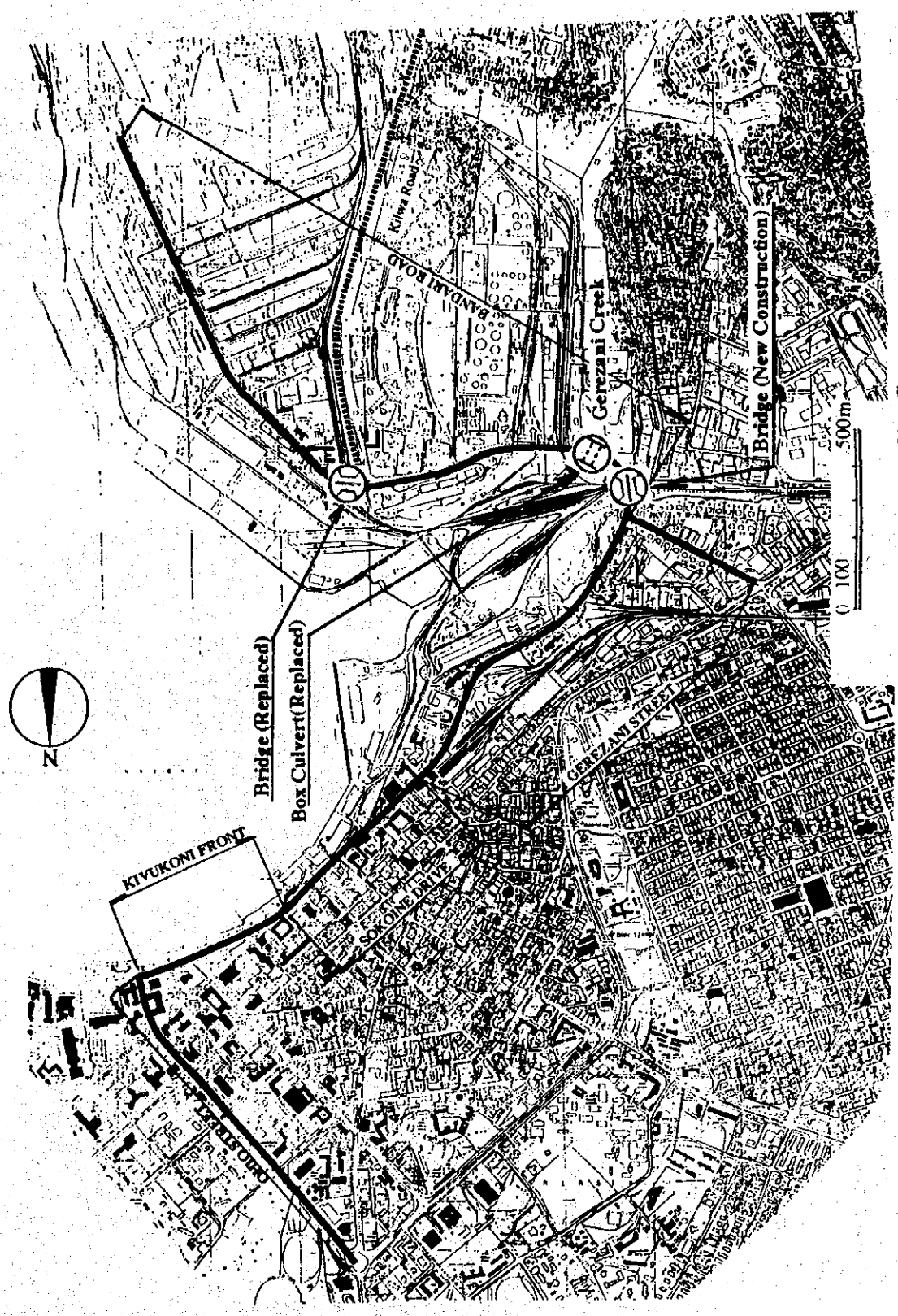
The preliminary design for the extending section of the Midlle Ring Road including grade separation at Mandela Road has been prepared for future extension to secure necessary construction site as well as to control rising of compensation costs and the development of nearby intersections and the proposed route.

The right-of-way plan is presented in the Drawing.

(3) Package 3: Widening of Radial Trunk Road (see Fig. 15.11)

Package 3 consists of widening to 4 lanes New Bagamoyo, Uhuru and Kilwa Roads. The proposed roads are running through urban and sub-urban areas and the present ROW strips are widely reserved.

The horizontal and vertical alignments were designed within the existing ROW strip taking into consideration the maximum use of the existing road .



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

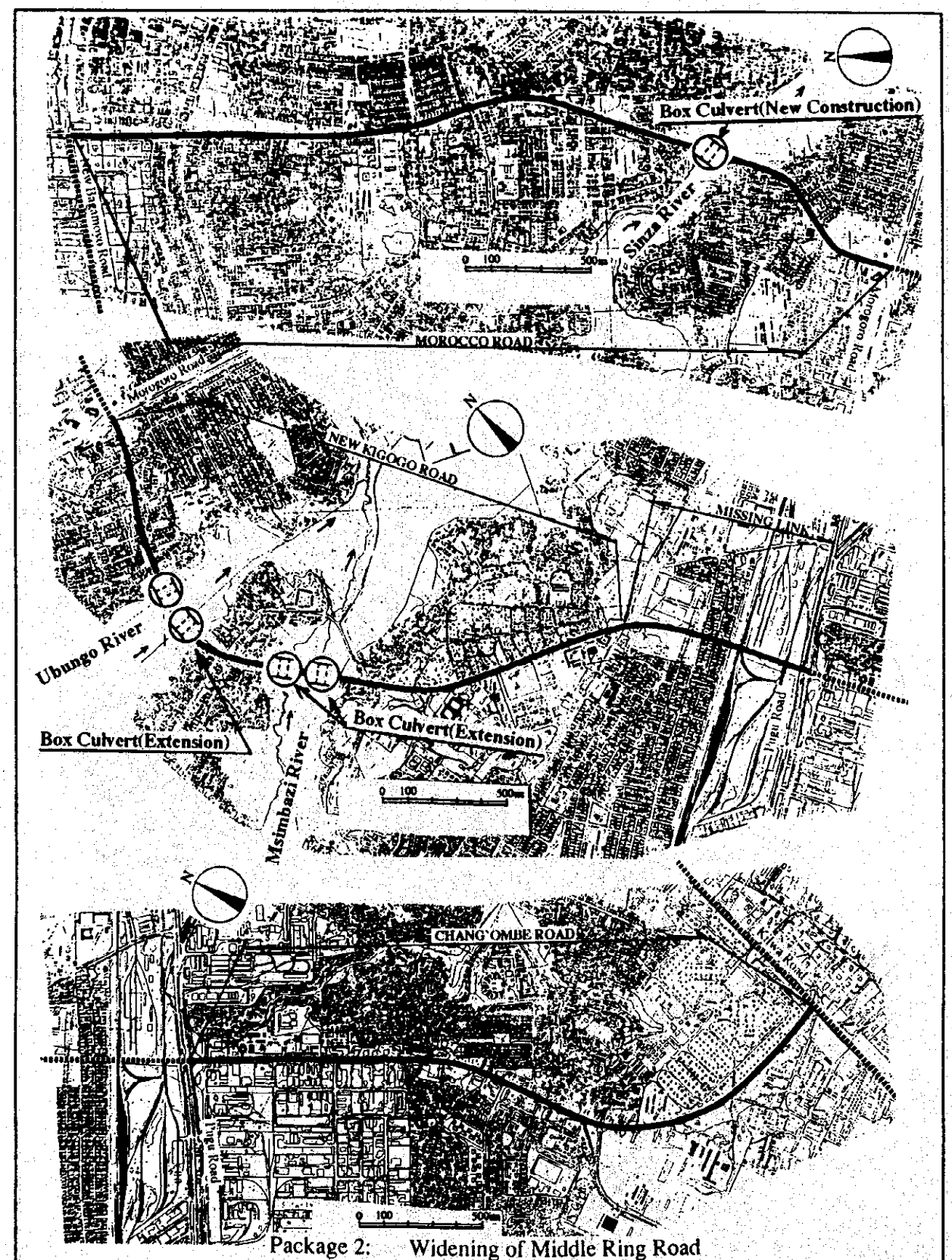
Fig. 15.9

Route Alignment Plan (1)

Proposed Road

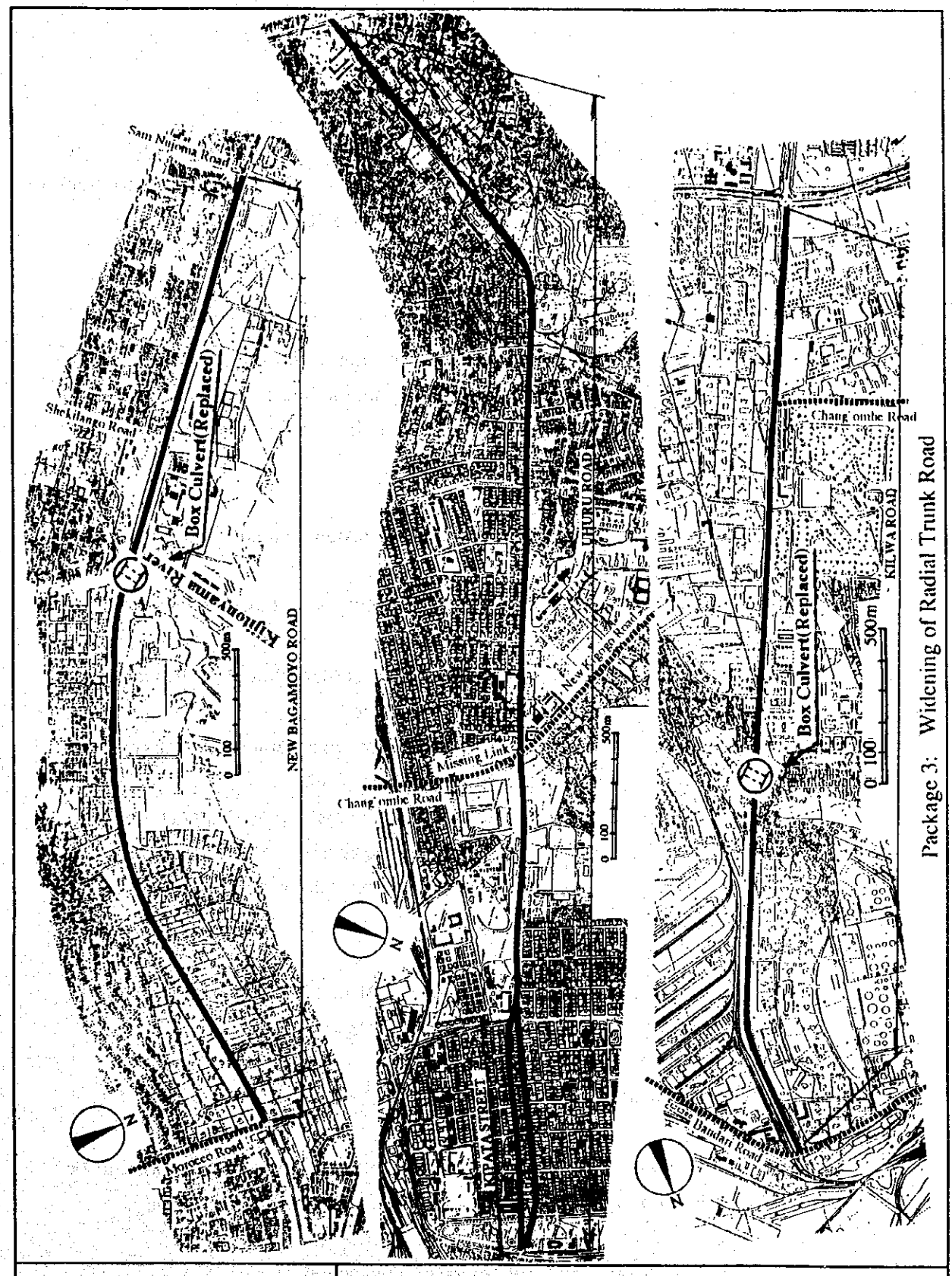
Bridge (Replaced or New Construction)

Box Culvert(New Construction or Extension)



Package 2: Widening of Middle Ring Road

THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN	**Proposed Road**
Fig. 15.10	**Bridge (Replaced or New Construction)**
Route Alignment Plan (2)	**Box Culvert(New Construction or Extension)**



Package 3: Widening of Radial Trunk Road

THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 15.11

Route Alignment Plan (3)

Proposed Road

Bridge (Replaced or New Construction)

Box Culvert(New Construction or Extension)

15.4 Intersection Design

The traffic capacity of an urban road is often governed by that of its intersections, so that the intersections should be designed with sufficient capacity to accommodate the planned future peak flows of traffic.

15.4.1 Major Intersections

The intersections where the volume of crossing or turning traffic is large are identified as major intersections. These major intersections are normally controlled by traffic signals with channelisation in view of safety and congestion.

At these major intersections, the following design elements were considered where the road widths are not restricted:

- Full visibility should be kept to the right and left turning lanes for safety reason.
- Transition or compound curves on the corners should be provided so that turning can be made easier and safer.
- Channelising islands should be provided to separate differing traffic streams, to assit the pedestrians to cross, etc.
- Guard rails, refugee islands, pedestrain crossings with signal controlls, (if necessary), should be considered for the pedestrains.
- Lighting, marking and signpost are essential for the safety of the traffic and pedestrains.

Fig. 15.12 shows the major intersections identified by the Study Team taking into account the importance of the crossing roads.

15.4.2 Grade Separated Intersections

Out of the above major intersections, the following three are planned to be grade separation in the long-term as discussed in the Master Plan Study:

- Morocco/Morogoro Road Intersection
- New Kigogo/Uhuru Road Intersection
- Chang'ombe Road Intersection

The locations of these intersections are shown in Fig. 15.13. Though the implementation of these grade separations have been recommended for the long-term plan, land acquisistion should be made in advance to secure necessary construction site for the grade separation. This will be necessary to control the rising compensation costs as well as the development of nearby intersections.

An outline of these intersections was, therefore, made for the purpose of the ROW acquisition, assuming that grade separation will be done in near future, and the ROW strip required for grade separation was incorporated in the preliminary design of the intersection.

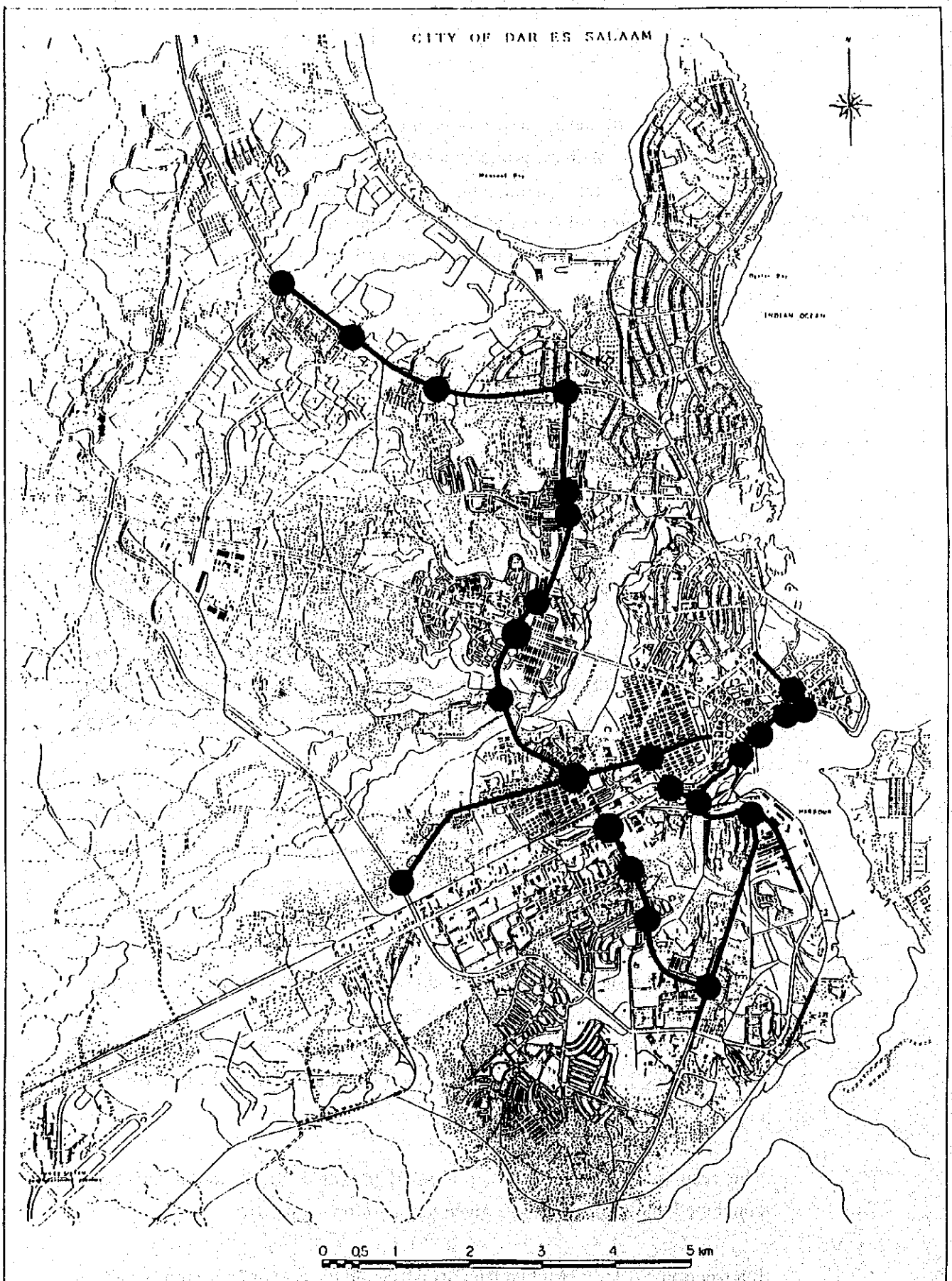
Generally speaking, grade separation should be planned with sufficient capacity to meet long-term traffic requirements; however, it should be designed as compact as possible in view of the restricted space available in urban areas and the high cost of structures. A diamond type intersection with signal controls was considered for the proposed grade separated intersections taking into consideration the restricted space and high compensation cost for house/buildings. A general view of proposed grade separated intersection is presented in Fig. 15.14.

Priority should be given to the major roads; however, where both of the intersecting roads are of about the same importance, the priority should be given to the road taking into consideration the following factors:

(i) The more heavily trafficked road.
(ii) The possibility of acquiring additional lands for construction of grade-separated intersections.
(iii) Physical conditions of the road to be intersected such as the maximum gradient of approach section, sight distance, cost, railway crossings, etc.

The results of evaluation are presented in Table 15. 2 and it has been concluded that priority is to be given to the following roads:

Intersection No.1: Middle Ring Road should cross over Morogoro Road.
Intersection No.2: Middle Ring Road should cross over Uhuru Road.
Intersection No.3: Pugu Road should cross over Middle Ring Road.

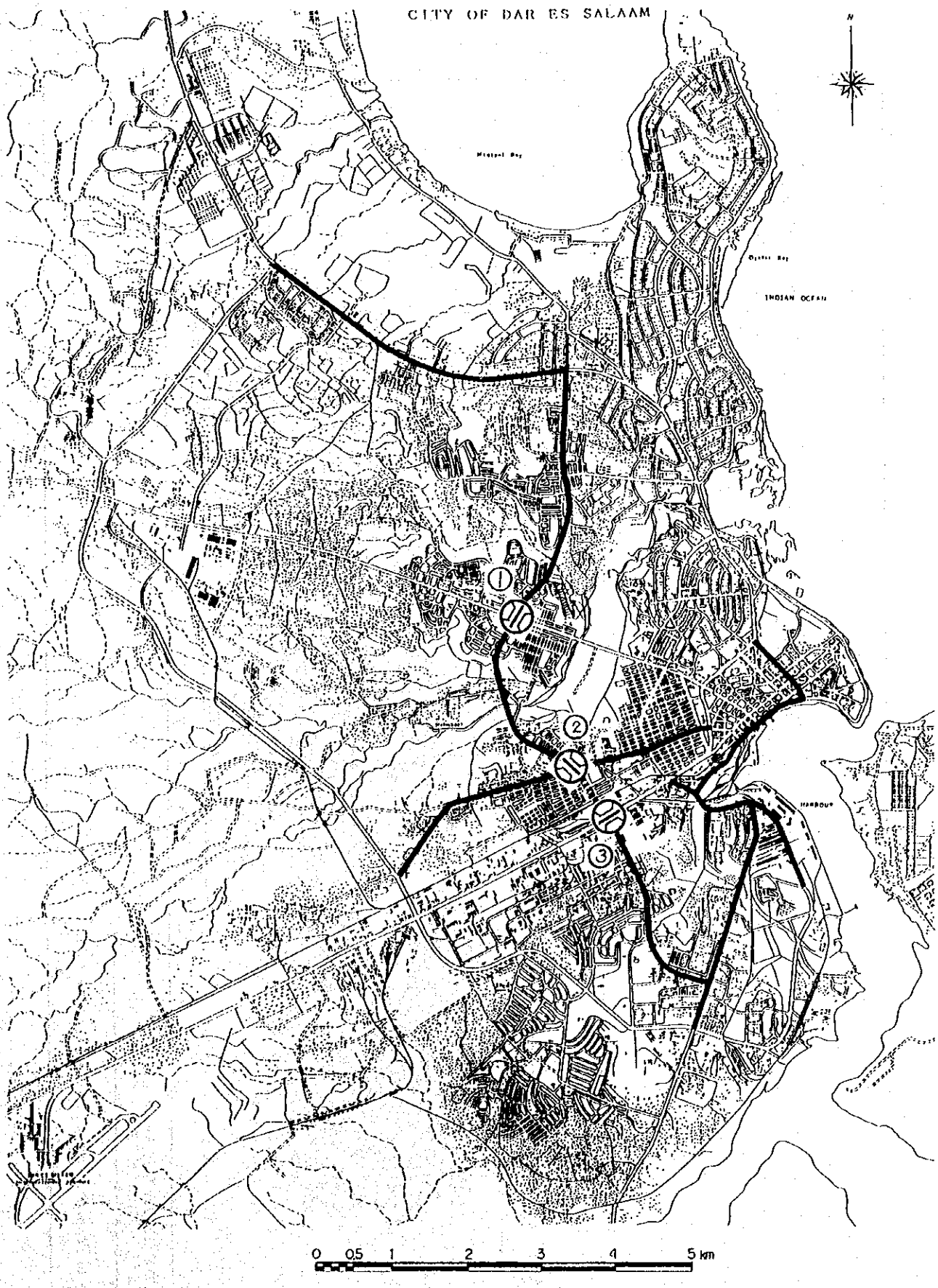


THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 15.12 Major Intersections

Major Intersections(Signal Controled)

New Bagamoyo Road	: 3 places
Middle Ring Road	: 8 places
Uhuru Road	: 2 places
Arterial Roads in City Center	: 8 places

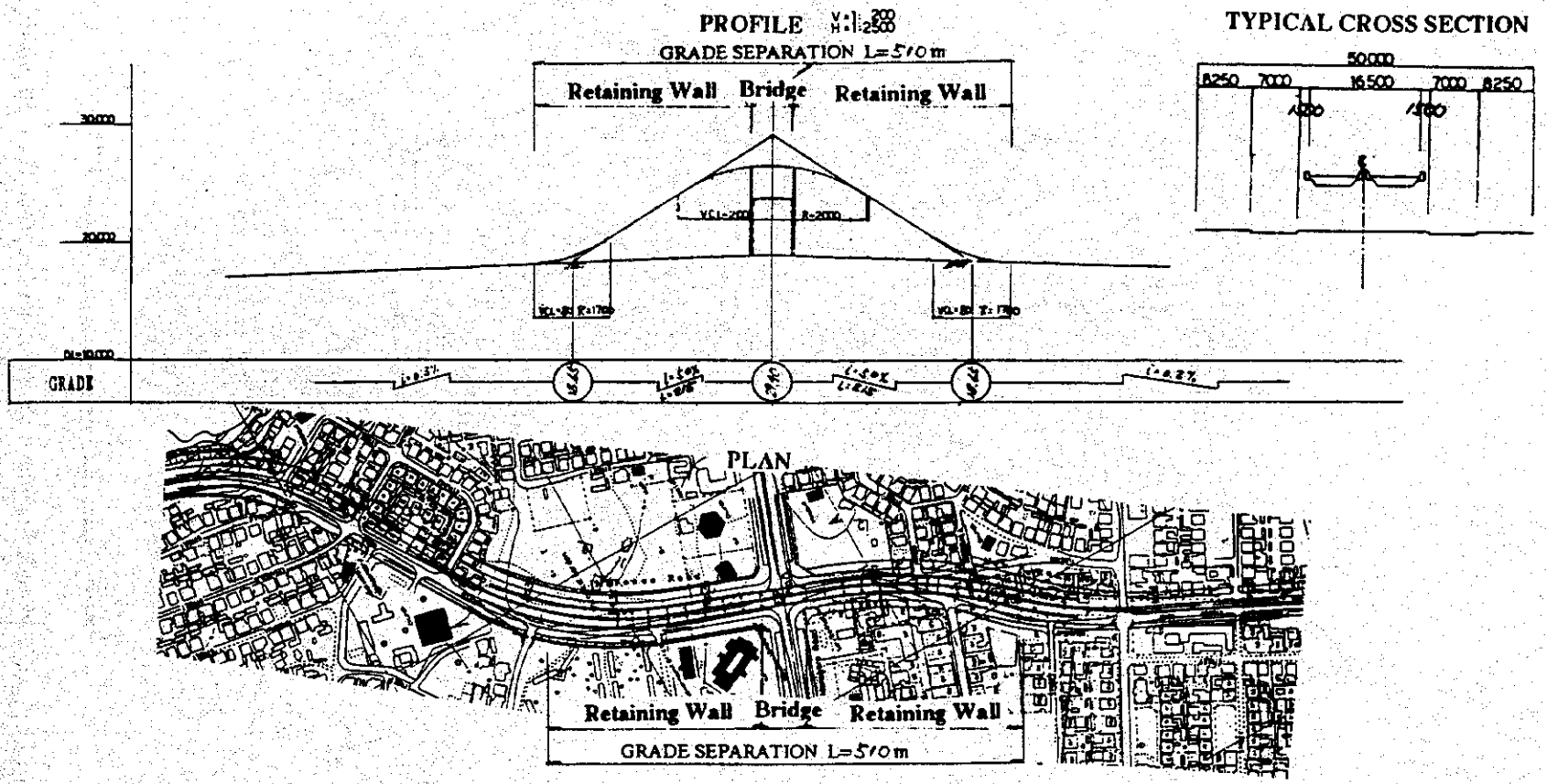


THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig. 15.13
Grade Separated Intersections

Grade Separated Intersections Proposed for high priority roads in Long Term Plan

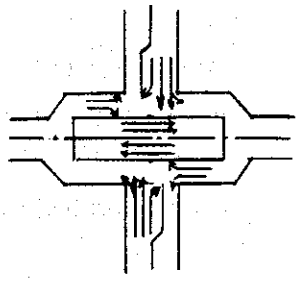
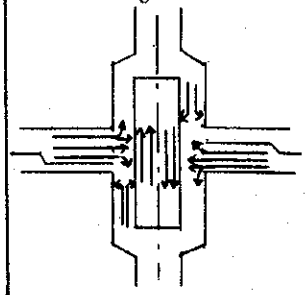
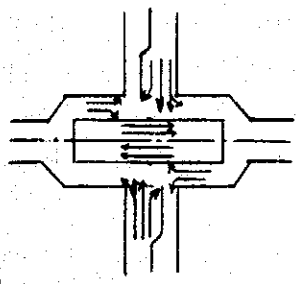
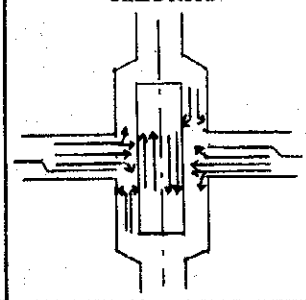
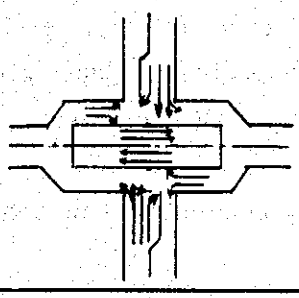
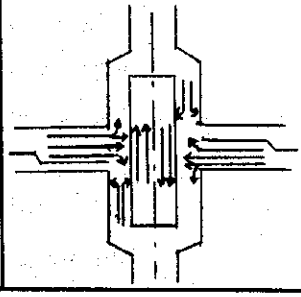
① — Morocco / Morogoro Road Junction
② — New Kigogo / Uhuru Road Junction
③ — Chang`ombe / Pugu Road Junction



THE STUDY ON DAR ES SALAAM
ROAD DEVELOPMENT STUDY

Fig. 15.14
General View of Proposed Grade Separated Intersection

Table 15.2 Evaluation of Grade Separated Intersections

	Evaluations Factors	Grade Separation of Middle Ring Road	Grade Separation of Roads to be Intersected
(1) Intersection No.1 : Morocco/Morogoro Roads Junction			
-	Future Traffic Demand in 2010 (p.c.u)	70,000 - 75,000	55,000 - 80,000
-	Landuse Situation/Possibility of Widenin	Difficult	Very difficult
-	Physical Conditions	None	Long distance with max. grade
-	Estimate Construction Cost	US$ 3.0 million	US$ 3.0 million
	Recommendation	O	
		Morogoro Road 	Morogoro Road 
(2) Intersection No.2 : New Kigogo/Uhuru Roads Junction			
-	Future Traffic Demand in 2010 (p.c.u)	56,000 - 68,000	55,000 - 72,000
-	Landuse Situation/Possibility of Widenin	Difficult	Very difficult
-	Physical Conditions	None	None
-	Estimate Construction Cost	US$ 3.0 million	US$ 3.0 million
	Recommendation	O	
		Uhuru Road 	Uhuru Road 
(3) Intersection No.3 : Chang`ombe/Pugu Roads Junction			
-	Future Traffic Demand in 2010 (p.c.u)	38,000 - 69,000	45,000 - 70,000
-	Landuse Situation/Possibility of Widenin	Very difficult	None(median strip be used)
-	Physical Conditions	TRC's railway tracks must be crossed over by fly-over bridge	None
-	Estimate Construction Cost	US$ 7.0 million	US$ 3.0 million
	Recommendation		O
		Pugu Road 	Pugu Road 

15.5 Bridge and Structural Design

15.5.1 General

The preliminary design for the bridge and other structures were conducted for the following items:

- Bridges
- Box Culverts
- Retaining Wall
- Slope Protection Work

The proposed location of bridges and structures are presented in Fig. 15.15.

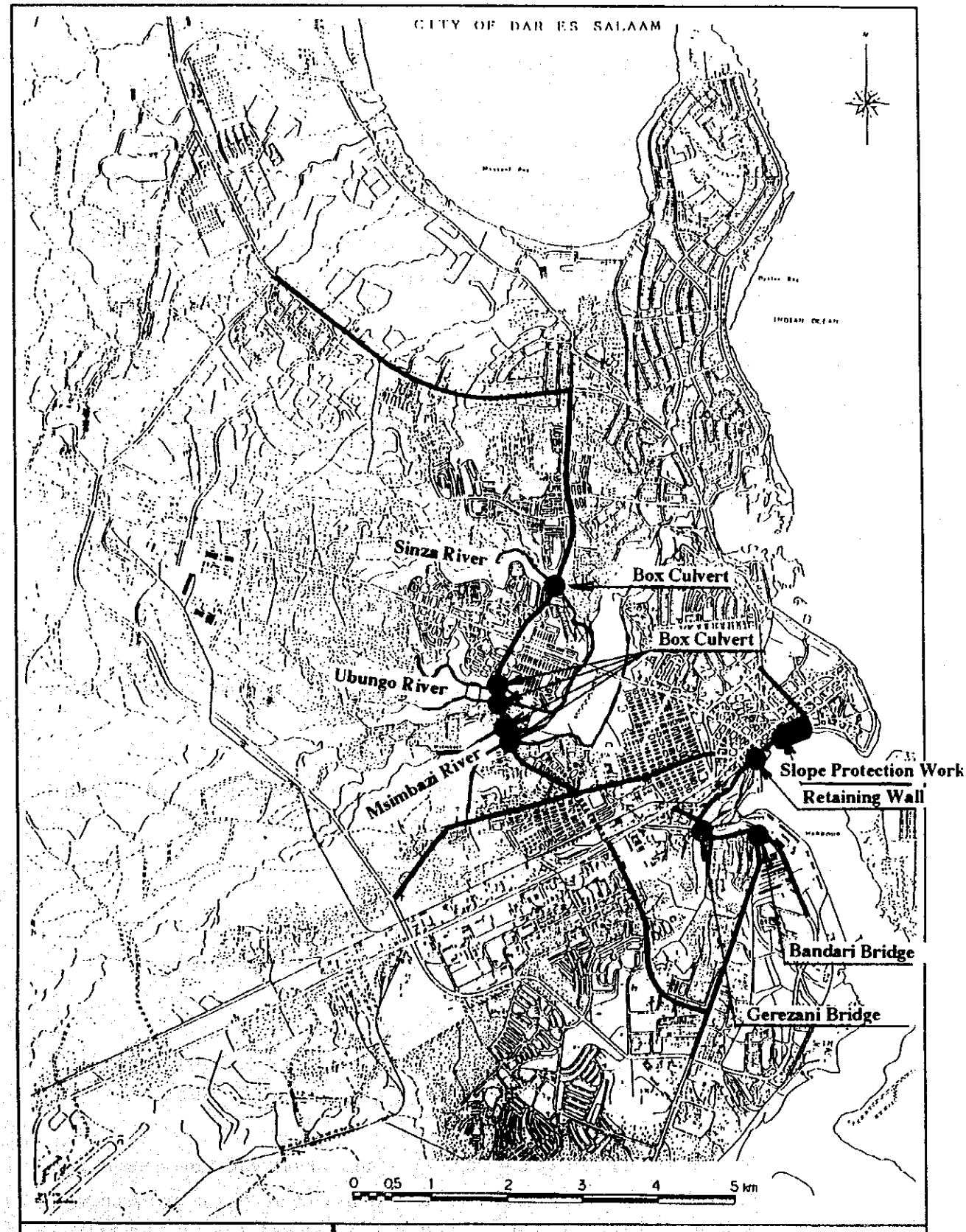
15.5.2 Existing Conditions of Proposed Bridges and Culverts Sites

The Study Team conducted the field investigation for the following six proposed bridge sites along the proposed roads:

Proposed Site No.1:	Sinza River at Morocco Road
Proposed Site No.2:	Ubungo River at New Kigogo Road
Proposed Site No.3:	Msimbazi River at New Kigogo Road
Proposed Site No.4:	Gerezani Bridge on Railway Crossing at Bandari Road
Proposed Site No.5:	Bandari Bridge on Railway Crossing at Bandari Road
Proposed Site No.6:*	Ilala Bridge on Railway Crossing at the Missing Link of the Middle Ring Road

Out of the proposed six bridge sites, No.6 Ilala Bridge was finally canceled because of the reason that the Middle Ring Road is determined to cross the railway tracks at the same level, not cross over by bridge, which was confirmed mutually in the letter between the MWCT and the Study Team after discussion of the alternative route study.

The existing conditions of the remaining five proposed bridge sites are as follows:



THE STUDY ON DAR ES SALAAM ROAD DEVELOPMENT PLAN

Fig.15.15
Location Map of Bridge and Structure

(1) Proposed Site No. 1: Sinza River at Morocco Road

There are four existing pipe culverts (D=1,200 mm) laid on the Morocco Road, however, they have not functioned well due to insufficient capacity of pipe culverts, blockage of the inlet due to lack of maintenance and inappropriate location of culverts, which have resulted in frequent flood of the Sinza River in the rainy seasons every years. These pipe culverts should be replaced by either bridge or box culverts to have a sufficient capacity for discharge of the River.

Geological survey indicated that proposed site are covered with soft sediments to a certain depth, for which box culvert is preferable taking into account the dispersion of reactions to the foundation.

The pipe culverts laid on the existing Morocco Road, therefore, shall be replaced by either box culvert or bridge structure.

(2) Proposed Sites No. 2 and No. 3: Ubungo River and Msimbazi River at New Kigogo Road

The existing New Kigogo Road has crossed the Ubungo River and Msimbazi River by box culverts, of which dimensions are as shown below:

- Proposed Site No. 2: Ubungo River
  No. 1 Box Culvert (W 5.0 m x H 2.9 m x 2 Cells)
  No. 2 Box Culvert (W 5.0 m x H 2.9 m x 2 Cells)

- Proposed Site No. 3; Msimbazi River
  No. 1 Box Culvert (W 5.0 m x H 2.8 m x 4 Cells)
  No. 2 Box Culvert (W 5.0 m x H 2.0 m x 3 Cells)

In addition to the above box culverts, a pipe culvert with a diameter of 800 mm is located in between box culverts. This culvert shall be replaced by a new pipe with a diameter of 1,000 mm and extended to a length that is necessary for the road widening plan.

Detailed investigation was made by the Study Team to examine the condition and durability of the existing box culverts. The survey revealed that the stains

caused by the floods in the past were found, however, traces of inferiority or large-sized cracks were not observed on the surface of the concrete. So, it was concluded that the existing culverts have no structural problems.

The capacity of each box culvert was also checked by conducting the hydraulic calculation on the basis of the recent rainfall data as well as referring to the flood records. As the result, it was found that they have enough capacity for flow water of the rivers.

Considering the sound conditions as well as the sufficient capacity of the existing box culverts, it is recommended to utilize the existing box culverts as they are but to be extended in accordance with the widening plan to 4-lanes at New Kigogo Road.

(3) Proposed Sites No. 4 and No. 5: Gerezani Bridge and Bandari Bridge

There are two existing bridges across the railway tracks on the proposed Banrari Road as shown below:

- Proposed Site No. 4: Gerezani Bridge over passing Railway

Type of bridge:		Pony Truss Steel Bridge
Dimension	:	42.9 m long 2- lanes bridge with a 9.7 m width of carriageway
		Span arrangement: (9.3+ 24.3+ 9.3)m

- Proposed Site No. 5: Bandari Bridge over passing Railway

Type of bridge:		Steel Girder Bridge
Dimension	:	30.4 m long 2-lanes bridge with a 9.7 m width of carriageway
		Span arrangement:(10.35+ 9.4+ 10.35)m

The detailed inspection was conducted by the Study Team to confirm the existing conditions of these bridges as well as to evaluate the availability of re-use for the Project.

The following are the result of inspections:

(i) Proposed Site No.4: Gerezani Bridge:

- The existing bridge is the type of pony truss bridge which will not meet the requirement of the design standard for proposed widening plan, especially width of the bridge is not sufficient and design live load dose not meet the current large-sized vehicle.

- The main beams of truss have rusted seriously and deflection and vibration due to heavy vehicles have exceeded far beyond the limit of designed value. Concrete of sub-structures are also damaged and seemed to be not healthy due to exposure of reinforced bar as well as poor quality of materials.

- Considering the existing conditions mentioned above, it is recommended to reconstruct the bridge by new 4-lanes bridge totally.

- The new bridge should be constructed at the western side of the existing bridge to minimize the bridge length or to minimize the construction cost.

- The existing bridge is old one, however, it should be maintained as it is for the use of pedestrian and bicycle. It can be used as a detour bridge during the construction of new road, so that no serious traffic congestion could be expected.

(ii) Proposed Site No. 5: Bandari Bridge:

- The conditions of the existing bridge seems to be not sound condition, so that it must be replaced totally by new bridge in accordance with the alignment of the proposed widening plan.

- Special care should be paid to the traffic management during the construction of new bridge, since no detour bridge sites are available nearby the proposed site.

15.5.3 Bridge Design

(1) Design Standards

According to the Design Manual prepared by the MWCT, the bridge loading for trunk roads shall be either HA Loading (BS 5400: HA+HB 25) or HS20 (AASHO: HS 20 - 40 Loading). However, in this Study, Highway Bridge Specifications published by the Japan Road Association (JRA: B-Loading) have been applied.

According to the JRA's specification, live loads consist of T-Loads, L-loads and crowded loading on the sidewalks described below.

(i) Live Loads to be Used for the Design of Bridge Slabs

Design Load: B - Loading (T-25)
Total weight: W = 25 tons
Rear wheel load: 10 tons (0.4 x W)

A bridge is assumed to be loaded when one vehicles in longitudinal axis is at the point of maximum stress on a slab member, and with an unlimited number of vehicles in the transfers axis.

Table 15.4 shows the comparison of live load specified in JRA B-Loading, AASHO(HS20-44) and BS 5400(HB25). This confirms that B-Loading in JRA is satisfied with AASHO and BS.

Table 15.3 Comparative Table of Live Load for Slab Design

	Japan Road Association B-Load	AASHTO HS20-44	BS H B-25
Wheel Load	10.0	7.2 (16,000 LBS.)	6.4(62.5 KN)*

* Impact load is included

Note: The design loads specified in JRA consists of two loadings; namely, A-Loading and B-Loading. A-Loading shall be used for bridges carrying heavy vehicles with less than 1,000 ADT, while B-Loading is for bridges carrying heavy vehicles of more than 1,000 ADT. B-Loading

shall be applied for this Project because the Bandari Road will carry heavy vehicles in excess of 3,000 ADT.

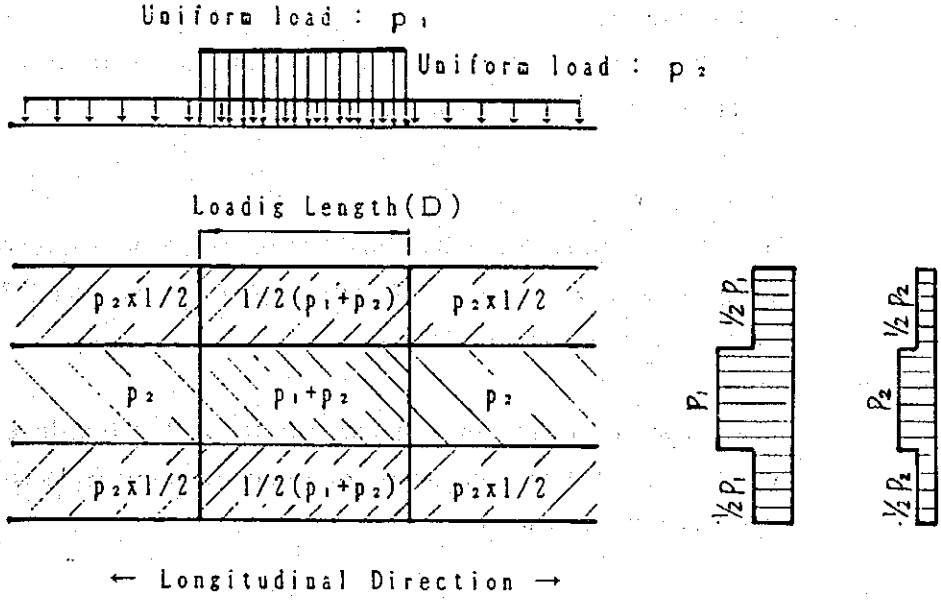
(ii) Live Loads to be used for the design of main girders

The design of main girders is carried out using L-Loading, which is the sum of the two uniform load. Distribution of the L-Load is assumed to be that which incurs the most unfavorable atress at any point of any structural member as shown in Fig. 15.16.

Fig. 15. 17 shows the comparison of JRA LB-Loading with AASHTO (HS20-44) and BS (HA+HB25) by bending moment of various span lengths, which indicate that LB-Loading of JRA is satisfied with the AASHTO and BS.

Based on the above comparison, the JRA standards have been used for this Study.

Seismic loading will not be considered in the design since no earthquakes have been recorded in Dar es Salaam.



	MAIN LOADING (width 5.5m)					SUB LOADING
	UNIFORM LOAD (p_1)		UNIFORM LOAD (p_2)			
	LOAD (kgf/m²)		LOAD (kgf/m²)			
Loading Length (m)	for Bending Moment	for Shearing Force	L ≦ 80	80 < L ≦ 130	L > 130	
10	1,000	1,200	350	430 − L	300	50 % of MAIN LOADING

L = Span Length (m)

Fig. 15.16 LA - Loading to be used for the Design of Main Girder

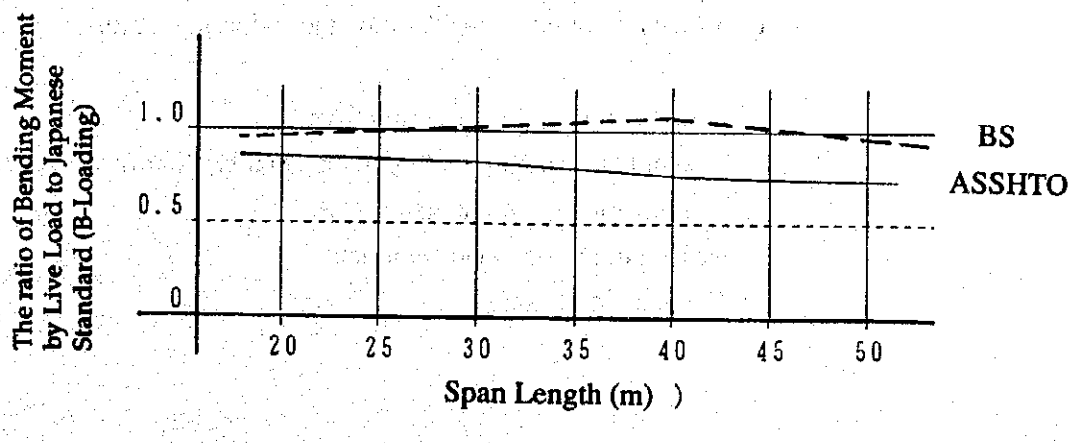


Fig. 15.17 Comparison of JRA LB-Loading, AASHTO and BS

(2) Soil Condition

As stated in the Chapter 14. 2, the test boring were performed using a drilling machine at two locations for each bridge site.

Sinza River

The investigation results indicated that the layers at the proposed bridge site of the Sinza River is very loose with high moisture content. No any bearing layers were found up to a depth of 20 m.

The surface of the proposed site are covered with soft sediments to a certain depth, so that the these unsuitable materials should be replaced by sand if box culverts wll be constructed.

Gerezani Bridge

The layers at the Gerezani Bridge sites were mostly comprised of medium dense sand consisting of SC layer (clay sand), SW layer (gravelly sand) and SM layer (silty sand). Partly contains thin layer of CL (sandy clay).

No bearing layer was found up to a depth of 20 m at both end of the bridge, therefore, pile foundation will be required.

Bandari Bridge

A hard strata having a N-value of more than 50 was found at a depth of 5 m to 6 m with a thickness of 6- 10 m, so that no pile foundations are required for this bridge.

(3) Criteria for Selection of Alternative Bridge

Alternative study on the proposed bridge were made for selecting the optimum type of bridge taking into consideration the following factors;

- Minimization of Construction Cost.
- Ease of Construction including the Quality Control
- Minimization of Maintenance Cost
- Maximum use of Local Materials
- Weather Conditions