No.10　砂利道工

No.13　粒状下層上層路盤工

No.14A　リーンコンクリート

NO.15　瀝青材散布工、サーフェースドレッシング

No.16　瀝青材舗装工

No.17　コンクリート工

No.20　道路施設工

No.21　雑工

No.22　ディワーク

No.23　杭工

11.3　建設工法の計画

11.3.1　考慮すべき基本条件

建設工法は工事の性格と設定される工事工期を考慮して計画される。また現地で調達可能な資材、人材、気象条件、土質条件、地形状態、機械化された工法等を考慮して計画される。

工事区間28.416kmについて、詳細な建設工法、工程を立案する手段として次の4区間に分割した。

第1工区　Mombasa Road Junction からUhuru Monument Junction

CH.0+000～CH.7+300

延長　7,300m

第2工区　Uhuru Monument Junction から Ngong Road Junction

CH.7+300～CH.15+800

延長　8,500m

第3工区　Ngong Road Junction から Dagoretti Forest Junction

CH.15+800～CH.21+000

延長　5,200m

第4工区　Dagoretti Forest Junction から Kikuyu Junction

CH.21+000～CH.28+416

延長　7,416m

(1) 稼働日数、時間

工事対象地域は4月から5月と11月から12月の年2回の雨期がある。稼働日数はダゴレッティ森林局、ウイルソン空港における1980年から1989年の月当たり降雨日を基礎として推定した。稼働日には降雨による休止日、祝祭日、日曜日を加味している。

各工種の稼働日数は以下のとうりである。

- 土工事は雨期乾期にわたって作業を行ない、稼働日数は盛土作業で1ヵ月当たり21日、掘削作業で1ヵ月当たり24日とする。
- 橋梁、ボックスカルバートの稼働日数は1ヵ月当たり24日とする。
- 舗装工の稼働日数は1ヵ月当たり24日とした、ただし、リーンコンクリート上層路盤工は雨期には施工しないものとした。

1日当たり作業時間は7時間として計画した。

(2) 土量変化率

土工作業量の計算において土の変化率を以下のように設定した。

	自然状態	ほぐした状態	締固めた状態
土砂	1.00	1.20	0.85
軟岩（風化岩）	1.00	1.40	1.00
硬岩	1.00	1.60	1.20

(3) 工事材料

工事材料の調達は以下のように計画した。

- 盛り土材料

  Black cotton soil、表土、ゴミ等、盛り土不適格材を除く道路掘削材。
- 砂利道用の砂利

  材料報告書に記載した教会、カレン採石場。
- 下層路盤用粒度調整砕石

  材料報告書に記載したキテンゲレ採石場。
- リーンコンクリート、コンクリート、チッピング用骨材

  材料報告書に記載したキテンゲレ採石場。

- 砂

現地マーケット、マチャコス砂

11.3.2 準備工

(1) 準備工、アクセス道路

工事区間の各ジャンクションには国道A104のほか各市道等舗装された道路によりアクセス可能であり、建設資材、機材の搬入はこれら各現道を利用して問題なくおこなわれる。

各採石場へのアクセス、骨材運搬路にもこれら現道を利用することができる。なお、工事に利用される現道は建設業者により建設期間中、維持管理される必要がある。

計画ルートに沿っては幅60mの道路用地内に仮設道路を建設するものとする。また、砂利道用他の各採石場にはそれぞれ1000mの仮設道路が必要とされる。

(2) 現場事務所、宿舎、仮設ヤード

建設業者の現場事務所、仮設ヤードはダゴレッティフォーレストジャンクション付近の公用地に計画した。エンジニアの監理事務所、土質試験室は建設業者の現場事務所の敷地内に計画した。

仮置き場、コンクリート等のプラント、機械置き場、修理工場等は道路用地内、または公用地に建設業者の責任において設置されるものとする。

採石場は材料報告書で述べるように本線より45km離れたブルートライアングルセメント工場近く、アッチ川横の、キテンゲレ地区に計画した。また、砂利道用の砂利の採石場は教会、カレンの採石場を選定した。

建設業者の事務所、キャンプ、エンジニアの事務所、土質試験室、その他の建物への電力の供給は The Kenya Power and Lighting Company Ltd. の配電線より供給されるものとする。また、各プラントの電力はジィーゼルジェネレータにより供給する。

エンジニアと建設業者の連絡は The Kenya Posts and Telecommunications の電話回線により行なうものとする。

工事用、飲料水の供給は The Water and Sewerage Department of Nairobi City Commission の既存配水管より供給されるものとする。

11.3.3 既存公共施設の移設、切り回し

伐開除根および土工事に着手前、舗装工事中に既存公共施設はその管理者により移設、改善がされる必要がある。管理者のリストは次のとうりである。

- 電話線

  Kenya Posts and Telecommunications

- 電力線

  Kenya Power and Lighting Co.,Ltd.

- 水道管

  Water and Sewerage Department of Nairobi City Commission

  Warer Department of Ministry Of Water Development

- 鉄道

  Kenya Railways Corporation

- 下水管

  Water and Sewerage Department of Nairobi City Commission

- 道路照明

  City Engineering Department, Highway

- ナショナルパーク通電柵

  Kenya Wildlife Service

- ケニア軍ライフル部隊キャンプ柵

  Kenya Rifles Ministry of Defence

11.3.4 交通保安対策

(1) モンバサロードジャンクション（タイプー1）

モンバサロードジャンクションの橋梁、道路建設の際、国道A104等の切り回し、維持管理、および復旧作業が必要である。国道A104には幅7m、延べ延長980mの切り回し道路が必要である、この切り回し道路の舗装は300mmの粒調路盤と50mmのアスファルト表層工を計画した。

(2) ウフルモニュメントジャンクション（タイプー1）

ランガッタ道路の切り回し道路は幅7m、延べ延長265mの切り回し道路が必要である、この切り回し道路の舗装は300mmの粒調路盤と50mmのアスファルト表層工を計画した。

(3) ゴングロードジャンクション、ダゴレッティフォーレストジャンクション
(タイプ−2)

ゴング道路、ダゴレッティ道路の切り回し道路は、幅員6mで、舗装は150mmの砂利道工にサーフェースドレッシングを計画した。延長はゴング道路800m、ダゴレッティ道路500mの合計1,300mとなる。

(4) タイプ−3 切り回し道路

タイプ−3の切り回し道路は幅員6mの砂利道工であり、モンバサロードジャンクションのリコニ道路（450m）、CH.12+400 ～ CH.12+60（300m）,CH.13+500 ～ CH.13+800（300m）,CH.26+440（120m）に計画した。

(5) タイプ−4 切り回し道路

タイプ−4の切り回し道路は幅員3mの砂利道工であり、ソゴトジャンクションの取付け道路に計画した。

(6) 鉄道橋、C63車道橋

鉄道橋、C63車道橋の工事箇所は用地条件、地形条件、橋梁型式が連続桁であることから、切り回し道路を計画することができない。このため、門型支保工を施工して現交通の確保を行なう。この門型支保工の建設、維持管理は建設業者が行なうものとし、その費用はコンクリート工の各項目に含める。

11.3.5 土工事

ナイロビバイパスの建設工法、工程は11.3.1で述べたように4工区に分割して計画するが、その全体土工量は1,563,000m^{3}である。

道路の盛土工は、切土作業と盛土作業で構成される。切土作業で発生した盛土材料は可能なかぎり盛土作業に流用する。土量配分計画の結果から62%の盛土材料は1000m以内の土運搬作業となっている。盛土工事は乾期、雨期をとうして行なう。

土量配分計画の結果、第2工区の掘削材は第1工区の盛土材として配分されるため、第1工区と第2工区は平行した作業となる。また、第3工区、第4工区はそれぞれ工区内でバランスした土量配分となっている。

各工区は起点側より2箇所の工事着手箇所を必要とするが、それぞれの工事着手箇所は道路用地内の仮設道路により連絡する。

土工作業は21tブルドーザ、32tリッパ付きブルドーザ、2.3m^{3}トラクターショベル

および11ｔダンプトラックにより行う。掘削土は11ｔブルドーザ、3.7mモータグレーダーにより敷均し、30ｔグリッドローラー、10ｔ振動ローラ、15ｔタイヤローラにより転圧する。

表土は106,700m^{3}発生する、この表土は道路用地内の仮置き場に仮置きされ、植生するのり面、土捨て場表面の表土工として使用する。

Black cotton soil 、ゴミ等の盛り土不適格材料は189,500m^{3}発生する。この不適格材料はモンバサロードジャンクションその他、計画道路沿いの土捨て場に運ばれる。

11.3.6　舗装工事

(1) 下層路盤工

下層路盤は粒調砕石により施行される。下層路盤工は土工事に追随して雨期乾期をとうして施工される。下層路盤材料はキテンゲレ砕石場に設置した120ｔ/hr クラッシングプラントにより生産される。原石は10m^3/min.のクローラードリル、13m^3/min.のエアーコンプレッサーにより掘削される。破砕岩は32ｔリッパ付きブルドーザ、2.3m^{3}トラクターショベル、11ｔダンプトラックにより集積、積み込み、プラントまでの運搬が行なわれる。路盤材料は国道A104、その他市道を通って計画道路の各ジャンクションまで11ｔダンプトラックにより運搬される。現場内運搬は盛土面、切土路床面を利用して行なわれる。下層路盤の敷均しは3.7mモーターグレーダー、転圧は10ｔ振動ローラー、20ｔタイヤローラ、10ｔマカダムローラにより行なわれる。

(2) 上層路盤工

上層路盤工は下層路盤施工後、雨期を除く期間に施工される。上層路盤はリーンコンクリートにより施工され、その粒度調製砕石はキテンゲレ砕石場で生産され、砂は90km離れたマチャコス地区より運搬する。

リーンコンクリートのセメント添加量は4%とし、混合は150ｔ/hr ポータブル撹拌プラントで行なう。プラントまでの砕石の運搬は下層路盤と同様である。混合物は直接11ｔダンプトラックに積み込まれ現場に運搬される。リーンコンクリートの敷均しは3.7mモーターグレーダにより行ない、転圧は20ｔタイヤローラ、10ｔ振動ローラ、10ｔマカダムローラにより行なう。

転圧されたリーンコンクリートの表面はビニルシートにより養生され、その後4,000litreデストリビュータ、600litreエンジンスプレアーによりプライムコートを散布する。

(3) 瀝青材表層工

瀝青材表層工は乾期に施工される。瀝青材表層工は主にアスファルトコンクリート表層工、基層工により計画されている。また、ダブル、シングルサーフェースドレッシングが本線、ランプの路肩、取付け道路、サービス道路に計画されている。このシール用骨材、チッピング材はキテングレ砕石場の120ｔクラッシングプラントにより生産され、11ｔダンプトラックにより運搬される。

アスファルト合材は道路用地内に設置した100ｔ/ｈアスファルトプラントにより混合され、8ｔダンプトラックにより運搬される。合材は3.7mアスファルトフィニッシャーにより規定された表層、基層工の層厚に敷均され、10ｔマカダムローラ、10～20ｔタイヤローラにより転圧される。タックコートは4,000litreデストリビュータ、600litreエンジンスプレアーにより散布する。

サーフェースドレッシングの施工は上層路盤表面に瀝青材を散布した後テール式チップスプレイアー、8ｔダンプトラックでチップを敷広げ、10～20ｔタイヤローラ、10ｔマカダムローラにより転圧する。第２層目についても同様に行なう。

11.3.7 橋梁、ボックスカルバート

車道橋、歩道橋、車道ボックスカルバート、水路カルバート等コンクリート構造物はそれぞれの位置する工区の土工事の進捗を考慮して施工手順が計画される。各構造物の着手まえに切り回し道路、交通保安対策が実施されなければならない。特に、鉄道橋、C63車道橋の交通保安対策は床版コンクリート工事下で実施される。

各コンクリート構造物の工程はAppendix-Cに示されるように各工区の工事内容の進捗と平行的に計画されている。

コンクリートプラントはポータブルプラント２台を、モンバサロードジャンクションとダゴレッティホーレストジャンクションに設置する。

日当たり平均コンクリート打設量は30～40m3/日と推定され、ピーク時コンクリート打設量は約100m3/日と推定される。コンクリートは0.5m3のポータブルコンクリートバッチャープラントで混合し、3.2m3アジテータトラックにより運搬される。0.75～1.0m3のコンクリートバケットに投入され、30ｔトラックレーンにより作業箇所へ投下する。

骨材及び砂の供給先は舗装材料と同様である。日常的なコンクリート打設を保障するため、マチャコスの砂はプラントヤードへ定常的にストックするよう計画した。

500 mm の鋼管杭の打込みは 2.5ｔディーゼルパイルドライバー、35ｔクローラクレー

ンにより行う。すべての杭材及び打込機械はダゴレッティホーレストジャンクションの仮置場から No.2 車道橋へトレーラーにより運搬される。

ボックスカルバート、橋台を施工後、選別された盛土材により埋戻しが行われる。埋戻し前にはコンクリート表面に防水処理をほどこす。

11.3.8 建設機械

必要とする主要建設機械台数は表 11.1 に示すとおりである。機械種別、台数は土工量、舗装工事、コンクリート工事量に基づいて計画した。

表 11.1 主要建設機械及びプラント

種　別	規　格	台　数
リッパ付ブルドーザー	30 トン	3
ブルドーザー	21 トン	9
〃	11 トン	9
〃	5 トン	2
トラクターシャベル	2.3 m^3	16
ホイールローダー	2.0 m^3	1
バックホウ	0.7 m^3	2
〃	0.2 m^3	2
ダンプトラック	11 トン	120
〃	8 トン	4
タンピングローラー	30 トン	4
振動ローラー	10 トン	4
〃	4 トン	2
〃	1 トン	4
ランマ・タンパー	100 kg	8
クローラードリル	10 m^3/min	6
エアコンプレッサー	13.5 m^3/min	6
モーターグラーダ	3.7 m	4
散水量	5.5 kl	2
マカダムローラー	10 トン	3
タイヤローラー	10-20 トン	4
アスファルトフィニッシャー	3-7 m	1
ディストリビューター	4 kl	2
エンジンスプレーヤー	600 lit	2
アスファルトプラント	100 t/hr	1
クラッシングプラント	120 t/hr	1
ソイルプラント	150 t/hr	1
コンクリートプラント	20 m^3/hr	2
アジテータトラック	3 m^3	4
コンクリートバアケット	1 m^3	
トラッククレーン	30 トン	2
〃	20 トン	1
チップスプレアー	2 m	1
ディゼルパイルドライバー	2.5 トン	2
トレーラ	20 トン	1
普通トラック	10 トン	1
コンクリートミキサー	0.2 m^3	4
コンクリート締固機	60 mm^2	10

11.4 工事工程

11.4.1 建設前準備工

建設前準備工として行うべきものは、詳細設計、契約図書の作成、工事資金の準備、コンサルタント選定、建設業者の資格審査、入札業務、評価と契約の締結等がある。

詳細設計と契約図書の作成は 1992 年の 8 月中旬に完了した。借款の手続きは実施計画書を提出後 9 ヶ月後の 1993 年 5 月と考えられる。コンサルタント選定は入札業務開始前に行われることとなる。

建設業者の資格審査は指名前の 2 ヶ月間は必要である。契約業務は工事着工等第 1 年度の 5 月末まで、図11.1 に示すように 10 ヶ月は必要とする。

用地買収、補償業務は工事着工前に Ministry of Works により完了される必要がある。

11.4.2 建設工程と目標期日

工事工程は気象条件、施工方法、工事速度、現場条件他を考慮して求められた。全体工程は図 11.1 に示されている。 工事の目標期日は以下にし示すとおりである。

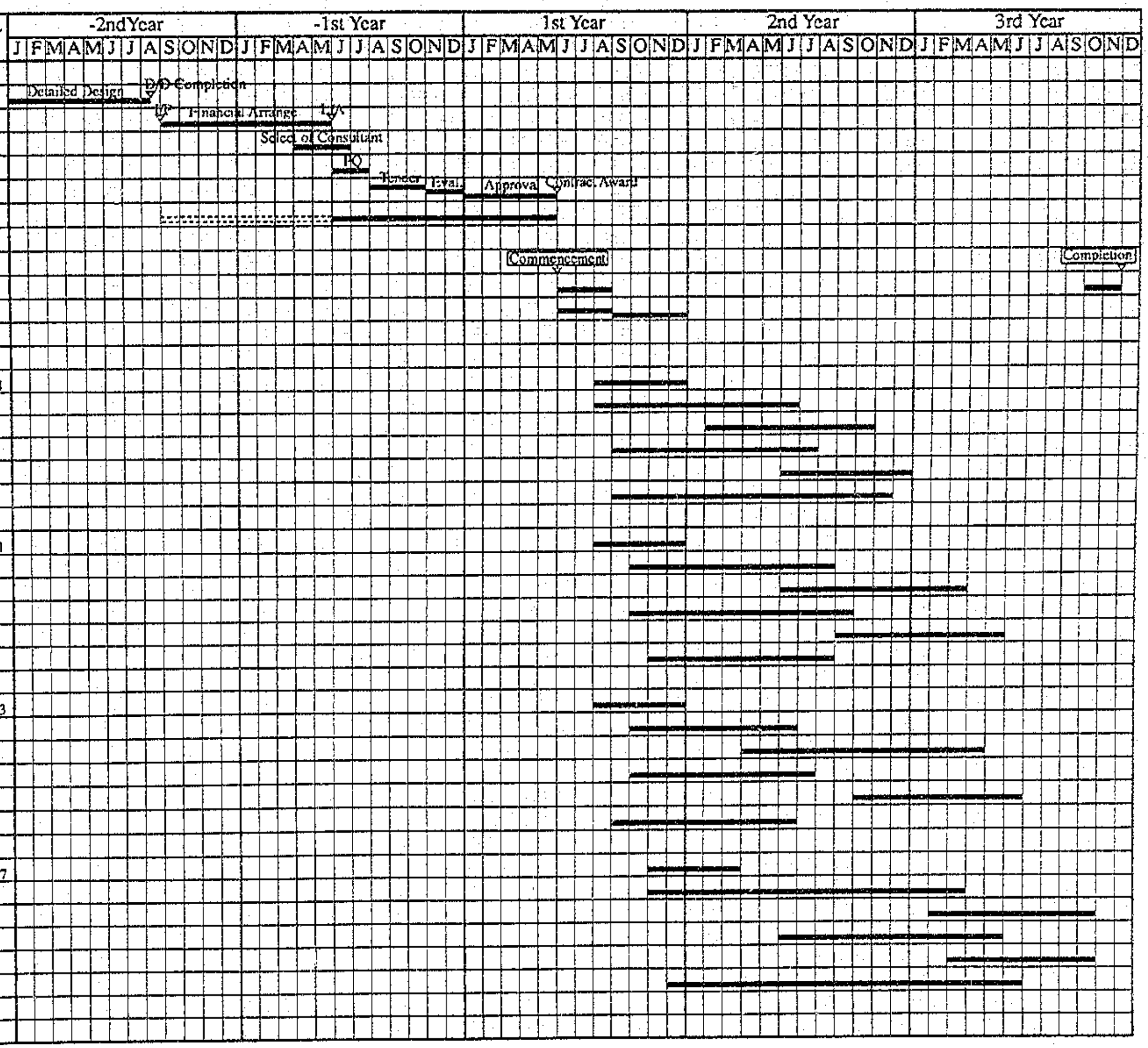
建設工期	:	30 ヶ月（2.5 年間）
工事着手	:	第 1 年度　6 月
工事完了	:	第 3 年度　11 月

各工区の工事は建設機械、プラントの転用を考慮して各工区間で工事時期をずらせて計画される。特に舗装工事は Appendix-G に示されるとおり各工区の工事量、工事内容に影響される。土工事はマスカーブにおける土量配分計画に基づいて行われる。

図 11.1 ナイロビバイパス工事の工事工程表

Construction Schedule for The Nairobi Bypass Project

DESCRIPTION	UNIT	QUANTITY
Detailed Design		
Financial Arrangement		
Prequalification		
Tender and Contract Award		
Land Acquisition and Compensation		
Construction Works		
Mobilization		
Preparatory Works		
Removal and Alteration		
Section-1 (CH.0+000-7+300)	m	7,300
Site Clearance	ha	52.4
Earthworks	m3	Exc. 161,160 Emb. 399,770
Pavement Work	m3	Asph. 15,270
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work		L.S.
Section-2 (CH.7+300-15+800)	m	8,685
Site Clearance	ha	41.1
Earthworks	m3	Exc. 58,550 Emb. 259,370
Pavement Work	m3	Asph. 15,510
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work		L.S.
Section-3 (CH.15+800-21+000)	m	5,200
Site Clearance	ha	30.3
Earthworks	m3	Exc. 34,200 Emb. 353,880
Pavement Work	m3	Asph. 9,510
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work		L.S.
Section-4 (CH.21+000-28+416)	m	7,416
Site Clearance	ha	47.7
Earthworks	m3	Exc. 42,190 Emb. 576,860
Pavement Work	m3	Asph. 15,440
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work		L.S.



12. 工事積算

工事積算は JICA 調査団により行われた。

建設費の記述は、このメインレポートから除外し、積算書として取りまとめた。

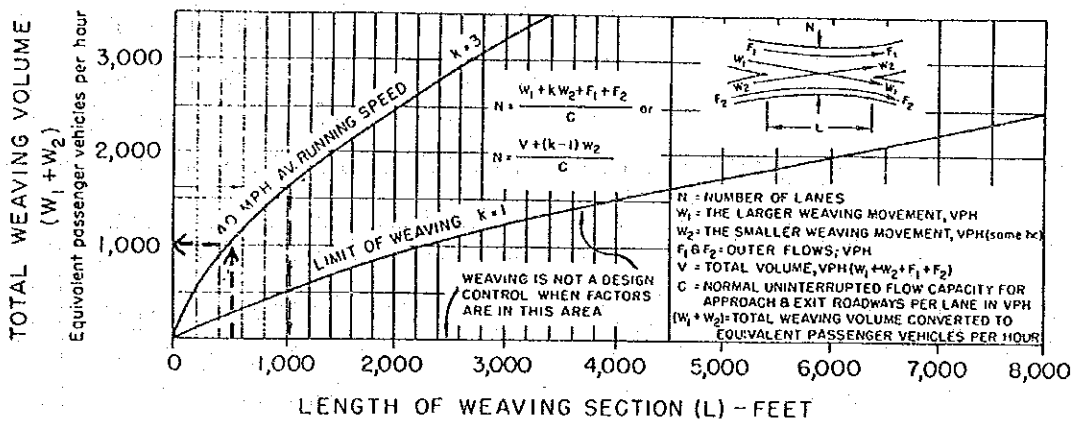
積算書では全体建設費、積算のための基礎データ、工種ごとの費用、外貨分、年次支出、一位代価について記述し、部外秘としている。

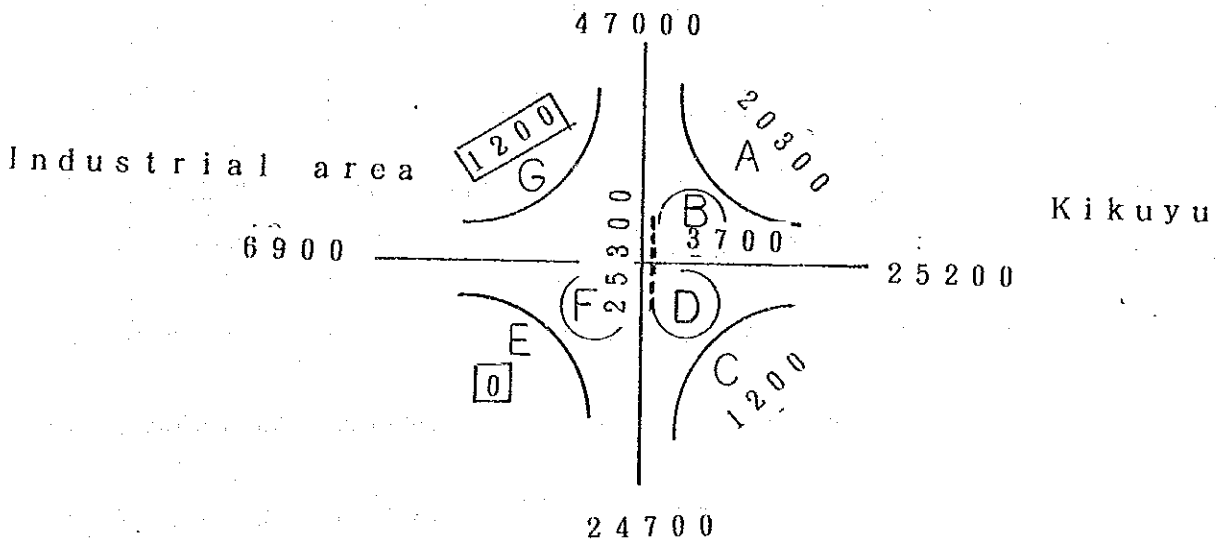
契約数量表についても積算書中に含まれている。

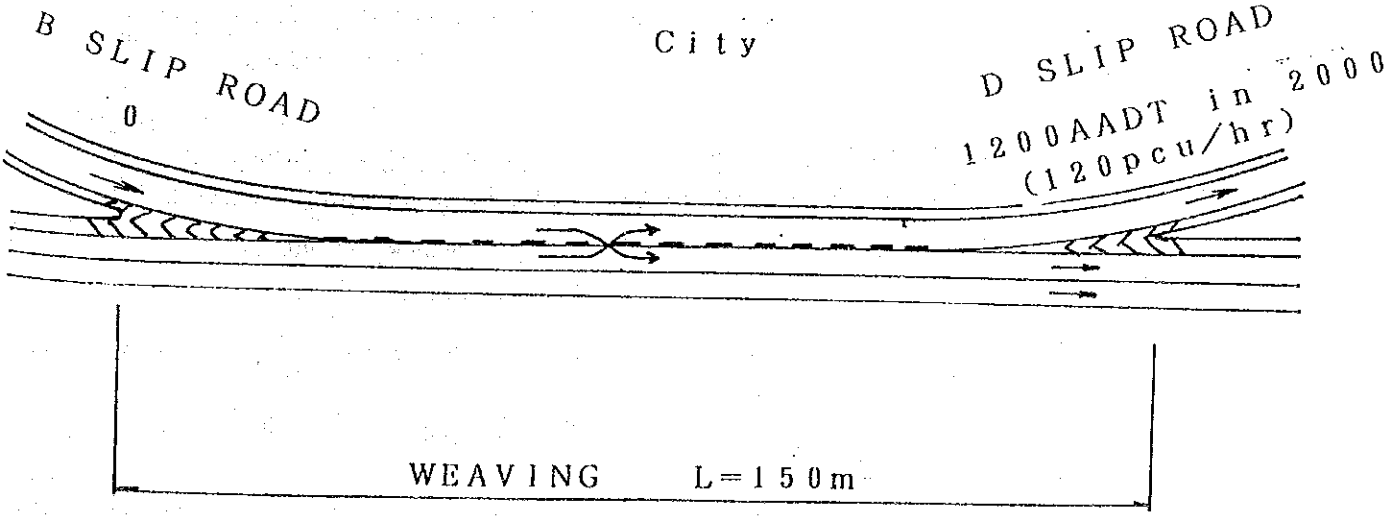
APPENDIX － A（変速車線、その他）

Weaving Length of B and D slip road at Mombasa Junction.

According to the following figure (AASHO), weaving lane with 150m long has a capacity of 1000pcu weaving volume per hour.







Acceleration Lane Length

1. Comparison of Acceleration length in other Manuals.

   Road Design Manual Part I indicate that Fig. 5.5.2 shall be used to determine the required acceleration distances but Acceleration length determined by Fig. 5.2.2. seems not to be reasonable because the length is so long.

   For reference, we compared it with other Manuals and a theoretical formula, and the reults are as shown in Table I herebelow.

   Table 1. Length of Acceleration Lane

Design Speed km/hr	Road Design Manual Part I	AASHO (Rural)	B. S. (Rural)	Japan Design Manual	Theoretical Formula
100km/hr (60mph)	more than 950m	1075ft 326m	270m	240m	191m ~ 261m See Attached Formula
80km/hr (50mph)	Heavy Vehicle 340m	625ft 192m	210m	210m	109m ~ 143m

Condition of comparison.

a. Original speed V = 30km/hr
b. Final Merging Speed = Design Speed x 80%
c. Acceleration Length: including Taper
d. Vertical gradients : i < 2%

2. Factors to be considered for designing acceleration lane

   a. Characteristics of Nairobi Bypass

      Bypass would be used very much as urban type road after ten or twenty years.

b. Type of Interchanges

Bypass hand has seven interchanges, and except Mombasa junction, the others are urban type interchanges which are designed with small entrance radius of 30m. It is considered that heavy vehicles will scarcely use these junctions, since most of them will be through traffic.

c. Manouver of Drivers and other conditions.

In Kenya, majority of cars are small cars .Generally Drivers in Kenya do not use acceleration lane effectively.

d. Recommendation

The length of acceleration lane should be composed of a length which come from theoretical formula and a length for merging.

Design Speed	100km/hr	80km/hr
Length by theoretical formula	226m	126
Length for merging:	0m	67m
Total (including taper)	226m=230m	193=200m
(Taper length)	50m	40m

Note: Time for merging = 3 ~ 5 seconds

$\frac{60}{3.6} \times (3 \sim 5) = 50m \sim 83m$ Average 67m

Taper length should be designed according to section 6.5.3 (i) Table 6.5.1 of Manual Part I.

* Length by theoretical formula, see table (2)

Acceleration Lanes (by Theoretical Formula)

The length of an acceleration lane is based on following factors in combination

(1) Vehicular running speed at merging through traffic.

(2) Vehicular running speed at nose of the acceleration lanes.

(3) Driver's manner of accelerating.

Distance of Acceleration is expressed as follows:

$$L = \frac{1}{2 \times 3.6^2 \times \alpha} \times (V^2 - V^2o)$$

L = Distance of Acceleration (m)

α = Accerelation (1 ~1.5 m/Sec²)

V = Final merging Speed (km/hr)

Vo = Original Speed at nose (km/hr)

V = 0.8 x VD VD : Design Speed
as VD = 100km/hr . V = 80 km/hr
as VD = 80km/hr . V = 60km/hr

Case 1. as Vo = 20km/hr and V = 60km/hr

$$L = \frac{1}{2 \times 3.6^2 \times (1 \sim 1.5)} \times (60^2 - 20^2)$$

$$= (0.0385 \sim 0.0257) \times 3200 = 123m \sim 82m$$

Case 2. as Vo = 30km/hr and V = 60km/hr

=(0.0385 ~0.0257)x 2700 = 103 m ~ 69 m

Therefore the necessary Length of Acceleration Lane in the Case 1, and Case 2, ranges from 69m to 123m and in the case of VD = 100km/hr.

Lengths of acceleration lane are as follows.

Vo = 20km/hr L = 231m ~154m

Vo = 30km/hr L = 211m ~141m

Table 2. Summary of Acceleration lane length

Design Speed of Road	Final Speed at the end of Acce-leration lane	Original Speed at Nose	Length by calculation	Taper	Length of Acceleration
80km/hr	60km/hr	20km/hr	82~ 123	40m	122m~163m
		30km/hr	69~ 103		109m~143m
					Average 126m
100km/hr	80km/hr	20km/hr	154 ~ 231	50m	204m~281m
		30km/hr	141 ~ 211		191m~261m
					Average 226m

NOTE: Factor (3) is neglected in these cases.

Study of Climbing Lane

The need for a climbing lane will be considered in areas with steep gradient of 5% or more.

1. Section: From Dagoretti Junction to Thogoto Junction

2. Climbing lane is designed in total considering the following factors:-

   (i) Length of speed reduced section is more than 200m
   (ii) Construction Cost
   (iii) Capacity of Traffic Volume

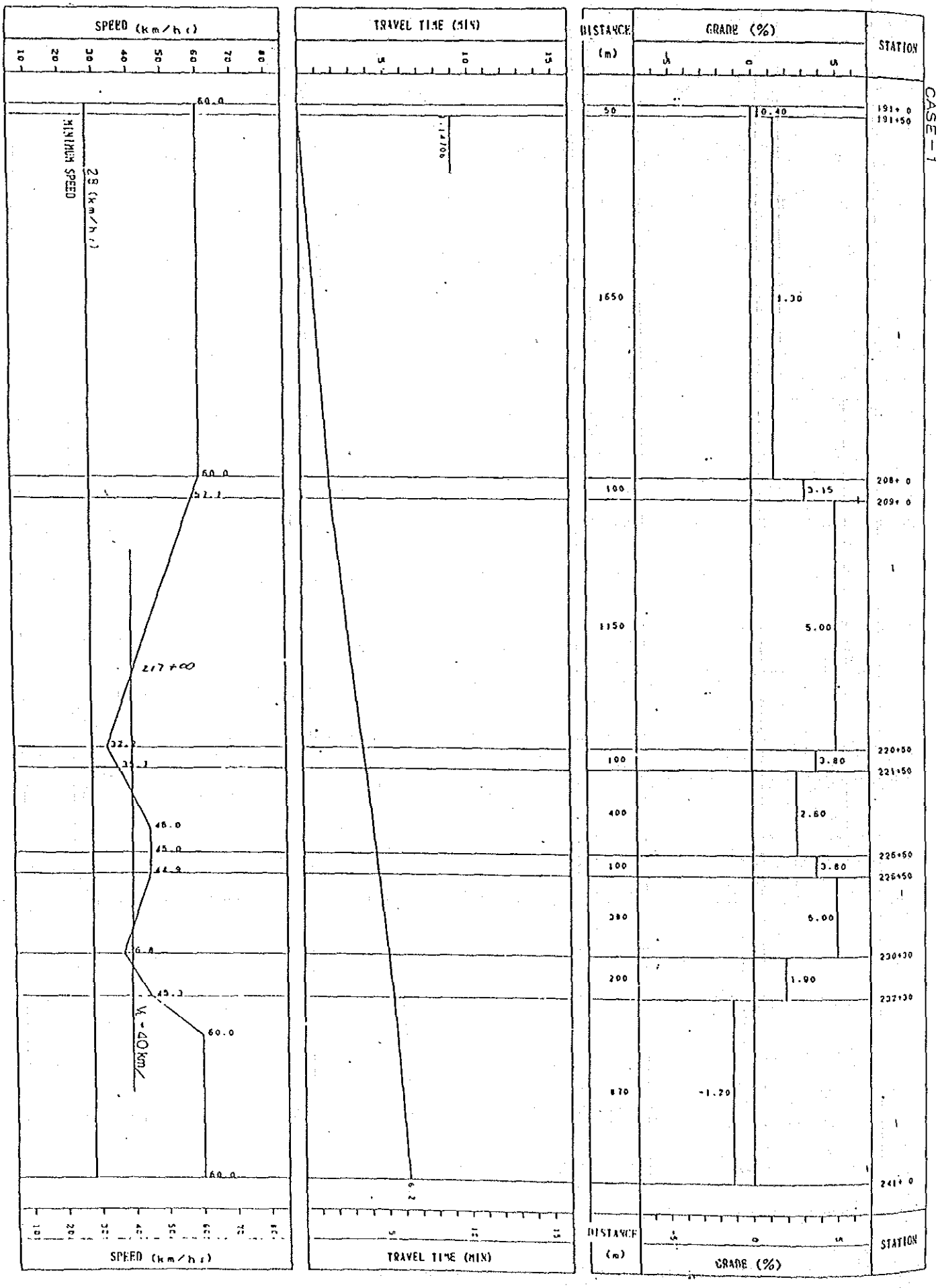
3. Speed Gradient - Diagram

Speed Gradient-Diagram shows as follows

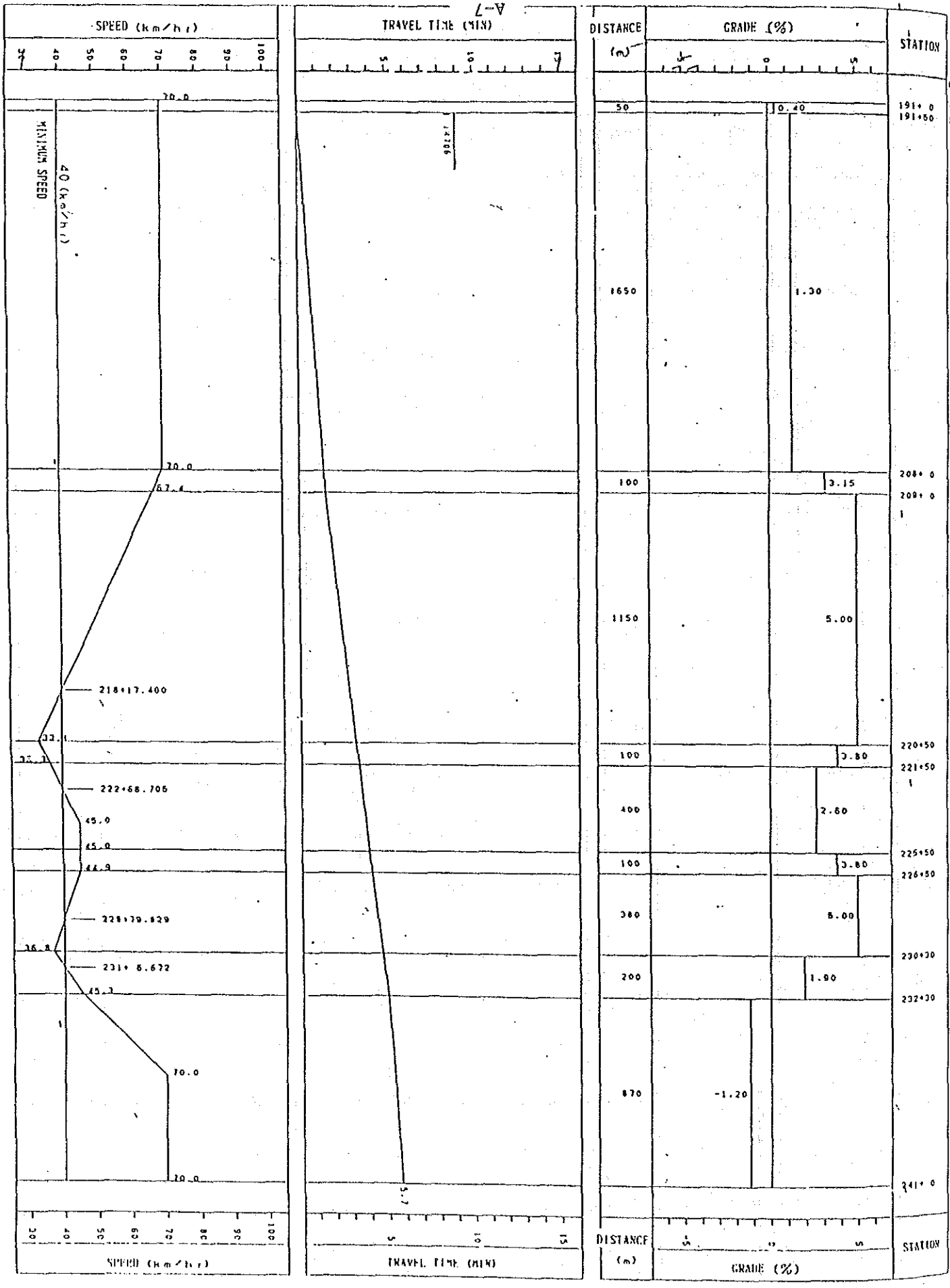
Case 1.	Stage I	VD = 60km/hr	VL = 28km/hr	L = 0	
Case 2.	Stage II	VD = 70km/hr	VL = 41km/hr	L = 250m	
				L 450m	on two section
Case 3.	Stage III	VD = 80km/hr	49km/hr	L = 1700m	

NOTE: Case 1 2 lane road
Case 2 Cases 3,4 lane road (Dual carriage way)
VL = VD x 8-15km/hr
VD = Design Speed
VL = Lowest Down Speed to be sustained.

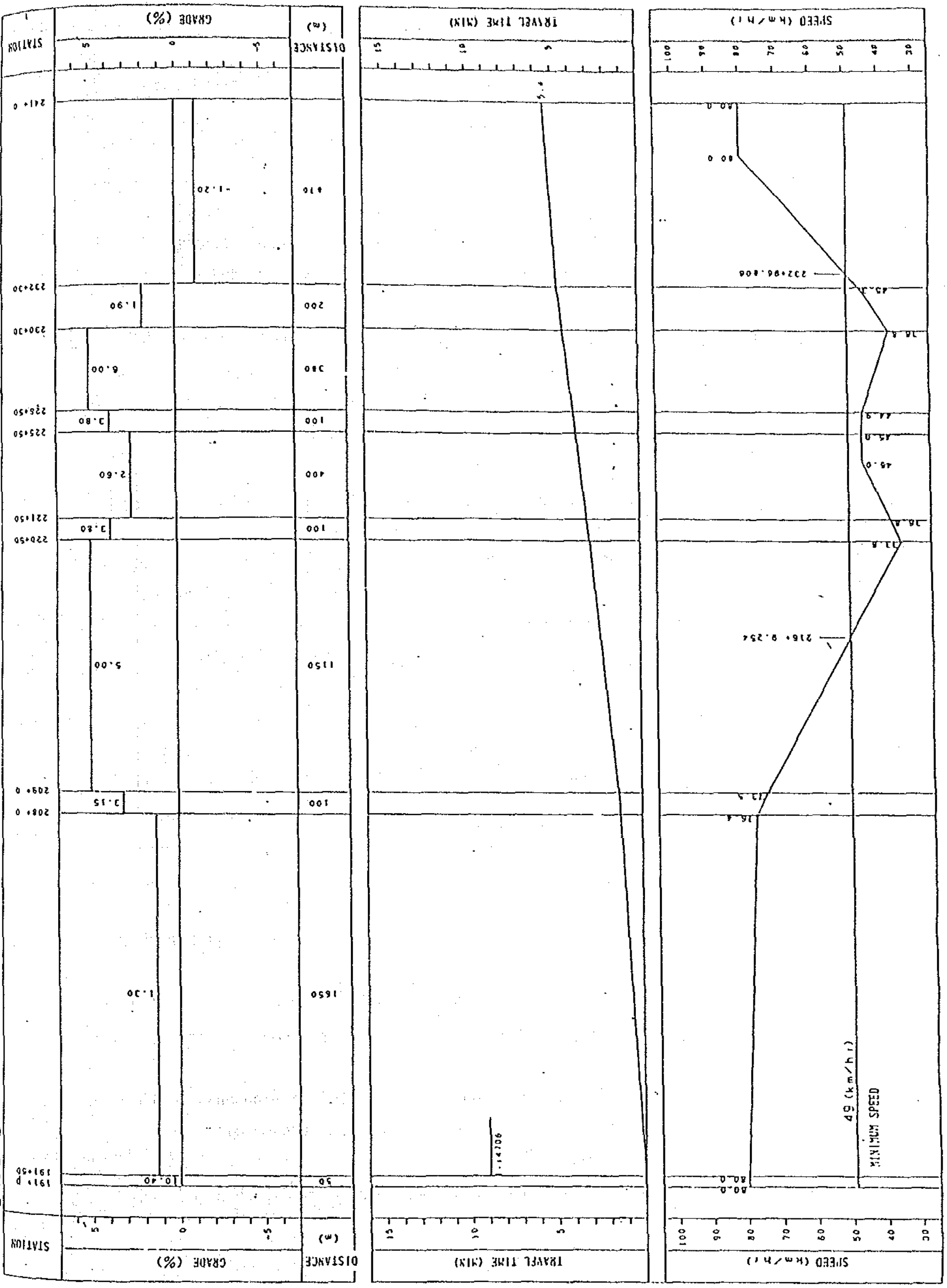
Speed Gradient - Diagram was studied in design speed of 60km/hr for stage I and 70km/hr and 80km/hr for stage II. The diagrams show as follows:-


SPEED (km/h)
TRAVEL TIME (MIN)
DISTANCE (m)
GRADE (%)
STATION
MINIMUM SPEED
28 (km/h)
60.0
60.0
52.1
277+00
32.2
35.1
46.0
45.0
44.9
46.8
45.3
60.0
60.0
V = 40 km/
1'47"06
6'2"
50
1650
100
1150
100
400
100
380
200
870
0.40
1.30
3.15
5.00
3.80
2.60
3.80
6.00
1.90
-1.20
191+ 0
191+50
208+ 0
209+ 0
220+50
221+50
226+50
229+50
230+30
232+30
241+ 0
CASE-1

CASE-2


SPEED (km/hr)
TRAVEL TIME (MIN)
DISTANCE (m)
GRADE (%)
STATION
MINIMUM SPEED
40 (km/hr)
70.0
70.0
67.4
218+17.400
33.1
222+68.705
45.0
45.0
44.9
228+79.829
36.8
231+ 8.672
45.1
70.0
70.0
5.7
50
1650
100
1150
100
400
100
380
200
870
0.40
1.30
3.15
5.00
0.80
2.60
0.80
5.00
1.90
-1.20
191+ 0
191+50
208+ 0
209+ 0
220+50
221+50
225+50
226+50
230+30
232+30
241+ 0

CASE-3



STATION
GRADE (%)
DISTANCE (m)
TRAVEL TIME (MIN)
SPEED (km/hr)
MINIMUM SPEED
49 (km/hr)

4.Comparison for necessity of climbing lane.

Condition of Comparison

(1). Earthwork is done in 4-lane width because Dagoretti junction and Thogoto junction are constructed in 4 lane width and the interval of each junction is short.

(2). Design speed 70km/hr is reasonable due to mountanious or rolling area.

Table: Summary of Study on necessity of climbing lane

	Stage I 2-lane VD=60km/hr		Stage II 4-lane VD=70km/hr	
Climbing lane	no	yes	no	yes
Capacity of Traffic Volume	down	enough	—	up
Running Speed	down	not down	down	not down
Cost	—	few	—	much

5. Results

(1) In the case of 2-lane road, traffic capacity and vehicle running speed are very much reduced and traffic accident of collision is forecasted.

(2) In the case of 4-lane road without climbing lane the capacity of traffic volume and vehicle running speed are not so much reduced.

(3) It is desirable to construct climbing lane in stage I (2-lane road).

6. Section of climbing lane

(i) Conditions for setting of climbing lane

. Target of critical speed is 40km/hr

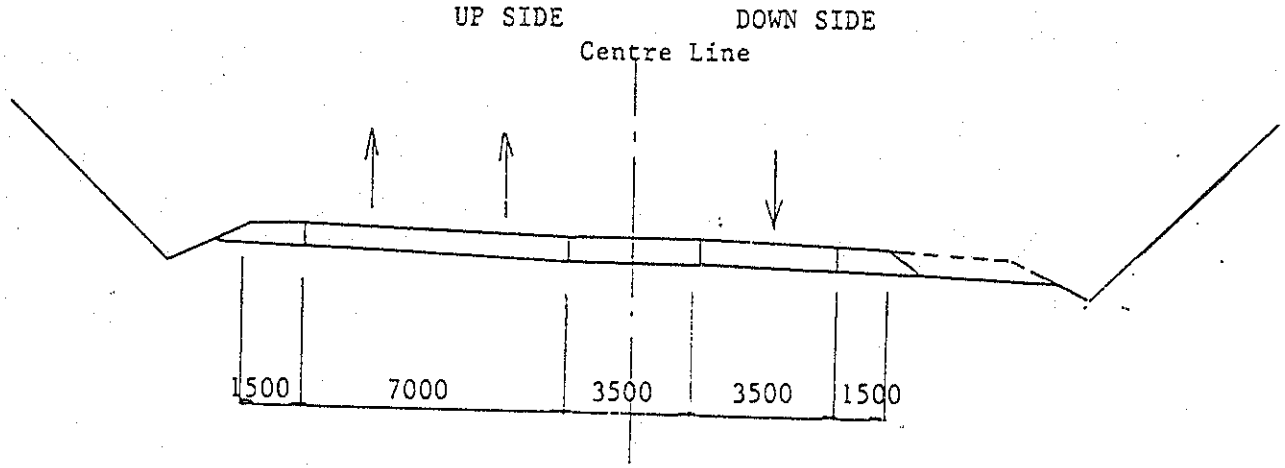
(ii) Section of climbing lane

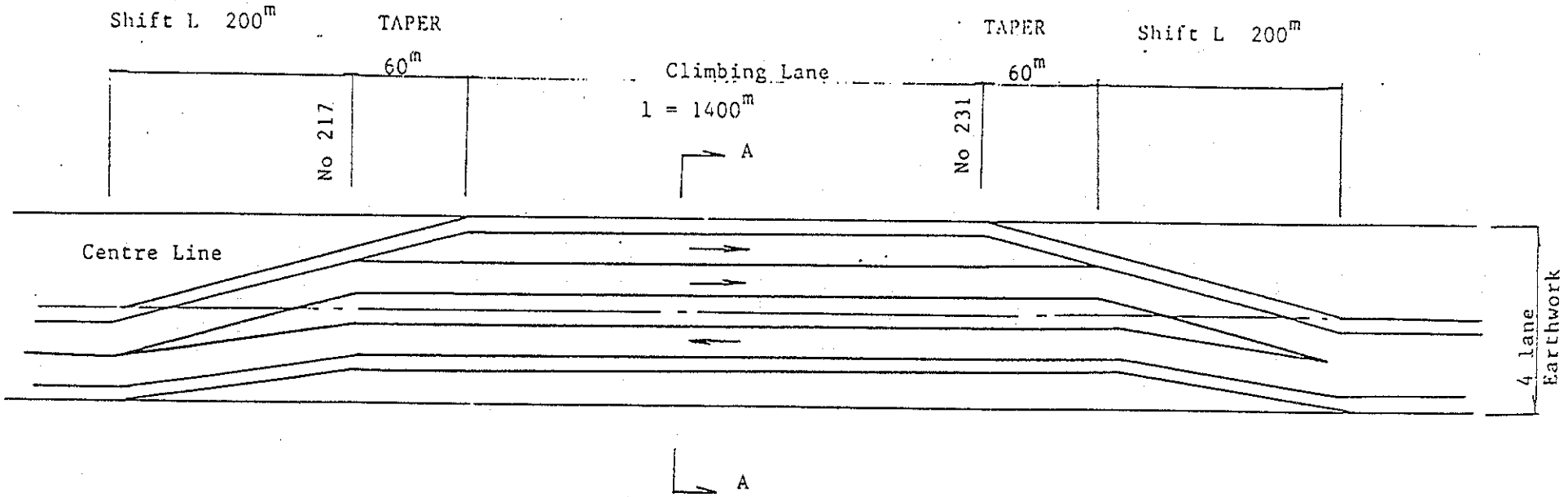
According to the Speed-Gradient diagram of case I and case II climbing lane should be set between Km 21 + 700 and Km 23 + 100 (L = 1400m).

7. Plan of climbing lane

see page 7-13

A-A SECTION

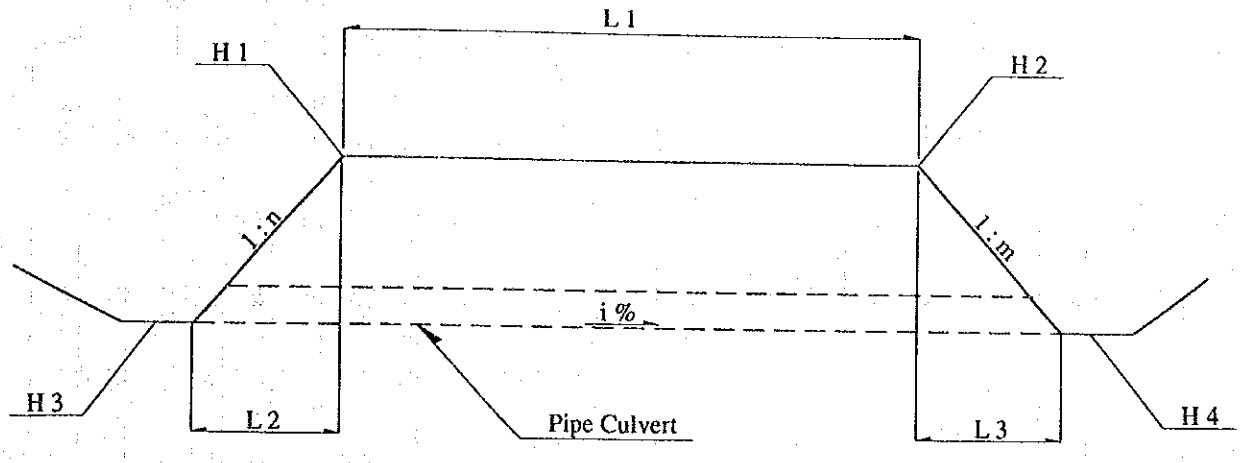




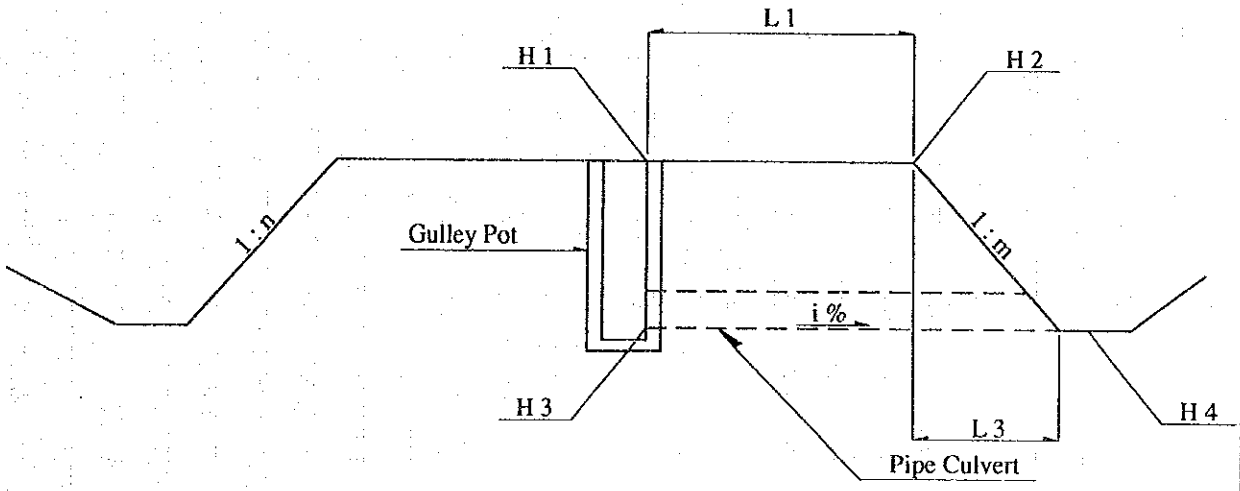
PLAN OF CLIMBING LANE AT STAGE I

APPENDIX - B (パイプカルバート)

Calculation of Pipe Culvert Elevation and Length



Type-I



Type-I

Figure B.1 Location of Pipe Culvert

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
Nairobi Bypass CH.0+300	600	1,654.053	1,654.103	1,652.650	1,652.700	1,652.657	1,652.700	1.396	1.403	15.605	1.500	0.000	13.500	2.105	0.000	-0.320%	M.D.- Left
CH.0+760	2x900	1,651.090	1,650.530	1,648.900	1,648.170	1,648.792	1,648.286	2.298	2.244	29.600	2.000	2.000	20.500	4.380	4.720	2.466%	
CH.0+820	600	1,650.474	1,650.184	1,649.074	1,648.400	1,649.074	1,648.578	1.400	1.606	13.518	0.000	2.000	9.950	0.000	3.568	4.986%	M.D.- Right
CH.1+000	900	1,651.177	1,650.963	1,649.777	1,649.463	1,649.736	1,649.522	1.441	1.441	16.040	1.500	2.000	10.940	2.100	3.000	1.958%	M.D.- Right
CH.5+280	2x900	1,683.914	1,683.588	1,681.036	1,681.400	1,681.140	1,681.321	2.774	2.267	20.082	2.000	2.000	9.950	5.756	4.376	-1.813%	M.D.- Left
CH.5+300	2x900	1,683.728	1,683.343	1,681.500	1,681.543	1,681.508	1,681.534	2.220	1.809	17.942	1.500	2.000	11.000	3.342	3.600	-0.240%	Right - M.D.
CH.6+200	600	1,705.865	1,706.028	1,702.776	1,704.100	1,703.267	1,704.100	2.598	1.928	16.667	2.000	0.000	10.489	6.178	0.000	-7.944%	M.D.- Left
CH.7+020	2x900	1,715.534	1,715.182	1,710.400	1,707.200	1,709.904	1,707.970	5.630	7.212	49.728	1.500	1.500	30.054	7.701	11.973	6.435%	
CH.7+028.438	600	1,715.282	1,715.312	1,710.900	1,713.400	1,711.701	1,713.400	3.581	1.912	20.523	1.500	0.000	13.950	6.573	0.000	-12.181%	M.D.- Left
CH.7+450	600	1,715.995	1,716.180	1,714.050	1,714.400	1,714.148	1,714.400	1.847	1.780	13.840	2.000	0.000	9.950	3.890	0.000	-2.529%	M.D.- Left
CH.7+700	900	1,724.343	1,724.980	1,722.100	1,722.300	1,722.130	1,722.265	2.213	2.715	30.346	2.000	2.000	20.500	4.486	5.360	-0.659%	
CH.8+000	600	1,729.168	1,729.494	1,727.700	1,728.000	1,727.768	1,728.000	1.400	1.494	12.886	2.000	0.000	9.950	2.936	0.000	-2.328%	M.D.- Left
CH.8+180	600	1,730.038	1,730.323	1,727.920	1,727.100	1,727.920	1,727.423	2.118	2.900	16.396	0.000	2.000	9.950	0.000	6.446	5.000%	M.D.- Right
CH.8+250	1200	1,730.078	1,730.508	1,728.000	1,724.400	1,727.600	1,725.577	2.478	4.931	37.372	2.000	2.000	21.000	4.156	12.216	9.633%	
CH.8+400	600	1,731.875	1,731.710	1,730.284	1,730.310	1,730.290	1,730.310	1.585	1.400	13.132	2.000	0.000	9.950	3.182	0.000	-0.200%	M.D.- Left
CH.8+880	600	1,740.376	1,740.177	1,738.751	1,738.777	1,738.758	1,738.777	1.619	1.400	13.200	2.000	0.000	9.950	3.250	0.000	-0.200%	M.D.- Left
CH.8+940	900	1,742.520	1,742.522	1,736.000	1,728.500	1,734.536	1,731.649	7.984	10.873	66.796	2.000	2.000	25.712	13.040	28.044	11.228%	
CH.9+340	600	1,754.722	1,755.048	1,753.314	1,753.340	1,753.320	1,753.340	1.402	1.708	12.766	2.000	0.000	9.950	2.816	0.000	-0.200%	M.D.- Left
CH.9+783.604	900	1,774.598	1,775.215	1,772.700	1,770.900	1,772.496	1,771.365	2.102	3.850	33.426	2.000	2.000	21.000	3.796	8.630	5.385%	
CH.9+800	600	1,775.853	1,776.014	1,773.709	1,772.900	1,773.709	1,773.211	2.144	2.803	16.178	0.000	2.000	9.950	0.000	6.228	5.000%	M.D.- Right
CH.11+100	600	1,789.347	1,789.394	1,787.950	1,787.898	1,787.950	1,787.910	1.397	1.484	12.942	0.000	2.000	9.950	0.000	2.992	0.400%	M.D.- Right
CH.11+240	1200	1,790.975	1,790.403	1,787.903	1,787.250	1,787.781	1,787.375	3.193	3.028	32.949	2.000	2.000	20.500	6.143	6.306	1.982%	
CH.12+400	2x900	1,807.186	1,807.186	1,805.380	1,805.296	1,805.369	1,805.308	1.817	1.878	27.891	2.000	2.000	20.500	3.612	3.779	0.300%	
CH.12+555.218	600	1,808.448	1,808.458	1,807.000	1,807.039	1,807.009	1,807.039	1.439	1.419	12.846	2.000	0.000	9.950	2.896	0.000	-0.300%	M.D.- Left
CH.12+900	600	1,811.171	1,810.866	1,808.567	1,808.600	1,808.578	1,808.600	2.593	2.266	15.158	2.000	0.000	9.950	5.208	0.000	-0.218%	M.D.- Left

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
CH.13+400	1200	1,814.816	1,814.816	1,811.524	1,810.296	1,811.300	1,810.603	3.516	4.213	36.124	2.000	2.000	20.500	6.584	9.040	3.400%	
CH.13+484.164	600	1,814.960	1,814.775	1,813.400	1,813.362	1,813.400	1,813.370	1.560	1.405	12.777	0.000	2.000	9.950	0.000	2.827	0.300%	M.D.- Right
CH.13+760	600	1,816.937	1,816.737	1,815.250	1,815.320	1,815.268	1,815.320	1.669	1.417	13.324	2.000	0.000	9.950	3.374	0.000	-0.525%	M.D.- Left
CH.14+595.083	600	1,820.588	1,820.403	1,819.030	1,818.998	1,819.030	1,819.005	1.558	1.398	12.760	0.000	2.000	9.950	0.000	2.810	0.250%	M.D.- Right
CH.14+865.086	600	1,822.862	1,821.498	1,820.424	1,819.800	1,820.424	1,819.959	2.438	1.539	13.346	0.000	2.000	9.950	0.000	3.396	4.676%	M.D.- Right
CH.15+160	600	1,822.862	1,823.182	1,821.370	1,821.780	1,821.465	1,821.780	1.397	1.402	12.934	2.000	0.000	9.950	2.984	0.000	-3.170%	M.D.- Left
CH.15+400	600	1,824.000	1,824.291	1,822.500	1,822.890	1,822.590	1,822.890	1.410	1.401	12.950	2.000	0.000	9.950	3.000	0.000	-3.012%	M.D.- Left
CH.15+440	600	1,825.325	1,825.558	1,823.925	1,823.890	1,823.925	1,823.897	1.400	1.660	17.284	0.000	2.000	13.950	0.000	3.334	0.200%	M.D.- Right
CH.15+700	600	1,826.824	1,826.992	1,825.424	1,825.397	1,825.424	1,825.404	1.400	1.588	13.256	0.000	2.000	10.067	0.000	3.189	0.200%	M.D.- Right
CH.16+100	600	1,833.030	1,833.215	1,831.600	1,831.750	1,831.633	1,831.750	1.397	1.465	12.810	2.000	0.000	9.950	2.860	0.000	-1.171%	M.D.- Left
CH.16+400	600	1,838.051	1,838.236	1,836.620	1,836.770	1,836.654	1,836.770	1.397	1.466	12.812	2.000	0.000	9.950	2.862	0.000	-1.171%	M.D.- Left
CH.17+360	900	1,856.343	1,856.343	1,850.400	1,854.250	1,851.284	1,853.835	5.059	2.508	38.813	1.500	2.000	25.712	8.914	4.186	-9.919%	
CH.17+717.493	600	1,865.563	1,865.573	1,864.147	1,864.173	1,864.153	1,864.173	1.410	1.400	12.781	2.000	0.000	9.950	2.831	0.000	-0.200%	M.D.- Left
CH.18+160	900	1,873.967	1,873.416	1,866.100	1,871.620	1,867.637	1,871.152	6.330	2.264	42.393	1.500	2.000	27.000	11.801	3.592	-13.021%	
CH.18+360	900	1,874.247	1,874.597	1,864.000	1,869.500	1,865.673	1,868.668	8.574	5.929	50.516	1.500	1.500	27.500	15.371	7.645	-10.888%	
CH.18+580	600	1,873.810	1,873.975	1,872.410	1,872.380	1,872.410	1,872.387	1.400	1.588	13.140	0.000	2.000	9.950	0.000	3.190	0.228%	M.D.- Right
CH.18+820	600	1,872.912	1,873.090	1,871.500	1,871.550	1,871.511	1,871.550	1.401	1.540	12.774	2.000	0.000	9.950	2.824	0.000	-0.391%	M.D.- Left
CH.19+020	600	1,872.512	1,872.677	1,871.112	1,870.550	1,871.112	1,870.718	1.400	1.959	14.204	0.000	2.000	9.950	0.000	4.254	3.957%	M.D.- Right
CH.19+100	900	1,872.615	1,872.965	1,864.600	1,867.500	1,865.456	1,866.916	7.159	6.049	40.720	1.500	1.500	20.500	12.023	8.197	-7.122%	
CH.19+520	900	1,879.469	1,879.565	1,867.600	1,871.900	1,869.107	1,870.927	10.362	8.638	50.801	1.500	1.500	21.500	17.804	11.497	-8.464%	
CH.19+665.167	600	1,880.345	1,880.160	1,878.500	1,876.750	1,878.500	1,877.344	1.845	2.816	15.065	0.000	1.500	9.950	0.000	5.115	11.616%	M.D.- Right
CH.19+900	600	1,881.050	1,880.865	1,879.490	1,879.460	1,879.490	1,879.467	1.560	1.398	12.760	0.000	2.000	9.950	0.000	2.810	0.235%	M.D.- Right
CH.20+120	600	1,881.875	1,881.710	1,880.260	1,880.310	1,880.272	1,880.310	1.603	1.400	13.180	2.000	0.000	9.950	3.230	0.000	-0.379%	M.D.- Left
CH.20+240	2x900	1,882.256	1,881.906	1,877.375	1,877.900	1,877.479	1,877.786	4.777	4.120	36.833	1.500	2.000	21.500	7.322	8.012	-1.425%	
CH.20+340	600	1,882.716	1,882.551	1,878.700	1,880.500	1,879.504	1,880.500	3.212	2.051	17.982	2.000	0.000	9.950	8.032	0.000	-10.010%	M.D.- Left

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
CH.20+600	600	1,886.265	1,886.100	1,881.650	1,883.900	1,882.566	1,883.900	3.699	2.200	22.680	2.000	0.000	13.450	9.230	0.000	-9.921%	M.D.- Left
CH.21+010	750	1,904.590	1,905.090	1,897.400	1,888.900	1,895.848	1,892.395	8.742	12.695	78.760	2.000	2.000	32.000	14.380	32.380	10.792%	
CH.21+060	600	1,906.850	1,907.015	1,905.450	1,904.350	1,905.450	1,904.662	1.400	2.353	18.780	0.000	2.000	13.450	0.000	5.330	5.857%	M.D.- Right
CH.21+600	600	1,933.850	1,934.015	1,932.450	1,932.424	1,932.450	1,932.430	1.400	1.585	13.133	0.000	2.000	9.950	0.000	3.183	0.200%	M.D.- Right
CH.22+380	2x1200	1,962.105	1,962.105	1,960.120	1,960.000	1,960.103	1,960.018	2.002	2.087	28.680	2.000	2.000	20.500	3.970	4.210	0.418%	
Outfall Channel CH.22+400	2x900	1,942.800	1,942.600	1,941.550	1,940.836	1,941.338	1,941.135	1.462	1.465	8.428	2.000	2.000	2.400	2.500	3.528	8.470%	
Outfall Channel CH.22+400	2x900	1,927.630	1,926.970	1,926.250	1,924.812	1,925.946	1,925.286	1.684	1.684	13.077	2.000	2.000	6.000	2.760	4.317	11.000%	
CH.23+560	900	1,989.170	1,989.257	1,987.220	1,987.156	1,987.212	1,987.164	1.958	2.093	32.102	2.000	2.000	24.000	3.900	4.202	0.200%	
CH.23+780	900	1,986.096	1,986.096	1,979.500	1,977.600	1,979.084	1,978.136	7.012	7.960	45.138	1.500	1.500	22.500	9.894	12.744	4.209%	
CH.24+280	600	1,979.886	1,979.638	1,978.486	1,978.164	1,978.486	1,978.237	1.400	1.401	12.899	0.000	2.000	9.950	0.000	2.949	2.500%	M.D.- Right
CH.24+380	2 x1200	1,981.379	1,980.889	1,977.300	1,976.955	1,977.239	1,977.034	4.140	3.855	34.486	1.500	2.000	20.500	6.118	7.868	1.000%	
CH.24+700	600	1,989.743	1,989.488	1,988.243	1,988.037	1,988.243	1,988.084	1.500	1.404	12.851	0.000	2.000	9.950	0.000	2.901	1.600%	M.D.- Right
CH.25+248.062	600	1,997.992	1,997.807	1,996.492	1,996.364	1,996.492	1,996.393	1.500	1.415	12.837	0.000	2.000	9.950	0.000	2.887	1.000%	M.D.- Right
CH.25+420	2x1200	1,997.256	1,997.256	1,993.400	1,993.250	1,993.375	1,993.285	3.881	3.971	34.296	1.500	2.000	20.500	5.784	8.012	0.437%	
CH.27+700	900	2,030.213	2,030.749	2,027.400	2,024.319	2,027.081	2,024.967	3.132	5.782	54.342	2.000	1.779	37.279	5.626	11.437	5.670%	
CH.27+800	600	2,030.293	2,030.081	2,028.700	2,028.674	2,028.700	2,028.680	1.593	1.401	12.763	0.000	2.000	9.950	0.000	2.813	0.200%	M.D.- Right
CH.28+040	600	2,029.530	2,029.310	2,027.930	2,027.904	2,027.930	2,027.910	1.600	1.400	12.761	0.000	2.000	9.950	0.000	2.811	0.200%	M.D.- Right
CH.28+240	750	2,029.130	2,028.800	2,022.196	2,022.150	2,022.164	2,022.150	6.966	6.650	14.901	1.500	0.000	4.500	10.401	0.000	0.309%	
CH.28+260	600	2,028.943	2,028.870	2,023.491	2,026.870	2,024.642	2,026.870	4.301	2.000	24.005	1.500	0.000	15.827	8.178	0.000	-14.076%	M.D.- Left
CH.28+380	600	2,028.393	2,028.510	2,026.943	2,027.110	2,026.992	2,027.110	1.401	1.400	9.850	2.000	0.000	6.950	2.900	0.000	-1.695%	M.D.- Left
CH.0+010R	600	1,645.470	1,645.560	1,644.365	1,644.557	1,644.399	1,644.526	1.071	1.034	12.616	2.000	2.000	8.400	2.210	2.006	-1.522%	
Monbasa Rd. J/C A-Slip Rd. CH.0+140	600	1,648.480	1,648.774	1,647.060	1,647.150	1,647.080	1,647.127	1.400	1.647	12.989	2.000	2.000	6.901	2.840	3.248	-0.693%	
B-Slip Rd. CH.0+275.614	600	1,648.424	1,648.750	1,646.800	1,646.850	1,646.811	1,646.837	1.613	1.913	14.148	2.000	2.000	7.100	3.248	3.800	-0.353%	
C-Slip Rd. CH.0+240	600	1,647.911	1,648.261	1,646.400	1,646.600	1,646.444	1,646.552	1.467	1.709	13.844	2.000	2.000	7.500	3.022	3.322	-1.445%	
D-Slip Rd. CH.0+065	600	1,648.205	1,648.471	1,646.820	1,646.750	1,646.805	1,646.769	1.400	1.702	13.008	2.000	2.000	6.796	2.770	3.442	0.538%	

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
E-Slip Rd. CH.0+025	600	1,647.304	1,647.694	1,645.900	1,645.930	1,645.906	1,645.922	1.398	1.772	13.836	2.000	2.000	7.500	2.808	3.528	-0.217%	
F-Slip Rd. CH.0+300	600	1,647.609	1,647.869	1,646.210	1,646.180	1,646.204	1,646.188	1.405	1.681	12.947	2.000	2.000	6.771	2.798	3.378	0.232%	
G-Slip Rd. CH.0+300	600	1,647.903	1,648.138	1,646.490	1,646.550	1,646.504	1,646.535	1.399	1.603	12.502	2.000	2.000	6.500	2.826	3.176	-0.480%	
Monbasa Rd.(A104) CH.0-800 L	2 x 900	1,645.680	1,645.680	1,642.650	1,643.080	1,642.795	1,642.956	2.885	2.724	17.960	2.000	2.000	6.700	6.060	5.200	-2.394%	
Monbasa Rd.(A104) CH.0-800 R	2 x 900	1,645.420	1,645.420	1,643.320	1,644.100	1,643.504	1,643.985	1.916	1.435	17.840	2.000	2.000	11.000	4.200	2.640	-4.372%	
Monbasa Rd.(A104) CH.0-650	2 x 900	1,646.900	1,646.900	1,645.516	1,645.434	1,645.499	1,645.452	1.401	1.448	13.500	2.000	2.000	7.800	2.768	2.932	0.607%	
Monbasa Rd.(A104) CH.0-260R	2 x 900	1,648.400	1,648.400	1,647.130	1,647.050	1,647.111	1,647.070	1.289	1.330	10.840	2.000	2.000	5.600	2.540	2.700	0.738%	
Monbasa Rd.(A104) CH.0+950	600	1,647.300	1,647.300	1,645.000	1,645.700	1,645.165	1,645.547	2.135	1.753	14.650	1.500	2.000	8.000	3.450	3.200	-4.778%	
Monbasa Rd.(A104) CH.0+950	600	1,647.300	1,647.300	1,645.000	1,645.700	1,645.165	1,645.547	2.135	1.753	14.650	1.500	2.000	8.000	3.450	3.200	-4.778%	
Service Rd. CH.1+220R	900	1,651.740	1,651.690	1,650.552	1,650.478	1,650.540	1,650.490	1.200	1.200	14.800	2.000	2.000	10.000	2.376	2.424	0.500%	
Uhuru Monument J/C A-Slip Rd.(CH.0+221.233) CH.6+520	600	1,716.602	1,716.722	1,715.000	1,715.300	1,715.085	1,715.300	1.517	1.422	11.254	2.000	0.000	8.050	3.204	0.000	-2.666%	
Langata Rd. (C58) CH.0+110L	600	1,721.517	1,721.044	1,719.995	1,719.025	1,719.760	1,719.336	1.757	1.708	12.582	2.000	2.000	5.500	3.044	4.038	7.710%	
Langata Rd. (C58) CH.0+140L	600	1,719.728	1,719.286	1,718.126	1,717.482	1,718.022	1,717.599	1.706	1.687	19.812	2.000	2.000	13.000	3.204	3.608	3.250%	
Langata Rd. (C58) CH.0+165R	600	1,718.495	1,718.931	1,716.871	1,717.556	1,717.006	1,717.442	1.489	1.489	16.498	2.000	2.000	10.500	3.248	2.750	-4.152%	
Langata Rd. (C58) CH.0+177L	300	1,718.270	1,718.270	1,717.148	1,717.128	1,717.141	1,717.135	1.129	1.135	6.527	2.000	2.000	2.000	2.244	2.283	0.300%	
Langata Rd. (C58) CH.0+220L	300	1,716.000	1,716.000	1,714.940	1,714.959	1,714.946	1,714.952	1.054	1.048	6.203	2.000	2.000	2.000	2.120	2.083	-0.300%	
Langata Rd. (C58) CH.0+235L	600	1,715.413	1,714.830	1,714.072	1,713.171	1,713.930	1,713.347	1.483	1.483	17.000	2.000	2.000	11.000	2.682	3.318	5.300%	
Langata Rd. (C58) CH.0+240R	300	1,714.840	1,714.840	1,713.840	1,713.858	1,713.846	1,713.852	0.994	0.988	5.964	2.000	2.000	2.000	2.000	1.964	-0.300%	
Langata Rd. (C58) CH.0+260R	600	1,713.648	1,714.310	1,711.989	1,712.969	1,712.165	1,712.827	1.483	1.483	18.500	2.000	2.000	12.500	3.318	2.682	-5.296%	
Service Rd. (C-Slip Rd.) CH.0+220	900	1,712.180	1,711.980	1,710.880	1,710.730	1,710.832	1,710.730	1.348	1.250	6.150	1.500	0.000	4.200	1.950	0.000	2.439%	
Service Rd. CH.7+020R	2x900	1,708.860	1,708.660	1,707.200	1,706.816	1,707.200	1,707.000	1.660	1.660	7.689	0.000	2.000	4.000	0.000	3.689	5.000%	
Service Rd. CH.7+340L	900	1,715.496	1,715.505	1,713.487	1,713.514	1,713.496	1,713.505	2.000	2.000	12.000	2.000	2.000	4.000	4.018	3.982	-0.225%	
Ngong Rd. J/C A-Slip Rd. CH.0+040	600	1,825.038	1,824.926	1,823.560	1,823.522	1,823.554	1,823.527	1.484	1.399	19.064	2.000	2.000	13.300	2.956	2.808	0.200%	
Ngong Rd. CH.0+260	600	1,815.197	1,815.510	1,813.970	1,814.100	1,813.991	1,814.076	1.206	1.434	15.274	2.000	2.000	10.000	2.454	2.820	-0.851%	
Ngong Rd. CH.0+440	600	1,819.800	1,819.400	1,818.200	1,817.000	1,817.987	1,817.320	1.813	2.080	18.000	2.000	2.000	10.000	3.200	4.800	6.667%	

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
Ngong Rd. CH.0+620	600	1,830.233	1,830.447	1,829.038	1,829.000	1,829.033	1,829.006	1.200	1.441	18.784	2.000	2.000	13.500	2.390	2.894	0.202%	
Ngong Rd. CH.0+740L	300	1,833.600	1,833.600	1,832.399	1,832.312	1,832.380	1,832.332	1.220	1.268	10.978	2.000	2.000	6.000	2.402	2.576	0.792%	
Service Rd. CH.18+400R	600	1,871.370	1,871.240	1,870.120	1,869.970	1,870.079	1,870.012	1.291	1.228	9.040	2.000	2.000	4.000	2.500	2.540	1.659%	
Service Rd. CH.18+480R	600	1,874.250	1,874.310	1,872.720	1,872.869	1,872.766	1,872.826	1.484	1.484	9.942	2.000	2.000	4.000	3.060	2.882	-1.500%	
Service Rd. CH.19+060 L	900	1,865.800	1,866.100	1,864.100	1,864.500	1,864.193	1,864.412	1.607	1.688	10.950	1.500	1.500	6.000	2.550	2.400	-3.653%	
Service Rd. CH.19+520 L	900	1,868.975	1,869.275	1,867.200	1,867.600	1,867.295	1,867.510	1.680	1.765	11.175	1.500	1.500	6.000	2.662	2.513	-3.579%	
Service Rd. CH.20+200L	300	1,878.210	1,878.150	1,877.253	1,877.072	1,877.210	1,877.121	1.000	1.029	8.070	2.000	2.000	4.000	1.914	2.156	2.240%	
Service Rd. CH.20+200R	300	1,879.548	1,879.660	1,878.490	1,878.710	1,878.548	1,878.658	1.000	1.002	8.016	2.000	2.000	4.000	2.116	1.900	-2.745%	
Service Rd. CH.20+220 L	2x900	1,882.200	1,881.850	1,877.000	1,878.650	1,877.361	1,878.354	4.839	3.496	35.700	1.500	2.000	21.500	7.800	6.400	-4.622%	
Dagoretti Forest J/C A-Slip Rd. CH.0+040	600	1,887.456	1,887.129	1,882.090	1,882.975	1,882.348	1,882.775	5.108	4.354	27.573	1.500	1.500	13.293	8.049	6.231	-3.210%	
Dagoretti Forest J/C A-Slip Rd. CH.0+260	600	1,887.095	1,887.605	1,885.040	1,885.600	1,885.160	1,885.483	1.935	2.122	19.120	2.000	2.000	11.000	4.110	4.010	-2.929%	
Dagoretti Forest J/C B-Slip Rd. CH.0+080	600	1,890.781	1,891.301	1,884.020	1,883.100	1,883.749	1,883.429	7.032	7.872	34.443	1.500	1.500	12.000	10.141	12.302	2.671%	
Approach Rd. (C63) CH.0+040	600	1,886.422	1,886.422	1,884.950	1,885.005	1,884.959	1,884.996	1.463	1.426	18.229	2.000	2.000	12.450	2.944	2.835	-0.300%	
Approach Rd. (C63) CH.0+160	900	1,888.905	1,889.425	1,887.150	1,887.950	1,887.309	1,887.816	1.596	1.609	17.626	2.000	2.000	11.166	3.510	2.950	-4.539%	
Approach Rd. (C63) CH.0+340	1200	1,888.310	1,888.310	1,886.200	1,886.625	1,886.285	1,886.557	2.025	1.753	21.090	2.000	2.000	13.500	4.220	3.370	-2.015%	
Service Rd. CH.21+000L	2x900	1,898.300	1,898.600	1,896.540	1,897.170	1,896.719	1,897.024	1.581	1.576	12.380	2.000	2.000	6.000	3.520	2.860	-5.089%	
Service Rd. CH.21+000R	900	1,893.600	1,892.500	1,892.400	1,890.240	1,891.999	1,890.996	1.601	1.504	12.920	2.000	2.000	6.000	2.400	4.520	16.718%	
Service Rd. CH.22+380 L	600	1,962.960	1,963.160	1,961.600	1,960.120	1,961.340	1,960.702	1.620	2.458	11.600	1.500	1.500	5.000	2.040	4.560	12.759%	
Service Rd. CH.22+380 R	2 x1200	1,962.200	1,962.000	1,960.000	1,959.850	1,959.957	1,959.892	2.243	2.108	11.525	1.500	1.500	5.000	3.300	3.225	1.302%	
Service Rd. CH.22+880L	900	1,976.840	1,976.900	1,975.300	1,975.425	1,975.338	1,975.388	1.502	1.512	10.030	2.000	2.000	4.000	3.080	2.950	-1.246%	
Service Rd. CH.22+880R	900	1,977.350	1,977.322	1,975.877	1,975.785	1,975.850	1,975.813	1.500	1.509	10.020	2.000	2.000	4.000	2.946	3.074	0.918%	
Service Rd. CH.23+100R	600	1,981.370	1,981.350	1,980.156	1,980.134	1,980.150	1,980.140	1.220	1.210	8.860	2.000	2.000	4.000	2.428	2.432	0.248%	
Service Rd. CH.23+240L	900	1,989.900	1,989.900	1,986.560	1,987.080	1,986.757	1,986.914	3.143	2.986	13.240	1.500	1.500	4.000	5.010	4.230	-3.927%	
Approach Rd. (D411) CH.0+010L	300	1,977.100	1,977.100	1,975.691	1,975.966	1,975.776	1,975.897	1.324	1.203	9.086	2.000	2.000	4.000	2.818	2.268	-3.027%	
Approach Rd. (D411) CH.0+080L	300	1,977.340	1,977.340	1,976.183	1,976.212	1,976.190	1,976.205	1.150	1.135	9.570	2.000	2.000	5.000	2.314	2.256	-0.303%	

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
Approach Rd. (D411) CH.0+140L	300	1,977.740	1,977.740	1,976.673	1,976.212	1,976.576	1,976.350	1.164	1.390	10.190	2.000	2.000	5.000	2.134	3.056	4.524%	
Approach Rd. (D411) CH.0+230	900	1,982.325	1,982.325	1,980.750	1,980.845	1,980.770	1,980.826	1.555	1.499	14.610	2.000	2.000	8.500	3.150	2.960	-0.650%	
Approach Rd. (D411) CH.0+280	900	1,985.917	1,985.810	1,984.200	1,984.349	1,984.234	1,984.319	1.683	1.491	14.857	2.000	2.000	8.500	3.434	2.923	-1.000%	
Approach Rd. (D411) CH.0+285L	300	1,986.650	1,986.650	1,984.420	1,985.520	1,984.878	1,985.288	1.772	1.362	10.720	2.000	2.000	4.000	4.460	2.260	-10.261%	
Approach Rd. (D411) CH.0+320L	600	1,987.925	1,988.155	1,986.510	1,987.032	1,986.673	1,986.903	1.252	1.252	9.076	2.000	2.000	4.000	2.830	2.246	-5.750%	
Approach Rd. (D411) CH.0+325L	300	1,988.800	1,988.800	1,987.670	1,987.900	1,987.734	1,987.849	1.066	0.951	8.060	2.000	2.000	4.000	2.260	1.800	-2.854%	
Approach Rd. (D411) CH.0+340L	300	1,990.017	1,990.017	1,988.880	1,989.150	1,988.931	1,989.111	1.086	0.906	12.008	2.000	2.000	8.000	2.274	1.734	-2.249%	
Thogoto J/C A-Slip Rd. CH.0+040	900	1,990.669	1,990.975	1,988.790	1,989.180	1,988.867	1,989.107	1.802	1.868	19.082	2.000	2.000	11.734	3.758	3.590	-2.044%	
Thogoto J/C B-Slip Rd. CH.0+040	900	1,990.978	1,990.942	1,984.000	1,983.900	1,983.969	1,983.931	7.009	7.011	33.733	1.500	1.500	12.703	10.467	10.563	0.296%	
Thogoto J/C B-Slip Rd. CH.0+280	600	1,978.415	1,978.372	1,976.550	1,976.600	1,976.561	1,976.590	1.854	1.782	17.174	2.000	2.000	9.900	3.730	3.544	-0.291%	
Service Rd. CH.25+420 L	2x900	1,995.250	1,994.950	1,993.600	1,993.400	1,993.554	1,993.443	1.696	1.507	10.800	1.500	1.500	6.000	2.475	2.325	1.852%	
Ondiri Swamp CH.26+420R	600	2,013.200	2,013.800	2,011.600	2,012.620	2,011.832	2,012.449	1.368	1.351	14.060	2.000	2.000	8.500	3.200	2.360	-7.255%	
Ondori Swamp CH.26+490L	900	2,018.000	2,018.700	2,016.250	2,017.200	2,016.479	2,017.003	1.521	1.697	14.500	2.000	2.000	8.000	3.500	3.000	-6.552%	
Kikuyu Town J/C A-Slip Rd. CH.0+020	600	2,022.778	2,022.603	2,021.300	2,020.820	2,021.214	2,020.924	1.564	1.679	16.522	2.000	2.000	10.000	2.956	3.566	2.905%	
Kikuyu Town J/C A-Slip Rd. CH.0+310R	300	2,025.160	2,025.165	2,024.052	2,024.073	2,024.059	2,024.066	1.101	1.099	6.699	2.000	2.000	2.300	2.215	2.184	-0.313%	
Kikuyu Town J/C A-Slip Rd. CH.0+335R	300	2,025.206	2,025.358	2,024.144	2,024.258	2,024.175	2,024.226	1.031	1.132	7.824	2.000	2.000	3.500	2.124	2.200	-1.457%	
Kikuyu Town J/C A-Slip Rd. CH.0+540	300	2,028.791	2,028.791	2,027.800	2,027.400	2,027.746	2,027.475	1.045	1.316	14.764	2.000	2.000	10.000	1.982	2.782	2.709%	
Kikuyu Town J/C A-Slip Rd. CH.0+640R	600	2,032.500	2,031.725	2,031.560	2,030.640	2,031.488	2,030.723	1.012	1.002	24.050	2.000	2.000	20.000	1.880	2.170	3.825%	
Kikuyu Town J/C A-Slip Rd. CH.1+060	900	2,024.552	2,024.552	2,023.000	2,022.350	2,022.885	2,022.514	1.667	2.038	17.508	2.000	2.000	10.000	3.104	4.404	3.713%	
Kikuyu Town J/C A-Slip Rd. CH.1+105R	300	2,026.400	2,026.100	2,024.900	2,024.099	2,024.682	2,024.390	1.718	1.710	11.002	2.000	2.000	4.000	3.000	4.002	7.280%	
Kikuyu Town J/C A-Slip Rd. CH.1+165R	300	2,029.129	2,028.914	2,028.029	2,027.434	2,027.912	2,027.592	1.217	1.322	11.161	2.000	2.000	6.000	2.200	2.961	5.335%	
Kikuyu Town J/C A-Slip Rd. CH.1+265R	300	2,034.758	2,034.600	2,033.529	2,033.007	2,033.409	2,033.164	1.349	1.436	10.643	2.000	2.000	5.000	2.458	3.185	4.900%	
Kikuyu Town J/C A-Slip Rd. CH.1+440	600	2,031.325	2,031.185	2,027.800	2,025.900	2,027.303	2,026.645	4.022	4.540	20.215	1.500	1.500	7.000	5.288	7.927	9.399%	
Kikuyu Town J/C C-Slip Rd. CH.0+040	600	2,032.950	2,032.608	2,031.150	2,031.220	2,031.163	2,031.210	1.787	1.398	19.741	2.000	2.000	13.365	3.600	2.776	-0.355%	
Kikuyu Town J/C C-Slip Rd. CH.0+060 L	600	2,034.278	2,034.278	2,031.810	2,032.793	2,032.067	2,032.639	2.211	1.639	18.906	2.000	2.000	11.000	4.936	2.970	-5.200%	

Table B.1 Caluculation Sheet of Pipe Culvert Elevation and Length

Chainage	Diameter (mm)	H1 (m)	H2 (m)	H3 (m)	H4 (m)	H5 (m)	H6 (m)	H1-H5 (m)	H2-H6 (m)	L (m)	n	m	L1 (m)	L2 (m)	L3 (m)	i (%)	Remarks
Kikuyu Town J/C D-Slip Rd. CH.0+030 L	300	2,039.631	2,039.639	2,037.593	2,037.716	2,037.628	2,037.683	2.003	1.956	14.423	2.000	2.000	6.500	4.076	3.847	-0.850%	
Kikuyu Town J/C D-Slip Rd. CH.0+040	600	2,038.653	2,038.653	2,037.350	2,037.300	2,037.341	2,037.309	1.312	1.344	15.312	2.000	2.000	10.000	2.606	2.706	0.327%	
Kikuyu Town J/C D-Slip Rd. CH.0+050 R	300	2,039.328	2,039.328	2,038.180	2,038.047	2,038.146	2,038.086	1.182	1.242	8.858	2.000	2.000	4.000	2.296	2.562	1.500%	
Kikuyu Town J/C D-Slip Rd. CH.0+090 L	300	2,039.945	2,039.945	2,038.480	2,038.577	2,038.509	2,038.549	1.436	1.396	9.667	2.000	2.000	4.000	2.930	2.737	-1.000%	
Kikuyu Town J/C D-Slip Rd. CH.0+120R	300	2,039.935	2,039.935	2,038.630	2,038.650	2,038.637	2,038.644	1.298	1.291	8.179	2.000	2.000	3.000	2.610	2.569	-0.250%	
Kikuyu Town J/C D-Slip Rd. CH.0+135L	300	2,039.665	2,039.666	2,038.628	2,038.581	2,038.614	2,038.596	1.051	1.069	6.742	2.000	2.000	2.500	2.074	2.168	0.690%	
Kikuyu Town J/C D-Slip Rd. CH.0+150R	300	2,039.371	2,039.371	2,038.345	2,038.469	2,038.382	2,038.436	0.989	0.935	6.856	2.000	2.000	3.000	2.052	1.804	-1.810%	
Kikuyu Town J/C D-Slip Rd. CH.0+160L	300	2,039.086	2,039.086	2,038.185	2,037.917	2,038.126	2,037.994	0.960	1.092	8.140	2.000	2.000	4.000	1.802	2.338	3.290%	
Kikuyu Town J/C D-Slip Rd. CH.0+260L	600	2,035.050	2,034.866	2,033.692	2,032.939	2,033.541	2,033.153	1.509	1.713	13.569	2.000	2.000	7.000	2.716	3.853	5.550%	
Kikuyu Town J/C D-Slip Rd. CH.0+420L	900	2,029.350	2,029.450	2,027.468	2,027.525	2,027.484	2,027.508	1.866	1.942	13.315	2.000	2.000	5.700	3.764	3.851	-0.425%	
Kikuyu Town J/C D-Slip Rd. CH.0+444.278	900	2,029.978	2,029.978	2,027.800	2,028.000	2,027.848	2,027.957	2.130	2.021	18.312	2.000	2.000	10.000	4.356	3.956	-1.092%	
CH.27+095L	900	2,027.886	2,027.886	2,026.032	2,026.321	2,026.131	2,026.238	1.755	1.648	10.837	2.000	2.000	4.000	3.708	3.129	-2.670%	
CH.28+050L	600	2,029.600	2,028.900	2,028.445	2,027.470	2,028.274	2,027.682	1.326	1.218	13.170	2.000	2.000	8.000	2.310	2.860	7.403%	
Kikuyu J/C A-Slip Rd. CH.0+460	900	2,036.314	2,036.529	2,034.200	2,032.950	2,033.913	2,033.437	2.401	3.092	18.386	2.000	2.000	7.000	4.228	7.158	6.799%	
Kikuyu J/C A-Slip Rd. CH.0+120	600	2,027.291	2,027.131	2,025.930	2,025.680	2,025.883	2,025.730	1.408	1.401	14.624	2.000	2.000	9.000	2.722	2.902	1.710%	
Kikuyu J/C A-Slip Rd. CH.0+020	600	2,024.890	2,024.952	2,022.300	2,023.500	2,022.543	2,023.364	2.347	1.588	25.584	2.000	2.000	17.500	5.180	2.904	-4.690%	
Road 3.1(Kabete-Limuru) CH.0+380	600	2,025.008	2,024.883	2,023.588	2,023.683	2,023.607	2,023.667	1.401	1.216	14.240	2.000	2.000	9.000	2.840	2.400	-0.667%	
CH.27+700	900	2,030.213	2,030.749	2,027.400	2,024.319	2,027.081	2,024.967	3.132	5.782	54.342	2.000	1.779	37.279	5.626	11.437	5.670%	

M.D.: Median Drain

APPENDIX - C (排水池)

Substitute Plan of Soak Pit near Thogoto J/C

In Preliminary Design Stage, it was proposed to construct a soak pit near Thogoto Junction, because of no stream or river to drain the surface run-off in this valley. The reason was that soak pits for sewerage under construction near here and it was judged that soil of the location had enough coefficient of infiltration.

But it was found that soil of the location is not enough coefficient of infiltration after boring survey and soil test. (refer to Material Report 3.7 GROUND CONDITION OF SOAK PIT)

In this stage, a drainage pond was designed as substitute plan of soak pit.

Design Discharge

In this case, calculations of the increased discharge by the road construction are as follows.

The area of new construction road and slope are about 52,000 m^2 in this valley.

This area of cultivated land changes to road and slope, so the run-off coefficient (C) changes to 0.9 from 0.4.

$$Q = 0.278 \times C \times I \times A$$

Q : The expected flow (m^3/sec)

C : The run-off coefficient (0.5)

I : The intensity of rainfall (mm/h)

A : The area drained (0.052km^2)

Return Period : 25 years

Duration time (hr.)	I (mm/hr.)	Total discharge (m3)
0.1	120.0	5,179
0.2	110.0	9,494
0.3	100.0	12,946
0.4	93.0	16,053
0.5	89.0	19,204
1.0	70.0	30,208
2.0	48.0	41,428
3.0	37.0	47,901
4.0	29.0	50,059
5.0	24.0	51,785
10.0	13.3	57,395
20.0	6.7	57,827
24.0	5.6	58,000

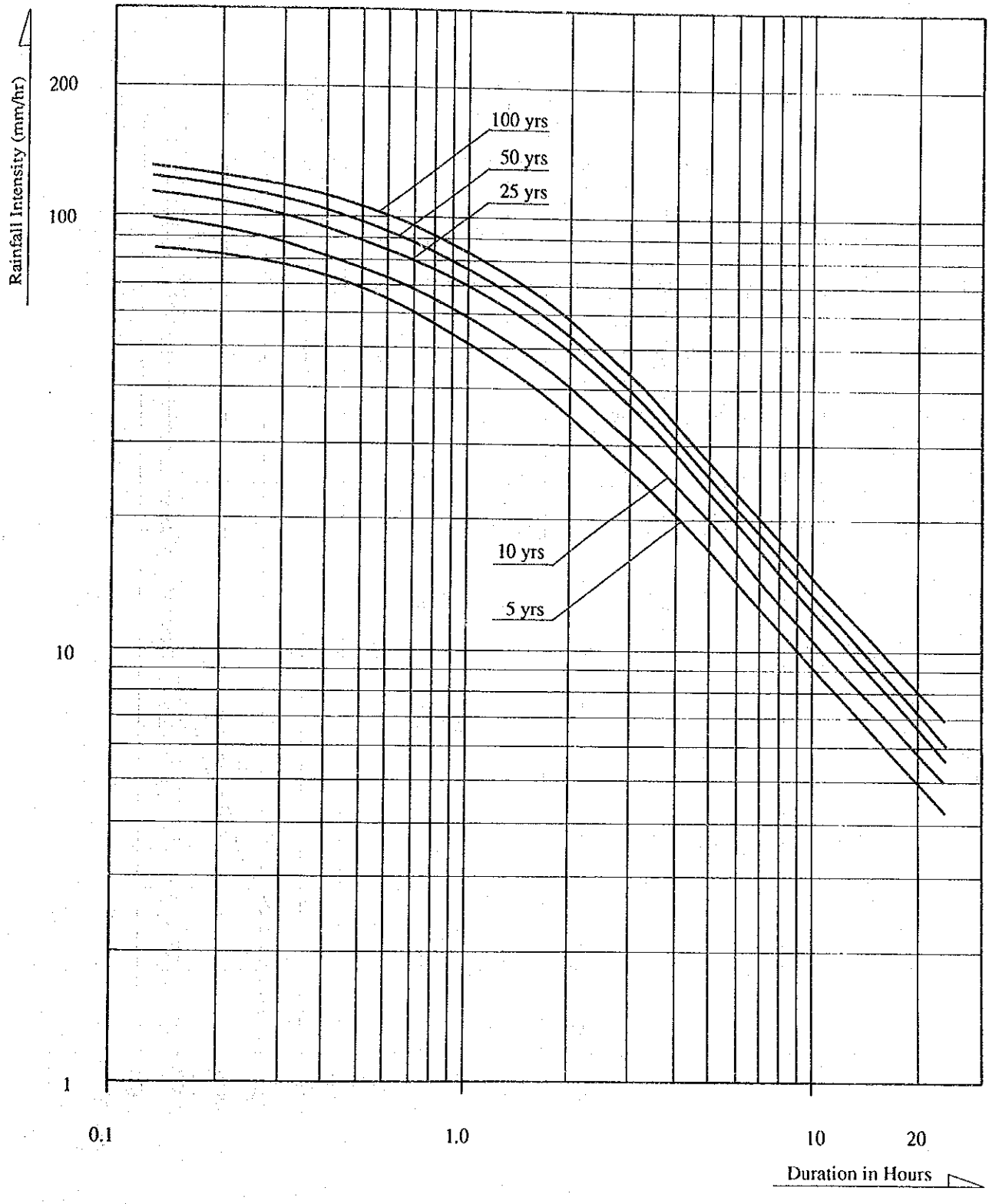


Figure C.1 Rainfall Intensity - Duration - Frequency Relationships for Dagoretti Headquarter

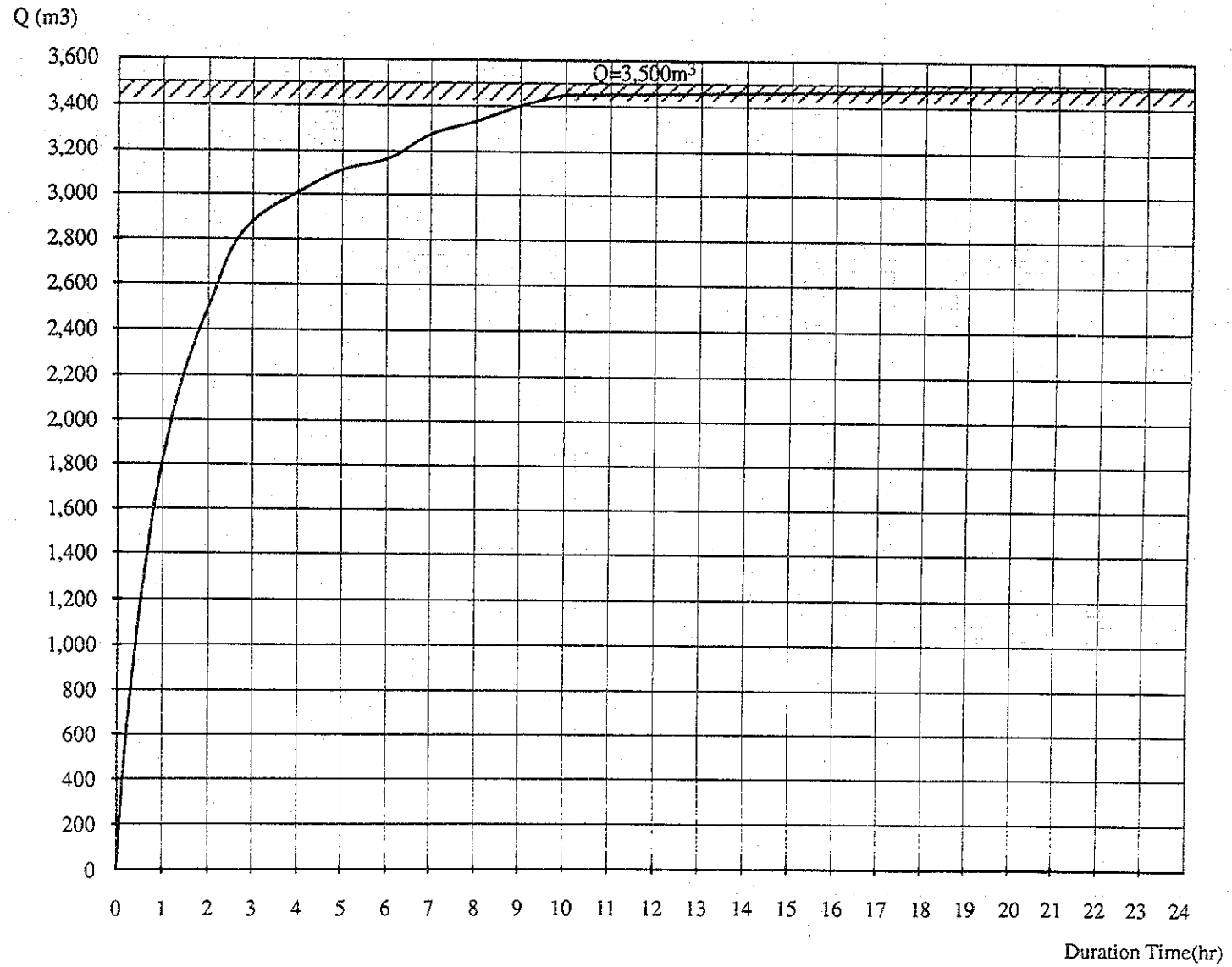


Figure C.2 Total Discharge (Return Period 25years)

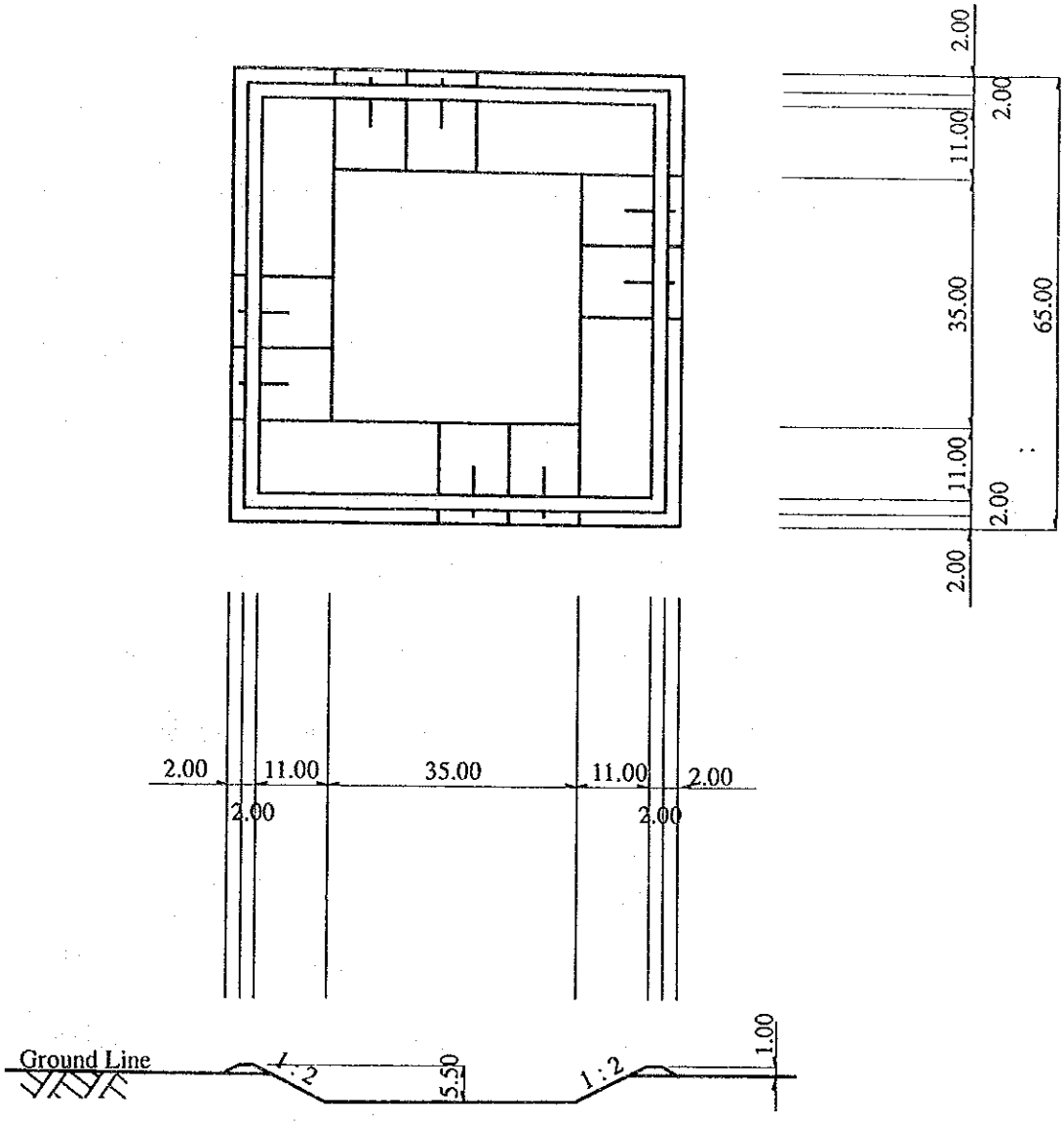


Figure. C.3 Plan and Profile of Drainage Pond

Scale 1:1,000

APPENDIX - D (排水計算)

Discharge Calculation

(1) Box culvert (13 + 978) (36°44.5'E, 1°19.2'S)

- Area 2.93 km^2
- Design return period 25 years
- Longest channel 2,500 m
- Average slope of the catchment

$$S_1 = \frac{1,875 - 1,805}{4,200} = 1.67\%$$

- Average slope of main channel

$$S_1 = \frac{1,840 - 1,805}{2,500} = 1.40\%$$

- Run-off coefficient C = 0.40

- Catchment areas elevation difference

H = 1,840 - 1,805 = 35 m

tc = 41.64 minutes

From Rainfall Frequency Atlas of Kenya 25 years 1 hour rainfall

Rainfall intensity for 60 minutes

I = 70 mm/hr

Rainfall intensity for 41.64 minutes

I = 80 mm/hr

Q' = 26.1 m^3/sec (THE RAINFALL FREQUENCY ATLAS METHOD)

From site inspection, catchment type close to poor pasture.

lag time K = 0.5 hrs

Standard contribution area coefficient (Cs)

Cs = 0.38 [catchment slope : 1.67%
soil type : slightly impeded drainage]

Catchment wetness factor (Cw)

(Nairobi is a wet zone)

$$Cw = 1.00$$

Land use factors (C1)

$$C1 = 1.00$$

Contributing area coefficient (C_A) given as

$$(C_A = 0.38 \times 1.0 \times 10 = 0.38)$$

Initial retention (Y) = 0

Estimated rainfall time for East African 10-years storms. (Kenya Aberdare Uluguru zone)

$$n = 0.85, \; Tp = 2.0$$

Design storm rainfall to be allowed for during time interval TB hours

$$TB = Tp + 2.3k + TA$$

TA : Flood wave in stream system taken as zero

$$\text{Base time } TB = 2.0 + 2.3 \times 0.5 = 3.15$$

Rainfall during base time

$$RTB = \frac{TB}{24}\left(\frac{24.33}{TB + 0.33}\right)^{n} \times R^{2/24}$$

$$RTB = 90.48 \text{ mm}$$

Areal reduction factor

$$ARF1 = 1 - 0.04 \times T^{1/3} A^{1/2} = 0.95$$

Average Rainfall (P)

$$P1 = ARF \times RTB = 86.25 \text{ mm}$$

Total Volume of Run-off

$$RO_1 = (P\text{-}Y) \times Ca \times A \times 10^3 = 96{,}035\ m^3$$

Average flow

$$Q_1 = \frac{0.93 \times RO}{3{,}600 \times TB} = 7.88\ m^3/sec$$

$$Q_2 = 7.69\ m^3/sec$$

$$\Delta = \frac{Q_2 - Q_1}{Q_1} \times 100 = 2.4\% < 5\%$$

$Q'' = 2.8 \times 7.69 = 21.5\ m^3/sec$ (The TRRL (EA) flood model)

$Q' > Q''$

$Q' < Q'' \times 1.5$

$Q = 26.1\ m^3/sec$

(2) Box culvert (14 + 943) (36°44'E, 1°187'S)

- Area 2.73 km^2
- Design return period 25 years
- Longest channel 650 m
- Average slope of the catchment

$$S_1 = \frac{1,890 - 1,813}{5,100} = 1.51\%$$

- Average slope of main channel

$$S_1 = \frac{1,821 - 1,813}{650} = 1.23\%$$

- Run-off coefficient C = 0.4

- Catchment areas elevation difference

H = 1,821 - 1,813 = 8 m

tc = 15.51 minutes

From Rainfall Frequency Atlas of Kenya 25 years 1 hour rainfall

Rainfall intensity for 60 minutes

I = 70 mm/hr

Rainfall intensity for 5.51 minutes

I = 103 mm/hr

Q' = 31.3 m^3/sec (THE RAINFALL FREQUENCY ATLAS METHOD)

From site inspection, catchment type close to poor pasture.

lag time K = 0.5 hrs

Standard contribution area coefficient (Cs)

$$Cs = 0.38 \begin{bmatrix} \text{catchment slope : } & 1.51\% \\ \text{soil type : } & \text{slightly impeded drainage} \end{bmatrix}$$

Catchment wetness factor (Cw)

(Nairobi is a wet zone)

$$Cw = 1.00$$

Land use factors (C1)

$$C1 = 1.00$$

Contributing area coefficient (C_A) given as

$$C_A = 0.38 \times 1.0 \times 1.0 = 0.38$$

Initial retention (Y) = 0

Estimated rainfall time for East African 10-years storms. (Kenya Aberdare Uluguru zone)

$$n = 0.85, \quad Tp = 2.0$$

Design storm rainfall to be allowed for during time interval TB hours

$$TB = Tp + 2.3\,k + TA$$

TA : Flood wave in stream system taken as zero

$$\text{Base time } TB = 2.0 + 2.3 \times 0.5 = 3.15$$

Rainfall during base time

$$RTB = \frac{TB}{24}\left(\frac{24.33}{TB + 0.33}\right)^{n} \times R^{2/24}$$

$$RTB = 90.48 \text{ mm}$$

Areal reduction factor

$$ARF1 = 1 - 0.04 \times T^{1/3} A^{1/2} = 0.95$$

Average Rainfall (P)

$$P1 = ARF \times RTB = 86.40 \text{ mm}$$

Total Volume of Run-off

$$RO_1 = (P\text{-}Y) \times Ca \times A \times 10^3 = 89{,}632\ m^3$$

Average flow

$$Q_1 = \frac{0.93 \times RO}{3{,}600 \times TB} = 7.35\ m^3/sec$$

$$Q_2 = 7.30\ m^3/sec$$

$$\Delta = \frac{Q_2 - Q_1}{Q1} \times 100 = 0.7\% < 5\%$$

$Q'' = 2.8 \times 730 = 20.4\ m^3/sec$ (The TRRL (EA) flood model)

$Q' = 31.3 > 30.6 = Q'' \times 1.5$

$Q = 30.6\ m^3/sec$

(3) Box culvert (15 + 560) (36°43.5'E, 1°18.5'S)

(4) Box culvert (Ngong Rd J/C B-Ramp 0 + 157)

- Area 7.36 km^2
- Design return period 25 years
- Longest channel 5,200 m
- Average slope of the catchment

$$S_1 = \frac{1,990 - 1,810}{7,700} = 2.34\%$$

- Average slope of main channel

$$S_1 = \frac{1,880 - 1,810}{5,200} = 1.35\%$$

- Run-off coefficient C = 0.3

- Catchment areas elevation difference

H = 1,880 - 1,810 = 70 m

tc = 74.29 minutes

From Rainfall Frequency Atlas of Kenya 25 years 1 hour rainfall

Rainfall intensity for 60 minutes

I = 70 mm/hr

Rainfall intensity for 74.29 minutes

I = 63 mm/hr

Q' = 43.0 m^3/sec (THE RAINFALL FREQUENCY ATLAS METHOD)

From site inspection, catchment type close to poor pasture.

lag time K = 0.5 hrs

Standard contribution area coefficient (Cs)

$$Cs = 0.38 \begin{bmatrix} \text{catchment slope : } & 2.34\% \\ \text{soil type : } & \text{slightly impeded drainage} \end{bmatrix}$$

Catchment wetness factor (Cw)

(Nairobi is a wet zone)

$$Cw = 1.00$$

Land use factors (C1)

$$C1 = 0.50$$

Contributing area coefficient (C_A) given as

$$C_A = 0.38 \times 1.0 \times 1.0 = 0.38$$

Initial retention (Y) = 0

Estimated rainfall time for East African 10-years storms. (Kenya Aberdare Uluguru zone)

$$n = 0.85, \quad Tp = 2.0$$

Design storm rainfall to be allowed for during time interval TB hours

$$TB = Tp + 2.3k + TA$$

TA : Flood wave in stream system taken as zero

Base time $TB = 2.0 + 2.3 \times 0.5 = 3.15$

Rainfall during base time

$$RTB = \frac{TB}{24}\left(\frac{24.33}{TB + 0.33}\right)^{n} \times R^{2/24}$$

$$RTB = 90.48 \text{ mm}$$

Areal reduction factor

$$ARF1 = 1 - 0.04 \times T^{1/3} A^{1/2} = 0.93$$

Average Rainfall (P)

$$P1 = ARF \times RTB = 83.78 \text{ mm}$$

Total Volume of Run-off

$$RO_1 = (P\text{-}Y) \times Ca \times A \times 10^3 = 117{,}160\ m^3$$

Average flow

$$Q_1 = \frac{0.93 \times RO}{3{,}600 \times TB} = 9.61\ m^3/sec$$

$$Q_2 = 9.14\ m^3/sec$$

$$\Delta = \frac{Q_2 - Q_1}{Q1} \times 100 = 4.89\% < 5\%$$

$Q'' = 2.8 \times 9.14 = 25.6\ m^3/sec$ (The TRRL (EA) flood model)

$Q' = 43.0 > 38.4 = Q'' \times 1.5$

$Q = 38.4\ m^3/sec$

(5) Box culvert (26 + 335) (36°39.5'E, 1°15'S)

- Area 38.74 km^2
- Design return period 25 years
- Longest channel 3,500 m
- Average slope of the catchment

$$S_1 = \frac{2,310 - 1,992}{18,000} = 177\%$$

- Average slope of main channel

$$S_1 = \frac{2,020 - 1,992}{3,500} = 0.8\%$$

- Run-off coefficient C = 0.2

- Catchment areas elevation difference

H = 2,020 - 1,992 = 28 m
tc = 66.92 minutes

From Rainfall Frequency Atlas of Kenya 25 years 1 hour rainfall
Rainfall intensity for 60 minutes
I = 70 mm/hr
Rainfall intensity for 66.92 minutes
I = 67 mm/hr

Q' = 150.8 m^3/sec (THE RAINFALL FREQUENCY ATLAS METHOD)

From site inspection, catchment type close to good pasture.
lag time K = 1.5 hrs
Standard contribution area coefficient (Cs)

$$Cs = 0.38 \begin{bmatrix} \text{catchment slope :} & 1.77\% \\ \text{soil type :} & \text{slightly impeded drainage} \end{bmatrix}$$

Catchment wetness factor (Cw)

(Nairobi is a wet zone)

$$Cw = 1.00$$

Land use factors (C1)

$$C1 = 0.50$$

Contributing area coefficient (C_A) given as

$$C_A = 0.38 \times 1.0 \times 0.50 = 0.19$$

Initial retention (Y) = 0

Estimated rainfall time for East African 10-years storms. (Kenya Aberdare Uluguru zone)

$$n = 0.85.\ Tp = 2.0$$

Design storm rainfall to be allowed for during time interval TB hours

$$TB = Tp + 2.3k + TA$$

TA : Flood wave in stream system taken as zero

$$\text{Base time TB} = 2.0 + 2.3 \times 1.5 = 5.45$$

Rainfall during base time

$$RTB = \frac{TB}{24}\left(\frac{24.33}{TB + 0.33}\right)^{n} \times R^{2/24}$$

$$RTB = 101.70 \text{ mm}$$

Areal reduction factor

$$ARF1 = 1 - 0.04 \times T^{1/3} A^{1/2} = 0.86$$

Average Rainfall (P)

$$P1 = ARF \times RTB = 87.32 \text{ mm}$$

Total Volume of Run-off

$$RO_1 = (P\text{-}Y) \times Ca \times A \times 10^3 = 642{,}700\ m^3$$

Average flow

$$Q_1 = \frac{0.93 \times RO}{3{,}600 \times TB} = 30.46\ m^3/sec$$

$$Q_2 = 29.4\ m^3/sec$$

$$\Delta = \frac{Q_2 - Q_1}{Q1} \times 100 = 3.5\% < 5\%$$

$Q'' = 2.3 \times 29.4 = 67.6\ m^3/se$ (The TRRL (EA) flood model)

$Q'' = 150.8 > 101.4\ m^3/sec = Q'' \times 1.5$

$Q = 101.4\ m^3/sec$

APPENDIX - E (公共施設)

Table E.1 Existing Utilities

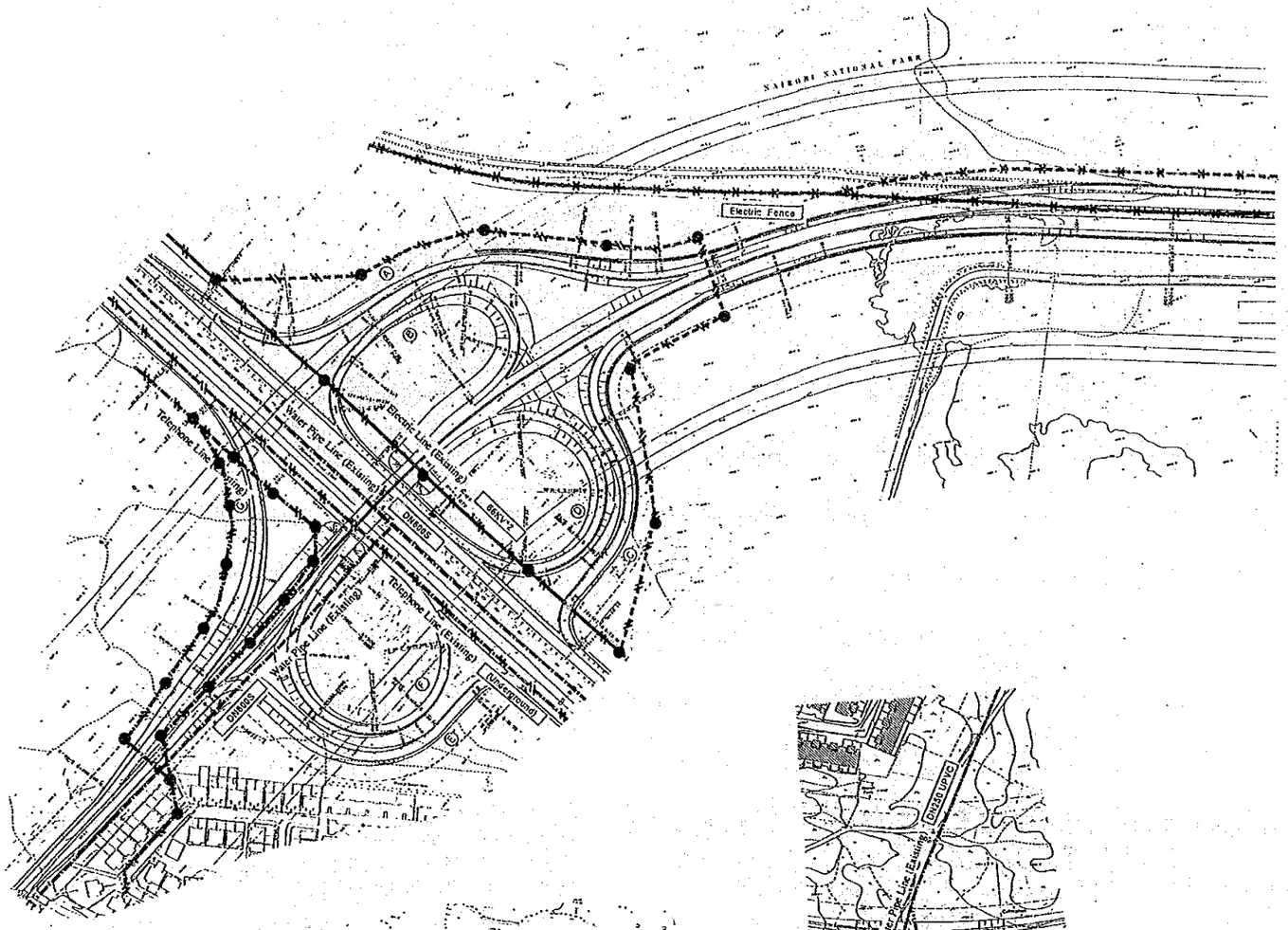
Chainage	Utility	Capacity or Size	Aerial or Underground
CH.0 + 000	Water Line	DN 600S	Aerial
to CH.0 + 500	Telecommunication Line		Aerial
(Mombasa Road J/C)	Electric Line	2 x 66 KV	Underground
	Telecommunication Line		
	Electric Fence		
CH.5 + 900	Electric Line	66 KV	Aerial
CH.6 + 650	Telecommunication Line		Underground
to CH.7 + 500	Telecommunication Line		Aerial
(Uhuru Monument J/C)	Electric Line	66 KV	Aerial
	Street Lighting		
	Sewerage Line	Dia. 300 mm	Underground
	Fence		
CH.7 + 150	Sewerage Line	Dia. 535 mm	Underground
CH.7 + 475	Sewerage Line	Dia. 535 mm	Underground
CH.7 + 910	Water Line	DN 250 UPVC	Underground
CH.8 + 660	Telecommunication Line		Aerial
CH.8 + 820	Electric Line	66 KV	Aerial
CH.9 + 400	Water Line	DN 400S 16"S	Underground
	Water Line	8" PVC	Underground
	Water Line	4" GI	Underground
CH.11 + 160	Electric Line	66 KV	Aerial
to CH.13 + 800			
CH.15 + 500	Telecommunication Line		Underground
(Ngong Rd J/C)	Telecommunication Line		Aerial
	Electric Line	2 x 11 KV	Aerial
CH.16 + 160	Electric Line	11 KV	Aerial
CH.19 + 550	Electric Line	66 KV	Aerial
CH.20 + 850	Telecommunication Line		Aerial
to CH.21 + 240	Electric Line	11 KV	Aerial
(Dagoretti Forest J/C)	Water Line	500 mm INLET	
	Telecommunication Line		Underground
CH.22 + 390	Water Line	3/4"	Underground
CH.22 + 640	Water Line	3/4"	Underground
CH.22 + 680	Electric Line	66 KV	Aerial
CH.22 + 880	Water Line	3/4"	Underground
CH.22 + 960	Water Line	1/2"	Underground
CH.23 + 010	Water Line	1/2"	Underground
CH.23 + 020	Water Line	3/4"	Underground
to CH.23 + 160			
CH.23 + 160	Water Line	2 1/2"	Underground
CH.23 + 170	Water Line	2 1/2"	Underground
CH.23 + 180	Telecommunication Line		Aerial
to CH.23 + 500	Electric Line	66 KV, 11 KV	Aerial
(Thogoto J/C)	Electric Line	11 KV	Aerial
	Electric Line	11 KV	Aerial
	Electric Line	66 KV	Aerial

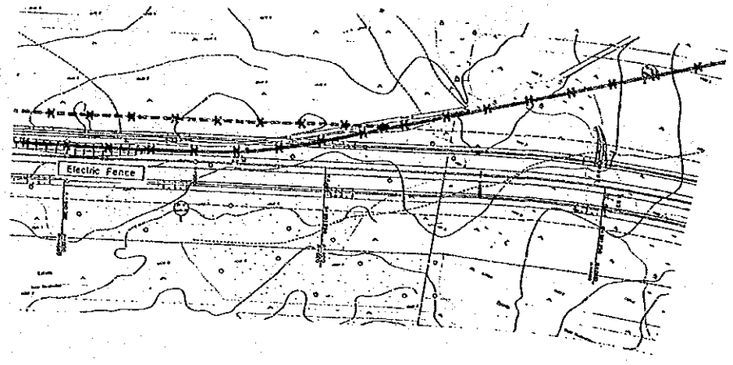
Table E.1 Existing Utilities

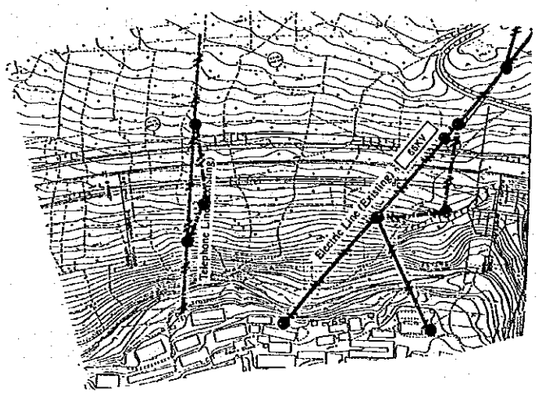
Chainage	Utility	Capacity or Size	Aerial or Underground
CH.23 + 560	Electric Line	11 KV	Aerial
CH.23 + 800	Sewerage line	Dia. 225 m	Underground
	Electric Line	11 KV	Aerial
CH.24 + 580	Electric Line	11 KV	Aerial
CH.24 + 720	Electric Line	11 KV	Aerial
CH.24 + 800	Electric Line	11 KV	Aerial
	Water Line	1 1/2"	Underground
CH.24 + 810	Water Line	1 1/2"	Underground
	Telecommunication Line	3/4"	Aerial
CH.24 + 900	Water Line	11 KV	Underground
CH.24 + 950	Electric Line	11 KV	Aerial
CH.25 + 020	Water Line	1/2"	Underground
	Electric Line	11 KV	Aerial
CH.25 + 120	Electric Line	66 KV	Aerial
CH.25 + 260	Electric Line	11 KV	Aerial
CH.25 + 380	Telecommunication Line		Aerial
CH.25 + 420	Water Line	1 1/2"	Underground
CH.25 + 480	Electric Line	66 KV	Aerial
CH.25 + 480	Water Line	1 1/2"	Underground
CH.26 + 660	Water Line	6"	Underground
	Water Line	2 x 2 "	Underground
CH.26 + 680	Telecommunication Line		Aerial
CH.26 + 700	Water Line	1"	Underground
CH.26 + 570	Water Line	3/4"	Underground
	Electric Line	11 KV	Aerial
CH.26 + 560 to CH.26 + 960	Telecommunication Line		Underground
CH.26 + 860	Water Line	1/2"	Underground
CH.26 + 860	Electric Line	11 KV	Aerial
CH.26 + 900	Water Line	3/4"	Underground
CH.26 + 960 to CH.27+ 360	Telecommunication Line		
CH.27 + 020	Railway		
CH.27 + 240	Water Line	1"	Underground
CH.27 + 300	Water Line	1"	Underground
CH.27 + 300 to CH.28 + 400	Water Line	2"	Underground
CH.27 + 360 to CH.27 + 780	Telecommunication		Aerial
CH.27 + 420	Electric Line	11 KV	Aerial
CH.27 + 240 to CH.27 + 720	Electric Line	11 KV	Aerial
CH.27 + 680	Water Line	1"	Underground
CH.27 + 720	Water Line	1"	Underground
CH.27 + 960 to CH.28 + 020	Electric Line	11 KV	Aerial
CH.28 + 220	Water Line	3/4"	Underground

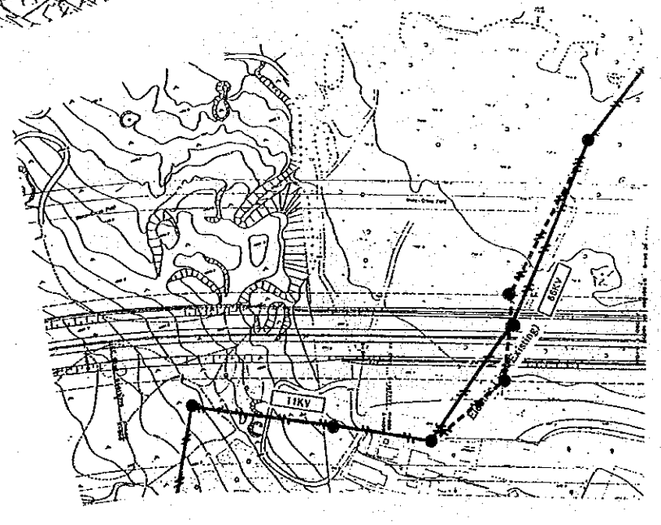
Table E.2 Utility Bill of Quantities

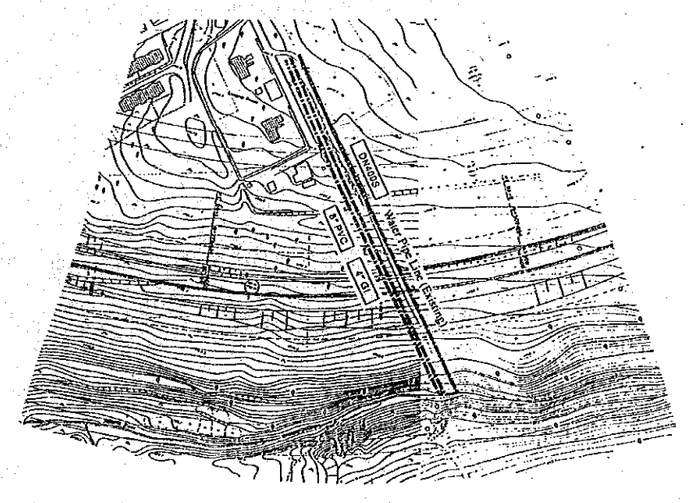
	Existing (m)	Pole (nos.)	Plan (m)	Pole (nos.)	Unit Quantities (/m) Excavation (m3)	Backfill (m3)	Class 15/20 Concrete (m3)	Form Work (m2)	Total Quantities Excavation (m3)	Backfill (m3)	Class 15/20 Concrete (m3)	Form Work (m2)	Remarks
Fence	755		675										Relocated
Electric Fence	4,335		4,340										Relocated
Street Lighting	6		6										Relocated
Swerage Line													
Dia.225 mm CP	65		65		2.475	2.199	0.236	1.050	160.875	142.959	15.331	68.250	Surrounded Concrete
Dia.300 mm CP	710		710		2.700	2.340	0.289	1.200	1,917.000	1,661.400	205.413	852.000	Surrounded Concrete
Dia.535 mm CP	140		140		3.405	2.708	0.472	1.670	476.700	379.089	66.139	233.800	Surrounded Concrete
									2,554.575	2,183.448	286.884	1,154.050	
Telephone Line													
Aerial	3,660	71	4,200	73									
Underground	2,470		2,520										
Water Line													
DN600S	380				3.600	2.790	0.527	1.800	1,368.000	1,060.200	200.358	684.000	Surrounded Concrete
DN250UPVC	65		80		2.550	2.248	0.253	1.100	204.000	179.800	20.273	88.000	Relocated
DN400S	65				3.000	2.510	0.364	1.400	195.000	163.150	23.682	91.000	Surrounded Concrete
500mm INLET	70				3.300	2.660	0.444	1.600	231.000	186.200	31.056	112.000	Surrounded Concrete
8"PVC	65				2.409	2.156	0.221	1.006	156.585	140.139	14.342	65.390	Surrounded Concrete
6"	110		110		2.256	2.052	0.186	0.904	248.160	225.687	20.477	99.440	Relocated
4'GI	65				2.105	1.944	0.153	0.803	136.812	126.329	9.956	52.208	Surrounded Concrete
2'1/2"	290		370		1.991	1.921	0.066	0.527	736.485	710.795	24.518	194.990	Relocated
2'GI	40				1.952	1.889	0.061	0.502	78.096	75.580	2.435	20.064	Surrounded Concrete
2'	1,420		1,420		1.952	1.889	0.061	0.502	2,772.408	2,683.089	86.441	712.272	Relocated
1'1/2"	70		90		1.914	1.858	0.056	0.476	172.287	167.185	5.000	42.858	Relocated
1'1/2"	220				1.914	1.858	0.056	0.476	421.146	408.674	12.221	104.764	Surrounded Concrete
1'	250		370		1.876	1.825	0.050	0.451	694.194	675.396	18.610	166.796	Relocated
3/4"	450		530		1.857	1.809	0.048	0.438	984.290	958.859	25.280	232.193	Relocated
3/4"	125				1.857	1.809	0.048	0.438	232.144	226.146	5.962	54.763	Surrounded Concrete
1/2"	80		100		1.838	1.793	0.045	0.425	183.810	179.286	4.511	42.540	Relocated
1/2"	245				1.838	1.793	0.045	0.425	450.335	439.250	11.053	104.223	Surrounded Concrete
									9,264.751	8,605.764	516.176	2,867.501	
Electric Line													
66KV x 2	400	3	930	9									Relocated
66KV	4,470	26	7,230	62									Relocated
11KV x 2	195	2	385	5									Relocated
11KV	2,200	16	3,030	36									Relocated











LEGEND

- Electric Line (Existing)
- Electric Line (Plan)
- Telephone Line (Existing)
- Telephone Line (Plan)
- Sewerage Pipe Line (Existing)
- Sewerage Pipe Line (Plan)
- Water Pipe Line (Existing)
- Water Pipe Line (Plan)
- Electric Fence (Existing)
- Electric Fence (Plan)
- Fence (Existing)
- Fence (Plan)
- Road Lighting (Plan)

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DESCRIPTION	DATE		

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CHIEF SUPT. ENG. (DESIGN)

SEN. SUPT. ENG. (DESIGN)

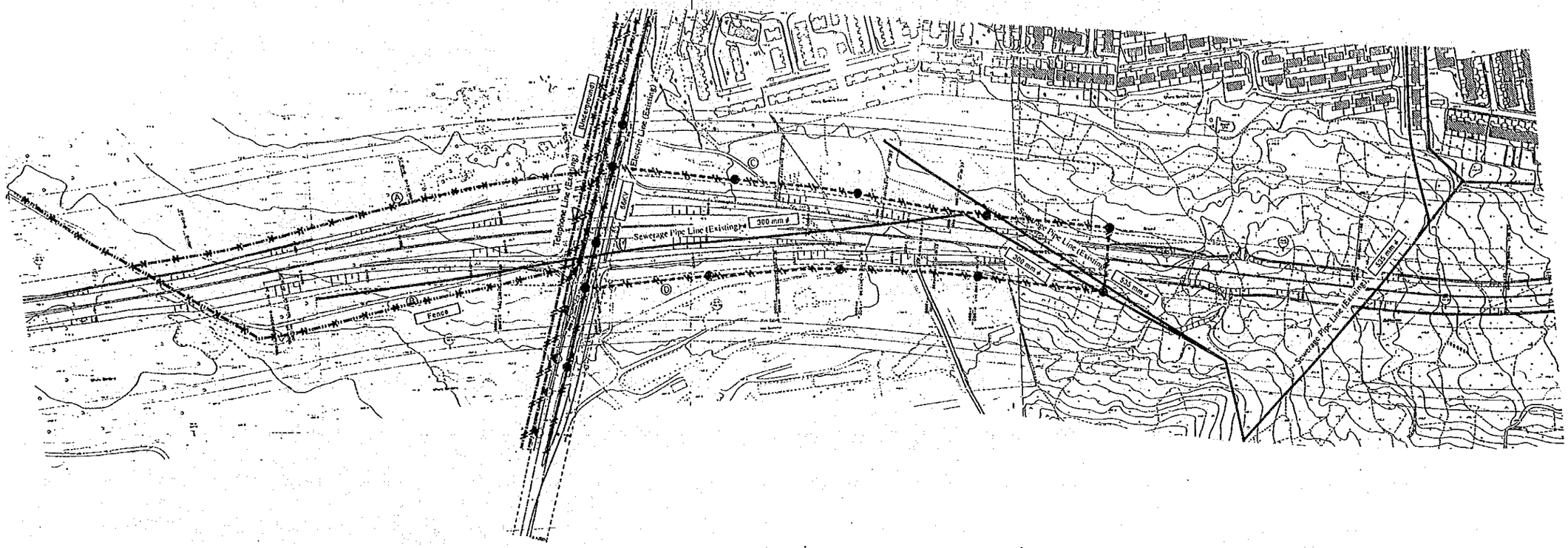
SUPT. ENGINEER (DESIGN)

PROJECT ENGINEER

SCALES

NAIROBI BYPASS

SHEET OF



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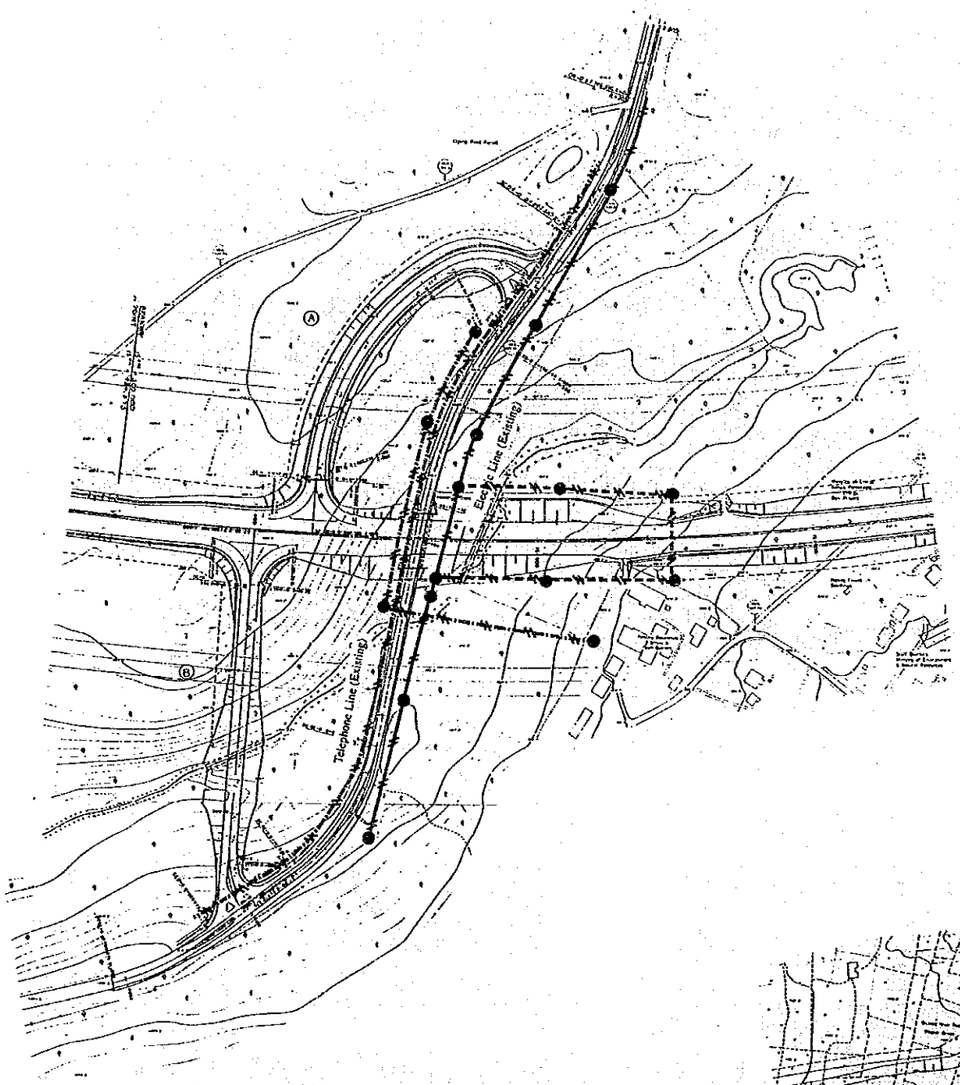

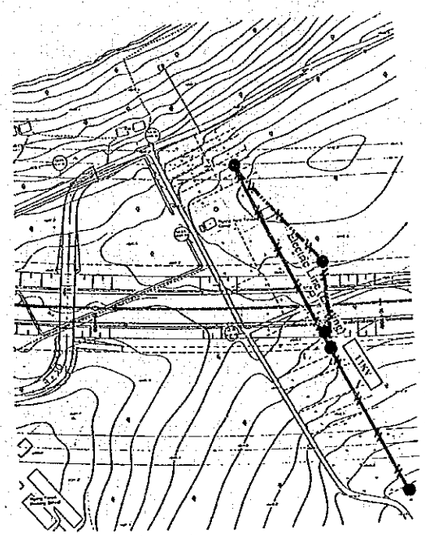

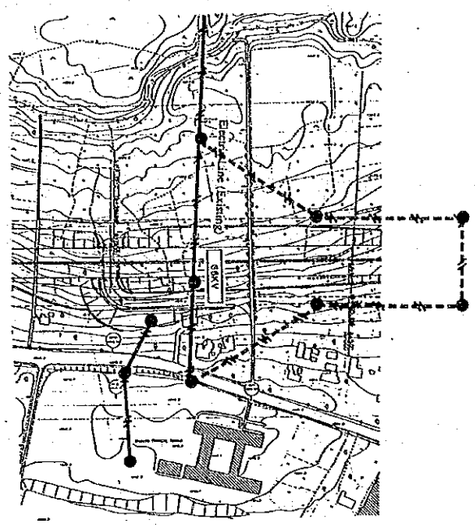

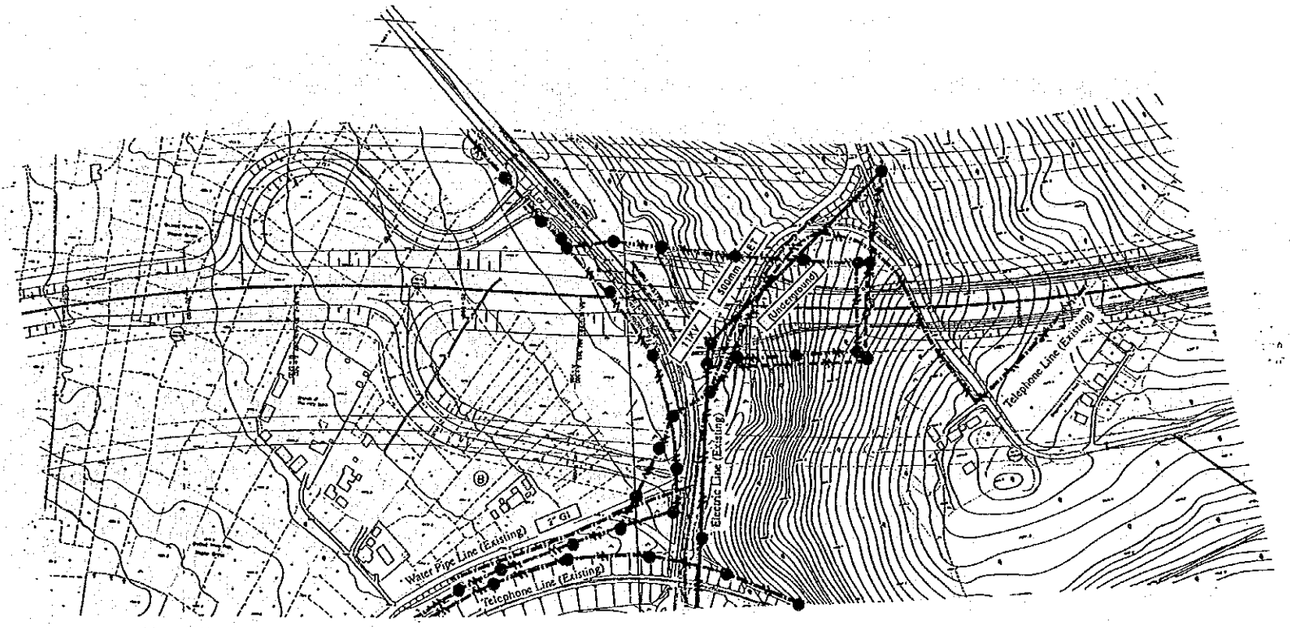

LEGEND

- Electric Line (Existing)
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- Telephone Line (Plan)
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- Sewerage Pipe Line (Plan)
- Water Pipe Line (Existing)
- Water Pipe Line (Plan)
- Electric Fence (Existing)
- Electric Fence (Plan)
- Fence (Existing)
- Fence (Plan)
- Road Lighting (Plan)

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		PROJECT ENGINEER	

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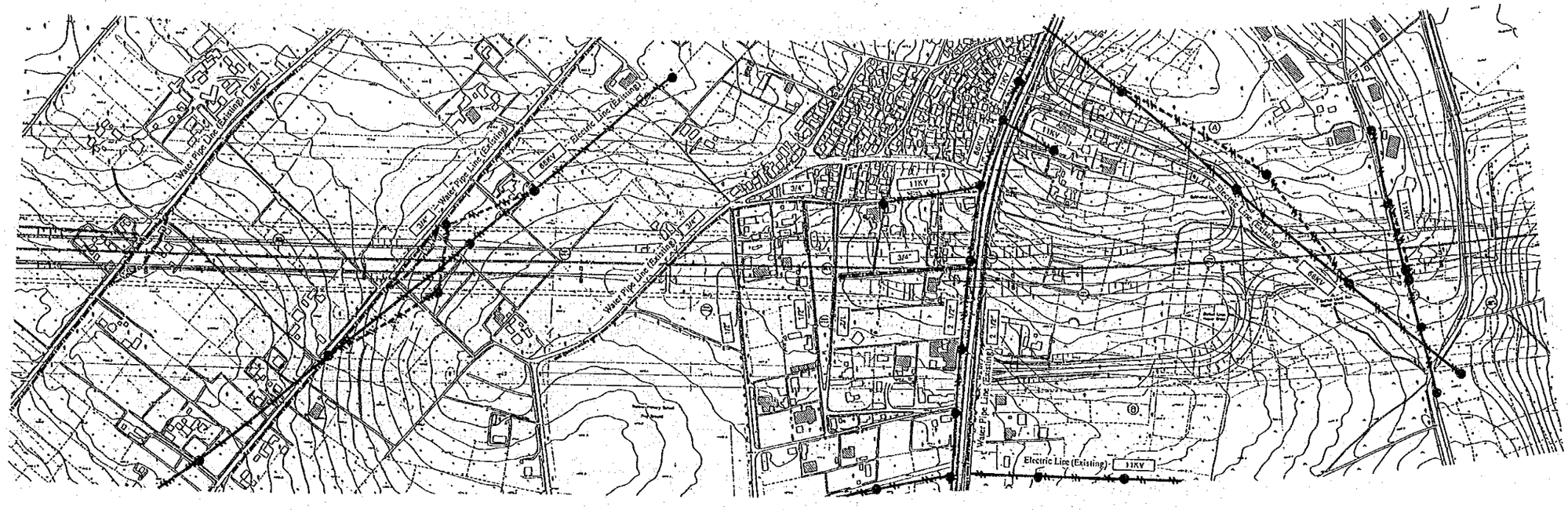

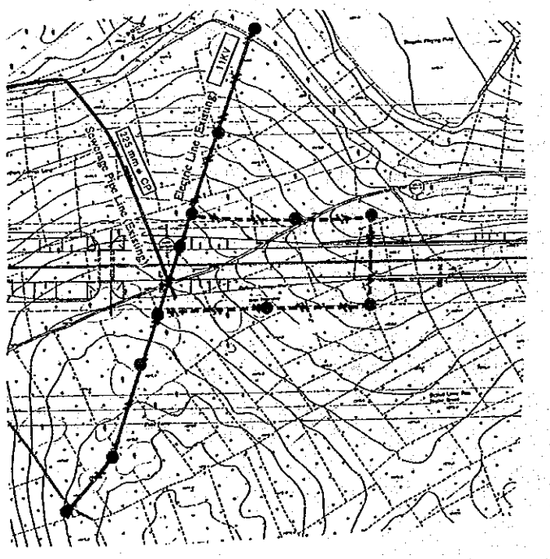

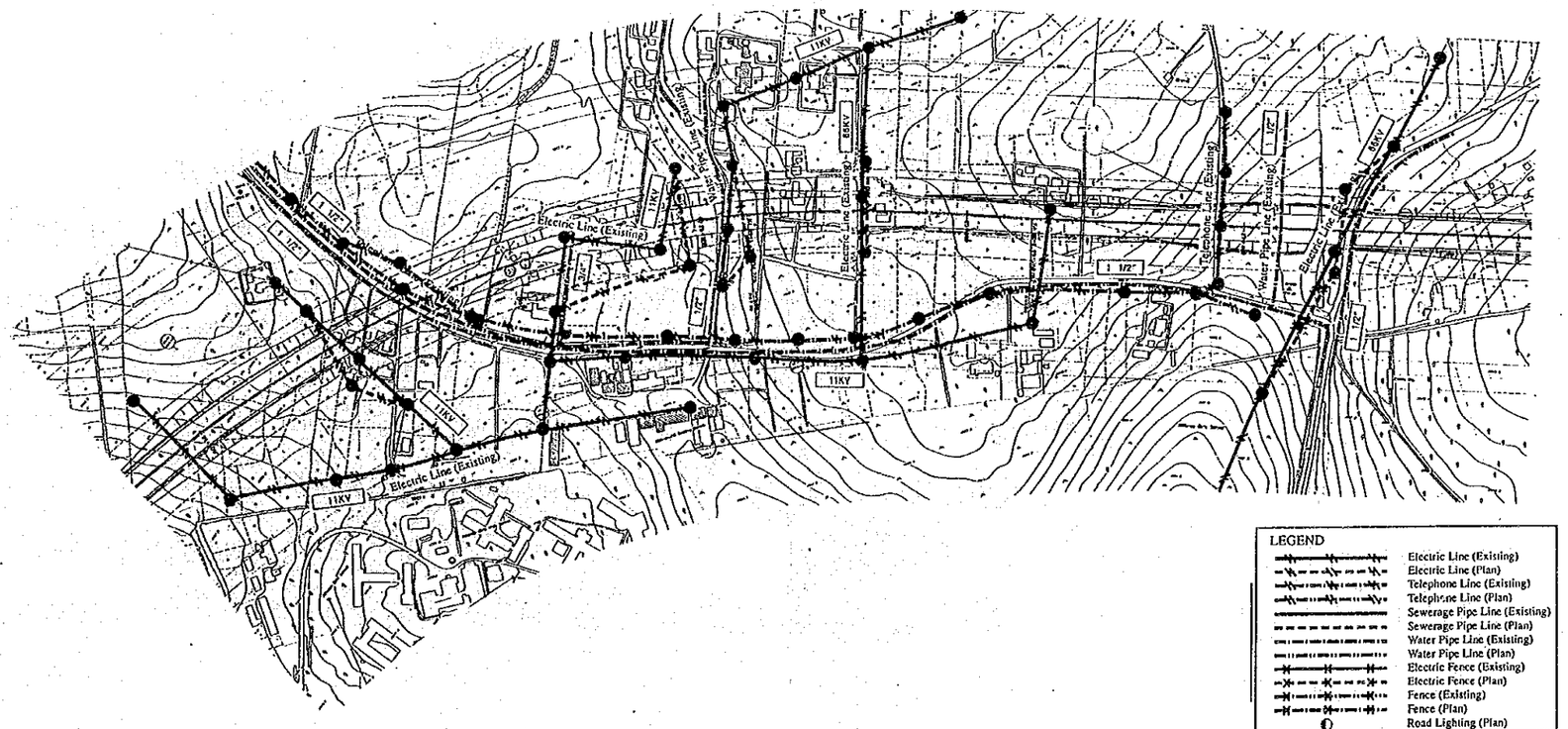

LEGEND

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- Sewerage Pipe Line (Plan)
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- Water Pipe Line (Plan)
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- Fence (Existing)
- Fence (Plan)
- Road Lighting (Plan)

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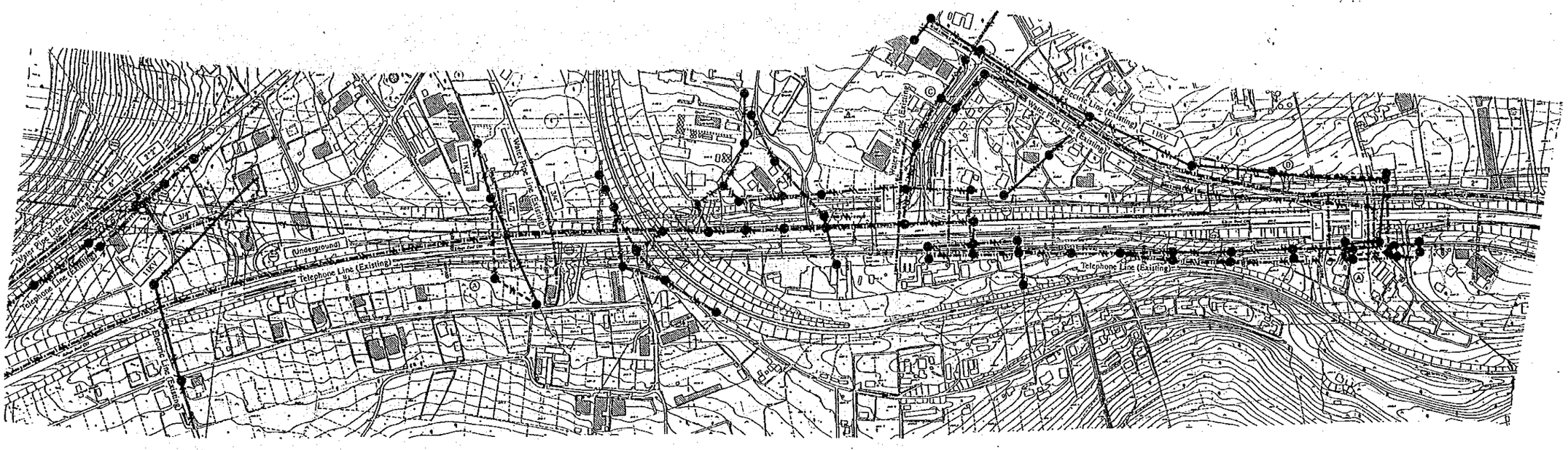

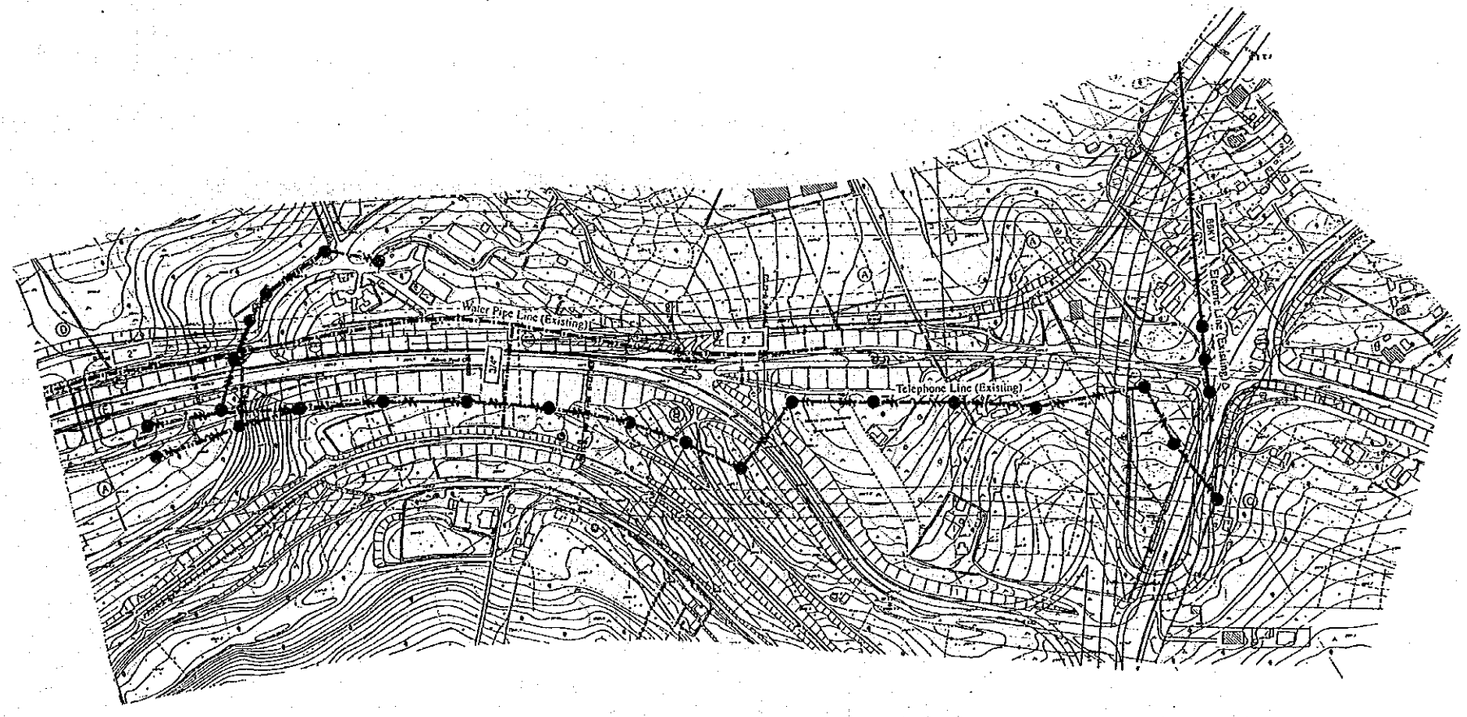

LEGEND

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- Electric Line (Plan)
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- Telephone Line (Plan)
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- Sewerage Pipe Line (Plan)
- Water Pipe Line (Existing)
- Water Pipe Line (Plan)
- Electric Fence (Existing)
- Electric Fence (Plan)
- Fence (Existing)
- Fence (Plan)
- Road Lighting (Plan)

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					CHIEF SUPT. ENG. (DESIGN)	PROJECT ENGINEER					

APPENDIX - F(構造物)

Appendix - F - 1

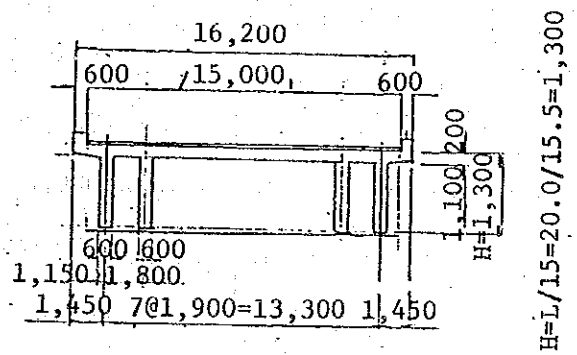
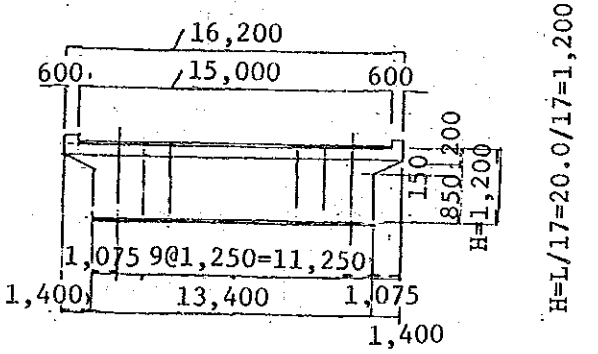
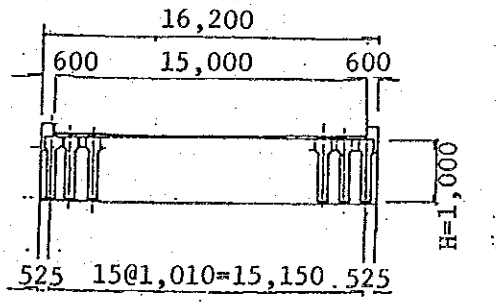
Selected and Comparison of Superstructure Type

Design conditions are as follows:

1. Span length: 20.0m (Maximum)
2. Width for Bridge: 15.0m (average)

Table Comparison of Superstructure

Price level: June 1990

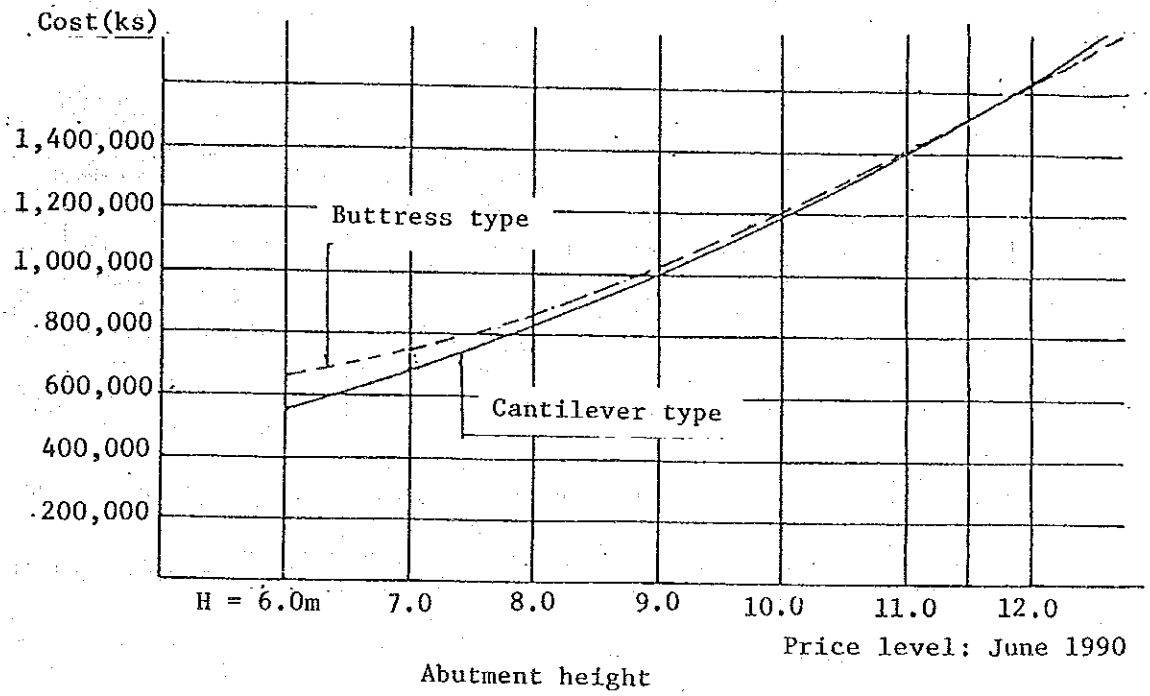
Type	Cross Section	Cost of Rough	Characteristic and Estimate
Reinforced Concrete of T-Girder		6,500 KS/m^2	·Construction period is long ·All staging method ·Structure height is the most high ·Work is easy and experience ESTIAMTE 1.
Reinforced Concrete of Hollow Slab		8,650 KS/m^2	·Construction period is long ·All staging method ·Structure height is higher than PC-T-Girder ·Formwork is complicated ESTIMATE 2.
Prestressed Concrete Pre-tension Type of T-Girder		10,200 KS/m^2	·Construction period is short ·Truck Crane Erection ·Structure height is the most low ESTIMATE 3.

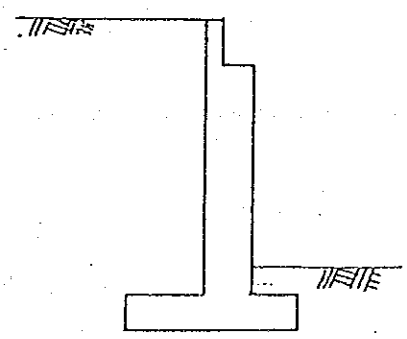
Appendix - F - 2

Selection and Comparison of Abutment Type

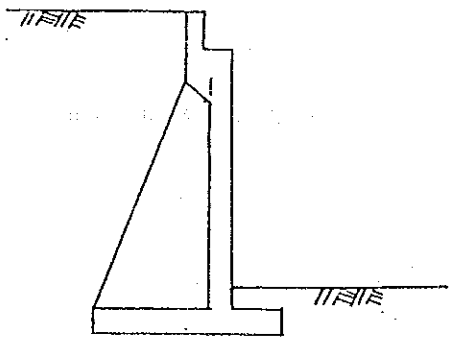
The types of Abutments are selected in consideration of construction height.

(cut fig. from draft and stick)





Cantilever type



Buttress type

Appendix - F - 3(1)

Selection and Comparison of box culvert and bridge

Culverts are planned at the cross point of the Bypass and existing roads or local road. Box culverts are designed in consideration of eacy construction and lower cost than bridge construction cost.

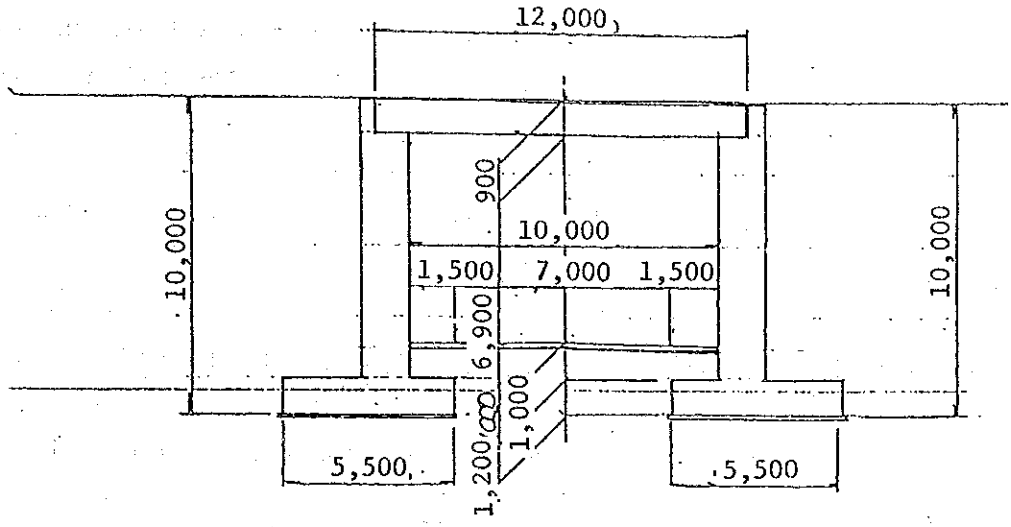
Comparison of Box Culvert and Bridge

		Unit Cost	Materials	Costs
Cost for Box Culvert	Concrete	1,900 KS/m^3	600.6 m^3	1,141,140 KS
	Form	330 KS/m^2	804.8 m^2	265,590 KS
	Reinforcement	20,000 KS/t	60.1 t	1,202,000 KS
	Others	—	—	781,270 KS
	Total	—	—	3,390,000 KS
Cost for Bridge	Superstructure	6,500 KS/m^2	180.0 m^2	1,170,000 KS
	Sub-structure	79,000 KS/m	32.4 m	2,559,600 KS
	Total	—		3,730,000 KS

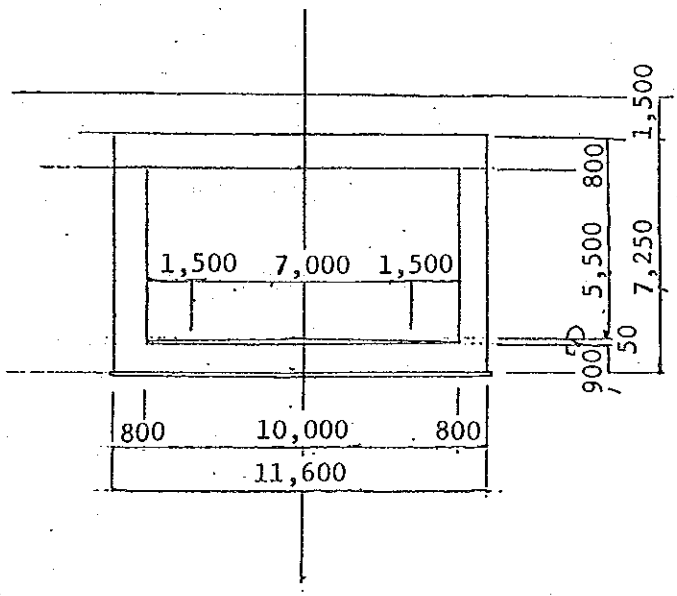
Price level: June 1990

Note: Drawings of the Box culvert and the Bridge are shownw on next page

Appendix - F - 3(2)



Profile for Birdge
(Bridges width = 15.0^{m} inside carriageway)



Cross Section for Box Culvert
(Box culvert length = 15.0^{m} + 0.6 x 2 + 2x 1.5^{m} x 1.5 = 21.0^{m}
(Wing wall length is nto over of 10.0^{m} long)

Appendix - F - 4

Comparison for box-culverts with Over 10.0m width
between one box section and two box section.

Comparison list of One box and two box

		Units Cost	Materials	Cost
	Concrete (m^3)	1.900 ks/m3	386.0	733,400 ks
	Form (m^3)	330 ks/m2	416.6	137,480 ks
	Rainforcement (t)	20,000 ks/t	30.9	618,000 ks
	Others	-	-	371,120 ks
	Total	-	-	1860.000 ks
	Concrete (m^3)	1,900 ks/m3	369.0	701,100 ks
	Form (m^3)	330 ks/m2	547.9	180,810 ks
	Rainforcement (t)	20,000 ks/t	33.2	664,000 ks
	Others	-	-	384,090 ks
	Total	-	-	1930,000 ks

Price level: June 1990

One box culvert work is lower cost and easier than two box culvert work.

Appendix - F - 5

Selection and comparison of piles foundation (for vehicle bridge)

Comparison of sp and ccp (for one abutment ——→)

	Materials		Unit Cost	Costs	Remarks
Steel pile,	length of pile	10.0mx18n=180.0m	400ks/m	72,000ks	Works of Pile
	Weight of pile	109kg/mx180mx10 $^{-3}$=19.7t	15,000ks	295,500ks	
	Others	-	-	92,500ks	
	Total	-	-	460,000ks	(2,500ks/m)
Cast in place of concrete pile	Length of pile	10.0mx8n=80.0m	2,000ks	160,000ks	Works of Pile
	Concrete	0.785x80.0x1.05=66.0 m^3	2,200ks	145,200ks	
	Rainfor-cement	0.120t/m^3x66.0=8.0t	20,000ks	160,000ks	
	Others	-	-	114,800ks	
	Total	-	-	580,000ks	(7,500ks/m)

Price level: June 1990

※ 1 Steel pile, - 500mm x 10,000m

※ 2 Cast in place of concrete pile - 1.000m x 10.000m

Because

the s.p are easy construction works safety with good quality and the ccp are expensive more than the sp.

Appendix - F - 6

Selection and comparison for high embankment

Comparison list of embankment and bridge

			Material	Unit costs	Costs	Remarks
Cost of Bridges plan		A1	23.0m³	110,000ks/m	2530,000ks	Appendix 7.1.8-2 1650.000ks/15.0m
		P1	767.0m³	7,500ks/m³	5752,500ks	
		P2	697.0m³	7,500ks/m³	5227,500ks	
		A2	23.0m	110,000ks/m	2530,000ks	
		Total	-	-	16,040,000ks	
	Supper Structure		1400.0t	100,000ks/t	140,000,000ks	
	Total				156,000,000ks	
Cost of Embank-ment plan	Box culvert		7100.0m³	8,000ks/m³	56,800,000ks	Apendix 7.18-3(1) 6,250x1.3
	Embankment		350,000.0	135ks/,³	47,250,000ks	
	Total		-	-	104,000,000ks	

Price level: June 1990

Emabnkment plan are low cost and easy construction works.

APPENDIX - G(事業計画)

APPENDIX–G Construction Schedule for The Nairobi Bypass Project

DESCRIPTION	UNIT	QUANTITY
Detailed Design		
Financial Arrangement		
Prequalification		
Tender and Contract Award		
Land Acquisition and Compensation		
Construction Works		
Mobilization		
Preparatory Works		
Section-1 (CH.0+000-7+300)		
Removal and Alteration		L.S.
Site Clearance	ha	52.4
Excavation (Topsoil, Unsuitable)	m3	161,160
Embankment	m3	399,770
Subbase and Shoulder	m3	41,710
Lean Concrete Base	m3	27,920
Asphalt Concrete	m3	15,270
Surface Dressing	m2	41,590
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work, Monbasa (1No.)	m	58
Uhuru Monument (1No.)	m	38
Pedestrian (1No.)	m	65
Section-2 (CH.7+300-15+800)		
Removal and Alteration		L.S.
Site Clearance	ha	41.1
Excavation (Topsoil, Unsuitable)	m3	58,550
Embankment	m3	259,370
Subbase and Shoulder	m3	42,610
Lean Concrete Base	m3	28,430
Asphalt Concrete	m3	15,510
Surface Dressing	m2	47,580
Drainage Work		L.S.
Road Furniture		L.S.
Box Culvert for Road (1 No.)	m	49
Box Culvert for Drainage (4 Nos.)	m	234
Section-3 (CH.15+800-21+000)		
Removal and Alteration		L.S.
Site Clearance	ha	30.3
Excavation (Topsoil, Unsuitable)	m3	34,200
Embankment	m3	353,880
Subbase and Shoulder	m3	26,340
Lean Concrete Base	m3	17,460
Asphalt Concrete	m3	9,510
Surface Dressing	m2	29,660
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work, Vehicle (1 No.)	m	29.5
Box Culvert for Road (2 Nos.)	m	53.5
Box Culvert for Footpath (2 Nos.)	m	54.7
Section-4 (CH.21+000-28+416)		
Removal and Alteration		L.S.
Site Clearance	ha	47.7
Excavation (Topsoil, Unsuitable)	m3	42,190
Embankment	m3	576,860
Subbase and Shoulder	m3	44,240
Lean Concrete Base	m3	28,710
Asphalt Concrete	m3	15,440
Surface Dressing	m2	47,720
Drainage Work		L.S.
Road Furniture		L.S.
Bridge Work, Railway (1 No.)	m	56.5
Vehicle (1 No.)	m	29.5
Pedestrian (1 No.)	m	76.2
Box Culvert for Road (4 Nos.)	m	135.5
Box Culvert for Footpath (2 Nos.)	m	51
Box Culvert for Drainage (1 No.)	m	150