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Ministry of Agriculture

Bay Region Agricultural Development Project

Mid-term Review

Volume 3
Annex 3 Roads
Annex 4 Water Supply

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Bay Region Agricultural Development Project

Mid-term Review

Volume 3

Annex 3 Roads

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Introduction

1.1 OBJECTIVES

The IDA Appraisal Report stated that the primary objective of this component of the project was to improve the road network by:

> "........upgrading and maintaining all roads in the Bay Region to give all-season access to areas where agricultural production is presently or potentially significant." (para. 2.02, IDA, 1979).

The upgrading of the network would include:

(i) rehabilitation of existing roads;

(ii) construction of new access/feeder roads;

(iii) clearing of access tracks;

(iv) maintenance of the road network.

1.2 ROAD STANDARDS

Two classes of construction were proposed for new project roads, defined as follows:

Class II - for roads carrying more than 50 vehicles per day: 6 m wide gravel carriageway on an 8 m wide formation;

Class III - for roads carrying less than 50 vehicles per day: 4 m wide gravel carriageway on a 6 m wide formation.

No geometric standards have been defined for the project roads but the relatively flat terrain presents little or no restraint to either horizontal or vertical alignment.

The construction cost estimates in the IDA Appraisal Report assumed that a Class II road on good sub-soils (Type A.6) would require a 500 mm high embankment of in situ material with a 200 mm compacted thickness of lateritic gravel for the running surface. For poor sub-soils (Type B.6) the gravel thickness was increased by 100 mm with a corresponding reduction in the height of the embankment fill. Similar embankment construction was assumed for Class III standard but the thickness of surfacing was reduced to 100 mm (Type A.4) and 200 mm (Type B.4) respectively. In the case of re-gravelling of existing roads, the estimates allowed for re-shaping of the cross section followed by the addition of 150 mm compacted thickness of gravel over a width of 7 metres (Type C.7). These outline specifications were adopted by Fintecs Consultants and drawn out in the form of sketches which also include crossfall (4 per cent), side slope (1:1.5), and longitudinal drainage ditches. The original listing of Project Roads is shown in Table 1.1.

TABLE 1.1 ORIGINAL LISTING OF PROJECT ROADS

Route and Road No.				Type*	Length (km)
Class II Roads;					
Boonkay	-	Uegit	(2)	C.7	27
				A.6	43
Baydhabo	-	Diinsoor	(4)	C.7	35
via Goof Guduud				A.6	60
				B.6	23
Diinsoor	-	Yaaq Braawe	(4)	A.6	50
Boonkay	-	Tagaal	(6)	A.6	40
				B.6	20
Dusta (Goof Guduud)	-	Qansaxdheere	(7)	A.6	20
				B.6	30
			Sub-Total		**348**
Class III Roads					
Awdiinle	-	Qansaxdheere	(8)	A.4	30
				B.4	25
Diinsoor	-	Qansaxdheere	(9)	A.4	30
				B.4	10
Buurhakaba	-	Dolon Dole	(10)	A.4	30
				B.4	20
Buurhakaba	-	Buur Heybo Spur	(10)	B.4	15
Baydhabo	-	Dolon Dole	(11)	B.4	50
			Sub-Total		**210**
Total Length of Roads					**558 km**
Tracks					
To be decided				T.3	250 km

Source: *Table 1, Annex 3, IDA, 1979.*

* *Key to type code:*
A.6 = 6 m gravel construction on good sub-soil
B.6 = 6 m gravel construction on poor sub-soil
A.4 = 4 m gravel construction on good sub-soil
B.4 = 4 m gravel construction on poor sub-soil
C.7 = 7 m re-gravelling of existing Class II road
T.3 = 3 m wide access track.

Note: No order of priority stated.

2

Performance in Stage I

2.1 PROCUREMENT OF CONSTRUCTION EQUIPMENT AND VEHICLES

This activity was the most significant achievement of Stage I but the time required for procurement exceeded the original estimate with the result that the construction programme suffered a delayed start. Furthermore, it is now recognised that the technical advice given to the Project Director was unsound in some aspects. As a result, the equipment and vehicles actually procured are not matched to the work tasks. A schedule of the items purchased, together with costs, is given in Table 2.1. The purchase took place in 1982.

TABLE 2.1 EQUIPMENT PROCUREMENT SCHEDULE - ACCESS ROADS

Item Description	No.	Unit Cost* (S.sh '000)	Total Cost* (S.sh '000)
Motor Vehicles			
Mercedes-Benz truck tractor unit	12	967	11 601
Trailer tipper	8	512	4 094
Units water tanker	5	839	4 194
fuel tanker	5	864	4 322
low loader	1	553	553
Pick-up 4WD (SWB)	9	138	1 241
Station wagon 4WD (SWB)	3	164	493
Sub-Total			26 498
Construction Equipment			
(D700) Bulldozer 210 HP with ripper and blade	2	1 302	2 605
(D600) Bulldozer 144 HP with ripper and blade	3	963	2 890
Grader 190 HP	4	1 155	4 620
Wheeled loader 210 HP (3 cu. m.)	4	1 156	4 623
C44 2-wheel Roller (vibrating)	5	856	4 282
C44 2-wheel Roller (sheeps-foot)	2	1 226	2 453
Mobile workshop trailer	2	877	1 754
Air compressor	2	371	742
Generator	4	293	1 174
Sub-Total			25 142
Construction Plant			
Stone crushing plant			5 702
TOTAL			75 342

* *Subject to rounding error.*

2.2 CONSTRUCTION OF BUILDINGS AND HOUSES

Unfortunately, the building construction segment of the entire project has suffered considerable delay with the result that construction is unlikely to commence until well into 1984 (i.e. the fourth year of the project). In the absence of the planned facilities, virtually all vehicle and plant maintenance is carried out in the field using two mobile workshops. While this is acceptable for routine servicing, it is entirely unsatisfactory when major repairs are required.

Some temporary office accommodation and open storage has been obtained by the assimilation of the former Highways Depot in Baydhabo and a building has been erected near the present PMU office to house vehicle and equipment spares. Housing for Technical Assistance personnel and counterpart staff has been provided by renting existing properties, generally of a lower standard than the proposed permanent housing.

2.3 ROAD CONSTRUCTION AND REHABILITATION

2.3.1 Goof Guduud - Qansaxdheere Road

Road construction commenced in December 1982 on a new alignment which will eventually connect Goof Guduud (on the Baydhabo - Diinsoor road) with Qansaxdheere. Earlier planning proposed a direct route via Dusta but this Class II standard road will now be routed through the larger settlement of Xabaalo Barba. Although this involves an increase in length from 50 to 68 km, it will better serve agricultural areas; more than 85 per cent of the alignment will be on the dark clay soils. However, despite the easy conditions for road construction, work is progressing very slowly; by September 1983 only some 13 km had been completed. No longitudinal drainage ditches had been constructed and no paved fords (Irish Bridges) had been built. Excluding delays caused by fuel shortages, average progress was estimated to be 0.33 km per week. Lack of recorded data precluded a full analysis of the cost of construction but from records compiled during June 1983 an assessment of the cost of construction of this Class II road on poor sub-soil was made (see Table 2.2 to 2.4). Costs were estimated at Ssh 295 000 per km. The standard of construction is generally poor and this is principally attributed to inadequate supervision and control (see Sub-Section 3.3).

2.3.2 Seed Farm Access Road

A short length (1.7 km approximately) of Class II standard road was constructed during March and April 1983 provide all-weather access to the Seed Farm at Boonkay.

2.3.3 Qansaxdheere - Buur Dhubo Road

The Qansaxdheere - Buur Dhubo road is currently under construction to a minimum standard which has been described as an 'all-weather track'. It is understood that completion of this 70 km track to the east bank of the Jubba River has been accorded a higher priority than construction of the Goof Guduud - Qansaxdheere road. When completed (apart from serving a small cultivated riverine area) it will permit access to a large refugee settlement on the west bank which can be reached by means of a vehicular ferrry. Construction had currently reached km 54 by September 1983 but the present carpet of fill, nominally 250 mm thick (but varying between zero and 700 mm), is poorly shaped and inadequately compacted. The latter deficiency is almost certainly a result of the difficulties which have been experienced in the procurement of water. There is as yet no provision for drainage and the already poor condition of this track can be expected to deteriorate rapidly during the next wet season. Towards the river valley the terrain becomes more uneven and, with frequent outcropping of limestone, construction difficulties may be expected to increase. Average progress, excluding some delays caused by fuel shortages, has been assessed at 2 km per week.

TABLE 2.2 UTILISATION OF CONSTRUCTION EQUIPMENT; GOOF GUDUUD TO QANSAXDHEERE

Type	Serial No.	9 Jun.	16 Jun.	23 Jun.	30 Jun.	7 Jul.	14 Jul.	21 Jul.	28 Jul.	4 Aug.	Total Hours to Date
		Week Ending 1983 (Hours)									
Dozer											
D.700	SO.5	Unservicable : Awaiting Repair by Manufacturer									325
D.600	SO.8	30	34	32	15	29	20	8	23	23	903
D.6	-	No Record of Operating Hours Maintained								30	N.A.
Average Weekly Engine Hours D600 = 23.8 hours (at borrow pit)											
Front End Loader 3 cu. m.											
T.66C	SO.2	40	45	42	40	42	35	1	0	4	766
T.66C	SO.4							16	0	22	N.A.
Average Weekly Engine Hours for FEL = 40.7 hours (at borrow pit)											
Motor Grader	**190 HP**										
T.600C	SO.14	Unservicable : Awaiting Repair									
T.600C	SO.15	23	24	40	15	2	0	0	11	19	677
T.600C	SO.17	Unservicable and Awaiting Repair Since 23rd July 1983									N.A.
Average Weekly Engine Hours for Grader = 19.1 hours											
Roller											
Pettibone	-	0	2	13	20	19	8	0	0	0	512
C-44 Vibrating	SO.11	7	20	13	5	13	-	0	0	0	178
Roller	SO.12	8	10	20	16	30	9	0	14	6	375
	SO.13	0	0	0	0	0	7	0	21	6	190
Average Weekly Engine Hours for Roller = 8.3 hours (per machine)											

Note 0 = Not Working
N.A. = Not Available

Source: HTS 1983, from Project Road Construction Unit Records

TABLE 2.3 UTILISATION OF TRACTOR UNITS ON GOOF GUDUUD - QANSAXDHEERE

Vehicle No.	40 554	40 555	40 556	40 558	40 561
Week Ending	Recorded Travel (in KM)				
9.6.83	No Records	585	650	720	600
16.6.83	No Records	585	658	727	740
23.6.83	No Records	465	600	530	447
30.6.83	No Records	85	555	435	375
7.7.83	741	721	807	694	814
14.7.83	941	928	735	332	548
21.7.83	200	630	400	200	300
28.7.83	1 128	115	-	297	93
4.8.83	110	500	519	321	516
Weekly Average	624	513	547	473	492

Overall Weekly Average = 530 km per unit

Odometer Reading at 4.8.83	20 452	15 415	21 202	13 630	16 121

Note: *(Due to interchange of trailer units it was not possible to identify utilisation on different tasks i.e. hauling gravel, water or fuel).*

Source: *HTS 1983 from Road Construction Unit records.*

TABLE 2.4 COST OF CONSTRUCTION OF ONE KILOMETRE OF CLASS II ROAD (GOOF GUDUUD TO QANSAXDHEERE) JUNE 1983

Vehicles and Equipment

		Week Ending (hours)					
		16 Jun.	23 Jun.	30 Jun.	Total	Rate[3] Ssh	Cost Ssh
Bulldozer	(2)	74[1]	72	55	201	257.7	51 798
Front End Loaders	(1)	45	42	40	127	294.4	37 135
Graders	(1)	24	40	15	79	292.3	23 092
Rollers	(3)	32	46	41	119	170	20 230
Trucks	(4)	2 710	2 042	1 450	6 202 km	19.3	119 697
4WD pick-ups		N.A.	N.A.	N.A.	1 500[2] km	2.7	4 050
					TOTAL Ssh		256 002

Notes: [1] *No engine time readings available for one of the bulldozers, therefore 40 hrs. assumed.*

[2] *MTR estimate*

[3] *MTR estimate (see Table 6.6).*

Labour *Actual monthly Wages and Salaries excluding overtime and allowances = Ssh 173 020*
For 3 weeks multiply by 0.75 and assume 30 per cent of costs relate to staff and labour directly engaged at this site. Therefore labour cost equals 173 020 x 0.75 x 0.3 = Ssh 38 930

Total *Estimated Cost = Ssh 294 932 per km.*

Source: *HTS 1983 from Road Construction Unit Records.*

2.4 ROAD MAINTENANCE

Apart from minor remedial works which are said to have been carried out on the Baydhabo - Goof Guduud road, no improvements to the condition of the existing road network have been made so far. Re-gravelling of the same road is currently planned to follow completion of the new Goof Guduud - Qansaxdheere road according to Fintecs work programme.

2.5 ACCESS TRACKS

Apart from some tentative proposals for 190 km of such tracks in the HTS Report (1982), no further consideration has been given to this aspect by the Project. In view of the very slow rate of road construction, the possibility of resources being made available for what is regarded as a low priority item is now remote. The access tracks were originally seen as a means of opening up potentially cultivable areas. This is no longer a major objective.

2.6 TECHNICAL ASSISTANCE AND TRAINING

Technical Assistance personnel have been supplied by Fintecs Consultants of Cairo, and it is understood that the initial appointees took up their position in August 1981. For various reasons the initial team proved to be unsuitable and a completely new team was mobilised between January and March 1983. The current team consists of the following personnel:

- S. Highway Engineer, team leader
- Mechanical Engineer
- 2 Plant Superintendents

3

Problems and Constraints

3.1 CONSTRUCTION EQUIPMENT AND VEHICLES

3.1.1 Scope of Work

In the construction of low-cost gravel roads on a new alignment to the standards defined in Section 1.2 the following principal operations are involved:

(a) Clear 20 metre wide road reserve of vegetation
(b) Construct shallow embankment (0.5 m approx) of *in situ* material, including shaping, watering and compacting
(c) Excavate overburden to expose suitable gravel deposits
(d) Rip gravel material and bulldoze into stockpiles
(e) Load from stockpiles and transport to site
(f) Spread, shape, water and compact gravel surfacing
(g) Form longitudinal drainage ditch(es)
(h) Construct paved fords ('Irish Bridges') for cross drainage.

For the rehabilitation of existing gravel roads the principal operations are:
(a) Scarify existing road surface, re-shape, water and re-compact
(b) Provide additional gravel surfacing material where required (i.e. operations (c) to (f) inclusive as for new construction)
(c) Clean out or re-excavate longitudinal drainage ditch(es)
(d) Repair or re-construct paved fords for cross drainage.

In general, the equipment and vehicles procured are more suited to the construction of new roads than the maintenance of the existing gravel roads. This is one of the reasons which have been put forward for not establishing any kind of road maintenance activity.

3.1.2 Graders

For rehabilitating existing gravel roads it is necessary for graders to be equipped with scarifiers. Under certain circumstances, although it might be possible to improvise by using a bulldozer fitted with the smallest possible ripper attachment, such action would be uneconomic and inappropriate for the roads under review.

3.1.3 Semi-Trailer Tippers

Although the 25 tonne capacity semi-trailer tipper units are rugged, heavy-duty vehicles which can perform well under adverse conditions, the relatively small fleet of eight (now reduced to seven as the result of an accident) requires an almost unattainable level of serviceability to be maintained. Another major breakdown will reduce the fleet to 75 per cent. For routine road maintenance work these vehicles are too large and inflexible. Similarly, the 25 000 litre water tankers are wholly unsuited to the requirements of road maintenance. It is apparent that, given the constraint of the existing inventory of vehicles and equipment, it is not practicable to re-assign any of the tippers or tankers to meet the needs of routine road maintenance and it is necessary that additional smaller and more flexible vehicles be procured.

3.1.4 Bulldozers

With the current methods of working, Fintecs' Team Leader has identified the bulldozers as the main factor controlling the rate of progress. Until recently, one of the 200 HP machines had been unserviceable for several months and its place had been taken by a Caterpillar D.6 borrowed from the Range Component. It is understood that the former has recently been repaired by the manufacturer's Field Service Engineer and that a quantity of urgently required spares and stores for all the Hanomag equipment will be delivered by air in the near future. Hence the serviceability situation may be expected to improve. However, it should be noted that the low output of the bulldozers could be improved by more effective control and supervision. The Construction Equipment Specialist noted that at one site on the Qansaxdheere - Buur Dhubo road three bulldozers were being used to work a small gravel pit and that a significant proportion of time was spent by operators waiting their turn. Other observations supported the view that plant was frequently operated simply because it was available for use. Another factor which contributed to the low output at the other site (Goof Guduud - Qansaxdheere) was the employment of both a bulldozer and a grader to construct the embankment. The Construction Equipment Specialist demonstrated to Fintecs' staff how to construct a shallow embankment in soft soil more rapidly by using a grader to cut a vee ditch and spread windrows to form the fill.

Furthermore it should be noted that until now haul distances from gravel quarry to road construction site have been relatively short (less than eight km). Reference to Figure 3.1 shows that when the haul distance exceeds 10 km, or unserviceability reduces the size of the tipper fleet, output will be controlled by the rate of supply of gravel material.

3.1.5 Stone Crushing Plant

Although the maintenance of Class I bitumen-sealed roads within the region has not been included as part of the work load of the Project, a crusher unit complete with generator for the production of crushed stone and chippings was procured. The acquisition of this piece of equipment cost some Ssh 5.7 million, a sum which could otherwise have funded the purchase of much-needed equipment (e.g. scarifier-equipped graders and medium-sized tipper trucks).

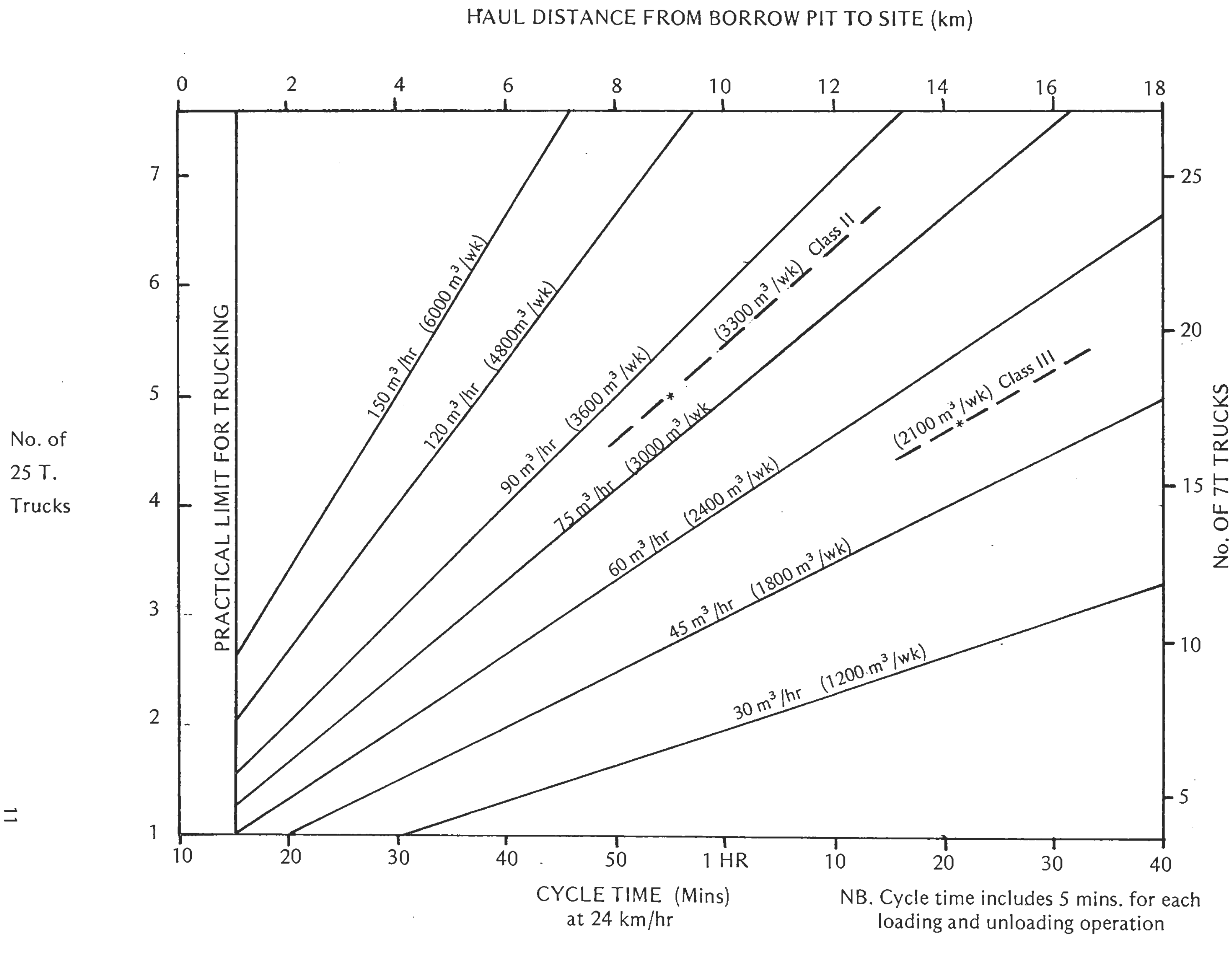
3.1.6 Sheepsfoot Vibrating Rollers

Conditions favouring the use of the sheepsfoot rollers are unlikely to occur sufficiently frequently to make their use effective. While the sheepsfoot type of roller is efficient for the compaction of fine-grained soils it tends to produce a larger amount of air voids than smooth wheel or rubber-tyred rollers. This would be very detrimental in the case of the black clay soil types because it would increase their ability to absorb moisture. The lack of any soil testing facilities precludes the possibility of comparative field trials to assess the suitability of these rollers for the compaction of black clay soils under differing moisture conditions.

3.1.7 Air Compressors

These are large compressors (almost 9 cu.m/min capacity) which were ordered with

FIGURE 3.1 HAULAGE CAPACITY OF DIFFERENT SIZES AND NUMBERS OF TRUCKS



rock breakers but delivered with rock drills. Apparently they were intended to be used in conjunction with the stone crusher. They are not required for their intended purpose and without breakers cannot be used as such. At present they are used, somewhat uneconomically, for cleaning plant in the absence of water.

3.1.8 Logistic Support

Problems have been experienced with regard to the procurement of spare parts and consumable stores (e.g. fuel, oils, lubricants, tyres, batteries and filters). Individual circumstances are well-known to the Project Management and it is unnecessary to enumerate them. With one or two exceptions, the PMU cannot be held responsible for the delays which have occurred in the supply of these essential items. Delays have resulted from:

- Poor or misleading technical advice
- Slow procedures on the part of the donor agency
- Delay by suppliers
- Delay in shipment
- National shortages of fuel.

3.2 CONSTRUCTION OF BUILDINGS

The buildings and houses for this component form part of the overall project building programme which has been subject to considerable delay. It is understood that this is in some measure the result of procedures for international tendering. However, it is noted that the construction of the workshops and office accommodation has been accorded the highest priority in the overall building programme.

A proposed design has been made by Norconsult and this design has been examined. The existing drawings show the workshop would be built in the Project Compound on the outskirts of Baydhabo. However, it is understood from the Project Director that it is intended to move the workshop elsewhere in Baydhabo.

It is assumed that this workshop will be used not only by the plant fleet but by all the vehicles in the Project. Thus, there will be 70+ items of equipment from the plant fleet plus at least 30 Land Rovers, Chevrolet pick-ups, plus some other tractors and trucks. The present workshop design is too small in the stores area and in the servicing area for the plant fleet and much too small for the total fleet. It is also assumed that repairs will be limited to major assembly changes as the upper limit. Major rebuilds of engines, gearboxes etc will not be undertaken. It is felt that this assumption must be made as setting up specialist equipment for reboring cylinders etc cannot be economically justified for the relatively small fleet being used.

On the basis of these two assumptions, it is concluded that:

(a) The central store is much too small. It probably needs to be at least quadrupled in size for normal spare parts and a second store of about the same size is needed for tyres.

(b) There is a requirement for 3 or 4 offices. These are 1 for the workshop and stores supervisors, 1 for stores records, 1 for plant and vehicle servicing schedules and spare parts documents, and a general office for costing and accounting.

(c) There should be at least three and preferably four servicing bays and at least two pits one of which should be suitable for Land Rover and pickups.

(d) The carpenters shop must be separated from the battery maintenance shop. The latter must be properly equipped to remove hydrogen and acid fumes.

(e) The Injection testing and Hydraulic testing rooms should be sealed and air-conditioned.

It is strongly recommended that the workshop designed layout is re-examined before tenders are requested, or at least variation orders produced before work actually starts.

3.3 ROAD CONSTRUCTION

Although the road construction programme has been in progress for some 9 - 10 months progress has been very slow and the quality of construction leaves much to be desired. The quality of work on the Qansaxdheere - Buur Dhubo 'track' is particularly bad, and major maintenance operations will be necessary to keep the road passable. At both construction sites the following shortcomings were noted:

- Low work output by construction equipment
- Poor standards of compaction - due to irregular and inadequate watering
- Non-existent quality control of gravel material
- Variations in camber - no monitoring of the finished crossfall
- No longitudinal drainage ditches
- No construction of paved fords ('Irish Bridges')
- Inadequate planning of the alignment
- Inadequate setting out and control of horizontal and vertical alignment
- Inadequate record-keeping.

In mitigation, it must be stated that most of these shortcomings can only be rectified if the existing technical and supervisory inputs are significantly increased.

3.4 TECHNICAL ASSISTANCE AND TRAINING

The replacement of the original Fintecs team inevitably created a lack of continuity and the absence of records renders an assessment of performance difficult. However, the indications are that very little effective on-the-job training was carried out up to the beginning of 1983. In the field of plant maintenance there has been encouraging progress. The Mechanical Engineer has set up a maintenance system. The Plant Superintendents work with the fitters and young, English-speaking fitters are teamed with more experienced non-English speakers to obtain maximum value from the English language servicing manuals.

In the case of civil engineering activities the prospects are less satisfactory. There appears to be a poor working relationship between the Fintecs Team Leader and the recently appointed Head of the Access Roads section. The Fintecs' Civil Engineer has assumed an advisory role instead of taking direct control of construction. In this context it must be noted that the numerous activities which he is expected to undertake (vide Job Description, Annex 3, IDA Appraisal Report) are unreasonably extensive. The Consultants consider them to be beyond the capacity of a single engineer, no matter how dedicated or competent.

The proposal to train no less than four graduate engineers to Master's degree standard with the objective of filling two posts in a Regional Road Maintenance organisation must be questioned. Serious consideration should be given to reducing the present number of

M.Eng courses and re-directing the funds towards more appropriate training courses. These should be tailored to suit the needs of this component of the Project and have a bias towards practical on-the-job training.

4

Rationale and Strategy for Stage II

4.1 PRIORITY RATING FOR NEW PROJECT ROADS

Reference has already been made in Section 3.3 to the very poor performance so far, but it should be noted that the targets set out in the IDA Appraisal Report were unrealistic. It is now widely recognised that the programme of road construction and rehabilitation cannot be completed during Stage II and that it is necessary to revise the plan. A revised plan has in fact been produced by the Project (Table 4.1), but the Construction Programme recently produced by the Fintecs' Civil Engineer (Table 4.2) recognises that there is no possibility of all the planned construction being completed within the timescale of Stage II, even with a substantial reduction in the length of Class II road.

4.2 ALTERNATIVE STRATEGIES FOR STAGE II

It is clear that the current programme is over-ambitious and that some re-ordering of priorities is needed to meet the project objectives of servicing the agricultural areas in the Region. Not only is the length of new construction at issue, but also the balance to be achieved between new construction and maintenance.

4.2.1 Criteria for New Construction

In drawing up a priority list for new construction the Consultants attempted to take the following factors into account:

- condition of the existing road
- existing and anticipated traffic
- population density of the surrounding area
- agricultural potential of the surrounding area
- serviceability of existing roads during the wet season
- availability of construction materials.

The Consultants' Roads' Engineer visited all the proposed roads to assess the conditions of the existing road or track as well as to form an opinion on the present traffic levels. Consideration was given to the carrying out of a number of simple traffic surveys, but it was felt that the results could be unrepresentative due to the current fuel shortages. However, it is recommended that a regular series of traffic surveys be mounted so that a data base for road planning can be established. The present system of police check points throughout the region would be a suitable framework to utilise for such an exercise.

4.2.2 Maintenance of Roads

It is essential to recognise that unless an effective organisation for road maintenance is established, all the new construction will ultimately be in vain. It is understood that ADF

TABLE 4.1 CURRENT LIST OF PROPOSED PROJECT ROADS (AUGUST 1983)
(in order of priority)

Route	Class	Type	Length (km)[1]
Goof Guduud - Qansaxdheere	II	A.6/B.6	64
Qansaxdheere - Buur Dhubo[2]	III	A.4/B.4	70
Ufurow - Diinsoor	III	A.4/B.4	43
Baydhabo - Goof Guduud	II	C.7	25
Boonkay - Tagaal	II	A.6/B.6	60
Buurhakaba - Dolon Dole	III	A.4/B.4	58
Buur Heybo spur	III	A.4/B.4	18
Goof Guduud - Diinsoor[3]	II	A.6/B.6	83
Diinsoor - Yaaq Braawe	II	A.6	62
Boonkay - Uegit	II	(C.7 (A.6	27) 43)
		TOTAL[4]	553 km

Notes: [1] *Total length of Class II roads = 312 km*
Class III roads = 189 km
To be re-gravelled = 52 km
Access tracks (to be decided) = 250 km

[2] *This road is currently under construction to a minimum standard, which has been described as an 'all-weather track'.*

[3] *Although described as 'Dusta to Diinsoor' in the original list of project roads (IDA, 1979), this is the existing Goof Guduud to Diinsoor section of the Baydhabo to Diinsoor raod. This road is probably little used beyond Manaas (5 km SW of Goof Guduud) since Baydhabo - Diinsoor traffic uses the new road to Ufurow and thence to Diinsoor. The Goof Guduud - Diinsoor road is in a very poor state over much of its length.*

[4] *The above listing does not include the completed link to the Seed Farm at Boonkay which was constructed to approximately Type II standard and is some 1.7 km in length.*

Source: *BRADP via Fintecs' Team Leader.*

are considering the provision of additional funds to allow purchase of equipment for road maintenance. If such funding is forthcoming, procurement would not be complete until 1985. In the meantime, the backlog of maintenance work would accumulate. It is therefore necessary to consider the redeployment of some of the construction equipment and the acquisition of plant from MPW, possibly in exchange for the obselete crushing plant.

4.2.3 The Recommended Strategy

The Consultants recommend that, for Stage II, the Project give priority to the establishment of a road maintenance organisation and to concentrating the construction equipment into a single coherent unit which can operate more efficiently than two separate, inadequately supervised units.

TABLE 4.2 ROAD CONSTRUCTION WORK SCHEDULE (SEPTEMBER 1983)

Road Construction Unit No.1 (2 bulldozers)

Road	Total Length (km)	Time to Complete (hrs)	Approx. date of completion
1. Goof Guduud - Qansaxdheere, Class II 14.5 assumed complete 1.9.83	68	3 800	Jul 1985
2. Baydhabo - Goof Guduud (regravelling)	25	800	Dec 1985
3. Buurhakaba - Dolon Dole (Class III)	58	2 900	Jun 1987
4. Buur Dhijis - Buur Heybo (Class III)	22	not to start before Jan 1987	
Road Construction Unit No.2 (3 bulldozers)			
1. Qansaxdheere - Buur Dhubo (Includes regravelling to approx. Class III standard)	70	3 400	Jun 1984
2. Ufurow - Diinsoor (Class III)	38	1 900	May 1985
3. Boonkay Tagaal (class II)	62	4 600	Sep 1987
4. Goof Guduud - Diinsoor	90	not to start before Jan 1987	

Summary: *Total length of Class II construction = 116 km*
Total length of Class III construction = 153 km
Total length of regravelled roads = 95 km

Source: *Fintecs 1983.*

Although it is hoped that further funding will enable the Project to continue into subsequent phases after the completion of the second stage of Phase 1, consideration must be given to the future of all the components in the event of the Project being wound up or substantially altered. There will continue to be a requirement for road maintenance and it is logical that the proposed Road Maintenance Unit, at least, should eventually be transferred to the Ministry of Public Works. In order to achieve a smooth transfer of financial and administrative control it will be necessary to give attention to the handing-over process well in advance of any disbandment of the Project Management Unit. Unless the Ministry of Agriculture can be assured of long-term finance for the Bay Region Project beyond the end of Phase 1, arrangements for an orderly transfer of control should be organised through close liaison with the Ministry of Public Works to ensure timely budgetary allocation.

5

Proposed Programme for Stage II

5.1 REORGANISATION OF THE ROADS COMPONENT

In order to serve the purposes envisaged in the project documents, namely to improve the roads to facilitate improved agricultural production and social infrastructure, a thorough reorganisation of the roads component is recommended. The proposed reorganisation is shown in Figure 5.1 which includes a mechanical section, a single Road Construction Unit (RCU) and a Road Maintenance Unit (RMU).

5.2 ALLOCATION OF VEHICLES AND EQUIPMENT

Vehicles and construction equipment would be allocated between the two units as shown in Table 5.1 The additional items required are summarised in Table 5.2

5.3 TECHNICAL ASSISTANCE

It is recommended that an additional two personnel are recruited to improve the direction and control of the construction and maintenance work. The TOR for these two staff are set out below.

5.3.1 Job Description of Road Construction Superintendent

The Road Construction Superintendent would report weekly to the Senior Highway Engineer and would be responsible to him for all aspects of the supervision of construction of new roads. He would be in overall control of all personnel assigned to the Road Construction Unit and would be responsible for the successful execution of the planned work programme within the budgeted cost. His duties would include, but not be limited to:

(a) Operating the road construction unit, including vehicle and construction equipment management and control;

(b) Ensuring compliance with specifications and standards for quality of construction, including selection of materials, compaction and dimensional accuracy of the finished work;

(c) Maintaining records of progress and the utilisation of vehicles, equipment, materials and labour;

(d) Supervising on-the-job training of Somali Staff.

The Road Construction Superintendent should be fluent in spoken English and able to prepare written reports and records in English. Formal technical qualifications are less important than extensive experience in the construction of gravel roads and a proven

5.1 PROPOSED ORGANISATION CHART

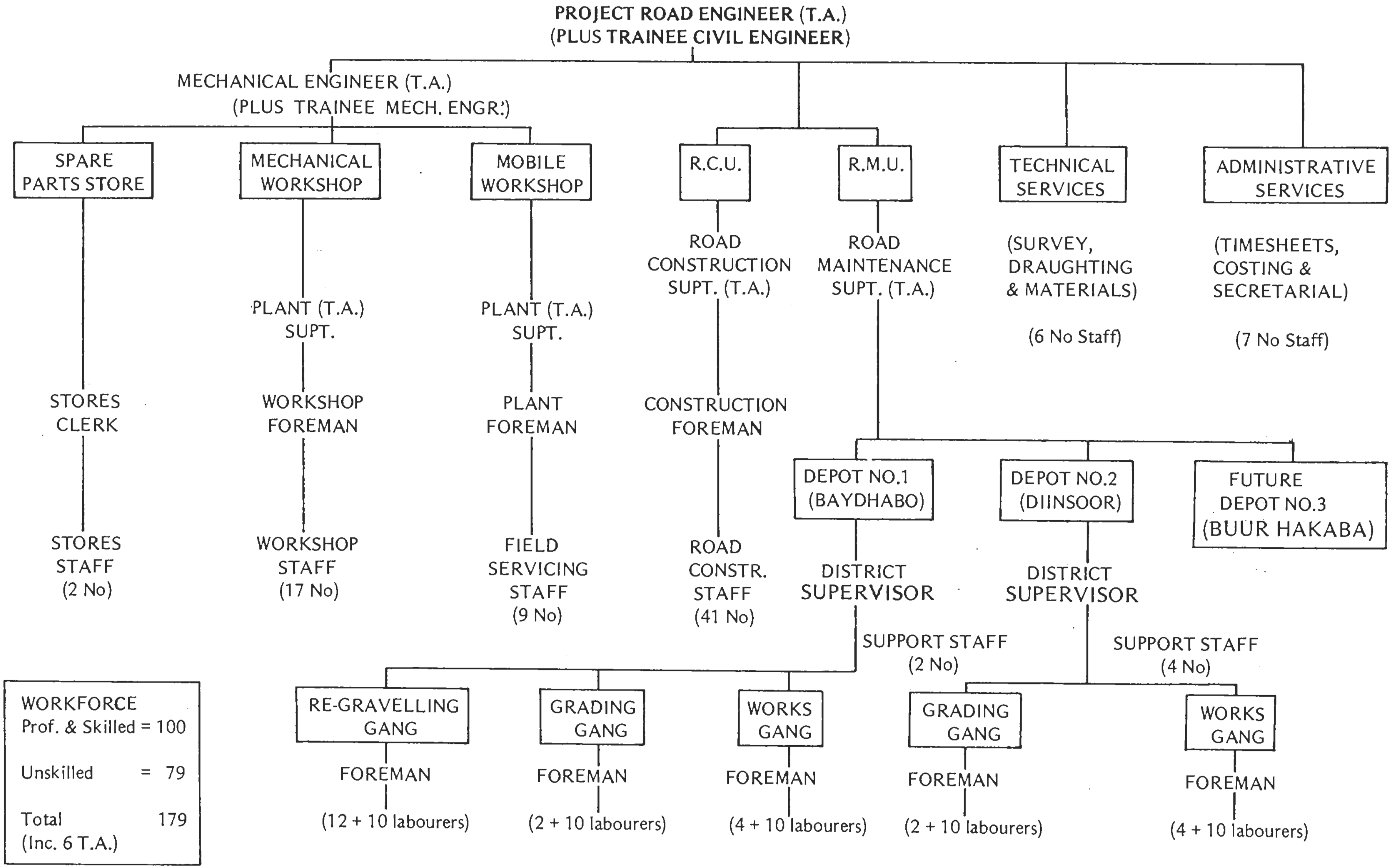


TABLE 5.1 PROPOSED RE-DISTRIBUTION OF VEHICLES AND EQUIPMENT

A. ROAD CONSTRUCTION UNIT

Type	No.	Type	No.
MB Tractor Unit	6	D 700 Bulldozer	1
MB Tipper Body	5	D 600 Bulldozer	2
MB Water Tanker body	2	T 660 Grader	2
MB Fuel Tanker body	2	T 66C F/E Loader	2
Mobile Workshop	1	C-44 Roller (VIB)	2
Land Rover Pick-up	2	Generator	1
		Compressor	1

B. ROAD MAINTENANCE UNIT

(a) District Supervisors - 2 No (based at Baydhabo & Diinsoor)

Land Rover Pick-up	1 each

(b) Regravelling Unit - 1 No (based at Baydhabo)

MB Tractor Unit	4	D 600 Bulldozer	1
MB Tipper Body	†3	*Grader with Scarifier	2
MB Water Tanker body	1	T 66C F/E Loader	1
MB Fuel Tanker body	1	C-44 Roller (VIB)	2
Mobile Workshop	1	Generator	1
		Compressor	1

(c) Grading Units - 2 No (based at Baydhabo & Diinsoor)

*7-T Tipper Truck	1 each	*Grader with Scarifier	1 each

(d) Works Units - 2 No (based at Baydhabo & Diinsoor)

*7-T Tipper Truck	1 each	*Water tank truck (5000L)	1 each

TABLE 5.1 cont.

C. H.Q. SUPPORT UNIT

(a) Personnel transport

Type	No.	Remarks
Land Rover Stn. Wagon	3	For C.E., M.E., & Maint. Supt.
Land Rover Pick-up	2	For Plant Supt. & Workshop Supt.
Land Rover Pick-up	1	For Technical Support use.
Land Rover Pick-up	1	For Mobile Workshops.
Land Rover Pick-up	1	Spare.

(b) Logistic support

MB Tractor Unit	2	For fuel supply.
MB Low Loader body	1	For transport of equipment.
MB Water Tanker body	2	For emergency use.
MB Fuel Tanker body	2	For fuel supply (at Mugdisho).
*7-T Tipper Truck	1	For transport and emergency use.
Water Tank Truck (5000L)	1	For emergency use.
Generator	2	For emergency use.

(c) Un-assigned equipment held in reserve

D 700 Bulldozer	1	To be rotated with assigned machines
T 660 Grader	1	as dictated by maintenance requirements.
T 66C F/E Loader	1	
C-44 Roller (VIB)	1	(Machine currently u/s at Afgoi)
C-44 Roller (S.F.)	2	Performance trials required.

(d) Equipment for sale or exchange

Parker Stone Crusher	1	Not required. To be exchanged for additional equipment (to include 2 Graders with scarifiers).

Notes: *These items to be procured
†One damaged beyond repair - replacement required

TABLE 5.2 VEHICLES AND EQUIPMENT

SCHEDULE OF ADDITIONAL ITEMS TO BE PROCURED

Type	No.	Purpose
Grader with Scarifier	3	Road maintenance and re-gravelling of existing roads.
7-T Tipper Truck	5	Road maintenance.
Water Tank Truck (5000L)	3	Road maintenance including re-gravelling and mixing concrete and mortar for masonry.
MB Tipper Trailer (25T)	1	Replacement of damaged unit.

Note: It is assumed that the above items could be procured by September 1984. The effectiveness of the RMU, particularly in re-gravelling, would be increased earlier if it proved possible to obtain 2 graders with scarifiers within Somalia in exchange for the redundant stone crushing plant. Alternatively it might be possible in the short term to obtain scarifying attachments for 3 of the existing graders, in which case the new graders ordered would come without scarifiers.

ability to manage labour and control heavy construction equipment under developing country working conditions. He would be stationed at Baydhabo but must be willing to live at work camps as and when required.

5.3.2 Job Description of Maintenance Superintendent

The Road Maintenance Superintendent would report directly to the Senior Highway Engineer and would be responsible to him for all aspects of the supervision of the maintenance of the road network. He would be in overall control of all personnel assigned to the Road Maintenance Unit and would be responsible for the successful execution of the planned road maintenance programme within the budgeted cost. His duties would include, but not be limited to:

(a) Operating the road maintenance unit, including vehicle and equipment management and control;

(b) Ensuring compliance with specifications and standards for quality of road maintenance, including selection of materials, compaction and dimensional accuracy of finished work;

(c) Maintaining records of completed works and the utilisation of vehicles, equipment, materials and labour;

(d) Supervising on-the-job training of Somali Staff.

The Road Maintenance Superintendent should be fluent in spoken English and able to prepare written reports and records in English. Formal technical qualifications are less important than extensive experience in the maintenance and repair of gravel roads and a proven ability to manage labour and equipment under developing country working conditions. He would be stationed at Baydhabo but required to travel extensively throughout the Bay Region and must be willing to live at work camps as and when required.

5.4 OVERSEAS TRAINING

It is recommended that provision be made for staff to attend courses of short duration (6 to 9 months) which would include a theoretical component (e.g. the design of low-cost roads) followed by secondment to a Highway Authority for relevant practical experience. Appropriate conditions exist in many parts of Australia or the mid-West of the USA, where trainees could gain sound practical experience in the construction and maintenance of gravel roads. The State of Wyoming in the USA would provide a suitable environment. Similarly, short term training for carefully selected technicians such as surveyors and soil technicians should be considered as a possible means of alleviating the critical shortage of trained personnel in these fields.

It is therefore proposed that only two engineers be sent overseas for training to Masters level during Stage II. In addition three trainees per year should be sent on 6-9 months practical training courses overseas.

5.5 PROPOSED WORK SCHEDULE

It is proposed that the road construction unit will finish constructing the Qansaxdheere - Buur Dhubo road, albeit to a low standard, by the end of 1983. From that time the unit will be disbanded. Equipment will be re-allocated to the Road Maintenance Unit (RMU). One grader and one truck will be transferred to the remaining RCU at work on the Goof Guduud - Qansaxdheere road. Work rates will improve as new techniques are learned, as additional TAs take up their posts and when the extra equipment is delivered. Figure 5.2 shows the location of the proposed works.

5.5.1 New Construction by the RCU

The rate of progress of the RCU is expected to increase from the 1983 level of 0.33 km to 0.5 km per week as the grader operators learn to form embankments. This rate is expected to be maintained from January 1984 to March 1984 by which time plant will have been received from the disbanded RCU 2 and the new TAs should be operational. Thereafter a rate of one kilometre per week is assumed (Table 5.3).

Figure 5.2 Proposed Works

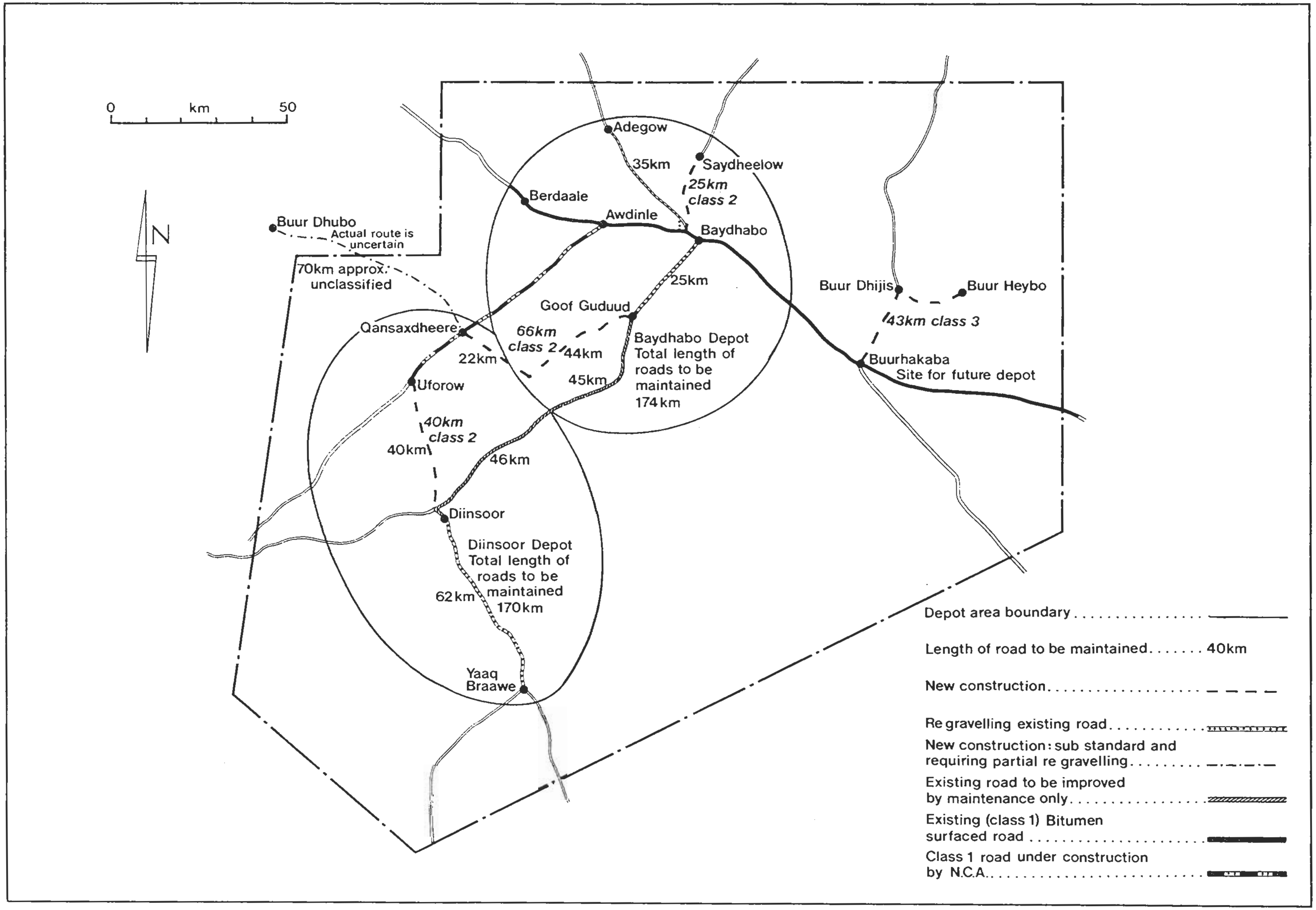


TABLE 5.3 PROPOSED CONSTRUCTION IN STAGE II

Road	Type	km	Irish bridges	Start date	Finish date
Goof Guduud - Qansaxdheere (assumed 20 km completed by 1 January 1984)	A6 B6	7 59	10	1 Jan 84	15 Dec 84
Ufurow - Diinsoor	A6 B6	16 24	5	1 Jan 85	30 Sep 85
Boonkay - Tagaal	B6	25	5	1 Oct 85	31 Mar 86
Buurhakaba - Buur Dhijis - Buur Heybo	A4 B4	8 36	15	1 Apr 86	31 Dec 86

Note: Type specification given in para. 1.2

5.5.2 Re-gravelling by the RMU
The RMU is expected to commence re-gravelling operations using equipment from the disbanded RCU 2 by late January 1984. The rate of work is expected to be 0.8 km per week until March 1984. By that time the additional TA should be functioning and the work rate will rise to 1.0 km per week until September 1984. The new more suitable equipment should have arrived by then and the work rate is assumed to be 1.2 km per week thereafter.

TABLE 5.4 PROPOSED RE-GRAVELLING IN STAGE II

Road	Class	Length Km	Start Date	Finish Date
Baydhabo - Goof Guduud	II	25	20 Jan 84	31 Aug 84
Boonkay - Adegow	II	35	1 Sep 84	31 Mar 85
Diinsoor - Yaaq Braawe	II	62	1 Apr 85	31 Mar 86
Qansaxdheere - Buur Dhubo [1]	n/c	70	1 Apr 86	15 Apr 87

Note: [1] This task involves the selective re-gravelling and upgrading of the existing poorly constructed road to Class III standard. The rate of progress is estimated at 1.3 km per week. Some 50 km would be completed by 31 December 1986.

5.5.3 Routine Road Maintenance
RMU works and grading units will not become operational until the new equipment arrives and the depots at Baydhabo and Diinsoor are established. The start date is assumed to be 1 January 1985. The work rate is estimated at some 1.67 km per week.

TABLE 5.5 PROPOSED SCHEDULE OF RMU WORKS UNITS

Road	Class	Length (km)	Year
A - BAYDHABO DEPOT			
Goof Guduud - Diinsoor (remainder to be maintained from Diinsoor depot)	II	45	1985
Goof Guduud - Qansaxdheere (remainder maintained from Diinsoor)	II	44	1985
Baydhabo - Goof Guduud	II	25	1986
Boonkay - Adegow	II	35	1986
Boonkay - Saydheelow	II	25	1986
B - DIINSOOR DEPOT			
Diinsoor - Goof Guduud	II	46	1985
Diinsoor - Yaaq Braawe	II	62	1985-86
Qansaxdheere - Goof Guduud	II	22	1986
Diinsoor - Ufurow	II	40	1986

5.6 MONITORABLE TARGETS

In general terms the anticipated results are the achievement of the principal objectives within the Stage II timescale and the establishment of a durable road maintenance organisation. The physical improvements to the road network within the Bay Region are shown in Table 6.1. For comparison with original and current programme see Table 5.7.

TABLE 5.6 SUMMARY OF PHYSICAL TARGETS

(i)	Construction of new Class II roads (20 km of which already built in Stage I)	-	131 km
(ii)	Construction of new Class III roads	-	44 km
(iii)	Construction of new unclassified road (Construction completed in Stage I)	-	70 km
(iv)	Rehabilitation of existing Class II roads (including re-gravelling)	-	122 km
(v)	Upgrading of unclassified road to Class III standard (including re-gravelling for 50 km)	-	70 km
(vi)	Total length of gravel road network under regular maintenance	-	344 km

TABLE 5.7 ORIGINAL AND PROPOSED WORK PROGRAMMES (EXCLUDING ROAD MAINTENANCE)

	Length of Road Constructed/Rehabilitated (km)		
Class Type	IDA (1979)	PMU/FINTEC	Mid-Term Review
New Class II	286	116	131
New Class III	210	153	114
Sub-Totals	496	269	245
Re-Gravel	62	95	122
GRAND TOTAL	558	364	367

Notes: For the purposes of comparison the totals shown for "PMU/FINTEC" are limited to work programmed for completion by February 1987 (see Tables 4.1 and 4.2).

6
Costs

The estimated costs of continuing the BRADP roads programme during Stage II between January 1984 and December 1986 are summarised in Table 6.1. The total cost is approximately Ssh 132 million, or US$ 8.6 million.

The cost estimates are based on 1983 levels, inflated by 8 per cent per year to take account of real inflation. Allowances have been made for contingencies and the initial purchase of spares with capital items.

Costs are presented in the following Tables:

TABLE 6.1 ACCESS ROADS - COST ESTIMATES (Ssh '000)

		1984	1985	1986
Capital Costs				
Buildings		4 001	6 803	-
Purchase of new equipment		9 818	-	-
TOTAL CAPITAL COSTS		13 819	6 803	-
Operating Costs				
Wages and Salaries -				
HQ and Support		797	797	797
RCU		716	716	716
RMU		1 146	1 146	1 146
Casual labour		400	400	400
Vehicles and Equipment -				
HQ and Support		1 011	1 011	1 011
RCU		7 527	8 278	7 599
RMU		3 128	6 418	6 696
Technical Assistance		9 216	9 216	9 216
Training		1 959	1 959	1 152
Other Costs			176	176
10 % contingencies		2 590	3 012	2 891
TOTAL OPERATING COSTS		28 490	33 129	31 800
TOTAL ALL COSTS		42 309	39 932	31 800
Inflation Factor from 1983 @ 8% p.a		1.08	1.17	1.26
FINAL TOTAL COST	- Ssh '000	45 693	46 720	40 068
	US$ '000	2 975	3 042	2 609

TABLE 6.2 ACCESS ROADS - BUILDINGS AND ASSOCIATED EQUIPMENT (Ssh '000)

Item	Rate	Total cost	1984	1985
Mechanical workshops - 460 m^2	7 700/m^2 (1)	3 542	1 771	1 771
Offices and labs - 335 m^2	7 000/m^2	2 345	1 173	1 172
Check in and check out - 16 m^2	7 000/m^2	112	-	112
Paved yard	estimated	750	-	750
Water system	estimated	300	-	300
Workshop equipment	US$ 150 000	2 304	576	1 728
Office equipment	20%	469	117	352
10% contingencies		982	364	619
TOTAL		10 804	4 001	6 803

Notes: (1) *Standard estimating rate of Ssh 7 000/m^2 inflated by 10 per cent to reflect variations proposed in subsection 4.3 above.*

TABLE 6.3 PURCHASE OF NEW EQUIPMENT (1984)

Item	Unit price US$	No	Total price (Ssh '000)
190 HP grader with scarifier	67 970	3	3 132
7 tonne 4 x 4 tipper truck	35 590	5	2 733
5000 L 4 x 4 water tank truck	38 280	3	1 764
25 t semi trailer (tipping)	36 000	1	553
+ 20% spares and contingencies			1 636
TOTAL COST			9 818

TABLE 6.4 WAGES AND SALARIES (HQ AND SUPPORT STAFF)

A. HQ AND SUPPORT STAFF

(i) Access Roads Office Staff

Designation	No.	Salary	Annual cost
Civil Engineer	1	46 800	46 800
Mechanical Engineer	1	46 800	46 800
Surveyor	1	24 000	24 000
Assistant Surveyor	2	18 000	36 000
Draughtsman	1	24 000	24 000
Soils Technician	2	24 000	48 000
Cost Clerk	1	18 000	18 000
Typist	1	12 000	12 000
Driver	4	18 000	72 000
Messenger	1	12 000	12 000
TOTAL	15 No.		Ssh 339 600

(ii) Mechanical Workshop Staff

Designation	No.	Salary	Annual cost
Workshop Foreman	1	28 800	28 800
Mechanic	4	21 600	86 400
Assistant Mechanic	2	14 400	28 800
Vehicle Electrician	2	19 200	38 400
Welder/Blacksmith	3	21 600	64 800
Battery Technician	1	18 000	18 000
Tyre Repairer	1	18 000	18 000
Plumber	1	18 000	18 000
Driver	1	18 000	18 000
Timekeeper	1	14 400	14 400
Watchmen	1	9 000	9 000
TOTAL	17 No.		Ssh 342 600

TABLE 6.4 (Continued)

(iii) Mobile Workshop Staff

Designation	No.	Salary	Annual cost
Plant Foreman	1	24 000	*
Field Mechanics	4	21 600	*
Tyre Repairer	1	18 000	18 000
Vehicle Electrician	1	19 200	19 200
Welder	1	21 600	*
Driver	2	18 000	36 000
TOTAL.	10 No.	Ssh	73 200

* Staff included in Construction Cost Estimates and costed under R.C.U. and R.C.U establishment.

(iv) Spare Parts Stores Staff

Designation	No.	Salary	Annual cost
Stores Clerk	1	18,000	18 000
Storeman	1	14,400	14 400
Watchman	1	9,000	9 000
TOTAL.	3 No.	Ssh	41 400

TOTAL WAGES AND SALARIES = Ssh 796 800

(Note: TA Personnel NOT included)

TABLE 6.4 (Continued)

B. ROAD CONSTRUCTION UNIT

Designation	No.	Salary	Annual cost
Construction Foreman	1	24 000	24 000
Plant Operator	10	19 200	192 000
Trainee	4	14 400	57 600
Driver	10	16 800	168 000
Timekeeper	1	14 400	14 400
Cook	2	12 000	24 000
Watchmen	4	9 000	36 000
Labourer	10	9 000	90 000
Mobile Workshop			
Plant Foreman	1	24 000	24 000
Field Mechanics	3	21 600	64 800
Welder	1	21 600	21 600
TOTAL			Ssh 716 400

TABLE 6.4 (Continued)

C. ROAD MAINTENANCE UNIT

(i) Depot No.1 (Baydhabo)

Designation	No.	Salary	Annual cost
District Supervisor	1	28 800	28 800
Foreman	3	24 000	72 000
Plant Operator	6	19 200	115 200
Trainee	1	14 400	14 400
Driver	8	16 800	134 400
Mason	2	20 000	40 000
Timekeeper	1	14 400	14 400
Watchman	1	9 000	9 000
Labourer	30	9 000	270 000
TOTAL	53 No.		Ssh 698 200

(ii) Depot No.2 (Diinsoor)

Designation	No.	Salary	Annual cost
District Supervisor	1	28 800	28 800
Foreman	2	24 000	48 000
Plant Operator	2	19 200	38 400
Driver	4	16 800	67 200
Mason	2	20 000	40 000
Timekeeper	1	14 400	14 400
Watchman	1	9 000	9 000
Labourer	20	9 000	180 000
Mobile Workshop Staff			
Field Mechanic	1	21 600	21 600
TOTAL	34 No.		Ssh 447 400

D. CASUAL LABOUR

Estimated at Ssh 400 000 per year.

TABLE 6.5 UNIT OPERATING COSTS OF VEHICLES AND EQUIPMENT (Ssh '000)

Item	1983 Cost[1]	Annual Usage	Fuel Use	Lubes Use	Annual Costs: POL[2] Cost	Spares[3] Cost	Tyre[4] Cost	Total Cost	Unit Cost (Ssh)
MB Tractor truck	1044.1	25000 km	2 km/L	.05 L/km	92.5	104.4	128.0	324.9	13.0/km
Semi-trailer - tipper	552.7	25000 km	-	-	-	55.3	102.4	157.7	6.3/km
- fuel	933.5	10000 km	-	-	-	93.4	51.2	144.6	14.5/km
- water	905.9	10000 km	-	-	-	90.6	51.2	141.8	14.2/km
Land Rover pickup	149.0	25000 km	5 km/L	.01 L/km	37.5	14.9	16.0	68.4	2.7/km
Land Rover station wagon	177.4	25000 km	5 km/L	.01 L/km	37.5	17.7	16.0	71.2	2.9/km
7 t Tipper truck	546.7	25000 km	3 km/L	.04 L/km	65.0	54.7	57.0	176.7	7.1/km
5000 L Water tank truck	587.9	12500 km	3 km/L	.04 L/km	32.5	58.8	57.0	148.3	11.9/km
D700 Bulldozer	1406.5	1600 hr	35 L/hr	.3 L/hr	281.6	140.7	75.0	497.3	310.8/hr
D600 Bulldozer	1040.6	1600 hr	30 L/hr	.3 L/hr	243.2	104.1	65.0	412.3	257.7/hr
Grader	1247.3	1600 hr	30 L/hr	.3 L/hr	243.2	124.7	99.8	467.7	292.3/hr
Grader with scarifier	1413.2	1600 hr	30 L/hr	.3 L/hr	243.2	141.3	99.8	484.3	302.7/hr
Front end loader	1248.3	1600 hr	30 L/hr	.3 L/hr	243.2	124.8	99.9	467.9	292.4/hr
Roller - vibrating	924.9	1600 hr	20 L/hr	.3 L/hr	166.4	92.5	-	258.9	161.8/hr
- sheepfoot	1324.4	1600 hr	20 L/hr	.3 L/hr	166.4	132.4	-	298.8	186.6/hr
Mobile workshop	947.0	-	-	-	-	-	-	40.0[5]	-
Compressor	400.7	-	-	-	-	-	-	25.0[5]	-
Generator	316.9	-	-	-	-	-	-	25.0[5]	-

Notes:

1 *Inflated by 8 per cent from 1982 costs.*

2 *Diesel at Ssh 4.81 per litre, petrol at Ssh 5.40 t per litre.*

3 *Estimated 10 per cent per year of initial capital cost.*

4 *MB Tractor truck - 2 sets per year; 10 @ Ssh 6040 each tyre. Tipper trailer - 2 sets per year; 8 @ Ssh 6040 each time.*
Other semi trailers - 1 set per year; 8 @ Ssh 6040 each tyre. Land Rovers - 2 sets per year; 4 @ Ssh 2000 each time.
Small trucks - 2 sets per year; 6 @ Ssh 4750 each tyre.
Bulldozers, costs estimated. Grader and loader - 8 per cent of capital cost.

5 *Estimated.*

TABLE 6.6 CLASS II ROAD CONSTRUCTION COST ESTIMATES

SUMMARY

(a) On Poor Sub-Soil (Type B.6)

TOTAL COST PER KM	=	Ssh 160 520

(b) On Good Sub-Soil (Type A.6)

TOTAL COST PER KM	=	Ssh 145.290

MAX. RATE OF PROGRESS = 1 km PER WEEK

TABLE 6.6 CLASS II ROAD CONSTRUCTION INPUT

(a) On Poor Sub-Soil

No.	Activity	Equipment	No. of Each	Machine Output	Hrs per Wk.	Total Output	Units
1	Clear 20 m R.o.W. (At 3 km/hr)	Bulldozer (D600)	1	0.5625 Ha/hr	35.5	20	Ha
2	Form Embankment	Grader	1	112.5 m^3/hr	30	3375	m^3
3	Excavate Gravel	Bulldozer (D700)	1	(a) Rip 840 m^3/hr (b) Heap 90 m^3/hr	40	3300	m^3
4	Load Gravel	F/E Loader (3 m^3)	1	178.5 m^3/hr	19	3300	m^3
5	Transport Gravel	Tipper (25 T.)	5 *	16.5 m^3/hr	40	3300	m^3
6	Transport Water (6% compacted vol.)	Tanker (25,000L)	1	Exceeds 50,000L per day	-	306 000	L
7	Spread and Grade (6 runs and 3 passes)	Grader	1	950 m^2/hr (1 layer)	9	8550	m^2
8	Compact (6 runs and 5 passes each layer)	Roller (VIB)	1	285 m^2/hr (2 layers)	30	8550	m^2
9	Supply fuel	Tanker (25,000 L)	1	12,500 L per week	-	1 Tanker every two weeks	L

MAXIMUM RATE OF PROGRESS = 1 km PER WEEK

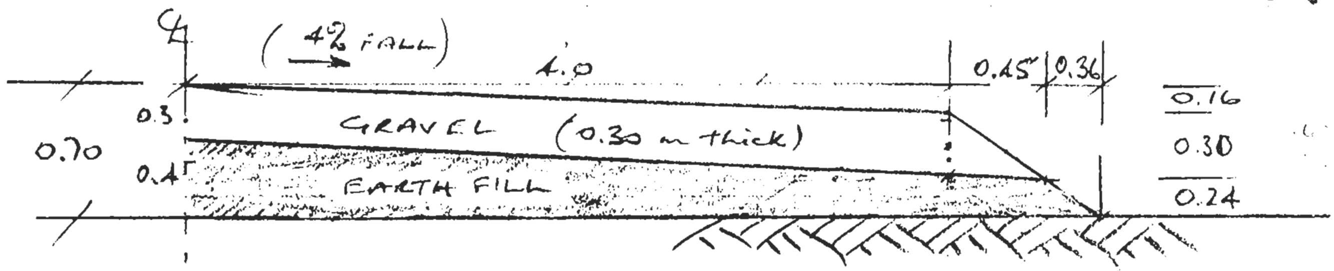
*Note: * No. of tipper trucks control progress - Rate of 16.5m³/hr assumes max. distance to borrow pit is 9 km.*

CLASS II ROAD

MOTT, HAY & ANDERSON
CROYDON, SURREY CR9 2UL

CALCULATIONS FOR QUANTITIES

CALC.BY	CHECKED	DATE	JOB.NO	SHEET NO.
		10.10.83	4.600	1 OF 5



(a) On poor sub-soil

(i) Vol. of earth fill $= 2\left\{\left[\left(\frac{4.81 + 4.45}{2}\right) \times 0.2\right] + \left[\frac{4.45 \times 0.16}{2}\right]\right\}$

$= 2\{[0.926] + [0.356]\}$

$= 2\{1.282\}$

$= 2.564$ cum/metre

(ii) Vol. of gravel $= 2\left[(4 \times 0.3) + \left(\frac{0.45 \times 0.30}{2}\right)\right]$

$= 2[1.2 + 0.0675]$

$= 2.535$ cu.m/metre

Total Volume = 5.099 cu m/metre

= 5100 cu.m/Km.

Assume bulking factor of 1.3

∴ Loose volume = 6630 cu.m/km.

(b) On good sub-soil

(i) Volume of earth fill = 2.564 cu.m/metre
(increased by 100mm thickness)
= 3.424 cu.m/metre

(ii) Volume of gravel = 2.535 cu.m/metre
(decreased by 100 mm thickness)
minus = 1.675 cu.m/metre

(N.B. Total Quantity (sum of (i) & (ii)) is constant)

TABLE 6.6 CLASS II ROAD CONSTRUCTION COST

(a) On Poor Sub-Soil

(1) Vehicles and Plant

	Activity	Equipment		Units	No.	Rate (Ssh)	Cost (Ssh)
1	Clear RoW	Bulldozer	(1)	hrs	36	257.7	9 277
2	Form Embankment	Grader	(1)	hrs	30	292.3	8 769
3	Excavate Gravel	Bulldozer D700	(1)	hrs	40	310.8	12 432
4	Load Gravel	F/E Loader	(1)	hrs	19	292.4	5 556
5	Truck Gravel *	Tipper Truck	(5)	Km	4 000	19.3	77 200
6	Water	Tanker	(1)	Km	650	27.2	17 680
7	Spread and Grade	Grader	(1)	hrs	9	292.3	2 631
8	Compact	Roller	(1)	hrs	30	161.8	4 854
9	Supervision	Land Rover	(2)	Km	400	2.7	1 080
10	Fuel Supply	Tanker	(1)	Km	300	27.5	8 250
	TOTAL					Ssh	147 729

(2) Labour

Designation	No.	Salary	Per Wk.	Cost (Ssh)
Foreman	2	24 000	480	960
Operators (incl. 1 spare)	6	19 200	384	2 304
Trainees	4	14 400	288	1 152
Drivers (incl. 1 spare)	10	16 800	336	3 360
Field Mechanics	4	21 600	432	1 728
Time Keeper	1	14 400	288	288
Cooks	2	12 000	240	480
Watchmen & Labourers	14	9 000	180	2 520
TOTAL	43 No.		Ssh	12 792

ESTIMATED COST PER KM = Ssh 160 520

Note: * *Assumes borrow pit less than 9 Km from site - otherwise costs will increase and rate of progress fall below 1 Km per week.*

TABLE 6.6 CLASS II ROAD CONSTRUCTION INPUT

(b) On Good Sub-Soil

No.	Activity	Equipment	No. of Each	Machine Output	Hrs per Wk	Total Output	Units
1	Clear 20 m RoW (At 3 Km/hr)	Bulldozer (D600)	1	0.5625 Ha/hr	35.5	20	Ha
2	* Form Embankment	Grader & Bulldozer (D700)	1 1	2 x 112.5 m^3/hr	20 20	4 500	m^3
3	Excavate Gravel	Bulldozer (D600)	1	(a) Rip 700 m^3/hr (b) Heap 75 m^3/hr	32	2 200	m^3
4	Load Gravel	F/E Loader	1	178.5 m^3/hr	12.5	2 230	m^3
5	Transport Gravel	Tipper (25T)	4	13.75 m^3/hr	40	2 200	m^3
6	Transport Water (6% Compacted Vol)	Tanker (25.000L)	1	Exceeds 50,000L per day	-	306 000	L
7	Spread and Grade	Grader	1	950 m^2/hr (1 layer)	9	8 550	m^2
8	Compact	Roller (VIB)	2	190 m^2/hr (3 layers)	45	8 500	m^2
9	Supply Fuel	Tanker (25 000L)	1	12 500 L per week	-	1 Tanker every two weeks	L

ASSUMED RATE OF PROGRESS @ 1 Km PER WEEK

*Note: * Assumes that in regosols (red sandy soils) incidence of boulders and rock outcrops will require use of bulldozer with ripper. Some surplus capacity exists for all vehicles and plant.*

TABLE 6.6 CLASS II ROAD CONSTRUCTION COST

(b) On Good Sub-Soil

(1) Vehicles and Plant

Activity	Equipment		Units	No.	Rate (Ssh)	Cost (Ssh)
Clear RoW	Bulldozer (D600)	(1)	hrs	36	257.7	9.277
Form Embankment	Grader	(1)	hrs	20	292.3	5 846
	Bulldozer (D700)	(1)	hrs	20	310.8	6 216
Excavate Gravel	Bulldozer (D600)	(1)	hrs	32	257.7	8 246
Load Gravel	F/E Loader	(1)	hrs	13	292.4	3 801
Truck Gravel *	Tipper Truck	(4)	Km	3 200	19.3	61 760
Water	Tanker	(1)	Km	650	27.2	17 680
Spread and Grade	Grader	(1)	hrs	9	292.3	2 631
Compact	Roller	(2)	hrs	45	161.8	7 281
Supervision	Land Rover	(2)	Km	400	2.7	1 080
Fuel Supply	Tanker	(1)	Km	300	27.5	8 250
TOTAL					Ssh	132,068

(2) Labour

Designation	No.	Salary	Per Week	Cost (Ssh)
Foreman	2	24 000	480	960
Operators (incl. 1 spare)	8	19 200	384	3.072
Trainees	4	14 400	288	1 152
Drivers (incl. 1 spare)	9	16 800	336	3.024
Field Mechanics	4	21 600	432	1.728
Time Keeper	1	14 400	288	288
Cooks	2	12 000	240	480
Watchmen and Labourers	14	9 000	180	2.520
TOTAL	44 No.			Ssh 13.224

ESTIMATED COST PER KM = Ssh 145 290/-

Note: * *Assumes borrow pit 11 Km from site - otherwise 5th truck will be required and cost will increase accordingly.*

TABLE 6.7 CLASS III ROAD CONSTRUCTION COST ESTIMATES

SUMMARY

(a) On Poor Sub-Soil (Type B.4)

TOTAL COST PER KM = Ssh 122 740

(b) On Good Sub-Soil (Type A.4)

TOTAL COST PER KM = Ssh 80.450

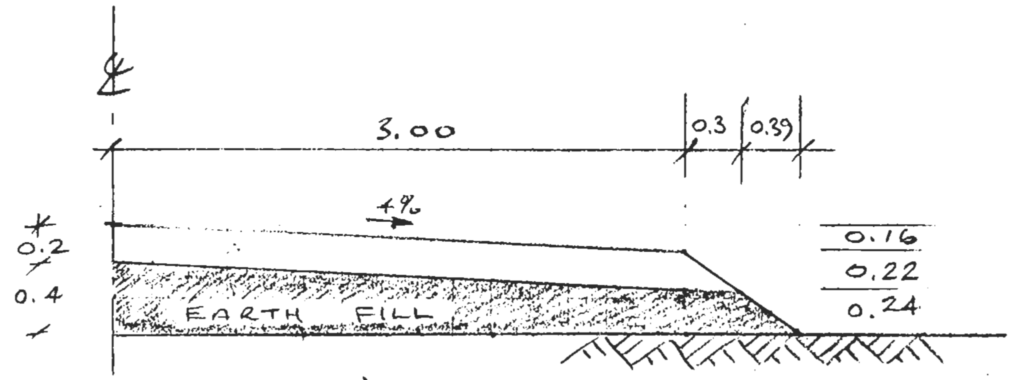
MAX. RATE OF PROGRESS = 1.25 Km per week

CLASS III ROAD

MOTT, HAY & ANDERSON

CROYDON, SURREY CR9 2UL

CALCULATIONS FOR	CALC. BY	CHECKED	DATE	JOB. NO	SHEET NO.
QUANTITIES			10.10.83	4.600	1 of 5



(a) On poor sub-soil

(i) VOL. OF EARTH FILL $= 2\left\{\left[\left(\frac{3.69+3.3}{2}\right)\times 0.24\right]+\left[\frac{3.3\times 0.16}{2}\right]\right\}$

$= 2\{[0.8388]+[0.264]\}$

$= 2\{1.1028\}$

$=$ 2.206 cu.m/metre

(ii) VOL. OF GRAVEL $= 2\left[(3\times 0.2)+\left(\frac{0.3\times 0.22}{2}\right)\right]$

$= 2[0.6 + 0.033]$

$=$ 1.266 cu.m/metre

Total Volume = 3.472 cu.m/metre

= 3500 cu.m/Km

Assume bulking factor of 1.3

∴ Loose Volume = 4550 cu.m/Km.

(b) On good sub-soil

(i) VOLUME OF EARTH FILL = 2.836 cu.m/metre
(increased by 100 mm thickness)

(ii) VOLUME OF GRAVEL = 0.636 cu.m/metre
(decreased by 100 mm thickness)

(N.B. Total Quantity (sum of (i) & (ii)) is constant)

TABLE 6.7 CLASS III ROAD CONSTRUCTION INPUT

(a) On Poor Sub-Soil

No.	Activity	Equipment	No. of Each	Machine Output	Hrs per Wk	Total Output	Units
1	Clear 20 m RoW (At 3 Km/hr)	Bulldozer (D600)	1	0.5625 Ha/hr	40	22.5	Ha
2	Form Embankment	Grader	1	112.5 m^3/hr	25	2 800	m^3
3	Excavate Gravel	Bulldozer (D700)	1	(a) Rip 840 m^2/hr (b) Heap 90 m^3/hr	25	2 100	m^3
4	Load Gravel	F/E Loader (3 m^3)	1	178.5 m^3/hr	12	2 142	m^3
5	Transport Gravel	Tipper (25T)	5	10.5 m^3/hr	40	2 100	m^3
6	Transport Water (6% Compact Vol)	Tanker (25 000 L)	1	Exceeds 50 000 L Per day	-	275 000	L
7	Spread and Grade (6 runs & 3 passes)	Grader	1	1,100 m^2/hr (1 layer)	7.5	8 250	m^2
8	Compact (6 runs & 5 passes each layer)	Roller (VIB)	1	330 m^2/hr (2 layers)	25	8 250	m^2
9	Supply Fuel	Tanker (25 000 L)	1	12 500 L per week	-	1 Full Tank every 2 weeks	L

TABLE 6.7 CLASS III ROAD CONSTRUCTION COST

(a) On Poor Sub-Soil

(1) Vehicles and Plant

	Activity	Equipment		Units	No.	Rate (Ssh)	Cost (Ssh)
1	Clear RoW	Bulldozer (D600)	(1)	hrs	40	257.7	10 308
2	Form Embankment	Grader	(1)	hrs	25	292.3	7 308
3	Excavate Gravel	Bulldozer (D700)	(1)	hrs	25	310.8	7 770
4	Load Gravel	F/E Loader	(1)	hrs	12	292.4	3 509
5	Truck Gravel *	Tipper Truck	(5)	Km	4 200	19.3	81 060
6	Water	Tanker	(1)	Km	550	27.2	14 960
7	Spread and Grade	Grader	(1)	hrs	8	292.3	2 338
8	Compact	Roller	(1)	hrs	25	161.8	4 045
9	Supervision	Land Rover	(2)	Km	400	2.7	1 080
10	Fuel Supply	Tanker	(1)	Km	300	27.5	8 250
TOTAL						Ssh	140 628

(2) Labour

Designation	No.	Salary	Per Week	Cost (Ssh)
Foreman	2	24 000	480	960
Operators (incl. 1 spare)	6	19 200	384	2 304
Trainees	4	14 400	288	1 152
Drivers (incl 1 spare)	10	16 800	336	3 360
Field Mechanics	4	21 600	432	1 728
Timekeeper	1	14 400	288	288
Cooks	2	12 000	240	480
Watchmen and Labourers	14	9 000	180	2 520
TOTAL	43 No.		Ssh	12 792

TOTAL COSTS FOR 1.25 Km = Ssh 153 420

ESTIMATED COSTS PER KM = Ssh 122 736

Note: * *Assumes Borrow pit approx. 15 Km from site - for lesser distance number of trucks can be reduced and cost will reduce accordingly.*

TABLE 6.7 CLASS III ROAD CONSTRUCTION INPUT

(b) On Good Sub-Soil

No.	Activity	Equipment	No. of Each	Machine Output	Hrs per Wk	Total Output	Units
1	Clear 20 m RoW (At 3 Km/hr)	Bulldozer (D600)	1	0.5625 Ha/hr	40	22.5	Ha
2	Form Embankment	Grader and Bulldozer (D700)	1 1	2 x 112.5 m^3/hr	20.5 20.5	4610	m^3
3	Excavate Gravel	Bulldozer (D600)	1	(a) Rip 700 m^3/hr (b) Heap 75 m^3/hr	15	1 050	m^3
4	Load Gravel	F/E Loader	1	178.5 m^3/hr	6	1 050	m^3
5	Transport Gravel	Tipper (25T)	2	15 m^3/hr	35	1 050	m^3
6	Transport Water	Tanker (25,000 L)	1	Exceeds 50 000 L per day	-	275 000	L
7	Spread & Grade	Grader	1	1 100 m^2/hr (1 layer)	2.7	8 250	m^2
8	Compact	Roller (VIB)	1	220 m^2/hr (3 layers)	37.5	8 250	m^2
9	Supply Fuel	Tanker (25 000 L)	1	12.500 L per week	-	1 Full Tank every 2 weeks	L

TABLE 6.7 CLASS III ROAD CONSTRUCTION COST

(b) On Good Sub-Soil

(1) Vehicles and Plant

Activity	Equipment		Units	No.	Rate (Ssh)	Cost (Ssh)
Clear RoW	Bulldozer (D600)	(1)	hrs	40	257.7	10 308
Form Embankment	Grader	(1)	hrs	21	292.3	6 138
	Bulldozer (D700)	(1)	hrs	21	310.8	6 527
Excavate Gravel	Bulldozer (D600)	(1)	hrs	15	257.7	3 866
Load Gravel	F/E Loader	(1)	hrs	6	292.4	1 754
Truck Gravel	Tipper Truck	(2)	Km	1,400	19.3	27 020
Water	Tanker	(1)	Km	550	27.2	14 960
Spread and Grade	Grader	(1)	hrs	8	292.3	2 338
Compact	Roller	(1)	hrs	38	161.8	6 148
Supervision	Land Rover	(2)	Km	400	2.7	1,080
Fuel Supply	Tanker	(1)	Km	300	27.5	8 250
TOTAL					Ssh	88 390

(2) Labour

Designation	No.	Salary	Per Week	Cost (Ssh)
Foreman	2	24 000	480	960
Operators (incl. 1 spare)	7	19 200	384	2 688
Trainees	4	14 400	288	1.152
Drivers (incl 1 spare)	7	16 800	336	2 352
Field Mechanics	4	21 600	432	1 728
Timekeeper	1	14.400	288	288
Cooks	2	12 000	240	480
Watchmen and Labourers	14	9 000	180	2 520
TOTAL	41 No.		Ssh	12 168

TOTAL COSTS FOR 1.25 Km = Ssh 100 558

ESTIMATED COST PER Km = Ssh 80 446

TABLE 6.8

RE-GRAVELLING

OF EXISTING CLASS II ROAD (TYPE C.7)

COST ESTIMATE

SUMMARY

TOTAL COST PER KM = Ssh 69 510

MAX RATE OF PROGRESS = 1.2 Km per week

TABLE 6.8 EXISTING CLASS II ROAD RE-GRAVELLING CONSTRUCTION INPUT

No.	Activity	Equipment	No. of Each	Machine Output	Hrs per Wk.	Total Output	Units
1	Scarify & Re-shape (12 runs @ 2 Km/hr)	Grader	1	1,100 m^2/hr	8	8 800	m^2
2	Excavate Gravel	Bulldozer (D600)	1	(a) Rip 700m^3/hr (b) Heap 75 m^3/hr	27	1 800	m^3
3	Load Gravel	F/E Loader	1	178.5 m^3/hr	10.5	1 875	m^3
4	Transport Gravel *	Tipper (25T)	3	15 m^3/hr	40	1 800	m^3
5	Transport Water (6% compacted Vol)	Tanker (25,000 L)	1	4 trips per week (50 Km ea.)	-	100 000	L
6	Spread & Grade (6 runs & 3 passes)	Grader	1	950 m^2/hr (1 layer)	9.25	8 800	m^2
7	Compact (6 runs & 5 passes each layer)	Roller (VIB)	1	550 m^2/hr (1 layer)	16	8 800	m^2
8	Supply Fuel	Tanker	1	8 000 L per week	-	1 tanker every 3 weeks	

MAXIMUM RATE OF PROGRESS = 1.2 Km PER WEEK

*Note: * Number of tipper trucks control progress - if haul distance exceeds 10 Km, rate of progress will fall and costs increase.*

TABLE 6.8 EXISTING CLASS II ROAD RE-GRAVELLING COST ESTIMATE

(a) Vehicles and Plant

	Activity	Equipment		Units	No.	Rate	Cost
1	Scarify & Re-shape	Grader	(1)	Hrs	8	302.7	2 422
2	Excavate Gravel	Bulldozer (D600)	(1)	Hrs	27	267.7	6 958
3	Load Gravel	F/E Loader	(1)	Hrs	11	292.4	3 216
4	Transport Gravel	Tipper Truck	(3)	Km	2 400	19.3	46 320
5	Water (25 Km haul)	Tanker	(1)	Km	200	27.2	5 440
6	Spread & Grade	Grader	(1)	Hrs	10	302.7	3 027
7	Compact	Roller (VIB)	(1)	Hrs	16	161.8	2 589
8	Supervision	Land Rover	(1)	Km	300	2.7	810
9	Fuel Supply	Tanker		Km	200	27.5	5 500
TOTAL						Ssh	76 282

(b) Labour

Description	No.	Salary	Per Week	Cost (S.Sh)
Foreman	1	24 000	480	480
Operators (incl. 1 spare)	5	19 200	384	1 920
Trainees	1	14 400	288	288
Drivers (incl. 1 spare)	5	16 800	336	1 680
Field Mechanics	1	21 600	432	432
Timekeeper	1	14 400	288	288
Cook	1	12 000	240	240
Watchmen & Labourers	10	9 000	180	1 800
TOTAL	23 No.		Ssh	7 128

TOTAL COST FOR 1.2 Km = Ssh 83 410

ESTIMATED COST PER KM = Ssh 69 508

TABLE 6.9 VEHICLE AND PLANT OPERATING COSTS

(1) H.Q. and Logistical Support Vehicles

Vehicle	No.	Unit Rate (Ssh)	Annual Cost (Ssh)
Land Rover Pickup	5	68 400	342 000
Land Rover Station Wagon	3	71 240	213 720
Fuel Tanker Semi-Trailer	1	275 000	275 000
Mobile Workshops	2	40 000	80 000
Compressors	2	25 000	50 000
Generators	2	25 000	50 000
		TOTAL	**1 010 720**

Costs incurred equally in all years

(2) R.C.U.

Year	No.	Item	Class	Unit Rate (Ssh)	Annual Cost (Ssh)
1984	7	Km of	A6	145 290	
	39	Km of	B6	160 520	
	10	Irish Bridges		25 000[1]	7 527 310
1985	16	Km of	A6	145 290	
	36	Km of	B6	160 520	
	7	Irish Bridges		25 000[1]	8 278 360
1986	8	Km of	A4	80 450	
	36	Km of	B4	122 740	
	13	Km of	B6	160 520	
	18	Irish Bridges		25 000[1]	7 599 000

Note: [1] *Assumed Contract Price.*

(3) R.M.U.

(i) Re-gravelling

1984	45	Km	@	69 510	=	3 127 950
1985	62	Km	@	69 510	=	4 309 620
1986	66	Km	@	69 510	=	4 587 660
						12 025 230

(ii) Grading Units (2 No)

Grader :	2	@	484 300	=	968 600
7-T Truck :	2	@	176 670	=	353 340
					1 321 940

(1985 & 1986 only)

(iii) Works Units (2 No)

7-T Truck :	2	@	176 670	=	353 340
5,000 Lt Tanker	2	@	148 290	=	296 580
					649 920

(1985 & 1986 only)

(iv) District Supervision

Land Rover Pick-up	2	@	68 400	=	136 800

(1985 & 1986 only)

(v) Annual Summaries

	1984	1985	1986
Regravelling	3 127 950	4 309 620	4 587 660
Grading Units	-	1 321 940	1 321 940
Works Units	-	649 920	649 920
District Supervision	-	136 800	136 800
Total	**3 127 950**	**6 418 280**	**6 696 320**

TABLE 6.10 TECHNICAL ASSISTANCE, TRAINING AND OTHER COSTS

1. Technical Assistance

Assume 6 persons per year from 1984 onwards.

Total cost per person	=	US $	100 000

This covers remuneration, travel, mobilisation, field allowances and accommodation.

Annual cost	=	Ssh	9 216 000

2. Training

Assume 1 person on 27 month M. Eng. course in 1984 and 1 in 1985

Assume 3 persons on 9 months technical training courses each year

Cost of M. Eng. course per person	=	US$ 52 550	=	Ssh 807 170
Cost of technical training per person	=	US$ 25 000	=	Ssh 384 000

1984 and 1985 cost	=	Ssh	1 959 170
1986 cost	=	Ssh	1 152 000

3. Other Costs

Building Maintenance at 2½% of Capital Value from 1985 onwards

Annual Cost	=	Ssh	176 225

Bay Region Agricultural Development Project

Mid-term Review

Volume 3

Annex 4 Water Supply

310261 57 83

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Introduction

1.1 OBJECTIVES

The main objective of the water supply component of this study is to review the progress of the activities undertaken by the Water Development Agency (WDA) and their consultants, the consortium of Louis Berger International Inc., and Roscoe Moss Company (LBI/RM), in relation to the aims of the Bay Region Agricultural Development Project (BRADP). At the planning stage of the BRADP, water development was to be included under the responsibilities of the Project Management Unit; however WDA concluded a wider agreement for technical assistance with the USAID and it was convenient to carry out the water supply work of the BRADP as a part of this wider programme.

Specifically mentioned in the Terms of Reference for the Mid Term Review are the following objectives:

- review the activities of the WDA/USAID groundwater programme in the Bay Region from the point of view of crop and livestock production and its influence on the quality of life;

- give particular attention to the location of new water sites;

- review the adequacy of the present programme to provide water to all critical areas;

- determine the adequacy of the provisions for stock watering sites;

- suggest any ecological problems which might arise at the new water sites;

- give special attention to the areas reported by Hunting Technical Services as being currently underutilised during the dry season because of the lack of water;

- evaluate the potential for groundwater irrigation in the Limestone Depression in the light of the latest drilling results;

- make recommendations and cost estimates for any constructions not included in the present plans.

We have consolidated these objectives as follows:

- review the plans for water supply development in the Region made by various agencies since 1977;
- evaluate the progress of the current WDA/LBI/RM programme in terms of the plans;
- review the results of the current WDA/LBI/RM programme in terms of water supply for domestic, livestock and irrigation demands;
- assess the adequacy of both the planning and the work implemented from the point of satisfying the water demand in the Region;
- make recommendations for any work considered necessary but not included in the present programme;
- review the financial position of the water supply component of the Project and make recommendations for any refinancing required to complete all the necessary work.

1.2 BACKGROUND

The Bay Region is located in the Inter-riverine zone of Somalia, between the Jubba and Shabeelle Rivers. Its climate is semi-arid with strongly seasonal rainfall; the whole Region contains no natural perennial surface water bodies; hence water supplies during the dry season can only be obtained by storing the wet season surface flows or from groundwater sources.

In the absence of large rivers and good storage sites, surface water is stored in excavated and bunded basins or reservoirs, called 'wars'. These water harvesting structures vary from slightly deepened natural depressions, with capacity sometimes of no more than 100 m^3, to major properly designed and engineered structures, with storage capacity of up to 30 000 m^3. The large wars have been constructed with foreign aid and many of them provide reliable, year-round supplies of drinking water for people and livestock. The smaller village wars usually run out of water a few weeks after the end of the rains.

Groundwater sources utilised for water supply include springs, dug wells and boreholes. All of these normally offer reliable supplies but in parts of the Region they are few and far between. The great majority of the springs occur on the Limestone Escarpment; dug wells are constructed in clusters at suitable sites in wadi channels on Basement Complex and in the neighbourhood of Baydhabo on the Limestone Plateau where a perched groundwater body exists with a relatively high water table; most of the successful boreholes are located on the Limestone Plateau, but a few tap fracture systems or the weathered zone of the Basement area.

Of special interest are a few small groundwater irrigation systems found in the Region. All of these are located at or near the Escarpment and rely on existing sources such as springs or sink holes enlarged by digging, and equipped with centrifugal pumps. In most cases the irrigated areas are small, a few hectares in size.

Taking the Bay Region as a whole, water is in very short supply during the dry season. In some areas, over much of the Limestone Plateau, this situation can be easily remedied by drilling wells, but on the Basement outcrop in particular, provision of perennial supplies may be difficult and expensive. Currently some of the villages in the cropped areas of the Basement are abandoned for much of the dry season as the population moves to some perennial source of water. In many locations all over the Region, people spend a substantial proportion of their time walking up to 20 km for water.

Clearly, the water supply situation in parts of the Region is unsatisfactory from the point of view of quality of life. It is also argued that lack of reliable supplies of water is a major constraint to increasing livestock and crop production; the enforced migration by farmers with their livestock to perennial water supplies is considered to have limited the intensity of crop cultivation and to have imposed a serious constraint on efficient use of the range for livestock production. Though some of these contentions are arguable, the quality of life consideration is taken to be overriding.

2

Water Resources

2.1 CLIMATE

2.1.1 General

The Bay Region has a tropical semi-arid climate with generally high daytime temperatures and only moderate diurnal and seasonal variations. There are two rainy seasons, the Gu in April and May, and the Dayr in October and November. The two intervening dry seasons are known as the Jillal (December to March) and the Haggai (June to September).

Only four climatic stations have ever operated within the Bay Region. The station at Baydhabo has operated periodically since 1922, Boonkay has been operational since 1978, Buurhakaba has 40 years of intermittent rainfall records but little other climatic data, and Diinsoor recorded rainfall only intermittently for six years. Several stations beyond the Project Area are useful for determining areal variations of rainfall, but the overall density is still too low for this to be done with any degree of accuracy.

The climatic data was analysed by HTS and summarised in their report of August 1982.

2.1.2 Rainfall

The rainfall records at Baydhabo were given in the FAO/World Bank project preparation report and can be summarised as follows:

Probability of Occurrence	Rainfall in mm		
	Gu	Dayr	Annual
Median (50%)	286	231	578
3 years in 4 (75%)	197	131	428
1 year in 4 (25%)	375	331	728

In the above table the Gu is defined as March to June and the Dayr as October to December. The HTS report, ignoring rainfall in June and December in the seasonal totals, gave the following figures for Baydhabo:

Probability of Occurrence	Rainfall in mm		
	Gu	Dayr	Annual
Median (50%)	240	215	547
3 years in 4 (75%)	181	129	441
1 year in 5 (20%)	344	344	740

The HTS report also updates the record and hence obtains different figures for annual as well as seasonal rainfall.

As HTS indicate, the choice of two whole months for each rainy season is purely arbitrary, but inevitable where daily data are not available. Each rainy season normally lasts for a period of considerably less than two months. The following data for Baydhabo is given by HTS:

Season	1 Year in 4		Median		3 Years in 4	
	Start	Duration	Start	Duration	Start	Duration
Gu	April 1	49 days	April 9	38 days	April 17	27 days
Dayr	Oct 2	46 days	Oct 10	33 days	Oct 18	20 days

No corresponding analyses are given for the duration of the intervening dry seasons, but from the above it may be deduced that the average length of the Jillal is about five months. The Jillal is the more severe dry season and its duration is significant in assessing the performance of wars.

Rainfall outside the Gu and Dayr seasons can be appreciable but is erratic and unreliable. The analysis of Baydhabo data by FAO/World Bank indicates median rainfall to be zero in January and February, 6 mm in December and 12 mm in March. The dry season rainfall may therefore be assumed to make a negligible contribution to the replenishment of either groundwater or surface water resources during a typical year.

Isohyetal maps were constructed by HTS (1982) on the basis of rainfall stations in and around the project area, allowance being made for differences in location. The isohyets for the median and 3 in 4 years annual rainfall are given in Figures 2.1 and 2.2.

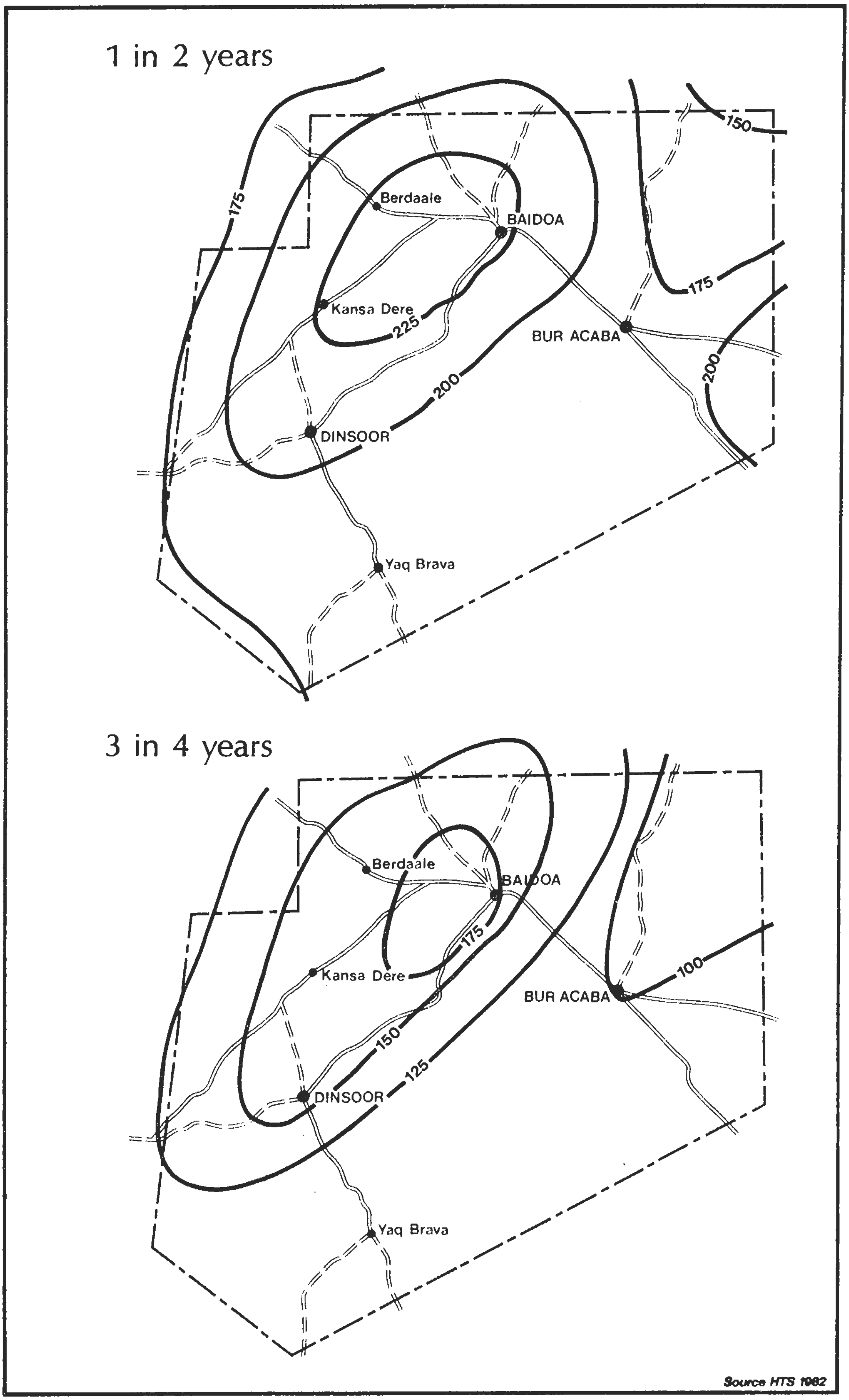
2.1.3 Temperature

The mean annual temperature is 26.3°C and mean monthly temperatures vary only about 2°C either side of this figure. Diurnal temperature variations may however be appreciable so that the maximum daily temperatures reach 35.5°C in February with the minimum night-time temperature falling to 16.1°C. In July mean maximum temperatures are 28.8°C and mean minimum temperatures 18.6°C.

2.1.4 Sunshine

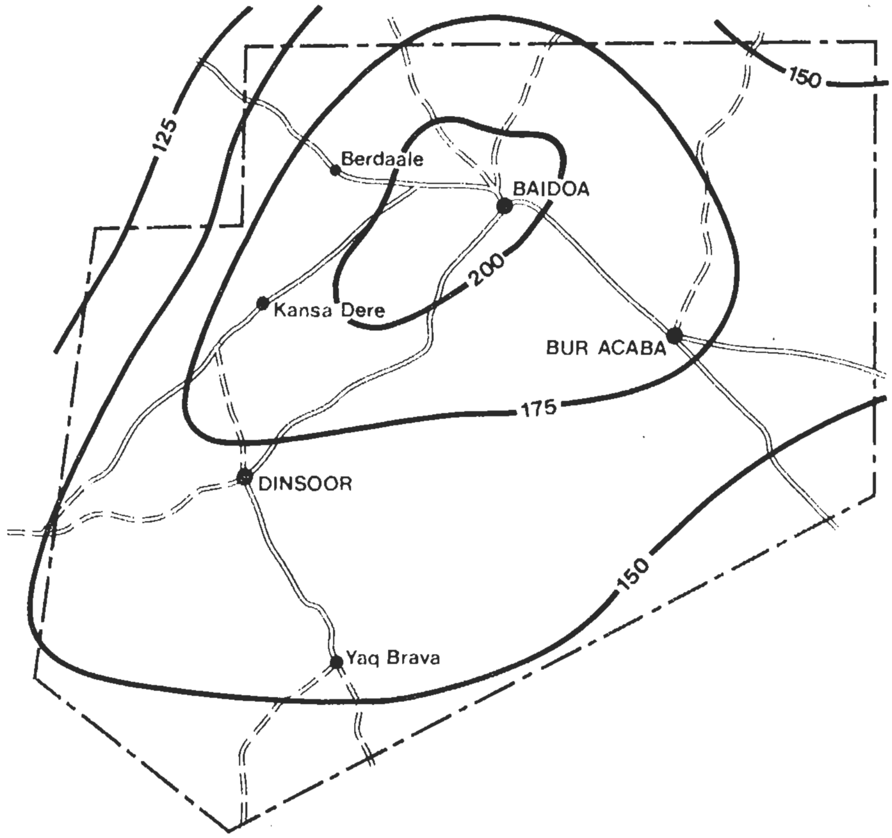
Sunshine records are only available for very short periods from the Boonkay climatic station. Cloud cover recorded at Baydhabo averages about 45 per cent throughout the year. There are however wide short term fluctuations as well as seasonal variations.

2.1 Gu season rainfall isohyets (mm)

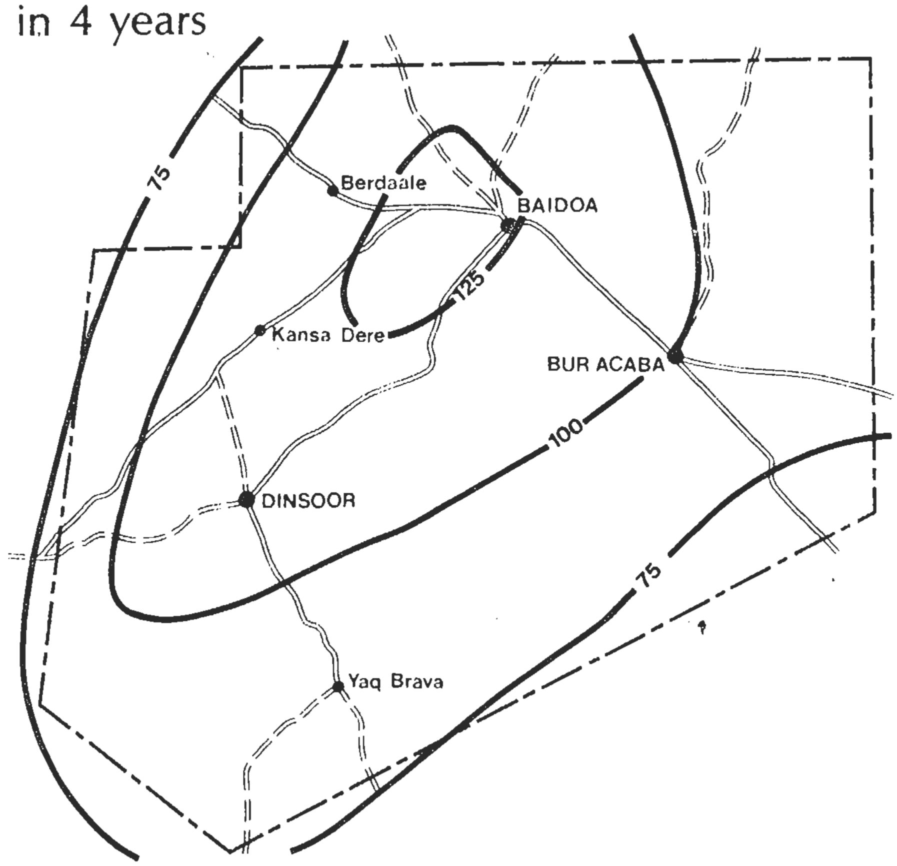


2.2 Dayr season rainfall isohyets (mm)

1 in 2 years



3 in 4 years



Source HTS 1982

2.1.5 Relative Humidity

Relative humidity averages 65-75 per cent with highest values in the Gu and Dayr seasons and lowest values during January to March.

2.1.6 Wind Speed and Direction

Wind speed reaches a peak of about 4 m/sec in June. It is lowest during the wet seasons. The wind is predominantly from the east during November to March and from south-south-west from June to September.

2.1.7 Evapotranspiration

Figures for potential evapotranspiration are quoted by FAO/World Bank and by HTS; the former gives a total annual potential evapotranspiration for Baydhabo of 1468 mm, the latter 2250 mm. The basis of the calculations are different and figures may refer to different parameters (open water surface or reference crop evapotranspiration). However the difference is substantial, particularly during the critical Jillal period when estimates during an average year would vary from 650 mm to nearly 1100 mm. The evaporation from an open water surface during this period is critical to performance of wars.

2.2 SURFACE WATER

There are no perennial rivers in the Project Area, apart from short streams fed by springs along the Baydhabo Escarpment. The discharges of the springs are generally small, the largest recorded flows by LBI/RM (1983) being 16.5 l/s at the Baydhabo spring and 12.6 l/s at Manaas (approximately 30 km from Baydhabo towards Diinsoor); however it is not clear whether these refer to average or minimum discharges or whether they are spot measurements at some particular time during a dry season; karst spring discharges can be expected to show a quick response to rainfall. The springs are sometimes used for irrigation (as at Baydhabo) or provide potable and livestock suppliesand are lost by evapotranspiration from natural vegetation.

The majority of rivers and streams only flow immediately after heavy rainfall. On the Basement Complex outcrop a distinct dendritic drainage pattern, running mainly north-west to south-east, is clearly visible on aerial photographs and satellite imagery. Occasionally incised channels are formed, but more often the channels are broad and shallow; these may be underlain by alluvial deposits, which are a useful source of groundwater.

Most of the Basement drainage lines originate at the Limestone Escarpment where steeper land slopes occur. Only one of the channels extends for any distance onto the Plateau; this is the Togga Sheikh Asharow, which passes through Baydhabo and carries some base flow up to two months after the end of the rainy season; it also has some sinkholes in its bed which are still used as water sources by the local population.

The catchments of most of Basement streams are small. Apparently none of the flows have ever been gauged, but judging by the size of the channels, these must be large on occasions. The general flow direction is towards the Shabeelle valley but none of the channels actually reach that river. Apparently the flows are of such short duration that they infiltrate into the soil and are evapotranspirated mainly within the Project Area.

On limestone outcrops a drainage pattern is seldom clearly visible except on the Escarpment. Elsewhere the generally flat topography, the relatively high permeability of the underlying rock and the high infiltration capacity of the soils, result in rapid transfer of rainfall to the subsurface where it is held in soil storage and eventually evapotranspired or passes to the groundwater reservoir. It is of interest to note that surface drainage lines are seldom developed even on the heavy clay soils of the Limestone Plateau; this is thought to be due to the very high infiltration capacity of these soils when dry and cracked. Apparently the intensity and duration of the rains are not sufficient to fill the soil moisture reservoir and to produce appreciable run-off.

Thus in the Region as a whole, very little surface water exists outside the rainy seasons. Storage of surface flows seems the obvious way of improving water supply, but unfortunately good storage sites are difficult to find. The Escarpment, which may have the right topography in places for relatively large dammed reservoirs, is mainly underlain by strongly karstified limestone, in which subsurface leakage would be a major problem. Elsewhere, in the very flat topography, reservoirs normally have to be excavated to below ground level. Such excavated ponds or wars are used very extensively for both on-stream and off-stream storage but most of them are small, easily damaged by floods, subject to rapid siltation and generally do not provide a year-round supply. A special case of wars are the storage reservoirs at the granite inselbergs or 'buurs'. Some of these are considerable in size and because of their steep slopes and non-absorbent surface, the run-off from them is very fast; many of them have earth embankments constructed at their bases to intercept and store this run-off.

The quality of most of the surface water in the Region is generally good in terms of mineralisation but carries a high silt load and is subject to bacteriological pollution.

2.3 GROUNDWATER

2.3.1 Introduction

The main source of information on the hydrogeology of the Bay Region has been the programme undertaken by WDA and their consultants LBI/RM. The recent report issued by the consultants under the title "Exploratory Report for the Bay Region" in February 1983, contains their results up to that time; since then several more boreholes have been drilled in the Region, the results of which are available in the LBI/RM files.

Prior to the current WDA programme very little systematic groundwater work had been done in the Bay Region or for that matter any other part of Somalia. Consequently the information on which the pre-project planning (described in Chapter 4) was based, was weak.

2.3.2 Review of Relevant Literature

Geology of Somalia in general and the Bay Region in particular is fairly well covered in published material. The earliest work in this field was done by Italian Geologists in the 1920s and 1930s (e.g. Stefanini 1925 and 1933). More recently, oil related work and academic studies have produced useful discussions of geology, relevant to groundwater occurrence (Beydoun, 1970; Beltrandi and Pyre, 1973; and Barnes, 1976). The Beltrandi and Pyre paper is particularly useful as it deals with the Jurassic succession of southern Somalia and discusses its lithology; it is the Jurassic that contains the major limestone aquifers of the Project Area.

It appears that the earliest overall appraisal of Somalia's hydrogeology was carried out by Ahrens and Azzaroli in 1951; their work divided the country into groundwater provinces, based largely on geology and physiography, and made recommendations for further investigations. Necessarily this work was of a qualitative nature and discussed the groundwater resources of Somalia largely in terms of theoretical concepts.

This pioneering work was followed by several equally generalised discussions of the hydrogeology of Somalia (Wilson, 1958; Dijon, 1967; and FAO/Lockwood, 1968). It was not until 1973 that a proper record of Somalia's groundwater resources was compiled and published in a UNDP report, "Mineral and Groundwater Survey, Phase II". This summarises all the previous work on the subject and gives the results of an extensive inventory of wells and boreholes; this report should be the starting point of all the regional groundwater surveys and development projects in Somalia. Unfortunately it is very difficult to obtain which to some extent defeats its purpose.

Another countrywide appraisal of the groundwater resources was done by Johnson (1978) on behalf of FAO. This was a conceptual desk study based largely on the UNDP report. It discusses the subject in terms of provinces and sub-regions and offers positively expressed professional opinion on the likely occurrence of exploitable fresh water aquifers.

There are also some technical reports dealing specifically with the groundwater of the Project Area. The most substantial of these is Idrotecneco's discussion of the Buur Region (1976). This gives a full discussion of the groundwater resources of the Basement Complex metamorphics based on extensive fieldwork, including an inventory of existing wells. Rather more speculative is Johnson's work (1977) on the Bay Region, in which predictions of exploitable fresh groundwater occurrence are made on the basis of very scant field evidence.

Discussions dealing with groundwater of the Region, specifically in relation to this project are contained in the FAO/World Bank Cooperative Programme Project preparation report (1977), the IDA Appraisal Report (1979) and the HTS resource evaluation (1982).

2.3.3 Geological Setting

The whole of Somalia lies on the East African Shelf, a region of mainly flat lying sedimentary rocks on the eastern flank of the African Shield, the core of the continent. The region has been one of relative tectonic stability and the sedimentary strata show little structural deformation. It is however affected by normal faulting resulting from the crustal tension associated with the great East African rift valleys of the neighbouring countries. Within Somalia, several major faults have been mapped, particularly those with NE-SW trend (Figure 2.3).

The Bay Region is located near the junction of two major structural units: the Buur Region Horst and the Mandera-Lugh Basin. Mandera-Lugh Basin is characterised by the occurrence of a thick sequence of Mesozoic sediments comprising mainly carbonates with suboordinate marls, shales and evaporites. The Buur block has probably been a land mass since Jurassic times, and its ancient metamorphic rocks occur either at the surface or under a thin cover of residual or recent alluvial deposits (Beltrandi and Pyre, 1973).

The overall stratigraphic sequence of the Region is given in Table 2.1.

The Bur Akaba metamorphics occur in a large outcrop in the south-east of the Region (the Buur lowland); it is a virtual peneplain, occasionally dramatically interrupted by spectacular inselbergs of granitic rocks (Bur Igneous Intrusives). The lower members of the Jurassic sequence form a prominent south and south-east facing escarpment (the Baydhabo Escarpment); the Jurassic strata stretch to the north of the Escarpment, with a general north-westerly dip, forming the Limestone Plateau. In the east of the Region, a thin remnant of the limestone formation occurs below the Escarpment, forming the Limestone Depression (Figure 2.4). According to the latest drilling results, this is a down-faulted block of

2.3 Generalised Geology of Southern Somalia

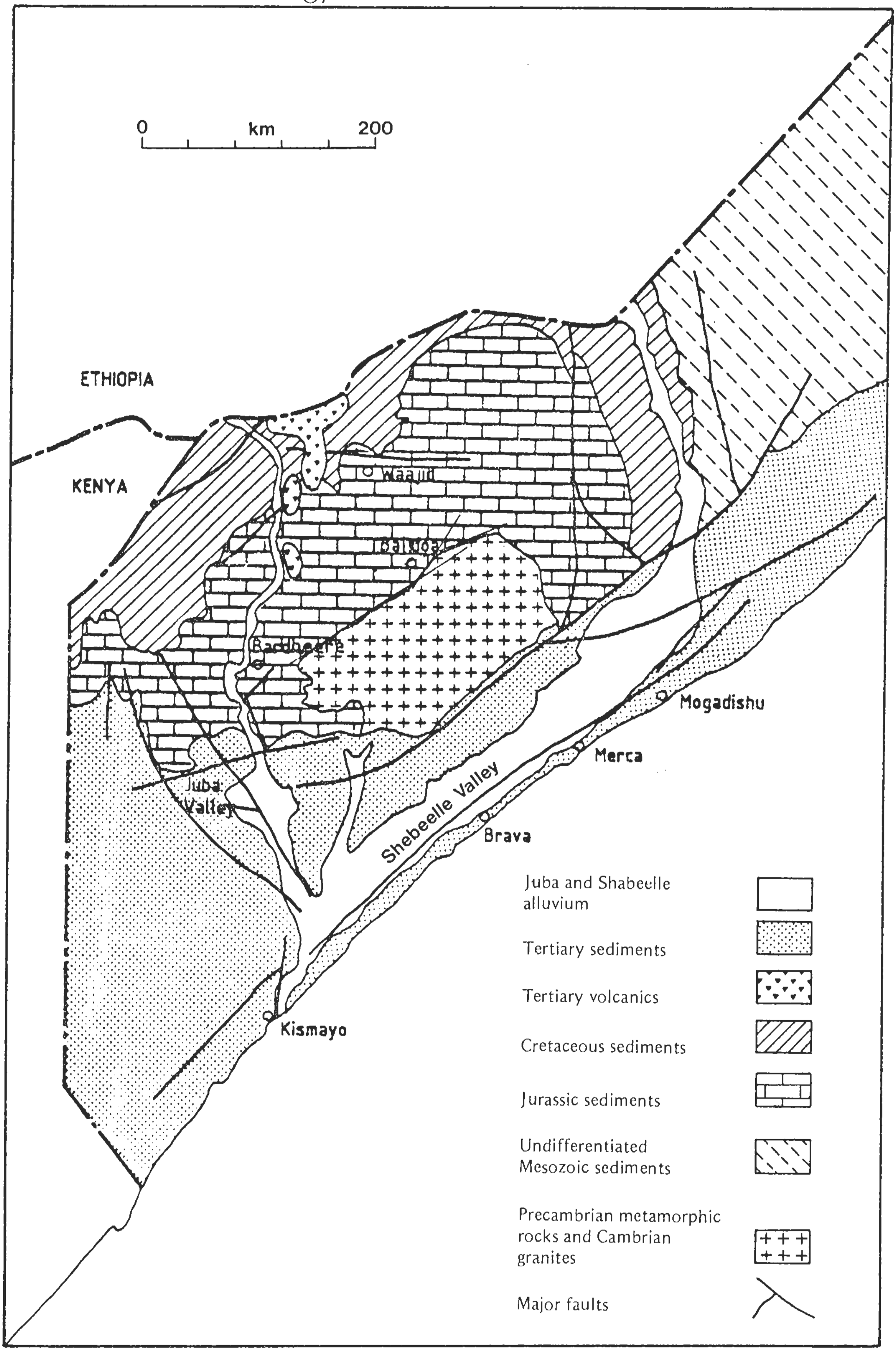
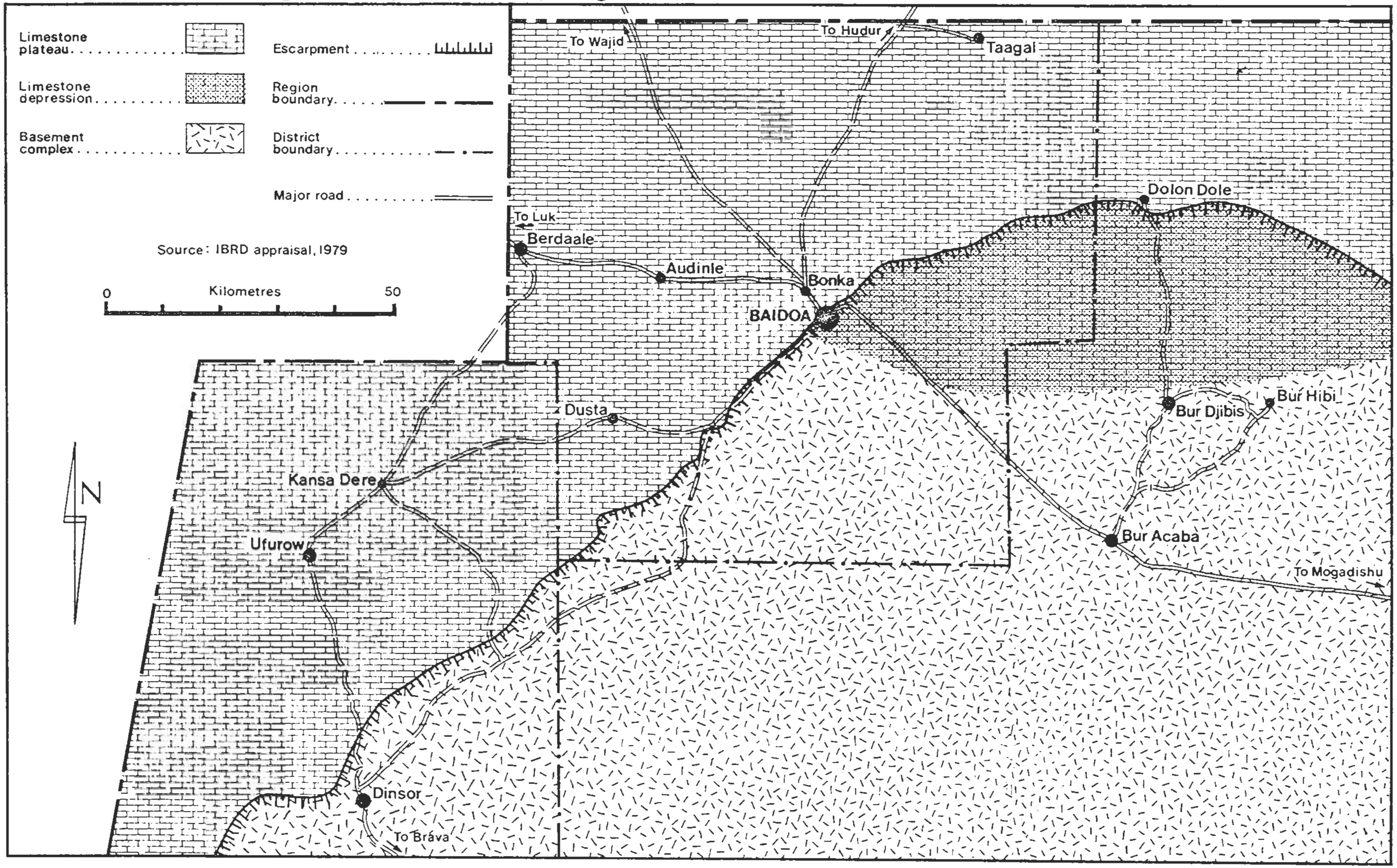


TABLE 2.1 STRATIGRAPHIC SEQUENCE OF THE REGION

Age	Formation	Member	Approx. Thickness (m)	Lithology
Recent	Superficial Deposits	-	0 - 10	Mainly residual clays and thin wadi channel alluvial silts, sands and gravels.
Jurassic	Anole		300	Marls with marly limestone and shale.
	Iscia Baidoa	Colado	up to 600	Organogenic, detrital and oolitic limestones with thin marls.
		Baidoa	100	Detrital and bioclastic limestones with pseudo-breccia and marl.
		Uanei	up to 120	Shales and marls with subordinate limestones.
		Deleb	30	Basal conglomerate and sandstones with thin shales and limestones.
Palaeozoic	Bur Igneous Intrusives	-	-	Mainly Granites.
Precambrian	Bur Akaba Series	Upper Series	?	Quartzite, marble and other metasediments.
		Lower Series	?	Mainly gneisses.

Source: *Technital (1975) and Beltrandi & Pyre (1973).*

2.4 Schematic Geological Map of the Bay Region



disturbed Iscia Baidoa Formation (LBI/RM 1983). The superficial deposits are mainly in the form of residual soils and alluvia along the channels of the seasonal streams. In addition the HTS (1982) soil survey has mapped a remnant of marine Quaternary, or Tertiary, deposition (the Marine Plain) in the extreme south of the Region; it is probable that these sandy deposits, which may be the edge of the Shabeelle alluvium rather than of marine origin, are very thin.

Though the only perennial streams in the Bay Region are the small and very short channels fed by the springs of the Baydhabo Escarpment, the overall drainage pattern is of interest as it is indicative of sub-surface conditions. The dense dendritic drainage pattern occurring on the Basement Complex outcrop, particularly in the west, reflects the relatively high rainfall and also the largely non-porous and impermeable nature of the underlying rock. On limestone outcrops there are very few drainage channels except in the immediate neighbourhood of the Escarpment, where steeper land slopes produce higher run-off. Most of the catchments are small. Only one of the channels draining the Escarpment extends for any distance onto the Limestone Plateau. This is the Togga Sheikh Asharrow which rises about 15 km north of the Escarpment and passes through Baydhabo; it has a well defined, incised bed and carries a baseflow till well after the end of the rainy seasons.

2.3.4 Occurrence of Aquifers

The crystalline metamorphic and igneous rocks of the Basement Complex are virtually impermeable in an unaltered state. Groundwater in such strata occurs only in fractures and fissures and particularly in the weathered zone. None of these are well developed in the Bur Akaba Series or the granitic intrusions; thus exploitable groundwater in the Buur lowland is found only in small isolated pockets. These are sometimes exploited by large diameters dug wells. The current LBI/RM drilling programme has drilled several boreholes in the Basement area and it is proposed to equip some of these with hand pumps, at least on a trial basis to see if they can sustain even very low discharges.

Some parts of the Jurassic Limestone sequence are karstified and consequently porous and permeable. The results of the current drilling programme, summarised in Table 2.2 (locations of the boreholes are shown in Figure 2.5) have provided detailed information on the water bearing characteristics of the various units of the Jurassic succession.

The Deleb Member of the Iscia Baidoa Formation, immediately overlying the Basement, consists of an intensely stratified sequence of thin sandstones, shales and limestones and forms an aquifer of low permeability. In the Limestone Depression, several of the boreholes drilled into what is presumed to be the Deleb Member failed to produce exploitable amounts of groundwater.

The Uanei Member consists mainly of shales and marls with thin limestone bands and forms an aquiclude. This may be important as it forms a confining bed and is responsible for perched water bodies in some areas, particularly near the Baydhabo Escarpment.

The difference between the Baidoa and the Goloda Members is not readily distinguished in boreholes; their lithology and water bearing properties are thought to be similar. The whole Baidoa/Goloda succession consists of limestones with subordinate marls and shales; the limestone beds are often thick and, when karstified, form highly productive aquifers; all the best yielding wells of the region derive their discharge from this source. Nevertheless it should be stressed that this is a typical karst aquifer, in which porosity and permeability in the subsurface are highly and unpredictably localised. Thus capacities of adjacent wells may vary hugely.

TABLE 2.2 SUMMARY OF LBI/RM GROUNDWATER PROJECT DRILLING RESULTS

Ref.	Location	Depth (m)	Stratigraphic Horizon	Lithology	Static WL (m)	Yield (l/s)	Specific Capacity (l/s/m)	EC x 10^6 @ 25°C
B1	Boonkay Farm	18.5	Baidoa M	Limestone	-	Dry	-	-
B2	Boonkay Farm	201.0	Baidoa & Uanei M	Limestone & shale	48.0	?	-	-
B3	Boonkay Farm	129.0	Baidoa & Uanei M	Limestone & shale	47.0	4*	-	-
B4	Tugerew I	42.0	Deleb M & Basement	Sandstone, Limestone & weathered grainite & mica schist	4.5	1*	-	1 100
B5	Gasarta	42.0	? Deleb M & Basement	Limestone & weathered granite & mica schist	11.0	v. low	-	-
B6	Waraji I	80.0	? Deleb M & Basement	Limestone, shale & decomposed granite	-	Dry	-	-
B7	Waraji II	42.0	? Deleb M & Basement	Limestone, shale & decomposed granite	-	Dry	-	-
B8	Tugerew II	48.0	? Deleb M & Basement	Limestone, shale & mica schist	-	Dry	-	-
B9	Buur Halab	32.0	Deleb M & Basement	Limestone, sandshale	-	Dry	-	-
B10	Sarman Dheere	85.0	Goloda & Baidoa	Mainly limestone, some shale	12.9	7.4	17.6	2 400
B11	Baydhabo Min. of Ag.	140.0	Baidoa & Deleb M & Basement	Limestone, shale & mica schist	5.9	3.7	8.0	1 400
B12	Hareero Jiifo	166.0	Baidoa M	Mainly limestone	29.5	3*	-	2 000
B13	Shabeelle Dugsilo	171.0	Anole F	Marl, shale & limestone	23.0	3*	-	24 000

TABLE 2.2 cont.

Ref.	Location	Depth (m)	Stratigraphic Horizon	Lithology	Static WL (m)	Yield (l/s)	Specific Capacity (l/s/m)	EC x 10^6 @ 25°C
B14	Warta Jaffa	91.0	Anole F	Marly limestone	18.0	3*	-	10 000
B15	Qansax Omane	174.0	Anole F	Limestone & sandstone	-	Dry	-	-
B16	Buulo Hawo	153.0	Baidoa M	Limestone with shale & marl	45.0	3*	-	2 000
B17	Roobay Gaduud	138.0	Baidoa, Uanei & Deleb M & Basement	Limestone, shale & decomposed granite	25.0	1.5-3*	-	?
B18	Gaduudo Dhunte	73.0	Baidoa M	Mainly limestone, some shale & marl	24.7	2*	-	?
B19	Buulo Fuur	94.0	Baidoa M	Marly limestone & shale	-	Dry	-	-
B20	Durei Ali Galle	118.0	Baidoa M	Limestone, marl & shale	58.0	1.5-3*	-	1 900
B21	Baydhabo Min of Ag.	42.0	Baidoa & Uanei M	Limestone & shale	2.6	3.8	20.8	?
B22	Buulo Gaduud	188.0	Baidoa & Uanei M	Limestone & shale	-	Dry	-	-
B23	Kurman	148.0	? Baidoa M	Mainly limestone with calcarenite & shale	9.0	1.5*	-	-
B24	Yaaq Braawe	10.0	Alluvium	Mainly sand with silt and clay	?1.0	?	-	?
B25	Dodole	24.0	Residium & Basement	Sand & decomposed granite	12.0	1-1.5*	-	850
B26	Shiidaalow I	66.0	Basement	Decomposed & fresh granite	?	v. low	-	32 000
B27	Shiidaalow II	56.0	Basement	Decomposed & fresh granite	?44.0	v. low	-	44 000

TABLE 2.2 cont.

Ref.	Location	Depth (m)	Stratigraphic Horizon	Lithology	Static WL (m)	Yield (l/s)	Specific Capacity (l/s/m)	EC x 10^6 @ 25°C
B28	Buurhakaba I	54.0	Basement	Mainly granite	22.00	v. low	-	800
B29	Buurhakaba II	54.0	Basement	Metamorphics & granite	48.0	0.5*	-	34 000
B30	Buurhakaba III	62.0	Basement	Metamorphics & granite	47.0	v. low	-	saline
B31	Buurhakaba IV	63.0	Basement	Metamorphics & granite	9.0	2*	-	saline
B32	Buurhakaba V	86.0	Basement	Mainly granite	9.0	0.5*	-	fresh
B33	Buur Heybo I	70.0	Basement	Mainly granite	22.0	v. low	-	fresh
B34	Buur Heybo II	60.0	Basement	Granite	-	Dry	-	-
B35	Buur Heybo III	34.0	Basement	? Granite	34.0	v. low	-	?
B36	Buur Heybo IV	?	Basement	? Granite	-	? Dry	-	-
B37	Buur Heybo V	27.0	Basement	Granite	-	Dry	-	-
B38	Buur Heybo VI	?	Basement	? Granite & limestone	-	Dry	-	-
B39	Buur Heybo VII	?	Basement	? Granite	-	? Dry	-	-
B40	Limestone Depression A	?	? Deleb M & Basement	Limestone & granite	-	Dry	-	-
B41	Dolondole	?162.0	Baidoa, Uanei & Deleb M & Basement	Limestone, shale & granite	?	Large	-	fresh
B42	Buulo Fuur	123.0	Baidoa M	Mainly limestone	27.0	Large	-	fresh
B45	Baydhabo AID Compound	102.0	Baidoa, Uanei & ? Deleb M	Limestone & shale	2.0	Large	-	2 000

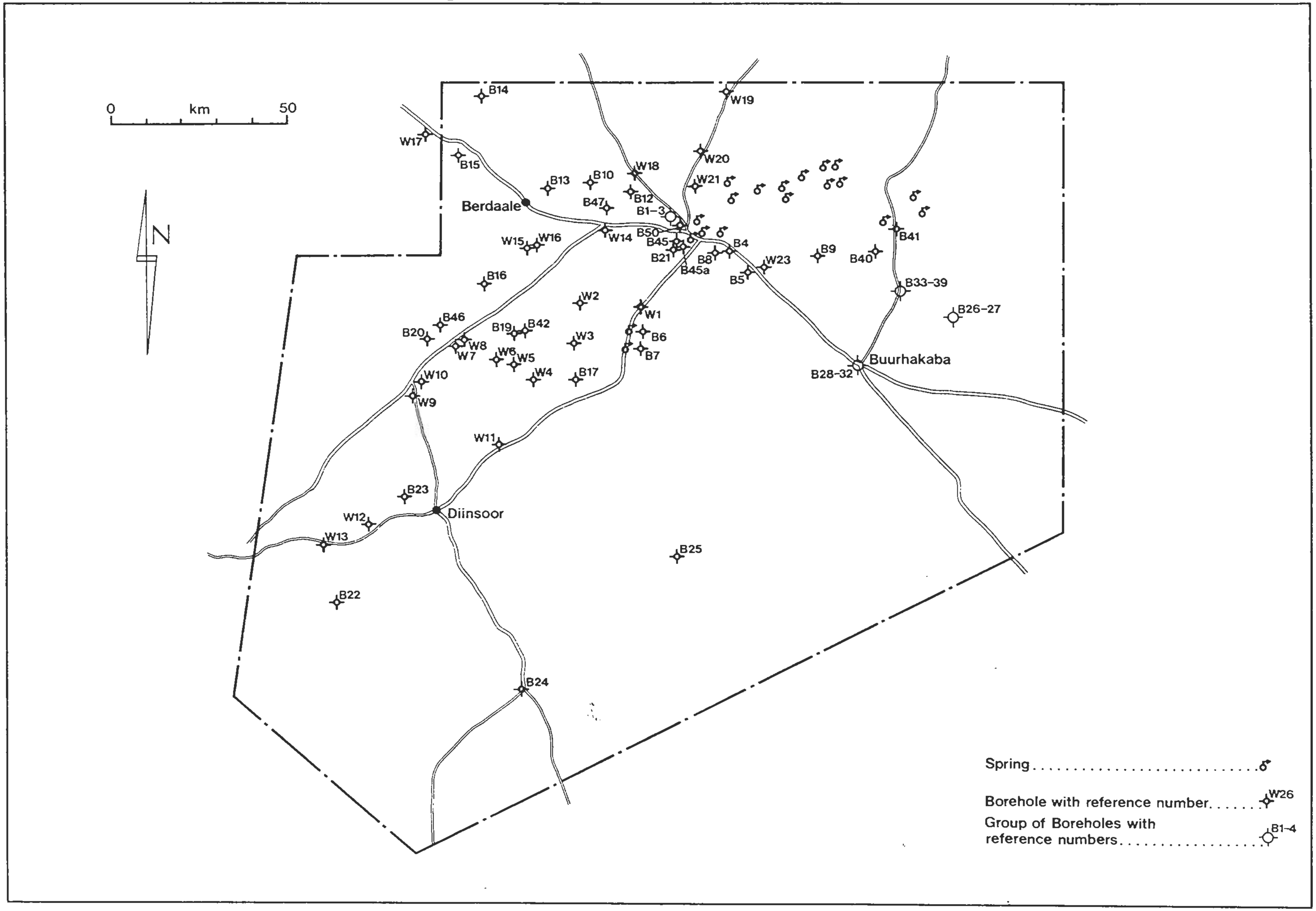
TABLE 2.2 cont.

Ref.	Location	Depth (m)	Stratigraphic Horizon	Lithology	Static WL (m)	Yield (l/s)	Specific Capacity (l/s/m)	EC x 10^6 @ 25°C
B46	Qansaxdheere Road Well	?	Goloda & Baidoa M	Mainly limestone	?	?	-	?
B47	Awshini	143.0	? Baidoa M	Mainly limestone	?	?	?	?
B50	Boonkay Seed Farm	198.0	Baidoa M	Mainly limestone	?	?	?	?

* Estimated Yield

Source: Louis Berger International (1983)

2.5 Locations of Boreholes and Springs



The Anole Formation, which occurs only in the north-west corner of the Project Area, consists mainly of a stratified sequence of marls, marly limestones and shales; some of the limestones are permeable but of low productivity; of the three holes drilled in this formation, one was dry and two produced very low yields of saline water.

Some of the superficial deposits form localised but important aquifers. In some particularly deep alluvial channels, groundwater is exploited by clusters of dug wells, from which supplies for watering livestock are obtained. Such clusters are relatively few and far between, but it is uncertain whether this reflects the scarcity of groundwater occurrence in the alluvials or whether it is merely due to the so-far inadequate search for exploitable groundwater.

The water levels in the Basement Complex area reflect the discontinuous nature of the groundwater bodies found there. Thus water may occur at vastly different levels in nearby boreholes. In the exploratory holes drilled so far the highest levels found have been less than 10 m below ground surface; in some cases depth to water has been up to 50 m and in some areas no water was found at all at depths exceeding 50 m.

In the limestone aquifers the water levels are also highly variable, reflecting both variable topography and variable hydrogeological conditions. On the Plateau the regional water level varies from about 10 to some 50 m below ground level, depending largely on topography. However in the immediate vicinity of the Escarpment, a perched groundwater body occurs, held up by the shales and marls of the Uanei Member. In the topographically lower Limestone Depression, water levels, if found at all, are normally within 10 m of ground surface. Figure 2.6 summarises the situation in the vicinity of Baydhabo.

It should be pointed out however, that the distribution of the water level in the limestone aquifers of the Region is not fully understood. Some apparent anomalies in the regional pattern remain unexplained. It is hoped that these will be resolved by further studies.

Little data is available on the oscillation of groundwater level with time. LBI/RM Exploratory Report gives two hydrographs one of which (well B2 at Boonkay) shows a rise of almost 20 m between April and June 1982; the other measurement is of much shorter duration and shows a smaller and different pattern of oscillation. In general water levels in karst aquifers may exhibit very large and rapid water level rise in response to rainfall, and this subject needs systematic study in the Bay Region, by monitoring of selected boreholes.

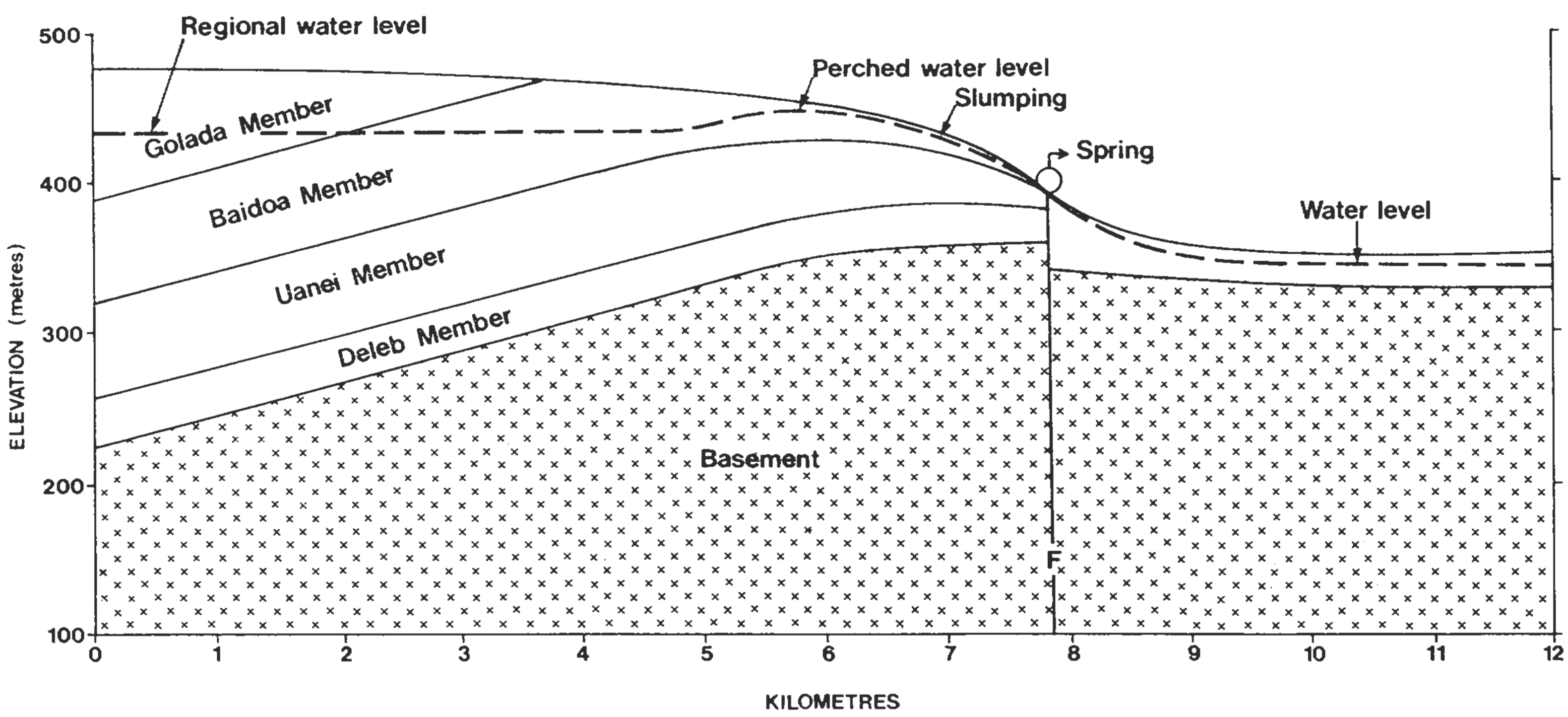
Water levels in alluvial wells are generally within 10 metres of ground surface. It is understood that some of these dry out completely in the dry seasons. No quantitative data on this subject is available.

2.3.5 Aquifer and Well Characteristics

No quantitative data on the hydraulic properties of the Basement aquifers are available. However, the transmission constants for such strata are always low as are normally the storage parameters. The one drilled Basement well currently in operation (at Daynuunay) produces a low discharge with large drawdown; however neither of these has been accurately measured.

Normally, karstified limestones exhibit very high localised transmissivity and low storativity. Typically, nearby wells in karst aquifers can produce vastly different yields depending on the amount of water bearing conduits that they intersect.

2.6 Hydrogeological Cross-section, Baydhabo Area



Records of the Limestone Plateau wells (Table 2.3 and Figure 2.5) installed prior to the current LBI/RM programme, though incomplete, suggested that karst features were not extensively developed in the Jurassic Limestones of the Region. All the wells have been equipped with low discharge pumps, set at great depths, suggesting large drawdowns. In the case of the four Baydhabo water supply wells, where formal pumping tests have been carried out, the results show low transmissivity. Thus on the basis of this evidence it was concluded that the Jurassic aquifer is generally of low permeability suitable only for exploitation for water supply (particularly rural water supply).

Some of the results of the current LBI/RM programme allow this conclusion to be questioned. Though most of these new wells fit in with this picture of generally low permeability, three boreholes, on which preliminary testing has been carried out, indicate high transmissivity; the details of these wells are listed below:

Well No	Depth (m)	Aquifer, Probably Tapped*	Static WL (m)	Discharge (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Transmissivity (m^2/d)
B10	85	B & G	12.9	7.4	0.42	17.6	1855
B11	140	D & B	5.9	3.7	0.46	8.0	834
B21	42	B	2.6	3.8	0.18	20.8	2192

* B - Baidoa Member
C - Goloda Member
D - Deleb Member

Source: *Louis Berger International (1982)*

Two of these wells are located in Baydhabo, near the Escarpment, where aquifer transmissivity may have been enhanced by squeezing of the Uanei Shales and slumping of the overlying Baidoa Member; however, the third well is in Sarmaan Dheere, well away from the Escarpment. The high productivity of the aquifer at these sites needs to be confirmed by formal aquifer tests (which are to be carried out shortly).

In addition to the high yielding drilled wells there are several springs at the Escarpment. The largest of these is just to the west of Baydhabo; its flow is used for irrigation of fruit and vegetable gardens. Other springs are mainly small, but lush vegetation in their neighbourhood, suggest that upward seepage may be feeding its evaporative demand. Thus excavation and pumping of the springs could produce much higher flows.

The drilling investigations in the Limestone Depression have clearly shown that the Baidoa Formation (probably mainly the Deleb Member) here is of particularly low permeability and most of the exploratory boreholes have been unproductive. Of the eight holes drilled six have been dry, one produced a very small yield and only one was considered sufficiently productive to be completed as a permanent production well (B4); even in this case the potential yeild is estimated at only about 1 l/s. The one exception to this general picture of very low permeability of the limestone remnant in the Depression is some intensely karstified carbonate rock in the proximity of the main drainage line of the area, the Togga Sheikh Asharrow; flooding from this channel is thought to have enhanced the

TABLE 2.3 OLD WDA BOREHOLE DATA

Ref.No.	Location	Depth	Aquifers Probably Tapped	Static WL	Pump Intake Setting	Discharge (l/s)	Drawdown (m)	Specific Capacity (l/s/m)	Specific Drawdown (m/l/s)	Estimated Transmissivity (m2/d)	EC x 10^6 @ 25°C
I	Baydhabo Water Supply Well	115.2	B	12.0	78.0	4.4	40.6	0.108	9.23	11.38	C.2000
II	Baydhabo Water Supply Well	111.4	B	10.6	96.0	4.2	52.4	0.080	12.48	8.45	C.2000
III	Baydhabo Water Supply Well	89.6	B	24.2	78.0	4.3	34.8	0.124	8.09	13.02	C.2000
IV	Baydhabo Water Supply Well	92.4	B	21.8	?	1.7	38.0	0.045	22.35	4.72	C.2000
W1	Gofgaduud Shalselow	150.0	D	-	114.0	-	-	-	-	-	6,000
W2	Dusta	100.0	B	-	45.0	-	-	-	-	-	1,700
W3	Wabdoore	166.0	B	-	102.0	-	-	-	-	-	900
W4	Xawal Barbaar	100.0	B	-	72.0	-	-	-	-	-	5,000
W5	Korumbod	100.0	B	-	78.0	-	-	-	-	-	3,800
W6	Lowraar	150.0	B	-	120.0	-	-	-	-	-	4,000
W7	Qansaxdheere I	150.0	B	-	130.0	-	-	-	-	-	2,000
W8	Qansaxdheere II	110.0	B	-	80.0	-	-	-	-	-	4,000
W9	Ufurow I	130.0	B	-	90.0	-	-	-	-	-	2,200
W10	Ufurow II	110.0	B	-	80.0	-	-	-	-	-	2,500
W11	Misra	120.0	D	-	90.0	-	-	-	-	-	1,250
W12	Xaafato	180.0	B	-	120.0	-	-	-	-	-	5,000
W13	Xabibiyaal	90.0	B	-	70.0	-	-	-	-	-	6,500
W14	Awdiinle	120.0	B & G	-	78.0	-	-	-	-	-	3,900
W15	Gelgel I	100.0	B & G	-	72.0	-	-	-	-	-	1,600
W16	Gelgel II	100.0	B & G	-	72.0	-	-	-	-	-	2,550
W17	Qansax Oomane	150.0	A	-	130.0	-	-	-	-	-	27,000
W18	Gofgaduud Buuray	130.0	B	-	120.0	-	-	-	-	-	2,600
W19	Barabaray	60.0	G	-	60.0	-	-	-	-		2,500
W20	Seydhelow	60.0	B & G	-	60.0	-	-	-	-	-	1,200
W21	Labaatan Jirrow	120.0	G	-	100.0	-	-	-	-	-	1,000
W22	Tagal Molimaadrotos	160.0	?	-	140.0	-	-	-	-	-	-
W23	Daynuunay	150.0	Bt	-	130.0	-	-	-	-	-	2,300

B - Baidoa Member
D - Deleb Member
G - Goloda Member
A - Anole Formulation
Bt - Basement

Source: *LBI 1983 and HTS 1982*

karstification. This high transmissivity area is small, but is intensively exploited by large diameter shallow wells.

No quantitative data on the storativity of the limestone aquifers is available. However, massive limestones with porosity dominated by joints, fissures and fractures usually have storage coefficients in the range of 1 to 2 per cent. Circumstantial evidence suggests that the aquifers of the Region have storage parameters of this order.

The alluvial aquifers are thought to have high permeability and storage properties, though their saturated thickness is normally small. In some areas these aquifers sustain their productivity despite being exploited by clusters of dug wells, comprising as many as 30 units; though water is drawn from them manually the total abstraction rate is sometimes considerable.

2.3.6 Groundwater Quality

The LBI/RM Exploratory Report gives a very large number of chemical analyses of groundwater samples from the Region. However, many of these have to be treated with caution; in many cases the relation between the EC and the total dissolved solids is anomalous; further, the balance between anions and cations is often poor. Therefore in general the analyses have a low credibility; where discrepancies exist, the EC, which is the easiest property to measure, is taken as the most likely to be correct.

In the Basement Complex groundwater quality reflects the discontinuous nature of the aquifer. Pockets of groundwater of vastly different quality occur; some of it is too saline for any use. The recent drilling investigations by LBI/RM, to find areas of fresh water, resulting from the infiltration of run-off from some of the major buurs (granite inselbergs), demonstrate the quality variability; the salinity of the exploratory boreholes near Buurhakaba varies from EC x 10^6 800 to 34 000. It appears that highly saline groundwater is particularly common in the Basement area to the north of the main Baydhabo-Mugdisho road.

The chemical composition of Basement Complex groundwater is also variable, though sodium and chloride are often relatively abundant, even in reasonably fresh water.

In the limestone aquifers (the Iscia Baidoa Formation) groundwater quality shows a more ordered pattern. Least saline water (EC x 10^6 less than 1 000) occurs along the Escarpment to the east of Baydhabo; this corresponds to an outcrop of strongly karstified limestone. North of the Escarpment in this region, groundwater quality is also expected to be good, in the range of EC x 10^6 of 1 000 to 2 500. To the west of Baydhabo, groundwater salinities are generally higher, even along the Escarpment - generally in the range 2 000 to 6 000 EC x 10^6. In the extreme north-west of the Region, there is an outcrop of the Anole Formation. This contains extremely saline groundwater probably of connate origin; EC x 10^6 values recorded from drilled wells there range from 10 000 to 27 000.

The chemical species of the limestone groundwater is variable, but because of the general inconsistencies in the available analyses, it is difficult to discuss the subject usefully. Highly saline water as always is dominated by sodium chloride; intermediate salinities also show abundant chloride, which suggests contamination rather than normal hydrochemical reaction as the source of mineralisation; very fresh water is often of the calcium/magnesium bicarbonate type.

Alluvial groundwater is also variable, with salinities often in the intermediate range of EC x 10^6 of 1 000 to 4 000. Again, because of the inconsistencies of the available chemical analyses, little of value can be said about the hydrochemistry of this water.

2.3.7 Recharge and Groundwater Movement

Very little direct piezometric evidence is available for any part of the Region. Piezometry would be expected to elucidate groundwater movement patterns only in more or less continuous aquifers such as the Jurassic limestones, but apparently the density of observation points is not yet sufficient to be informative. Thus groundwater movement has to be deduced from indirect evidence such as physiography, soil type distribution, geology, climate, hydrochemistry and surface hydrology.

Average annual rainfall in the Region is low (less than 600 mm everywhere), but tends to occur in high intensity showers; consequently run-off and/or infiltration to the groundwater reservoir can be expected. Well developed drainage pattern exists only on the Basement and on Limestone outcrops, where the sedimentary cover is thin. Elsewhere, the absence of surface drainage channels is interpreted as occurrence of high infiltration and recharge of the groundwater reservoir. Some of the streams may themselves be sources of recharge where they pass over material of high infiltration.

Thus the main source of aquifer recharge in the Bay Region is thought to be direct infiltration of rainfall with seepage from seasonal streams a secondary source. Because of the relatively arid climate the recharge is probably low; 5 per cent of average annual rainfall has been suggested (LBI/RM, 1983) as the likely magnitude on the basis of estimates done elsewhere in similar environments.

The direction of the underflow is thought to follow that of the surface drainage; that is in the Limestone Plateau zone, part of the aquifer drains towards the Escarpment and part drains down dip towards the north and north-west. The southward moving part of the groundwater body comes up to the surface as a series of springs along the Escarpment.

There is strong evidence that the recharge on the Plateau is much greater to the east of Baydhabo than in the west; in the east springs are much more common and the groundwater is considerably less mineralised. This fits in with the occurrence of high moisture holding capacity clayey soils in the west, and much more permeable stony soils in the east.

It has been claimed (Johnson, 1978) that it is only the higher units of the limestone aquifer in the Escarpment zone that contribute to the springs, from perched groundwater bodies; it is further argued that in the basal beds the direction of the underflow is reversed and that the Limestone Depression forms the major intake zone for the underflow of the Plateau. Though the first contention is undoubtedly correct, the second is certainly wrong. Recent drilling evidence clearly shows that the Limestone Depression sedimentary strata are mainly almost impermeable and, anyway, their topographic position is too low to feed the aquifers underlying the Plateau.

In the Basement and alluvial aquifers, the groundwater movement is thought to be mainly vertical; regional transmissivities are too low for any significant lateral groundwater transfers. Thus the main inflow to the aquifers is infiltration from rainfall and streams; the main natural outflow is thought to be evapotranspiration by deep rooting plants.

2.3.8 Groundwater Development Potential

On the basis of existing information on geology, climate, permeability distribution, surface hydrology and groundwater quality, several groundwater development potential zones have been tentatively delineated in the Region. Their geographical position is shown in Figure 2.7 and their description is given in Table 2.4. It should be clearly understood that these present a generalised, simplified picture and that in view of the generally high degree of uncertainty inherent in karst aquifer productivity, anomalous results are possible anywhere.

2.7 Groundwater Development Potential

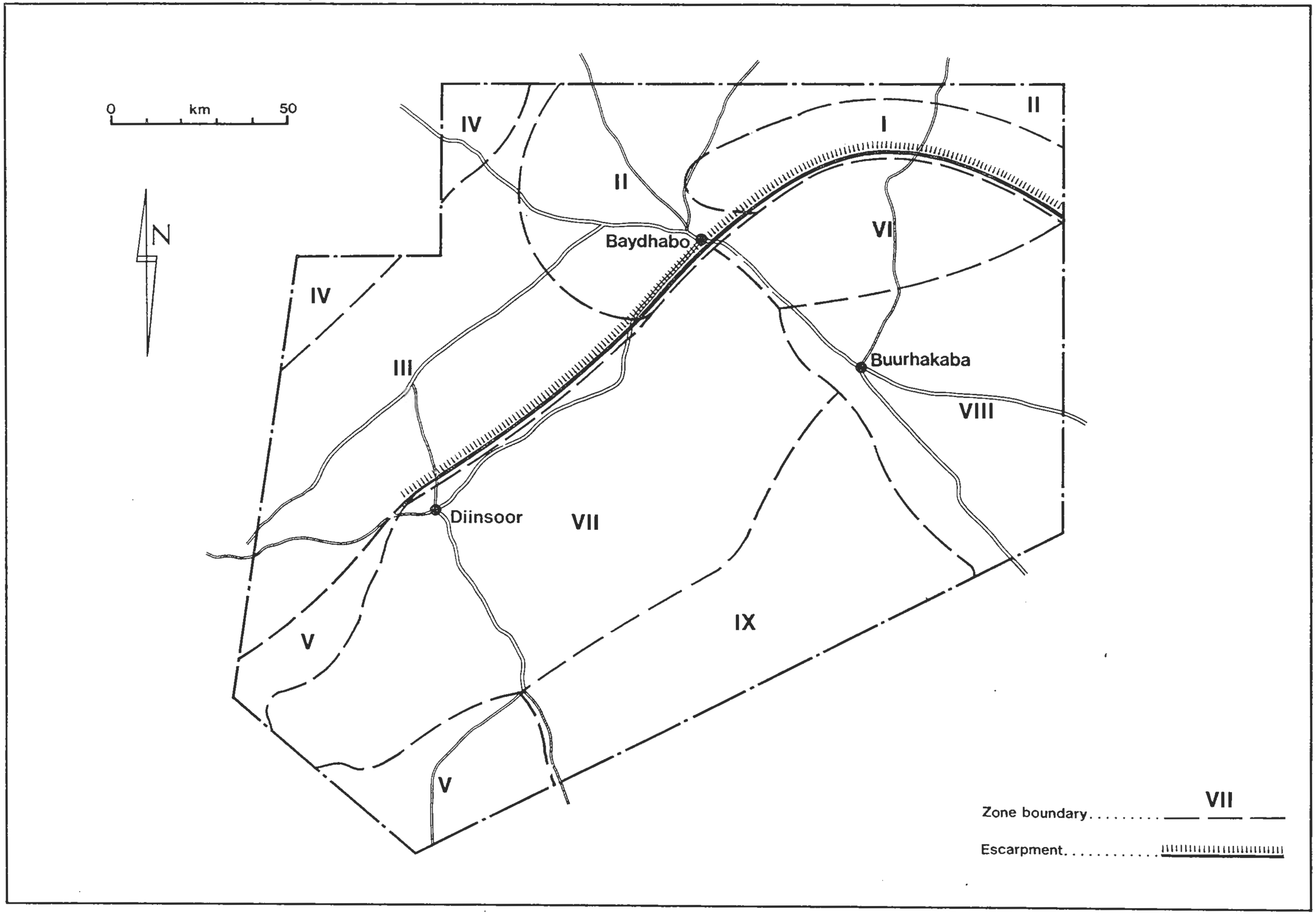


TABLE 2.4 GROUNDWATER DEVELOPMENT POTENTIAL

Zone	Aquifers	Recharge Conditions	Groundwater Quality	Development Potential
I	Good; highly karstified limestone; many springs and seepages on the Escarpment - once excavated and pumped sustains a high discharge; little drilling evidence but high capacity boreholes likely.	Good; rainfall relatively high and high infiltration likely on thin rocky soils.	Excellent; most of the groundwater likely to have EC x 10^6 of less than 1 000; suitable for potable supplies and irrigation of salt sensitive crops such as fruit and vegetables.	Very good; drilled and dug wells for drinking supplies for people and livestock should be easy; small scale irrigation may be possible by pumping excavated springs and possibly drilled wells.
II	Good; limestone sometimes karstified; yields of existing wells variable but some very high and no failures; high discharge springs at Baydhoba.	Good; rainfall relatively high and high infiltration intake soils particularly in the north.	Good; EC x 10^6 of groundwater mainly in the range of 1 000 to 2 500; acceptable for potable supplies and irrigation; suitable for livestock.	Good; suitable for deep drilled wells for drinking water for people and livestock; drilled wells for irrigation may be possible in cases of high specific capacity and relatively shallow static water level.
III	Fair; limestone seldom strongly karstified. yields of existing wells mainly low; some dryholes; only one major spring on the Escarpment.	Fair; relatively high rainfall; in much of the area soils clayey with low infiltration capacity but large areas of sandy soil occurs as well.	Moderate to poor; much of the groundwater in the range of 2 500 to 5 000 EC x 10^6; often marginal for potable supply; suitable for livestock.	Fair; suitable for deep drilled wells; small yields likely suitable for livestock; more saline water to be used by people only when no other supplies available.
IV	Poor; the Anole Formation mainly marl, marly limestone and shale.	Poor; relatively low rainfall; low vertical permeability	Very poor; water from existing boreholes is in the EC x 10^6 range of 10 000 to 27 000.	Very poor; some areas may be suitable for shallow dug wells.
V	Marginal to poor; limestone seldom strongly karstified.	Fair to poor; relatively low rainfall; mainly clayey soils.	Generally poor; EC x 10^6 range 5 000 to 10 000.	Poor; low yielding wells and poor quality water; some suitable for livestock.
VI	Mainly marginal to poor; thin limestone of low permeability except for a few sink holes along the Togga Sheikh Asharrow which are pumped for irrigation; several dry holes drilled.	Appear to be good; relatively high rainfall and some light soils.	Good; most of the existing dug wells produce water with EC x 10^6 range of 1 000 to 2 500.	Poor; mostly underlain by strata of very low permeability; low yielding drilled wells may be possible in some areas.

Table 2.4 Continued

Zone	Aquifers	Recharge Conditions	Groundwater Quality	Development Potential
VII	Fair to poor; Basement mainly of very low permeability; well developed drainage pattern with wadi beds containing aquifers material and groundwater.	Good; infiltration of wadi flows to alluvial aquifers may be high.	Variable; Basement groundwater mainly saline; alluvial channel groundwater mainly in the range 1 000 to 5 000 EC x 10^6.	Fair; drinking water supplies for people and livestock can often be obtained by shallow dug or drilled wells in wadi beds.
VIII	Very poor; mainly practically impermeable Basement.	Poor; soils often clayey.	Poor; groundwater mainly saline (up to EC x 10^6 45 000) though small patches of fresh water occur.	Very poor; even very small quantities of usable groundwater are very difficult to obtain.
IX	Probably poor; probably mainly Basement under thin alluvial cover.	Moderate; rainfall is relatively low but land surface absorbent.	Not known	Not known but probably poor; complete lack of shallow dug wells.

3

Current Water Supply Situation

3.1 INTRODUCTION

Water for human and livestock consumption in the Region is obtained from wars, springs, shallow hand dug wells and boreholes equipped with mechanically driven pumps. Wars and dug wells are the main sources but deep wells and perennial springs are significant, particularly late in the dry seasons when many wars tend to dry out. The movement of livestock appears to be controlled to an appreciable extent by the availability of water and in some areas whole village communities are forced to move when the local wars dry up. In many areas people spend a large proportion of their time carrying water from a distant source.

3.2 WATER DEMAND

Water demand was originally estimated by the FAO/WB Project Preparation Mission (1977) as 250 litres/d per rural family including livestock. Further work on this subject has been done by the CGDP as a part of their socio-economic survey.

Human population of the Bay Region has been estimated on the basis of the 1975 census, projected to 1983 as follows:

	(Local Gov.) Maximum	Minimum (USAID 1980)
Population of Baydhabo*	50 000	50 000
Rural Population	774 000	324 000
Total Bay Region	**824 000**	**376 000**

Note: * *Baydhabo is treated separately as it is an urban area with its own water supply system.*

Per capita water usage is given by LBI/RM (1983) as between 3 and 12 litres/d depending on the distance that it has to be carried. These figures are very low, well below those normally recommended (15 litres/d per capita) by organisations such as WHO (World Health Organisation) for rural Africa. Accepting that water consumption in the Bay Region is severely restricted by availability, 15 litres/d per capita is taken for calculating total demand.

Livestock numbers have been estimated on the basis of the recent aerial survey (Watson and Nimmo, 1982) as follows:

Cattle	370 000
Camels	320 000
Goats and Sheep	390 000

It is estimated that on average cattle and camels require 20 litres/d of water per head and goats and sheep require 3 litres/d per head.

Thus total daily water demand of the Bay Region is estimated as follows:

Population		Total Daily Demand (litres) Minimum	Maximum
Minimum	376 000 x 15 litres	5 640 000	
Maximum	824 000 x 15 litres		12 360 000
Cattle	370 000 x 20 litres	7 400 000	7 400 000
Camels	320 000 x 20 litres	6 400 000	6 400 000
Goats & Sheep	390 000 x 3 litres	1 170 000	1 170 000
	TOTAL	20 610 000	27 330 000

Therefore, if water were to be supplied on demand, the Region's requirements would probably be between 20 and 30 thousand cubic metres per day.

Of course, the demand is not evenly distributed spatially. The greatest concentrations of settled rural population are in the south west of the Limestone Plateau, where water is relatively easy to get by means of deep tubewells. Another major area of settled agriculture is to the north and north west of Buurhakaba; in the Basement Complex area, provision of water supplies in the dry season is extremely difficult.

3.3 WATER SUPPLY SOURCES

3.3.1 Wars

Wars are an extremely common source of water supply in the Bay Region. An aerial survey of the Region in February and March 1982 estimated the total number of wars to be approaching 9 000, of which 3 000 contained water at that time. The wars are particularly concentrated on the clay plains around Baydhabo, Qansaxdheere and north of Buurhakaba. The great majority of the wars in the Region are small excavations, capacity normally less than 1 500 m^3, constructed by local people. Those built by the government include 14 wars, each with capacity of 5 500 m^3, excavated in 1963 on the Limestone Plateau, with USAID assistance; others were constructed with the equipment left by the USAID project. Many of these have become silted-up and are no longer used. In 1974 the EEC-funded Inter-Riverine Livestock Project built 40 large wars (24 of them in the Bay Region) on major livestock routes; these have capacities larger than 20 000 m^3 and are lined with plastic to prevent seepage losses; though often run down, most are still operational and have proved effective as perennial sources of water.

(a) Traditional Wars

Traditional wars are dug by local people who thereby gain rights to the use of water. Generally they are excavated to a depth of one to two metres, but sometimes a little more. The volume of storage was given by the FAO/WB Preparation Report (1977) as between 100 and 1 500 m^3 with an average of 800 m^3, but on the basis of the present field reconnaissance it seems that storage larger than 1 500 m^3 are also common.

Siltation of the wars appears to be a major problem and up to one metre depth of silt has to be removed before the start of each rainy season. The silt is piled up on the surrounding embankment, the size of which is indicative of the age of the war. Desilting is done by hand labour and each member of the community is normally required to do a share of the work to maintain his right to the use of the water.

Wars are used to meet both livestock and human demand for water. In some areas a particular war may be designated specifically for either one or the other, but usually both use the same water. In the better controlled wars animals are kept out by *Euphorbia* or thorn hedges, with water for livestock being carried to the troughs provided outside the hedge. Washing is also normally done outside the hedge. In all the wars the risk of pollution is high as people walk into the water to fill their containers and in the majority of cases there is evidence of animals entering the water.

Very few traditional wars are perennial sources of water even in wet years. There is some evidence that water is conserved for human consumption in some wars by moving livestock away relatively early in the dry season. Even so, it is clear that the great majority of wars dry up in the Jillal and most are also empty well before the end of the Haggai.

The durability of war water supply during the latter part of a dry season is not uniform throughout the Region. Clearly, all other things being equal, wars in areas of most permeable soil will dry up quicker. Even on apparently similar clay soils, considerable variations were noted. During the period of the study (August 1983) all wars in the Qansaxdheere and Ufurow area were dry, whereas north of Baydhabo most contained water. This was reported by local people to have been due to uneven spatial distrubution of rainfall in the 1983 Gu season.

Apart from uneven rainfall, other factors affecting the variability of war supplies may be: war dimensions, different water demands, seepage losses and evaporation losses. No systematic study has been carried out so far to determine which of these factors are important; however it is likely that on clayey soils seepage losses are low and it is certain that evaporation losses are high everywhere. It is probable that deepening the wars to improve their surface-area to volume ratio would improve their performance, though it might well increase seepage losses.

(b) EEC Wars

The EEC wars have been constructed mainly to provide water for livestock and play a relatively minor role in meeting the water needs of the human population of the Region. Nevertheless they provide perennial water sources in areas some of which are desparately short of water during the dry seasons.

The gross capacities of these wars range from 22 000 to 34 000 m^3. They are 60 to 70 m square in plan and about 6 m deep; heavy duty plastic lining has been provided to prevent seepage losses. Water is usually channelled to them through an excavated off-take from a natural channel via a silt trap and a 750 mm inlet pipe. Each war is surrounded by a fence to keep livestock out. Water is abstracted from the war by a centrifugal pump to a low level steel storage tank, from which it is taken by bucket.

Originally hand pumps were provided to pump the water from the steel tank to a series of cattle troughs, but it appears that at present all these are missing or broken.

Much criticism has been voiced on the EEC wars; a recent survey of all 40 of these structures, found the following problems (Boggs, LBI 1983):

- six of the wars were leaking because of damage to the plastic lining;
- five of the wars were improperly sited and did not receive sufficient inflow;
- eleven of the wars have been damaged by floods because of inadequate spillway structures;
- eighteen of the wars had problems caused by excessive silting and poor maintenance;
- most of the wars had problems with erosion of the outer embankment (1:2 slope);
- as already mentioned all the wars had inadequate distribution facilities (hand pumps); this in some cases has led to breaking of the fence and to people and animals entering the wars;
- the main pumps were too small for their duties;
- in all cases there has been virtually no maintenance in the last 10 years.

Originally the responsibility of the WDA, the EEC wars have been handed over to the National Range Agency (NRA), who do not have the resources to maintain them properly. There is a current UN funded project for the evaluation and rehabilitation of these reservoirs.

Despite all the problems, the EEC wars have shown that perennial water supplies can be provided from small-scale surface storage. No doubt, a careful review of the past performance of these wars could produce improvement in design of any such reservoirs constructed in the future.

3.3.2 Shallow Dug Wells

The recent aerial survey estimated that there are almost 10 000 dug wells in the Bay Region. Water could probably be drawn from a shallow well at a rate of 0.1L/s therefore, theoretically, these wells could meet the whole water demand of the Region. However the distribution of such wells is highly uneven, being restricted to limited areas where water of adequate quality is available at relatively shallow depths. Most of the shallow dug wells are 1.5 to 2 m in diameter and 5 to 20 m in depth; since no de-watering equipment is used in their construction, most penetrate only about one metre below the water-table. A few of the wells are excavated in hard rock such as limestone or slightly weatherd Basement but most penetrate soft strata, particularly alluvial accumulations in the wadi beds on the Basement. As already mentioned, once a suitable site for shallow wells is located, whole clusters of them (up to 30) are sometimes constructed close together with different wells serving different livestock owners.

Water is drawn from the dug wells invariably by bucket and rope, without any leverage aids. No hand-pump equipped wells were seen anywhere in the Region.

A special kind of dug well exists in the Limestone Depression near Baydhabo and at the Limestone Escarpment at Habare. These are enlarged sink holes or excavated springs, which are pumped by centrifugal pumps for small scale irrigation of fruit and vegetables.

3.3.3 Drilled Wells

Outside Baydhabo, there are 23 drilled wells, which have been equipped with diesel driven pumps and operated by WDA. Apparently they have been installed about 20 years ago; most of them are believed to be still operational. Details of individual installation vary but the following is the summary of their design:

Depth of well	-	60 to 120 m
Casing and screen diameter	-	submersible or line shaft turbine
Pump setting depth	-	60 to 140 m
Pump discharge rating	-	about 3 L/s
Power source	-	slow speed diesel with belt drive or right angle shaft and gearbox
Discharge works	-	galvanised pipe and small galvanised steel storage tanks
Distribution works	-	a system of taps for domestic supply and troughs for livestock, filled from a storage tank; sometimes a more extensive piped distribution system feeds a few more distant water points.

The wells are run by WDA, who pay the operator, provide fuel, and maintain the pump. Charges are levied for water consumed. No accounts or operating records for individual wells are kept.

In addition to these old wells, there are several completed wells constructed in the Region by the LBI/RM programme. However none of these are as yet equipped with pumps.

3.3.4 Springs

There are about twenty perennial springs in the Region, the great majority of them on the Limestone Escarpment. All but one of the Escarpment springs are very close to or to the east of Baydhabo. Elsewhere there are a few small seepages at the base of some of the buurs, one or two of which are perennial.

The discharges of most of the springs are small; the largest are those at Baydhabo (probably about 15 L/s at minimum flow) and at Manaas (about 12 L/s). All the others are less than 5 L/s. The variation of flow with season is not known, but in view of the karst nature of the aquifer could be expected to be considerable.

Though the springs are few and far between, they are extremely important as sources of drinking water for people and livestock. As the main sources of supply, the wars, dry up in the dry season, much livestock and human populations of some whole villages migrate to the springs to await the next rainy season.

3.4 OVERALL WATER AVAILABILTY

The overall picture of water availability in the Region is one of plentiful supplies during the two rainy seasons, with water becoming increasingly scarce as the dry seasons advance. Towards the end of both dry seasons, but, particularly the usually longer Jillal, many of the water sources dry out and the local rural population may have to:

- rely on much smaller supplies;
- carry water over larger distances;
- migrate to a perennial water source.

The major source of water for most of the rural inhabitants of the Bay Region is the war. Taking the number of active wars as 8,600 (Watson and Nimmo, 1982) and the average gross capacity as 800 m^3 (World Bank, 1979) gives the total storage 6.9 x 10^6 m^3. This would seem adequate for the total demand during the Jillal of three to four million m^3; however, usable war storage is thought to be less than 40 per cent of the gross storage capacity (say, 2.8 x 10^6 m^3) because of evaporation and seepage losses. Moreover in dry years many of the wars do not fill to capacity.

Of course, the density of wars is not the same everywhere; highest densities of more than one per square kilometre, are found on the clay plains of the Limestone Plateau. In the critical area to the north of Buurhakaba, the density has increased rapidly in the last ten years (from 0.16 to 0.81 wars per square kilometre) but severe shortages of water persist; it is likely that less and less suitable sites are adopted as time goes on.

The other major source of water, the dug well, is also unevenly distributed throughout the Region. Greatest densities (more than one well per sq. km.) are found along the Basement-Limestone junction between Baydhabo and Diinsoor. Density of wells is also high in the Basement area to the south east of the Limestone Escarpment between Baydhabo and Diinsoor but is low (about 0.16 well per sq. km) in the cultivated area to the north of Buurhakaba. These densities reflect the hydrogeological conditions.

Deep wells (boreholes) and springs are also localised and at present provide only a small proportion of the current requirements. Assuming that all the 23 WDA wells equipped with pumps are currently operational and could be pumped at 12 m^3/h for twelve hours a day, they could still provide only about 3 300 m^3/day or only some 15 per cent of the demand. However the proposed new 60 deep wells on the Limestone Plateau will make an appreciable difference to the water supply in that area, by substantially increasing the number of reliable, perennial water points.

Thus parts of the Region suffer from water shortages every dry season and much of it is affected in dry years. The overall pattern is perhaps best shown by plotting all perennial water sources (those that do not dry up in an average rainfall year) on a map (Figure 3.1). This clearly shows the areas particularly short of water; where these coincide with cultivated land and settled population, they are in need of urgent attention. The largest such area is that to the north and north-east of Buurhakaba.

3.5 WATER QUALITY

3.5.1 General

Several water samples from various water supply systems in the Region have been collected during the current Review and analysed using a portable laboratory; the results are shown in Table 3.1. These results confirm the mineralogical variability of the supplies.

3.5.2 Groundwater

The chemical quality of groundwater in the Region has been discussed already. It will suffice to say here that much of the groundwater currently abstracted and used for drinking, falls well outside the WHO (1977) permissible limits for potable supplies.

3.1 Perennial Water Points

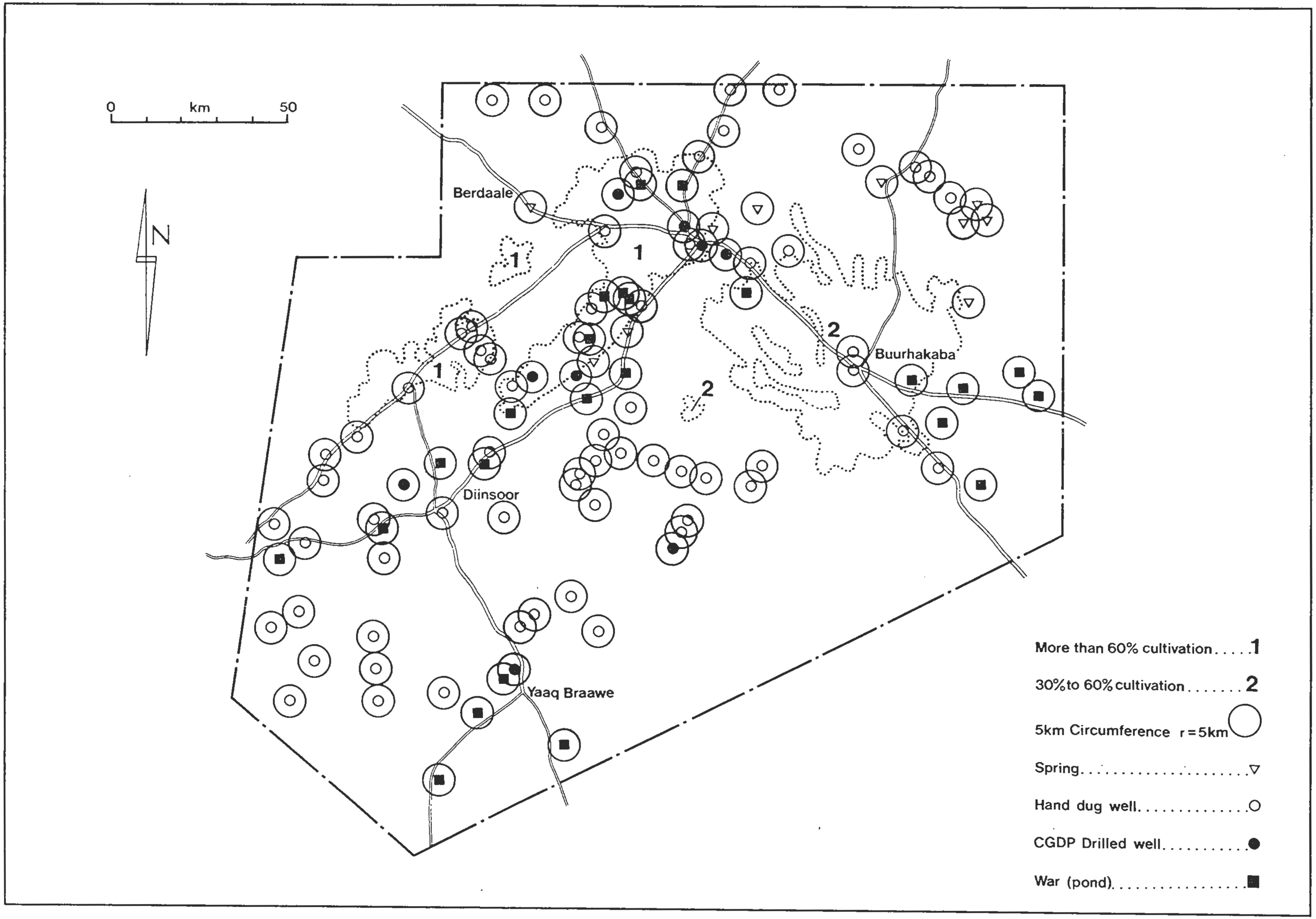


TABLE 3.1 ANALYSES OF WATER SAMPLES

Location	Ufurow	Daynuunay	Daynuunay	Buurhakaba	Buurhakaba	Bisia Cadde	Habedo
Type of Source	Deep Well	Deep Well	Shallow Well	Shallow Well	Shallow Well	Shallow Well	Shallow Well
Geological Area	Limestone Plateau	Basement	Basement	Basement	Basement	Basement	Basement
Turbidity (FTU)	90	< 5	-	< 5	-	< 5	5
pH	7.5	7.5	-	7.4	-	7.4	7.5
EC (umhos/cm)	2 300	1 770	2 700	1 500	800	5 200	3 500
Ca (mg/l)	200	55	-	165	-	110	55
Fe (mg/l)	0.6	Nil	-	Nil	-	Nil	Nil
HCO_3 (mg/l)	300	340	-	260	-	690	560
SO_4 (mg/l)	160	150	-	200	-	700?	260
Cl (mg/l)	400	305	-	185	-	1 120	930
NO_3 (mg/l)	Nil	-	-	12	-	35	20
F (mg/l)	-	2.0	-	-	-	1.4	1.4
TOTAL HARDNESS (mg/l $CaCO_3$)	-	380	-	550	-	1 180	650

TABLE 3.1 ANALYSES OF WATER SAMPLES (Continued)

Location	Buur Heybo	Dolon Dole	Manaas	Awdheere	Berdaale	Hawlaha Guud	Godoboy	Tosili Maleel
Type of Source	Spring Well	Spring Well	Spring	Shallow Well	Shallow Well	Shallow Well	War	War
Geological Area	Basement	Limestone Escarpment	Limestone Escarpment	Limestone Plateau	Limestone Plateau	Limestone Plateau	Limestone Plateau	Limestone Plateau
Turbidity (FTU)	-*	-	-	-	-	-	40**	20**
pH	6.3	-	7.1	-	-	-	8.4	8.0
EC (umhos/cm)	320	960	5 800	4 300	3 300	4 300	690	560
Ca (mg/l)	12	70	500	-	200	150	50	-
Fe (mg/l)	0.45	-	Nil	-	Nil	Nil	-	-
HCO_3 (mg/l)	20	335	290	330	285	390	150	170
SO_4 (mg/l)	12	25	510	300	100	300	160?	-
Cl (mg/l)	65	60	1 900	-	730	1 230	-	15
NO_3 (mg/l)	5	10	-	-	45	-	<1	1
F (mg/l)	0.2	-	-	-	-	-	-	-
TOTAL HARDNESS								
(mg/l $CaCO_3$)	30	310	1 700	-	1 250?	1 500?	-	-

Source: *HTS 1983.*

* *Apparent colour = 75 units.*

** *After 25 hours settlement.*

Since the WHO standards could not be met without desalination of groundwater (which is not a practical proposition), LBI/RM (1983) suggested that more liberal standards be adopted in the Region, namely:

	EC x 10^6 @ 25°C	C/l (mg/l)	SO_4 (mg/l)
Human Supplies	3 500	800	600
Camels	10 000	-	-
Other Livestock	7 500	-	-

On the evidence of current water use in the Region, these standards appear reasonable. Since some of the Limestone Plateau boreholes produce water higher than EC x 10^6 3 500, it is certain that even more saline water will be used for human consumption when no better water is easily available.

Regarding the individual chemical constituents of groundwater, little use can be made of the mass of chemical data given by LBI/RM (1983) because of the prevalence of internal inconsistencies in the analyses. More accurate analyses are required.

Little data on the bacteriological quality of groundwater is available. Apparently shallow, dug wells are commonly polluted, with high counts of colliform bacteria. In the case of drilled wells, bacteriological contamination has been recorded in wells actually in the villages, whereas no such contamination has apparently occurred in wells sited a few hundred metres outside the village (Edgreen, LBI 1983).

There is evidence that some of the groundwater may be corrosive to unprotected steel. Calculations based on groundwater chemistry (LBI/RM 1983), admittedly often using internally inconsistent analytical data, indicate a corrosion potential in some of the borehole water. Further, many of the galvanised steel tanks installed at WDA deep wells are now badly corroded; however no reports of serious corrosion of pumps and rising main have been received.

The whole subject of corrosion needs further study. Well-head analyses, using portable equipment, are required, as is a systematic inspection of various above-ground metal fixtures at existing wells.

3.5.3 Surface Water

Few analyses of surface water are available. The LBI/RM Report (1983) gives the analyses of eight war samples and a further two samples were partially analysed during the Mid-term Review.

Salinity of water is generally low (EC x 10^6 from 300 to 700) except at very low storages, when concentrated by evaporation; in one war a value of 3 700 micromhos/cm was recorded. Sulphate is often the dominant anion and in one case 2 305 mg/l has been recorded (LBI/RM 1983), but the analyses listed suffer from internal inconsistencies and consequently have a low credibility. High sulphates, particularly if associated with magnesium, cause gastro-intestinal irritation.

War water has high turbidity, which is only partially improved by settlement; allowing two samples to stand for 24 hours reduced their turbidity from about 100 FTU to 40FTU in one and to 20 FTU in the other.

Any surface water source is liable to bacteriological pollution. When water is stored most bacteria will die within one month and even within a few days there will be a substantial reduction; thus if people and livestock are excluded from a war, its bacteriological quality should improve with time. Unfortunately normally both people and livestock are given access to the war and the water is continually recontaminated.

There are no data available on the bacteriological quality of surface water or on the incidence of water-borne diseases. Therefore all that can be said at present is that the risk is high.

3.6 WATER CHARGES

Current water charges for livestock are given by LBI/RM (1983) as follows:

Animal	Tuulo Fees (Ssh)	WDA Fees (Ssh)	EEC War Fees (Ssh)
Camels	1.0 - 2.0	0.50	1.0
Cattle	0.50	0.25	0.5
Goats/Sheep	0.10 - 0.25	0.10	0.2

The charge for a traditional clay pot holding about 12 litres is usually Ssh 0.20 and for a 200 litre drum it is normally Ssh 2.0. Water is also sold from private water points during the dry seasons.

At present,revenues from the WDA wells do not cover the operating costs. Reportedly total receipts from these wells were Ssh 112 000 which is said to be inadequate to cover running costs. Since the charge per unit volume of water seems rather high, it may be that the fees are not rigourously collected, particularly during the periods of relatively abundant availability. This may also be the case at other government water points.

4

Development Planning

4.1 FAO/WORLD BANK COOPERATIVE PROGRAMME (1977)

The Bay Region Agricultural Development Project was first formulated with the assistance of the FAO/World Bank Cooperative Programme. The Project Preparation Mission visited Somalia in November/December 1976; a second mission in March 1977 helped with further preparation work on the Project.

Lack of water was identified as one of the major constraints to crop and livestock production. To remedy the situation, it was proposed to provide 70 deep boreholes on the Limestone Plateau and 100 shallow boreholes or dug wells in the Basement area and the adjacent Limestone Depression. Practically all the new water points were to be located in areas suitable for cropping, either at existing villages or in areas where settlement was to be encouraged. The exception would be 10 deep boreholes located in the Limestone Plateau rangelands for use by nomadic stock. Locations of 69 of the proposed wells were suggested in a table listing 'areas requiring water supply' (Table 4.1).

Demand per rural family and its livestock was estimated at 250 litres per day. Design production capacities were to be about 10 000 litres per hour (l/h) for a borehole on the Limestone Plateau and 1000 l/h for a shallow Basement or Limestone Depression well.

The deep wells were to be equipped with mechanised, diesel driven (single cylinder, slow speed, water cooled engines) pumps and the shallow wells with hand pumps. Funds would be allocated for operation and maintenance of the pumps, but 80 per cent of these recurrent costs would be recovered by levying water charges on the population benefitting from the installations.

In addition to the improvement in drinking water supplies a groundwater irrigation component was included in the Project, subject to confirmation of appropriate potential by a study. Apparently a preliminary appraisal by the Preparation Mission indicated the presence of an extensive, exploitable groundwater body in the Limestone Depression. This, if confirmed by further studies, was to be developed for irrigation. Funds were allocated for the construction of irrigation systems totalling 400 ha.

The time allocated for all the necessary work involved in the water component was three years. The deep drilling was to be done by sub-contract (with an international drilling contractor). The rest of the work would be undertaken by a 'Design and Supervision Section' operating under the Project Manager and his Deputy, and strengthened by technical assistance, comprising two engineers (part time on water), hydrogeologist, a geophysicist and a senior driller.

The total cost of water related works (including irrigation) was estimated at Ssh 33.7 million (about US$ 5.4 million). In addition about half of the estimated cost of technical assistance and studies (Ssh 13.7 million) should be allocated to the water supply component of the Project. A contingency item of 15 per cent was added to these base costs.

4.2 WORLD BANK APPRAISAL (1979)

The BRADP as prepared by the FAO/World Bank Cooperative Programme was put forward for appraisal by the World Bank before financing could be made available. The Appraisal Mission visited Somalia June/July and issued their report in November 1979. The Mission accepted the general concept of the Project but made several important changes to various items including the water supply component.

Recognising the weakness of the data base, the Mission recommended that the first three years of the Project be utilised for various investigations to gain a better understanding of groundwater occurrence and the effective use of wars, dug wells and boreholes. It was thought that drilled well construction on the Limestone Plateau could be started within that period but concurrently it would be necessary to prepare a water development strategy for the Basement and Limestone Depression areas. The plans formulated in this first stage of the Project, would be implemented in a second stage, another three year period.

The main proposal for the Limestone Plateau was the construction of about 60 deep boreholes, fully equipped with pumps, engines and discharge works, to supply water for domestic and livestock use. The boreholes would be located mainly in currently cropped areas except for six, which were to be sited in the range areas of the proposed 'Pilot Agricultural Development Units' (PADU). Though a high success rate in terms of water production was expected, it was recommended that the early stage of the Project be utilised for proper site selection and that the first 10 boreholes be spaced widely throughout the area to serve both the water supply and an investigatory function. The newly constructed and equipped wells were to be operated and monitored by WDA to identify future operational and maintenance problems.

For the Limestone Depression, the proposals were to investigate groundwater availability using geophysics, exploratory drilling and test well construction and pumping. Two test wells were proposed; if successful they were to be converted to permanent irrigation wells, each serving a five hectare plot. It was also proposed that investigations be undertaken to identify ways of improving groundwater use along the Limestone Escarpment, where at least one small, manually supplied, irrigation system was then in existence (at Habare).

Realising the difficulties of providing reliable water supplies in the Basement area, the Appraisal Mission proposed a major study to establish rational guidelines for improving the effectiveness of siting, design and construction of wars, dug wells and boreholes. Specifically, the search for groundwater was to include a geophysical survey, exploratory drilling of 40 boreholes and the construction of 10 dug wells. Successful boreholes (expected to be about half of those drilled) and dug wells were to be equipped with hand pumps which would be an innovation for the Region. The standard design of the various types of wars was to be reviewed and four pilot wars, smaller and less expensive than those constructed with the EEC aid, but larger and better designed than typical village excavations, were to be constructed and monitored.

TABLE 4.1 AREAS REQUIRING WATER SUPPLY

No.	Site	Location	Population Settled	Population Nomadic
	BAIDOA			
1	Sormadore	20 km from Baidoa along Dinsoor road	5,000	4,000
2	Goarsane	35 km from Baidoa along Qansah Dheere road	5,000	3,000
3	Hoobishoale	42 km from Baidoa along Qansah Dheere road	2,000	3,000
4	Isgooy	75 km from Baidoa along Q.D. road then 20 km north	4,000	3,000
5	Xagarkaa	45 km from Baidoa along Qansah Dheere road	1,000	2,000
6	Manaas	30 km from Baidoa along Dinsoor road then 15 km east	1,000	2,000
7	Roobay Gaduud	60 km from Baidoa along Q.D. road then 12 km east	1,500	2,000
8	Xaawaay Qirimey	55 km from Baidoa along Q.D. road then 15 km west	1,000	1,500
9	Goof Yaron	30 km from Baidoa along Lugh road then 15 km south	1,500	1,000
10	Qasalow	25 km from Baidoa along Lugh road then 13 km west	2,000	1,000
11	Abes Masayidica	30 km from Baidoa along Lugh road then 15 kmssouth west	3,000	2,000
12	Jirow	20 km from Baidoa along Lugh road then 15 km west	3,000	1,500
13	Busley	22 km from Baidoa along Lugh road	2,000	1,000
14	Awdheerow	45 km from Baidoa along Lugh road then 20 km west	1,000	500
15	Shabeele Omar Guud	12 km north of Berdale	2,000	500
16	Doorah Weri	90 km from Baidoa along Oddur road	2,000	500
17	Kooraar	10 km west of Berdale	1,000	500
18	Erinleen	30 km south west of Berdale	2,000	3,000
19	Tosikaar	20 km from Berdale along Qansah Dheere road	1,500	500
20	Gof Guudud Burey	35 km from Baidoa along Vegit road	5,000	2,000
21	Dhexyaal	15 km west of location No.20	1,000	5,000
22	Harreri Jiife	20 km south east of location No.21	1,000	2,000
23	Afweeyne	15 km west of location No. 21	1,000	500
24	Sarman Dheere	15 km north of location No. 23	3,000	2,000
25	Maleel	54 km from Baidoa along Oddur road	3,000	1,000
26	Deebe Gass	17 km north west from Lavantin Gira	1,000	1,000
27	Dumbalo Aaalin	30 km from Baidoa along Lugh road then 15 km east	1,500	500
28	Borame	28 km south of Baidoa	2,500	1,000
29	Lowjar		-	-
30	Bur Dhimbil		3,000	500
31	El Doon	15 km north east of Baidoa (existing spring)	none	2,000
32	Adable Corum	30 km from Baidoa along Lugh road then 20 km west	1,500	500

TABLE 4.1 AREAS REQUIRING WATER SUPPLY (Continued)

No.	Site	Location	Population Settled	Population Nomadic
	BAIDOA (continued)			
33	Moro Warraabe	10 km north east of Berdale	2,000	500
34	Bootis	30 km from Baidoa along Dinsoor road then 20 km north	1,000	500
35	War Xargaan	48 km north east of Baidoa	2,000	2,500
36	Geooda Dheryo	50 km from Baidoa along Oddur road	none	3,000
	QANSAH DHEERE			
1	Weel Nurri	20 km from Ofuro towards Juba river	3,000	-
2	Gadudo Dhunto	10 km north of Xawal Barbaar	2,500	-
3	Golol Tur	15 km from Qansah Dheere along Ofuro road	3,000	-
4	Durei Ali Galle	5 km west of location No.3	2,500	-
5	Deib Weyne	5 km south of Xawal Barbaar	4,000	-
6	Burlo Fur	12 km east of Qansah Dheere	4,500	-
7	Xabaasha Xadayya	20 km from Ofuro along Dinsoor road	3,000	-
8	Bulo Guman	10 km south of Qansah Dheere	2,000	-
	BUR ACABA			
1	Bunlo Fullay	115 km south of Bur Acaba	6,000	-
2	BurAcaba	in town	10,000	-
3	Dooy Gaab	10 km south west of Bur Acaba (Cooperative area)	5,000	-
4	Dalandoolle	65 km north east of Bur Acaba	5,000	-
5	Wadiina	30 km south west of Baidoa	3,000	-
6	Bur Haibi	35 km east, north east of Bur Acaba	4,000	-
7	Shiidaalow	10 km east of Bur Hibi	-	-
8	Dhafaad	55 km south, south west of Bur Acaba	-	-
9	Moodo Moode	30 km from Bur Acaba along Baidoa road	-	-
10	Waamo	40 km north west of Bur Acaba	-	-
11	Ciqale Hoole	50 km from Bur Acaba along Mogadishu road	-	-
12	Goof	40 km north east of Bur Acaba	-	-
13	Yuubka	25 km south, south east of Bur Acaba	-	-

TABLE 4.1 AREAS REQUIRING WATER SUPPLY (Continued)

No.	Site	Location	Population Settled	Population Nomadic
	DINSOOR			
1	Adaadgeri	35 km from Dinsoor along Bardera road	500	1,000
2	Gelay	50 km north east of Dinsoor	600	2,500
3	Degomar	25 km from Dinsoor towards Bardera then 13 km north west	2,500	5,000
4	Bunbegay	20 km from Dinsoor towards Bardera then 35 km north	2,000	6,000
5	Bulo Omane	25 km from Dinsoor along lac Brava road	600	1,500
6	Welgaras	15 km from Dinsoor towards Bardera then 80 km north	2,000	7,000
7	Buagadud	25 km from Dinsoor towards Bardera then 45 km west south west	2,000	5,000
8	Ibraheim Gurbaan	25 km from Dinsoor towards Bardera then 5 km north west	3,000	6,000
9	Kurow	35 km from Dinsoor towards Bardera then 5 km south	600	2,000
10	Kurmaan	14 km from Dinsoor towards Bardera then 11 km north west	2,500	5,000
11	Kenaaynax	40 km from lac Brava along Dinsoor/I.B. road going south	5,000	8,000
12	lac Brava	Town	2,500	8,000

Source: District Commissioners and Government Officials, Bay Region as quoted by FAO/World Bank, 1977.

In the implementation plan, no special time was allocated for the very considerable investigation proposed. It was considered that the time gap between specifying and ordering various equipment and its delivery and commissioning would be sufficient to accommodate this work.

The time allocated to the Project as a whole was six years; water related activities were to be carried out in 5.5 years. All the water related work was to be executed under the control of the Project Management Unit (PMU), though with the fullest possible participation of WDA.

All the items of the water component were to be implemented by the PMU, strengthened, where considered necessary, by technical assistance; the GOS were reluctant to allow international contractor participation and the Mission agreed that all the necessary equipment and materials would be procured instead and that the Regional WDA organisation would be seconded to the PMU. The technical assistance was to consist of the provision of six internationally recruited experts and technicians, vehicles, equipment, operating costs and an extensive training programme for Somali staff.

The major items of equipment considered necessary for the work to be carried out were as follows:

2 rotary drilling rigs with accessories
1 cable-tool rig with accessories
1 crane truck
2 compressors
1 concrete mixer
3 7-ton 4WD trucks
2 water tankers
7 4WD pick-ups
1 4WD station wagons
5 800 m of well casing
2 300 m of well screen
2 test pumps
60 deep well pumps with engines.

The total base cost of the water supply component of the Project (excluding technical assistance) was estimated at Ssh 30.8 million (US$4.9 million). That of technical assistance and training in water related disciplines was estimated at some Ssh 25.5 million (US$ 4.1 million). In addition 5.5 per cent physical and 26.5 per cent price contingencies were allowed.

The costs of boreholes were to be recovered by a levy per animal watered. The level of such charge rates was to be proposed by GOS and approved by the IDA, with the stipulation that the revenue thus gained would be sufficient to at least ensure full cost recovery for the establishment and maintenance of water supply in the Bay Region.

Funds to implement the water component of the Project (excluding technical assistance) were to be obtained from the following sources:

Source		Amount (US$ Equivalent)
GOS		1 100 000
IDA		1 400 000
IFAD		1 000 000
USAID		2 900 000
	Total	**6 400 000**

The GOS/IDA/IFAD contributions were allocated to pay for housing, local salaries and operating costs of equipment (including spares) and project installed water supply facilities. USAID were to finance all vehicles, equipment and materials, and technical assistance.

4.3 USAID PROJECT PAPERS

The USAID (1980) who agreed to finance the equipment and technical assistance involved in the water component of the Project, added very little to the World Bank's plan. In fact they reproduced much of the IDA Appraisal Report almost verbatim: it could therefore be taken that they agreed with the main conclusions and proposals. In a slight change of emphasis, USAID stressed even more strongly the need to improve the data base by studies and investigations in the first 3 years of the Project.

Under the USAID programme, the water component of the BRADP became part of the wider Comprehensive Groundwater Development Project (CGDP), under the control of WDA and not the PMU, which was to have only a coordinative function.

The USAID Project Paper (1979) for the CGDP recommended a very extensive programme of water supply work, covering both groundwater and surface water in several of Somalia's Regions over a period of six years. Equipment to be procured included the following major items:

Drilling Programme
3 Rotary Drilling Rigs
2 Cable - tool Drilling Rigs
3 Small Service Rigs
3 Compressors
2 Test Pumps
12 4-Wheel-drive Station Wagons and Pickups
5 7 ton Trucks
3 Water Tankers
4 500 m Well Casing
800 m Well Screen
38 Pumps and Engines

Surface Water Development
1 Bulldozer
1 Motor Grader
1 Tractor and Roller
3 Dump Trucks
3 Machinery Trailers
3 Concrete Mixers
1 000 tons Cement

In addition it was proposed to supply several different kinds of exploratory geophysical equipment, well maintenance equipment and over 60 man-years of technical assistance. The estimated cost of the whole proposed package was US$17 million.

It seems however that the scope of the CGDP has been drastically reduced. In effect, under this project USAID supplied 3 rotary drilling machines with spares and accessories and engaged a consultant namely the consortium of Louis Berger International Inc. and Roscoe Moss Company (LBI/RM) to carry out a programme of surface and groundwater investigations and development. In the Bay Region this programme was to be, in the first place, a reduced version of the World Bank proposals; the reductions had to be introduced because the consultant contract was for three years only. The USAID financing of the consultants work was to be as follows:

Under CGDP		US$ 3 685 000
Under BRADP		US$ 2 574 000
	Total	**US$ 6 259 000**

LBI/RM prepared a plan of operations for their work programme in 1981. This proposed an unspecified number of exploration holes and 48 completed production wells by mid - 1984. Apparently little work was proposed for the surface water component.

4.4 HUNTING TECHNICAL SERVICES STUDY (1982)

Hunting Technical Services (HTS) were contracted by BRADP to carry out a soil and vegetation survey, groundwater irrigation potential evaluation and a livestock study. In addition their terms of reference required ' a tentative master plan at a scale of 1 250 000'.

In the field of water supply the most important outcome of the HTS study was the conclusion that none of the aquifer systems of the Bay Region were suitable for large scale development for irrigation. Specifically dealing with the Limestone Depression, HTS recommended some further drilling in the east of that area, but pointed out firmly that the chances of successful irrigation wells there were very small. Otherwise, the HTS study offers little comment on water supply development.

5

Assessment and Recommendations

5.1 ASSESSMENT

5.1.1 Planning

The greatest weakness of the proposals in all the project planning documents was that inherent in the haste with which the Project was undertaken. Though it was realised that the data base was too weak to design a sound development project and attempts were made to allow time for the necessary investigations, insufficient emphasis was given to the possibility of substantial changes to the planned work programme in the light of the results of these studies. This was to some extent acknowledged by the USAID appraisal (1980), which strongly stressed the need of the first stage to be largely investigatory, thereby implying the necessity of reviewing the programme for the second stage.

A further serious planning deficiency was lack of adequate provision for evaluation of water demand and formulation of a water supply strategy. No guidelines were given on what constituted a water-short area, in which a new supply facility should be installed and in what manner the local population should be consulted.

All of the planning documents concentrated on the construction of drilled wells, almost to the exclusion of other water supply facilities. The World Bank and USAID proposals include proposals for new shallow wells and wars, but boreholes were treated in much greater detail.

The philosophy behind the World Bank proposal to construct ten hand-dug wells was not explained. A clarification is necessary in view of the fact that the local population are perfectly capable of undertaking such work themselves without government help. Since just 10 wells could not make any real impact on the water supply situation in the Region, their purpose was presumably intended to be investigatory or demonstrative; however, this should have been clearly specified.

The purpose of the four pilot wars is somewhat clearer; these were to be smaller (and cheaper) than the large government wars (which provide perennial water), but nevertheless capable of providing year-round water supplies to small communities. Implicit in this proposal is an extensive study of existing wars, which should have been clearly specified in the Appraisal Report. Furthermore, the feasibility of small wars providing perennial water should not have been taken for granted.

No water quality standards for domestic supplies or for watering of livestock were indicated in the appraisal documents. The water contained even in the best controlled wars is turbid and likely to be a source of waterborne diseases. However, there was no requirement to consider possible treatment methods to improve the water quality in the design of the four new pilot wars. No criteria for chemical quality of well water were given although the presence of highly saline groundwaters in the Basement Complex was noted.

Despite these deficiencies the proposed overall water supply work programme was reasonable in terms of its aims and the time, personnel and equipment allocated for attaining them.

5.1.2 Timing

Though the BRADP became effective in April 1980, LBI/RM field operations did not start until July 1981. In fact, intensive studies in the Bay Region started late in 1981 with the arrival and comissioning of two rotary drilling machines. At the same time some ancillary equipment and well components were supplied, but many important items including surface geophysical instrumentation, steel casing and screen for deep wells, and test and permanent production deep well pumps did not arrive in Mugdisho until August 1983. Some problems arose from these delays.

There is no doubt that the drilling investigations, which are well advanced, would have been more effective, had they been accompanied by surface geophysical surveys such as resistivity, seismic and magnetometer. The difficult problem of siting wells in the Basement and Limestone Depression areas would have certainly been taken much closer to a solution.

Delays with pumping plant procurement have led to delays with well testing, which would have provided useful data and facilitated further groundwater development planning. More seriously, the lack of permanent production pumps has substantially reduced the consultants' opportunity to monitor the performance and usage of the new wells, from which valuable lessons might have been learned.

Systematic work on water supply in the critically important Basement Complex area, including comparison of the relative merits of drilled wells, dug wells and wars in various regions, and the possibility of the conjunctive use of these sources, has not yet been undertaken. This has been due to various reasons, including poor planning, but also due to delays in hand pump procurement.

Perhaps the most serious delay (or even omission) has been the neglect (so far) of surface water studies. It is apparent that much of the Basement area will have to continue to rely on surface water for potable and livestock supplies; consequently work in this field is urgently necessary. Particularly, immediate action on the procurement of war construction equipment is required, if work on experimental wars, stipulated by the World Bank Appraisal Mission, is to have any chance of implementation during the current phase of the Project (by April 1986).

Nevertheless, despite the late start, the delays in equipment delivery and the neglect of the surface water work, the water component of the Project can boast of substantial achievements and, if continued to the end of Phase I of BRADP, it should attain all the specified objectives as well as undertake any further work identified as essential during the Project.

5.1.3 Staff and Equipment

The comparison of expatriate staff inputs planned by the World Bank Appraisal and actually provided by LBI/RM under Technical Assistance, is given in Table 5.1. The numbers are not strictly comparable because the 'Actual' category includes all the staff provided under the Comprehensive Groundwater Development Project, which has wider scope than the water component of the BRADP; it includes groundwater work outside the Bay Region. However, apparently about 80 per cent of the CGDP effort was spent on the Bay Region; thus, so far, about twice as many man-months of expatriate expert time has been provided to the Project as has been planned, despite the late start.

The situation with Somali staff, (Table 5.2) assigned by WDA to the Project, is rather different. The planned and actual staff inputs are basically similar apart from casual labour, which probably does not show in the CGDP records and pump operators, who have not yet been engaged because of delays with pump delivery.

Comparison of planned and actually provided equipment and materials is difficult, because again the machinery and the well components actually procured were for the wider CGDP and because the LBI/RM contract was for three years only; thus they ordered rigs and machinery, suitable for all kinds of well construction that might be required anywhere in Somalia; moreover because of delays with the delivery of well components, some such items from old WDA stocks had been used. In general the quantities of various major machinery items have been comparable.

5.2 PLANNING CRITERIA

5.2.1 Water Supply Strategy

As already mentioned, a major dificiency of all the water supply planning exercises so far undertaken is the lack of any attempt to formulate a clear water supply strategy. Clearly, the activities of this Project should be viewed as a part of a long term strategy and should be compatible with Somalia's overall water supply policy. It is outside the Terms of Reference of this review to formulate such a policy, but some ideas on the subject are given below for discussion by the relevant agencies.

Viable long term objectives of all the water supply work in the region might be:

(a) To provide perennial water supply with piped distribution and stand pipes at say, 200 m centres, to all towns with a population of 10 000 or more.

(b) To provide perennial water supply within say, 500 m of any agricultural settlement of more than 1000 population.

(c) To provide perennial water supply within five km of any agricultural settlement of less than 1000 population.

(d) To provide livestock watering points at, at least 10 km centres throughout the Region.

(e) To meet the following quality standards for water for human consumption:
  - (i) bacteriologically safe
  - (ii) EC x 10^6 @ 25°C less than 3 500
  - (iii) Chlorides (Cl) less than 800 mg/L
  - (iv) Sulphates (SO_4) less than 600 mg/L
  - (v) all other constituents within WHO permissible limits.

TABLE 5.1 TECHNICAL ASSISTANCE - PLANNED AND ACTUALLY PROVIDED

Staff Member	Man-months							
	Year 1		Year 2		Year 3		Year 4*	
	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
Project Manager	0	0	0	8	0	12	0	6
Hydrogeologist	6	0	12	11	12	34	6	16
Water Engineers	0	0	0	0	12	0	6	6
Drilling Superintendent	6	0	12	8	12	12	6	6
Chief Driller	0	0	12	5	12	24	6	12
Chief Mechanic	0	0	6	7	12	12	6	6
Chemist	0	0	0	3	0	12	0	6
Geophysicist	0	0	0	2	0	12	0	6
Pump Technician	0	0	0	4	0	12	0	6
Mechanic	0	0	0	0	0	0	0	3
Electrician	0	0	0	3	0	9	0	0
Support Services	0	0	0	1	0	12	0	6
Unassigned	0	0	0	10	0	10	0	8
Total	12	0	42	62	60	161	30	87

Grand Total - Planned 144 man-months
Actual 310 man-months

* First 6 months only

Source: LBI/RM, 1983

TABLE 5.2 ASSIGNMENT OF WDA STAFF TO THE PROJECT

Staff Category	Man-months							
	Year 1		Year 2		Year 3		Year 4*	
	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
Hydrogeologist	12	0	24	12	24	24	12	12
Geophysicist	0	0	6	3	12	12	6	6
Water Engineer	0	0	0	0	24	0	12	0
Senior Driller	0	0	18	24	36	48	18	24
Assistant Driller	0	0	24	48	48	96	24	48
Mechanic	0	0	18	12	36	24	18	12
Drivers	24	0	108	36	168	72	84	36
Rig Hands	0	0	120	180	240	360	120	180
Camp Cooks	0	0	18	18	48	36	24	18
Casual Labour**	0	0	60		120		60	
Accountant	0	0	6	6	12	12	6	6
Clerk	0	0	6	12	12	24	6	12
Production Pump Operators*	0	0	0	0	120	0	180	0
Total	36	0	288	351	660	708	330	354

Grand Total - Planned 1314 man-months.
Actual 1413 man-months.

* First 6 months only
** Excluded from the total

Source: LBI/RM, 1983

(f) Water quality for livestock to have salinity lower than that equivalent to EC x 10^6 @ 25°C of 7500.

It is clear that such ambitious objectives would take many years to attain, particularly in the face of the currently high population growth rate in the Region; however the Project should make a start in that direction.

5.2.2 Comparison of Wells and Wars

It has been generally assumed that drilled wells are preferable to wars in terms of reliability of supply and quality of the water produced. Because of high mineralisation of some of the groundwater produced by wells, this contention is no longer generally acceptable and a cost comparison of these two sources is necessary.

Table 5.3 gives the approximate cost of water from a deep well with a diesel driven pump on the Limestone Plateau, a drilled well with a handpump in the Basement Complex area and a war constructed somewhere with suitable conditions. It is necessary to say something about the assumptions on which the derivation of these costs is based.

Well costs are based largely on a report by LBI 'Preliminary Economic Analysis of the CGDP' (1982); for comparison purposes the same procedure has been used in estimating the costs of wars. In all cases costs have been expressed in US dollars; for prices available for 1982, a 10 per cent inflation rate has been assumed. Discount rate of five per cent has been used for calculating present values and amortised capital costs. In all cases a life of 15 years has been assumed for the water facility constructed, with no allowance made for replacement of mechanical items.

In addition, the following further assumptions have been made for the specific cases:

(a) Deep wells with diesel driven pumps

- the wells would be 150 m deep, lined with corrosion resistant steel casing of eight inches (200 mm) diameter
- the wells would be fitted with positive displacement ('mono') pumps with capacity of about 3 L/s, operating on average for 7.5 hours per day
- 24 production wells would be drilled by a rig per year
- 80 per cent of holes drilled would be successful.

(b) Drilled wells equipped with handpumps

- the wells would be 100 m deep, constructed to the same standard as above
- the wells would be equipped with hand pumps with capacity of 0.25 L/s
- operating factors would be 7.5 hr/d on average
- 25 per cent of the holes drilled would be successful (this corresponds approximately to the experience of the current Basement Complex drilling programme)

TABLE 5.3 COST OF WATER FROM WELLS AND WARS

Item	Well + diesel pump	Well + handpump	War	War + filter
Capital Cost ($)				
Preliminary investigations	1 570	1 570	1 570	1 570
Draft construction costs	18 200	13 000	20 350	35 350
Pumps	16 600	3 150	5 500	5 500
Surface installation	8 600	nil	8 600	8 600
Capital equipment recovery	20 200	20 200	12 750	12 750
Administrative overheads	9 900	9 900	7 400	7 400
Non-productive drilling	1 000	11 200	nil	nil
TOTAL CAPITAL COST	76 070	59 020	56 170	71 170
Operating Costs ($/yr)				
Labour	1 050	nil	1 050	1 050
Fuel	5 700	nil	220	220
Maintenance	980	680	220	220
TOTAL OPERATING COST	7 730	680	1 490	1 490
Amortised Capital Cost ($/yr)	7 325	5 680	5 410	6 850
TOTAL ANNUAL COST ($/yr)	15 055	6 360	6 900	8 340
Water Production (m^3/yr)	32 850	2 500	5 000	5 000
Cost of Water $/$m^3$	0.46	2.55	1.38	1.66

- no allowance is made for any well operator or watchman.

(c) Wars

- the total capacity of the wars would be 6 300 m^3 each, with net usable storage of 40 per cent or 2 500 m^3
- the wars would be constructed using a 140 HP bulldozer excavating 50 m^3/h working 8 hr/d
- the bulldozer would spend half of its time excavating and half rolling and trimming bunds
- minor excavations would be done by hand by hired labour
- an additional 2 500 m^3 of excavation would be done for a silt trap and a by-pass channel
- 150 m^3 of masonry would be required for the inlet weir and bund protection
- no plastic lining would be used but nevertheless seepage losses would be negligible
- water from the war would be pumped to a high level tank and would then be gravity fed to cattle troughs and domestic water taps
- research costs and surface installation costs would be the same as for deep wells
- five wars would be constructed per year and the mechanical plant would be written off in five years
- desilting would be done by local labour at no cost.

Though the cost estimates are at best rough approximations, they should be comparable, since more or less the same assumptions have been made in each case.

The results indicate that water from deep wells, pumped by diesel driven pumps, is considerably cheaper than that from other sources; since deep wells provide the most reliable supplies, all other things being equal they are clearly preferable.

The very high estimated costs of water from a drilled well equipped with a hand pump is partly due to the low success ratio of drilling in the Basement area and partly due to the fact that drilling diameters and various well components, being the same as for the mechanically pumped wells, are too large for their duties. Thus these costs could be substantially reduced by better siting procedures (using geophysics) and by using more appropriate well components.

The biggest weakness of cost estimates of war water is the assumption that seepage losses are negligible; moreover, another assumption implicit in the above treatment, that suitable catchments with adequate run-off to fill the wars are easily available, may also not be correct.

Dug wells, equipped with hand pumps have not been included in this treatment, but it is certain that they would produce cheap water.

5.2.3 Water Quality Control

Water quality of the discharges of many deep and shallow wells is poor in terms of its chemical composition; the main problem is that of high overall salinity. The only way to improve this would be through desalination and base exchange treatment, which would be extremely expensive and quite inappropriate for the small systems envisaged. The only practical measure which can be taken is to avoid areas of high salinity groundwater in the well installation programme.

The bacteriological quality of well water can be controlled by proper well siting and sanitary protection. Water in karst limestone aquifers is not necessarily free of pathogenic bacteria, but by siting a village well outside (say at least 200 m from the village) and, if possible, up the groundwater gradient, the chances of intercepting polluted groundwater would be much reduced. Moreover, during well construction, attention should be paid to sealing the annulus around the upper well casing to prevent direct infiltration of surface pollutants into the well. After construction, the area in the immediate vicinity of the well should be kept clear of animals. In the case of shallow dug wells used for providing water for human consumption, they should be sealed with concrete slabs and equipped with hand pumps. Chlorination of well water is not recommended for the Region, because of difficulties with maintaining proper residuals, servicing equipment and supplying chemicals.

Properly constructed and protected borehole and dug well installations are shown in Figures 5.1 and 5.2.

Water from wars is normally relatively pure chemically, but is usually highly turbid and often badly polluted. Since such water, used for human consumption, constitutes a health hazard, steps should be taken to improve it.

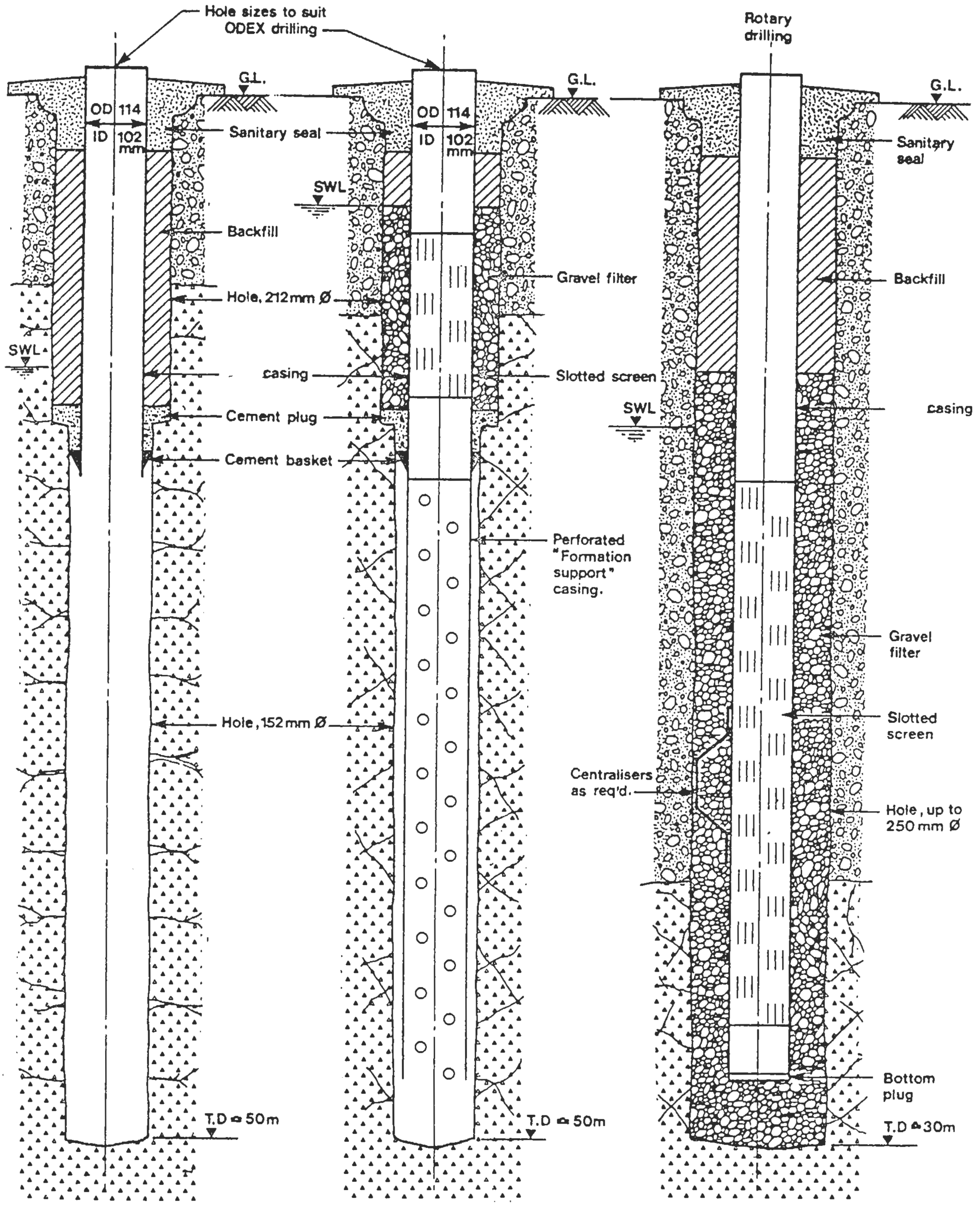
The easiest improvement to implement, would be to exclude animals from the war by fencing and some arrangement by which animals are watered outside. However, this by itself would not produce clear, safe drinking water and further improvements should be considered and tried at a pilot scale during the Project. One treatment which suggests itself and may be practicable under local conditions is the slow sand filter or a method which simulates this process.

Slow sand filtration is a complex process, involving a combination of physical, chemical and biological actions, rather than simple physical straining. In treatment of war water, this could take the following form:

(a) Conventional slow sand filters could be set up at pumped wars; such systems would have a relatively high capital cost but would be simple to operate. Filters would have to be cleaned regularly as they would tend to clog quickly because of the turbidity of the war water.

(b) Infiltration galleries could be constructed under the wars, leading to shallow wells fitted with hand pumps (Figure 5.3). The disadvantage of such systems would be that the filters would be difficult to clean when clogged.

5.1 Typical Drilled Well Completions

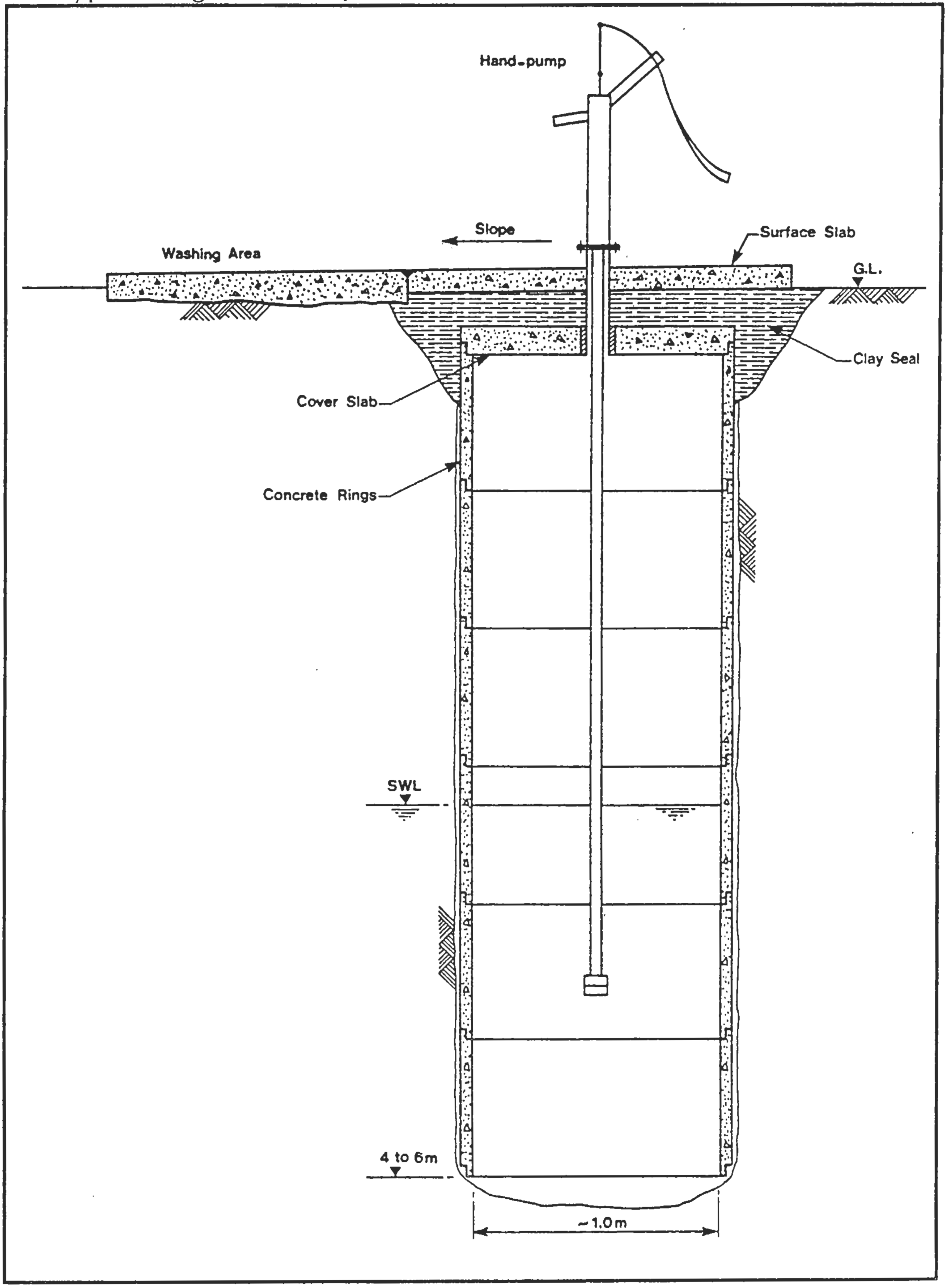


a). Stable (fissured) Hard Rock

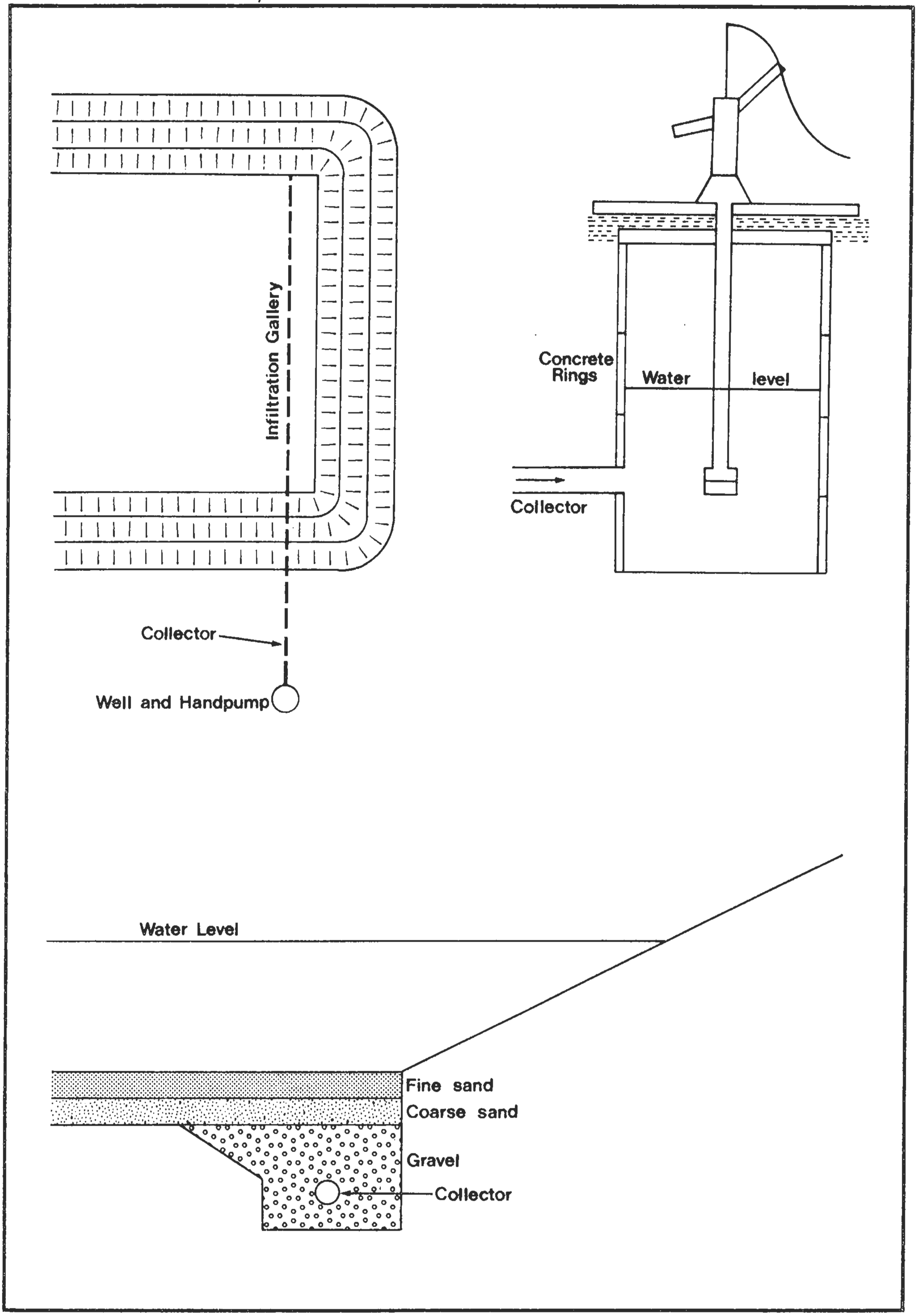
b). Unstable (fractured) Hard Rock

c). Alluvium & Weathered Zone

5.2 Typical Dug Well Completion



5.3 Infiltration Gallery at War



(c) Small domestic filters based on two clay pots have been suggested (Edgreen, LBI 1983); these would have the advantage that they could be used by households drawing water from existing traditional wars (that is by the majority of the Region's population), whereas the other systems could only be included in new wars. The LBI/RM project staff are currently experimenting with domestic size, sand/charcoal filters; this line of research should certainly be pursued further.

At present there does not seem to exist sufficient awareness amongst the local population of the benefits of clear and safe water supplies. This can only be overcome by education which is a slow, long term process. All that the Project could hope to do, it so provide such water on a pilot scale and hope that the practices adopted will spread. The USAID Health Delivery Project, based in Baydhabo trains rural health workers in public health, including instruction on the benefits of clean water supplies.

5.2.4 Improved War Design

The aim of the Project on war design would be to establish guidelines for constructing reservoirs, smaller and considerably cheaper than those built with the EEC assistance, but capable of providing perennial supplies to small agricultural communities and their livestock. It is hoped that the proposed review of the design and operation of existing traditional wars would give some useful pointers for design improvements, which may modify the criteria discussed below.

The first consideration should be the selection of a suitable site for a war. In this three main factors should be kept in mind:

(a) That the war is located at a site acceptable to the local population who would use the water;

(b) That the selected site is underlain by clayey soil of sufficient thickness to minimise seepage losses.

Thus preliminary sociological, hydrological and soil surveys would be required which would include:

- consultations with the local communities

- determination of catchment area and run-off coefficients on the basis of existing nearby wars

- determination of thickness and permeability of the soil using an auger hole survey.

Once a suitable site has been identified, the design should take the following factors into consideration:

- the capacity of the war in relation to the catchment area, run-off and the likely demand for water (aerial photography would be valuable for this);

- the surface area to volume ratio of the war should be considered in terms of evaporation and seepage losses;

- the requirement for flood by-pass channel;
- inlet arrangements and the provision of a silt trap to minimise siltation;
- means of preventing pollution of the war by animals and people;
- means of purifying the water for human consumption;
- means of abstracting water from the war, in particular the requirement for pumping (if any) and the source of power.

It is considered that the operation and management of the completed war would be best left to the local community. Desilting of the inlet channel could be done by hand but regular desilting of the war itself may be difficult if it is much larger than a traditional hand-dug reservoir. Such problems should be sorted out at the time of site selection of the proposed pilot wars.

5.2.5 Environmental Impact

Environmental impact of the water component of the Project is specifically mentioned in the Terms of Reference. This topic has been the subject of a special report prepared by LBI (Pape, 1982); the findings, summarised in a Table, are reproduced in Table 5.4.

The report is a detailed treatment of the subject and only two of the points considered are of major importance. These are local damage by concentration of livestock and overgrazing (defoliation and surface erosion around well) and regional overpopulation and overgrazing in response to easy availability of water (population increases beyond long-term carrying capacity). Though there is no doubt that there are significant risks, widespread ecological damage can be avoided by the actions recommended in Table 5.4.

5.2.6 Alternative Power Sources

Groundwater from boreholes and dug wells has to be pumped to the surface; moreover it is proposed that water from wars is taken outside the reservoir before use. Thus pumps and power will be required. Since, in most cases, small quantities of water would be pumped, in the case of wars and dug wells through relatively low heads, alternative power sources such as windmills or solar cells may well be applicable.

Windmills appear superficially attractive for pumping water in the Bay Region. The measured values of wind run are regularly high, particularly during the dry seasons. However they have several disadvantages, notably high capital costs, low output and high maintenance requirements. The discharge of a well fitted with a windmill would be less than 10 per cent of that equipped with a diesel installation of similar capital cost. Therefore, in terms of discounted cash flow, the cost of a unit volume of water pumped may actually be higher from a windmill pump. The high maintenance requirements are seldom satisfied in developing countries; consequently the record of wind powered pumps in such countries (including Somalia) is poor.

If maintenance problems could be overcome, windmills may become economically advantageous for pumping water from wars and wells with a high water level. However at the present time they are not recommended; it is considered that they would introduce yet another demand on the already stretched servicing facilities available in the Region.

TABLE 5.4 POTENTIAL ENVIRONMENTAL IMPACTS OF NEW WATER POINTS

Impact considered	Development stage	Significant risks Regional	Local	Recommended actions
Damage to access tracks	Construction	No	No	adequately addressed now
Removal and disposal of material from well	Construction	No	No	adequately addressed now
Aquifer contamination by insertion of material into well	Construction	No	No	adequately addressed now
Aquifer contamination by water source mixing	Construction Operation	No Minor	No Possible	- - - proper construction techniques proper construction materials proper operation and mainatennce filling and sealing at closure
Aquifer depletion	Operation	No	Possible	dependent on site-specific characteristics
Land subsidence	Operation	No	Possible	dependent on site-specific characteristics
Defoliation and surface erosion around well	Operation	Minor	Yes	research, planning, management and monitoring of grazing wells monitoring of foliage and use of all wells coordination of efforts with other Government of Somalia agencies
Villagers' health Villagers' productivity Villagers' quality of life	Operation	No	Improvements expected	no actions necessary monitoring for research purposes
Population increases beyond long-term carrying capacity	Operation	Minor	Yes	research, planning and monitoring of carrying capacity and population around well coordination of efforts with other Government of Somalia agencies

After LBI 1982.

Solar pumps have reportedly been used successfully in some refugee camps in Northern Somalia. Nevertheless their use in the Bay Region cannot be recommended because:

- high degree of cloud cover even during the dry seasons
- high capital costs of solar pump installations
- susceptibility of such installations to damage.

Thus in the current phase of the Project, the energy requirements of water pumping will have to be supplied by manpower for low discharges and diesel engines for high yields.

5.3 RECOMMENDED WORK PROGRAMME 1984 - 1986

5.3.1 Groundwater

The recommended work plan in the field of groundwater is basically that needed to complete the programme laid out by the World Bank Appraisal (1979) with only minor additions and modifications. It would consist of the following items:

(a) Inventory and Monitoring

A partial field inventory of wells in the Region should be carried out. Say, 200 wells (including all the WDA boreholes), spread throughout the Project Area, should be visited by expatriate or local hydrogeologists and the following information collected on specially prepared proformas:

- well location
- ownership of the well
- well depth
- well diameter
- water abstraction method
- estimated withdrawals
- type of pump (if any)
- water quality (the EC, pH, Fe and,in drilled wells, Eh, should be measured on site)
- static water level
- dynamic water level
- water use

It is possible that this work has been done already, but not been reported on.

Forty of the wells (say, 10 boreholes and 30 dug wells) spread throughout the Region, should be selected for monitoring. The monitoring would comprise visiting each well once a fortnight if easily accessible and once a month if remote; on each visit the water level (if possible) and EC of the water would be measured and any change in the production and use status of the well noted.

(b) Geophysical Surveys

The recently arrived geo-electric, seismic and magnetometer equipment should be of great assistance in the search for groundwater in the Basement Complex area. It is recommended that the geophysical exploration concentrates on the cultivated area around Buurhakaba (Groundwater Zone VIII) and the area in the south identified by

HTS as having underutilised grazing potential (Groundwater Zone IX). In the latter area, traces may have to be cut through the bush for access. Specifically the seismic refraction method should also be used for evaluating the groundwater potential of the wadi channel alluvia in the Basement area between Baydhabo, Diinsoor and Buurhakaba (Groundwater Zone VII).

The details of the geophysical techniques to be used are left to the WDA and their consultants, but both standard exploration methods and calibration runs at sites of known hydrogeology are recommended.

(c) Drilling and Well Construction

The present status of the drilling and well construction programme and the work still required to meet the World Bank Appraisal objectives are given below.

Area	Work completed		Work to be done	
	Boreholes	Production wells	Boreholes	Production wells
Limestone Plateau	22	19	? 47	41
Limestone Depression	8	1	-	-
Basement Complex	16	4	24	8
TOTAL	**46**	**24**	**? 71**	**49**

It appears that even in the Limestone Plateau area, not all the drilled boreholes will be suitable for completion as permanent production wells. In the Basement area the 50 per cent success ratio envisaged by the World Bank Appraisal Report is almost certainly too high, even with the assistance of geophysically aided well site selection. It is unlikely that more than a third of the holes will be suitable for conversion to production wells.

No more drilling in pursuit of groundwater for irrigation in the Limestone Depression is recommended. The evidence obtained already shows conclusively that no additional groundwater irrigation development potential exists in that area.

(d) Drilling Site Selection

The selection of drilling sites should be based on technical grounds (that is hydrogeological and geophysical considerations) and on such water supply strategy as is adopted (as for example that laid out in Section 5.2.1). The imaginative approach of the Consultant to assessing demand for a well by a series of consultations with the local population is strongly endorsed.

Apart from drilling in the agricultural areas, with the basic objective of improving water supply for the settled population, purely exploratory drilling is recommended particularly in Groundwater Zones VII and IX. Here site selection should be largely on the basis of geophysics with the objective of evaluating groundwater availability in areas currently particularly short of water.

(e) Dug Well Construction

It is recommended that if possible, the 10 dug wells proposed by the World Bank Appraisal be constructed, equipped with hand pumps and properly insulated from surface pollution, as a demonstration of proper installation of such wells for production of water for human consumption.

The only suitable aquifers in the Region for such wells are probably wadi fill alluvials and decomposed Basement. Thus the implementation of this component of the work programme would be contingent on the location of suitable sites for these wells.

It is proposed that these wells be constructed by local labour hired by the Project for the purpose.

(f) Irrigation Studies
In view of the unexpectedly high capacities of some of the wells drilled on the Limestone Plateau, particularly along the Baydhabo Escarpment, as well as the success of the private irrigation venture at Habare, it is recommended that the feasibility of small scale groundwater irrigation development be studied further. It should be stressed that it is certain that no large scale irrigation development will be possible; the investigations recommended are designed to evaluate the viability of isolated patches of a few hectares of irrigation of high value crops such as fruit and vegetables.

The studies recommended are:

- more rigorous testing of the high capacity wells (such as those at Sarmaan Dheere and Dolondole)

- careful inspection of the springs on the Escarpment, particularly those that are not fully utilised

- pending the results of testing the Dolondole well, construction of high capacity type wells in the vicinity of other underutilised springs

- evaluation of irrigable soil resources in the neighbourhood of probable groundwater availability

- if appropriate, preparation of type designs and estimates of costs and benefits of small scale irrigation

- assessment of technical, economic and financial feasibility of small scale irrigation in the Region and recommendations for further action.

Should these studies indicate that some groundwater irrigation development is feasible, small scale pilot irrigation projects should be undertaken in the future phases of the Project.

5.3.2 Surface Water

It is now clearly apparent that some areas in the Bay Region have no groundwater development potential and will have to continue to rely on surface water, or more precisely on small scale storage of surface water, namely the war. Though the present Project cannot hope to make a major impact on such areas in terms of constructing sufficient wars to significantly improve the water supply situation, it can and should initiate the work which might make such improvement possible.

The recommended work programme follows that of the World Bank (1979), but with major modifications in some areas.

(a) Inventory and Monitoring

A partial inventory of wars in the Region should be carried out. Say, 200 wars including some large government reservoirs), spread throughout the Project Area, should be visited and the following information obtained and recorded on special proformas:

- location of the war
- who controls the water rights
- measured dimensions, including the depth of water
- EC of the war water
- type of soil at the war site
- size and nature of catchment
- details of inlet channel
- details of outlet (if any)
- details of the embankment
- numbers of people and animals relying on water supply from the war
- means of abstracting the water
- approximate daily abstractions
- reported duration of the storage.

In addition samples for full chemical and bacteriological analyses should be collected at selected wars.

Forty of the wars, of different types and sizes, spread throughout the Region, should be selected for monitoring. These would be equipped with a staff gauge, so that their water level could be easily observed. They would be visited once a fortnight and the following information recorded each time:

- water level
- EC of the water
- numbers of people and animals relying on the war
- approximate daily abstractions
- any other relevant observations.

In addition the bacteriological quality of the war water would be monitored at selected sites.

(b) Outline Design of Experimental Wars

On the basis of the above surveys and theoretical considerations, designs would be prepared for experimental wars, which might provide perennial water supplies for small agricultural communities and their livestock, without incurring the prohibitive expense of the very large EEC-type war. The experimental reservoirs would incorporate some arrangement for providing filtered water for human consumption.

(c) War Site Selection

It is proposed that the aim of the Project should be to construct four experimental wars during the current phase (that is by December 1986). Their geographical distribution would be decided after the inventory, but two or three should be located in the Buurhakaba area (Groundwater Zone VIII).

Individual sites would be selected on the basis of technical considerations (see Section 5.2.4), water demand and compatability with the water supply strategy. Consultations with the local population are strongly recommended.

(d) Detailed Designs and Construction
Once the individual sites for the four wars are chosen, site surveys would be carried out and detailed designs prepared.

It is proposed that the construction be undertaken by WDA with equipment procured by the Project. This equipment, which was not included in the provisions of the World Bank Appraisal, would comprise the following major items:

Item	No. of Units
140 HP bulldozer and roller	1
Dump truck	1
Flat bed truck	1
Hand operated vibrating roller	1
Concrete mixers	2
Pick-ups	2
Supply of spare parts	
Hand tools	

Additional technical assistance would be required as well.

(e) Rehabilitation of Existing Wars
Since the replacement of all existing wars by better designed reservoirs would probably take several decades, the feasibility of rehabilitation and improvement of the former should be investigated. Moreover, it is possible that in some areas most of the good sites for wars in terms of run-off and clayey sub-soil are occupied already by traditional structures. Thus the only way to improve water supply in such areas may be to improve the yield and its reliability from existing wars.

The most obvious improvement which could be done quickly and cheaply with a bull-dozer, is deepening and thus increasing the storage capacity of a war without a concomitant rise in evaporation losses. However before such deepening is undertaken it would have to be ascertained that the clayey subsoil extended to a sufficient depth to contain excessive seepage losses. Other possible improvements could be extension and deepening of the intake channels, provision of silt traps and construction of bypass channels to prevent flood damage. The most appropriate rehabilitation measures would be identified during the inventory and monitoring.

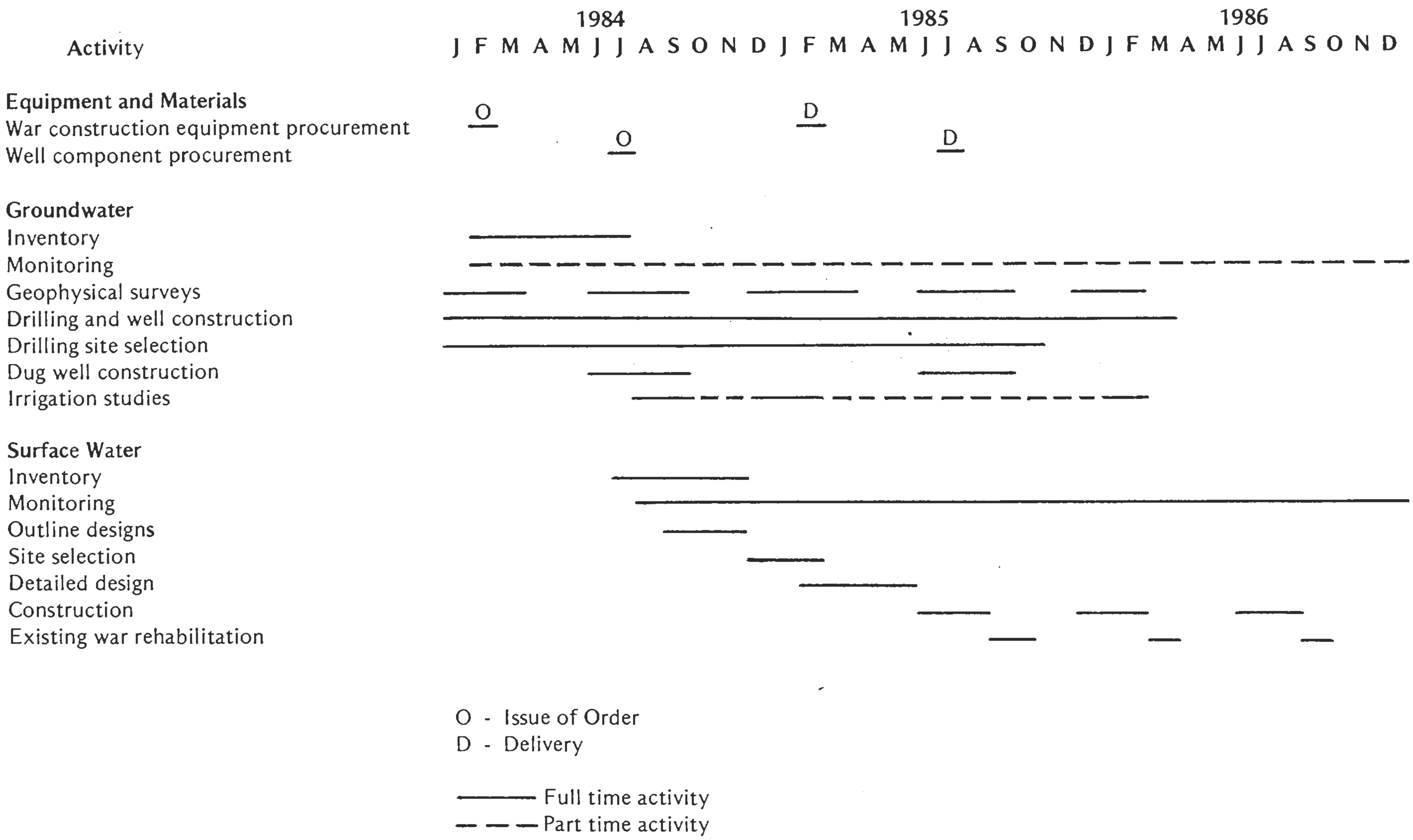
At this stage, no special allowance for equipment and materials for existing war rehabilitation is made. It is proposed that the war construction equipment, specified above, would be used part-time for this purpose. At the end of the current phase of the project, a report on the efficacy of the various measures should be prepared and a programme for further work in the field (including equipment requirements) recommended.

5.3.3 Plan of Operations

If the recommendations given above are accepted, a coordinated effort will have to be made by the Project to complete all the work stipulated, on schedule. Particularly, in the case of the proposed surface water work, which involves procurement of heavy equipment, prompt action is required if the programme is to be completed in time.

The proposed plan of operation for all the activities in the Bay Project water supply is shown in Figure 5.4.

FIGURE 5.4 WATER COMPONENT PLAN OF OPERATION



6

Costs

The estimated capital and operating costs of the proposed water supply developments for 1984 - 1986 are set out in this Section. Problems arise in allocating estimated costs between works in Bay Region and in other regions covered by the Comprehensive Groundwater Development Project. It is recognised that the proposals contained in this Annex will be considered as part of an overall appraisal of the CGDP by USAID and the Government of Somalia. The costs given are therefore indicative.

Costs are presented in the following tables:

TABLE 6.1 WATER COMPONENT - SUMMARY OF COSTS (Ssh '000)

		1984	1985	1986
Capital Costs				
Equipment for Well Construction		34 113	3 588	1 006
Equipment for War Construction		8 324	-	-
TOTAL		**42 437**	**3 588**	**1 006**
Operating Costs				
Technical Assistance	- Wells	21 760	21 760	5 632
	Wars	1 152	5 120	4 096
	Irrigation	512	1 280	-
Local Staff Costs	- Wells	1 422	1 422	437
	Wars	38	549	354
	Irrigation	50	50-	
Operating Costs of Machinery	- Drilling	6 299	6 299	1 574
	War Construction	75	557	634
	Pumps	2 072	3 461	4 166
Training		3 150	3 150	-
TOTAL		**36 530**	**43 648**	**16 893**
Plus 10% Contingencies		7 897	4 724	1 790
Overall Total		**86 864**	**51 960**	**19 689**
Inflation Factor @ 8% per year		1.08	1.17	1.26
Total Inflated Cost (Ssh '000)		**93 813**	**60 793**	**24 808**
(U$ '000)		**6 108**	**3 958**	**1 615**

TABLE 6.2 CAPITAL COSTS OF WATER COMPONENT (U$ '000)

	1984	1985	1986
(1) Well Construction			
* Spares for Rigs etc [1]	625.5	-	-
* Spares for Transport [2]	136.1	-	-
Drilling Foam [3] 12 T @ U$ 850/T	10.2	-	-
Cement [4] 50 T @ U$ 773/t	38.6	-	-
Conductor Casing [5] 320 m @ U$ 164/m	52.4	-	-
Steel Casing 8" [5] 3 600 m @ U$ 83/m	297.8	-	-
Well Screen 8" [5] 1 900 m @ U$ 93/m	176.2	-	-
Pump and Engine [5] 40 @ U$ 14 855	594.2	-	-
Hand Pumps 10 @ U$ 950	9.5	-	-
Pump House & Surface Works 65 @ U$ 8 915	280.4	233.6	65.5
TOTAL U$ '000	2 220.9	233.6	65.5
Ssh '000	34 113.0	3 588.1	1 006.1
(2) War Construction			
140 HP Bulldozer & Roller [6] 1 @ U$ 117 000	117.0	-	-
Dump Truck [6] 1 @ U$ 78 000	78.0	-	-
Flat Bed Truck [6] 1 @ U$ 78 000	78.0	-	-
Pick-up [6] 2 @ U$ 20 000	40.0	-	-
Hand Operated Vibrating Roller [6] 1 @ U$19 800	19.5	-	-
Concrete Mixer [6] 2 @ U$ 5 000	10.0	-	-
Cement [6] 40 T @ U$ 773/t	30.9	-	-
Miscellaneous (Fencing, Pipework, etc.) estimated	100.0	-	-
Spare Parts [7]	68.5	-	-
TOTAL U$ '000	541.9	-	-
Ssh '000	8 323.6	-	-

Notes:

* *60% allocated to BRADP, 40% to other projects under CGDP.*

[1] *20% of costs given in USAID Project Paper (BRADP 1980) inflated to 1983 at 10% p.a.*

[2] *20% of costs given in LBI "Preliminary Economic Analysis", 1982, inflated to 1983 at 10% p.a.*

[3] *From LBI "Preliminary Economic Analysis", 1982, inflated to 1983 at 10% p.a.*

[4] *Current price in Somalia.*

[5] *As Note [3]; estimated requirements take into account the recent delivery of some of these items.*

[6] *Estimated from recent quotations to LBI.*

[7] *20% of cost of mechanical plant.*

TABLE 6.3 TECHNICAL ASSISTANCE (Ssh '000)

	Item	Unit	Rate	1984 Units	1984 Cost [1]	1985 Units	1985 Cost [1]	1986 Units	1986 Cost [1]	Total
	Technical Assistance									
	Expatriate Experts (Wells)									
*	Project Manager	Man Months		12		12		4		
*	Chief Hydrogeologist	Man Months		12		12		4		
*	Hydrogeologist (1)	Man Months		12		12		3		
*	Hydrogeologist (2)	Man Months		12		12		3		
*	Chief Driller	Man Months		12		12		3		
*	Driller (1)	Man Months		12		12		3		
*	Driller (2)	Man Months		12		12		3		
*	Chemist	Man Months		12		12		4		
*	Geophysicist	Man Months		12		12		3		
*	Pump Technician	Man Months		12		12		3		
*	Civil Engineer	Man Months		12		12		4		
*	Chief Mechanic	Man Months		12		12		3		
*	Support Services	Man Months		12		12		4		
	Unassigned	Man Months		14		14		-		
		Sub-Total		170	21 760	170	21 760	44	5 632	
	Expatriate Experts (Wars)									
	Water Engineer	Man Months		6		12		10		
	Civil Engineer	Man Months		3		12		10		
	Mechanic	Man Months		-		12		9		
	Unassigned	Man Months		-		4		3		
		Sub-Total		9	1 152	40	5 120	32	4 096	
	Expatriate Experts (Irrigation)									
	Irrigation Engineer	Man Months		4		4		-		
	Economist	Man Months		-		3		-		
	Unassigned	Man Months		-		3		-		
		Sub-Total		4	512	10	1 280	-	-	
		TOTAL		183	23 424	220	28 160	76	9 728	

Notes: * *Already with the Project.*
[1] *At U$ 100 000 per man year on average.*

TABLE 6.4 LOCAL STAFF COSTS (Ssh '000)

Item	Annual Cost [1] (Ssh)	1984 Months	1984 Cost	1985 Months	1985 Cost	1986 Months	1986 Cost	Total
Local Staff (Wells)								
* Hydrogeologists	50 400	24	100.8	24	100.8	16	67.2	
* Geophysicist	50 400	12	50.4	12	50.4	2	8.4	
* Engineer	50 400	12	50.4	12	50.4	3	12.6	
* Senior Driller	32 400	48	129.6	48	129.6	12	32.4	
* Assistant Drillers	29 600	96	236.8	96	236.8	24	59.2	
* Mechanics	25 200	24	50.4	24	50.4	6	12.6	
* Drivers	21 600	72	129.6	72	129.6	24	43.2	
* Rig Hands	18 600	360	558.0	360	558.0	90	139.5	
* Camp Cooks	15 600	36	46.8	36	46.8	9	11.7	
* Accountant	25 600	12	25.6	12	25.6	10	21.3	
* Clerks	21 600	24	43.2	24	43.2	16	28.8	
Sub-Total			**1 421.6**		**1 421.6**		**436.9**	
Local Staff (Wars)								
Water Engineer	50 400	6	25.2	12	50.4	10	42.0	
Civil Engineer	50 400	3	12.6	12	50.4	9	37.8	
Mechanic	25 200	-	-	12	25.2	9	18.9	
Foreman	32 400	-	-	12	32.4	9	24.3	
Bulldozer Operator	33 600	-	-	12	33.6	9	25.2	
Drivers	21 600	-	-	36	64.8	27	48.6	
Machine Operators	28 600	-	-	48	114.4	24	67.2	
Masons	33 600	-	-	24	67.2	16	44.8	
Survey Team (4 men)	27 600	-	-	48	110.4	24	55.2	
Sub-Total			**37.8**		**548.8**		**354.0**	
Local Staff (Irrigation)								
Soil Surveyor	50 400	6	25.2	-	-	-	-	
Agriculturalist	50 400	6	25.2	12	50.4	-	-	
Sub-Total			50.4		50.4		-	
Total Cost			1 509.8		2 020.8		790.9	

Notes: * *Already with the Project.*
[1] *Including field allowance.*

TABLE 6.5 OPERATING COSTS OF MACHINERY (Ssh '000)

	1984		1985		1986	
		Cost		Cost		Cost
Drilling Machinery[1]		6 299.1		6 299.1		1 674.4
War Construction	**Months**		**Months**		**Months**	
Bulldozer [2] @ Ssh 311/hour	-	-	4	165.9	5	207.3
Truck [3] @ Ssh 13/km	-	-	8	216.7	10	270.8
Pick-up[3] @ Ssh 3/ km	12	75.0	24	150.0	20	125.0
Other Machinery [4] @ Ssh 6 150/month	-	-	4	24.6	5	30.8
Sub-Total	-	75.0		557.2		633.9
Pumps at Completed Wells	Units		Units		Units	
Fuel & Lubricants @ Ssh 8 450/1 000 hours	81	685.1	135	1 141.2	162	1 368.6
Spares @ 10% of Capital Cost per annum	30	751.1	50	1 251.8	60	1 502.2
Maintenance @ 5% of Pump and Surface Works Cost per annum	30	612.9	50	1 021.4	60	1 225.7
Hand Pump Spares @ 10%	10	15.4	20	30.7	30	46.1
Hand Pump Maintenance @ 5%	10	7.7	20	15.4	30	23.0
Sub-Total		2 072.2		3 460.5		4 165.6
Overall Total		8 446.3		10 316.8		6 373.9

Notes:
1 *Based on WDA expenditure in 1982/1983 inflated by 5 per cent to mid 1983 values.*
2 *At 1 600 hours per year per unit.*
3 *At 25 000 km per year per unit.*
4 *Estimated.*

TABLE 6.6 TRAINING COSTS (Ssh '000)

(1) Academic
2 persons each in 1984 and 1985.
At U$ 52 550 per course = Ssh 1 614 300 per year.

(2) Short Term
20 man months in 1984 and in 1985.
At U$ 5 000 per month = Ssh 1 536 000 per year.

APPENDIX A

REFERENCES

REFERENCES

Ahrens, T.P. and Azzaroli, F.	1951	'A Reconnaissance Groundwater Survey of Somalia, East Africa', Rome.
Barnes, S.U.	1976	'Geology and Oil Prospects of Somalia', Assoc. Amer. Petrol. Geol., 60/3.
Beltrandi, M.D. and Pyre, A.	1973	'Geologic Evolution of Southwest Somalia', In Blant, G. (ed) Sedimentary Basins of African Coasts, ASGS, Paris.
Beydoun, Z.R.	1970	'Southern Arabia and Somalia, Comparative Geology', Phil. Trans. Royal Soc. London, Ser.A 267, No. 1181.
Boggs, D., LBI/RM	1983	Personal Communications, Mugdisho.
Dijon, R.E.	1967	'Groundwater in Somali Republic'.
Edgreen, M., LBI/RM	1983	Personal Communications, Mugdisho.
FAO/Lockwood,	1968	'Agricultural and Water Surveys, Rome.
FAO/World Bank Cooperative Programme	1977	'Draft Report of the Somalia Bay Region Agricultural Development Project, Preparation Report', Rome.
Hunting Technical Services Limited	1982	'Bay Region Agricultural Development Project', Ministry of Agriculture, Mugdisho.
Idrotecneco,	1976	'Hydrogeological Study of the Bur Region', Ministry of Mineral and Water Resources, Mugdisho.
Johnson, J.H.	1977	'Groundwater Resources of the Bay Region', Working Paper No.1, Somalia BRADP, World Bank Preliminary Plan, Rome.
Louis Berger International Inc and Roscoe Moss Company	1983	'Exploratory Report for the Bay Region', Water Development Agency, Mugdisho.
Pape, M.	1982	'Preliminary Economic Analysis, Comprehensive Groundwater Development Project', Louis Berger International Inc.
Pape, M.	1982	'Potential Environmental Impacts of Comprehensive Groundwater Development Project', Louis Berger International Inc.

Stefanini, G.	1925	'Sur la Constitution Geologique de la Somalie Italienne Meridionale', 13th International Geol. Congress, Brussels.
Stefanini, G.	1933	'Carta Geologica dell'Eritrea della Somalia e dell'Ethiopia, 1:2 000 000', Consiglio Nazionalle dell Ricerche.
Technital SpA.	1975	'Juba Valley Development Study' European Development Fund, Rome.
UNDP/Mineral and Groundwater Survey (Phase II) Somalia	1973	'Groundwater in the Somali Democratic Republic', Technical Report No.3, New York.
USAID	1979	'Somalia Comprehensive Groundwater Project', Washington, DC.
USAID	1980	'Somalia Bay Region Agricultural Development', Mugdisho.
Watson, R.M. and Nimmo, J.M.	1982	'An Aerial Livestock and Resource Survey of the Bay Region', Resource Management & Research, London.
Wilson, G.	1958	'Groundwater Geology in Somalia', Mugdisho.
World Bank	1979	'Somalia, Bay Region Agricultural Development Project Staff Appraisal Report', Washington, DC.
World Health Organisation	1977	'International Standards for Drinking Water', 3rd ed.