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Somalia Delegation

Water Resources Assessment, Water Supply Planning and Rehabilitation Surveys; Hydrogeological & Geophysical Surveys

Gedo Region - Somalia

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ACKNOWLEDGMENT

The water resource assessment in Gedo Region from 21st January to 11th February 2002 was conducted under difficult circumstances during the Jilal dry season, when the assessment team experienced the lack of water first hand. Water related illness of several members of the team, technical problems with the cars, demanding road conditions forcing us to cut our way through bushes for km on end at times slowed the progress of the survey, which aimed at finding available water sources, recognising the need for rehabilitation, and identifying the most strategic water points and alternative solutions to secure water availability.

In recognition of the hard work done, the author would like to thank all those who contributed to the success of this assessment for their commitment, the information and support provided. In particular

Ahmed Abdullahi Ali	Electromechanical engineer
Aden Isak Aden	Hydrogeologist
Ahmed Mohamed Abdi	ICRC field officer
Abdi Wahab Haayi Mohamed	Field officer assistant

and all helpers in the field, the community of Gedo, colleagues from other humanitarian organisations in Nairobi, and colleagues from the Somalia delegation of the ICRC.

Christian Gajsek

STRUCTURE AND AIM OF THE REPORT

The first three chapters introduce the reader to the region, giving a brief overview of and background information on the location, physiography, drainage, climate and water demand, and explain the goal of the assessment and the methodology used.

The next three chapters go in further technical detail on the geology and hydrogeology of the region and introduce the geophysical investigation methods used, to set the basis for the individual assessment of waterpoints.

The main body of the report is made up of detailed assessments of each of the **50 locations** visited. **For each location concrete recommendations are made as to the need for and feasibility of the rehabilitation of existing structures and - where applicable - alternatives are presented.** Although the survey followed the main livestock migration and marketing routes - as it is assumed that ensuring these routes will have the greatest impact on livelihoods as well as food security in Gedo - these recommendations are based on the technical and geophysical feasibility and at this stage do not necessarily indicate priorities on a regional level and should not be interpreted as a list of indispensable interventions. We hope however that they will help organisations involved in the improvement of water infrastructure in Gedo region in designing appropriate and co-ordinated strategies to improve overall water availability, and in ensuring appropriate choice of interventions in strategic locations and technically successful implementation.

In this sense, this report should on the one hand serve as a technical handbook for the water engineers on the field, facilitating the choice of appropriate solutions in any given location, but will hopefully also serve as a basis for discussions on comprehensive and co-ordinated interventions in the water sector in Gedo.

With this in mind, we hope to make a contribution to the effective use of resources available to support the population of Gedo region.

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ABBREVIATIONS AND GLOSSARY OF TERMS

ABBREVIATIONS: (NOTE: SI units used throughout).

km	kilometers
m	meters
m amsl	meters above mean sea level
m bgl	meters below ground level
swl	static water level (in m bgl) (the piezometric level or water table, see below)
wsl	water struck level (in m bgl)
Ec	Electrical conductivity in micro Siemens/cm
TDS	Total dissolved solids expressed in mg/l (ppm)
VES	Vertical electrical sounding

GLOSSARY OF TERMS:

Aquifer	A geological formation or structure which transmits water and which may supply water to wells, boreholes or springs.
Confined	Confined aquifers are those in which the piezometric level, or the water rest level, is higher (ie, at a greater elevation relative to sea level) than the elevation at which the aquifer was encountered.
Barkads	Concrete lined below ground surface reservoir, fed during the wet season by small catchments up slope. These have roofs of branches or thatch to limit evaporation and are comparatively efficient at retaining stored water.
Waroh	Large open dams, excavated from inside, with excavated material used to provide embankments. These are much larger than Barkads, but are unlined and not roofed.
Recharge	The general term applied to the passage of water from surface sources (ie, from rivers or rainfall) into the groundwater store.
Unconformable	The representation in physical geology (ie, in the rock record) of a break in the ordered succession of rocks.
Volcanics	Here used as a general term describing geological material of volcanic origin.
Intercalated	Interbedded - a lava flow may occur between layers of sediment, or vice-versa.
Laaq	Seasonal rivers which transmit water during wet season. They normally dry up shortly after the rains
Aquiclude	An impermeable geological formation having poor transmissivity e.g. clays

1. INTRODUCTION

This report presents the results of water resources assessment, water supply planning and rehabilitation surveys in Gedo Region of Somalia carried out by the International Committee of the Red Cross (ICRC), Somalia Delegation. The assessment was carried out in January to February 2002, and included hydrogeological and geophysical investigations for shallow wells, rain water catchments and boreholes at selected villages within the Region. Furthermore, it included the physical evaluation of the existing water supply facilities throughout the selected villages in the Gedo Region to assess the rehabilitation and improvement requirements to upgrade water delivery to the communities.

During the assessment various water supply development technological options were evaluated and their relative application reviewed in the context of the water demand, distribution, availability, quality, community ability to manage and construction costs. For all these purposes, hydrogeological observations were made, and data collected and geophysical investigations were carried out.

The assessment focused on acquisition of detailed information on prospects of rehabilitating, improving or upgrading existing water supply facilities in the investigated area. Furthermore possibilities of developing new water points was assessed. These water points will be used as domestic water supply for the local community, and also for watering livestock. For each investigated village, the estimated amount of water for such usage will be in excess of 20 m^3/day which may rise to over 100 m^3/day during extended dry seasons due to increased livestock consumption and influx of nomadic population.

The objective of the present study is to assess the available groundwater, to recommend suitable shallow well digging or borehole drilling site at each village and to comment on aspects of depth to potential aquifers, aquifer availability and type, and water quality. For this purpose all the available hydrogeological information of the area has been analyzed, and a geophysical survey carried out using resistivity method. Vertical electrical soundings were carried out at selected sites in the villages to determine the underground geological conditions.

In addition to the above the existing water supply facilities were inspected and assessed for rehabilitation, improvement and protection against pollution.

2. BACKGROUND INFORMATION

2.1 Location

The investigated sites are situated in Dolow, Belet Xaawo, Ceel Wak, Garbaharey and Bhadeere Districts, Gedo Region of Southern Somalia. All the villages lie within river Juba drainage basin. They lie approximately within longitudes 041° 00' 00''E and 042° 05' 00" E and latitudes 02° 00' 00'' N and 04° 05' 00'' N. The western part of the Region is bordering Kenya while the area is bordered to the east by river Juba at Badheere.

2.2 Physiography

The investigated area lie at an altitude of between 100 and 500 m amsl. All the villages lie within the Juba river basin, gently sloping to the south east towards the Juba river. Regionally the area is formed of a plain sloping to the south east towards the Indian Ocean, with shallow, broad bottomed "laaqs" which, in most cases, spread their water in depressions The area is predominantly flat, covered by reddish sands of various thicknesses, and the flat topography being interrupted by incisions of streams and stabilized hills which are typified by a variety of morphological features. These include gentle to very steep slopes forming a hilly belt in the central part of Gedo region, characterized by low undulating hills topped by low escarpments and drifts. This area is severely eroded by wind and run-off water. Deep gullies can be discerned on the gentle slopes whereas sheet structure occurs on the low lying areas. Parts of the area have varying topography from gently rolling to rough , with flat topped mesas.

2.3 Drainage

The drainage pattern in the Gedo Region of Southern Somalia is towards the south-east towards the Indian Ocean. The Juba emanates from the Ethiopian highlands and flows perennially through this area into the Indian Ocean. The central part of the Gedo region has numerous seasonal streams which flow only during the wet season and shortly thereafter. The Juba alluvial plain is largely used for regular cropping while areas further away from the river are used for grazing livestock.

2.4 Climate

The climate of the area can be classified as arid to semi-arid. Rainfall over the greater part of this area is irregular with periods of precipitation receiving an average of 250 to 400 mm of rainfall. Rainfall increase from the north west to the south east. The main rainy season (Gu season) is March to May and the minor rainy season (Der season) is October to December and is characterized by the north east monsoons. Cool temperatures are brought by the south west monsoons. The period between July and August (Hagai season) is generally dry The driest

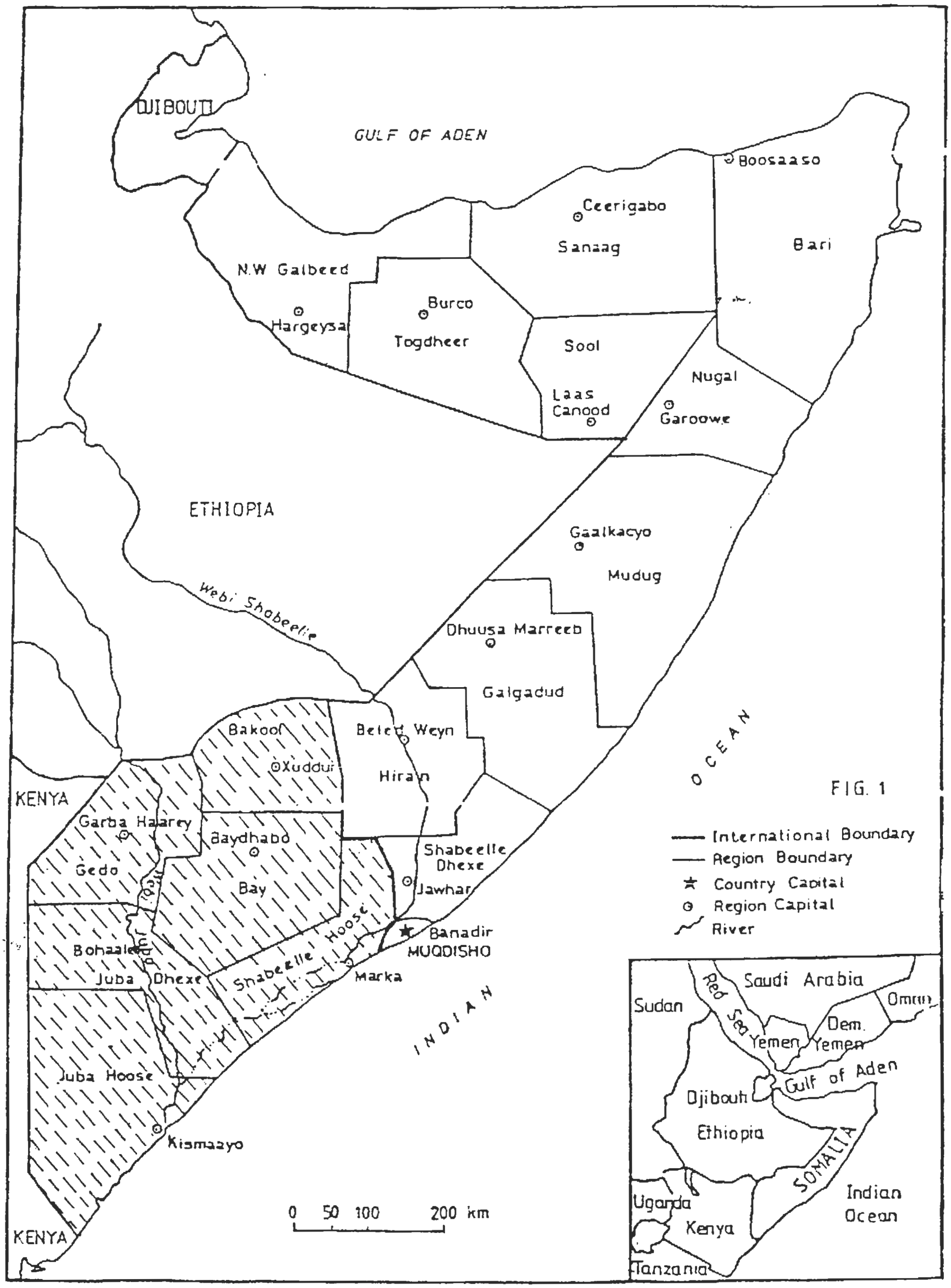


Figure 1 - General Location Map of Gedo Region

period of the year (Jilaal season) occurs from December through March, and is caused by the northern monsoons.

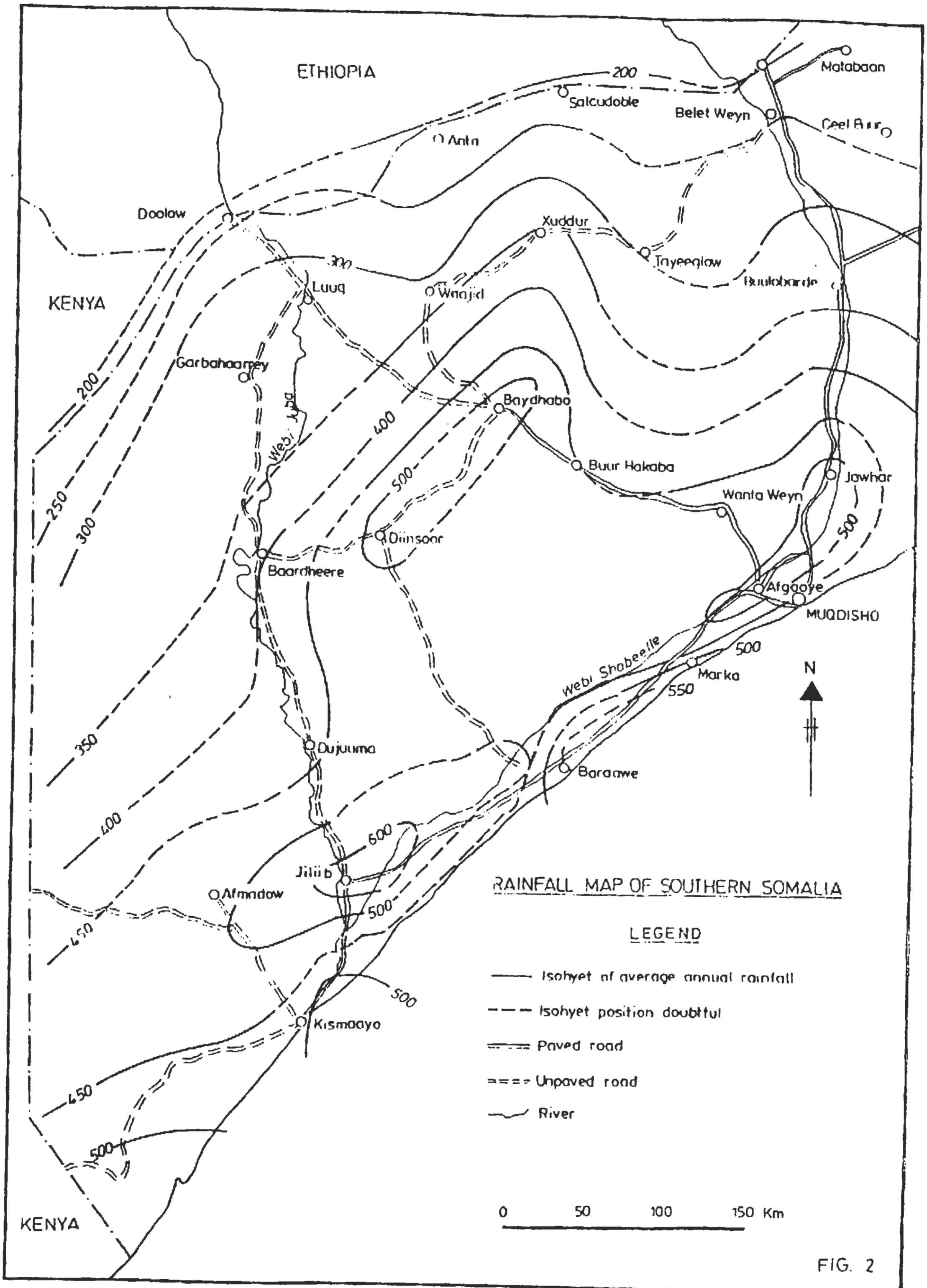
Temperatures vary between 20 - 40 °C. The average annual potential evapotranspiration is well estimated at 2225 mm per year Relative monthly humidity in the area is lower than 50% in May and October for most of the area.

During the period 1997/8, a departure from the known climatic pattern occurred, in which exceptionally high rainfall with resultant floods were experienced in the area in what is referred to as El nino phenomenon. After the El nino floods in 1998, the Gedo area has experienced a continuous period of drought.

2.5 Water Demand

The expected daily water demand for most of the investigated villages will be above 20 m3/day being mainly for domestic use. However, during dry seasons, the demand increases sharply, exceeding 50 m3/day especially due to livestock consumption and high influx of nomadic population.

A shallow well with a capacity of 2 m^3/hr pumping for 10 hours in a day will adequately meet the domestic water demand for each village. This does not include satellite consumers from nomadic families.



SOURCE: Inter-Riverine Agricultural Study. Hunting Technical Services, Ltd., November 1977. Fantoli, 1960, and other sources.

Figure 2 - Rainfall Pattern in Gedo region

3. APPROACH BY THE INVESTIGATING TEAM

3.1 Planning for the Fieldwork

Prior to commencement of the fieldwork planning of the activities was done in consultation with the ICRC Field Staff. As a first step to meet the objectives of the investigations, the pastoralists' movement routes were identified and drawn on a map. This enabled a target oriented output such that it was possible to ensure that every 40 to 60 km along the route, a water point was identified for rehabilitation or establishment

3.2 Inventory

This involved compilation of a full inventory of existing data, reports etc., covering all aspects of water resources in the Project Area (i.e. meteorology, geology, hydrology, drainage, hydrogeology, soils, vegetation, land-use and demographic data, maps etc); this included an exhaustive literature review. Unfortunately aerial photographs or satellite imageries were not available for analysis at the time of the investigations.

3.3 Field Reconnaissance

A field reconnaissance at every site was conducted initially before geophysical investigations was done. The purpose of the field reconnaissance was to verify the interpretation of the geological and hydrogeological data obtained from the inventory and check on further geological and hydrogeological conditions. It provided the basis for the detailed geophysical fieldwork in the area which was to follow

3.4 Water Resources Inventory and Site Selection Fieldwork

This comprised a field survey and inventory of the existing water points in the study area and included the qualitative field assessment of human and livestock population at the village level, from which demands can be estimated. This task was done in collaboration with the respective ICRC (Somalia) staff. In the course of the fieldwork, discussions were held with genuine representatives of the village who in most cases included the respective Village Water Committees (VWC's). This was meant to provide a detailed background of the water situation in the area, pastoralist movements, water point availability, reliability, distribution and duration of usage.

3.5 Detailed Site Investigations

After agreement was reached on prospective sites, detailed surveys were executed to investigate if the selected site has good prospects, and to select the optimum site for water supply development, rehabilitation or improvement. Geophysical field measurements were carried out which included deep vertical resistivity soundings. The results provided information on underground conditions and the likelihood of striking sufficient water for a shallow hand dug well or borehole site. In addition, interpretation of the VES measurements enabled determination of the geological strata in order to establish the possibility of rain water catchment construction or rehabilitation including de-silting, excavation and enlarging and deepening. Results are presented on Map 2. Detailed interpretation graphs and tables with the interpretation data for each investigated site with accompanying GPS co-ordinates are given.

3.6 Siting Methodology

The investigating team followed a standard approach for the groundwater investigations and assessment of rain water harvesting structures which is described in this section. It has to be stressed, however, that this approach could not be followed strictly under all circumstances, as the team when visiting the site, certainly met exceptions to these general guidelines, which required modification of the approach as required.

Approach
The approach for the groundwater and rain water harvesting investigations focused on:

a. Assessment of hydrogeological conditions in the immediate vicinity of the village by analysing geological data and information on shallow wells and seepage zones to map important indicators of geological and hydrogeological conditions, water quality, structural weakness zones (lineations), rainfall, catchment conditions and boundaries, soils and vegetation. In addition observations on relief and vegetation were made. On the basis of this analysis combined with all other relevant available data a pre-selection of the site/sites for geophysical investigations could be made.
b. Hydrogeological fieldwork;
c. Shallow Groundwater. Evidence of its occurrence may be apparent from a variety of features, both natural and anthropogenic, but some hydrogeological interpretation is necessary to assess its significance. Shallow groundwater above shallow bedrock will usually have small storage with development feasible only by shallow wells which may be seasonal. Shallow groundwater in the sedimentary succession is indicative of greater groundwater potential since the sequence can be assumed to be saturated from shallow depths if the underlying formations are permeable.
d. Geology. The geology is one of the key controls to aquifer occurrence and some deductions on the basis of bedrock mineralogy, petrology and structure assisted in the interpretations of the geophysical surveys. Lineaments were correlated with conductive features in the electromagnetic horizontal traverses.
e. Geophysical fieldwork focused on areas selected from the reconnaissance survey. Initially traverses by means of electromagnetic profiling were carried out at promising sites where fault zones or deep weathering was suspected, resistivity soundings were used on a limited scale to verify observed anomalies, determine depth of weathering and the lithological nature of the underlying geological formations.

It should be stressed that geophysical field measurements are only applied to confirm conditions as observed under the steps (a) to (d) described above. The presence of groundwater cannot be determined by merely carrying out a few resistivity soundings.

f. Data evaluation and site recommendation focused on sites with thickest profile and greatest depth to fresh rock, or by preference of shallow or deep seated fracture zones. Regional characteristics of groundwater flow were considered seriously when selecting a shallow hand dug site. Of particular importance in the selection of the shallow well site is the expected water quality with respect to salinity due to presence of shallow saline aquifers, sites were selected where the salinity is low. In this case, it was further recommended that shallow saline aquifers be sealed off during well construction.

g. Having evaluated the site as detailed above, the possibility of rehabilitation of existing rain water harvesting structures was assessed, taking into consideration the geology of the sub-surface.

3.7 Data Analysis and Reporting

All the reporting was done in Nairobi. A detailed Report for each investigated site has been prepared, detailing the findings of the studies, and giving details on the products of the investigations. The report gives the recommendations for shallow well and borehole construction, locations, depths, and qualitatively, the relative projected aquifer productivity. It also gives the recommendations of water supply rehabilitation, improvement, upgrading and protection.

4. GEOLOGY

The geology of Somalia is presented on a geological map at a scale of 1 1,000,000 by Kezerenko V.N., 1972. It was subsequently updated incorporating further information from a variety of sources by Chernyshev, 1974. The Southern Somalia Region is covered by Jurassic to Recent sediments, limestones, marls, sands and sandstones All these are underlain by the Basement System rocks.

4.1 Regional Geology

The region in which the investigated sites are situated is almost entirely covered by Jurassic Formations which are the oldest sedimentary rocks in the area overlying the Basement System rocks. The most important of these are the Upper Jurassic formations subdivided into four units the Baydabho, Canoole, Waajid and Garbhaarrey formations. However latter three are the ones outcropping in the study area. The following Table summarizes the Geology:-

STRATIGRAPHY OF THE GEDO REGION, SOUTHERN SOMALIA

ERA	PERIOD	EPOCH	SERIES OR SUITES	THICKNESS (M)	LITHOLOGICAL CHARACTERISTICS
CENOZOIC	NEOGENE	Recent - Pleistocene	surface cover	0-10	Caliche over Limestone. laterite, breccia, talus. gypsum crust
			Stream alluvium	0-20	Gravel, sand, sandy clay, filling togga beds : red quartz sandy clay.
		Pleistocene to late Tertiary	Fluvio-lagunal deposits	0-25	Coral limestone partially covered by sand and residual soil.
MESOZOIC	CRETACEOUS	Lower Cretaceous	Cambar Formation	450	
	JURASSIC	Upper Jurassic	Garbabaarrey formation	700	2 members. Bussul (base)- limestone, sandstone, marls, dolomite, Macow gypsum, anhydrite, sandstone
		Upper Jurassic	Waajid Formation	500	Quartzitic limestone, sandstone, thin bedded calcrenite, intercalation of shale(Curgo Menber)
			Canoole Formation	500	Argillaceous limestone, shales, marls
			Baydahabo Formation	100-800	Deleb Member(base)-quartz sandstone, and conglomerate: Uaeni- marls and thin bedded limestone; Baydahabo karstic limestone with thin marls layers;Golada-karsticlimestoneandmarls
PALEOZOIC	PRE-CAMBRIAN	Pre-cambrian	Basement Complex (undifferentiated)		Granite, granodiorite, gneiss, quartzite. marble. and amphibolite

4.2 Geology of the Investigated Area

4.2.1 Baydhabo Formation

Baydhabo Formation belongs to the Upper Jurassic age. It is unconformable on the Basement Complex and outcrops along a gentle escarpment which runs in a NNE-SSW direction near the town of Baydhabo. The contact between the limestones and the Basement is covered by alluvial deposits. The total thickness of this formation is over 800 m, consisting of four members:- Deleb, Uanei, baydhabo and Golada members in order of age. The formations include coarse sand and thinly stratified quartzitic sandstones, shales, stratified, karstified and argillaceous limestones and marls.

4.2.2 Canoole Formation

The Canoole Formation belongs to the Upper Jurassic and is named after a hill located near Badheere and rest conformably over the Baydhabo Formation. Its base comprise thick argillaceous limestone and black shales, overlain by grey marls with thinly bedded limestone. The Canoole formation were deposited and sedimented in a deep marine environment when the Jurassic sea reached its greatest extension. The thickness of the Canoole formation has been estimated at about 500 m.

4.2.3 Waajid Formation

The Wajid Formation belongs to the Upper Jurassic and is named after the town in Bakool Region. Its contact with the underlying Canoole formation is about 10 km south of Waajid. The base of this formation is characterized by a sequence of quartzitic sandstone beds and limestone. Thin bedded limestone and calcarenite and shale beds are found contemporaneous with the main beddings.

4.2.4 Garbahaarrey Formation

The Garbahaarrey Formation takes it's name from the town of Garbahaarrey It belongs to the Upper Jurassic and is composed of two members: the Bussul Member with limestone, sandstone, dolomite, marls and shales, and the Macow Member with gypsum, anhydrite, sandstone, marls and limestones. The thickness of the two members is estimated at 700m. This formation underlies both the Taleex and Karkar formations. It does not outcrop in the investigated area but outcrops in the Nugal Valley and Ogaden further north.

4.2.5 Cambar Formation

The Cambar Formation belong to the Lower Cretaceous and is composed of reddish, quartzose sandstone, varying from massive to thin-bedded, and is often cross-bedded. It interfingers with the Macow Member of the Garbahaarrey Formation on it's eastern side. The formation is expected to be of considerable hydrogeological importance. It lies mainly in a depression and has the best structural conditions for receiving a considerable amount of recharge from rain and floods.

The Cambar sandstone has been tapped by the two boreholes drilled in Dhamasse which supply the best water of the entire Gedo Region both qualitatively and quantitatively

4.2.6 Pleistocene to Recent Deposits

These include Lake deposits, fluvial deposits and coastal sand deposits along the Upper and Lower Juba plains. Other deposits include the fluvial quartz sand, residual clay soils, caliche. The caliche overlies the Cretaceous formations.

4.2.7 Fluvio-Lagoonal Deposits

The Lower Juba plain is covered partly by fluvio-lagoonal deposits consisting of clays, sandy clay, sand, silt and gravel generally intercalated in lenticular bands. Their variable thickness, extent and lithological nature indicates that the deposition was rapid and derived from adjacent eroded areas. The upper part of these sediments are covered by grey and dark blue sandy clay which was deposited mainly under lagoonal conditions with shallow marine incursions.

5. HYDROGEOLOGY

The hydrogeology of an area is normally intimately dependent upon the nature of the parent rock, structural features, weathering processes, recharge mechanism and the form and frequency of precipitation. It is evident that deep aquifer yields in the region are very variable, depending on the presence of fractures, coarseness, sorting, compaction and cementation of the aquifer material. The deep aquifers are basically confined as evidenced by the rise of the water level above the water struck levels. The shallow riverine aquifers are however unconfined and the water level coincides with the water struck level.

5.1 Regional Hydrogeology

In general groundwater in sedimentary rocks is limited to pores, fractures, faults and erosion levels within the formations. Clays and compact rocks are not water bearing because of their unfractured and impervious character.

The recharge mechanism and the rate of replenishment of the confined aquifers which underlie the area have not been fully established. However a broad pattern of recharge can be described. The recharge mechanisms are by overland run-off from the northwest through infiltration of rain at the surface and indirect recharge via faults, lateral recharge through the primary porosity of the underlying sedimentary formations. The Juba river forms the overall regional piezometric base level. It is projected that the recharge from rains is sufficient to sustain considerable east and southward underflow and also to sustain annual withdrawals.

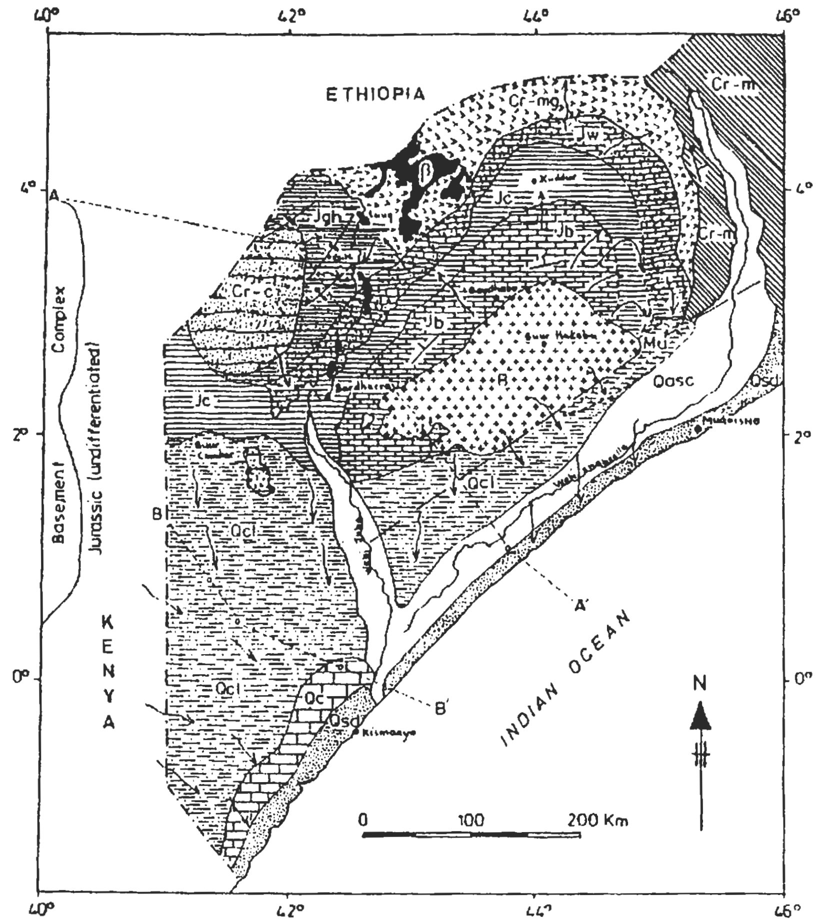
There is evidence of direct recharge from the surface to the unconfined aquifers, particularly to the shallow aquifer along the seasonal streams, as they are not deep and have no up-dip surface exposure. These shallow aquifers are replenished directly through the soil or via the local temporary stream systems. Due to the possible connection with the deep aquifers, the shallow aquifer may then be a recharge conduit to deeper aquifers.

The most important recharge area for the aquifers in the Region is formed by the Juba river basin. Water percolates directly into the faults and cracks within the Pleistocene sedimentary formation through which deeper and adjacent units are recharged over time.

Assuming that suitable storage media exist below the ground, the aquifer potential is affected by the downward percolation of rain water to the aquifer. If the infiltration is low due to presence of an aquiclude like clay, the recharge to the aquifer is low. Percolation will also depend on the soil structure, vegetation cover and the state of erosion of the parent rock. Rocks weathering to clayey soils naturally inhibit percolation. Aquifers may also be recharged laterally if the rock is permeable over a wide area.

5.2 Hydrogeology and Aquifer Occurrence in the Investigated Sites

The investigated area is located in a hydrogeological zone considered to be characterized by a low to moderate groundwater potential. From available borehole and shallow wells



TIME UNITS	BASINS AND AQUIFERS	SYMBOL
	Coastal Basin Aquifers	
Quaternary	Alluvial deposits of Shabeelle & Juba	Qasc
Quaternary	Sand dunes	Qsd
Quaternary-Pleistocene	Coral limestone	Qc
Quaternary - Pleistocene	Fluvio-lagunal deposits	Qcl
Miocene	Mudug - Marka	Mu
	Xuddur-Bardheere Basin Aquifers	
Tertiary	Basalt	β
Upper Cretaceous	Mustaxiil - Fer Fer - Belet Weyn	Cr-m
Lower Cretaceous	Main Gypsum	Cr-mg
Lower Cretaceous	Cambar	Cr-c
Upper Jurassic	Garbahaarrey	Jgh
Upper Jurassic	Waajid	Jw
Upper Jurassic	Canoole	Jc
Upper Jurassic	Baydhabo	Jb
Pre-Cambrian	Basement Complex	B

Syncline *Anticline* A-------A' *Cross-section* *Fault*

Dip *Assumed general direction of underground flow*

Figure 3 - Generalized Hydrogeological Map of Southern Somalia

Compiled by C. Faillace; geology modified from Beltrandi & Pyne data, it can be deduced that the most important aquifer in the area is the sandy sediments and limestones of the Jurassic and Cretaceous formations. Data on yields of shallow wells and deep boreholes are scarce, but it is considered that there is a fair chance of striking over 5 to10 m^3/hr for deep boreholes The yields are lower for the shallow hand dug wells.

In the investigated sites there are favourable conditions for direct recharge from rainfall through infiltration of precipitation into the ground through porous geological formations. However, the sedimentary aquifers are most likely to be recharged indirectly through lateral groundwater flow. The movement of water within the aquifers follows hydraulic gradient, so groundwater flows from the north west and percolates through successive formations to the southeast and southwards along the Juba river basin.

Deep aquifers are encountered in sands and fissured limestones at various depths. The boreholes in the general area have been tested at varying yields. The wide range is accounted for by different total depths, differences in geology, and differences in the quality of borehole construction and completion.

Three types of aquifers are expected in the general area:

- Shallow aquifer
- Intermediate/deep aquifer
- Deep confined aquifer

For the present investigations, all the three aquifer types were encountered for depths ranging between 2 m and 250 m bgl. The shallow aquifers are predominant along the seasonal valleys. In addition, the water level is very shallow and it would be possible to reach the water by digging a few metres deep. ***However, the shallow aquifer is in some places very saline (EC>10,000 uS/cm), sometimes being unsuitable for human and animal consumption.***

5.2.1 Shallow Aquifers

Along the seasonal streams groundwater is found at shallow depths and can be tapped by hand-dug wells or shallow drilled wells. Water levels in wells located along the seasonal streams and close to the banks of river Juba are generally 5-6 m below ground level. Levels are deeper away from the river banks. The fresh shallow aquifer along the riparian belt is hydrogeologically connected to the river through water bearing sand lenses. Shallow aquifers are also encountered away from the riparian belt.

In many instances the first water entry, generally at 5-6m, has been found to be of poor quality due to the high clay and gypsum content. Quality may improve with depth in sandy layers. Previous shallow well digging has shown that groundwater quality changes within short distances. This is due to the heterogenous nature of the alluvial deposits along the river system. Wells tapping water bearing sand lenses hydraulically connected with webi Juba and the seasonal rivers produce good quality water

5.2.2 Medium and Deep Confined Aquifers

The medium and deep aquifers are the most significant aquifer type in the area. Previous drilling in the area indicate that deep boreholes have significantly better quality water, while some are artesian, due to confining clay layers, and basalts at some places. These basalts are found along the upper part of the Juba valley and originated from Ethiopia, and followed paleo-Juba where they overlap gypsiferous rocks of the Ghabaharrey formation. Most of the highly productive boreholes have struck water from the Baydhabo Formation under confined conditions due to underlying marls and clay layers. Only a few boreholes have penetrated the Cambar formation. The deep aquifers extend to depths greater than 200 meters in the investigated area. It is therefore desirable to fully penetrate the aquifer in order to optimize the borehole yields where deep boreholes are constructed.

5.2.3 Recharge, Movement and Discharge of Groundwater in the Investigated Area

Recharge occurs mainly by direct precipitation in the region. The Jurassic formations in the area are also recharged by run-off water and by the Juba river. Recharge in areas covered by sedimentary formation is relatively high along depressions and togga beds. Minor infiltration occurs in the deeper formations where limestone layers alternate with impervious marls and shales. The amount of infiltration may not be higher than 4-5% of the precipitation due to the low and erratic rainfall which ranges from 200 to 400 mm/year.

Along the riparian belt of the Juba river, groundwater moves according to the river regime. During the rainy season the river recharges the water bearing alluvial deposits along it's banks and the water moves away from the sides of the river bed. During low river flow there is an inversion of groundwater flow, and shallow riparian aquifer discharges along the river bed.

Aquifer discharge zones are difficult to identify in this region. Most of the groundwater discharge occurs along the coastal line. Seepage zones are located at the terminal part of the ancestral drainage systems where they meet the hilly Coastal Belt. Some seepage zones are covered by salty soils: they generally coincide with terminal floodable zones of the main ancestral systems.

5.2.4 Aquifer Types in the Investigated Area

Both hand-dug and drilled wells located in aquifers within the Canoole formation bear water of the bicarbonate type. The EC values in the shallow wells ranges from 1,250 to 1,750 micro Siemens/cm. Because of the relative low amount of TDS in these wells, water is accepted by people and livestock.

Groundwater from deep boreholes is in many places saline. Previous attempts to strike better quality water at depths greater than 200 m in the Canoole Formation were negative due to presence of fossil saline water. From the consistency of the results, it is highly likely that the water is of a fossil nature and is in stagnant condition. It may however be possible that the boreholes were drilled without proper hydrogeological and geophysical investigations.

Wells and boreholes located within the Baydhabo formation bear water of much better quality than the younger Canoole formation. While drilling in the Canoole formation, the upper aquifers have to be sealed off so that only the deeper aquifers within the Baydhabo formation are exploited.

The hydrogeological characteristics of the Wajiid formation are better than those of Canoole formation, on which it conformably rests. Water is of the sodium chloride type. From available data, it is deduced that the area underlain by this formation has a fair chance of recharge and storage of groundwater which can be tapped by boreholes 50 to 80 m deep.

Boreholes penetrating the Garbaahaarrey Formation include Tuulo Burawaqo, Malkarey, Belet Xaawo. Garbahaarrey Formation is a poor aquifer from both the qualitative and the quantitative points of view. Most of the wells drilled in this formation yield a limited amount of water of poor quality. However, results from different wells located at a short distance between one another are very inconsistent, the differences in water quality and quantity are due to the physical and chemical conditions of the various water-bearing layers and depend on the depth of the wells and the structural conditions. Garbahaarrey town is located on a syncline and it's wells yield more water than wells drilled in different structural conditions.

The Cambar Formation is expected to be of considerable hydrogeological importance in the area from Dhamasse and extending as far as Dhadable and Ceel Cade. This area is a depression and has the best structural conditions for receiving a considerable amount of recharge from rainfall and floods. The Cambar sandstones has been penetrated by the two boreholes at Dhamasse and Ceel Cade which give the best quality water of the entire Gedo Region.

5.2.5 Water Quality

Groundwater quality in this area is related to the nature of the sub-surface formations. Two types of groundwater may be encountered in a sedimentary terrain as in the investigated area. These are: connate (fossil) water trapped in sediments at the time of deposition; and meteoric water that penetrates the rock through sub-surface infiltration.

The connate water may be expected to reflect its original composition to a large extent. The meteoric water will be influenced by the composition of the conduit rock, when during longer contact with the sediments, salts will dissolve. The irregular distribution of water level in wells and rapid change in chemical composition and quality in neighbouring wells reflects the discontinuity of these small groundwater bodies. The water type in the Juba river varies according to seasons and flow regime. Generally from the middle of October to the middle of March, with the river flow gradually receding, the water becomes predominantly of the calcium Sulphate type. During the wet season, from April to October, water becomes mainly of the Bicarbonate type.

The EC of the seasonal rivers along their course and during the year varies quite a lot. No data is available on the water quality fluctuations over the year. The highest values occur with the first flow after long, dry periods, when the soluble salts deposited in the nearly dry river bed and on the land surface are brought into the rivers by the first rains. This in effect reflect the fluctuation of the base flow and therefore the increase in EC within short distances as experienced in Carase, Fan Weyn and Dubaar.

The higher base flow salinity along the many saline toggas in Gedo region (e.g. togga Fan Weyn) can be explained as being due to the highly saline water-bearing layers found along the seasonal riverine belt. The alluvial sediments deposited along this belt contain a considerable amount of gypsum. In addition, seepages from the underlying formations are, in most cases, brackish or salty.

When deposition occurs in a land-locked basin under conditions of semi-aridity, evaporation of the connate water occurs with the consequent precipitation of mineral salts, mainly carbonates, chlorides, and sulphates. These are disseminated throughout the succession with varying degrees of concentration and, being partly soluble, are readily re-dissolved by meteoric groundwater; hence the water derived from these beds is liable to be saline.

Groundwater in Somali has been classified based on salinity by Pozzi R, Benvenuti G, Xaaji Mohammed C, and Shuurije Lidle C, as shown in Table 1 below

Table 1 - Somalia Groundwater Classification Based on Salinity

Category	TDS (ppm)	EC (μS/cm)
Very fresh water	0-1,300	400-1500
Good quality	1300-3200	1500-3000
Fair quality	2700-5000	3000-5000
Highly marginal	4200-6500	5000-7500
Very Bad	5500-7500	7500-10,000
Unusable	>7500	> 10,000

Table 2 - General Groundwater Classification Based on Salinity

Category	TDS (ppm)	EC (μS/cm)
Fresh water	0-1,500	0-2,000
Brackish water	1,500-10,000	2,000-15,000
Saline water	10,000-100,000	15,000-150,000
Brine	>100,000	> 150,000

TDS : Total Dissolved Solids (in parts per million = mg per liter)
EC : Electrical Conductivity in micro Siemens/cm

Table 3 – General Salinity Limits for Groundwater Use

EC (μS/cm)	TDS (ppm)	Use/Limitation
< 2,000	< 1,500	Potable water
> 2,000	> 1,500	Unsuitable for domestic purposes
2,000-3,000	1,500-2,000	Generally too salty to drink but still fit for livestock
> 3,000	> 2,000	Generally unfit for dairy cattle and young cattle
> 7,000	> 4,500	Unfit for grazing cattle and sheep

6. GEOPHYSICAL INVESTIGATION METHODS

Investigations of the groundwater resources and water point rehabilitation sites in Gedo Region included the use of geophysical techniques to probe the sub-surface. A variety of methods are available to assist in the assessment of geological sub-surface conditions. The main emphasis of the fieldwork undertaken was to determine the thicknesses and composition of the sub-surface formations and to identify water-bearing zones with low salinity.

This information was principally obtained in the field using vertical electrical soundings (VES) with the SAS 300 B Terrameter

The VES probes the resistivity layering below the site of measurement. This method is described below.

6.1 Resistivity Method

Vertical electrical soundings (VES) were carried out to probe the condition of the sub-surface and to probe the existence of groundwater. The VES investigates the resistivity layering below the site of measurement. This technique is described below.

6.2 Basic Principles

The electrical properties of rocks in the upper part of the earth's crust are dependent upon the lithology, porosity, the degree of pore space saturation and the salinity of the pore water. Saturated rocks have lower resistivities than unsaturated and dry rocks. The higher the porosity of the saturated rock, or the higher the salinity of the saturating fluids, the lower the resistivity. The presence of clays and conductive minerals also reduces the resistivity of the rock.

The resistivity of earth materials can be studied by measuring the electrical potential distribution produced at the earth's surface by an electric current that is passed through the earth.

The resistance R of a certain material is directly proportional to its length L and cross-sectional area A, expressed as:

$$R = Rs * L/A \quad \text{(in Ohm)}$$

where Rs is known as the specific resistivity, characteristic of the material and independent of its shape or size.

With Ohm's Law,

$$R = dV/I \quad \text{(Ohm)}$$

where dV is the potential difference across the resistor and I is the electric current through the resistor. The specific resistivity may be determined by:

$$Rs = (A/L) * (dV/I) \quad \text{(in Ohm m)}$$

6.3 Vertical Electrical Sounding (VES)

When carrying out a resistivity sounding, current is led into the ground by means of two electrodes. With two other electrodes, situated near the centre of the array, the potential field generated by the current is measured.

From the observations of the current strength and the potential difference, and taking into account the electrode separations, the ground resistivity can be determined.

During a resistivity sounding, the separation between the electrodes is step-wise increased (in what is known as a Schlumberger Array), thus causing the flow of current to penetrate greater depths. When plotting the observed resistivity values against depth on double logarithmic paper, a resistivity graph is formed, which depicts the variation of resistivity with depth. This graph can be interpreted with the aid of a computer, and the actual resistivity layering of the subsoil is obtained. The depths and resistivity values provide the hydrogeologist with information on the geological layering and thus the occurrence of groundwater.

6.3.1 Interpretation of VES Data

Preliminary (visual) interpretation of resistivity soundings is based on experience which is gained in particular while doing computer interpretation in the office. **The Hydrogeologist is able to estimate the approximate interpretation from the shape of the sounding. Interpretation of the VES curve is based on the convolution method of Ghosh (1971), a mathematical curve-fitting procedure. Without additional data for correlation it can easily lead to a fitting solution which does not quite correspond to the real geological layering. The layered earth model is actually very much a simplification of the many different layers which may be present.** The various equivalent solutions which can be generated by a computer programme should therefore be carefully analysed. In general, a single resistivity sounding should never be interpreted in isolation as this leads to a meaningless result.

<u>a) Equivalence Problem</u>
Equivalence is the problem of having different interpreted computer models for the same resistivity curve. This is the result of the fact that usually more than one solution is possible e.g. a relatively thin layer with an extremely low resistivity may give the same result as a thick layer with only a slightly low resistivity

<u>b) Suppression Problem</u>
When the thickness of a layer intercalated within a sedimentary sequence is relatively small, it may not be noticed in the resistivity graph, and is 'suppressed' and therefore not sensitive to the computer interpretations. Nevertheless, where justified (e.g. when it is known to exist from borehole data records) this 'invisible' layer may be introduced into the interpreted model.

FIELDWORK AND RESULTS

7. BELET XAAWO

7.1 Location

The town of Belet Xaawo is located within Belet Xaawo District, Gedo Region of Southern Somalia. The town is located on the north-eastern corner of Somalia on the Somalia-Kenya-Ethiopia border The town is located at longitude and latitude approximately 03^0 55` 46`` N and $041^0$ 52` 41`` E

7.2 Physiography

The town lies on the southern flood plain of Daua Parmar river. The area is generally flat and featureless except some isolated hills south of the town. It is gently sloping to the north west towards river Daua Parmar and to the east towards the Juba. East of the village is a dry drainage valley dissecting the area.

7.3 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are restricted to Daua Parmar located approximately 10 km further north. Additional surface water includes seasonal streams, which during heavy rains, flow south of the village. The area has a large catchment extending north westward within Daua Parmar basin in an area of over $50km^2$. There are no springs within or in the immediate surroundings of the site. The area is classified as arid due to the high rate of evaporation and the low rainfall.

7.4 Geology

The area is underlain by limestones on the hill slopes while the intermontane areas are overlain by alluvial deposits and clay soils. Along the drainage valleys are coarse sands, gravels and cobbles. At the surface Recent superficial deposits overlie the older sedimentary formations.

7.5 Structures

Based on the drainage characteristics and structure of the rock strata in the site, faults/fractures orientated in a northwest-southeast direction are suspected to occur in the investigated area.

7.6 Hydrogeology

7.6.1 Existing Wells

Several shallow hand dug wells with a depth of 11m bgl and a water struck level of 7 m bgl have been dug in the vicinity of the town. However shallow well digging in the town have been abandoned due to high salinity in the wells tapping the shallow aquifer. A concrete protection cover and an animal watering trough have been constructed on the well. Water is withdrawn from the well by rope and bucket.

7.6.2 Current Water Sources

Water is transported by trucks from about 10 km away for domestic consumption. The water is collected from the Daua Darma River and distributed to the population. Close to the town there is a 'waroh' which is used only for a few months after the rainy seasons. From previous investigations it appears that there is little chance of finding water of good quality for Belet Xaawo by drilling deep wells. Reports of the boreholes drilled in the area indicate continuous salinization with pumping.

Water is also collected from about 20 hand dug wells in the area of Bannaney and Malkariyey, located 5 to 8 km from the town. Ec measurements in these wells indicate good quality water with Ec of 1,670 uS/cm. From previous studies it is reported that the Ec decreases as low as 600 uS/cm. All these wells have been dug in the red alluvial sandy clay and sand. Reliable water sources include the Daua which flows approximately 9 months in a year and the shallow wells.

7.6.3 Aquifers

Deep aquifers are expected to occur within the fractured limestones and sandstones. Shallow aquifers occur in the sedimentary deposits along the drainage valleys of dry river beds.

7.7 Geophysical Investigations

No geophysical resistivity investigations were executed within close proximity to the town in order to determine the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations.

7.8 Water Quality

There is not much information available on the groundwater quality. However, based on the measurement of the Ec of one well sample, the water is clear and the electrical conductivity of water was measured to be 1,670 micro Siemens/cm.

7.9 Conclusions and Recommendations

Conclusions

Belet Xaawo town is located in an area which is considered to have a poor to medium groundwater potential. Both shallow and deep aquifers occur in the area. However the deep aquifers previously penetrated produced productive aquifers with high salinity unsuitable for human consumption. Shallow aquifers exploited by use of shallow hand dug wells would be a viable water supply source especially for drinking water.

Based on the available information on the shallow wells and boreholes in the surroundings of the town it is concluded that the area around Bannaney and Malkariyey has good quality water at shallow depths.

Recommendations

It is recommended to rehabilitate five of the existing wells in Malkariyey and Bannanney.

In order to determine the possibility of deepening the wells, it will be necessary to carry out geophysical investigations to delineate the lateral and vertical aquifer extent.

Alternative water sources are available through tankering of water from the Daua and the shallow wells at Ceel Dhere, Bannaney, Follaley and Firwayne and construction of barkads.

8. CARACASE

8.1 Location

The village of Caracase is located within Garbahaaley District, Gedo Region of Southern Somalia. The town is located on the southern banks of Togga Caracase approximately 33 km from Belet Xaawo along the Belet Xaawo-Garbahaaley road. The village is located at longitude and latitude approximately 03^0 40' 45" N and 042^0 01' 23" E.

8.2 Physiography

The village lies on the southern banks of togga Caracase. The area is generally flat being interrupted by isolated hills and numerous seasonal rivers. The topography is gently sloping to the north towards the seasonal river and generally to the east in the direction of the drainage.

8.3 Population and Water Demand

From the information given by the local people, the village is currently having a population of 100 families who rely on the available shallow wells In addition 2000 nomadic families rely on the 15 shallow wells for supply of domestic and animal requirements.

8.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present except for togga Caracase which flow during the wet seasons for a short period. The site has a large catchment extending westward in an area of over 20km^2 There are no springs within or in the immediate surroundings of the investigated site.

8.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

8.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a northwest-southeast direction are suspected to occur in the investigated area.

8.7 Hydrogeology

8.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. A total of 15 shallow hand dug wells have been sunk by the local community in the area to depths of about 12 m bgl. The water level at the time of this investigation was 2.5 m bgl.

8.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river banks of togga Caracase. Only 2 of the 15 shallow wells are being used for human consumption while the rest are for animal watering. The surface water from seasonal rivers is unreliable because the rivers only flow a weeks after the rainy season. During extended drought, the wells run dry The last time the river flowed was during El nino rains 5 years ago

8.7.3 Aquifers

Aquifers are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

8.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

8.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 4: Interpretation Results of VES 1

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.3	3.7	Dry clayey top soils
0.3 - 0.8	61	Sandy sub-soil
0.8 - 38	14	Potable water-bearing sediments/highly weathered limestones
>38	3.4	Brackish water-bearing sedimentary rocks

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a shallow superficial layer of 3 7 Ohm-m to a depth of 0.3 m bgl, comprising mainly Recent deposits composed of clays. The superficial layer is underlain by a higher resistivity layer of 61 Ohm-m to a depth of up to 0.8 m bgl comprising sandy and gravelly sub-soil. This is underlain by a 14 Ohm-m layer to a depth of 38 mbgl. This layer is underlain by a layer of 3.4 Ohm-m to depths extending beyond 38 m bgl. These two layers are interpreted to represent weathered limestones. The low resistivity of the bottom layers depicts brackish to saline water conditions.

8.9 Water Quality

The Ec of the shallow well used for domestic consumption was measured to be 4,750 μS/cm which is considered to be slightly brackish but nevertheless used for domestic consumption.

VES 1

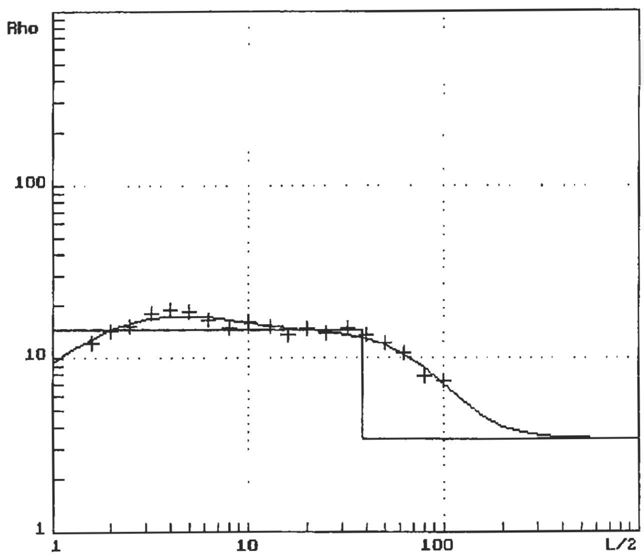


Figure 4 - Interpretation Graph for VES1

8.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Caracase site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones up to a depth of about 38 m bgl. Deeper aquifers are evidently saline from the VES measurement executed in the village. There is no possibility of a rain water catchment due to lack of a shallow aquiclude.

In view of the above it is recommended that 2 of the existing 15 wells be cleaned out and rehabilitated. The wells should be deepened to 15 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure should be constructed approximately 1 m above the river bed in order to avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.

An additional alternative water source would be drilling a shallow borehole to 30 m bgl and installation of a hand pump

9. BURSAQAR

9.1 Location

The village of Bursaqar is located within Garbahaaley District, Gedo Region of Southern Somalia. The village is located on the eastern banks of Togga Bursaqar approximately 52 km from Belet Xaawo along the Belet Xaawo-Garbahaaley road. The village is located at longitude and latitude approximately 03^{0} 32' 47'' N and 042^{0} 06' 20'' E.

9.2 Physiography

The village lies on the eastern banks of togga Bursaqar at an elevation of 233 m amsl. The area is generally flat being interrupted by a few isolated hills and several seasonal rivers. The topography is gently sloping to the west towards the seasonal river and generally to the east in the direction of the drainage.

9.3 Population and Water Demand

The population of the village is currently 107 families who rely on the existing shallow wells. In addition 600 nomadic families rely on the 5 shallow wells for supply of domestic and animal requirements.

9.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present except for togga Bursaqar which flow during the wet seasons for a short period. The site has a large catchment extending north westward. There are no springs within or in the immediate surroundings of the investigated site.

9.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

9.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a northwest-southeast direction are suspected to occur in the general area.

9.7 Hydrogeology

9.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. A total of 5 shallow hand dug wells have been sunk by the local community in the area to depths of about 4.5 m bgl. Out of the 5 wells 4 are operational. The water level at the time of this investigation was 2.5 m bgl.

9.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river banks of togga Bursaqar. Only 4 of the 5 shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season.

9.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

9.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

9.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 5: Interpretation Results of VES 2

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.5	57	Sandy top soils
0.5 - 2.2	4	Clayey sub-soil
2.2 - 28	11	Brackish water bearing limestones
28 - 60	36	Potable water-bearing sediments/highly weathered limestones
>60	2	Saline water-bearing sedimentary rocks

RE Resistivity (Ohmm) **DE** Depth (m).

The VES interpretation results indicate a shallow superficial layer of 57 Ohm-m to a depth of 0.5 m bgl, comprising mainly Recent deposits composed of sands. The superficial layer is underlain by a lower resistivity layer of 4 Ohm-m to a depth of up to 2.2 m bgl comprising clayey sub-soil. This is underlain by a 11 Ohm-m layer to a depth of 28 mbgl. This layer is underlain by a layer of 36 Ohm-m to a depth of 60 m bgl representing fresh water bearing limestones. The bottom layer with a resistivity of 2 Ohm-m is found at depths greater than 60 m bgl. This is interpreted to represent weathered limestones. The low resistivity of the bottom layers depicts highly brackish to saline water conditions.

9.9 Water Quality

The Ec of the shallow well used for domestic consumption was measured to be 3,700 µS/cm which is considered to be slightly brackish but nevertheless used for domestic consumption.

VES 2

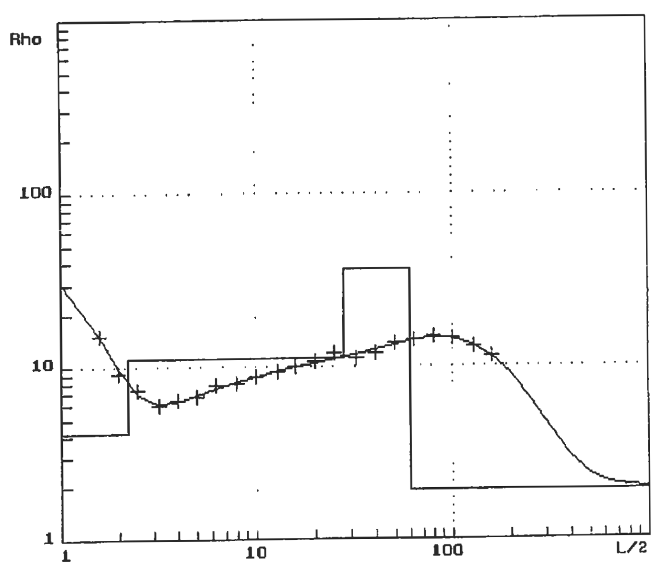


Figure 5 - Interpretation Graph for VES 2

9.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Bursaqar site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the alluvial deposits on the river bed and the sedimentary succession comprising weathered limestones up to a depth of about 80 m bgl at the location of VES 1.

In view of the above it is recommended that 3 of the existing 5 shallow wells be cleaned out and rehabilitated to provide a permanent water supply to the village. The wells should be deepened to about 6 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.

Alternative water sources include -

1) Drilling a borehole to 80 m bgl and installation of a hand pump. This would become necessary if the shallow aquifer up to 25 m bgl is depleted due to continued abstraction of water and extended dry seasons.
2) Construction of a rain water catchment of 100x50x2 m.

10. GARBAHAALEY

10.1 Location

The town of Garbahaley is located within Garbahaley District, Gedo Region of Southern Somalia. The town is located approximately 80 km from Belet Xaawo along the Belet Xaawo-Garbahaaley road. It is located at longitude and latitude approximately 03^0 20' 03" N and 042^0 12' 59" E.

10.2 Physiography

The village lies on the eastern banks of togga Garbahaley at an elevation of 212 m amsl. The area is generally flat with several limestone ridges and several seasonal rivers. The topography is gently sloping to the east towards river Juba.

10.3 Population and Water Demand

The population of the town could not be estimated by the local elders but it is projected to be over 1000 families who rely on the existing borehole. In addition 5000 nomadic families are expected to rely on the water supply for domestic and animal requirements.

10.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present except for togga Garbahaley which flow during the wet seasons for a short period. The site has a large catchment extending north westward. There are no springs within or in the immediate surroundings of the investigated site.

10.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

10.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a northwest-southeast direction are suspected to occur in the general area.

10.7 Hydrogeology

10.7.1 Existing Boreholes

One borehole has been sunk within the town and is operational. Details about the borehole are given below.

Table 6 - Gabhaharey Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1985	102	8"	13	17	18	10	4690

10.7.2 Current Water Sources

The major source of water in the area is the operational borehole drilled within the town which supply water for both domestic and animal consumption. Water is pumped into a catchment in the seasonal river bed for watering the animals. Urban water supply with tap stands and donkey cart delivery stands is in place. The water supply meets the requirements for the town. The surface water from seasonal rivers is unreliable flow only a few weeks after the rainy season.

10.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

10.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing borehole. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

10.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 2: Interpretation Results of VES 3

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	94	Sandy top soils
0.4 - 3	2.4	Clayey sub-soil
3 - 59	27	Brackish water bearing limestones
>59	1000	Fresh limestones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a shallow superficial layer of 94 Ohm-m to a depth of 0.4 m bgl, comprising mainly Recent deposits composed of sands. The superficial layer is underlain by a lower resistivity layer of 2.4 Ohm-m to a depth of up to 3 m bgl comprising clayey sub-soil. This is underlain by a 27 Ohm-m layer to a depth of 59 m bgl. This is interpreted to be the fresh to brackish water bearing limestones. This layer is underlain by a layer of 1000 Ohm-m representing fresh hard limestones.

10.9 Water Quality

The Ec of the borehole water was measured to be 4,690 µS/cm which is considered to be slightly brackish but nevertheless used for domestic consumption.

VES 3

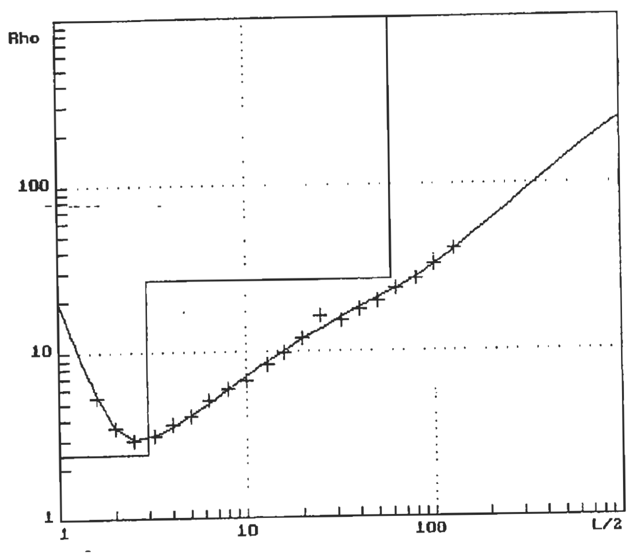


Figure 6 - Interpretation Graph for VES3

10.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Garbahalery site is located in an area which is considered to have a medium groundwater potential. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones up to a depth of about 100 m bgl at the location of VES 3.

In view of the fact that the borehole water supply is operational and meets the requirements for the town no recommendations are given for expansion of the water supply at the moment. Nevertheless, with increasing demand, it will necessitate drilling of an additional borehole to supplement the existing facility.

11. BURAAL

11.1 Location

Buraal village is located within Garbahaaley District, Gedo Region of Southern Somalia. The village is located on the eastern banks of Togga Buraal approximately 23 km south west of Garbahaley town along the Garbahaaley-Ceel Guduud road. The village is located at longitude and latitude approximately 03^0 10` 11" N and $042^0$ 08` 26" E.

11.2 Physiography

The village lies on the eastern banks of togga Buraal at an elevation of 302 m amsl. The area is generally flat being interrupted by a few isolated hills and several seasonal rivers. The topography is gently sloping to the west towards the seasonal river and generally to the east in the direction of the drainage.

11.3 Population and Water Demand

The population of the village is currently estimated at 250 families who rely on the existing shallow wells. In addition 750 nomadic families rely on the shallow wells in the village for supply of domestic and animal requirements.

11.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present except for togga Buraal which flow during the wet seasons for a short period. The site has a large catchment extending north eastward. There are no springs within or in the immediate surroundings of the investigated site.

11.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

11.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a southwest-northeast direction are suspected to occur in the general area.

11.7 Hydrogeology

11.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Three shallow hand dug wells have been sunk by the local community in the area to depths of about 4 m bgl which are operational. The water level at the time of this investigation was 2 m bgl.

11.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river banks of togga Buraal. The three shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season.

11.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

11.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

11.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 7: Interpretation Results of VES 4

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 2.8	25	Sandy top soils (alluvium)
2.8 - 5.4	28	Brackish water bearing alluvial sediments and limestones
5.4 - 10	9	Brackish water bearing limestones
10 - 105	32	Fresh water bearing limestones
>105	69	Slightly weathered to fresh limestones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a shallow superficial layer of 25 Ohm-m to a depth of 2.8 m bgl, comprising mainly Recent deposits composed of sands and alluvium. It is underlain by a of 28 Ohm-m resistivity layer to a depth of up to 5 4 m bgl comprising brackish water bearing sediments. This is underlain by a 9 Ohm-m layer to a depth of 10 m bgl. This corresponds to brackish water bearing highly decomposed limestones and clays. These are underlain by a 32 Ohm-m layer to a depth of 105 m corresponding to fresh to brackish water bearing limestones. This layer is underlain by a 69 Ohm-m layer representing slightly weathered to fresh hard limestones.

11.9 Water Quality

The Ec of the shallow wells was measured to be 10,640. 6,670 and 5,400 µS/cm. The first well is about 10 m from the river bank while the second one is on the river bank and the last one is on the river bed. The trend indicates an improvement in water quality towards the river bed. The first one is used exclusively for animal watering while the 2nd and 3rd one are used for both domestic and animal consumption although slightly brackish.

VES 4

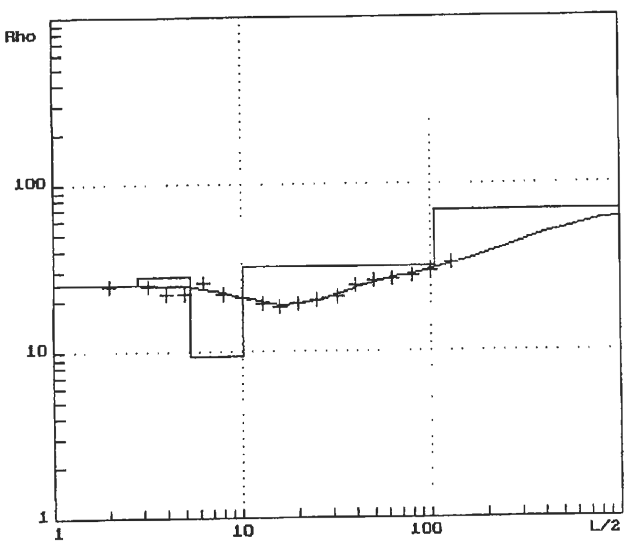


Figure7 - Interpretation Graph for VES 4

11.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Buraal site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the alluvial deposits on the river bed and the sedimentary succession comprising weathered limestones up to a depth of about 80 m bgl at the location of VES 4.

In view of the above it is recommended that 1 shallow well be constructed on the river bed to provide a permanent water supply to the village for human consumption. The well should be dug to about 6 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.

Alternative water sources include:-

1) Drilling a borehole to 80 m bgl and installation of a hand pump.

12. SEERE

12.1 Location

Seere village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located approximately 16 km south west of Buraal village and 39 km south west of Garbahaley town along the Garbahaaley-Ceel Guduud road. The village is located at longitude and latitude approximately 03^0 03' 08" N and 042^0 03' 18" E.

12.2 Physiography

The village lies at an elevation of 378 m amsl. The area is generally flat being interrupted by a few isolated hills and several seasonal rivers. The topography is gently sloping to the east.

12.3 Population and Water Demand

The population of the village is currently estimated at 75 families and an additional 300 nomadic families. The water demand is estimated to be 7,500 liters.

12.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

12.5 Geology

The site is underlain by sandstones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

12.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

12.7 Hydrogeology

12.7.1 Existing Water Suppliess

The only available water supply facility in the village is a 10x10x1 m rain water catchment which holds water for only a short period after the rains. The major source of water in the area is the shallow wells dug in the river banks of togga Buraal 16 km away where people get the water using donkey carts. The three shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season.

12.7.2 Aquifers

Aquifers in the area are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

12.8 Geophysical Investigations

No geophysical measurements were done for this village. Geological observations made on the small rain water catchment indicate presence of clay superficial layers in the sub-surface.

12.9 Water Quality

The water used in this village is brought from Buraal. The Ec of the shallow wells was measured to be 10,640, 6,670 and 5,400 µS/cm. The first well is about 10 m from the river bank while the second one is on the river bank and the last one is on the river bed. The trend indicates an improvement in water quality towards the river bed. The first one is used exclusively for animal watering while the 2nd and 3rd one are used for both domestic and animal consumption although slightly brackish.

12.10 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Seere village site is located in an area which is considered to have a poor groundwater potential. No shallow aquifers occur in the area. Deeper aquifers may exist in the sedimentary succession comprising weathered limestones. Due to proximity of the village to Buraal it is not a priority for the development of a permanent water supply.

In view of the above it is recommended that the existing 10x10x1 m rain water catchment be deepened and enlarged to 50x50x2 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on Buraal for a certain period of the year

13. WARADEY

13.1 Location

Waradey village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located on the approximately 49 km south west of Garbahaley town along the Garbahaaley-Ergaduud road. The village is located at longitude and latitude approximately 03^0 01' 47" N and 042^0 00' 04" E.

13.2 Physiography

The village lies at an elevation of 395 m amsl. The area is low lying with a few flat topped isolated hills and several seasonal rivers. The topography is gently sloping to the east towards in the direction of the drainage.

13.3 Population and Water Demand

The population of the village is currently estimated at 50 families who rely on the existing rain water catchment. In addition 200 nomadic families rely on the same rain water catchment during the dry season for supply of domestic and animal requirements. The total water demand is projected at 25,000 liters per day for domestic consumption alone.

13.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present except for the existing rain water catchment and the minor toggas which flow during the wet seasons for a short period. The site has a large catchment for rain water harvesting extending north westward and demarcated by the adjoining hills. There are no springs within or in the immediate surroundings of the investigated site.

13.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

13.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a southwest-northeast direction are suspected to occur in the general area. The adjoining flat topped hills appear to have resulted from faulting and subsidence.

13.7 Existing Water Supplies

No boreholes or shallow wells have been sunk within the village. The only available water supply at the village is a rain water catchment constructed by local people and which retains water for short periods after the rainy seasons. The catchment measures 30x30x1.5 m and supplies water mainly for animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season. Water for domestic consumption is brought from Ceel Guduud 6 km away.

13.8 Geophysical Investigations

No vertical electrical soundings were executed in the area.

13.9 Water Quality

The Ec of the shallow water in the rain water catchment was measured to be 780 µS/cm which is potable and within accepted limits.

13.10 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Waradey village site is located in an area which is considered to have a poor groundwater potential. No shallow aquifers occur in the area. Deeper aquifers may exist in the sedimentary succession comprising weathered limestones but the quality may be salty Due to proximity of the village to Ceel Guduud it is not a priority for the development of a permanent water supply.

In view of the above it is recommended that the existing 30x30x1.5 m rain water catchment be deepened and enlarged to 75x75x2 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on Ceel Guduud for a certain period of the year.

14. CEEL GUDUUD

14.1 Location

The village of Ceel Guduud is located within Garbahaaley District, Gedo Region of Southern Somalia. The village is located approximately 54 km from Garbahaley along the Garbahaaley-Ceel Guduud road. It is located at longitude and latitude approximately 02^0 59' 43" N and 041^0 57' 08" E.

14.2 Physiography

The village lies at an elevation of 438 m amsl. The area is gently sloping towards the south east. The area has a few limestone ridges and several seasonal rivers.

14.3 Hydrology

The mean annual rainfall ranges between 300 and 350mm. There are no surface water sources in the village apart from seasonal rivers which only flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

14.4 Population and Water Demand

The population of the village is currently estimated at 700 families who rely on the existing borehole. In addition 2000 nomadic families rely on the borehole in the village for supply of domestic and animal requirements.

14.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

14.6 Structures

Based on the geological observations near the investigated site, faults/fractures orientated in a northwest-southeast direction are suspected to occur in the general area.

14.7 Hydrogeology

14.7.1 Existing Boreholes

One borehole has been sunk within the town and is operational. Details about the borehole are given below.

Table 8 - Ceel Guduud Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1985	180	8"	10	43	60	5	5400

14.7.2 Current Water Sources

The only source of water in the area is the operational borehole drilled within the village which supply water for both domestic and animal consumption. The borehole is equipped with a generator and a submersible pump Water is pumped into a tank. Tap stands and donkey cart delivery stands are in place. The water supply meets the requirements for the town despite inadequate storage reservoir The surface water from seasonal rivers is unreliable flow only a few weeks after the rainy season.

14.7.3 Aquifers

Deep aquifers in the area are expected to occur within the fractured limestones/sandstones.

14.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing borehole. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

14.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 9: Interpretation Results of VES 5

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.9	100	Sandy top soils
0.9 - 4.7	110	Slightly weathered limestones
4.7 - 10	251	Hard compact limestones
10 - 14	80	Slightly weathered limestones
14 - 24	3	Clay
24 - 200	16	Fresh water bearing highly weathered limestones
>200	22	Slightly weathered limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 100 Ohm-m to a depth of 0.9 m bgl, comprising mainly Recent deposits composed of top soils, underlain by a 110 Ohm-m resistivity layer to a depth of up to 4.7 m bgl comprising slightly weathered limestone.

This is underlain by a 251 Ohm-m resistivity layer to a depth of 10 m and an 80 Ohm-m layer to a depth of 14 m bgl These correspond to hard compact limestones and slightly weathered limestones respectively. Below these is a 3 Ohm-m resistivity layer to a depth of 24 m bgl. Underlying it is a 16 Ohm-m layer to 200 m bgl. This is interpreted to be the fresh water bearing layer This is underlain by a 22 Ohm-m layer representing slightly weathered to fresh hard limestones or sandstones.

14.9 Water Quality

The Ec of the borehole water was measured to be 6,000 µS/cm which is considered to be slightly brackish but nevertheless used for domestic consumption.

VES 5

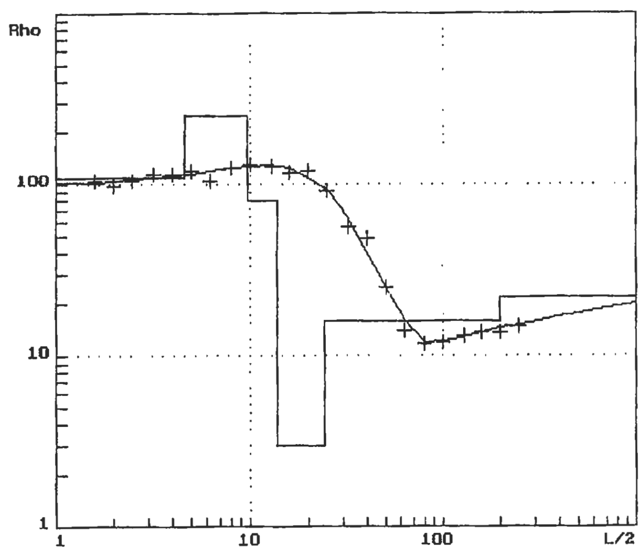


Figure 8 - Interpretation Graph for VES 5

14.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Ceel Guduud site is located in an area which is considered to have a medium groundwater potential. No shallow well is possible in the area as the hard rock occurs to depths greater than 20 m bgl, and no shallow aquifers are existing. In addition there is no possibility of a rain water catchment due to the shallow hard rock at less than 1 m. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones up to a depth of about 200 m bgl at the location of VES 5.

In view of the fact that the borehole water supply is operational and meets the requirements for the town no recommendations are given for expansion of the water supply at the moment. Due to the low storage capacity of the existing tank, it is recommended to construct the following:-

1) 1 tank of 45,000 liters capacity
2) 2 animal troughs
3) 1 set of 6 water delivery tap stands

15. CEEL CADE

15.1 Location

The village of Ceel Cade is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located approximately 11 km from Ceel Guduud south west of Garbahaley along the Garbahaaley-Ceel Cade road It is located at longitude and latitude approximately 03^0 02' 09" N and 041^0 52' 07" E.

15.2 Physiography

The village lies at an elevation of 444 m amsl. The area is generally flat with no topographical features. A few limestone ridges occur east of the village, from which several seasonal rivers emanate.

15.3 Hydrology

The mean annual rainfall ranges between 300 and 350mm. There are no surface water sources in the village apart from seasonal rivers which emanate from the hills and only flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

15.4 Population and Water Demand

The population of the village could not be established during the fieldwork, but it is in excess of 1000 families who rely on the existing borehole. In addition about 3000 nomadic families rely on the borehole in the village for supply of domestic and animal requirements.

15.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

15.6 Structures

Based on the geological observations near the investigated site. faults/fractures orientated in a northwest-southeast direction are suspected to occur in the general area.

15.7 Hydrogeology

15.7.1 Existing Boreholes

Three boreholes have been sunk within the village but only one is operational. Details about the borehole are given below.

Table 10: Ceel Cade Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1985	151	8"	16	24	24	10	2800

15.7.2 Current Water Sources

The only source of water in the area is the operational borehole drilled within the village which supply water for both domestic and animal consumption. The borehole is equipped with a generator and a submersible pump Water is pumped into a 20,000 litre capacity tank. Tap stands and donkey cart delivery stands are in place. The water supply meets the requirements for the town despite inadequate storage reservoir The surface water from seasonal rivers is unreliable flow and only a few weeks after the rainy season.

15.7.3 Aquifers

Shallow, medium and deep aquifers in the area are expected to occur within the fractured limestones and sandstones of the Cambar formation.

15.8 Geophysical Investigations

One vertical electrical sounding (VES 39) was executed at a selected site near the existing borehole. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

15.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 11: Interpretation Results of VES 39

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 2.2	298	Sandy top soils
2.2 - 18	103	Hard compact limestones
18 - 26	18	Highly decomposed limestones
26 - 36	46	Highly weathered limestones
36 - 67	167	Hard compact limestones
67 - 196	25	Highly weathered limestones (with fresh water)
>196	57	Slightly weathered limestones/sandstones (with fresh water)

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 298 Ohm-m to a depth of 2.2 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 103 Ohm-m resistivity layer to a depth of 18 m bgl comprising hard compact limestone. This is underlain by a 18 Ohm-m resistivity layer to a depth of 26 m and a 46 Ohm-m layer to a depth of 36m bgl. These correspond to highly decomposed limestones and highly weathered limestones respectively. Below these is a 167 Ohm-m resistivity layer to a depth of 67 m bgl interpreted to be hard compact limestone. Underlying it is a 25 Ohm-m layer to 196 m bgl. This is interpreted to be the fresh water bearing layer. This is underlain by a 57 Ohm-m layer representing slightly weathered to fresh hard limestones and/or sandstones. At this location, aquifers are expected at 18 to 36 m bgl and 67 to 196 m bgl respectively.

15.9 Water Quality

The Ec of the borehole water was measured to be 2,800 µS/cm which is considered to be slightly brackish but potable.

VES 39

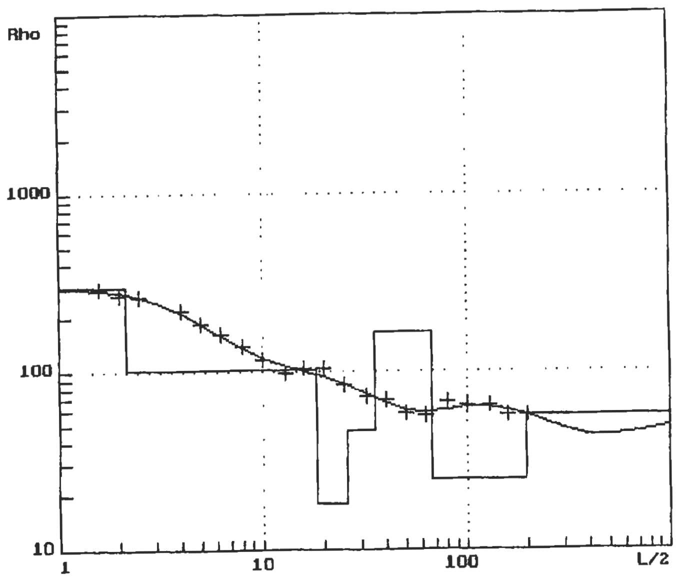


Figure 9 - Interpretation Graph for VES 39

15.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Ceel Cade site is located in an area which is considered to have a medium groundwater potential.

Shallow and deep aquifers in the area are expected to occur within the fractured limestones and sandstones of the Cambar formation at depths of 18 to 36 m and 67 to 196 m bgl respectively. The deep aquifers occur in the area within the sedimentary succession comprising weathered limestones up to a depth of about 196 m bgl at the location of VES 39.

In view of the fact that the borehole water supply is operational and meets the requirements for the town no recommendations are given for expansion of the water supply at the moment. Nevertheless increased demand would necessitate drilling of an additional borehole to supplement the current water supply

It was gathered from the community that UNICEF is currently in the process of undertaking rehabilitation and improvement of the water supply

16. FAN WEYN

16.1 Location

Fan Weyn village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located on the northern banks of Togga Fan Weyn approximately 50 km south of Garbahaley town along the Garbahaaley-Badheere road. The village is located at longitude and latitude approximately 02^0 53' 50" N and 042^0 16' 52" E.

16.2 Physiography

The village lies on the eastern banks of togga Fan Weyn at an elevation of 186 m amsl. The area is generally flat being interrupted by a few isolated flat topped limestone hills and several seasonal rivers north and south of the village. The topography is gently sloping to the east towards the seasonal river and generally to the east in the direction of the drainage towards Webi Juba.

16.3 Population and Water Demand

The population of the village is currently estimated at 60 families who rely on the existing shallow wells. In addition 600 nomadic families rely on the shallow wells and rain water catchment in the village for supply of domestic and animal requirements.

16.4 Hydrology

The mean annual rainfall ranges between 350 and 400 mm. Surface water sources in the area are not present except for togga Fan Weyn which flow during the wet seasons for a short period. The site has a large catchment extending westwards to the hilly areas. There are no springs within or in the immediate surroundings of the investigated site.

16.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

16.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a southwest-northeast direction are suspected to occur in the general area.

16.7 Hydrogeology

16.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Two shallow hand dug wells have been sunk by the local community in the seasonal stream south of the village to depths of about 4 m bgl. Only one of the well located on the river bed is operational while the other one on the river bank is saline and inoperational The water level at the time of this investigation was 1 m bgl.

16.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river bed of togga Fan Weyn. There is an existing rain water catchment of dimensions 50x20x1 m being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season

16.7.3 Aquifers

Aquifers in the area are to occur within the alluvial sediments on the river bed and deeper, fractured limestones/sandstones. The deeper aquifer is however saline. The shallow aquifer is slightly saline but still potable. The shallow aquifer further downstream is observed to be saline due to presence of evaporites of anhydrite which at the time of this study had been precipitated on the surface.

16.8 Geophysical Investigations

Three vertical electrical soundings (VES) were executed at selected sites. VES 6 was done near the existing rain water catchment while the VES33 was done on the dry river bed north of the village. VES 34 was done near the existing shallow existing well on the river bed south of the village. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

16.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 12: Interpretation Results of VES 6, 33 and 34

VES	LAYER 1		LAYER 2		LAYER 3		LAYER 4		LAYER 5		LAYER 6	
	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE
6	30	0.2	1	0.3	2	2	1.3	8	3.2	40	10	>40
33	93	2.5	17	13.5	4	38	20	>38				
34	196	2.2	15	19	75	>19						

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of VES 6 indicate a superficial layer of resistivity varying between 30 Ohm-m to a depth of 0.2 m bgl. And a 1 to 3.2 Ohm-m layer to a depth of 40 m bgl corresponding to saline soils and saline water saturated sediments, underlain by a 10 Ohm-m layer corresponding to limestones and sandstones. Interpretation of VES 33 and 34 done on the river beds indicate a 93 to 196 Ohm-m layer to a depth of 2.5 m bgl. This is underlain by a 15 to 17 Ohm-m layer to a depth of 13.5 and 19 m bgl respectively. This is interpreted to be the brackish water saturated alluvial sediments. At VES 33, it is underlain by a 4 Ohm-m layer to a depth of 38 m bgl interpreted to be saline water saturated limestones. This layer is underlain by a 20 Ohm-m layer corresponding to slightly weathered to fresh limestone. At VES 34, the layer below 19 m bgl is a 75 Ohm-m layer interpreted to be the slightly weathered to fresh limestones and/or sandstones. The only aquifers with brackish water are in the river bed.

16.9 Water Quality

Two shallow hand dug wells are found in the river bed south of the village. Of the two wells, the first one is about 10 m from the river bank while the second one is on the river bed. The Ec of the operational shallow well on the river bed was measured to be 4,140 µS/cm. The trend indicates an improvement in water quality towards the river bed. The river bank well has been abandoned while the second one is used exclusively for domestic consumption although slightly brackish.

VES 6

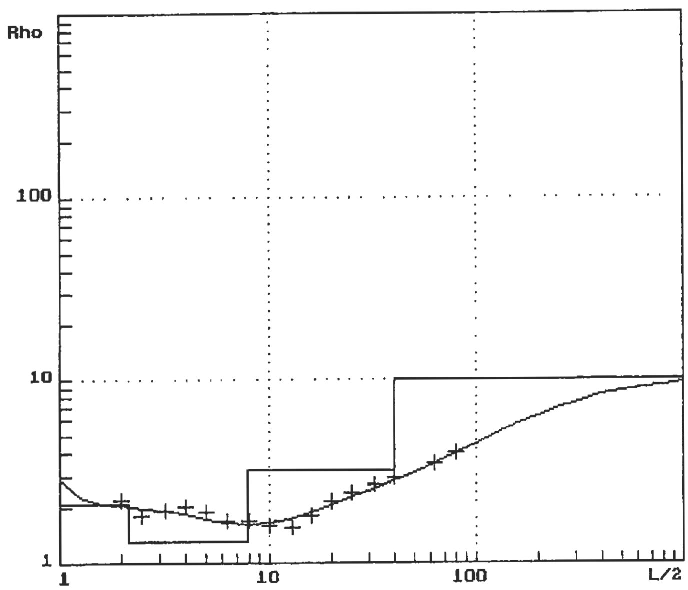


Figure 10 - Interpretation Graph for VES 6

VES 33

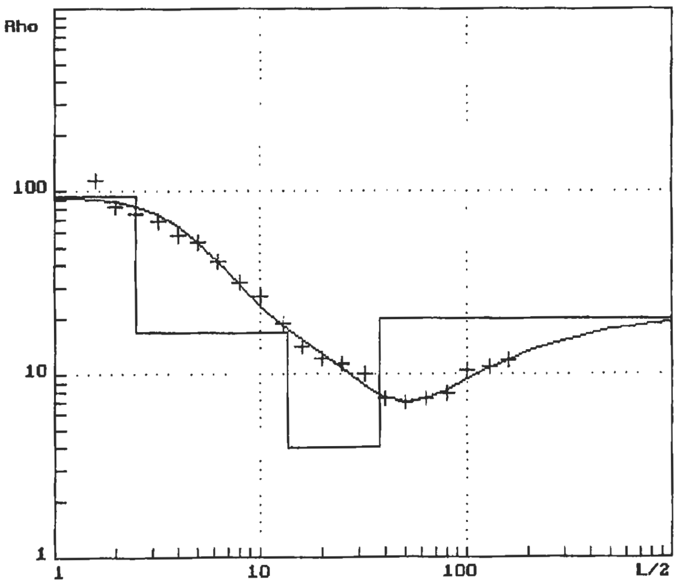


Figure 11 - Interpretation Graph for VES 33

VES 34

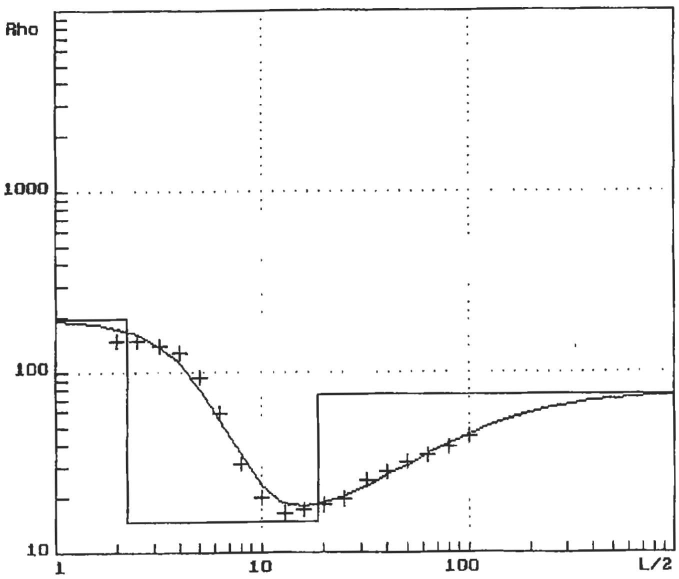


Figure 12 - Interpretation Graph for VES 34

16.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Fan Weyn site is located in an area which is considered to have a poor to medium groundwater potential. Shallow and deep aquifers occur in the area.

At VES 33, the shallow aquifer within the alluvial deposits and sedimentary succession on the river bed is expected to produce water of fair quality. The shallow aquifer extends to a depth of approximately 13.5 m bgl at VES 33. The deeper aquifer at this location in the sedimentary succession comprising weathered limestones up to a depth of about 38 m bgl is expected to be saline and not suitable for domestic or animal consumption.

At VES 34, the shallow and deep aquifer within the alluvial deposits and sedimentary succession on the river bed is expected to produce water of fair quality. The shallow aquifer extends to a depth of approximately 19 m bgl at VES 34. The deeper aquifer at this location in the sedimentary succession comprising weathered limestones could not be delineated.

The existing rain water catchment had water during this study. Aquifers underlying the area away from the river bed are highly saline as depicted by the low resistivity of the formations at VES 6. The salinity is caused by the salts deposited on the land surface (evaporites) being washed away during the rains into the aquifer system. Furthermore presence of anhydrites in the subsurface which dissolve in the water and leaks into the valleys increase the salinity of the riverine baseflow

In view of the above the following is recommended:-

1) construction of a shallow well inside the river bed to 6 m bgl be done to provide a permanent water supply to the village for human consumption. The well should be dug at the location of VES 34 to a depth of about 6 m bgl. The internal diameter should be enlarged to 3 m in order to enhance storage. The superstructure should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.
2) Enlargement and deepening of the existing rain water catchment from 5x20x1 m to 100x50x3 m

Alternative water sources include:-

1) Digging of a 6 m deep shallow well in the seasonal stream north of the village at the location of VES 33. At this location water quality is expected to be marginal though.

17. DUBAA

17.1 Location

The village of Dubaa is located within Garbahaley District, Gedo Region of Southern Somalia. It is located on the northern banks of Togga Dubaa approximately 30 km south of Garbahaley town along the Garbahaaley-Badheere road. The village is located at longitude and latitude approximately 03^0 05' 19" N and 042^0 17' 01" E.

17.2 Physiography

The village lies on the northern banks of togga Dubaa at an elevation of 238 m amsl. The area is generally flat. A few isolated flat topped limestone hills and several seasonal rivers occur west of the village. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage towards Webi Juba.

17.3 Population and Water Demand

The population of the village is currently estimated at 30 families who rely on the existing shallow wells. In addition 500 nomadic families rely on the shallow wells.

17.4 Hydrology

The mean annual rainfall ranges between 350 and 400 mm. Surface water sources in the area are not present except for togga Dubaa which flow during the wet seasons for a short period. The site has a large catchment extending westwards to the hilly areas. There are no springs within or in the immediate surroundings of the investigated site.

17.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

17.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a NE-SW direction are suspected to occur in the general area.

17.7 Hydrogeology

17.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Ten shallow hand dug wells have been sunk by the local community in the river bed of the seasonal stream south of the village to depths of between 6.5 and 7 m bgl. The water level in all the wells is approximated at about 3 m bgl. Only three of the wells are used for domestic consumption since the other seven are saline and are used for animal watering.

17.7.2 Current Water Sources

The current source of water in the area is the shallow wells dug in the river bed of togga Dubaa. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season. Information from the villagers indicate that the seasonal river was last flowing during the El nino rains.

17.7.3 Aquifers

Aquifers in the area are to occur within the alluvial sediments on the river bed and deeper, fractured limestones/sandstones. The deeper aquifer is however saline. The shallow aquifer is slightly saline but still potable.

17.8 Geophysical Investigations

Two vertical electrical soundings (VES) were executed at selected sites near the village and the second one near the existing wells on the river bed. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

17.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below

Table 13: Interpretation Results of VES 7

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.6	380	Sandy top soils
0.6 - 6	113	Hard compact limestones
6 - 30	41	Weathered limestones
>30	1.4	Saline water saturated limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 380 Ohm-m to a depth of 0.6 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 113 Ohm-m resistivity layer to a depth of 6 m bgl comprising hard compact limestone. This is underlain by a 41 Ohm-m resistivity layer to a depth of 30 m corresponding to weathered limestones. At the bottom is a 1 4 Ohm-m layer interpreted to be saline water bearing limestones and sandstone layer.

Table 14: Interpretation Results of VES 8

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1	650	Sandy top soils
1.0 - 3	50	weathered limestones
3 - 22	10	Highly weathered limestones (probably with brackish water)
>22	185	hard compact limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 650 Ohm-m to a depth of 1 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 50 Ohm-m resistivity layer to a depth of 3 m bgl comprising weathered limestone. This is underlain by a 10 Ohm-m resistivity layer to a depth of 22 m corresponding to highly weathered limestones, probably with brackish water. At the bottom is a 185 Ohm-m resistivity layer interpreted to be hard compact limestones and sandstones.

17.9 Water Quality

The salinity of the wells starting upstream was measured 3.850, 4700. 4900 an 8450 µS/cm. The four shallow wells are about 40 m apart for each. The shallow aquifer further downstream is observed to be saline. The trend indicates an improvement in water quality towards the upstream along the river bed.

VES 7

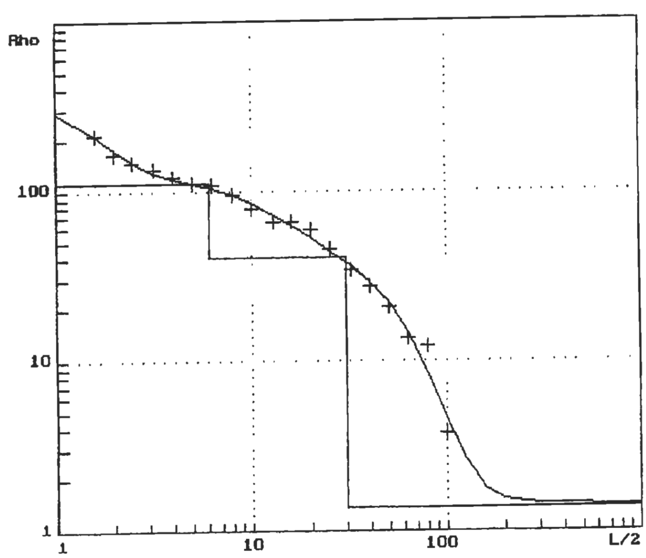


Figure 13 - Interpretation Graph for VES 7

VES 8

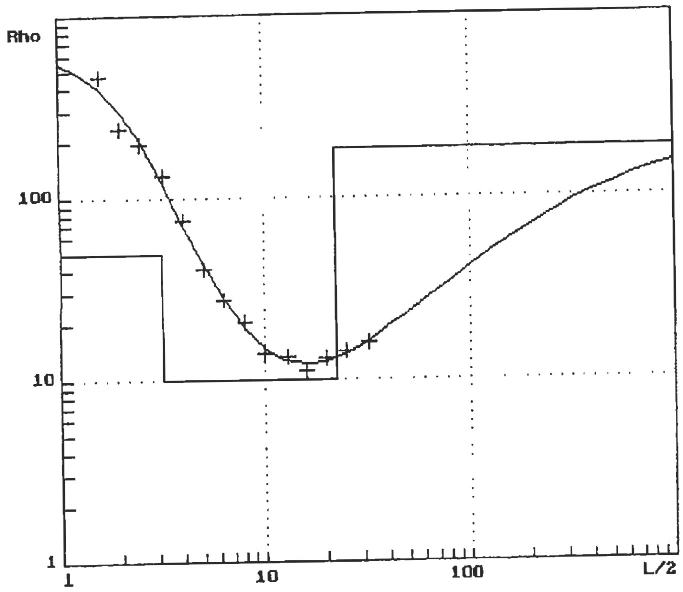


Figure 14 - Interpretation Graph for VES 8

17.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Dubaa site is located in an area which is considered to have a poor to medium groundwater potential. The shallow aquifer within the alluvial deposits on the river bed is expected to produce water of fair quality The shallow aquifer extends to a depth of approximately 10 m bgl. The deeper aquifers in the sedimentary succession comprising weathered limestones are expected to be saline and not suitable for domestic or animal consumption. At VES 8 the base rock occurs at 22 m bgl, underlying soft weathered rock. Construction of a rain water catchment by deepening the existing river bed one is possible.

In view of the above the following is recommended:-

1) Enlargement and construction of 2 shallow wells inside the river bed to 10 m bgl upstream of the existing well field to provide a permanent water supply to the village for human consumption. The wells should be dug to about 6 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.
2) Construction of rain water catchment of dimensions 15x10x8 m on the tributary to the major seasonal stream near the village.

18. DEQFULEY

18.1 Location

The Deqfuley site is located within Garbahaley District, Gedo Region of Southern Somalia. It is located approximately 16 km south of Fan Weyn along the Garbahaaley-Badheere road. The village is located at longitude and latitude approximately 02^0 46' 44" N and 042^0 16' 29" E.

18.2 Physiography

The village lies at an elevation of 296 m amsl on a generally flat area. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage towards Webi Juba.

18.3 Hydrology

The mean annual rainfall ranges between 350 and 400 mm. Surface water sources in the area are not present. The site has a large catchment extending westwards to the hilly areas. There are no springs within or in the immediate surroundings of the investigated site.

18.4 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

18.5 Structures

No geological structures could be identified in the area.

18.6 Hydrogeology

18.6.1 Existing Shallow Wells

No boreholes or shallow wells have been sunk within the village.

18.6.2 Current Water Sources

The current source of water in the area is the rain water catchment constructed off the road. There is however no human settlement in the area, and this catchment serves the nomadic population.

18.7 Geophysical Investigations

No vertical electrical soundings (VES) were executed at sites near the village.

18.8 Conclusions and Recommendations

Based on the available information and the geological observations it is concluded that Deqfuley site is located in an area which is considered to have a poor groundwater potential. However no geophysical investigations were carried out due to close proximity of this village to fan Weyn.

The existing rain water catchment had little amount of water during this study.

In view of the above the following is recommended:-

1) Enlargement, rehabilitation and reconstruction of rain water catchment of 70x40x1 m to 70x50x2 m.

19. DAAR

19.1 Location

Daar village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located approximately 42 south of Fan Weyn village along the Garbahaaley-Badheere road. The village is located at longitude and latitude approximately 02^0 35' 43" N and 042^0 11' 32" E.

19.2 Physiography

The village lies on the northern banks of togga Daar at an elevation of 237 m amsl. The area is undulating with several significant seasonal rivers. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage.

19.3 Population and Water Demand

The population of the village is currently estimated at 25 families who rely on the existing shallow wells. In addition 200 nomadic families rely on the shallow well and rain water catchment in the village for supply of domestic and animal requirements

19.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. Surface water sources in the area are only present during in togga Daar which flow during the wet seasons for a short period. The site has a large catchment extending westwards. There are no springs within or in the immediate surroundings of the investigated site.

19.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

19.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a west-east direction are suspected to occur in the general area.

19.7 Hydrogeology

19.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Two shallow hand dug wells have been sunk by the local community in the area to depths of about 5 m bgl which are operational. The water level at the time of this investigation was 0.5 m bgl.

19.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river banks of togga Daar. The two shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season. An additional source of water is in the two catchments next to the village with dimensions of 50x30x1 m. The rain water catchments have backfilled and there are no channels to drain runoff water into the catchments.

19.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

19.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

19.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 15: Interpretation Results of VES 9

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.7	83	Dry sands and gravels (alluvial sediments)
0.7 - 1.6	29	Moist sands and gravels
1.6 - 8	76	Weathered limestones (probably with fresh water)
8 - 21	580	Hard compact limestone
>21	56	Highly weathered limestones/sandstones (with fresh water)

RE Resistivity (Ohm-m) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 83 Ohm-m to a depth of 0.7 m bgl, comprising mainly Recent alluvial fluviatile deposits, underlain by a 29 Ohm-m resistivity layer to a depth of 1.6 m bgl comprising moist sands and gravels. This is underlain by a 76 Ohm-m resistivity layer to a depth of 8 m bgl corresponding to weathered limestones, saturated with fresh water. It is underlain by a 580 Ohm-m layer to a depth of 21 m bgl interpreted to be compact hard limestone. At the bottom is a 56 Ohm-m resistivity layer interpreted to be highly weathered limestones and sandstones.

19.9 Water Quality

The Ec of the shallow wells was measured to be 2400 µS/cm. The wells are about 5 m away from the river. Water quality improves towards the river bed. The two wells are used for animal watering and domestic consumption.

VES 9

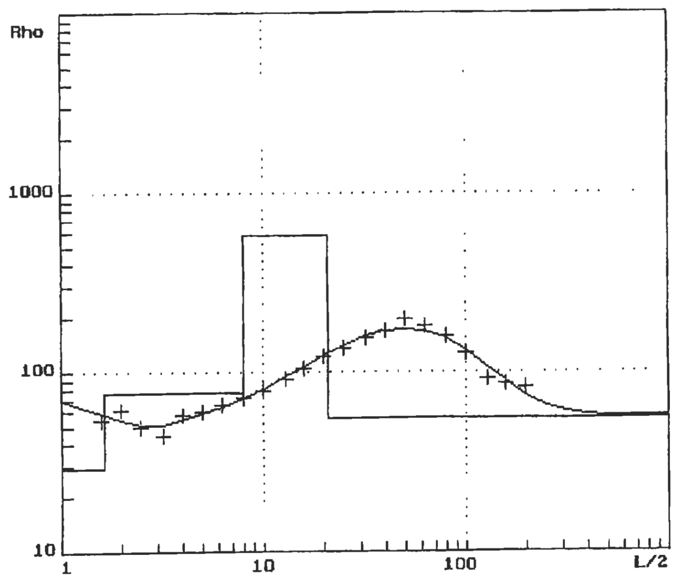


Figure 15 - Interpretation Graph for VES 9

19.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Daar site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the alluvial deposits on the river bed and the sedimentary succession comprising weathered limestones up to a depth of about 150 m bgl at the location of VES 9.

In view of the above it is recommended that:-

1) the two rain water catchments are rehabilitated and cleaned out.
2) 1 shallow well be dug and constructed on the river bed to provide a permanent water supply to the village for human consumption. The well should be dug to about 6 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure

should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.

Alternative water sources include:-

1) Drilling a borehole near the river bed at the location of VES 9 to a depth of about 150 m bgl and installation of a hand pump.

20. BADHEERE

20.1 Location

The town of Badheere is located within Garbahaley District, Gedo Region of Southern Somalia. The town is located approximately 135 km from Ghabahaley town on the banks of river Juba.

20.2 Physiography

The town lies on the eastern banks of Webi Juba at an elevation of 103 m amsl. The area is generally flat with a wide flood plain demarcated by limestone ridges on its fridges and numerous seasonal rivers. The topography is gently sloping to the south east towards the Indian Ocean.

20.3 Population and Water Demand

The population of the town could not be estimated by the local elders but it is projected to be over 2000 families who rely on the existing borehole In addition 10000 nomadic families are expected to rely on the water supply for domestic and animal requirements.

20.4 Hydrology

The mean annual rainfall ranges between 350 and 400 mm. Surface water sources in the area are the most reliable from river Juba which flow perennially. During the rainy seasons the Juba breaks its banks over-flooding the expansive flood plain.

20.5 Geology

The area is underlain by alluvial deposits underlain by limestones and older sedimentary rocks.

20.6 Structures

No structural features are visible on the flood plain of the river due to the thick alluvial deposits. Fault lines can be inferred on the limestone hilly areas along which local drainage channels seem to conform.

20.7 Existing Water Supply

The town is currently supplied by river water which is collected by water vendors and is distributed by means of donkey carts. A drilled well was previously operational but has since been abandoned. The river supply water for both domestic and animal consumption.

Water is pumped into an Oxfam tank with a capacity of 45000 liters. Urban water supply with tap stands and donkey cart delivery stands is in place. The water supply meets the requirements for the town. The surface water is however heavily polluted and there is no water treatment carried out

20.7.1 Aquifers

Aquifers in the area are expected to occur within the alluvial sediments in the flood plain and deeper fractured and weathered limestones/sandstones. The shallow aquifer is known to have varying water quality with most areas being saline.

20.8 Water Quality

The Ec of the Juba river water was measured to be 480 µS/cm which is considered to be potable water fit for both domestic and animal consumption. However there is no water treatment undertaken before water is supplied for consumption.

20.9 Conclusions and Recommendations

Based on the available information and the physical evaluation of the existing facilities, it is concluded that the area has a medium groundwater potential. Deep aquifers occur in the area within the sedimentary succession. Shallow aquifers occur at depths less than 5 meters. Inspite of presence of groundwater resources, it is viewed that the abundant surface water resources from river Juba are the most feasible to exploit in order to re-install the urban water supply for the town.

In view of the poor storage capacity and treatment conditions of the existing water supply, it is recommended to construct and install the following:-

1) 4 tanks of 45,000 liters capacity
2) intake
3) 2 pumps
4) pump house
5) piping from intake to the tanks
6) fencing of area around the tanks
7) water testing kit

21. JUNGEL

21.1 Location

Jungel village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located on the northern banks of Togga Jungel approximately 27 km south west of Badheere town along the Badheere-Fafadun road. The village is located at longitude and latitude approximately 02^0 22' 28" N and 042^0 04' 37" E.

21.2 Physiography

The village lies at an elevation of 113 m amsl. The area is undulating with rolling topography with a few isolated hills and several seasonal rivers. The topography is gently sloping to the south east towards the seasonal river

21.3 Population and Water Demand

The population of the village is currently estimated at 20 families with an additional 200 nomadic families who rely on the existing shallow well and small dam on the river bed for supply of domestic water and animal requirements.

21.4 Hydrology

The mean annual rainfall ranges between 350 and 400 mm. Surface water sources in the area are not present except for togga Jungel which flow during the wet seasons for a short period. The site has a large catchment extending north westward. There are no springs within or in the immediate surroundings of the investigated site. The last rains were experienced for 2 days only 3 months ago.

21.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils.

21.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a NW-SE direction are inferred in the general area.

21.7 Existing Water Supplies

No boreholes have been sunk within the village. One shallow hand dug well has been sunk by the local community in the river bed to a depth of about 1.5 m bgl which is operational. The water level at the time of this investigation was near the surface.

The major source of water in the area is the shallow wells dug in the river banks of the togga for both domestic and animal consumption. The surface water from togga Jungle seasonal river is also being exploited by collecting it from pods on the river bed. After the river flow ceases, the community is able to access the water by digging shallow holes in the alluvial sediments after the rainy season.

21.7.1 Aquifers

Aquifers in the area are expected to occur within alluvial sediments in the drainage valleys and in the deeper fractured limestones/sandstones.

21.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing well on the river bed. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

21.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 16 - Interpretation Results of VES 10

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	1	Clay
0.4 - 3.0	6	Moist clays and silts (with saline water)
3.0 - 25	15	Highly weathered limestones (with fresh water)
25 - 60	24	Highly weathered limestones (probably with fresh water)
>60	32	Weathered limestones/sandstones (partially with fresh water)

RE Resistivity (Ohm-m) **DE** Depth (m)

The interpretation results indicate a 1 Ohm-m superficial layer to 1 m bgl, comprising clays, underlain by a 6 Ohm-m layer to a depth of 3 m bgl comprising moist clays and silts. This is underlain by a 15 Ohm-m resistivity layer to a depth of 25 m bgl corresponding to highly weathered limestones, saturated with fresh water. It is underlain by a 24 Ohm-m layer to a depth of 60 m bgl interpreted to be weathered limestone also with fresh water. At the bottom is a 32 Ohm-m resistivity layer interpreted to be weathered limestones and sandstones. The upper zones of this layer has fresh water.

21.9 Water Quality

The water quality of the shallow well and the surface waters were measured to be the same with Ec of 5400 µS/cm. Although slightly brackish, the water is used for both domestic and animal consumption.

VES 10

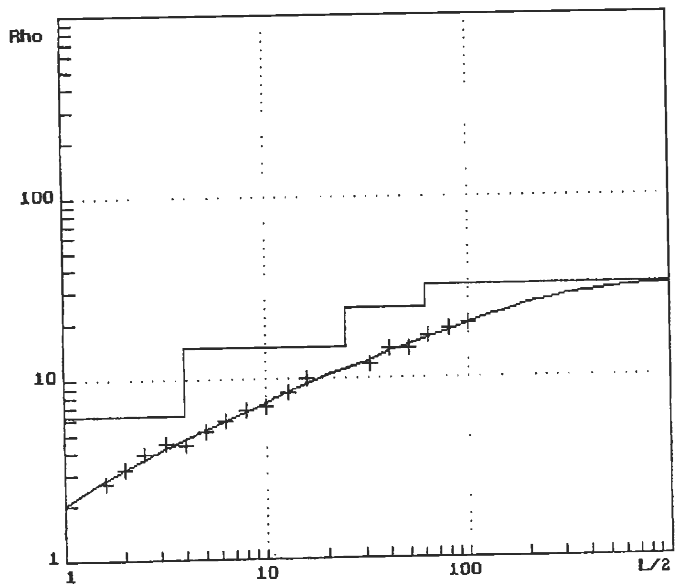


Figure 16 - Interpretation Graph for VES10

21.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Jungel site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the alluvial deposits on the river bed and the underlying sedimentary succession comprising weathered limestones to a depth of 60 m bgl. Deeper aquifers are expected as depicted by the resistivity values.

In view of the above it is recommended that:-

1) 1 shallow well be constructed on the river bed to provide a permanent water supply to the village for human consumption. The well should be dug at the location of VES 10 to about 6 m bgl and the internal diameter enlarged to 6 m in order to enhance storage. The superstructure should be constructed in such a way that will avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the well for watering.

Alternative water sources include:-

1) Construction of an earth dam with a spill way. This would require excavation of the top soil to 3 m deep for the dam wall to be constructed in the river bed.
2) Drilling of a borehole near the river bed at the location of VES 10 and equip with a hand pump

22. TARAKO

22.1 Location

Tarako village is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located approximately 59 km south west of Badheere village along the Badheere-Fafadun road. The village is located at longitude and latitude approximately 02^0 16' 10" N and 041^0 51' 16" E.

22.2 Physiography

The village lies at an elevation of 249 m amsl. The area is generally flat and featureless, the general topography gently sloping to the east.

22.3 Population and Water Demand

The village is a nomadic one and at present people have moved away with their animals to seek green pastures. It is a strategic location for nomadic movements.

22.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

22.5 Geology

The site is underlain by sandstones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils. It lies near the contact between the limestones and sandstones

22.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

22.7 Existing Water Suppliess

The only available water supply facility in the village is two 75x50x1 m rain water catchment which hold water for only a short period after the rains. Aquifers in the area would be expected to occur within the fractured limestones/sandstones. No water was available for sampling and evaluation of the water quality in the area.

22.8 Geophysical Investigations

One geophysical resistivity measurement were done next to the existing rain water catchment in order to determine the underground conditions for rehabilitation of the rain water catchment. Geological observations made on the small rain water catchment indicate presence of clay superficial layers in the sub-surface.

Table 17: Interpretation Results of VES 11

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.5	340	Top sandy soils
0.5 - 11	2.3	Clays and silts
>11	50	Slightly weathered sandstones

RE Resistivity (Ohm-m) **DE** Depth (m)

The interpretation results indicate a 340 Ohm-m superficial layer to 0.5 m bgl, comprising sandy soil, underlain by a 2.3 Ohm-m layer to a depth of 11 m bgl comprising clays and silts. This is underlain by a 50 Ohm-m resistivity layer interpreted to be weathered limestones and sandstones. No aquifers are expected at this location.

VES 11

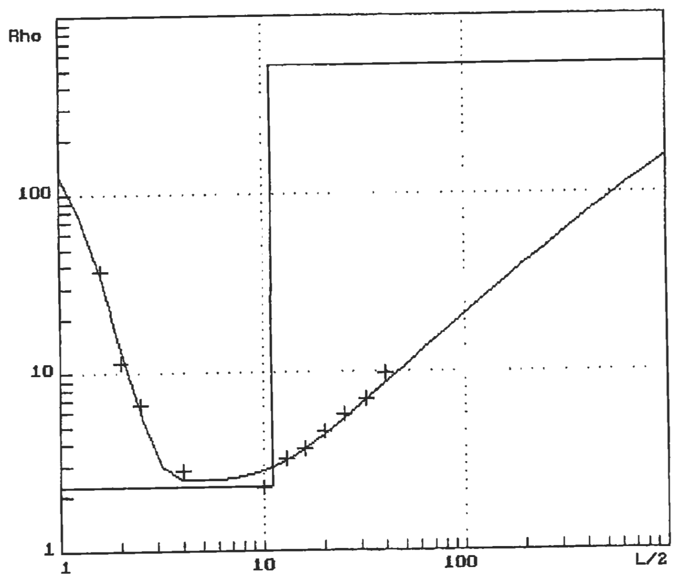


Figure 17 - Interpretation Graph for VES 11

22.9 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Tarako village site is located in an area which is considered to have a poor groundwater potential. No shallow aquifers occur in the area. Deeper aquifers may exist in the sedimentary succession comprising weathered limestones but the quality may be suspect.

In view of the above it is recommended that the existing 75x50x1 m rain water catchment be deepened and enlarged to 100x100x3 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year

23. FAFADUN

23.1 Location

The village of Fafadun is located within Badheere District, Gedo Region of Southern Somalia. The village is located approximately 85 km from Badheere town at longitude and latitude approximately 02^0 12' 22" N and 041^0 37' 29" E.

23.2 Physiography

The village lies on the eastern banks of togga Bursaqar at an elevation of 222 m amsl. The area is generally flat and featureless. The most conspicuous physiographic feature is the wide depression at the depression. A number of seasonal rivers are found in the area. The topography is gently sloping to east towards the wide drainage valley forming a depression.

23.3 Population and Water Demand

The population of the village is currently 200 families who rely on the existing shallow wells. In addition 2500 nomadic families rely on the shallow wells for supply of domestic and animal requirements. It must be pointed out that this is a strategic nomadic village where the population of animals is very high, and during dry seasons, the nomads stop at the village on transit down south with their herds

23.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. Surface water sources in the area are not present except. The wide depression only has surface flow only during heavy rains which are not frequent and at times will take 10 years. The site has a large catchment extending north westward. There are no springs within or in the immediate surroundings of the investigated site.

23.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils. Along the depression, the area is underlain by red soils and alluvium.

23.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a northwest-southeast direction may be inferred in the general area.

23.7 Hydrogeology

23.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. A total of 15 shallow hand dug wells have been sunk by the local community in the area to depths of about 10 m bgl. Out of the 15 wells 2 are operational. The water level at the time of this investigation was 8.2 m bgl.

23.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the depression. Only 2 of the 15 shallow wells are being used for both domestic and animal consumption but they are very saline. During dry seasons, the community is supplied by tankers from Badheere 84 km away and fill the existing barkad.

23.7.3 Aquifers

Both shallow and deep aquifers are existing in the village. The shallow aquifer is saline and extends from approximately 8 m bgl to 20 m bgl in the superficial alluvial deposits. Deeper aquifers in the area are expected to occur within the fractured limestones/sandstones at depths of up to 250 m.

23.8 Geophysical Investigations

Three vertical electrical sounding (VES) were executed at selected sites near the existing saline wells and also behind the village. VES 12 was done near the existing saline wells on the wide drainage valley. VES 30 was done next to the village near the edge of the valley and VES 31 south of the village. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

23.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 18: Interpretation Results of VES 12, 30 and 31

VES	LAYER 1		LAYER 2		LAYER 3		LAYER 4		LAYER 5		LAYER 6	
	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE
12	353	0.3	2	0.7	23	8	21	100	234	>100		
30	4.7	0.6	155	1.2	6.9	9	142	22	12	>22		
31	8.5	2.8	64	5	2.5	12	63	57	15	215	24	>215

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of the three VES indicate a superficial layer of resistivity varying between 4.7 and 353 Ohm-m to a depth of 8 to 12 m bgl. This is interpreted to be top soils comprising sands, clays and silts, underlain by 21 to 142 Ohm-m layer to depths of up to 100. At VES 30 the it is underlain by a 12 Ohm-m layer This layer is interpreted to be brackish water bearing weathered limestones and sandstones. At VES 31, a 15 Ohm-m layer exists to a depth of 215 m bgl which is again interpreted to be brackish water bearing. This is underlain by a 24 Ohm-m layer Interpreted to be highly weathered limestones and sandstones with fresh water At VES 12, the 21 Ohm-m layer extends to a depth of 100 meters underlain by 234 Ohm-m layer At this village both shallow, medium and deep groundwater exists and of different quality. The shallow aquifer is saline as depicted by the high Ec in the wells. Deeper aquifers are interpreted to be fresh water bearing as depicted by their higher resistivity

23.9 Water Quality

The Ec of the shallow wells was measured to be 19,200 μS/cm which is considered to be highly saline and not suitable for domestic and animal consumption. There being no other source of water, the people have to use this water inspite of the poor quality

VES 12

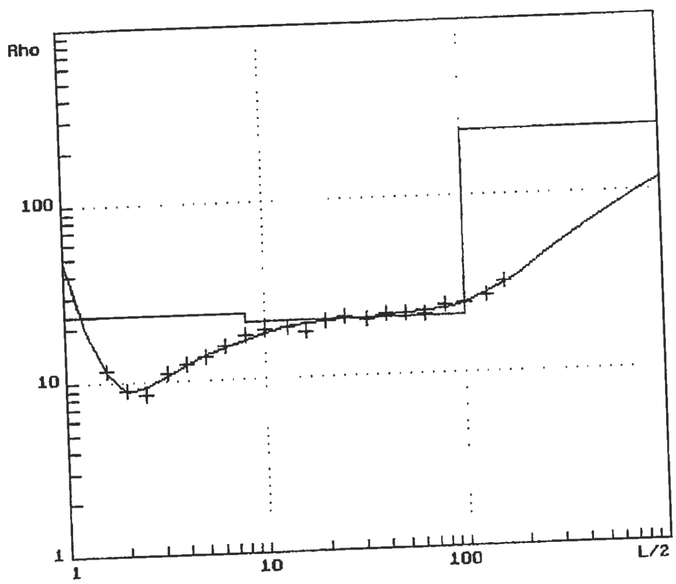


Figure 18 - Interpretation Graph for VES 12

VES 30

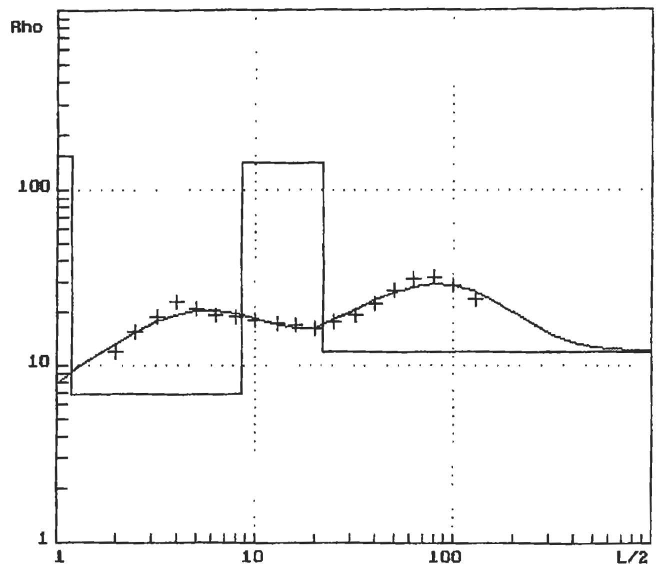


Figure 19 - Interpretation Graph for VES 30

VES 31

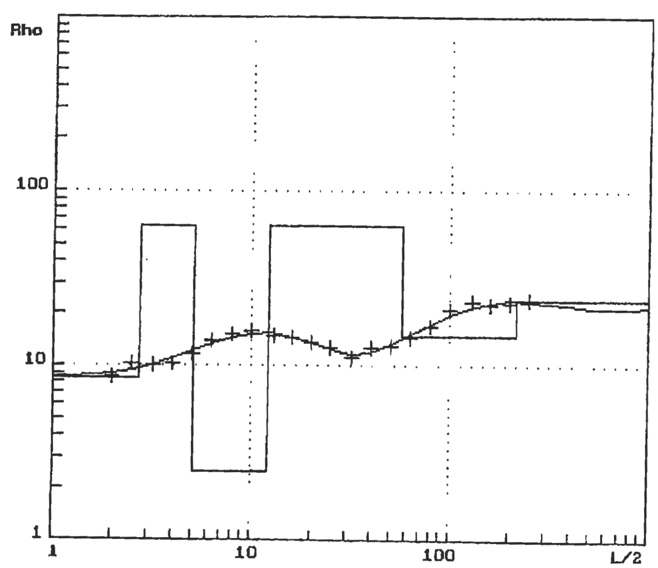


Figure 20 - Interpretation Graph for VES 31

23.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Fafadun site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the alluvial deposits on the wide depression. However, the quality in terms of salinity is poor. Bacteriological quality is also poor in view of the large number of animals in the area and poor construction of the wells. Deeper aquifers occur within the sedimentary succession comprising weathered limestones up to a depth of about 250 m bgl at the location of VES 31. However, the deeper aquifers along the depression appear to be saturated with saline water while south of the village, better quality water is to be found.

In view of the above it is recommended that:-

1) A borehole be drilled to a depth of 250 m bgl at the location of VES 31. The borehole should be equipped with a generator and a submersible pump. To identify the most suitable drilling position, further detailed geophysical investigations should be undertaken.
2) During drilling continuous monitoring of the conductivity of the water is necessary in order to delineate accurately the shallow saline water saturated aquifers.
3) During borehole installation, the upper zones should be sealed off completely to avoid mixing of the shallow saline water with the deeper aquifer.

Alternative water sources include:-

1) Construction of a barkad for water tracking. This is however too expensive for the community, and is not feasible for animal watering due to the high demand.
2) Although construction of a rain water catchment of 100x50x2 m would be feasible, it is not recommended due to the poor rainfall reliability and frequency

24. ABDIKHAYR

24.1 Location

The village is located within Badheere District, Gedo Region of Southern Somalia. The village is located approximately 105 km south west of Badheere town and 20 km from Fafadun. The village is located at longitude and latitude approximately 02^0 03' 59" N and 041^0 28' 33" E.

24.2 Physiography

The village lies at an elevation of 186 m amsl. The area is generally flat and featureless, the general topography gently sloping to the east.

24.3 Population and Water Demand

The village is a nomadic one and at present people have moved away with their animals to seek green pastures. It is a strategic location for nomadic movements. The area has very good grazing land and is highly populated during the rainy seasons.

24.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

24.5 Geology

The site is underlain by limestones and sandstones, and older sedimentary rocks which are overlain at the surface by a thick Recent superficial clayey alluvial deposits and soils to a depth of about 4 m bgl.

24.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

24.7 Existing Water Suppliess

The only available water supply facility in the village is one rain water catchment which hold water for only a short period after the rains. The rain water catchment has dimensions of approximately 70x75x2 which is currently backfilled. Aquifers in the area would be expected to occur within the fractured limestones/sandstones. No water was available for sampling and evaluation of the water quality in the area.

24.8 Geophysical Investigations

One geophysical resistivity measurement was done next to the existing rain water catchment in order to determine the underground conditions for rehabilitation of the rain water catchment. Geological observations made on the rain water catchment indicate presence of clay superficial layers in the sub-surface.

Table 19: Interpretation Results of VES 13

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	42	Dry sandy top soils and alluvial sediments
0.4 - 8	1.4	Clays
8 - 36	6	Highly decomposed limestones and clays
>36	19	Slightly weathered limestones/sandstones/siltstones

RE Resistivity (Ohm-m) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 42 Ohm-m to a depth of 0.4 m bgl, comprising mainly Recent alluvial deposits and sandy top soils underlain by a 1 4 Ohm-m resistivity layer to a depth of 8 m bgl comprising clays probably very salty. This is underlain by a 6 Ohm-m resistivity layer to a depth of 36 m bgl corresponding to highly weathered limestones and clays. It is underlain by a 19 Ohm-m layer interpreted to be slightly weathered limestones, sandstones and siltstones.

VES 13

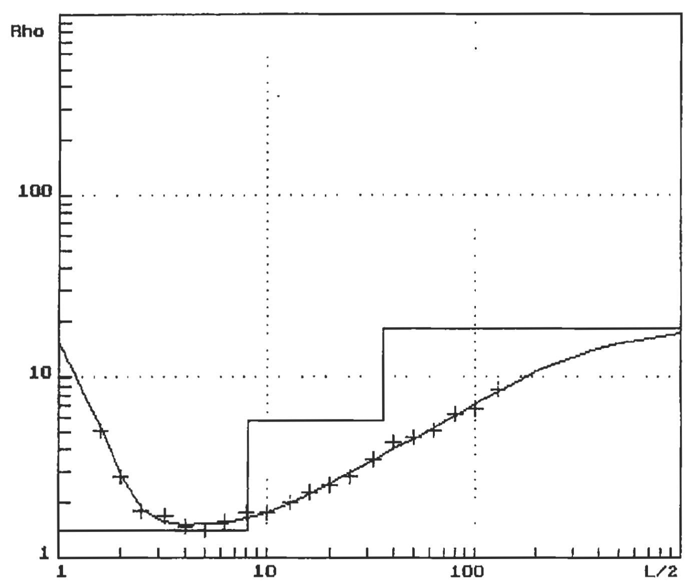


Figure 21 - Interpretation Graph for VES 13

24.9 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Abdikhayr village site is located in an area which is considered to have a poor groundwater potential. No shallow aquifers occur in the area. It is possible that the clayey formation to a depth of 36 m bgl might have some water but most likely saline. At shallow depth, clays are interpreted to be depicted by the low resistivity values.

In view of the above it is recommended that:-
1) The existing backfilled rain water catchment be deepened and enlarged to 100x100x4 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year.

25. DARASALAM/KURDO

25.1 Location

The village of Darasalam/Kurdo is located within Badheere District, Gedo Region of Southern Somalia. The village is located approximately 58 km from Badheere town and 163 km from Fafadun at longitude and latitude approximately 01^0 57' 18" N and 041^0 04' 29" E.

25.2 Physiography

The village lies at an elevation of 235 m amsl. The area is generally flat and featureless. There are no seasonal rivers near the village. The topography is gently sloping to east.

25.3 Population and Water Demand

The population of the village is currently 120 families who rely on the existing shallow well. In addition 2500 nomadic families rely on the shallow well for supply of domestic and animal requirements. It must be pointed out that this is a strategic nomadic village where the population of animals is very high, and during dry seasons, the nomads stop at the village on transit down south with their herds.

25.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. Surface water sources in the area are not present except. The site has a large catchment extending north westward. There are no springs within or in the immediate surroundings of the investigated site.

25.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils. Along the depressions, the area is underlain by red soils and alluvium.

25.6 Structures

No geological structures could be inferred due to blanketing by thick alluvial deposits and soils.

25.7 Hydrogeology

25.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. One shallow hand dug well has been sunk by the local community in the area to depths of about 27 m bgl. The well is operational and supplies water for domestic and animal consumption. The water level at the time of this investigation was 26 m bgl.

25.7.2 Current Water Sources

The major source of water in the area is the shallow well dug in the depression south of the village at Kurdo. There is an existing rain water catchment of dimensions 50x50x30 m which supply water for domestic and animal consumption. During dry seasons, the community moves away from the area with the animals

25.7.3 Aquifers

Both shallow and deep aquifers are existing in the village. The shallow aquifer is saline and extends from approximately 26 to 35 m bgl. Deeper aquifers in the area are expected to occur within the fractured limestones/sandstones at depths of up to 100 m.

25.8 Geophysical Investigations

Three vertical electrical sounding (VES) were executed at selected sites near the existing shallow well, next to the village and near the rain water catchment. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

25.8.1 Resistivity Soundings

VES 14 was carried out next to the existing rain water catchment, VES 15 next to the existing shallow hand dug well and VES 20 at the village. Interpreted results of the sounding are shown in the table presented below:

Table 20: Interpretation Results of VES 14, 15 and 20

VES	LAYER 1		LAYER 2		LAYER 3		LAYER 4		LAYER 5	
	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE
14	34	1	7	14	26	45	15	88	54	>100
15	19	0.4	90	4.6	33	85	995	>85		
20	5.3	0.9	6.7	9	9	34	27	>34		

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of the three VES indicate a superficial layer of resistivity varying between 5.3 and 90 Ohm-m to a depth of 4.6 to 14 m bgl. This is interpreted to be top soils comprising sands, clays, gravels and silts of various sizes and composition. At VES 14, it is underlain by a 26 Ohm-m layer to a depth of 45 m bgl interpreted to be highly weathered limestones and a 15 Ohm-m layer to 88 m bgl. These two layers have fresh water as observed in the shallow well. At VES 15 the aquiferous layer has a resistivity of 33 Ohm-m and extends to a depth of 85 m bgl. Below this is compact limestones and sandstones. From the interpreted resistivities the deeper aquifers are expected to be fresh water bearing.

In this village both shallow and deep groundwater exists and of is of different quality. The shallow aquifer is brackish as depicted by the high Ec in the shallow hand dug well, and the lower resistivity of the formation. Deeper aquifers are interpreted to be fresh water bearing as depicted by their higher resistivity.

25.9 Water Quality

The Ec of the shallow well was measured to be 5500 µS/cm which is considered to be slightly brackish but still used for domestic and animal consumption.

VES 14

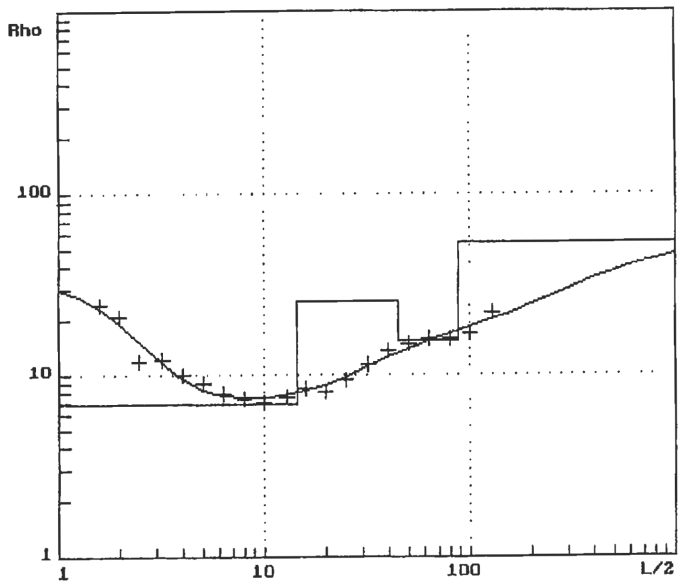


Figure 22 - Interpretation Graph for VES 14

VES 15

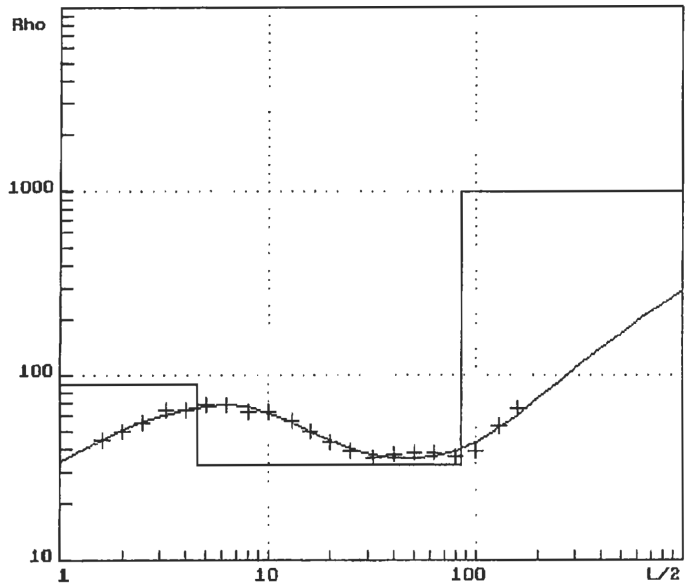


Figure 23 - Interpretation Graph for VES 15

VES 20

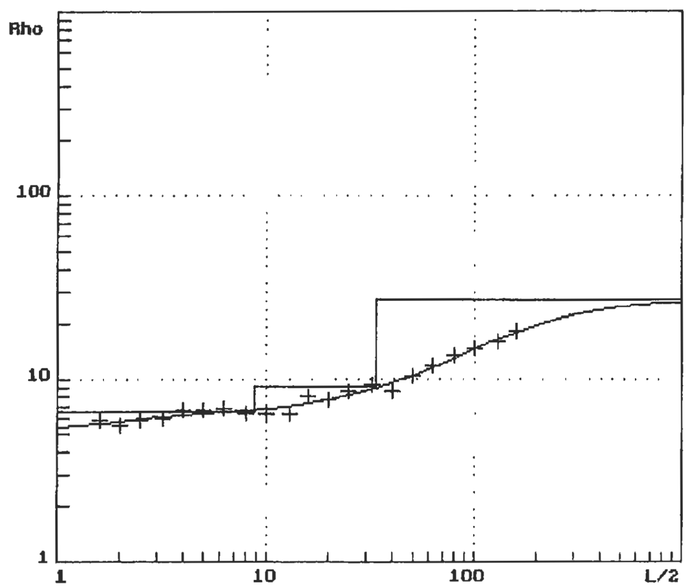


Figure 24 - Interpretation Graph for VES 20

25.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Darasalam site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Deep productive aquifers are occur south of the village in the Kurdo area, within the sedimentary succession comprising weathered limestones up to a depth of about 100 m bgl. Water quality improves with depth.

In view of the above it is recommended that.-

1) 2 boreholes be drilled to a depth of about 100 m bgl in the area south of the village near the location of VES 14 and 15.
2) To identify the most suitable drilling position, further detailed geophysical investigations should be undertaken.
3) During drilling, continuous monitoring of the electrical conductivity will be necessary to identify the saline aquifers.
4) During installation, the upper zones should be sealed off completely to avoid mixing of the shallow saline water with the deeper aquifer. The boreholes should be equipped with a hand pumps.
5) As an additional water source, the rain water catchment should be enlarged, rehabilitated to reduce water problems during drought.

Alternative water sources include:-

1) Digging and deepening of the existing shallow well from 27 to 35 m bgl. The shallow well should be enlarged to 6 m diameter. This enhances the storage and production. Construction of a cattle trough next to the shallow well. This option is however difficult to implement due to difficulties involved in digging the deep well and risks of collapsing formations in the subsurface.

26. BAKHTILEY

26.1 Location

The village is located within Badheere District, Gedo Region of Southern Somalia. The village is located approximately 188 km south west of Badheere town and 25 km from Darasalaam. The village is located at longitude and latitude approximately 01^0 44` 19" N and 041^0 04' 59" E.

26.2 Physiography

The village lies at an elevation of 205 m amsl. The area is generally flat and featureless, the general topography gently sloping to the east.

26.3 Population and Water Demand

The village is a nomadic one and at present people have moved away with their animals to seek green pastures. It is a strategic location for nomadic movements being on the nomadic corridor during dry seasons. The area has very good grazing land and is highly populated during the rainy seasons.

26.4 Hydrology

The mean annual rainfall ranges between 350 and 400mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

26.5 Geology

The site is underlain by sandstones, and older sedimentary rocks which are overlain at the surface by a thick layer of Recent superficial clayey alluvial deposits and soils.

26.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

26.7 Existing Water Suppliess

The only available water supply facility in the village is one rain water catchment which hold water for only a short period after the rains. The rain water catchment has dimensions of approximately 100x100x1 which is currently backfilled and neglected.

26.8 Geophysical Investigations

One geophysical resistivity measurement was done next to the existing rain water catchment in order to determine the underground conditions for rehabilitation of the rain water catchment. Geological observations made on the rain water catchment indicate presence of clay superficial layers in the sub-surface.

Table 21: Interpretation Results of VES 16

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 2.8	26	Dry sandy top red soils and alluvial sediments
2.8 - 80	5	Decomposed limestones and clays (highly saline)
>80	995	Hard compact limestones/sandstones/siltstones

RE Resistivity (Ohm-m) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 26 Ohm-m to a depth of 2.8 m bgl, comprising mainly Recent alluvial deposits and sandy top soils underlain by a 5 Ohm-m resistivity layer to a depth of 80 m bgl comprising clays, most probably very salty This is underlain by a 995 Ohm-m resistivity layer corresponding to hard compact limestones. sandstones and siltstones.

VES 16

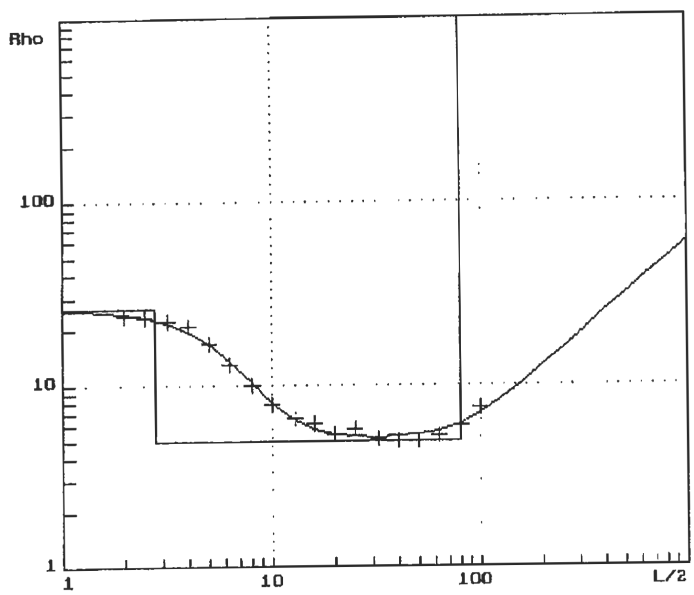


Figure 25 - Interpretation Graph for VES 16

26.9 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Bakhtiley village site is located in an area which is considered to have a poor groundwater potential. No shallow aquifers occur in the area. The deep aquifer extends to about 80 m but from interpretation of resistivity data, the aquifer is highly saline and consists mainly clays and decomposed limestones which are not expected to be productive.

In view of the above it is recommended that:-

1) The existing backfilled rain water catchment be deepened and enlarged to 100x100x4 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year.

27. GARILEY

27.1 Location

The village is located within Badheere District, Gedo Region of Southern Somalia. It is located approximately 220 km south west of Badheere town. The village is located at longitude and latitude approximately 01^0 41` 59" N and $041^0$ 01` 28" E.

27.2 Physiography

The village lies at an elevation of 180 m amsl. The area is generally flat and featureless, the general topography gently sloping to the east.

27.3 Population and Water Demand

The village is a new one and present people moved from Daresalaam to settle with their animals to seek green pastures. The population was estimated as 50 families and about 200 nomads.

27.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

27.5 Geology

The site is underlain by limestones and sandstones. and older sedimentary rocks which are overlain at the surface by a thick layer of Recent superficial clayey alluvial deposits and red soils.

27.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

27.7 Existing Water Suppliess

The only available water supply facility in the village is one rain water catchment approximately 10 km away which hold water for only a short period after the rains. Currently the rain water catchment is dry. The dimensions of the rain water catchment is approximately 100x100x1 which is currently backfilled and neglected.

27.8 Geophysical Investigations

Three geophysical resistivity measurements were done next to the well currently being dug in order to determine the underground conditions and aquifer presence. At the location of VES 17, the community is currently digging a shallow well next to the village where they have reached 12 m bgl. The depth at which water is to be found would be 25 to 30 m bgl but the water is saline. Additional measurements were made outside the village after the first one indicated poor groundwater potential.

The following table summarizes the interpretation results.

Table 22: Interpretation Results of VES 17, 18 and 19

VES	LAYER 1 RE	LAYER 1 DE	LAYER 2 RE	LAYER 2 DE	LAYER 3 RE	LAYER 3 DE	LAYER 4 RE	LAYER 4 DE	LAYER 5 RE	LAYER 5 DE	LAYER 6 RE	LAYER 6 DE
17	61	1	20	6	5	12	8	92	1000	>92		
18	1470	0.2	6.7	5	3	14	10	22	2.5	81	985	>81
19	47	0.7	6	5	1.5	12	15	21	1.5	66	1000	>66

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of the three VES indicate a superficial layer of resistivity varying between 47 and 1470 Ohm-m to a depth of up to 1 m bgl. This is interpreted to be dry top sandy soils, underlain by 6 to 20 Ohm-m layer to a depth of 5 to 6 m bgl. They are underlain by a 1.5 to 5 Ohm-m layer to a depth of 12 to 14 m bgl interpreted to be clays. These are underlain by a 1.5 to 15 Ohm-m layer to a depth of 66 to 92 m bgl. This is expected to be brackish water saturated weathered limestones and sandstones. Below this is the hard compact limestones and sandstones. At this village both shallow, medium and deep groundwater exists but the aquifer is saline as depicted by the low resistivity values.

VES 17

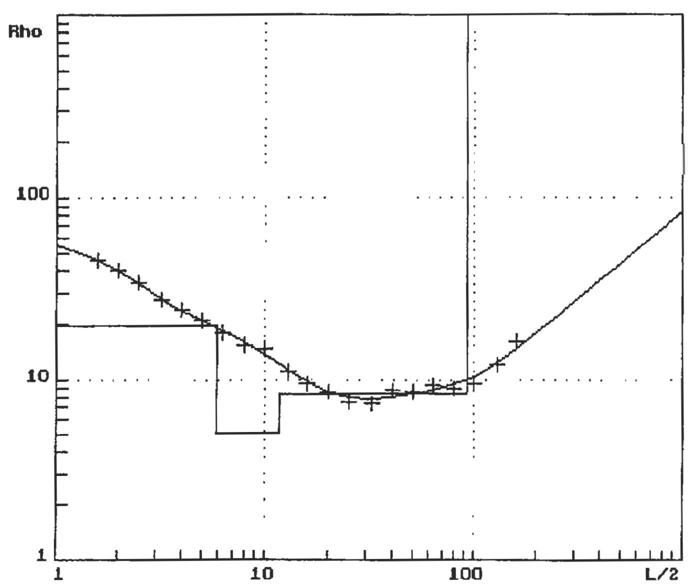


Figure 26 - Results of Interpretation of VES 17

VES 18

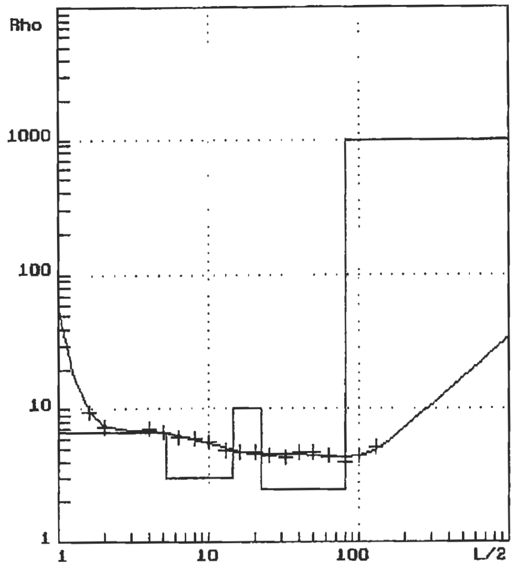


Figure 27 - Interpretation Graph for VES 18

VES 19

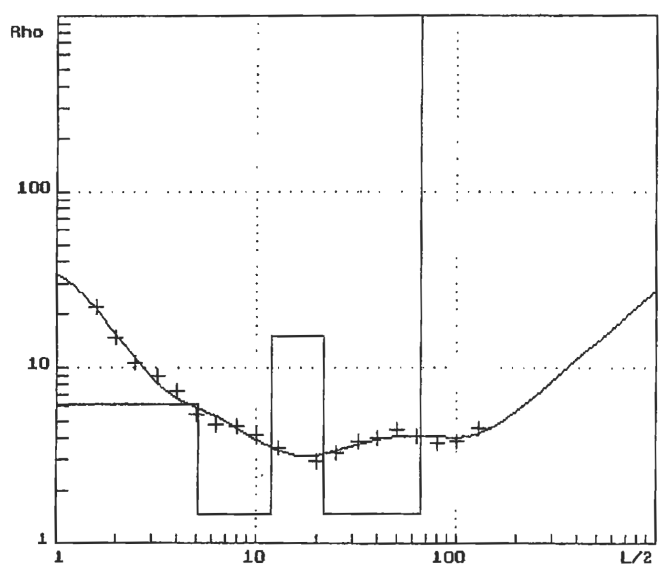


Figure 28 - Interpretation Graph for VES 19

27.9 Conclusions and Recommendations

Based on the available information and the geological observations, it is concluded that Gariley village site is located in an area which is considered to have a poor groundwater potential. Both the shallow and deep aquifers occur in the area. The aquiferous layers extend to about 90 m bgl. From interpretation of the resistivity data, the aquifers are expected to be highly saline as depicted by the low resistivity values.

In view of the above it is recommended that:-

1) The existing rain water catchment be rehabilitated and deepened to provide water source in the period after the rains. It should be deepened to dimensions of 150x150x4 m.

28. CAWSQURIN

28.1 Location

Cawsqurin village is located within Badheere District, Gedo Region of Southern Somalia. The village is located 33 km north of Darasaalam village along the Darasaalam-Ceel Wak road. The village is located at longitude and latitude approximately 02^0 12' 04" N and 041^0 09' 21" E.

28.2 Physiography

The village lies at an elevation of 245 m amsl. The area is generally flat being interrupted by a few isolated hills and several seasonal rivers. The topography is gently sloping to the west and towards the direction of the drainage.

28.3 Population and Water Demand

The population of the village could not be estimated by the local community Nevertheless there is a large number of people and animals in the village. It was reported that the population of nomadic families is very large. The entire population rely on the existing shallow wells in the village for supply of domestic and animal requirements.

28.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no surface water sources in the area and the few toggas in the area are reported to be dry most of the time. They flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

28.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and red soils.

28.6 Structures

No structures could be identified in the area. However, based on the drainage characteristics at the site, faults/fractures orientated in a southwest-northeast direction are inferred in the general area.

28.7 Hydrogeology

28.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Thirteen shallow hand dug wells have been sunk by the local community in the area to depths of about 17 m bgl which are operational. The water level at the time of this investigation was 15 m bgl.

28.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the village. The shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season.

28.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured and weathered limestones/sandstones and in the alluvial sediments in the drainage valleys. The upper aquifer is being exploited using the shallow wells.

28.8 Geophysical Investigations

One vertical electrical sounding (VES) were executed at a selected site near the existing wells whose water is described by the community as the best among the two. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

28.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 23: Interpretation Results of VES 21

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 5.4	104	Sandy top soils
5.4 - 15	56	weathered limestones (with brackish water)
15 - 116	6.5	Highly weathered limestones (with saline water)
116 - 228	15	Weathered limestones/sandstones (with brackish water)
>228	1000	Hard compact limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 104 Ohm-m to a depth of 5.4 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 56 Ohm-m resistivity layer to a depth of 15 m bgl comprising weathered limestone with brackish water. This is underlain by a 6.5 Ohm-m resistivity layer to a depth of 116 m corresponding to highly weathered limestones, probably with saline water. It is underlain by a 15 Ohm-m layer to a depth of 228 m bgl. This comprises highly weathered limestones and clays with brackish water At the bottom is a 1000 Ohm-m resistivity layer interpreted to be hard compact limestones and sandstones.

28.9 Water Quality

The Ec of the shallow wells was measured to be 4610 µS/cm for the first well which is reported to be the best among all the wells. Its depth is 12.5 m bgl and water level 11 m bgl. On the other side of the village the water quality decreases with the furthest well having an Ec of 9400 µS/cm. The water level was measured to be 10 m bgl and the depth 11.5 m bgl. The trend indicates a decline in water quality towards the north. It was reported that animals were dying after drinking the well water.

VES 21

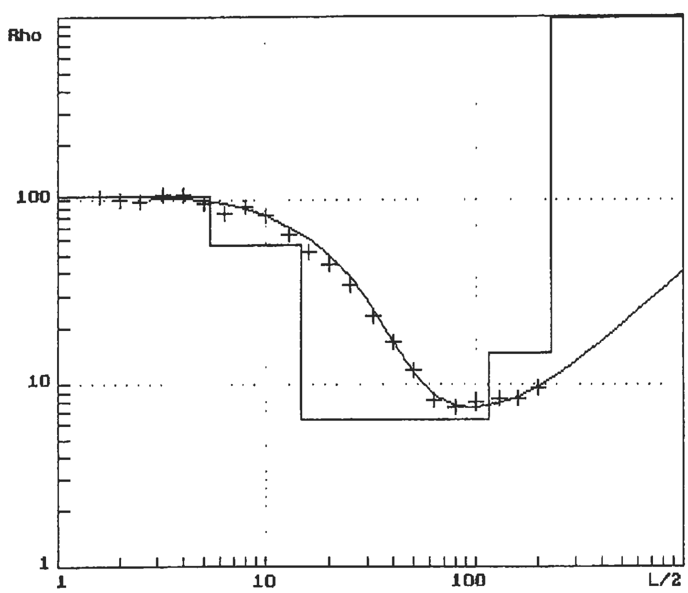


Figure 29 - Interpretation Graph for VES 21

28.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Cawsqurin site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the weathered limestone layer in the sub-surface and the deeper sedimentary succession comprising weathered limestones and sandstones to a depth of about 228 m bgl. The water quality in the deeper aquifer is poorer than for the shallow water in terms of salinity. A lot of pollution of the shallow water aquifer has been caused by animal excreta.

In view of the above it is recommended that:-

1) no further expansion of the current water supply be undertaken. Instead basic hygiene be observed in handling water for human consumption by the community.

Alternative water sources include:-

1) Drilling and construction of a deep borehole to 230 m bgl for the animals. This alternative would especially be implemented if the shallow aquifer is depleted or becomes very saline.

29. WAREY

29.1 Location

The village is located within Badheere District, Gedo Region of Southern Somalia. The village is located approximately 78 km north of Daresalaam and 44 km north of Cawsqurin village. The village is located at longitude and latitude approximately 02^0 31' 22" N and 041^0 06' 36" E.

29.2 Physiography

The village lies at an elevation of 342 m amsl. The area is generally flat and featureless, the general topography gently sloping to the east.

29.3 Population and Water Demand

The village is a nomadic one and at present people have moved away with their animals to seek green pastures. It is a strategic location for nomadic movements.

29.4 Hydrology

The mean annual rainfall ranges between 250 to 300mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

29.5 Geology

The site is underlain by sandstones, and older sedimentary rocks which are overlain at the surface by a thick Recent superficial clayey alluvial deposits and soils to a depth of about 4 m bgl.

29.6 Structures

No geological structures could be identified in the area due to the thick alluvial soils.

29.7 Existing Water Suppliess

The only available water supply facility in the area is one rain water catchment which hold water for only a short period after the rains. The rain water catchment has dimensions of approximately 70x75x1 which is currently backfilled. Aquifers in the area would be expected to occur within the fractured limestones/sandstones.

29.8 Geophysical Investigations

One geophysical resistivity measurement was done away from the existing rain water catchment in order to determine the underground conditions for rehabilitation of the rain water catchment. Geological observations made on the rain water catchment 4 km further north indicate presence of clay superficial layers in the sub-surface.

Table 24: Interpretation Results of VES 22

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.5	204	Sandy top soils
1.5 - 6	50	weathered limestones
6 - 18	6	Highly weathered limestones and clays
18 - 113	34	Weathered limestones/sandstones (with brackish water)
>113	1000	Hard compact limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 204 Ohm-m to a depth of 1.5 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 50 Ohm-m resistivity layer to a depth of 6 m bgl comprising weathered limestone. This is underlain by a 6 Ohm-m resistivity layer to a depth of 18 m corresponding to highly weathered limestones and clays. It is underlain by a 34 Ohm-m layer to a depth of 113 m bgl This comprises weathered limestones with brackish water. At the bottom is a 1000 Ohm-m resistivity layer interpreted to be hard compact limestones and sandstones.

VES 22

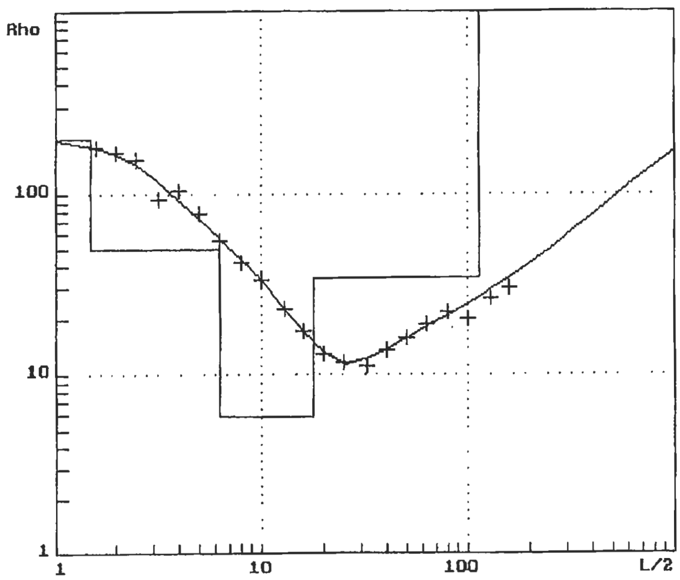


Figure 30 - Interpretation Graph for VES 22

29.9 Conclusions and Recommendations

Based on the available information, geophysical and hydrogeological investigations, and the geological observations, it is concluded that Warey village site is located in an area which is considered to have a poor to medium groundwater potential. No shallow aquifers occur in the area. Deep aquifers occur to a depth of up to 113 m bgl.

In view of the above it is recommended that:-

1) The existing backfilled rain water catchment be deepened and enlarged to 100x100x3 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year

An alternative water source is:-

1) Drilling of a borehole to a depth of 113 m bgl equipped with a hand pump.

30. HAGERSOW

30.1 Location

The site is located within Ceel Wak District, Gedo Region of Southern Somalia. The village is located approximately 89 km north of Daresalaam (56 km north of Cawsqurin village). The site is located at longitude and latitude approximately 02^0 36' 15" N and 041^0 04' 03" E.

30.2 Physiography

The site lies at an elevation of 400 m amsl. The area is undulating with many seasonal rivers. It lies at the confluence of two toggas. The general topography gently slopes to the west.

30.3 Population and Water Demand

The village is a nomadic one and at present people have moved away with their animals to seek green pastures. It is a strategic location for nomadic movements.

30.4 Hydrology

The mean annual rainfall ranges between 250 to 300mm. There is no surface water sources in the area and no springs within or in the immediate surroundings of the investigated site are existing.

30.5 Geology

The site is underlain by sandstones, and older sedimentary rocks which are overlain at the surface by a thick Recent superficial clayey alluvial deposits and soils to a depth of about 4 m bgl.

30.6 Structures

From geological observations on the sandstone flat topped ridges, faults and fractures are seen to be oriented in a SW-NE direction. These faults usually acts as groundwater movement controls generally becoming preferential flow paths.

30.7 Existing Water Suppliess

The only available water supply facility in the area is one rain water catchment which hold water for only a short period after the rains. The rain water catchment has *dimensions* of

29.9 Conclusions and Recommendations

Based on the available information, geophysical and hydrogeological investigations, and the geological observations, it is concluded that Warey village site is located in an area which is considered to have a poor to medium groundwater potential. No shallow aquifers occur in the area. Deep aquifers occur to a depth of up to 113 m bgl.

In view of the above it is recommended that:-

1) The existing backfilled rain water catchment be deepened and enlarged to 100x100x3 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year.

An alternative water source is:-

1) Drilling of a borehole to a depth of 113 m bgl equipped with a hand pump.

approximately 70x75x1 which is currently backfilled. Aquifers in the area would be expected to occur within the fractured limestones/sandstones.

30.8 Geophysical Investigations

One geophysical resistivity measurement was done next to the existing rain water catchment in order to determine the underground conditions for rehabilitation of the rain water catchment. Geological observations made on the rain water catchment indicate presence of clay superficial layers in the sub-surface.

Table 25: Interpretation Results of VES 23

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.5	138	Sandy top soils
1.5 - 6	45	weathered limestones
6 - 9.5	4	Highly weathered sandstones and clays
9.5 - 70	18	Weathered sandstones (with brackish water)
>70	1000	Hard compact sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 138 Ohm-m to a depth of 1.5 m bgl, comprising mainly Recent deposits composed of top sandy soils, underlain by a 45 Ohm-m resistivity layer to a depth of 6 m bgl comprising weathered sandstones. This is underlain by a 4 Ohm-m resistivity layer to a depth of 9.5 m bgl corresponding to highly weathered sandstones and clays. It is underlain by a 18 Ohm-m layer to a depth of 70 m bgl. This comprises weathered sandstones with brackish water. The bottom layer is a 1000 Ohm-m resistivity layer interpreted to be hard compact sandstones.

VES 23

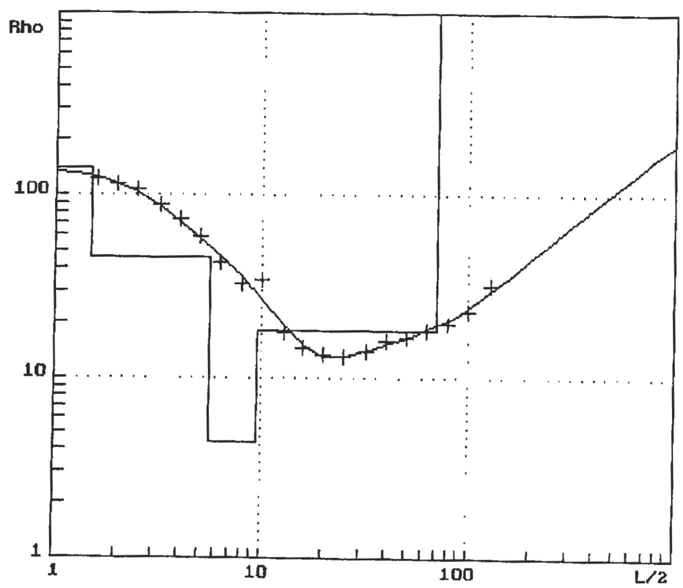


Figure 31 - Interpretation Graph for VES 23

30.9 Conclusions and Recommendations

Based on the available information, geophysical and hydrogeological investigations, and the geological observations, it is concluded that Hargesow site is located in an area which is considered to have a poor to medium groundwater potential. No shallow aquifers occur in the area. Deeper aquifers occur to a depth of up to 70 m bgl.

In view of the above it is recommended that:-

1) The existing backfilled rain water catchment be deepened and enlarged to 100x50x3 m to enhance storage. It is envisaged that the proposed rain water catchment will offer water retention such as to reduce water dependency on other villages for a certain period of the year

Alternative water source :

1) Drilling of a borehole to about 80 m bgl near the location of VES 23 and equipping with a hand pump.

31. CEELWAK

31.1 Location

Ceel Wak town is located within Ceel Wak District, Gedo Region of Southern Somalia. The town is located at the Somalia-Kenya border at longitude and latitude approximately 02^0 47' 30" N and 041^0 00' 57" E.

31.2 Physiography

The town lies at an elevation of 388 m amsl. The area is generally flat being interrupted by a few isolated hills to the west and east and several seasonal rivers. The topography is gently sloping to the east and towards the direction of the drainage.

31.3 Population and Water Demand

The population of the town could not be estimated by the local community. Nevertheless there is a large number of people and animals in the town. It was reported that the population of nomadic families is very large. The entire population rely on the existing shallow wells in the town for supply of domestic and animal requirements.

31.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no surface water sources in the area and the few toggas in the area are reported to be dry most of the time. They flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the town.

31.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and red soils. The limestones outcrop locally. They are underlain by sandstones.

31.6 Structures

Based on the local structural geology and the drainage characteristics in the area faults/fractures orientated in a west-east direction are inferred in the general area.

31.7 Hydrogeology

31.7.1 Existing Shallow Wells

There are no boreholes operating within the village. Numerous shallow hand dug wells have been sunk by the local community in the area to depths of about 13 m bgl which are operational. The water level at the time of this investigation was 10 m bgl. The shallow aquifer is confined by the overlying limestone. The aquifer appears extensive and the recharge area must be from far.

31.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the town. The shallow wells are being used for both domestic and animal consumption. The surface water from seasonal rivers is unreliable because the rivers only flow a few weeks after the rainy season.

31.7.3 Aquifers

Aquifers in the area are expected to occur within the fractured and weathered limestones/sandstones and in the alluvial sediments in the drainage valleys. The upper aquifer is being exploited using the shallow wells and occurs at the interface of the superficial deposits and the weathered limestones.

31.8 Geophysical Investigations

One vertical electrical sounding (VES) were executed at a selected site near the existing wells whose water is described by the community as the best among all. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

31.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 26: Interpretation Results of VES 24

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.4	3	Clays
1.4 - 6	42	weathered limestones
6 - 15	10	Highly weathered limestones with brackish water
>15	1	Weathered limestones/sandstones with saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 3 Ohm-m resistivity to a depth of 1.4 m bgl, comprising Recent deposits composed of top sandy soils, underlain by a 42 Ohm-m resistivity layer to a depth of 6 m bgl comprising weathered limestones. This is underlain by a 10 Ohm-m resistivity layer to a depth of 15 m bgl corresponding to highly weathered limestones with brackish water. The bottom layer is a 1 Ohm-m resistivity layer interpreted to be weathered limestones/sandstones with saline water.

VES 24

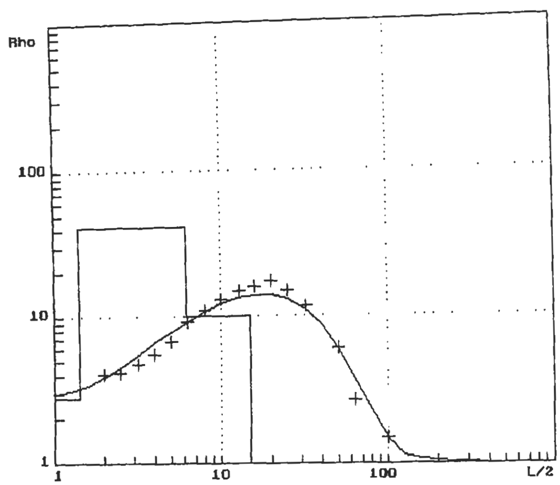


Figure 32 - Interpretation Graph for VES 24

31.9 Water Quality

The Ec of the shallow wells was measured to be 3650 µS/cm for the well which is reported to be the best among all the wells. Its depth is 13 m bgl and water level 10 m bgl. The water is used for both domestic and animal consumption inspite of being slightly brackish.

31.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Ceel Wak town is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers are expected within the weathered limestones and the contact between the alluvial sediments and the limestones. The shallow aquifer is confined by massive limestones which locally outcrop. It appears that the shallow aquifer is extensive

The water quality in the deeper aquifer is poor than for the shallow. A lot of pollution of the water has been caused by animal droppings.

In view of the above it is recommended that -

1) no further expansion of the current water supply be undertaken. Instead basic hygiene be observed in handling water for human consumption by the community.

32. SAMAROLE

32.1 Location

The village of Samarole is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located on the southern eastern banks of Togga Samarole approximately 27 km east of Ceel Wak along the Ceel Wak-Ceel Cade road. The village is located at longitude and latitude approximately 02^0 47' 32" N and 041^0 13' 37" E.

32.2 Physiography

The village lies on the southern banks of togga Samarole at an elevation of 323 m amsl. The area is generally flat being interrupted by isolated hills and numerous seasonal rivers. The topography is gently sloping to the south towards the seasonal river and generally to the east in the direction of the drainage. The most conspicuous physiographic feature in the area is Buur Samarole west of the village.

32.3 Population and Water Demand

From the information given by the local people. the village is currently having a population of 50 families who rely on the available shallow wells. In addition 1000 nomadic families rely on the 2 operational shallow wells for supply of domestic and animal requirements.

32.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present except for togga Samarole which flow during the wet seasons for a short period. The site has a large catchment extending northward in an area of over $20km^2$. There are no springs within or in the immediate vicinity of the investigated site.

32.5 Geology

The site is underlain by limestones overlying sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits.

32.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a west-east direction are inferred from the flat topped hills in the investigated area.

32.7 Hydrogeology

32.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. Three shallow hand dug wells have been sunk by the local community in the area to depths of about 21m bgl. The water level at the time of this investigation was 19.5 m bgl. The well that is not operating was initially dug with the assistance of GTZ. During the El nino rains 5 years ago, it was backfilled hill wash sediments and soils.

32.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the togga Samarole. Only 2 of the 3 shallow wells are being used for both human consumption and animal watering. Abstraction from these wells is by bucket and rope. The surface water from seasonal rivers is unreliable because the rivers only flow a weeks after the rainy season. During extended drought, the wells run dry. The last time the river flowed was during El nino rains 5 years ago.

32.7.3 Aquifers

Aquifers are expected to occur within the fractured limestones/sandstones and in the alluvial sediments in the drainage valleys.

32.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

32.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 28: Interpretation Results of VES 25

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1	244	Sandy top soil
1 - 6	38	weathered limestones
6 - 50	10	Highly weathered limestones with brackish water
>50	23	Weathered limestones/sandstones with brackish water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 244 Ohm-m resistivity to a depth of 1 m bgl, comprising Recent deposits composed of top sandy soils, underlain by a 38 Ohm-m resistivity layer to a depth of 6 m bgl comprising weathered limestones. This is underlain by a 10 Ohm-m resistivity layer to a depth of 50 m bgl corresponding to highly weathered limestones with brackish water The bottom layer is a 23 Ohm-m resistivity layer interpreted to be weathered limestones/sandstones with brackish water.

32.9 Water Quality

The Ec of the shallow wells was measured to be 6580 and 7860 µS/cm respectively which is considered to be slightly brackish but nevertheless used for domestic consumption. Due to the congested presence of animals for watering and the unprotected status of the wells, bacteriological contamination of the wells is likely to have occurred.

VES 25

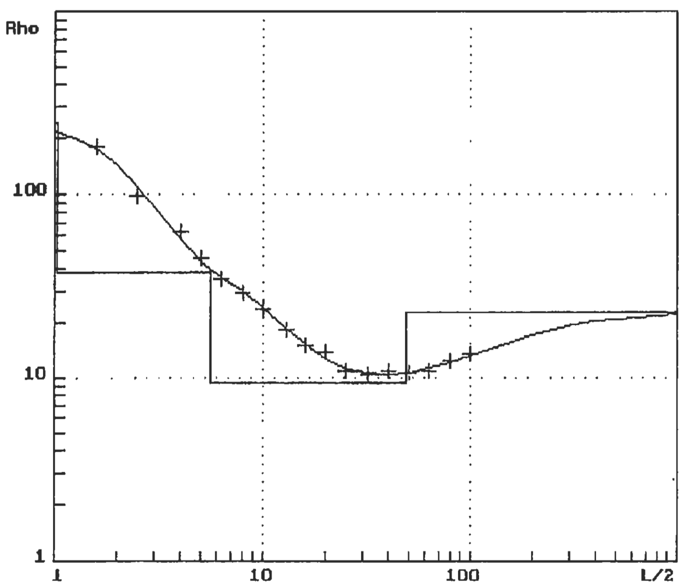


Figure 33 - Interpretation Graph for VES 25

32.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Samarole site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones up to a depth of about 100 m bgl. There is no possibility of a rain water catchment due to lack of a shallow aquiclude.

In view of the above it is recommended that:-

1) the two existing wells should be cleaned out the backfill and rehabilitated.
2) The superstructure should be constructed approximately 1.5 m above the ground in order to avoid saline run-off water and sediments infilling the wells.
3) It is further recommended to construct animal troughs next to the well for watering.

An additional alternative water source would be drilling a borehole to 100 m bgl and installation of a hand pump.

33. GARSAAL

33.1 Location

The village of Garsaal is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 34 km east of Ceel Wak along the Ceel Wak-Ceel Cado road. The village is located at longitude and latitude approximately 02^0 49' 12" N and 041^0 16' 28" E.

33.2 Physiography

The village lies at an elevation of 326 m a msl The area is generally flat with a few conspicuous hills and numerous seasonal rivers. The topography is gently sloping to the south towards the seasonal river and generally to the east in the direction of the drainage. The most conspicuous physiographic feature in the area is Buur Samarole west of the village.

33.3 Population and Water Demand

From the information given by the local people, the village is currently having a population of 370 families who rely on the available shallow wells. In addition 12,000 nomadic families rely on the 15 operational shallow wells for supply of domestic and animal requirements.

33.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present except for togga Samarole which flow during the wet seasons for a short period. The site has a large catchment extending northward in an area of over $20km^2$. There are no springs within or in the immediate vicinity of the investigated site.

33.5 Geology

The site is underlain by limestones overlying sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits.

33.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a west-east direction are inferred from the flat topped hills in the investigated area.

33.7 Hydrogeology

33.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. It is reported that the first shallow well was dug 42 years ago. Every year the community digs one additional well Up till 1998 (during El nino rains) there was no water quality problem. After the rains, the taste of the water changed drastically and the quality became poor. During that time. all the wells were flooded. The productivity of the wells increased. Two shallow wells were inspected during this survey. The total depth was 15.5 and 15 m bgl for worst and best respectively The water level at the time of this investigation was 14.5 and 14 m bgl respectively.

33.7.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the village. All the shallow wells are being used for both human consumption and animal watering. Abstraction from these wells is by bucket and rope. The surface water from seasonal rivers is unreliable because the rivers only flow a weeks after the rainy season. During extended drought, the wells run dry

33.7.3 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top. It occurs at the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones.

33.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

33.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 29: Interpretation Results of VES 26

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 5	186	Sandy top soil
5 - 7	58	weathered limestones
7 - 20	15	Highly weathered limestones with brackish water
>20	3.5	Weathered limestones/sandstones with saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 186 Ohm-m resistivity to a depth of 5 m bgl, comprising Recent deposits composed of top sandy soils, underlain by a 58 Ohm-m resistivity layer to a depth of 7 m bgl comprising weathered limestones. This is underlain by a 15 Ohm-m resistivity layer to a depth of 20 m bgl corresponding to highly weathered limestones with brackish water. The bottom layer is a 3.5 Ohm-m resistivity layer interpreted to be weathered limestones/sandstones with brackish water

33.9 Water Quality

The Ec of 2 of the shallow wells was measured according to information by the community that one well is too salty and the other "very sweet". The measurements showed the EC to be 13500 and 9160 μS/cm respectively which is considered to be very saline and unfit for domestic consumption. Due to the congested presence of animals for watering and the unprotected status of the wells, bacteriological contamination of the wells is likely to have occurred. It was reveled during the study that during the last month, 12 people had died from diarrhoea after drinking the water from the wells.

VES 26

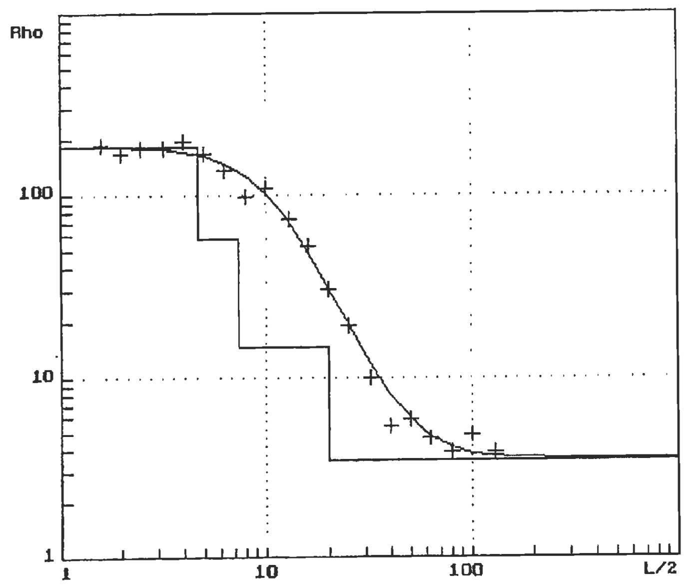


Figure 34 - Interpretation Graph for VES 26

33.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Garsaal site is located in an area which is considered to have a poor groundwater potential.

Both shallow and deep aquifers occur in the area. Productive aquifers with potable water are not expected within the sedimentary succession comprising weathered limestones because as you go deeper, the salinity of the water is increasing. There is no possibility of a rain water catchment due to lack of a shallow aquiclude. The water is heavily polluted with animal dung since the wells are not properly covered.

In view of the above it is recommended that -

1) all the 11 wells should be cleaned out and rehabilitated.
2) The superstructure should be constructed approximately in a way as to avoid saline run-off water and sediments infilling the wells.
3) One well should be identified out of the existing wells and reserved solely for human use.
4) Hygiene education be implemented.

34. BURSSAR

34.1 Location

The village of Burssar is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 45 km east south east of Ceel Wak along the Ceel Wak-Fafadun road. The village is located at longitude and latitude approximately 02^{0} 40' 21" N and 041^{0} 19' 21" E.

34.2 Physiography

The village lies at an elevation of 295 m a msl. The area is generally flat with a few conspicuous hills and numerous seasonal rivers. The topography is gently sloping to the south towards the seasonal river and generally to the east in the direction of the drainage. The most conspicuous physiographic feature in the area is Buur Samarole northwest of the village.

34.3 Population and Water Demand

From the information given by the local people, the village is currently having a population of 300 families who rely on the available shallow wells. In addition 1,000 nomadic families rely on the 11 operational shallow wells for supply of domestic and animal requirements.

34.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present. The site has a large catchment extending northward in an area of over 30km^2. There are no springs within or in the immediate vicinity of the investigated site.

34.5 Geology

The site is underlain by limestones overlying sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits.

34.6 Structures

Based on the drainage characteristics at the site, faults/fractures orientated in a north-south direction are inferred from the flat topped hills in the investigated area.

34.7 Hydrogeology

34.7.1 Existing Shallow Wells

No boreholes have been sunk within the village. A total of 11 shallow wells have been dug in the village of which six have superstructures constructed with concrete. The rest are not properly constructed. Measurements were made on the worst and best well according to the community tasting the water. The total depth was 14.6 and 12.7 m bgl for worst and best respectively. The water level at the time of this investigation was 13.5 and 10.3 m bgl respectively. The two wells are on each side of the village, and approximately 1 km apart.

34.7.2 Current Water Sources

The only perennial source of water in the area is the shallow wells dug in the village. All the shallow wells are being used for both human consumption and animal watering. Abstraction from these wells is by bucket and rope. The surface water from seasonal rivers flow only a few weeks after the rainy season During extended drought, the wells run dry

34.7.3 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and sediments. It occurs at the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones.

34.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

34.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 30: Interpretation Results of VES 27

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.3	2.5	Clay top soil
0.3 - 2.6	300	Hard compact limestones
2.6 - 3	43	Weathered limestone
3 - 21	20	Highly weathered limestones with brackish water
>21	10	Weathered limestones/sandstones with brackish to saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 2.5 Ohm-m resistivity to a depth of 0.3 m bgl, comprising Recent deposits composed of clay soils, underlain by a 300 Ohm-m resistivity layer to a depth of 2.6 m bgl comprising hard compact limestones. This is underlain by a 43 Ohm-m resistivity layer to a depth of 3 m bgl corresponding to weathered limestones. This is underlain by a 20 Ohm-m layer to a depth of 21 m bgl interpreted to be highly weathered limestones with brackish water. The bottom layer is a

10 Ohm-m resistivity layer interpreted to be weathered limestones/sandstones with brackish to saline water.

34.9 Water Quality

The Ec of 2 of the shallow wells was measured according to information by the community that one well is too salty and the other "very sweet". The measurements showed the EC to be 5700 and 2540 μS/cm respectively which is considered to be very slightly brackish but still can be used for domestic consumption. Due to the congested presence of animals for watering and the unprotected status of the wells, bacteriological contamination of the wells is likely to have occurred. It was revealed during the study that some animals had died after drinking the water from the wells.

VES 27

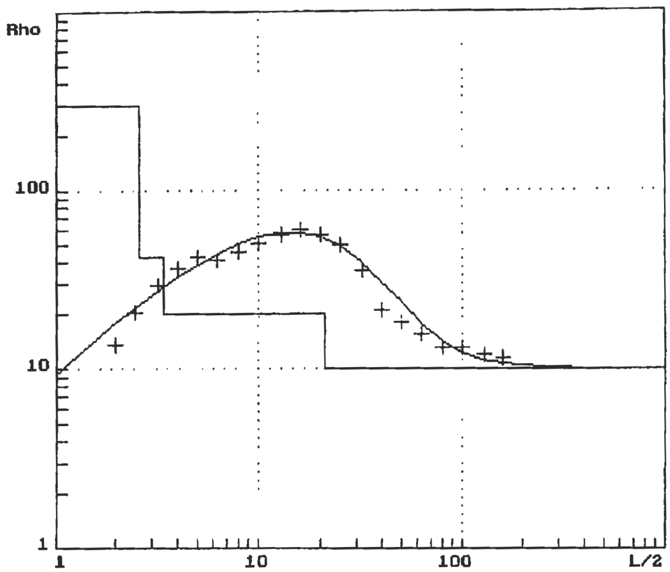


Figure 35 - Interpretation Graph for VES 27

34.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Bussar site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones because as you go deeper, the salinity of the water is increasing. There is no possibility of a rain water catchment due to lack of a shallow aquiclude. The water is heavily polluted with animal dung since the wells are not properly covered.

In view of the above it is recommended that:-

1) all the 5 unprotected wells should be cleaned out and rehabilitated.
2) The superstructure should be constructed in a way that prevent saline run-off water and sediments infilling the wells.
3) One well should be identified out of the existing wells and reserved solely for human use.
4) Hygiene education should be implemented.

As an alternative water source:-The wells should be deepened to 25 m bgl if the upper aquifer depletes. They should also be enlarged to 3 to 6 m diameter to enhance storage.

35. MUUDAALE

35.1 Location

Muudaale site is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 30 km south of Bussar The site is located at longitude and latitude approximately 02^0 32' 29" N and 041^0 28' 43" E.

35.2 Physiography

The site lies at an elevation of 403 m a msl. The area is undulating with a few conspicuous hills composed of sandstones and siltstones and numerous seasonal rivers. The topography is gently sloping to the south towards the seasonal river and generally to the north east in the direction of the drainage. Deep gullies cut through the surface as a result of erosion by surface run-off.

35.3 Population and Water Demand

There is no human settlement at the site, but it is a very important for nomads as it lies along their movement corridor towards grazing areas further south.

35.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present. The site has a large catchment extending northward in an area of over $20km^2$. There are no springs within or in the immediate vicinity of the investigated site.

35.5 Geology

The site is underlain by sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits. The alluvial deposits are predominantly silty clays. The sand stones and siltstones are dark to grey with high limonite which give the soils a deep red colour

35.6 Structures

Based on the drainage characteristics in the area and general structure, faults/fractures orientated in a SW-NE direction are inferred from the flat topped hills in the investigated area.

35.7 Existing Water Sources

No boreholes or shallow wells have been sunk within the village. The only water supply facility in the area is the existing rain water catchment with dimensions 150x150x1m. The rain water catchment is highly backfilled with soil and alluvial deposits. It provides water for the nomads for about three months after the rainy season.

35.7.1 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is unconfined in the alluvial deposits in the catchment. It occurs at the contact between the sandstones and siltstones and the overlying superficial layer to a depth of about 30 m bgl. Deeper aquifers are expected to occur within the fractured sedimentary succession to a depth of approximately 200 m.

35.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site inside the catchment. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

35.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 31: Interpretation Results of VES 28

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.7	102	Sandy top soil
1.7 - 6	18	Highly weathered sandstones
6 - 31	33	Weathered sandstone
31 - 56	134	Compact sandstone
56 - 206	25	Highly weathered sandstones with fresh water
>206	2000	Hard compact sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 102 Ohm-m resistivity to a depth of 1.7 m bgl, comprising Recent deposits composed of sandy soils, underlain by a 18 Ohm-m resistivity layer to a depth of 6 m bgl comprising highly weathered sandstones. This is underlain by a 33 Ohm-m resistivity layer to a depth of 31 m bgl corresponding to weathered sandstones. This is underlain by a 134 Ohm-m resistivity layer to a depth of 56 m bgl interpreted to be compact sandstones. It is underlain by a 25 Ohm-m resistivity layer to a depth of 206 m bgl interpreted to be highly weathered sandstones with fresh water. The bottom layer is a 2000 Ohm-m resistivity layer interpreted to be hard compact sandstones.

VES 28

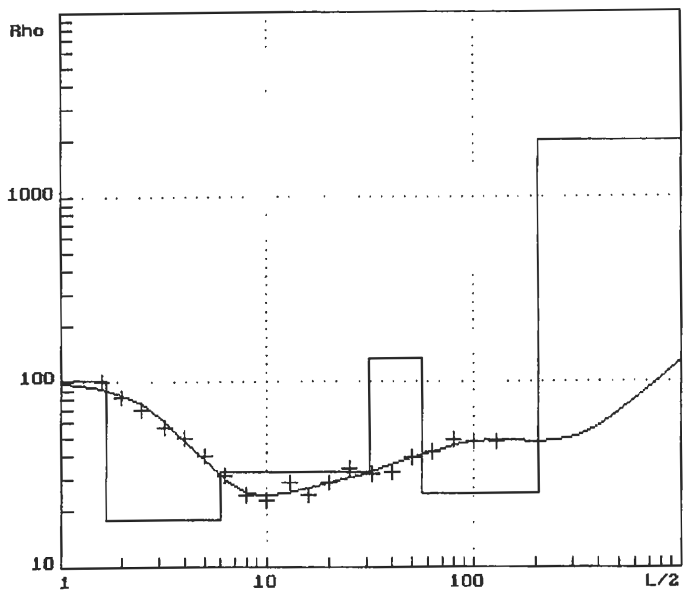


Figure 36 - Interpretation graph of VES 28

35.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Muudale site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered sandstones. The salinity of the water is decreasing with depth. There existing rain water catchment is underlain by clays and silty clays to depths of up to 6 m bgl.

In view of the above it is recommended that -

1) The existing rain water catchment should be cleaned out, deepened and rehabilitated with dimensions 150x150x4 m.
2) The channels should be excavated to collect water into the catchment.

As an alternative water source -

1) A borehole should be drilled to a depth of 200 m bgl at the location of VES 28 and equipped with a generator and a submersible pump.

36. CEEL ADD

36.1 Location

The village of Ceel Add is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 46 km south east of Bussar along the Ceel Wak-Fafadun road. The village is located at longitude and latitude approximately 02^0 20' 40" N and 041^0 28' 43" E.

36.2 Physiography

The village lies at an elevation of 241 m a msl. The area is generally flat with a few conspicuous isolated hills and seasonal rivers. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage.

36.3 Population and Water Demand

Although accurate data on population of people and animals was not available. it is viewed from the number of animals being watered that the population is very high. This village is viewed as needy one. The total population would exceed 1,000 including the nomads who rely on the only operational shallow wells for supply of domestic and animal requirements.

36.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present. There are no springs within or in the immediate vicinity of the investigated site.

36.5 Geology

The site is underlain by brown sands on the surface, underlain limestones overlying sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits.

36.6 Hydrogeology

36.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. Only one shallow hand dug well has been dug in the village. The well is not protected with superstructures constructed with concrete. The total depth was 8.8 m bgl. The water level at the time of this investigation was 8 m bgl.

36.6.2 Current Water Sources

The only perennial source of water in the area is the shallow well dug in the village which is currently being used for only animal watering. Abstraction from these wells is by bucket and rope. The surface water from seasonal rivers flow only a few weeks after the rainy season. During extended drought, the well run dry and salinity increases significantly Water for domestic use is brought from Mugdule approximately 20 km away.

36.6.3 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones.

36.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

36.7.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 32: Interpretation Results of VES 29

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 2.8	287	Sandy top soil
2.8 - 7	8	Highly weathered limestones
>7	1.9	Weathered limestones with saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 287 Ohm-m resistivity to a depth of 2.8 m bgl, comprising Recent deposits composed of sandy soils, underlain by a 8 Ohm-m resistivity layer to a depth of 7 m bgl comprising highly weathered limestones. The bottom layer is a 1.9 Ohm-m resistivity layer interpreted to be weathered limestones with saline water.

36.8 Water Quality

The Ec of the only shallow well was measured to be 15100 µS/cm respectively which is considered to be saline but still can be used for animal watering but not for domestic consumption. Due to the congested presence of animals for watering and the unprotected status of the wells, bacteriological contamination of the wells is possible.

VES 29

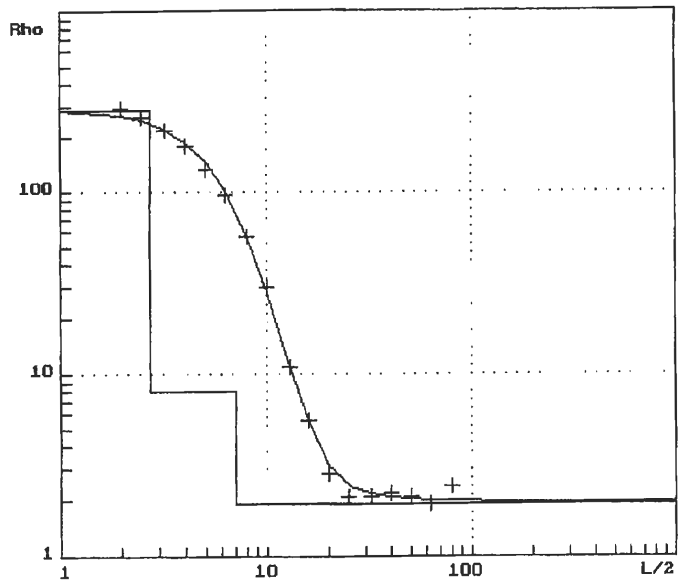


Figure 37 - Interpretation Graph for VES 29

36.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Ceel Add site is located in an area which is considered to have a poor to medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality between brackish to saline. Productive aquifers with potable water are not expected within the sedimentary succession comprising weathered limestones because the salinity of the water is increasing with depth. There is no possibility of a rain water catchment due to lack of a shallow aquiclude. The water is likely to be polluted with animal dung since the well is not properly covered.

In view of the above it is recommended that:-

1) The existing well be cleaned out, rehabilitated and protected against pollution.
2) The superstructure should be constructed in a way that prevent saline run-off water and sediments infilling the wells.
3) The shallow well at Mugdule 20 km away should be rehabilitated and reserved for human use.
4) Digging and construction of 2 shallow wells to 15 m bgl. The water quality is marginal but would greatly alleviate the serious water problem in the area.

There is no alternative water source.

37. WELMARER

37.1 Location

The village of Welmarer is located within Badheere District, Gedo Region of Southern Somalia. It is located approximately 25 km south east of Fafadun. The village is located at longitude and latitude approximately 02^0 01' 55" N and 041^0 35' 53" E.

37.2 Physiography

The village lies at an elevation of 192 m a msl. The area is generally flat with a few conspicuous isolated gentle sloping ridges and seasonal rivers. The topography is gently sloping to the east in the direction of the drainage.

37.3 Population and Water Demand

Accurate data on population of people and animals was not available. Several animals were being watered and some people were drawing water by digging on the existing catchment to get water This village is viewed as needy one and is strategically placed on the nomadic movement corridor The total population would exceed 1,000 families including the nomads who rely on the only rain water catchment in the area for supply of domestic and animal requirements.

37.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present. There are no springs within or in the immediate vicinity of the investigated site.

37.5 Geology

The site is underlain by brown sands on the surface. underlain limestones overlying sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits. The site lies on the contact zone between the limestones and sandstones. The limestones are outcropping on the eastern banks of the catchment while the sandstones appear west of the catchment.

37.6 Hydrogeology and Available Water Sources

No boreholes or shallow well have been sunk within the area. A rain water catchment with dimensions approximately 50x50x2 m has been dug. It is however backfilled due to silting. The surface water from seasonal rivers flow only a few weeks after the rainy season.

37.6.1 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones and the superficial layer up to a depth of 13 m bgl. Deeper aquifers are expected to occur within the fractured limestones/sandstones up to depths of 250 m bgl. The water quality for the shallow aquifer is expected to be brackish but suitable for domestic and animal consumption.

37.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing rain water catchment. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

37.7.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 33: Interpretation Results of VES 32

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.5	68	Sandy top soil
1.5 - 13	20	Highly weathered limestones (with fresh water)
13 - 45	58	Weathered limestones (with fresh water)
>45	15	Highly weathered limestones/sandstones with brackish water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 68 Ohm-m resistivity to a depth of 1.5 m bgl, comprising Recent deposits composed of sandy soils, underlain by a 20 Ohm-m resistivity layer to a depth of 13 m bgl comprising highly weathered limestones with fresh water. It is underlain by a 58 Ohm-m resistivity layer to a depth of 45 m bgl interpreted to be weathered limestones with fresh water. The bottom layer has a resistivity of 15 Ohm-m and is interpreted to be weathered limestones/sandstones with brackish water.

VES 32

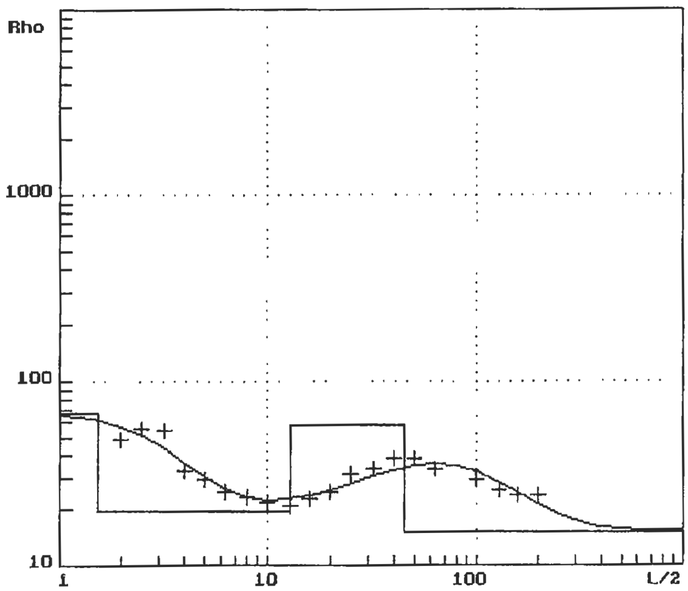


Figure 38 - Interpretation Graph for VES 32

37.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Welmarer site is located in an area which is considered to have a poor to medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality between brackish to saline. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones underlain by sandstones. There exists a shallow aquiclude at the existing rain water catchment.

In view of the above it is recommended that:-

1) A shallow hand dug well be sunk to a depth of about 13 m bgl at a diameter of 6 m. Water is expected between 4 and 13 m bgl.
2) The superstructure should be constructed in a way that prevent saline run-off water and sediments infilling the wells.
3) Rehabilitation of the catchment, deepening and enlarging to 100x50x3 m.

The other alternative water source is:-

Drilling of a deep borehole to 250 m bgl equipped with a submersible pump. Detailed hydrogeological and geophysical investigations will be necessary to pinpoint the exact drilling location.

38. TUULO BARWAAQO

38.1 Location

The village of Tuulo Barwaaqo is located within Garbahaley District, Gedo Region of Southern Somalia. The village is located approximately 22 km north west of Garbahaley along the Garbahaaley-Belet Xaawo road. It is located at longitude and latitude approximately 03^0 30' 05" N and 042^0 09' 38" E.

38.2 Physiography

The village lies at an elevation of 186 m amsl. The area is generally flat or gently sloping towards the north east. A number of limestone flat topped hills occur east of the village from which several seasonal rivers emanate.

38.3 Hydrology

The mean annual rainfall ranges between 300 and 350mm. There are no surface water sources in the village apart from seasonal rivers which emanate from the hills and only flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

38.4 Population and Water Demand

The population of the village could not be established during the fieldwork, but it is in excess of 300 families who rely on the existing borehole. In addition about 5000 nomadic families rely on the borehole in the village for supply of domestic and animal requirements.

38.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and red soils.

38.6 Structures

Based on the geological observations near the investigated site, faults/fractures orientated in a southwest-northeast direction are inferred in the general area.

38.7 Hydrogeology

38.7.1 Existing Boreholes

Two boreholes have been sunk within the village but only one is operational. Details about the operational borehole are given below

Table 34 - Tuulo Barwaaqo Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1985	51	8"	20	22.6	6.5	15	4140

The second borehole that is currently out of operation is known to have had a static water level of 18 m bgl. No other details are available.

38.7.2 Current Water Sources

The only source of water in the area is the operational borehole drilled within the village which supply water for both domestic and animal consumption. The borehole is equipped with a generator and a submersible pump. Water is pumped into the animal troughs. UNICEF supplied the community with a generator recently. Pipes are required to connect the village tank of 20,000 litre capacity tank. Tap stands and donkey cart delivery stands are also required. The water supply if rehabilitated would meet the requirements for the village despite inadequate storage reservoir. The surface water from seasonal rivers is unreliable flow and only a few weeks after the rainy season.

38.7.3 Aquifers

From the static water level of the borehole, it is highly likely that there are shallow aquifers. But the drilling data are not available. Deep aquifers in the area are expected to occur within the fractured limestones and sandstones of the Cambar formation.

38.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing borehole. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

38.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 35: Interpretation Results of VES 35

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	4688	Sandy top soil
0.4 - 2.8	43	Weathered limestones
2.8 - 16	18	Highly weathered limestones
16 - 88	15	Highly weathered limestones (with fresh water)
>88	1000	Highly weathered limestones/sandstones with brackish water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 4688 Ohm-m resistivity to a depth of 0 4 m bgl, comprising Recent deposits composed of sandy soils, underlain by a 43 Ohm-m resistivity layer to a depth of 2.8 m bgl comprising weathered limestones. It is underlain by a 18 Ohm-m resistivity layer to a depth of 16 m bgl interpreted to be highly weathered limestones. This is underlain by a 15 Ohm-m layer to a depth of 88 m bgl interpreted to be highly weathered limestones with fresh water. The bottom layer has a resistivity of 1000 Ohm-m and is interpreted to be hard compact limestones/sandstones.

38.9 Water Quality

The Ec of the borehole water was measured to be 4140 µS/cm which is considered to be slightly brackish but potable.

VES 35

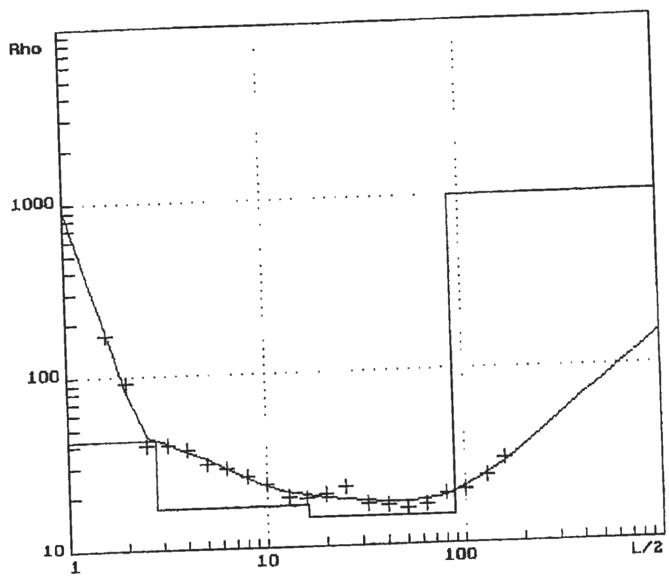


Figure 40 - Interpretation Graph for VES35

38.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Tuulo Barwaaqo site is located in an area which is considered to have a high groundwater potential. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones up to a depth of about 88 m bgl at the location of VES 35. The water quality is considered fair for drinking and animal watering.

In view of the fact that the borehole water supply is operational and meets the requirements for the town it is recommended that:

1) 2 new animal troughs are constructed
2) Piping from the borehole to the existing tank in the village be undertaken.

It was gathered from the community that UNICEF is currently in the process of undertaking rehabilitation and improvement of the water supply.

39. MAYKAREEBY

39.1 Location

The village of Maykareeby is located within Garbhahaley District, Gedo Region of Southern Somalia. It is located approximately 17 km north of Garbhahaley. The village is located at longitude and latitude approximately 03^0 26' 53'' N and 042^0 16' 08'' E.

39.2 Physiography

The village lies at an elevation of 197 m a msl. The area is generally undulating with a few conspicuous isolated hills and seasonal rivers. The site is located on top of a minor limestone hill. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage. The drainage basin is demarcated by elongated limestone hills with vertical to sub-vertical fault planes.

39.3 Population and Water Demand

Although accurate data on population of people and animals was not available, it was projected that the total population is approximately 1,000 families including the nomads who rely on the only operational shallow wells for supply of domestic and animal requirements.

39.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. Surface water sources in the area are not present. There are no springs within or in the immediate vicinity of the investigated site.

39.5 Geology

The site is underlain by brown sands on the surface, underlain by limestones and sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits.

39.6 Hydrogeology

39.6.1 Existing Boreholes and Shallow Wells

One borehole has been sunk within the village. The borehole was drilled in 1989 by GTZ. Details of this borehole are given below.

Table 36 - Tuulo Barwaaqo Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1989	31	8"	6.1	7.3	13.5	-	4400

It was gathered that the pump had been installed to 29 m bgl and the borehole was operational until 7 years ago. UNICEF has supplied a pump, 2" diameter GI pipes for riser main and a 3 cylinder lister engine. UNICEF removed the pump to undertake maintenance work, but before re-installation, the borehole casing was found to have been backfilled with stones to a depth of 5 m bgl.

In addition, a total of 5 shallow hand dug wells have been dug in the village. The wells are protected with superstructures constructed with concrete. The total depth of the wells vary between 6.1 and 7.3 m bgl. Two of the wells have been abandoned due to backfilling during the El nino floods. The water level at the time of this investigation was 5.5 to 6 m bgl.

39.6.2 Current Water Sources

The only perennial source of water in the area is the shallow wells dug in the village which are being used for domestic consumption and animal watering. Abstraction from these wells is by bucket and rope. The surface water from seasonal rivers flow only a few weeks after the rainy season. During extended drought, the wells run dry and salinity increases significantly. Water for domestic use is brought from Gabhahaley approximately 17 km away.

39.6.3 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones.

39.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

39.8 Water Quality

The Ec of the three operational shallow wells was measured to be 5400, 5000 and 5680 µS/cm respectively which is considered to be saline but still can be used for animal watering and sparingly, for domestic consumption.

39.8.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below

Table 37: Interpretation Results of VES 36

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.3	11.7	Silty top soil
1.3 - 2.3	58	Weathered limestones
2.3 - 4.5	8	Clays/decomposed limestones
4.5 - 10	58	Weathered limestones (with fresh water)
10 - 100	15	Highly weathered limestones (with brackish water)
>100	21	Highly weathered limestones/sandstones with brackish water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 11.7 Ohm-m resistivity to a depth of 1.3 m bgl, comprising Recent deposits composed of silty top soils, underlain by a 58 Ohm-m resistivity layer to a depth of 2.3 m bgl comprising weathered limestones. It is underlain by a 8 Ohm-m resistivity layer to a depth of 4.5 m bgl interpreted to be highly decomposed limestones and clays. This is underlain by a 58 Ohm-m layer to a depth of 10 m bgl interpreted to be highly weathered limestones with fresh water It is underlain by a 15 Ohm-m layer to a depth of 100 m bgl interpreted to be highly weathered limestones with brackish water. The bottom layer has a resistivity of 21 Ohm-m and is interpreted to be highly weathered limestones/sandstones with fresh to brackish water.

VES 36

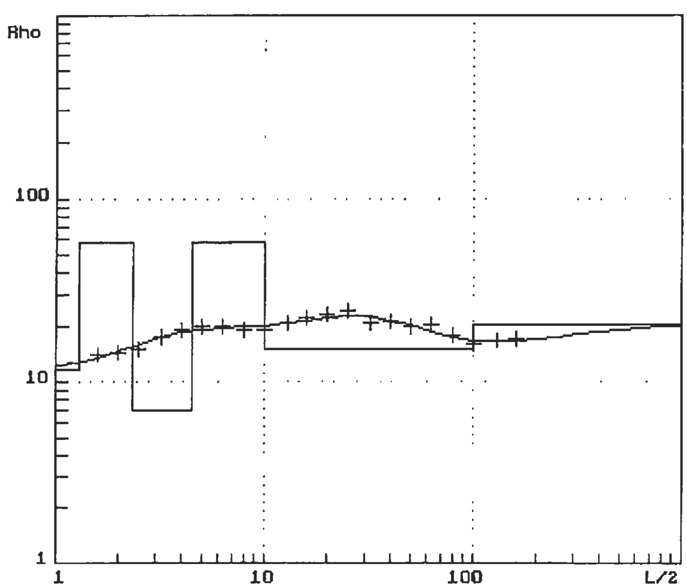


Figure 41 - Interpretation Graph for VES 36

39.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Maykaareeby site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality between brackish to saline. Productive aquifers with potable water are also expected within the sedimentary succession comprising weathered limestones to depth of up to 200 m bgl.

In view of the above it is recommended that:-

1) The existing shallow wells should be cleaned out, rehabilitated and deepened to 10 m bgl.
2) One shallow well should be dug at 3 m diameter to 15 m bgl.
3) The superstructure should be constructed in a way that prevent saline run-off water and sediments infilling the wells.
4) Cattle troughs should also be constructed appropriately

The alternative water source would be exploitation of the deeper aquifer by:-

1) rehabilitation of the existing borehole and equip with submersible pump and generator.
2) drilling and construction of another borehole to 50 m bgl and equip with submersible pump and generator

40. DAABLEY

40.1 Location

The village of Dabley is located within Garbhahaley District, Gedo Region of Southern Somalia. It is located approximately 40 km west of Garbhahaley. The village is located at longitude and latitude approximately 03^0 13' 59" N and 042^0 01' 13" E.

40.2 Physiography

The village lies at an elevation of 327 m a msl. The area is generally undulating with several conspicuous isolated hills and seasonal rivers. Village is located on a flat area with no major features. The topography is gently sloping to the east towards the seasonal river and in the direction of the drainage. The drainage basin is demarcated by elongated limestone ridges with vertical to sub-vertical fault planes.

40.3 Population and Water Demand

There was no data on population of people and animals available for this area, but the community representatives remark that there are thousands of animals watered daily on the river bed spring and the natural pond

40.4 Hydrology

The mean annual rainfall ranges between 300 and 350mm. One very unique surface water source is the river bed spring located at coordinates:- approximately 03^0 19' 59" N and 042^0 00' 20" E. There are no other springs within or in the immediate vicinity of the investigated site.

40.5 Geology

The area is underlain by brown sands on the surface, underlain by limestones and sandstones and older sedimentary rocks. These are overlain at the surface by Recent superficial alluvial deposits

40.6 Hydrogeology

40.6.1 Existing Boreholes and Shallow Wells

No boreholes have been sunk within the village. There are 3 shallow hand dug wells dug in the village. One of the wells is protected with a superstructure constructed with concrete and the rest are unprotected. The total depth of the wells vary between 10 to 12 m bgl. The water level at the time of this investigation was 8 to 10 m bgl.

40.6.2 Current Water Sources

The only perennial source of water in the area is the shallow wells dug in the village on the banks of togga Dabley which are being used for domestic consumption and animal watering. Abstraction from two of these wells is by bucket and rope while 1 is equipped with a hand pump. The surface water from the river bed spring is another perennial water supply. Its salinity is high and is only used for animal consumption. Water for domestic use is brought from the hand pumped well.

40.6.3 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones.

40.7 Geophysical Investigations

VES 37 was done near the existing spring on the river bed. VES 38 was done next to the existing shallow hand dug wells near the river. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

40.7.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 38: Interpretation Results of VES 37

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1.7	395	Sandy top soil
1.7 - 4	6.7	Highly weathered limestones/clays
4 - 49	20	Weathered limestones (with brackish water)
>49	5.6	Highly weathered limestones/sandstones with saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 395 Ohm-m resistivity to a depth of 1.7 m bgl, comprising Recent deposits composed of sandy top soils, underlain by a 6.7 Ohm-m resistivity layer to a depth of 4 m bgl comprising highly weathered limestones and clays. It is underlain by a 20 Ohm-m resistivity layer to a depth of 49 m bgl interpreted to be weathered limestones with brackish water. The bottom layer has a resistivity of 5.6 Ohm-m and is interpreted to be highly weathered limestones/sandstones with saline water.

VES 37

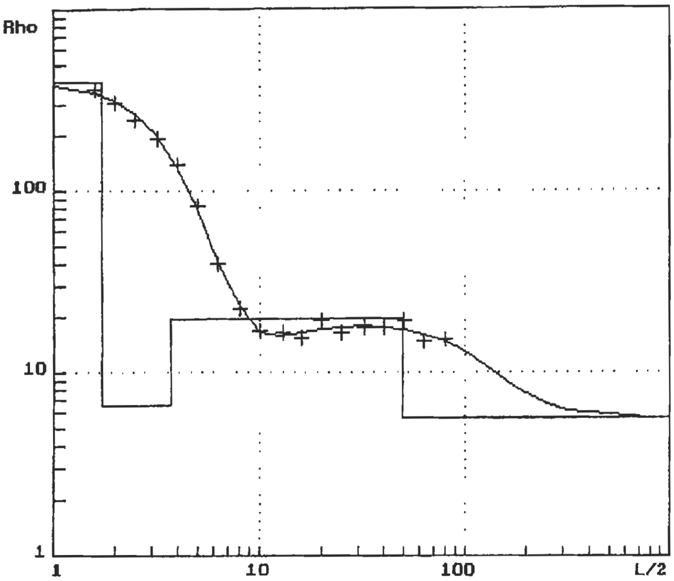


Figure 42 - Interpretation Graph for VES 37

Table 39: Interpretation Results of VES 38

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.3	8	Sandy top soil
0.3 - 1.4	267	Sandy soils
1.4 - 3.9	2.4	Clays
3.9 - 40	15	Highly weathered limestones (with brackish water)
>40	18	Weathered limestones/sandstones with saline water

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 8 Ohm-m resistivity to a depth of 0.3 m bgl, comprising Recent deposits composed of clayey top soils, underlain by a 267 Ohm-m resistivity layer to a depth of 1.4 m bgl comprising sandy soils. It is underlain by a 2.4 Ohm-m resistivity layer to a depth of 3.9 m bgl interpreted to be clays. This is underlain by a 15 Ohm-m resistivity layer to a depth of 40 m bgl interpreted to be weathered limestones with brackish water The bottom layer has a resistivity of 18 Ohm-m and is interpreted to be highly weathered limestones/sandstones with brackish water.

40.8 Water Quality

The Ec of the three operational shallow wells was measured to be 2400, 2550 and 2600 μS/cm respectively which is considered to be potable. The Ec of the river bed spring was measured to be 12500 μS/cm which is considered too saline for domestic use, and also marginal quality for animal consumption.

VES 38

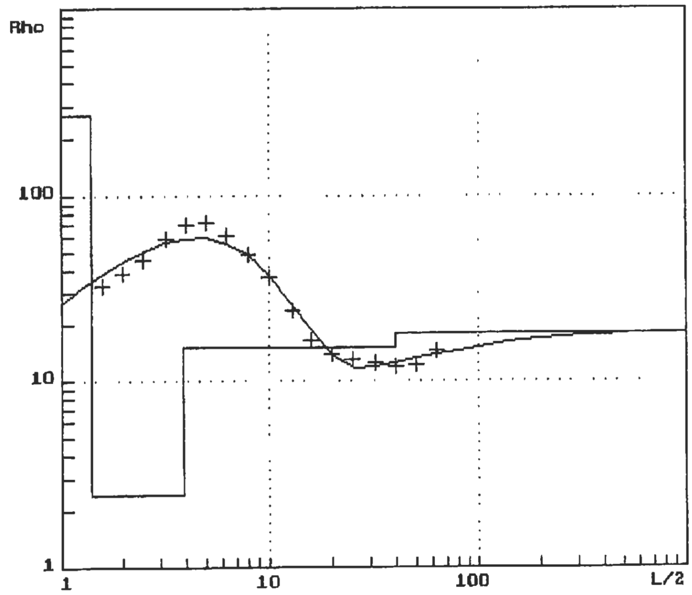


Figure 43 - Interpretation Graph for VES 38

40.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Dabley site is located in an area which is considered to have a poor to medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is susceptible to seasonal variations in quality between brackish to saline. Productive aquifers with potable water are also expected within the sedimentary succession comprising weathered limestones to a depth of up to 50 m bgl. Some of the seasonal streams carry highly saline water. It is envisaged that the salinization process is not local, but emanates from leakage of saline water from anhydrite which dissolves the salts, hence becoming saline.

In view of the above it is recommended that:-
1) The hand pump in the existing shallow well should be removed together with the rods.
2) A new hand pump should be installed once the actual depth has been confirmed.
3) The existing unprotected shallow well of 1 m diameter should be enlarged to 3 m diameter and deepened to 15 m bgl.
4) An additional well should be dug at 3 m diameter to 15 m bgl.
5) The wells should be constructed in such a way as to avoid saline water saturated surface run-off and sediments infilling the wells.
6) Cattle troughs should also be constructed appropriately

An alternative water source would be:-
1) Drilling of a borehole to 40 m bgl near the location of VES 37 and equipping with a hand pump.

41. HARAMANDERA

41.1 Location

Haramandera site is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 94 km southwest of Garbhahaley town and 27 km south west of Ceel Cade. The site is located at longitude and latitude approximately 02^0 52' 56" N and 041^0 42' 50" E.

41.2 Physiography

The site lies at an elevation of 514 m a msl. The area is generally flat and featureless. A few conspicuous isolated hills and seasonal rivers are observed in the area.

41.3 Population and Water Demand

There is no settlement next to the existing rain water catchment and therefore, data on population of people and animals available for this area was not available. Nevertheless the few nomadic people in the area expressed their willingness to settle should there be available water for the numerous animals in the area.

41.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no springs within or in the immediate vicinity of the investigated site. No surface water resources are available in the area apart from run-off water during the wet seasons.

41.5 Geology

The area is covered on the surface by Recent superficial alluvial deposits and sandstone boulders, underlain by limestones and sandstones and older sedimentary rocks. From examination of the soil texture, it is inferred that the site lies near the contact between the limestones and sandstones.

41.6 Hydrogeology and Existing Water Sources

The only perennial source of water in the area is the existing rain water catchment. The catchment has dimensions of 100x100x1 m. It is silted up and backfilled to near the top with silts and clayey erosion and deposition material. There are two privately owned rain water catchments within 5 km. The nomads on their pastoral route down south have to pay for the water for animal consumption. It is evident that majority of them are unable to pay for this water and would in dry seasons loose their animals. The existing rain water catchments are dry for the last three years.

41.6.1 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones at greater depths.

The water quality from the aquifers is expected to be fit for both domestic and animal consumption as it is within the same geological formation as good quality water productive boreholes in Ceel Cade.

41.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing rain water catchment The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

41.7.1 Resistivity Sounding

Interpreted results of the sounding are shown in the table presented below:

Table 40: Interpretation Results of VES 40

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 2.4	24	Sandy top soil
2.4 - 4	2.4	Clays
4 - 18	35	Weathered limestones
18 - 125	19	Highly weathered limestones (with fresh water)
>125	487	Hard compact limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 24 Ohm-m resistivity to a depth of 2.4 m bgl, comprising Recent deposits composed of sandy top soils, underlain by a 2.4 Ohm-m resistivity layer to a depth of 4 m bgl comprising clays. It is underlain by a 35 Ohm-m resistivity layer to a depth of 18 m bgl interpreted to be weathered limestones. This is underlain by a 19 Ohm-m resistivity layer to a depth of 125 m bgl interpreted to be highly weathered limestones with fresh water. The bottom layer has a resistivity of 487 Ohm-m and is interpreted to be fresh limestones/sandstones.

VES 40

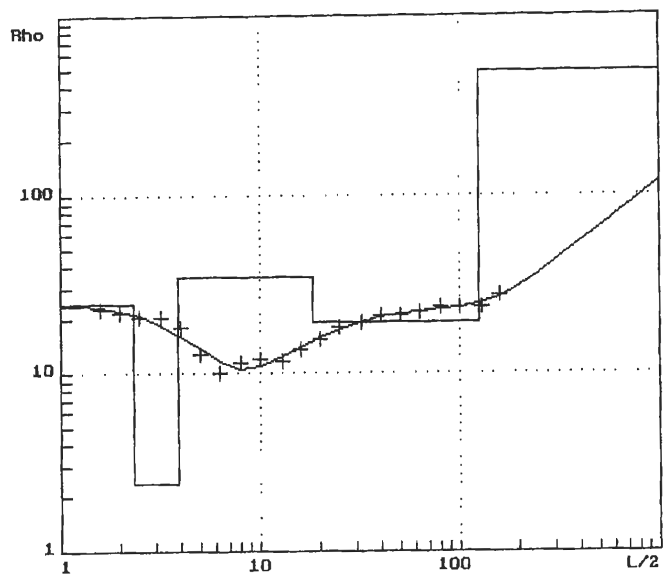


Figure 44 - Interpretation Graph for VES 40

41.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Haramandera site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality between fresh to brackish. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones and sandstones from 18 to 125 m bgl.

In view of the above it is recommended that -

1) A borehole be drilled to a depth of 125 m bgl and equipped with either hand pump or generator and submersible pump.
2) Detailed geophysical investigations should be done to identify precisely the optimum location of the borehole.

Alternative water sources include:-

1) Rehabilitation of the existing rain water catchment and deepening with dimensions 100x100x3 m. This option is however complicated by presence of two privately owned rain water catchments within 5 km.

42. DASO

42.1 Location

Daso village is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 130 km southwest of Garbhahaley town and 63 km south west of Ceel Cade. The village is located at longitude and latitude approximately 02^{0} 52' 41'' N and 041^{0} 28' 05'' E.

42.2 Physiography

The site lies at an elevation of 358 m a msl. The topography of the area is undulating with several conspicuous hills and ridges. Seasonal rivers are observed in the area. The village site itself is generally sloping to the west towards the drainage valley.

42.3 Population and Water Demand

The population of the village is about 50 families and 500 nomadic families who rely on the existing rain water catchment and two barkads for domestic and animal consumption.

42.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no springs within or in the immediate vicinity of the investigated site. No surface water resources are available in the area apart from run-off water during the wet seasons.

42.5 Geology

The area is covered on the surface by Recent superficial alluvial deposits and sandstone boulders, underlain by limestones and sandstones and older sedimentary rocks. From examination of the soil texture, it is inferred that the site lies near the contact between the limestones and sandstones.

42.6 Hydrogeology and Existing Water Sources

There is no perennial source of water in the area. However there is an existing rain water catchment with dimensions 100x100x1 m. This will only hold water a few weeks after the rains since it is silted up and backfilled to near the top with silts, clayey erosion and deposition material. An additional temporary water sources include the two barkads collecting run-off water during wet seasons. The barkads are of dimensions 12x5x3.5 and 8x5x3.5 m. They are constructed with concrete together with accompanying sedimentation chamber.

42.6.1 Aquifers

There exists both shallow and deep aquifers. The shallow aquifer is confined by the thick limestone layer on top and the alluvial sediments and soils. It occurs below the contact between the limestones/sandstones and the superficial layer. Deeper aquifers are expected to occur within the fractured limestones/sandstones at greater depths. The community elders revealed that they had dug a shallow well to a depth of 21 m in 1969 and had struck significant amount of good quality water. However due to pervasive collapse of the well, it was difficult to continue digging and consequently the well was abandoned.

The water quality from the aquifers is expected to be fit for both domestic and animal consumption.

42.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the village. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

42.7.1 Resistivity Sounding

Interpreted results of the sounding are shown in the table presented below:

Table 41: Interpretation Results of VES 41

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.7	230	Sandy top soil
0.7 - 1	25	silts
1 - 2.2	380	Hard compact sandstones
2.2 - 6.8	49	Weathered sandstone
6.8 - 98	14	Highly weathered sandstones (with fresh to brackish water)
>98	607	Hard compact sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 230 Ohm-m resistivity to a depth of 0.7 m bgl, comprising Recent deposits composed of sandy top soils, underlain by a 25 Ohm-m resistivity layer to a depth of 1 m bgl comprising silt. It is underlain by a 380 Ohm-m resistivity layer to a depth of 2.2 m bgl interpreted to be weathered limestones. This is underlain by a 49 Ohm-m resistivity layer to a depth of 6.8 m bgl interpreted to be weathered sandstones. This is underlain by a 14 Ohm-m resistivity layer to a depth of 98 m bgl interpreted to be weathered sandstones with fresh to brackish water. The bottom layer has a resistivity of 607 Ohm-m and is interpreted to be fresh sandstones.

VES 41

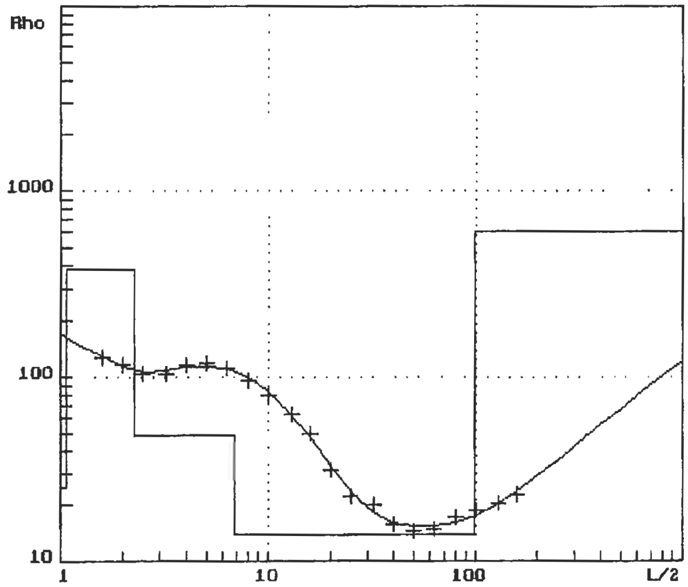


Figure 45 - Interpretation Graph for VES 41

42.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Daso village site is located in an area which is considered to have a poor to medium groundwater potential. Both shallow and deep aquifers occur in the area. The upper aquifer is however susceptible to seasonal variations in quality between fresh to brackish. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones and sandstones from approximately 30 to 100 m bgl.

In view of the above it is recommended that:-

1) A borehole be drilled to a depth of 80 m bgl and equipped with hand pump to provide a permanent water supply to the communities relying on the existing facilities.
2) Rehabilitate the existing rain water catchment to dimensions of 100x100x4 m.

Alternative water sources include:-

1) Digging of a 6 m diameter well to a depth of 30 m bgl. Previous experience with the local people indicate presence of collapsible formation in the upper zones of the sub-surface. Technically this option is possible but its implementation is dangerous due to caving in.
2) Construction of an additional barkad near the village.

43. DHAMASSE

43.1 Location

The village of Dhamasse is located within Ceel Wak District, Gedo Region of Southern Somalia. The village is located approximately 60 km north east of Ceel Wak along the Ceel Wak-Belet Xaawo road and 130 km south west of Belet Xaawo. It is located at longitude and latitude approximately 03^0 09' 12" N and 041^0 20' 10" E.

43.2 Physiography

The village lies at an elevation of 399 m amsl The area is gently sloping towards the south east. The area is generally flat with a few limestone ridges and several seasonal rivers.

43.3 Hydrology

The mean annual rainfall ranges between 200 and 250mm. There are no surface water sources in the village apart from seasonal rivers which only flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

43.4 Population and Water Demand

The population of the village is currently estimated at 1000 families who rely on the existing borehole. In addition 12000 nomadic families rely on the borehole in the village for supply of domestic and animal requirements.

43.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and soils. At greater depths, sandstones are to be encountered. The village is at the contact between limestones and sandstones.

43.6 Structures

Based on the geological observations near the investigated area, faults/fractures in the area orientated in a southwest-northeast direction are expected to occur in the general area.

43.7 Hydrogeology

43.7.1 Existing Boreholes

Two boreholes have been sunk within the area. Only the one drilled in 1986 is operational. Details about the two boreholes are given below.

Table 42 - Dhamasse Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1986	105	8"	30		40	10	1020
1973	117	8"			40	10	880

The operational borehole is functioning unreliably due to numerous break downs. It has no animal troughs, tanker filling stand, tap stands water tank (except for 100 m3 underground tank reserve during maintenance)

43.7.2 Current Water Sources

The only source of water in the area is the operational borehole drilled within the village which supply water for both domestic and animal consumption. The borehole is equipped with a generator and a submersible pump Water is pumped into a tank. Tap stands and donkey cart delivery stands are not in place. The water supply does not meet the requirements for the village due to inadequate storage reservoir The borehole is operating for 24 hours.

The second borehole is out of operation since the casings have been filled with stones to the surface.

The surface water from seasonal rivers is unreliable flow only a few weeks after the rainy season. Digging of shallow wells is not possible in the area since there are no shallow aquifers with potable water. An additional borehole would be required in order to ease the overpumping of the existing borehole. It must however be noted that the existing borehole is capable of 30,000 liters an hour and is only pumped at 10.000 liters an hour.

43.7.3 Aquifers

Deep aquifers in the area are expected to occur within the fractured limestones/sandstones.

43.8 Geophysical Investigations

Three vertical electrical sounding (VES) were executed at selected sites in the village. VES 42 was carried out east of the village next to the Kenya/Somalia border to establish the possibility of deeper aquifers. VES 43 was executed 6 km north of the village along an existing seasonal river to explore the possibility of sinking shallow wells while VES 44 was done near the existing abandoned borehole. The VES were carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

43.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below:

Table 43: Interpretation Results of VES 42, 43 and 44

VES	LAYER 1		LAYER 2		LAYER 3		LAYER 4		LAYER 5	
	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE
42	2753	0.4	309	3.5	94	39	20	100	56	>100
43	195	0.7	83	2.9	8	17	329	>17		
44	125	3.6	47	35	17	57	50	160	66	>160

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of VES 42 and 44 are similar but different for VES 43. VES 42 and 44 indicate a superficial layer of resistivity varying between 125 and 2753 Ohm-m to a depth of 0.4 to 3.6 m bgl. This is interpreted to be top sandy soils, underlain by 47 to 309 Ohm-m layer to a depth of 39 to 57 m bgl. The aquiferous layer with a resistivity of 20 to 50 Ohm-m is encountered at a depth of 39 to 160 m bgl. It is interpreted to be highly weathered limestones. The bottom layer with a resistivity of 56 to 66 Ohm-m occur at depths greater than 100 to 1609 m bgl and is interpreted to be fresh water bearing weathered limestones and sandstones. At VES 43, a 195 Ohm-m layer occur to a depth of 0.7 m bgl which is interpreted to be top sandy soil. This is underlain by a 83 Ohm-m layer to a depth of 2.9 m bgl interpreted to be sandy sub soil. It is underlain by a 8 Ohm-m layer to a depth of 17 m bgl interpreted to be clays The bottom layer with resistivity of 329 Ohm-m is interpreted to be fresh sandstones. No aquifers are expected at the location of this VES measurement.

At this village both medium and deep groundwater exists and of potable quality. Both aquifers are saturated with fresh water as depicted by the low Ec of the borehole water.

VES 42

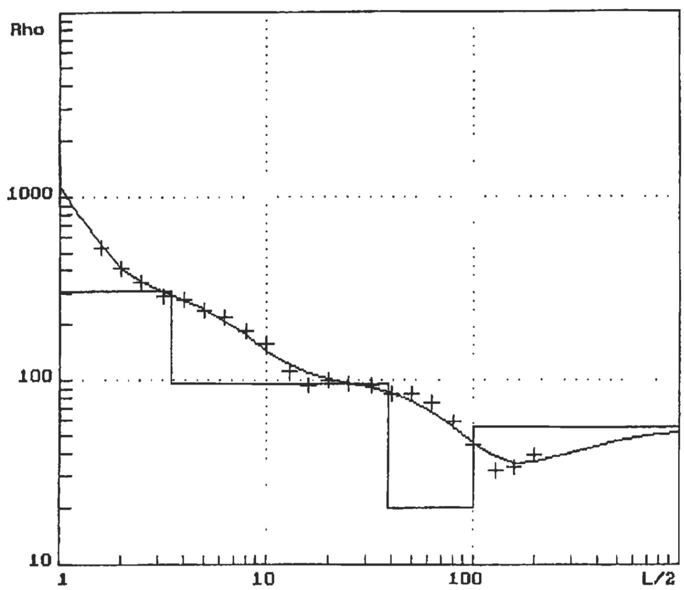


Figure 46 - Interpretation Graph of VES 42

VES 43

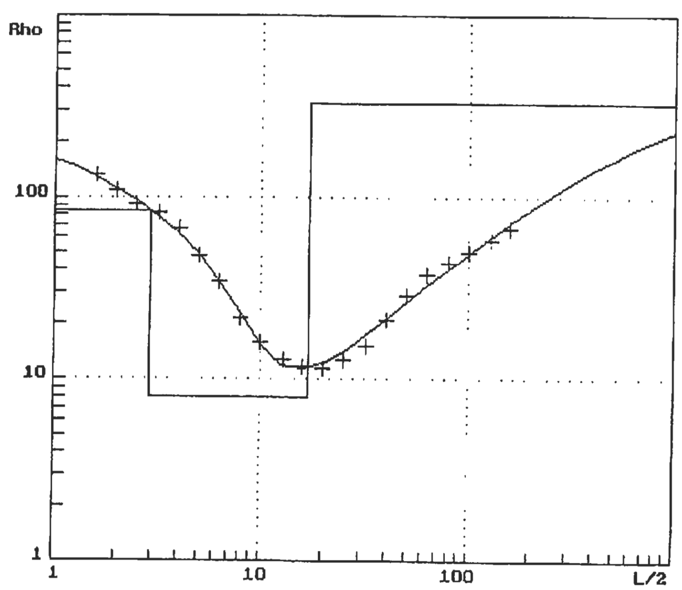


Figure 47 - Interpretation Graph of VES 43

VES 44

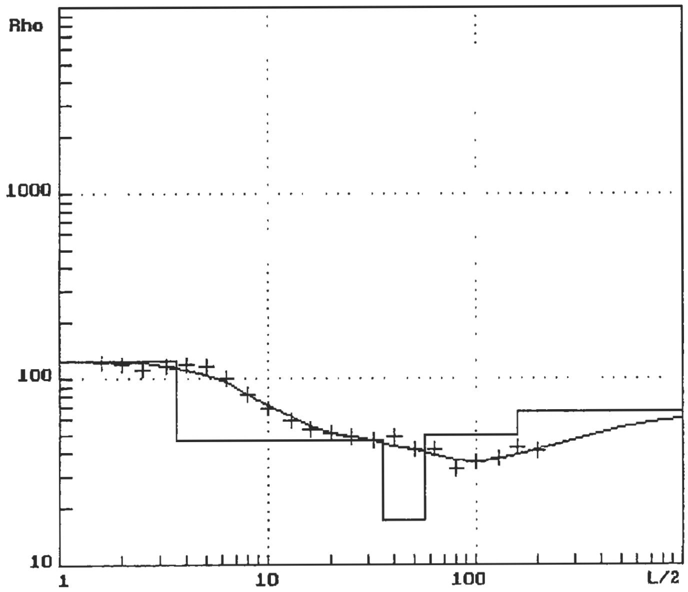


Figure 48 - Interpretation Graph of VES 44

43.9 Water Quality

The Ec of the borehole water was measured to be 1,20 µS/cm which is considered to be fresh water suitable for both domestic and animal consumption. The water quality for any borehole drilled in the village would be expected to be similarly potable

43.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Dhamasse village is located in an area which is considered to have a high groundwater potential. Shallow aquifers are not existing in the area. The geological formations in the sub-surface are not suitable for construction of rain water catchments. Medium and deep aquifers occur in the area within the sedimentary succession comprising weathered limestones up to a depth of about 200 m bgl at the location of VES 42 and 43

In view of the fact that the borehole water supply is operational and provides water of good quality suitable for both domestic and animal consumption which do not meet the requirements for the village and satellite users. recommendations are given for expansion of the water supply as follows:-

1) Drilling of an additional borehole to 160 m bgl equipped with generator and pump
2) rehabilitation of the existing productive borehole
3) 4 tanks of 45,000 liters capacity
4) 1 pump house
5) Construction of animal troughs
6) Construction of water delivery tap stands

44. AL WHEELE

44.1 Location

Al Wheele site is located within Garbahaarey District, Gedo Region of Southern Somalia. It is located approximately 49 km east south east of Dhamasse village. The site is located at longitude and latitude approximately 03^0 04' 33" N and 041^0 42' 35" E.

44.2 Physiography

The site lies at an elevation of 495 m a msl. The area between Dhamasse and Al wheele is undulating, with one conspicuous sandstone ridge. Wide drainage valleys are present in the area between successive ridges. A few seasonal rivers are observed in the area.

44.3 Population and Water Demand

There is no settlement next to the existing rain water catchment and therefore, data on population of people and animals available for this area was not available. Nevertheless the site is a strategic one for nomadic movements.

44.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no springs within or in the immediate vicinity of the investigated site. No surface water resources are available in the area apart from run-off water during the wet seasons.

44.5 Geology

The area is covered on the surface by Recent superficial alluvial deposits and deep red soils. There are also sandstone boulders. These are underlain by limestones and sandstones and older sedimentary rocks.

44.6 Hydrogeology and Existing Water Sources

The only perennial source of water in the area is the existing rain water catchment. The catchment has dimensions of 250x140x1.5 m. It is silted up and backfilled with silts and clayey erosion and deposition material. The nomads on their pastoral routes towards the south stop over the catchment for watering. The existing rain water catchment has been dry for the last three years.

44.6.1 Aquifers

There are no shallow aquifers at the site. Deeper aquifers are expected to occur within the fractured limestones/sandstones at greater depths.

The water quality from the aquifers is expected to be fit for both domestic and animal consumption as it is within the same geological formation as good quality water productive boreholes in Ceel Cade.

44.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site inside the existing rain water catchment The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

44.7.1 Resistivity Sounding

Interpreted results of the sounding are shown in the table presented below:

Table 44: Interpretation Results of VES 45

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	731	Sandy top soil
0.4 - 7.8	10.3	Clays
7.8 - 30	60	Weathered limestones
30 - 130	40	Highly weathered limestones/sandstones (with fresh water)
>130	1000	Hard compact limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 731 Ohm-m resistivity layer to a depth of 0.4 m bgl, comprising Recent deposits composed of sandy top soils, underlain by a 10.3 Ohm-m resistivity layer to a depth of 7.8 m bgl comprising clays. It is underlain by a 60 Ohm-m resistivity layer to a depth of 30 m bgl interpreted to be weathered limestones. This is underlain by a 40 Ohm-m resistivity layer to a depth of 130 m bgl interpreted to be highly weathered limestones with fresh water. The bottom layer has a resistivity of 1000 Ohm-m and is interpreted to be hard compact fresh limestones/sandstones.

VES 45

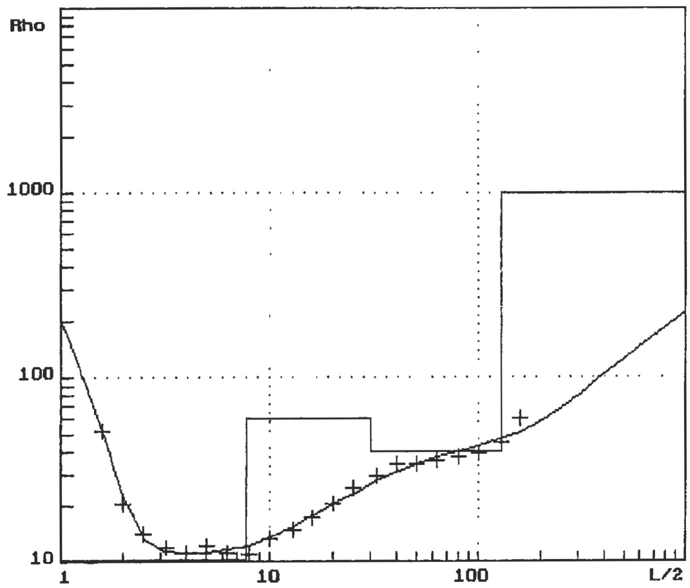


Figure 49 - Interpretation Graph for VES 45

44.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Al Wheele site is located in an area which is considered to have a medium groundwater potential. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones and sandstones from 40 to 130 m bgl.

In view of the above it is recommended that:-

1) A borehole be drilled to a depth of 130 m bgl and equipped with either hand pump or generator and submersible pump.
2) Detailed geophysical investigations should be done to identify precisely the optimum location of the borehole

Alternative water sources include:-

1) Rehabilitation of the existing rain water catchment and deepening with dimensions 240x140x4 m. The only part of the rain water catchment which can be excavated is the central part (150x100m) which is composed of soils, silts and clays. All the excavated material must be removed away from fridges of the rain water catchment to avoid being washed back into the catchment.

45. DADHABLE

45.1 Location

Dadhable site is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 39 km north west of Al Wheele village. The site is located at longitude and latitude approximately 03⁰ 15' 03" N and 041⁰ 42' 24" E.

45.2 Physiography

The site lies at an elevation of 499 m a msl. The area between Dhamasse and Al wheele is undulating, with a few sandstone/siltstone ridges, occasionally limestone. Wide drainage valleys are present in the area between successive ridges. A few seasonal rivers are observed in the area.

45.3 Population and Water Demand

There is no settlement next to the existing rain water catchment and therefore, data on population of people and animals available for this area was not available. Nevertheless the site is a strategic one as it falls within the nomadic movement corridor in the western part of Gedo.

45.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no springs within or in the immediate vicinity of the investigated site. No surface water resources are available in the area apart from run-off water during the wet seasons.

45.5 Geology

The area is covered on the surface by Recent superficial alluvial deposits and deep red soils. There are also sandstone boulders. These are underlain by limestones and sandstones/siltstones and older sedimentary rocks.

45.6 Hydrogeology and Existing Water Sources

The only source of water in the area is the existing rain water catchment. The catchment has dimensions of 250x140x1.5 m. It is silted up and backfilled with silts and clayey erosion and deposition material on its central part. The nomads on their pastoral routes towards the south stop over the catchment for watering. During the current study, the catchment had some water in this central part. The Ec of the water was measured to be 483 μS/cm which is very good quality suitable for both domestic and animal consumption. It is reported that the catchment dries up three months after the rains.

45.6.1 Aquifers

There are no shallow aquifers at the site. Deeper aquifers are expected to occur within the fractured limestones/sandstones at greater depths.

The water quality from the aquifers is expected to be fit for both domestic and animal consumption as it is within the same geological formation as good quality water productive boreholes in Ceel Cade.

45.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site inside the existing rain water catchment The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

45.7.1 Resistivity Sounding

Interpreted results of the sounding are shown in the table presented below:

Table 45: Interpretation Results of VES 46

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 1	102	Sandy top soil
1 - 2.8	209	Hard fresh sandstones
2.8 - 3.6	22	Weathered sandstones
3.6 - 36	181	Hard fresh sandstone
36 - 161	59	Highly weathered sandstones (with fresh water)
>161	1000	Hard compact sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a superficial layer of 102 Ohm-m resistivity layer to a depth of 1 m bgl, comprising sandy top soils, underlain by a 209 Ohm-m resistivity layer to a depth of 2.8 m bgl hard fresh sandstones. It is underlain by a 22 Ohm-m resistivity layer to a depth of 3.6 m bgl interpreted to be weathered sandstones This is underlain by a 181 Ohm-m resistivity layer to a depth of 36 m bgl interpreted to be hard fresh sandstones. This is underlain by a 59 Ohm-m resistivity layer to a depth of 161 m bgl interpreted to be highly weathered sandstones with fresh water. The bottom layer has a resistivity of 1000 Ohm-m and is interpreted to be hard compact fresh limestones/sandstones

VES 46

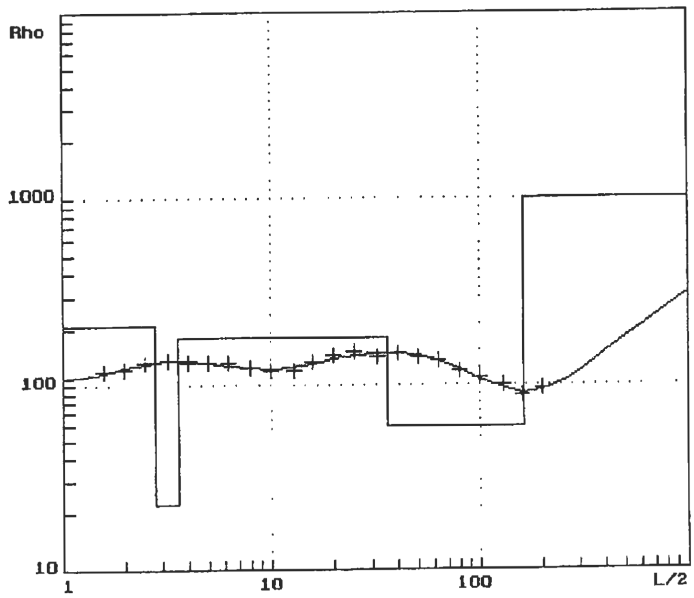


Figure 50 - Interpretation Graph for VES 46

45.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Dadhable site is located in an area which is considered to have a medium groundwater potential. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones and sandstones from 60 to 160 m bgl.

In view of the above it is recommended that:-

1) Rehabilitation of the existing rain water catchment and deepening with dimensions 240x140x4 m. The only part of the rain water catchment which can be excavated is the central part (150x100m) which is composed of soils, silts and clays. All the excavated material must be removed away from fridges of the rain water catchment to avoid being washed back into the catchment.

Alternative water sources include:-

1) A borehole be drilled to a depth of 160 m bgl and equipped with generator and submersible pump.
2) Detailed geophysical investigations should be done to identify precisely the optimum location of the borehole.

46. YAQLE

46.1 Location

Yaqle site is located within Ceel Wak District, Gedo Region of Southern Somalia. It is located approximately 7 km north west of Dadhable village. The site is located at longitude and latitude approximately 03^0 16' 34" N and 041^0 39' 23" E.

46.2 Physiography

The site lies at an elevation of 493 m a msl. The area between Dadhable and Yaqle is undulating, with a few sandstone/siltstone ridges, occasionally limestone boulders were encountered. Wide drainage valleys are present in the area between successive ridges.

46.3 Population and Water Demand

There is no settlement next to the existing rain water catchment and therefore, data on population of people and animals available for this area was not available. Nevertheless the site is a strategic one as it falls within the nomadic movement corridor in the western part of Gedo.

46.4 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no springs within or in the immediate vicinity of the investigated site. No surface water resources are available in the area apart from run-off water during the wet seasons.

46.5 Geology

The area is covered on the surface by Recent superficial alluvial deposits and deep red soils. There are also boulders of conglomerate on the surface and a few sandstone boulders These are underlain by limestones and sandstones/siltstones and older sedimentary rocks.

46.6 Hydrogeology and Existing Water Sources

The only source of water in the area is the existing rain water catchment. The catchment has dimensions of 400x150x1 m. It is silted up and backfilled with silts and clayey erosion and deposition material on its central part. The nomads on their pastoral routes towards the south stop over the catchment for watering when it has water. During the current study, the catchment was dry and it was reported that the catchment has not had water for the last three years.

46.6.1 Aquifers

There are no shallow aquifers at the site. Deeper aquifers are expected to occur within the fractured limestones/sandstones at greater depths.

The water quality from the aquifers is expected to be fit for both domestic and animal consumption as it is within the same geological formation as good quality water productive boreholes in Ceel Cade.

46.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site inside the existing rain water catchment The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

46.7.1 Resistivity Sounding

Interpreted results of the sounding are shown in the table presented below:

Table 46: Interpretation Results of VES 47

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.5	894	Sandy top soil
0.5 - 4.2	58	Weathered sandstones
4.2 - 19.5	196	Hard fresh sandstones
19.5 - 132	78	Weathered sandstones (with fresh water)
>132	45	Highly weathered sandstones (with fresh water)

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a 894 Ohm-m resistivity layer to a depth of 0.5 m bgl, comprising sandy top soils, underlain by a 58 Ohm-m resistivity layer to a depth of 4.2 m bgl interpreted to be weathered sandstones. It is underlain by a 196 Ohm-m resistivity layer to a depth of 19.5 m bgl interpreted to be hard fresh sandstones. This is underlain by a 78 Ohm-m resistivity layer to a depth of 132 m bgl interpreted to be weathered sandstones likely to have some aquifers with fresh water The bottom layer has a resistivity of 45 Ohm-m and is interpreted to be highly weathered sandstones with fresh water

VES 47

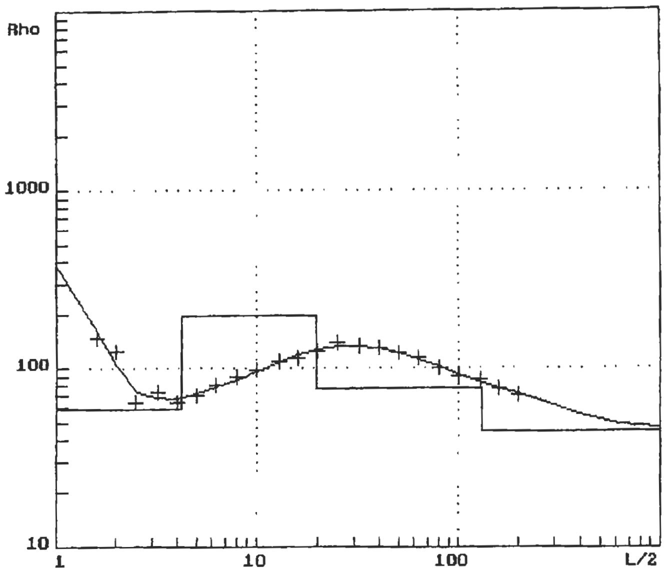


Figure 51 - Interpretation Graph for VES 47

46.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Yaqle site is located in an area which is considered to have a medium groundwater potential. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones and sandstones from 60 to 250 m bgl. The soft rocks extends to a depth of 3 m bgl. This is underlain by a hard formation to about 30 m bgl and a weathered formation to a depth of 130 m bgl and is underlain by highly weathered formation between 130 and 250 m bgl.

In view of the above it is recommended that:-

1) A borehole be drilled to a depth of 250 m bgl and equipped with generator and submersible pump.
2) Detailed geophysical investigations should be done to identify precisely the optimum location of the borehole.

Alternative water sources include:-

1) Rehabilitation of the existing rain water catchment and deepening with dimensions 240x140x4 m. The only part of the rain water catchment which can be excavated is the central part (100x100x3m) which is composed of soils, silts and clays. All the excavated material must be removed away from fridges of the rain water catchment to avoid being washed back into the catchment.

47. GADOON DHAWE

47.1 Location

The village of Gadoon Dhawe is located within Belet Xaawo District, Gedo Region of Southern Somalia. The village is located on the southern banks of Togga Gadoon Dhawe approximately 49 km from Yaqle along the Ceel Wak-Belet Xaawo road. The village is located at longitude and latitude approximately 03^0 34' 09'' N and 041^0 49' 16'' E.

47.2 Physiography

The village lies on the southern banks of togga Gadoon Dhawe. The elevation of the village is 383 m a msl. The area is gently sloping towards the east generally to the east in the direction of the drainage. It is undulating with small elongated isolated hills and numerous seasonal rivers.

47.3 Population and Water Demand

From the information given by the local people, the village is currently having a population of 100 families who rely on the available shallow wells. In addition 2000 nomadic families rely on the 15 shallow wells for supply of domestic and animal requirements.

47.4 Hydrology

The mean annual rainfall ranges between 200 and 250mm. Surface water sources in the area are not present except for togga Gadoon Dhawe which flow during the wet seasons for a short period. The site has a large catchment extending westward in an area of over $30km^2$. There are no springs within or in the immediate surroundings of the investigated site.

47.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

47.6 Hydrogeology

47.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. A total of 15 shallow hand dug wells have been sunk by the local community in the area to depths of about 6 bgl. The water level at the time of this investigation was about 5 m bgl.

47.6.2 Current Water Sources

The major source of water in the area is the shallow wells dug in the river banks of togga Gadoon Dhawe. All the 15 shallow wells are being used for human consumption and animal watering The surface water from seasonal rivers is unreliable because the rivers only flow a weeks after the rainy season. During extended drought, the water level in the wells decline.

47.6.3 Aquifers

Aquifers are expected to occur within the alluvial sediments in the drainage valleys and in the fractured limestones/sandstones.

47.7 Geophysical Investigations

Two vertical electrical soundings (VES) were executed at selected sites near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

47.7.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 47: Interpretation Results of VES 42, 43 and 44

	LAYER 1		LAYER 2		LAYER 3		LAYER 4		LAYER 5		LAYER 6	
VES	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE	RE	DE
48	165	1.2	15	10.6	6.9	16	23	24	5.8	66	783	>66
49	158	0.6	11	13	37	19	12	94	1000	>94		

RE Resistivity (Ohmm) **DE** Depth (m)

Interpretation of the two VES indicate a superficial layer of 158 to 165 Ohm-m resistivity interpreted to be alluvial sands, underlain by 11 to 15 Ohm-m layer to a depth of 13 m bgl. This is interpreted to be water bearing shallow aquiferous layer. It is underlain by a 6.9 to 37 Ohm-m resistivity layer to a depth of 66 to 94 m bgl. The bottom layer with resistivity of 783 to 1000 Ohm-m is interpreted to be fresh limestones/sandstones.

47.8 Water Quality

The Ec of the shallow wells was measured to be 1820. 2050, 1400, 1130, 1090 920 1820 and 2340 µS/cm from west to east for wells spaced approximately 100 m from each other. The water quality considered to be fresh and suitable for domestic consumption.

VES 48

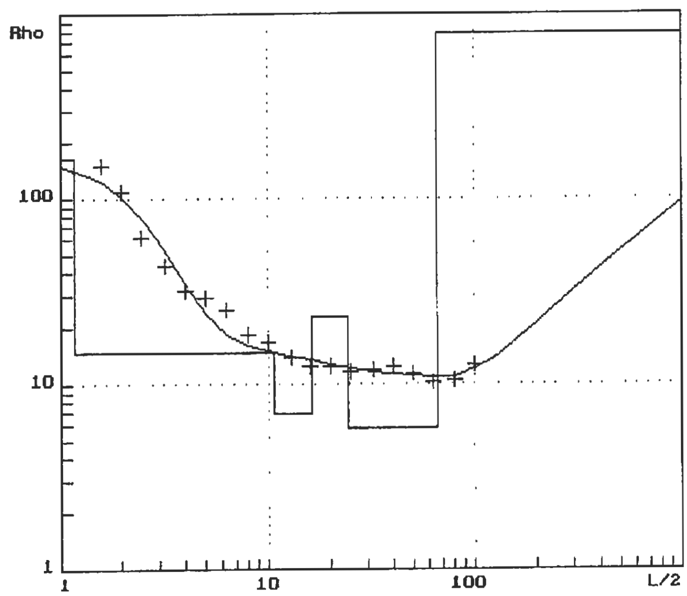


Figure 52 - Interpretation Graph for VES 48

VES 49

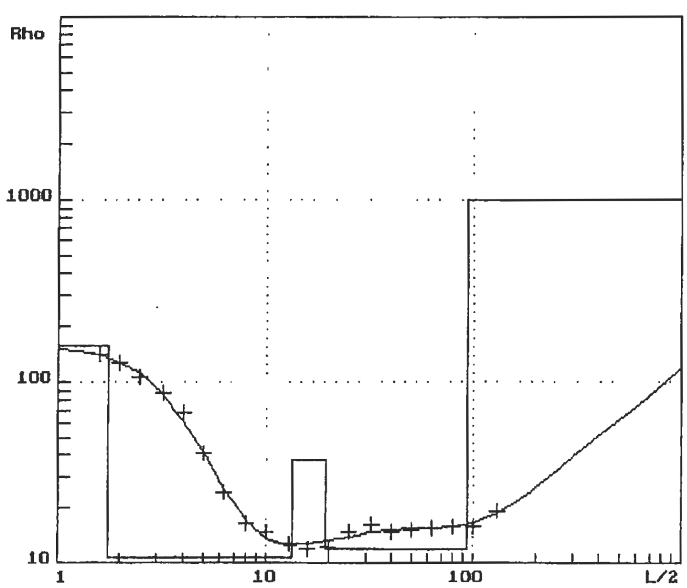


Figure 53 - Interpretation Graph for VES 49

47.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Gadoon Dhawe site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones up to a depth of about 100 m bgl. There is no possibility of a rain water catchment due to lack of a shallow aquiclude.

In view of the above it is recommended that 10 of the existing 15 wells be cleaned out and rehabilitated. The wells should be deepened to 20 m bgl and the internal diameter enlarged to 3 m in order to enhance storage. The superstructure should be constructed approximately 1 m above the river bed in order to avoid saline run-off water and sediments infilling the wells. It is further recommended to construct animal troughs next to the wells for watering.

An additional alternative water source would be drilling a borehole to 100 m bgl and installation of a hand pump.

48. KHADIJO XAAJI

48.1 Location

The village of Khadijo Xaaji is located within Belet Xaawo District, Gedo Region of Southern Somalia. The village is located approximately 22 km east of Gadoon Dhawe on the Somali-Kenya border. It is located at longitude and latitude approximately 03^0 55' 12" N and 042^0 10' 12" E.

48.2 Physiography

The village lies at an elevation of 365 m amsl. The area is gently sloping towards the south west. The area has a few limestone ridges and several seasonal streams which transmit water during the wet seasons.

48.3 Hydrology

The mean annual rainfall ranges between 250 and 300mm. There are no surface water sources in the village apart from seasonal rivers which only flow during the wet seasons for a short period. There are no springs within or in the immediate surroundings of the investigated site.

48.4 Population and Water Demand

The population of the village is currently estimated at 50 families who rely on the existing borehole. In addition 500 nomadic families rely on the borehole in the village for supply of domestic and animal requirements

48.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits and red soils.

48.6 Structures

Based on the geological observations near the investigated site, faults/fractures orientated in a northeast-southwest direction are suspected to occur in the general area.

48.7 Hydrogeology

48.7.1 Existing Boreholes

Three boreholes have been sunk within the village but are not operational. Details about the boreholes are given below.

Table 48 - Khadijo Xaaji Borehole Data

Year drilled	Depth (m)	Dia	Observed Yield (m^3/hr)	drawdown (m)	SWL (m)	Prod.Yield (m^3/hr)	EC (µS/cm)
1985	125	5"	4	46.2	53.8	3	8120
1985	125	-	4	46.2	53.8	3	8120
1985	125	-	4.8	19.5	58.5	3	8120

48.7.2 Current Water Sources

The only source of water in the area is the shallow wells at Gadoon Dhawe. The boreholes are not operational. One of the existing boreholes is equipped with a generator and a monolift pump. It stopped operating 10 years ago. There is an existing tank of 20.000 liter capacity which is in good condition The connection pipes need to be replaced. Tap stands and donkey cart delivery stands are in place The borehole is 125 m and the pump is installed at 95 m bgl. It was reported that the water supply used to meet the requirements for the village. The surface water from seasonal rivers is unreliable flow only a few weeks after the rainy season.

48.7.3 Aquifers

Deep aquifers in the area are expected to occur within the fractured limestones/sandstones. The shallow aquifers are found in the area at depths of 20 to 60 m

48.8 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing borehole. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

48.8.1 Resistivity Soundings

Interpreted results of the sounding are shown in the table presented below

Table 49 - Interpretation Results of VES 50

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 4.6	118	Sandy top soil
4.6 - 57	12	Weathered limestones
57 - 75	173	Hard fresh limestones
75 - 250	20	Highly weathered limestones (with fresh water)
>250	39	Weathered limestones/sandstones (with fresh water)

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a 118 Ohm-m resistivity layer to a depth of 4.6 m bgl, comprising sandy top soils, underlain by a 12 Ohm-m resistivity layer to a depth of 57 m bgl interpreted to be highly weathered limestones. It is underlain by a 173 Ohm-m resistivity layer to a depth of 75 m bgl interpreted to be hard fresh limestones. This is underlain by a 20 Ohm-m resistivity layer to a depth of 250 m bgl interpreted to be highly weathered limestones/sandstones which has aquifers with fresh water. The bottom layer has a resistivity of 39. again interpreted to be highly weathered limestones/sandstones with fresh water.

48.9 Water Quality

The Ec of the borehole water is reported to be 8,000 µS/cm which is considered to be brackish but nevertheless used for animal consumption.

VES 50

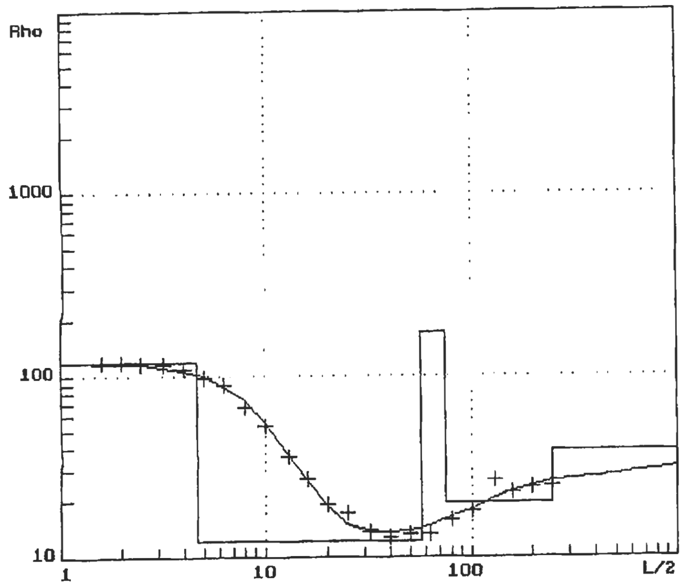


Figure 54 - Interpretation Graph for VES 50

48.10 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Ceel Khadijo Xaaji site is located in an area which is considered to have a medium groundwater potential. Shallow aquifers occur at 20 to 60 m bgl. The shallow aquifer is likely to have high salinity as depicted by the low resistivity. Deep aquifers occur in the area within the sedimentary succession comprising weathered limestones at 120m to a depth of about 250 m bgl at the location of VES 50. The deep aquifer is likely to have better quality water.

In view of the fact that the borehole water supply when operational used to meet the requirements for the village the following is recommended:-

1) Remove the pump and inspect the borehole i.e. measure the depth, water level.
2) Installation of the generator and pump.
3) Rehabilitation of the piping system
4) Construction of 2 animal troughs and repair of old ones
5) 1 set of 6 water delivery tap stands

49. BERGINI

49.1 Location

The village of Bergini is located within Dolow District, Gedo Region of Southern Somalia. The village is located approximately 35 km from Belet Xaawo along the Belet Xaawo-Geedwyne road. The village is located at longitude and latitude approximately 03^0 55' 12" N and 042^0 10' 12" E.

49.2 Physiography

The elevation of the village is 224 m a msl. The area is gently sloping towards the east generally to the south east in the direction of the drainage. It is undulating with elongated isolated hills. There are no seasonal rivers.

49.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well. However, the well serves the nomadic population for supply of domestic and animal water requirements.

49.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. The site has a large catchment extending westward in an area of over $30km^2$ There are no springs within or in the immediate surroundings of the investigated site.

49.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits. The upper part of the sub surface is comprising highly weathered and decomposed limestones.

49.6 Hydrogeology

49.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. Two shallow hand dug wells have been sunk by the local community in the area to depths of about 6 m bgl. The water level at the time of this investigation was about 5 m bgl.

49.6.2 Current Water Sources

The major source of water in the area is the two shallow hand dug wells The two shallow wells are being used for human consumption and animal watering. During extended drought, the water level in the wells decline.

49.6.3 Aquifers

Aquifers are expected to occur within the fractured and weathered limestones/sandstones.

49.7 Geophysical Investigations

One vertical electrical sounding (VES) was executed at a selected site near the existing wells. The VES was carried out in an attempt to reveal the existence of any aquifers and to explore the hydrostratigraphy of the underlying formations. In addition the VES would reveal the geological formations underneath and the quality of the geology for the construction of rain water harvesting facilities.

49.7.1 Resistivity Soundings

Interpreted results of the soundings are shown in the table presented below:

Table 50: Interpretation Results of VES 51

Depth (m)	Resistivity (Ohm-m)	Formation
0 - 0.4	254	Sandy top soil
0.4 - 4.4	89	Weathered limestones
4.4 - 20	35	Highly weathered limestones (with fresh water)
>20	250	Hard fresh limestones/sandstones

RE Resistivity (Ohmm) **DE** Depth (m)

The VES interpretation results indicate a 254 Ohm-m resistivity layer to a depth of 0.4 m bgl, comprising sandy top soils. underlain by a 89 Ohm-m resistivity layer to a depth of 4.4 m bgl interpreted to be weathered limestones. It is underlain by a 35 Ohm-m resistivity layer to a depth of 20 m bgl interpreted to be highly weathered limestones which has aquifers with fresh water. The bottom layer has a resistivity of 250 and is interpreted to be hard fresh limestones and/or sandstones with no aquifers.

49.8 Water Quality

The Ec of the shallow wells was measured to be 9300 and 8300 μS/cm for the two wells spaced approximately 1 km apart each other. The water quality is considered to be brackish, but nevertheless used for domestic and animal consumption

VES 51

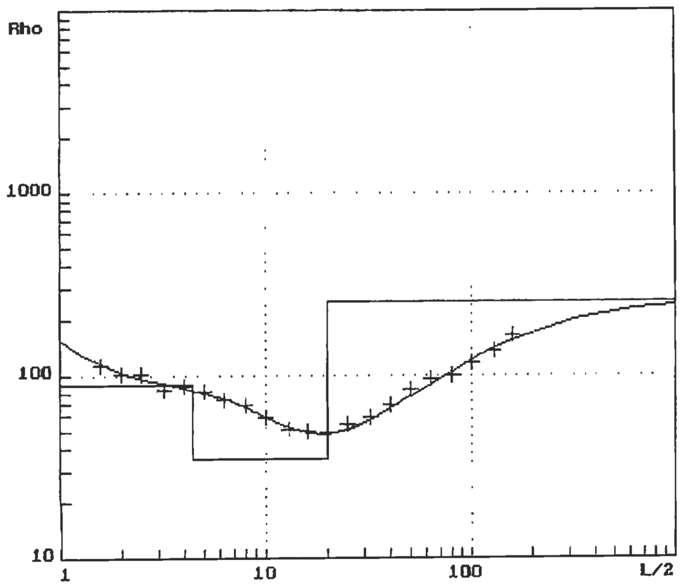


Figure 55 - Interpretation Graph for VES 51

49.9 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Bergini site is located in an area which is considered to have a medium groundwater potential. Both shallow and deep aquifers occur in the area. The shallow aquifer has high salinity due to high mineralization in the upper zone. Productive aquifers with potable water are expected within the sedimentary succession comprising weathered limestones up to a depth of about 35 m bgl.

In view of the above it is recommended that.-

1) A shallow hand dug well be constructed next to the existing one to a depth of approximately 20 m bgl. The well should be dug at 3 m diameter It is desirable to seal off the upper zone completely up to about 10 m bgl and digging should proceed to 20 m bgl.

50. GEEDWEYNE

50.1 Location

The village of Gedweyne is located within Dolow District, Gedo Region of Southern Somalia. The village is located approximately 56 km from Belet Xaawo along the Belet Xaawo-Geedwyne road. It lies approximately 35 km from Dolow along Dolow-Luuq road. The village is located at longitude and latitude approximately 04^0 01' 45" N and 042^0 17' 41" E.

50.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage towards river Juba. It is undulating with elongated isolated hills. There are no seasonal rivers.

50.3 Population and Water Demand

The population of the village comprise 300 permanent families. In addition an estimated 3000 nomadic families make use of the existing rainwater catchment for supply of domestic and animal water requirements.

50.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. The site has a large catchment extending westward in an area of over $20km^2$. There are no springs within or in the immediate surroundings of the investigated site.

50.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

50.6 Existing Water Resources

Three boreholes have been sunk within the village by the government of Somalia, Muslim Organization and the IRC, prior to 1990, 1993 and 1996 respectively. All these boreholes were salty and unsuitable for human consumption. No shallow wells have been dug in the area. A total of 4 rain water catchments have been dug in the village with dimensions of 50x30x1m each. The last time it rained sufficiently to collect water in the catchments was El nino rains 1n 1998. The catchments have been practically dry during this time. They are also silted up. The only source of water is river Juba, 8 km away where people fetch water using donkey carts.

50.6.1 Aquifers

Aquifers are expected to occur within the fractured and weathered limestones/sandstones. However, from previous drilling the deep aquifers are known to be saline and have water unsuitable for human consumption.

50.7 Conclusions and Recommendations

Based on the available information it is concluded that Geedweyn site is located in an area which is considered to have a poor groundwater potential. Both shallow and deep aquifers occur in the area but are highly saline for domestic or animal watering. The area receives too low rainfall and the existing rain water catchments have not had any water for a long time.

In view of the above it is recommended that

1) no expansion of the existing rain water catchments be undertaken. There is a reliable source of water from river Juba at fairly close proximity (8 km).

51. SINUJIF

51.1 Location

The village of Sinujif is located within Dolow District, Gedo Region of Southern Somalia. The village is located approximately 48 km from Dolow and 13 km from Geedweyne. The village is located at longitude and latitude approximately 03^{0} 53' 46.8" N and 042^{0} 15' 07.7" E.

51.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage. It is undulating with elongated isolated hills. There are no seasonal rivers.

51.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well. However, the well serves the nomadic population for supply of domestic and animal water requirements, estimated at 300 families.

51.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site.

51.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits. The upper part of the sub surface is comprising highly weathered and decomposed limestones.

51.6 Hydrogeology

51.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. One shallow hand dug well have been sunk by the local community in the area to a depth of about 6.3 m bgl. The water level at the time of this investigation was about 6 m bgl. The shallow well is in a fair condition.

51.6.2 Current Water Sources

The major source of water in the area is the shallow hand dug well. The shallow well is being used for human consumption and animal watering. During extended drought, the water level in the well decline.

51.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine th possibility of aquifer occurrence.

51.7 Water Quality

The Ec of the shallow wells was measured and described as "high" which means it is greater than 2000 μS/cm. The water quality is considered to be brackish, but nevertheless used for domestic and animal consumption.

51.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Sinujiv site is located in an area which is considered to have a poor to medium groundwater potential. A shallow aquifer occur in the area with a salinity higher than 2000 μS/cm due to high mineralization in the upper zone. The productive well is not in a good condition.

In view of the above it is recommended that:-

1) The shallow hand dug well be cleaned out and rehabilitated. This will include construction of the trough, drainage, apron and cylinder.

52. SINUJIF

52.1 Location

The village of Sinujif is located within Dolow District, Gedo Region of Southern Somalia. The village is located approximately 48 km from Dolow and 13 km from Geedweyne. The village is located at longitude and latitude approximately 03^0 53' 46.8" N and 042^0 15' 07.7" E.

52.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage. It is undulating with elongated isolated hills. There are no seasonal rivers.

52.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well However, the well serves the nomadic population for supply of domestic and animal water requirements, estimated at 300 families.

52.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site.

52.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits. The upper part of the sub surface is comprising highly weathered and decomposed limestones.

52.6 Hydrogeology

52.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. One shallow hand dug well have been sunk by the local community in the area to a depth of about 6.3 m bgl. The water level at the time of this investigation was about 6 m bgl. The shallow well is in a fair condition.

52.6.2 Current Water Sources

The major source of water in the area is the shallow hand dug well. The shallow well is being used for human consumption and animal watering. During extended drought, the water level in the well decline.

52.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine th possibility of aquifer occurrence.

52.7 Water Quality

The Ec of the shallow wells was measured and described as "high" which means it is greater than 2000 µS/cm. The water quality is considered to be brackish, but nevertheless used for domestic and animal consumption.

52.8 Conclusions and Recommendations

Based on the available .information and the geophysical investigations it is concluded that Sinujiv site is located in an area which is considered to have a poor to medium groundwater potential A shallow aquifer occur in the area with a salinity higher than 2000 µS/cm due to high mineralization in the upper zone. The productive well is not in a good condition.

In view of the above it is recommended that.-

1) The shallow hand dug well be cleaned out and rehabilitated. This will include construction of the trough, drainage, apron and cylinder

53. BOHOL

53.1 Location

Bohol site is located within Dolow District, Gedo Region of Southern Somalia. The site is located approximately 56 km from Dolow and 8 km from Sinujiv.

53.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage. It is undulating with elongated isolated hills. There are no seasonal rivers.

53.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well. However, the well serves the nomadic population for supply of domestic and animal water requirements, estimated at 300 families.

53.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site

53.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits. The upper part of the sub surface is comprising highly weathered and decomposed limestones.

53.6 Hydrogeology

53.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. Three shallow hand dug wells have been sunk by the local community in the area to depths of up to 8 m bgl. The water level at the time of this investigation was about 6 m bgl. The shallow wells are in a bad condition.

53.6.2 Current Water Sources

The major source of water in the area is the three shallow hand dug wells The shallow wells are being used for human consumption and animal watering. During extended drought, the water level in the wells decline.

53.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine th possibility of aquifer occurrence.

53.7 Water Quality

The Ec of the shallow wells was measured to be 1820 to 1920 µS/cm. The water quality is considered to be potable and suitable for domestic and animal consumption.

53.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Bohol site is located in an area which is considered to have a medium groundwater potential. A shallow aquifer occur in the area with a salinity less than 2000 µS/cm. The three existing productive wells are not in a good condition.

In view of the above it is recommended that.-

1) The three shallow hand dug wells be cleaned out and rehabilitated. This will include construction of the trough, drainage, apron and cylinder.

54. BABAA

54.1 Location

Babaa site is located within Belet Xaawo District, Gedo Region of Southern Somalia. The site is located approximately 52 km from Belet Xaawo town. The village is located at longitude and latitude approximately 03^0 45' 00.2" N and 042^0 10' 28.2" E.

54.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage. Several seasonal rivers are found in the area.

54.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well. However, the well serves the nomadic population for supply of domestic and animal water requirements, estimated at 700 families.

54.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site.

54.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

54.6 Hydrogeology

54.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. Two shallow hand dug wells have been sunk by the local community in the area to depths of up to 8.8 m bgl The water level at the time of this investigation was about 8 m bgl The shallow wells are in a poor condition.

54.6.2 Current Water Sources

The major source of water in the area is the two shallow hand dug wells. The shallow wells are being used for human consumption and animal watering. During extended drought, the water level in the wells decline.

54.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine the possibility of aquifer occurrence.

54.7 Water Quality

The Ec of the shallow wells was measured to be 1980 µS/cm. The water quality is considered to be potable and suitable for domestic and animal consumption.

54.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Babaa site is located in an area which is considered to have a medium groundwater potential. A shallow aquifer occur in the area with a salinity of 1980 µS/cm. The two existing productive wells are not in a good condition.

In view of the above it is recommended that:-

1) The two existing shallow hand dug wells be cleaned out and rehabilitated. This will include construction of the trough, drainage, apron and cylinder.

55. HARERITUR

55.1 Location

Hareritur site is located within Belet Xaawo District, Gedo Region of Southern Somalia. The site is located approximately 62 km from Belet Xaawo town. The village is located at longitude and latitude approximately 03^0 43` 59" N and 042^0 08' 13" E.

55.2 Physiography

The area is gently sloping towards the east generally to the south east in the direction of the drainage. Several seasonal rivers are found in the area.

55.3 Population and Water Demand

Information regarding the population was not available given that there is no settlement next to the well. However. the well serves the nomadic population for supply of domestic and animal water requirements, estimated at 1500 families.

55.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site.

55.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

55.6 Hydrogeology

55.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. Five shallow hand dug wells have been sunk by the local community in the area to depths of up to 22 m bgl. The water level at the time of this investigation ranged between 12.7 and 13.4 m bgl. The shallow wells are in a poor condition.

55.6.2 Current Water Sources

The major source of water in the area is the five shallow hand dug wells. The shallow wells are being used for human consumption and animal watering. During extended drought, the water level in the wells decline.

55.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine the possibility of aquifer occurrence.

55.7 Water Quality

The Ec of the shallow wells was measured to be 830 to 1360 µS/cm. The water quality is considered to be potable and suitable for domestic and animal consumption.

55.8 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Babaa site is located in an area which is considered to have a medium groundwater potential. A shallow aquifer occur in the area with a salinity of up to 1360 µS/cm. The five existing productive wells are not in a good condition.

In view of the above it is recommended that:-

1) The five existing shallow hand dug wells be cleaned out and rehabilitated. This will include construction of the animal troughs, drainage, apron and cylinder.

56. IRRIDDA

56.1 Location

Irridda site is located within Belet Xaawo District, Gedo Region of Southern Somalia. The site is located approximately 37 km from Belet Xaawo town. The village is located at longitude and latitude approximately 03^0 40' 45.4" N and 042^0 01' 23.3" E.

56.2 Physiography

The area is gently sloping towards the east generally to the south in the direction of the drainage. Several seasonal rivers are found in the area.

56.3 Population and Water Demand

The population of the village was approximated to 200 permanent families. It was reported that the nomadic population was high that rely on the existing shallow wells during transit. The well is used for supply of domestic and animal water requirements, estimated at 1500 nomadic families.

56.4 Hydrology

The mean annual rainfall ranges between 250 and 300 mm. Surface water sources in the area are not present and there are no seasonal streams. There are no springs within or in the immediate surroundings of the investigated site.

56.5 Geology

The site is underlain by limestones and older sedimentary rocks which are overlain at the surface by Recent superficial alluvial deposits.

56.6 Hydrogeology

56.6.1 Existing Shallow Wells

No boreholes have been sunk within the village. One shallow hand dug well has been sunk by the local community in the area to a depth of up to 10 m bgl on the river bed. The water level at the time of this investigation ranged between 4 and 6 m bgl. The shallow well is in a poor condition.

56.6.2 Current Water Sources

The major source of water in the area is the shallow hand dug well. The shallow well is used for human consumption and animal watering. During extended drought, the water level in the wells decline.

56.6.3 Aquifers

No geophysical measurement was executed at the site. It is therefore not possible to determine the possibility of aquifer occurrence.

56.7 Conclusions and Recommendations

Based on the available information and the geophysical investigations it is concluded that Irridda site is located in an area which is considered to have a medium groundwater potential. A shallow aquifer occur in the area with a water suitable for domestic and animal consumption.

In view of the above it is recommended that:-

1) The existing shallow hand dug well be cleaned out and rehabilitated. This will include construction of the animal troughs, drainage, apron and cylinder.

57. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

The studies carried out concludes that

- The groundwater resources in the area are quite variable, both in occurrence and quality.
- Fresh to brackish water can be found in some formations constituting the base of the alluvial deposits along dry river beds This water fluctuated in level through the seasons. Salinity in these aquifers also fluctuate a lot depending on the seasons.
- Potable water suitable for human consumption and animal watering is to be found in the deep aquifers. Proper hydrogeological and geophysical surveys are necessary to select sites for drilling or shallow well digging.
- Shallow hand-dug wells in the area have indicated that water quality changes rapidly within short distances. Water of fair to good quality is found along the dry river valleys and very close to the river banks or in the scarps bordering the flood plains. Chances of finding good water are better where the alluvial deposits have a high degree of permeability, resulting in an hydraulic connection between the river base flow water and groundwater
- Water of poor quality is found away from the river banks in the major toggas flood plain.
- River water recharges the shallow aquifer during rainy seasons. During dry seasons, there is still some base flow along the alluvial sediments in the river.
- Considerable changes in water quality and water type occur during the hydrologic cycle. In most cases water reaches high E.C values during the wet seasons in hand-dug wells. With the lowering of the water table during the dry season, water salt content in most wells becomes progressively low.
- Due to the limited thickness and the extension of the water bearing lenses, there will be a need for constant water quality and abstraction control once a water supply system is constructed.

Recommendations

The following is a summary of the recommendations for each investigated site as detailed below.

Name of Site	Current Water Source	Recommended Water Development Options	Alternative source
1. Belet Xaawo	S/wells, Daua river, waroh	S/well rehabilitation & protection	S/well, barkads
2. Caracase	S/wells	S/wells rehabilitation	b/h. S/well
3. Bursaqar	S/well	S/wells rehab & protection	S/well, b/h, RWC
4. Garbahaley	B/h	B/h	B/h
5. Buraal	S/wells	S/wells rehab & protection	B/h,
6. Seere	S/well, RWC	Digging of RWC	
6. Waradey	RWC	Digging of RWC	
7. Ceel Guduud	B/h	B/h	B/h
8. Ceel Cade	B/h	None	B/h
9. Fan Weyne	S/wells, RWC	S/wells, RWC rehabilitation	b/h. S/well
10. Dubaa	S/well, RWC	S/wells rehab & protection, new RWC	S/well, b/h, RWC
11. Deqfuley	RWC	RWC rehabilitation	
12. Daar	S/wells, RWC	S/wells and RWC rehab, new S/well	B/h
13. Badheere	River Juba	Rehab of city water supply	B/h, S/wells
14. Jungle	S/well. natural dam	New agro well	earth dam, B/h, /well

Note : rehab - rehabilitation **b/h** - borehole **S/well** - Shallow well

Name of Site	Current Water Source	Recommended Water Development Options	Alternative source
15. Tarako	RWC	Rehabilitation of RWC	
16. Fafadun	S/wells. RWC	New B/h	RWC, S/well
17. Abdikhayr	RWC	RWC rehabilitation	
18. Darasalaam/Kurdo	RWC, S/well	2 new B/h. RWC rehab.	S/well. RWC
19. Bakhtiley	RWC	RWC rehab	-
20. Gariley	RWC	Rehab of RWC	-
21. Cawsqurin	S/well	-	B/h
22. Warey	RWC	RWC rehab	B/h
23. Hargasow	RWC	RWC rehab	B/h
24.Ceel Wak	S/wells	-	-
25. Samarole	S/wells	S/wells rehab & protection	B/h. b/h. RWC
26. Garsaal	S/wells	S/wells rehab	
27. Bussar	S/wells	S/wells rehab & protection	B/h,
28. Muudale	RWC	Digging and rehab of RWC	B/h
29. Ceel Add	S/well	S/wells rehab. new S/well	-
30. Welmarer	RWC	RWC rehab. New agrowell	B/h, S/well
31. Tuulo Burowaaqo	B/h	B/h rehab.	-
32. Maykareebey	B/h, S/well	S/wells rehab	S/well, b/h rehab
33. Daabley	S/well, spring	S/well rehab. new s/well, 3HP	B/h
34. Haramandera	RWC	New B/h	-
35. Daso	Barkad, RWC	Rehab of RWC. New B/h - 1 HP	S/well
36. Dhamasse	B/h	Drilling new B/h, rehab of B/h	-
37. Al Wheele	RWC	RWC rehab	B/h
38. Dadhable	RWC	RWC rehab	B/h
39. Yaqle	RWC	RWC rehab, New B/h	
40. Gadoon Dhawe	S/wells	S/wells rehab & protection	S/well, b/h
41. Khadijo Xaaji	B/h	B/h rehab. barkad rehab	-
42. Bergini	S/wells	S/wells new	B/h,
43. Geedwyene	RWC	None	-
44. Sinujif	S/wells	rehab of S/wells	-
45. Bohol	S/wells	rehab of S/wells	-
46. Babaa	S/wells	rehab of S/wells	-
46. Hareeritu	S/wells	rehab of S/wells	-

Note : **rehab** - rehabilitation **b/h** - borehole **S/well** - Shallow well

Rainwater Reservoirs

Barkards have been developed as an alternative source of water during the dry season. A barkard consists of a rectangular hand-dug underground reservoir lined by cement constructed by local people and privately owned. Run-off water is collected by means of hand-dug furrows leading into the tank with a capacity of 10 to 100 m^3. Hygienic conditions of barkads are very poor with insects, dust, and dead leaves having an access into the tank. Thus it is imperative that the tanks are properly protected.

Boreholes

Drilling of boreholes in this region is subject to proper planning aimed at distributing the water sources according to the grazing capacity of the various areas. In the alluvial sediments on dry river beds, the average depth of boreholes varies between 50 and 100m. Deeper boreholes are expected at higher grounds.

As an alternative water source, boreholes may be drilled at some of the sites indicated above. Drilling methods appropriate to the various hydrogeological conditions should be employed although rotary drilling is the most appropriate in the Gedo Region.

The main constraint of drilling successful wells is the water quality, which in large areas is very poor and unsustainable for people and livestock. However, with detailed geophysical investigations, it is possible to delineate fairly accurately areas with low salinity levels.

It is imperative that during drilling, the electrical conductivity is closely monitored in order to identify saline water saturated aquifers. These should be sealed completely during borehole installation.

Well Construction

Digging of the well should be done until sufficient water is struck. If the upper zone of the aquifer is saline, it should be sealed off using cement in the annular space. Well rings (culverts) should be used to line the well to ensure centrality within the borehole. This is particularly important to insert the artificial gravel pack all around the screen. Once the gravelpack covers the productive fresh water aquifer, the remaining annular space should be backfilled with an inert material, and the top three metres grouted with cement to ensure that no surface water at the well head can enter the well bore and thus prevent contamination.

Chemical Water Quality

In order to be sure about the water quality and its suitability for human consumption, a water sample should be submitted to a qualified laboratory for a complete chemical analysis.

Well Testing

After completion of the well, it will be necessary to perform a well test to determine the well performance.

58. REFERENCES

DRISCOLL F.G., 1986. Groundwater and Wells, 2nd Ed. Johnson Division.

FAILLACE C & FAILLACE E R, 1986. Water Quality Data Book of Somalia: Hydrogeology and Water Quality of Northern Somalia Volume II. Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ) GMBH, Water Development Agency (WDA),Somalia.

EARTH WATER LTD, 1997. Borehole Site Investigations, Adale, Somalia. ADRA Somalia

EARTH WATER LTD, 1999. Borehole Site Investigations, Bergadid, Fidow, and El Bilal, Somalia. ADRA Somalia

EARTHWATER LTD, (2000) - Geophysical and Hydrogeological Investigations, Bur Weyn, Jalalaqsi District, Hiran Region, Somalia. ADRA SOMALIA

FAILLACE C. AND FAILLACE E.R., 1986. Hydrogeology and Water Quality of Central Somalia, Water Development Agency, Somalia; GTZ Project No. 80.2193. 3-09.112

FAILLACE C. AND FAILLACE E.R., 1986. Hydrogeology and Water Quality of Southern Somalia, Water Development Agency, Somalia; GTZ Project No. 80.2193. 3-09.112

GHOSH, D P (1971) - Inverse filter coefficients for the computation of apparent resistivity standard curves for a horizontally stratified earth. *Geophysical Prospecting. v. 19. pp. 769-775*

MINISTRY OF WATER ENERGY AND MINERALS, (1968) - Groundwater and Mineral Sources of Somalia. UNDP, 1968.

WILLIAMS, E., 1996. Study for the Rehabilitation of Infrastructure, Water Supply and Sanitation In Gedo Region, Somalia, Vol. 1 and 2; Rehabilitation Programme for Somalia, Project No. 6.SO.82. European Commission Somalia Unit

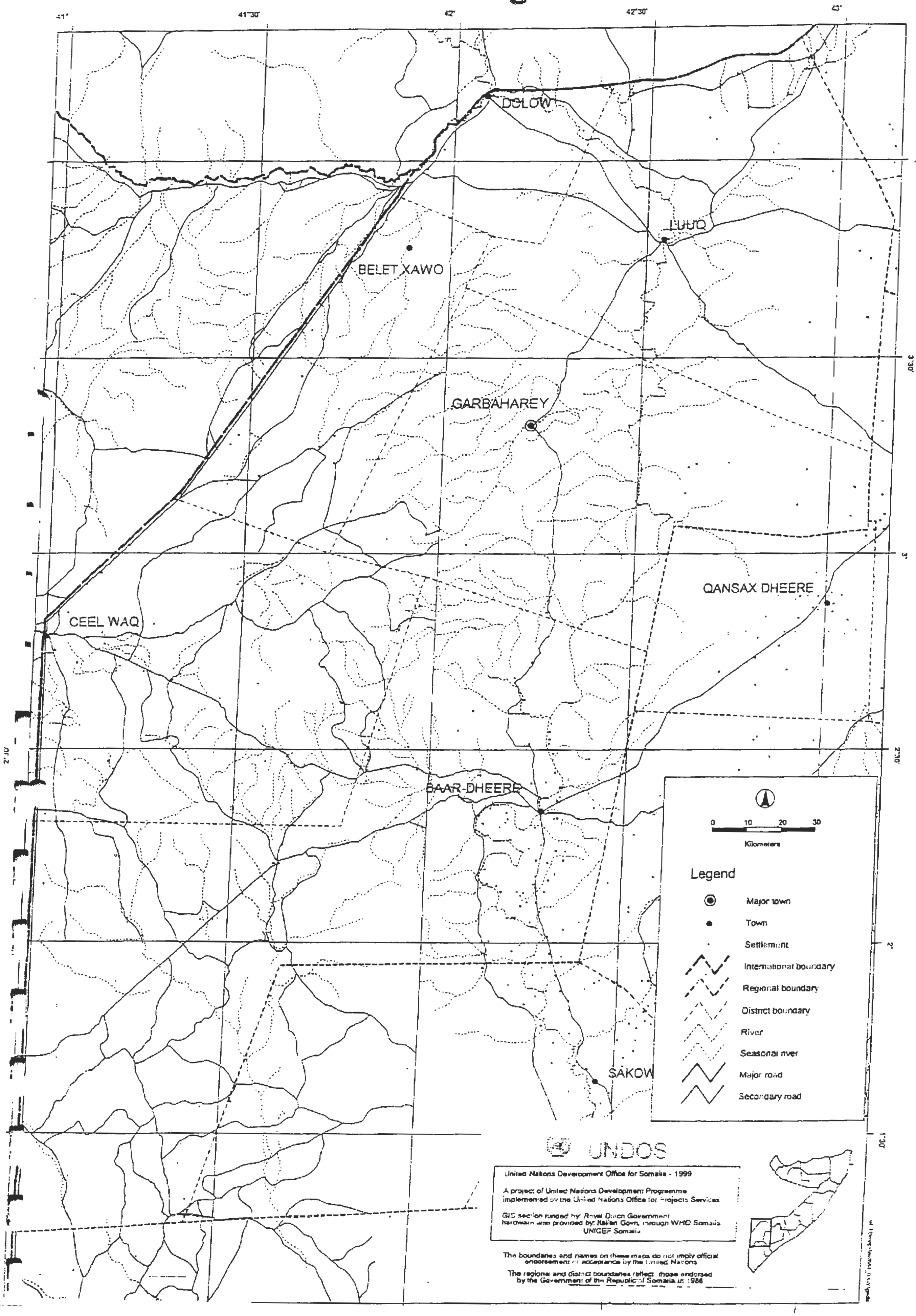
European Commission Somalia Unit
Final report volume -1 and 2.
Project Title .REHABILITATION PROGRAMME FOR SOMALIA
Project No. 6.SO.82
Contract No. 103-STA-W15-96
Contractor. Evan Williams

APPENDICES

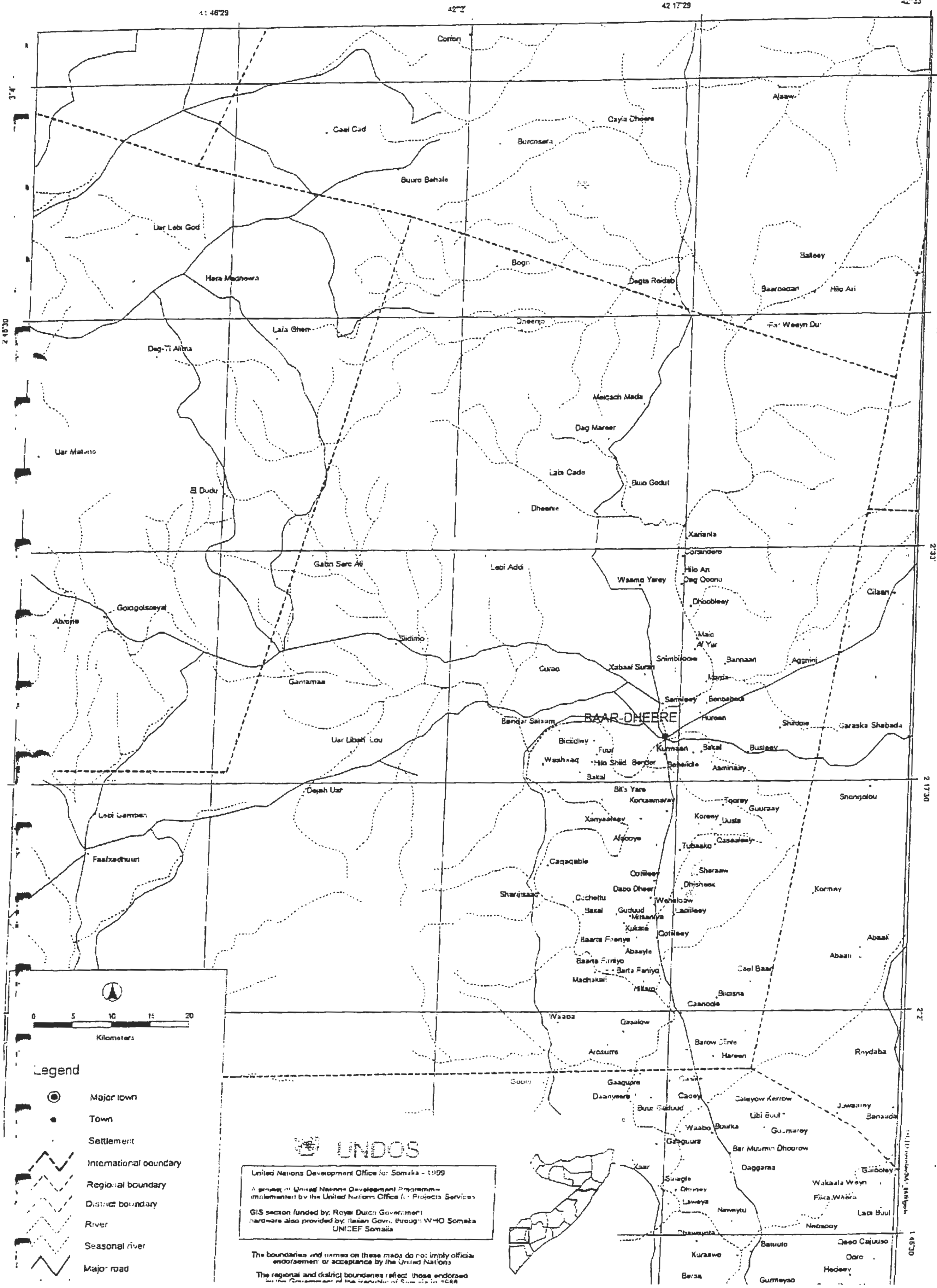
APPENDIX 1

MAPS FOR GEDO REGION

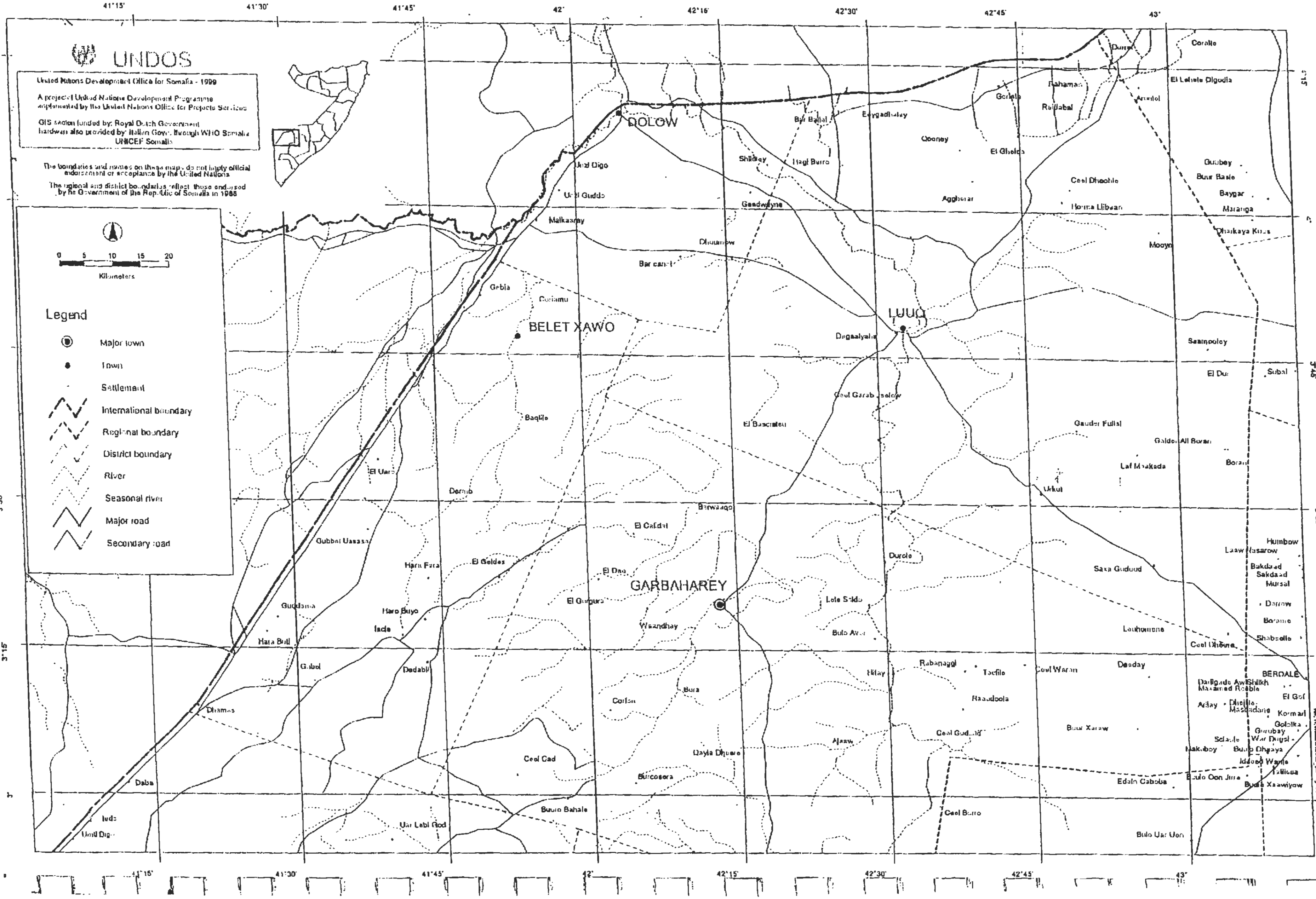
Gedo Region


41°
41°30'
42°
42°30'
43°
4°
3°30'
3°
2°30'
2°
1°30'
DOLOW
LUUQ
BELET XAWO
GARBAHAREY
QANSAX DHEERE
CEEL WAQ
BAAR-DHEERE
SAKOW
0
10
20
30
Kilometers
Legend
Major town
Town
Settlement
International boundary
Regional boundary
District boundary
River
Seasonal river
Major road
Secondary road
UNDOS
United Nations Development Office for Somalia - 1999
A project of United Nations Development Programme
implemented by the United Nations Office for Projects Services
GIS section funded by: Royal Dutch Government
hardware also provided by: Italian Govn. through WHO Somalia
UNICEF Somalia
The boundaries and names on these maps do not imply official endorsement or acceptance by the United Nations
The regional and district boundaries reflect those endorsed by the Government of the Republic of Somalia in 1986

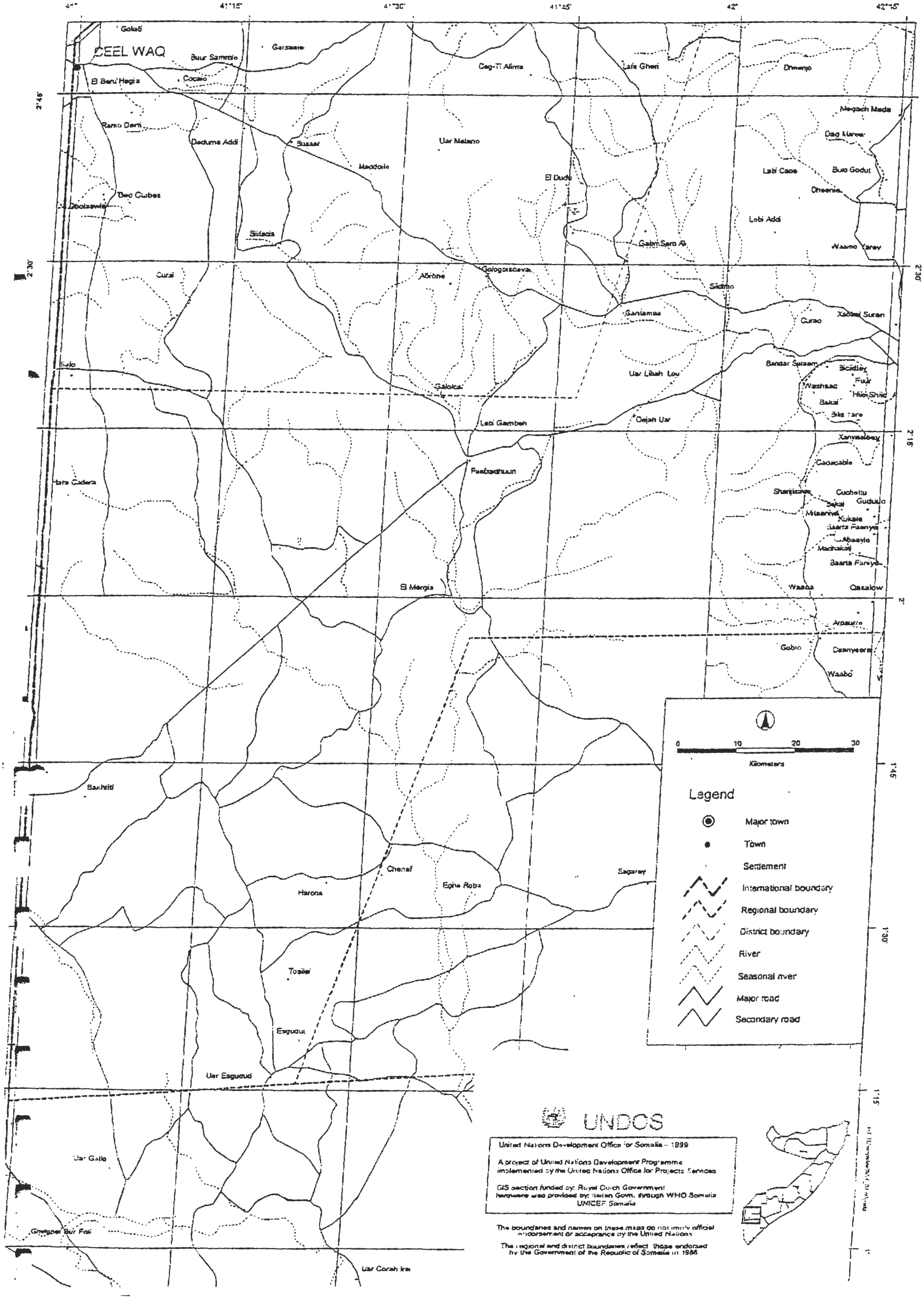
Gedo Region: Baar Dheere District



Gedo Region: Northern Districts



Gedo Region: Southern Districts

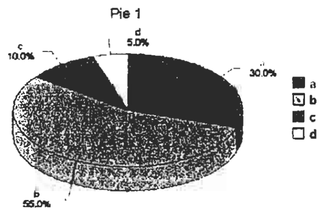


APPENDIX 2

REGIONAL PROFILE - GEDO

Region profile - Gedo

7 districts: Bardera, Belet Hawa, Burdhudo, Dolo, El Waq, Garbaharey and Luuq
Four main food economy groups: (a) southern agro-pastoral, 25-35%, (b) southern pastoral, 50-60%, (c) riverine, around 10%, and (d) urban at around 5%.
No profile is available for the urban group
Generally there is a decreasing trend of vulnerability north to south, due largely to climatic reasons.



• population figures: UNDOS estimate 385 000 in 1998.

Socio-political context and affiliation

Agro-pastoralists in Gedo are more closely integrated with their pastoralist neighbours than further south in Somalia. The east bank of the Jubba is occupied largely but not exclusively by groups identified with the Rahanweyn. West bank of the Jubba is dominated by pastoral clans affiliated with the Darod, notably the Marehan (and the Ogaden branch further south). Although the Darod have historically shown an aversion to cultivation, agro-pastoralism has began to be used as an adaptive strategy over the past 50 years. West bank agro-pastoralism tends to be opportunistic and less regimented than on the east bank where agro-pastoralism has been practised for several centuries. The Marehan had strong kin-based and political ties with Mogadishu before 1991. Political connections have, in the past, favoured the economic gains of west bank pastoralists and agro-pastoralists. During 1991-2 many urban Marehan moved back to northern Gedo and lay claim to land. The clan dominates both social and political activities in the region.

The recent background of conflict and relief

Although Gedo has been affected by the same forces that shaped the down river regions of southern Somalia, the region also differs in particular ways. Government intervention was always more limited pre-war and the influence of international borders (Kenya and Ethiopia) is strongly felt in Gedo. Varying market possibilities in Mandera greatly affects the livelihoods of pastoralists in Gedo, there is also trade of commodities such as clothing from Somalia to Kenya across the border. 1991 and 1992 saw an influx of approximately 60,000 Somali refugees (fleeing both drought and war in Somalia) in Mandera district, Kenya. Insecurity in Bay and Bakol leads to population movement into Gedo.

The region experienced periodic unrest between 1998-2000 with regular inter-clan fighting exacerbated by changes of control between the Al-Itihad, Massale and Burale groups of the SNF, with Ethiopian involvement. A rift within the Somali National Front (SNF) led to fighting for control of Luuq in 1999. It has been a common practise to cross over the border into MSF Spain's feeding centres in Mandera, Kenya (for example during December 2000 over 70% of those attending the centres were from Somalia). The feeding centres closed in May 2001. Following the March 2001 interclan conflict in Bulla Hawa district of Gedo region large numbers of people moved into Mandera district in northern Kenya. Recent reports put this number at 5-7 thousand.

Production information

Following climatic shock and successive crop failures that have hit southern Somalia as a whole, the Gu 2000 harvest was poor in the Juba valley (Lower Jubba, Middle Jubba and Gedo) in contrast to the good harvests in Bay and Bakol. Sorghum production in Gedo was 51% of the post-war average. Production of irrigated maize was above the post-war average according to FSAU figures for the 1999/2000 Deyr harvest. Rainfed production in Gedo suffered as in Bay region. The overall cereal availability was much higher in 2000 than in 1999. Good production in Gedo was supported by good production in the Bay region. Crops in rainfed fed areas in 2001 are suffering the same problems in Gedo as in Hiran, Bakol and Bay. Prospects for an average Gu season are poor. Increased fuel prices have affected irrigation but crop condition presently fair.

In northern Gedo in general the contribution of agriculture is small, more important in Dolo than in Bulla Hawa. Gedo is, in a 'normal' year, drier than the lower and middle Jubba regions, drier also than Bakol and Bay regions. Rainfed sorghum production has in the past been the main crop in Gedo, however over recent years (particularly the last 2 years) maize has become increasingly important both as food and as cash crop. Although rainfed sorghum has suffered from the same problems as in Bay and Bakol region, irrigated agriculture is also practised in Gedo region, both maize and vegetable crops are grown. Potential for the highest agricultural incomes in the Jubba valley are found in Gedo.

Irrigated agriculture in Gedo
from
Craven, Merryman and Merryman 1989 Jubba Environmental and Socioeconomic Studies, *vol 3:Socioeconomic Studies* Associates in Rural development. Vermont.
Merryman 1996 The economy of Gedo Region and the Rise of Smallholder Irrigation in (eds) Besteman and Cassanelli *The Struggle for Land in Southern Somalia. The War Behind the War* Westview Press. London p73-90.

No more than 10 percent of Gedo agro-pastoral households had irrigated plots in 1988. Gedo's riverine homesteads are dispersed longitudinally along the river. The flood plain (except in the north of Luuq) is extremely narrow or non-existent, helping to explain to adoption by the riverine farmers in Gedo, of pump irrigation technology (portable diesel pumps) since the early 1970's. The tradition of irrigation is, however, considerably older. In the 1980's agricultural plots of riverine groups averaged 8 hectors, more than twice the mean plot size for the middle and lower Jubba regions. Agricultural income was three to four times greater. The increase in irrigation prompted Gedo farmers to take up cash crops, mainly onions and tomatoes. By 1988, 42% of riverine households sampled in fieldwork from which the above documents were produced, had irrigated plots. This is in contrast to 4% in the middle Jubba region.

It is unclear to what extent the conflict in the area has affected irrigated agriculture, but it is suggested to be great; due to conflict in the vicinity, destroyed pumps, looting, loss of access to fuel etc. The El Nino floods of 1997/8 appear to have resulted in a heavy loss of pumps which where either destroyed or have not been repaired. GTZ estimates suggest that the number of pumps in Bardhere district pre 1990 may have been around 1000; SCF estimates for 1996 were 350-500. FSAU wealth group characteristics, in terms of pump ownership, suggest that the figure may have risen again considerably despite El Nino.

units of measurement

- 100g of cereal - *quintal*
- 8.3 *tacab* = 1 ha of land

Nutrition surveys in Gedo (in z-scores) as recorded by FSAU

organisation	date	district and target group	GAM	severe
UNICEF	Aug. 1999	Bardera - town	23%	5.5%
ACF	April 2000	Luuq - town	14%	1.9%
ACF	April 2000	Luuq - IDP's	20%	4.2%
UNICEF	May 2000	Beled Hawo - district	21.5%	3.5%
UNICEF	Sep. 2000	Burdhudo	17%	3%

Severe Acute Malnutrition: Weight/Height < -3 Z-scores and/or oedema
Global (Total) Acute Malnutrition (GAM): Weight/Height < -2 Z-scores and/or oedema
All surveys listed have reportedly followed SACB Nutrition Survey Guidelines.

Food economy profile: Southern agro-pastoral

Note for comparison and use with other sources. 'the southern agro-pastoral food economy group' corresponds with the 'agro-pastoral: camel. cattle and sorghum' FEG together with 'Bay-Bakol, high potential' of the most recent FSAU mapping (March 2001- see map included [note that this doesn't correspond to all previous FSAU FEG profiles]) and a combination of the agro-pastoral (farming) and agro-pastoral (livestock) of the SCF-UK/FSAU 1999 profiles. Lastly this group may be compared to the SCF/UK 1998 profile 'agro-pastoral'.

General profile:

Southern agro-pastoralists may emphasis either livestock or farming. In general, the greater the focus on livestock the less intensive the farming. Variations exist within the FEG in terms of livestock composition, types of crops grown and market dependence. Camels, cattle and shoats are all found in this FEG. Cattle holdings will, in general, decrease as one moves further away from rivers while shoat and camel holdings increase.

The majority of farming among this group is rain-fed. Sorghum is the main crop with some maize. Some households grow cowpea or mung bean (inter-cropped with sorghum) and may plant tomatoes and sesame. Although sorghum is the main crop there may have been an increase in maize production since around 1990. Small scale well irrigation is found in some locations and some seasonally rain flooded land.

Cereal production for this group is dependant on the type of land owned. High-yielding land and land producing moderately good yield is expensive to purchase. These are areas of *potential* surplus in both 'normal' and good years. Land with poor yields (generally that which has been cultivated over many generations) may not produce yields sufficient for household consumption. As noted above the FSAU consider those in the high potential areas (mainly found in Bay) to be a separate FEG. The main differences between those in high potential areas and other areas are as follows: those in high potential areas are, in general, more dependant on crops than livestock. Although soil is of better quality in these areas and they receive more rain, households may have fewer livestock and therefore be more vulnerable when harvests fail.

Livestock makes a significant contribution to the food economy of agro-pastoral households. Livestock provides an alternative source of food and potentially, particularly for the middle and better-off wealth groups, an income source. In a 'normal' year households with limited livestock numbers will avoid selling livestock. As a very general rule, while amount of land cultivated *may not* always differ between wealth groups, livestock holdings do differ significantly. Therefore livestock is usually considered the clearer indicator of wealth.

Some risks and vulnerabilities and constraints:

- erratic and below-normal rain fall during growing season
- crop pests, disease and bird attacks
- conflict-induced asset depletion of immobile assets
- trade disruptions
- lack of farm inputs

The FEG as a whole is generally considered resource-poor with little access to remittances and limited community support. Of the southern agro-pastoral FEG the communities who concern themselves more with livestock than farming (and therefore tend to have larger livestock herds) tend to have a larger better-off wealth group than the communities who's concern emphasises farming over livestock.

Profile by wealth group:

The percentage of agro-pastoral households in each wealth group stated here is an average collected from different sources available and should be considered a rough approximation. The very poor wealth group is between 5 and 15% of the agro-pastoral FEG, the larger percentage is more likely to be found within agro-pastoral communities which have small livestock holdings and concern themselves mainly with farming. The same applies to the poor wealth group (including the very poor) which has been estimated at between 25-50 percent of the total. The middle wealth group is seen to be between 30-60%, the higher percentage within communities with higher livestock holdings. The better-off wealth group between 5-20% with the same general rule applying.

	very poor	poor	middle	better-off
livestock	very few or none	0-5 cattle, 0-3 camels, 2-5 shoats • may be less in high potential areas	4-6 camels 6-8 cattle 10-15 goats 5-7 sheep •may be less in high potential areas	15+ camels, 15+ cattle, 50-100 shoats •will be less in high potential areas • employ labour for herding
land	• rent or borrow poor quality land • little time available for own farming	• own land • cultivate 1-3ha	• own land • cultivate 4-7 ha • employ agricultural labour	• own land •4-6 ha cultivated • employ agricultural labour
support networks	• weak, often having no relatives locally	• relatives locally	• local and non-local • some remittances	• local and non-local • some remittances
migration	• most likely to migrate in search of work	• likely to migrate in search of work	• seasonal migration by some family members with herds	• seasonal migration by some family members with herds
employment	• agricultural and herding labour	• agricultural and herding labour		
self-employment	• most dependant on income generating activities • collection and sale of bush products	• dependant on income generating activities • as for very poor	• sale of own production • investments in petty trade	• sale of own production including livestock and livestock products • investments in petty trade
mitigation possibilities/ coping mechanisms (themes rather than exhaustive)	• more bush product collection/sale • more seeking of employment • migration to other zones	• as very poor • selling or consumption of shoats	• sale of livestock • remittances • consumption of "cash crops" within the h/h	• more sale of livestock • remittances • consumption of "cash crops" within the h/h
main food sources	• limited own production, more than 50% of food must be purchased • relief	• limited own production, need to purchase • relief • gifts from relatives/relief	• mainly from own production • small proportion from purchase	• purchase and production

Food economy profile: Southern Pastoral

Note for comparison and use with other sources: 'the southern pastoral food economy group' corresponds with the 'pastoral: camel and shoats' FEG of the most recent FSAU mapping (March 2001- see map included [note that this doesn't correspond to all previous FSAU FEG profiles]) and the 'pastoral' group of the SCF-UK/FSAU 1999 profiles and the SCF-UK 1998 profile.

General profile:

Pastoralism in Somalia requires constant or periodic movement in search of pasture and water. Pastoralists do engage in supplementary economic activities, such as cultivation and trade and nearly always consume products that they do not produce themselves. Increasingly, and out of necessity, many pastoralists are becoming dependant on supplementary activities, particularly cultivation where possible and for this reason the dividing line between the 'southern pastoral' and 'southern agro-pastoralist' is not clear cut. Some of the 'southern agro-pastoral' group have been combining cultivation and livestock for generations, others have 'fallen out' of the 'pure pastoralist' system as livestock numbers became to small to sustain them. Such households have begun to combine cultivation and herding through necessity or have joined the agro-pastoralist group with the profile of the poorest members of that group - with very little or no livestock.

This group depend heavily on livestock, mainly goats and camel[1] both economically and because livestock, particularly camels, play a prominent role in socio-cultural relations. Livestock suffers during dry periods due to the poor state of the pasture and dry water catchments. Pressure on resources means that pastoralist communities are prone to be involved in violent conflict over access to pastures, water sources and raiding. Average livestock holdings are higher than for agropastoral and riverine FEG's. However, due to consecutive drought and civil strife, which resulted in big livestock losses, holdings are lower than normally expected for this FEG. Herd splitting during dry seasons or drought is a common strategy for those with larger holdings - strong animals of different species may be sent long distances to where water or pasture availability is better.

Where pastoralists have been able to sustain their herds, households will tend to accommodate supplementary activities to the demands that animal husbandry makes. In the pastoral areas some shifting cultivation of small quantities of sorghum, cowpeas and maize is practised. Families may be split in order to accommodate supplementary activities such as the search for employment opportunities in urban areas or overseas (access to remittance for this group is considered high in comparison to other FEG's in southern Somalia). Family splitting also occurs in times of hardship when members of the family may be sent to live with relatives either inside or outside the FEG and geographical zone.

Urban centres and agro-pastoralist communities are important to the southern pastoral food economy group who need to trade. 'Good connections and relations' are said to exist between this FEG with non Bantu agro-pastoralist but nothing is documented detailing these relationships. In general terms the pastoralist group are seen to belong to the larger, more powerful sub-clans in the area and can rely on a strong network of support and obligation and thus on access to credit or loans. The group is also involved in trans-border commercial activities with or via related pastoralist groups.

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[1] FSAU has identified pastoralist communities that keep cattle has their main stock rather than camels. The location of these communities appears on the FASU Food Economy Group map in areas marked 'Pastoral: cattle and shoats'. Little has been documented regarding this FEG to date, apart from that all wealth groups appear to have larger livestock holdings than other southern pastoralists and the better-off wealth group includes some camels in their holding.

Some risks and vulnerabilities and constraints.

- restricted grazing mobility due to insecurity
- conflict/drought induced asset depletion
- population expansion and sedentarisation
- poor livestock health care systems
- volatile fluctuations in livestock and food prices
- any diminished purchasing power on the part of the agro-pastoralists

The livestock ban

The livestock ban imposed by Saudi Arabia and other Gulf states has had/is having limited impact on the southern part of Somalia. 70-75% of the total number of livestock in Somalia is found in the central and northern areas where the impact of the livestock ban has been great. The impact has been mitigated to some extent in the south by the use of internal markets and markets in Ethiopia and northern Kenya.

The southern pastoralist FEG is generally seen as less vulnerable than the agro-pastoralist group. This is based partly on the assumption that their livestock holdings (larger than those of the agro-pastoralists) act as an 'insurance policy' against hard times, in that they can be sold or exchanged against food. Wealth is determined by livestock ownership and pastoralists aim to own animals in excess of the requirements of daily subsistence. Without this excess or at the very least enough livestock for daily subsistence, a household or group of households would be, by definition no longer part of this FEG unless supported by other members within it together with income generating activities and possibly through remittance from other family members. What is clear, is that the poorer wealth group cannot sustain themselves solely with their limited livestock holdings. The ability of the community to cope with supporting a group of households of this size (FSAU puts the poor wealth group at 20-30% of the total population) and the rate of 'drop out' from the pastoralist FEG needs to be researched further.

Profile by wealth group:

Because this FEG is seen as less vulnerable than other FEG's in the area, there is less information available about them. Wealth group characteristics in terms of livestock holdings below come solely from the FSAU baseline profile and it has not been possible to cross-check the information with other sources. Some of the notes on coping strategies are from general knowledge about pastoralists rather than research on this specific group.

	very poor	poor	middle	better-off
livestock	to be completed	2-3 camels, 2-3 cattle, 5-10 shoats	20-30 camels 3-5 cattle 20-35 shoats	50-60 camels, 5-10 cattle, 20-30 shoats • employ labour for herding
support networks	• weak, often having no relatives locally	• relatives locally	• local and non-local • remittances	• local and non-local • remittances
migration	• seasonal migration with herds (not nec. own)	• seasonal migration with herds (not nec. own)	• seasonal migration with herds	• seasonal migration with herds
employment	• agricultural and herding labour	• agricultural and herding labour		
self-employment	• most dependant on income generating activities • collection and • sale of bush products - firewood, charcoal building poles • sale of honey and wild foods	• dependant on income generating activities • as for very poor	• sale of own livestock and livestock products	• sale of own livestock and livestock products
mitigation possibilities/ coping mechanisms themes rather than exhaustive	• more bush product collection/sale • more seeking of employment • migration of family members to other zones • sale rather then consumption of milk	• more bush product collection/sale • more seeking of employment • borrowing and credit increase • migration of part of family to other zones • selling or consumption of shoats • sale rather than consumption of milk	• sale of livestock • herd splitting • remittances	• more sale of livestock • herd splitting • remittances
main food sources	• most food needs obtained by exchanging livestock products for cereal, sugar and oil (85%).	• most food obtained through exchanging livestock products for cereal, sugar and oil (85%)	• own production and purchase	• purchase and production

Food Economy Profile - Riverine

Note for comparison and use with other sources: the 'riverine food economy group' presently corresponds to the FSAU Hiran riverine and the Jubba pump irrigated FEG in combination. It has been written with the riverine communities in Gedo and Hiran in mind. There are other riverine communities in southern Somalia and as the region profiles of these area have not yet been written. it remains to be seen whether these other groups can/should be included in this FEG.

General profile:

The general characteristics of this group are as follows: the main food source and source of income comes from crop production. Livestock holdings are lower than for both the pastoral and agro-pastoral groups. Most of this group have never had livestock in the numbers held by pastoralists or even agro-pastoralists, while some of the riverine group are ex-pastoralists who have lost herds. Looting has also been concentrated in many riverine areas and trypanosomiasis is often a problem along rivers which makes restocking high risk.

A more diverse range of crops are grown by this group than by the agro-pastoralists and the group concern themselves in the main with irrigated agriculture. Most of the riverine group practise supplementary irrigation and access to pumps is a limiting factor for irrigated production. There are a number of ways in which land is cultivated. generally it is some kind of sharecropping system. The pump/land owner may advance food to the sharecropper. When the crop is harvested it is split 50:50 between the sharecropper(s) and the pump/land owner and the sharecropper would pay back the food that was advanced. The pump/land owner will generally provide inputs such as seed and fuel. Many riverine households own fruit trees, the fruit providing additional food and income source.

Middle and better off wealth groups can be expected to farm both rain fed and irrigated land. Assuming *a harvest from rain* fed areas, a middle income household will be able to acquire most of their cereal requirement from rain fed production and irrigated areas would be reserved for cash crops. The middle and better off households within this FEG are generally considered relatively secure. Poorer households will not be able to cultivate rain fed land and irrigated land but will concern themselves with irrigated land only. Access to other income generating activities will be similar to those of the urban poor. The combination of irrigated farming and other income generating activities leaves them more secure than either the urban or agro-pastoralists with no access to irrigated land. The very poor do not own land. rather borrow, rent or sharecrop where possible.

Some risks and vulnerabilities and constraints.

- violence and economic exploitation
- lack of capital to purchase fuel, labour and pumps
- high production costs and low market prices for produce
- lack of available land or secure tenure
- lack of access to and maintenance of irrigation infrastructure
- seasonal flooding
- limited access to markets

The major differences between riverine communities in Gedo and Hiran are as follows: those in Gedo appear to own much larger areas of land than in Hiran, have more access to pumps and are more likely to own pumps. In Hiran households are more likely to own livestock, including cattle, than those in Gedo and therefore have access to milk at least for household consumption.

Profile by wealth group:

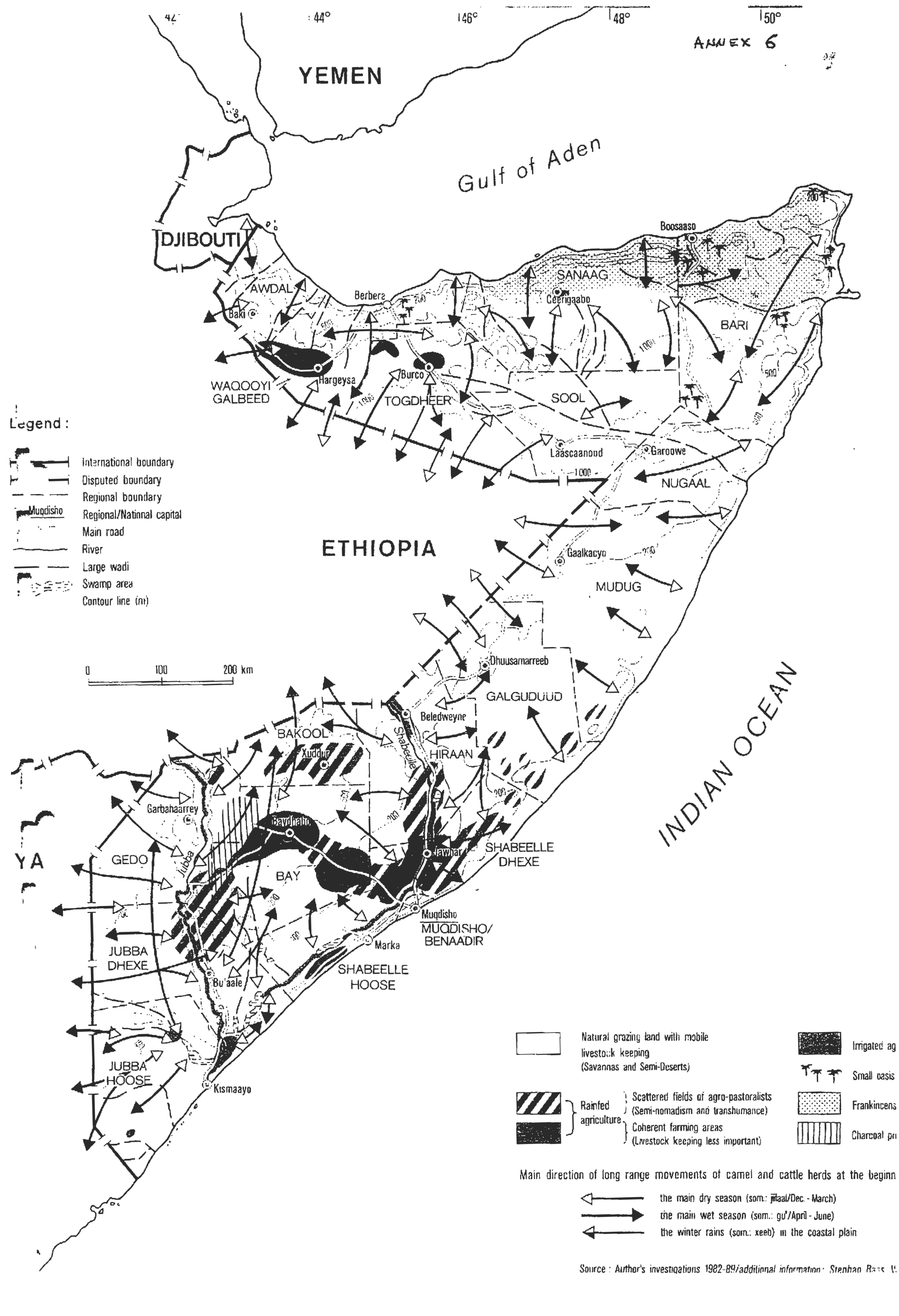
The percentage of this FEG in each wealth group is estimated as follows. poor 30-40%, middle 50-60% and better off 5-15%. It is likely that the better off group is slightly larger in the Gedo area than in Hiran.

	poor	middle	better-off
land and pumps	• predominantly sharecrop • may own small piece of land	• may own or rent pumps (very unlikely to own in Hiran) • pump owner may link up with a land owner • up to 15 ha of land in Gedo • 1.5-3 rainfed. .5-1.5 ha irrigated in Hiran • employ agricultural labour	• 1-3 pumps owned in Gedo, 5% of the total population owning pumps in Hiran • up to 20 ha of land in Gedo • 3-6 rainfed, 2-3 ha irrigated in Hiran • employ agricultural labour
livestock	• few or none	• Hiran - 3-5 cattle, 10-15% shoats • Gedo - few or none	• Hiran - 5-10 cattle, 20-25 shoats • Gedo - may own cattle kept with kin inland
support networks	• weak particularly for Bantus	• stronger for non-Bantus than Bantu • good access to credit/loans	• stronger for non-Bantu than Bantu • good access to credit/loans and to remittance
employment	• agricultural labour (more so in Hiran)		
self-employment	• sale of honey (Hiran) • sale of crop residue for fodder • collection and sale of bush products •sale of cereal (to make purchase or settle a debt not because there is excess cereal)	• sale of cereal • sale of milk (Hiran) • collection and sale of bush products with aid of donkey cart • cash crops	• sale of cereal • sale of milk • cash crops
mitigation possibilities/ coping mechanisms (themes rather than exhaustive)	• increased self-employment • increased labouring • increased seeking of credit/loan • increased wild food consumption and sale	• some remittance (non-Bantu) • increased seeking of credit/loan • increased self-employment	• remittance (non-Bantu) • increased seeking of credit/loan
main food sources	• most food from own products (60-70%) • purchase (30-35%) • also gifts and wild foods	• majority own products, some purchase • in Hiran - own milk	• purchase and own products • in Hiran - own milk

APPENDIX 3

LIVESTOCK MOVEMENT PATTERN OF SOMALIA

ANNEX 6


42°
44°
46°
48°
50°
YEMEN
Gulf of Aden
DJIBOUTI
AWDAL
Baki
Berbera
Boosaaso
SANAAG
Ceerigaabo
BARI
WAQOOYI
GALBEED
Hargeysa
Burco
TOGDHEER
SOOL
Laascaanood
Garoowe
NUGAAL
ETHIOPIA
Gaalkacyo
MUDUG
Dhuusamarreeb
GALGUDUUD
Beledweyne
HIRAAN
BAKOOL
Xuddur
Shabeelle
Garbahaarrey
GEDO
Baydhabo
BAY
Jawhar
SHABEELLE
DHEXE
Muqdisho
MUQDISHO/
BENAADIR
Marka
SHABEELLE
HOOSE
Jubba
JUBBA
DHEXE
Bu'aale
JUBBA
HOOSE
Kismaayo
YA
INDIAN OCEAN
Legend:
International boundary
Disputed boundary
Regional boundary
Muqdisho
Regional/National capital
Main road
River
Large wadi
Swamp area
Contour line (m)
0
100
200 km
Natural grazing land with mobile livestock keeping
(Savannas and Semi-Deserts)
Rainfed agriculture
Scattered fields of agro-pastoralists
(Semi-nomadism and transhumance)
Coherent farming areas
(Livestock keeping less important)
Irrigated ag
Small oasis
Frankincens
Charcoal pr
Main direction of long range movements of camel and cattle herds at the beginn
the main dry season (som.: jiilaal/Dec. - March)
the main wet season (som.: gu'/April - June)
the winter rains (som.: xeeb) in the coastal plain
Source: Author's investigations 1982-89/additional information: Stephan Baas

APPENDIX 4

GPS DATA FROM GEDO ASSESSMENT

GPS - Data from Gado Assessment

Location Name	GPS - Data	GPS - Data	Level	Typ	Location of:
Mandera Border Town Kenya	03° 55` 53`` N	041° 50` 51`` E	227	WGS 84	
Belet Xaawo Border Town Som	03° 55` 46`` N	041° 52` 41`` E	227	WGS 84	Shallow Wells / Berkets Truck supply
Caracase	03° 40` 45`` N	042° 01` 23`` E	268	WGS 84	Village
	03° 40` 49`` N	042° 01` 14`` E	264	WGS 84	Shallow Well
	03° 40` 47`` N	042° 01` 17`` E	271	WGS 84	Shallow Well
Bursagar	03° 32` 47`` N	042° 06` 20`` E	235	WGS 84	Village
	03° 33` 49`` N	042° 05` 13`` E	258	WGS 84	Rain water catchment
	03° 32` 42`` N	042° 06` 33`` E	224	WGS 84	Shallow Wells
Garbaharey	03° 20` 03`` N	042° 12` 59`` E	212	WGS 84	Bore Hole
Buraal	03° 10` 11`` N	042° 08` 26`` E	302	WGS 84	Village
	03° 10` 14`` N	042° 08` 10`` E	296	WGS 84	Shallow Wells
Seere	03° 03 08` N	042° 03` 18`` E	378	WGS 84	Rain water catchment
Waradey	03° 01` 47`` N	042° 00` 04`` E	395	WGS 84	Rain water catchment
Elgadud	02° 59` 43`` N	041° 57` 08`` E	437	WGS 84	Bore Hole
Ceel Cado	03° 02` 09` N	041° 52` 07`` E	444	WGS 84	Bore Hole
Fanweyn	02° 53` 50`` N	042° 16` 52`` E	186	WGS 84	Village
	02° 53` 21`` N	042° 16` 58`` E	172	WGS 84	Shallow Well
	02° 53` 50`` N	042° 16` 38`` E	190	WGS 84	Rain water catchment
Dubaa	03° 05` 19`` N	042° 17` 01`` E	238	WGS 84	Village
	03° 05` 18`` N	042° 17` 21`` E	236	WGS 84	Shallow Wells
	03° 05` 19`` N	042° 17` 16`` E	234	WGS 84	Rain water catchment
Degfulay	02° 46` 44` N	042° 16` 29` E	296	WGS 84	Rain water catchment
Daar	02° 35` 43`` N	042° 11` 32`` E	237	WGS 84	Rain water catchment
Jungle	02° 22` 28`` N	042° 04` 37`` E	113	WGS 84	Village
	02° 22` 50`` N	042° 03` 54`` E	113	WGS 84	Shallow Well
Tarako	02° 16` 10`` N	041° 51` 16`` E	249	WGS 84	Rain water catchment
Fafahdoone	02° 12` 22`` N	041° 37` 29` E	222	WGS 84	Shallow Wells
Abdi Khayr	02° 03` 59`` N	041° 28` 38`` E	186	WGS 84	Rain water catchment
Kurdo (Dar A Salaam)	01° 56` 15`` N	041° 04` 00`` E	224	WGS 84	Rain water catchment
	01° 56` 27`` N	041° 03` 38`` E	221	WGS 84	Shallow Well
Paqtiley	01° 44` 19`` N	041° 04` 59`` E	205	WGS 84	Rain water catchment

Gariley	01° 41' 59'' N	041° 01' 28'' E	183	WGS 84	Village
Cawsqurun Village 1	02° 12' 04'' N	041° 09' 21'' E	245	WGS 84	Shallow Wells
Cawsqurun Village 2	02° 12' 38'' N	041° 08' 59'' E	242	WGS 84	Shallow Wells
Warey	02° 31' 22'' N	041° 06' 36'' E	342	WGS 84	Rain water catchment
Hagarsow	02° 47' 30'' N	041° 00' 57'' E	400	WGS 84	Rain water catchment
Ceel Wak	02° 47' 30'' N	041 00' 57'' E	389	WGS 84	Shallow Wells
Samerole	02° 47' 32'' N	041° 13' 37'' E	323	WGS 84	Shallow Wells
Garsal	02° 49' 12'' N	041° 16' 28'' E	326	WGS 84	Shallow Wells
Bussar	02° 40' 21'' N	041° 19' 21'' E	295	WGS 84	Shallow Wells
Muudaale	02° 32' 29'' N	041° 30' 15'' E	403	WGS 84	Rain water catchment
Ceel Add	02° 20' 40'' N	041° 28' 43'' E	241	WGS 84	Shallow Wells
Uel Merer	02° 01' 55'' N	041° 35' 53'' E	192	WGS 84	Rain water catchment
Tuulobarwaaqo	03° 30' 05'' N	042° 09' 38'' E	186	WGS 84	Bore Hole
Maykaareebay	03° 26' 53'' N	042° 16' 08'' E	198	WGS 84 WGS 84	Bore Hole Shallow Wells
Daabley	03° 14' 54'' N 03° 13' 59'' N	042° 00' 20'' E 042° 01' 13'' E	351 327	WGS 84 WGS 84	River Water Shallow Wells
Haramandera	02° 52' 56'' N	041° 42' 50'' E	514	WGS 84	Rain water catchment
Daso	02° 52' 11'' N	041° 28' 05'' E	358	WGS 84	Rain water catchment Berkets
Damase	03° 09' 12'' N	041° 20' 10'' E	399	WGS 84	Bore Hole
Al Wheele	03° 04' 33'' N	041° 42' 35'' E	495	WGS 84	Rain water catchment
Dadable	03° 15' 03'' N	041° 42' 24'' E	499	WGS 84	Rain water catchment
Yaqle	03° 16' 34'' N	041° 39' 23'' N	493	WGS 84	Rain water catchment
Gaddondowe	03° 34' 09'' N	041° 49' 16'' E	383	WGS 84	Shallow Wells
Khadijo Haji	03° 37' 49'' N	041° 41' 43' E	365	WGS 84	Bore Hole
Bergini	03° 55' 04'' N	042° 10' 27'' E	214	WGS 84	Shallow Well
Bohol	03° 50563 N	04211307 E		WGS 84	Shallow well
Handher	03°43591N	04208130E		WGS 84	Shallow well
Hareritur	03°43590 N	04208130 E		WGS 84	Shallow well
Carro Casse	03°43590 N	04208130 E		WGS 84	Shallow well
Irridda	03°40455 N	04201233 E		WGS 84	Shallow well
Nus Dariiq	03°17168 N	041°30302 E		WGS 84	WC

Ceelbaando	02°47082 N	040°59443 E	WGS 84	Shallow well
Garsal	02°49085 N	041°16222 E	WGS 84	Shallow well
Haro madhera	02°52511 N	041°42319 E	WGS 84	Shallow well
Buraa	03°10173 N	042°08116 E	WGS 84	Shallow well
Maykaareebay	03°26474 N	042°16095 E	WGS 84	BH
Alwille	03°04314 N	041°42352 E	WGS 84	WC
Yaqle	03°16383 N	041°39212 E	WGS 84	WC
Haroodi	03°50460 N	04150120 E	WGS 84	WC
Malkaariyey	03°53350 N	041°53290 E	WGS 84	Shallow well
Berginni	03°55118 N	042°1011 E	WGS 84	Shallow well
Sin ujiif	03°53468 N	042°1O11 E	WGS 84	Shallow well
Babaa	03°45005 N	042°1028 E	WGS 84	Shallow well
Gedweyne	040°1451 N	042°1740 E	WGS 84	WC
Geddoon dhawe	03°33576 N	042°0819 E	WGS 84	Shallow well
Dhamasse	03°09161 N	041°2011 E	WGS 84	BH
Samaroole	02°47338 N	041°1337 E	WGS 84	Shallow well
Dhasso	02°52098 N	041°2805 E	WGS 84	Shallow well
Ceel cadde	03°02082 N	041°5206 E	WGS 84	SW/BH
Tuulo Barwaaqo	03°30057 N	042°0937 E	WGS 84	BH
Ceelguduud	02°59356 N	041°5706 E	WGS 84	BH
Dhadhaable	03°15028 N	041°4226 E	WGS 84	WC
Xawaal Benni	03°16377 N	041°3920 E	WGS 84	WC
Caddey	03°53360 N	041°53360 E	WGS 84	WC
Khadiijo Xaaji	03°37484 N	041°4142 E	WGS 84	BH

APPENDIX 5

EXISTING WATER FACILITIES - GEDO REGION

		The existing Water Facilitise										Alternatives						
No	Name of location	RWC	BH	BT	SW	RW	AGW	SP.	CWS	DC	WT	BH	BT	SW	RWC	AGW	SP.	CWS
1	Belet -Xawo	3		X	20	X	X		X		X			5 SW - R				
2	Caracas				15							1 BH - N		2 SW - R				
3	Bursagar				5							1 BH - N		3 SW - R				
4	Garbaharey		1					X				1 BH - N						
5	Buraal				3							1 BH - N		1 SW - R	1 RWC - R			
6	Seere	1			3													
7	War Addey	1													1 RWC - R			
8	Ceel Gaduud		1															
9	Ceel cadde		1															
10	Faanwen	1												1 SW - N	1 RWC - R			
11	Bubaa													2 SW - R	1 RWC - R			
12	Deqfuley	2													1 RWC - R			
13	Daar	2			2							1 BH - N		1 SW - N	2 RWC-R			
14	Bardhere					X			XX	X								2 CWS - N
15	Jungel				1									1 SW-N	1 RWC-N			
16	Tarako	2													1 RWC-R			
17	Faafaduun				15							1 BH-N						
18	Abdikhayr	1													1 RWC-R			
19	Darasalam/Kurdo	1			1							2 BH-N		1 SW-R	1 RWC- R			
20	Bakhtiiley	1													1 R WC-R			
21	Gariley	1																
22	Cawsqurun				13							1 BH-N						
23	Warey	1													1 RWC- R			
24	Hagarsow	1										1 BH-N			1 RWC-R			
25	Ceel waaq				30													
26	Samarole				5									5 SW-R				
27	Garsall				11									11 SW-R				
28	Busaar				11									5 SW-R				
29	Muudaale	1										1 BH-N		1 SW-R				
30	Ceel aad				1									1 SW-R				
31	Weel-Mareer	1												1 SW-N	1 RWC-R			
32	Tuulobarawaaqo		1									2 A.Trough						
33	Maykaareebay		1	X										2 SW-R				
34	Daabley				3									1 SW-R				

35	Haramadheera	1										1 BH-N			1 RWC-R			
36	Dhaso	1										1 BH-N	1 BT-N		1 RWC-R			
37	Dhamase 1		2									1 BH-N						
38	Dhamase 2											1 BH - R						
39	Al Wheele	1										1 BH-N			1 RWC-R			
40	Dhadhaable	1										1 BH-N			1 RWC-R			
41	Yaqle	1										1 BH-N			1 RWC-R			
42	Gaddoondhawe				15							1 BH-N		10 SW-R				
43	Khadiija Xaaji		1									1 BH-R						
44	Birgini				2									1 SW-R				
45	Sin ujiif				1									1 SW-R				
46	Babaa				2									2 SW-R				
47	Bohol				3									3 SW-R				
48	Hareerituur				4									3 SW-R				
49	Handhar				1									1 SW -R				
50	Irridda				1									1 SW-R				

K E Y

RWC -Rain Water Catchment
BT-- Berkat
BH - Bore hole
SW- - Shallow Well
Ag.w.- Agrowell
Sp.- Spring Natural Spring Water
CWS- City Water Supppy
WT-- Water Trucking
N.- New
R ----- Rehabilitation
X ---- Un known Number

APPENDIX 6

BASIC INFORMATION ON SHALLOW WELLS OF GEDO

BASIC INFORMATION ON SHALLOW WELLS OF Geao REGION

Nr.	Cont.Personel /District	V/T/Co-ordinate	Population	No of well	Condition	SWL (m)	T.depth (m)	Inside diam. (m)	E.C m/sim	Diameter of AprOn	tur b.	Job to be performed [redacted]
1	Dolow District	Birgini GBS N: O3 55 11 8 E:042 10 11 3	a) no of families permanente-------- b) no 0f families nomadic-300-----------	No 1	a) Good b) Fair c) Bad X	5	66	15	High	2m		a) Cleaning x b) Redeepening x c) New const. of cylinder x d) Apron const x e) Drainage x f) animal troug h x g) Fencing
2	Dolow District	Birgini GBS N: O3 55 11 8 E:042 10 11 3	a) no of families permanente-------- b) no 0f families nomadic-300----------	No 2	a) Good b) Fair c) Bad X	5	55	45	High	2m		a) Cleaning x b) Redeepening x c) New const. of cylinder x d) Apron const x e) Drainage x f) animal troug h x g)
3	- "-	Sin u jiif GBS N: 03 53 46 8" E. 042 15 07 7"	a) no of families permanente-------- b) no 0f families nomadic--200-	No 1	a) Good b) Fair X c) Bad	6	630	25	High	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron rehabt x e) Drainage x f) animal trougH rehab x x g) Fencing
4	- " -	Bohol	a) no of families permanente-------- b) no 0f families nomadic---300-	No 1	a) Good b) Fair c) Bad X	6	620	420	1,92 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug h x g) Fencing
5	- " -	Bohol	a) no of families permanente-------- b) no 0f families nomadic----------	No 2	a) Good b) Fair c) Bad X	78		25	1.82 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF Gedo REGION

6	Beletxaawo	Bohol No 3	a) no of families permanente b) no 0f families nomadic 300	No 3	a) Good b) Fair c) Bad X	8	84	4	-	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug h x g) Fencing
7	Belet xaawo	Babaa No 1 GBS N:0"34 500 2 E:042 1O28,2"	-a) no of families permanente-------- b) no 0f families nomadic 700	N0 1	a) Good b) Fair c) Bad X	810	870	47	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal trough x g) Fencing
8	Belet Xaawo	- " -	a) no of families permanente-------- b) no 0f families nomadic 700	No 2	a) Good b) Fair c) Bad X	86	88	42	1,98 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
9	Belet xaawo	Handhar GBS N:034 500 9" E:O42 10263	a) no of families permanente------- b) no 0f families nomadic- 300	No 1	a) Good b) Fair c) Bad X	36	4	39	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
10	Balet xaawo	Hareritur N: 03 4359 0 E 42 0813 0	a); no of families permanente 1,500 b) no 0f families nomadic 15,00	N0 1	a) Good b) Fair c) Bad x	12.7	13.4	2.2		2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal trough x g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF Gedo REGION

11	Balet xaawo	- " -	a) no of families permanente 1500 b) no 0f families nomadic----------	N0 2	a) Good b) Fair c) Bad x	13.4	16	5.7 (2m)	--	2m		a) Cleaning x b) Reh.of cylind c) New const. of cylinder x d) Apron const x e) Drainage x f) animal troug h x g) Fencing
12	Baled xaawo	- " -	a) no of families permanente 1500 b) no 0f families nomadic----------	No 3	a) Good b) Fair c) Bad	10.4	16.6	5.7 (2m)	830	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug h x g) Fencing
13	Balet xaawo	- " -	a) no of families permanente 1500 b) no 0f families nomadic----------	N0 4	a) Good b) Fair c) Bad	13.2	22	7 (2m)	1,36 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug h x g) Fencing
14	Balet xaawo	Irridda N: 03 4045.4" E:042 0123.3"	a) no of families permanente 200 b) no 0f families nomadic----------	No 1	a) Good b) Fair c) Bad x	--	--	---	---	2m	--	a) Cleaning x b) Reh.of cylind x c) New const. of cylinder x d) Apron const x e) Drainage x f) animal troug x g) Fencing
15	Balet xaawo	Gadoon dhawe N: 033 3576 E: 041 4903	a) no of families permanente 400 b) no 0f families nomadic 1000	No 1	a) Good b) Fair c) Bad x	3.7	3.7	3.2O	1,26 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF Gedo REGION

16	Balet xaawo	- " -	a) no of families permanente 400 b) no 0f families nomadic 1000	No 2	a) Good b) Fair c) Bad x	6.8	9	1.2O	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder) Apron const x Drainage x f) animal troug x g) Fencing
17	Balet xaawo	- " -	a) no of families permanente 400 b) no 0f families nomadic 1000	No 3	a) Good b) Fair c) Bad	4.6	6.1	2.1O (1.2)	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
18	Balet xaawo	- " -	a) no of families permanente- b) no 0f families nomadic----------	No 4	a) Good b) Fair c) Bad x	4.5	5.6	2.4O	840	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
20	Ceel waaq	Ceel bande GPS N. 0247079 E: 04059446	a) no of families permanente500-- b) no 0f families nomadic 500	No 1	a) Good b) Fair x c) Bad	11.6	15.7	2.3O	---	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
21	Ceel waaq	Samarole GPS N:024733.8" E:0411337.9"	a) no of families permanente------- b) no 0f families nomadic 2000	No 1	a) Good x b) Fair c) Bad	18	20.1	1.7O	---	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF Geuo REGION

22	Ceel waaq	-"-	a) no of families permanente-------- b) no 0f families nomadic 2000	No 2	a) Good x b) Fair c) Bad	16.4	21 7	1.7O	---	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing
23	Ceel waaq	Garsal GPS N· 024908.5" E 0411622.2"	a) no of families permanente 370 - b) no 0f families nomadic-8.000-	No 1	a) Good b) Fair x c) Bad	15 4	16.9	2.5O	--	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug h g) Fencing
24	-"-	-"-	a) no of families permanente 370 b) no 0f families nomadic 8000	No 2	a) Good x b) Fair c) Bad	15.2	21	2.9	-	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug h g) Fencing
25	-"-	-"-	a) no of families permanente 370 b) no 0f families nomadic8000	No 3	a) Good b) Fair c) Bad x	15.4	21	2	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal trougH x g) Fencing x
26	-"-	-"-	a) no of families permanente 370 b) no 0f families nomadic 8000	No 4	a) Good b) Fair c) Bad x	14.8	16	3.2	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF Gedo REGION

27	- " -	- " -	a) no of families permanente 370 b) no 0f families nomadic 8000	No 5	a) Good x b) Fair c) Bad	15.4	23	2	--	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing
28	Garbaharay	El-adde GPS N:O3 02O8 2" E:041 52O6 1"	a) no of families permanente 830 b) no 0f families nomadic	No 1	a) Good X b) Fair c) Bad	10	106	17	-	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing
29	Garbaharey	El adde GPS N:O302OO8 2" E:041 5206 1"	-a) no of families permanente-830------ b) no 0f families nomadic	NO 2	a) Good X b) Fair c) Bad	98	1,230	126	--	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing
30	Garbaharey	El adde GPS N:03 0208 2" E:O41 5208 2"	a) no of families permanente 830------- b) no 0f families nomadic----------	No 3	a) Good b) Fair c) Bad X	105	11	35	1,50 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal trough x g) Fencing
31	Garbaharay	Buraa GSP N:031017.3" E:0420811.6"	Permanent families 750	No 1	Fair recently rehabilitated	3.8	4.3	1.5	2	2m		Recently rehabilitated

BASIC INFORMATION ON SHALLOW WELLS OF Gedo REGION

32	Garbahaarey	Maykaareebay GBS N:03 26513 E:0421558"	a) no of families permanente-300------- b) no 0f families nomadic- 300 -	No 1	a) Good b) Fair c) Bad X	73	73	1	--	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug h x g) Fencing
33	Garbaharey	Maykaareebey GPS N:03 26513" E: 421558"	a) no of families permanente-300------- b) no 0f families nomadic 300	N0 2	a) Good b) Fair X c) Bad x	73	73	17	--	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal trough x g) Fencing
34	Garbaharay	- " -	a) no of families permanente 300 - b) no 0f families nomadic 300	N0 3	a) Good x b) Fair c) Bad	6.1	6.3	1.3	--	2m		a) Cleaning b) Reh.of cylind c) New const. of cylinder d) Apron const e) Drainage f) animal troug g) Fencing
35	Baled xaawo	Malkaariyey GPS N: 035335.0" E: 045329.0"	a) no of families permanente 25.000 b) no 0f families nomadic	No 1	a) Good b) Fair c) Bad x small diesel engine with bad condition	6 4	6.8	1 2	800	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
36	Balet xaawo	- " -	a) no of families permanente 25,000 b) no 0f families nomadic-----------	N0 2	a) Good b) Fair c) Bad x small diesel engine with bad condition	4.5	9.1	2.1	800	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing

BASIC INFORMATION ON SHALLOW WELLS OF G REGION

37	Balet xaawo	Malkariyey GPS N. 035925.1" E: 0415505.8"	a) no of families permanente 25,000 b) no 0f families nomadic-----------	No 3	a) Good b) Fair c) Bad x	5	6.6	2.2	1,40 0	2m	--	a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
38	Balet xaawo	Malkaariyey GPS N 035335.0" E: 045329.0"	a) no of families permanente 25,000 b) no 0f families nomadic	No 4	a) Good b) Fair c) Bad x	4	8	1.3	1.40 0	2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing
39	Balet xaawo	- " -	a) no of families permanente ----- - b) no 0f families nomadic	No 5,6,7	a) Good b) Fair c) Bad x COLLAPS E	-	-	-	--	--2m		a) Cleaning x b) Reh.of cylind x c) New const. of cylinder d) Apron const x e) Drainage x f) animal troug x g) Fencing

APPENDIX 7

REPORT ON CHEMICAL ANALYSIS OF WATER SAMPLES - CAWSQURIN AND GARSAAL VILLAGES

REPUBLIC OF KENYA

MINISTRY OF ENVIRONMENT AND NATURAL RESOURCES

Water Testing Laboratory

Tel No. 553834
P. O. Box 30521
NAIROBI

PHYSICAL CHEMICAL WATER ANALYSIS REPORT

Sample No. 174 .... Date Received 15-2-2002
Source Gawsqurin Gedo region shallow well Submitted by [illegible]
Date of Sampling 3-2-2002 (Somali) Address ....
Purpose of Sampling Domestic

PARAMETERS	UNIT	RESULTS	REMARKS
pH	pH Scale	8.0	
Colour	mg pt/l	10	
Turbidity	N.T.U.	3	
Permanganate Value (20 min boiling)	mg O_2/l	–	
Conductivity (25°C)	µS/cm	5020	
Iron	mgFe/l	0.22	✓
Manganese	mgMn/l	Less than 0.01	✓
Calcium	mgCa/l	435	
Magnesium	mgMg/l	29	✓
Sodium	mgNa/l	650 - X	
Potassium	mgK/l	30	
Total Hardness	mg$CaCO_3$/l	1208	
Total Alkalinity	mg$CaCO_3$/l	376	
Chloride	mgCl/l	861	
Fluoride	mgF/l	2.8	
Nitrate	mgN/l	150 ✓	
Nitrite	mgN/l	0.05	
Ammonia	mgN/l	–	
Total Nitrogen	mgN/l	–	
Sulphate	mgSO_4/l	596 X	
Orthophosphate	mgP/l	–	
Total Suspended Solids	mg/l	–	
Free Carbon Dioxide	mgCO_2/l	20	
Dissolved Oxygen	mgO_2/l	–	
TDS	mg/l	3112	
Silica	mgSiO_2/l		
Others			

COMMENTS

Very hard, highly mineralized water requiring demineralisation before use.

OI/C [illegible]
Water Testing Laboratory

REPUBLIC OF KENYA

MINISTRY OF HEALTH

GOVERNMENT CHEMIST'S DEPARTMENT

Telephone: 725806/7
P.O. Box 20753
NAIROBI, KENYA

REPORT ON CHEMICAL ANALYSIS OF WATER

Report Reference: P/WAT/VOL.I/2002/82
Laboratory Sample No. W.52/2002
Sender: ICRC, Box 73226 NBI
Source: Shallow Well – Gedo Region (Sample 7)

Date: 21st Feb. 2002
Date Received: 4/02/2002
Date Sample Taken:

RESULTS

PHYSICAL TESTS

Colour: 10 (Hazen Units)
Deposit: Organic matter
Taste: –
pH: 8.2

Turbidity: clear (J.T.U.'s)
Odour: none (T.O.N.)
Electrical Conductivity at 25°C (micro mhos/cm^3)
18,300.0

CHEMICAL TESTS

	mg/l(ppm)	*me/l*
Total Alkalinity as $CaCO_3$	180.0	
Phenolphthalein $(CO)_3=$	40.0	
Methyl Orange $(HCO_3)-$	140.0	
Chloride (Cl)–	2750.0	
Sulphate $(SO_4)=$	1950.0	
Nitrate (NO_3)	–	
Nitrite $(NO_2)-$	0.3	
Fluoride (F)–	1.5	
Total Anions		
Sodium (Na)+	2204.0	
Potassium (K)+	220.0	
Calcium (Ca)++	200.0	
Magnesium (Mg)++	278.4	
Iron (Total) (Fe)+++	0.1	
Manganese (Mn)++	0.01	
Ammonia—Free & Saline $(NH_4)+$	–	
Ammonia—Albuminoid $(NH_4)+$	–	
(Pb Cu Zn) Pb^{2+}	0.06	
Total Cations Cu^{2+}	0.01	
Zn^{2+}	0.06	

REPUBLIC OF KENYA

MINISTRY OF HEALTH

GOVERNMENT CHEMIST'S DEPARTMENT

Telephone: 725806/7
P.O. Box 20753
NAIROBI, KENYA

REPORT ON CHEMICAL ANALYSIS OF WATER

Report Reference: P/WAT/VOL.I/2002/83
Laboratory Sample No. W.53/2002
Sender: ICRC, Box 73226 NBI.
Source: Shallow Well - Gedo (Sample 2)

Date: 21st Feb. 2002
Date Received: 4/02/2002
Date Sample Taken:

RESULTS

PHYSICAL TESTS

Colour: 200 (Hazen Units)
Deposit: Organic matter
Taste:
pH: 7.7

Turbidity: Turbid (J.T.U.'s)
Odour: None (T.O.N.)
Electrical Conductivity at 25°C (micro mhos/cm³)
17,000

CHEMICAL TESTS

	mg/l (ppm)	me/l
Total Alkalinity as $CaCO_3$	280.0	
Phenolphthalein $(CO_3)^{=}$	60.0	
Methyl Orange $(HCO_3)^{-}$	220.0	
Chloride $(Cl)^{-}$	2750.0	
Sulphate $(SO_4)^{=}$	1900.0	
Nitrate (NO_3)	–	
Nitrite $(NO_2)^{-}$	4.0	
Fluoride $(F)^{-}$	1.5	
Total Anions		
Sodium $(Na)^{+}$	2419.8	
Potassium $(K)^{+}$	201.4	
Calcium $(Ca)^{++}$	128.0	
Magnesium $(Mg)^{++}$	321.6	
Iron (Total) $(Fe)^{+++}$	0.07	
Manganese $(Mn)^{++}$	0.05	
Ammonia—Free & Saline $(NH_4)^{+}$	–	
Ammonia—Albuminoid $(NH_4)^{+}$	–	
(Pb Cu Zn) Pb^{2+}	0.08	
Cu^{2+}	0.01	
Total Cations Zn^{2+}	0.08	

APPENDIX 8

BASIC INFORMATION ON RAINWATER CATCHMENTS OF GEDO REGION

C BASIC INFORMATION ON RAIN WATER CATCHMENT OF GEDO REGION

No	Cont.Persone/District	V/T/Co-ordinate	Population	No catchment	Condition	length (m)	Width (m)	depth	Job to be performed
1	Dolow	Geedweyne GPS N:04 01 45 1" E:042 17 40.5"	a) no of families permanente 300 b) no 0f families nomadic-3000	No: 1	a) Good b) Fair c) Bad X	50M	30M	0.8m	**a) desalting X b) re-deeping X c) intake channels X d) filter basin X e) Fencing X f) enlarging X**
2	-"-	-"-	a) no of families permanente 300 b) nof families nomadic 3000	No: 2	a) Good b) Fair c) Bad x	20m	20m	1m	**a) desalting x b) re-deeping x c) intake channels x d) filter basin x e) Fencing x f) enlarging x**
3	Baled xaawo	Nusdariiq GPS N. 03 17 16 8 E:041 30 30 2	permanente 600	N. 1	a) Good b) Fair x c) Bad	44m	30m	2.5m	**a) desalting b) re-deeping c) intake channels x d) filter basin x e) fencing x f) enlarging x**
4	Ceel-waaq	Dhaso GPS N: 025209.8" E. 0412805.3"	nomadic-3000		a) Good b) Fair c) Bad x	120m	89m	0.50m	**a) desalting X b) re-deeping X c) intake channels X d) filter basin X e) fencing X f) enlarging X**
5	Ceel waaq	Haro Madheera GPS N: 025251 1" E: 0414231.9"	a) no of families permanente 200 b) no 0f families nomadic 2500	No: 1	a) Good b) Fair x c) Bad	58M	50m	2m	**a) desalting X b) re-deeping c) intake channels X d) filter basin X e) fencing X f) enlarging X**
6	Ceel waaq	Dhadhable GPS N: 031502."8 E: 0414226 4"	a) no of families permanente-------- b) no 0f families nomadic CENTER OF NOMADIC	No: 1	a) Good b) Fair x c) Bad	500	500	1.5m	**a) desalting X b) re-deeping X e) animal troughs X**

C BASIC INFORMATION ON RAIN WATER CATCHMENT OF GEDO REGION

ANNEX 2

7	Ceel waaq	Yaaqle N: 031638 3" E: 0413921.2"	a) no of families permanente-------- b) no 0f families nomadic----------- NOMADIC CENTRE	No: 1	a) Good b) Fair c) Bad x	250m	140m	1m	a) desalting X b) re-deeping X c) intake channels X d) animal troughs X
8	Ceel waaq	Xawaala binteey GPS N: 031637.7" E: 0413920.9"	a) no of families permanente-------- b) no 0f families nomadic 100	No 1	a) Good b) Fair c) Bad x	40m	30m	0.6m	a) desalting x b) re-deeping x c) intake channelsr x
9	Garbahaaray	Alwiile GPS N: 0304314 E: 04142352	a) no of families permenant b) no of families nomadic 3500	No 1	a) Good b) Fair c) Bad X	250m	140m	1m	a) desalting x b) re-deeping x c) intake channels x d) filter basin x e) fencing f) enlarging
10	Balet xaawo	Haroodi GPS N: 035046."0 E. 0415012.0"	a) no of families permanente-------- b) no 0f families nomadic 300	No: 1	a) Good b) Fair c) Bad x	100m	100m	0.8m	a) desalting x b) re-deeping x c) intake cjhannels x d) fencing x
11	Balet xaawo	Warcaday GPS N: 035336.0" E: 0415330.5"	a) no of families permanente-------- b) no 0f families nomadic 400	No: 1	a) Good b) Fair x c) Bad	100m	40m	1.5m	a) desalting x b) re-deepining x c) enlarging x d) fencing x e) intake channel x

APPENDIX 9

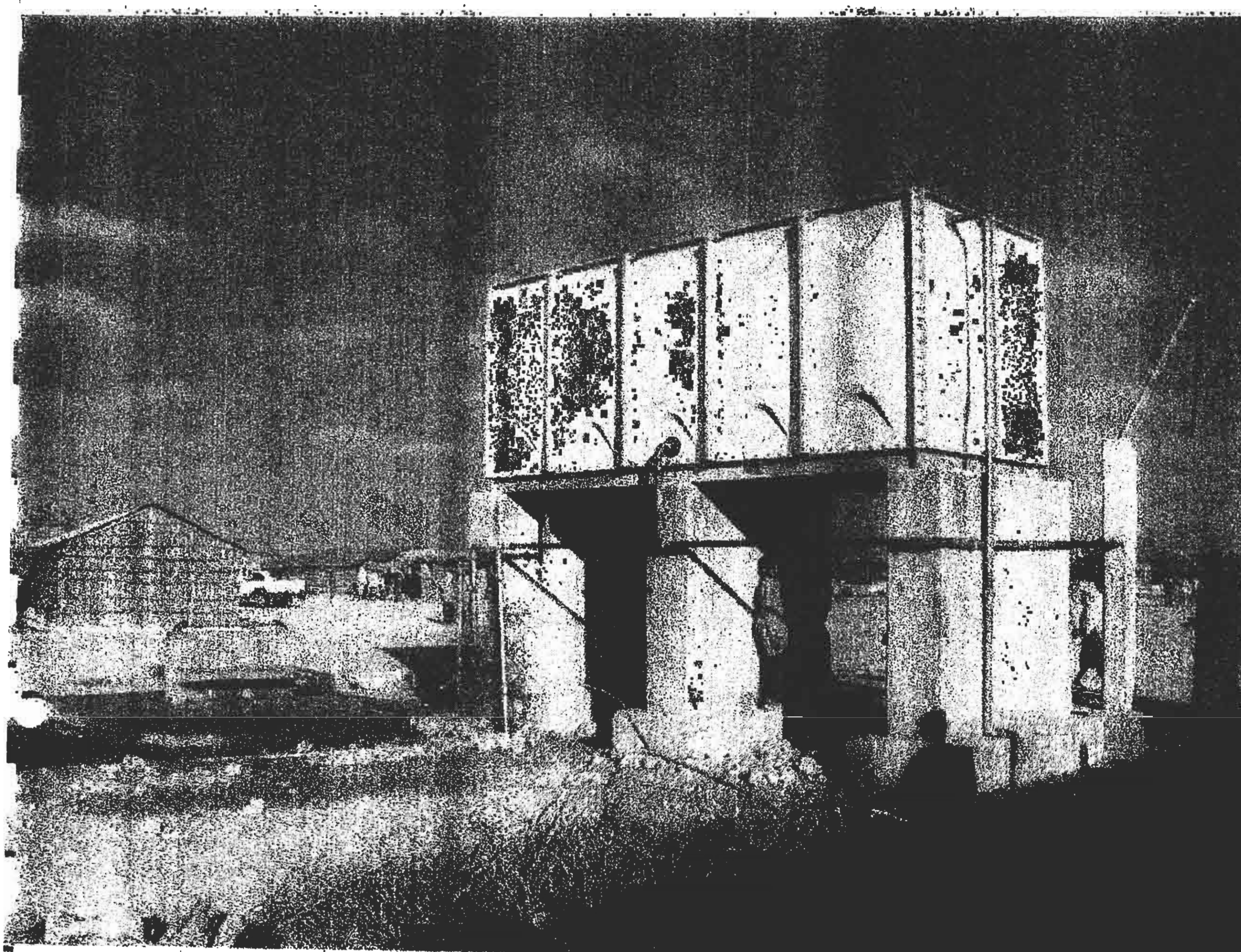
BASIC INFORMATION ON BOREHOLES OF GEDO REGION

BASIC INFORMATION ON Bore Hole OF GEDO REGION

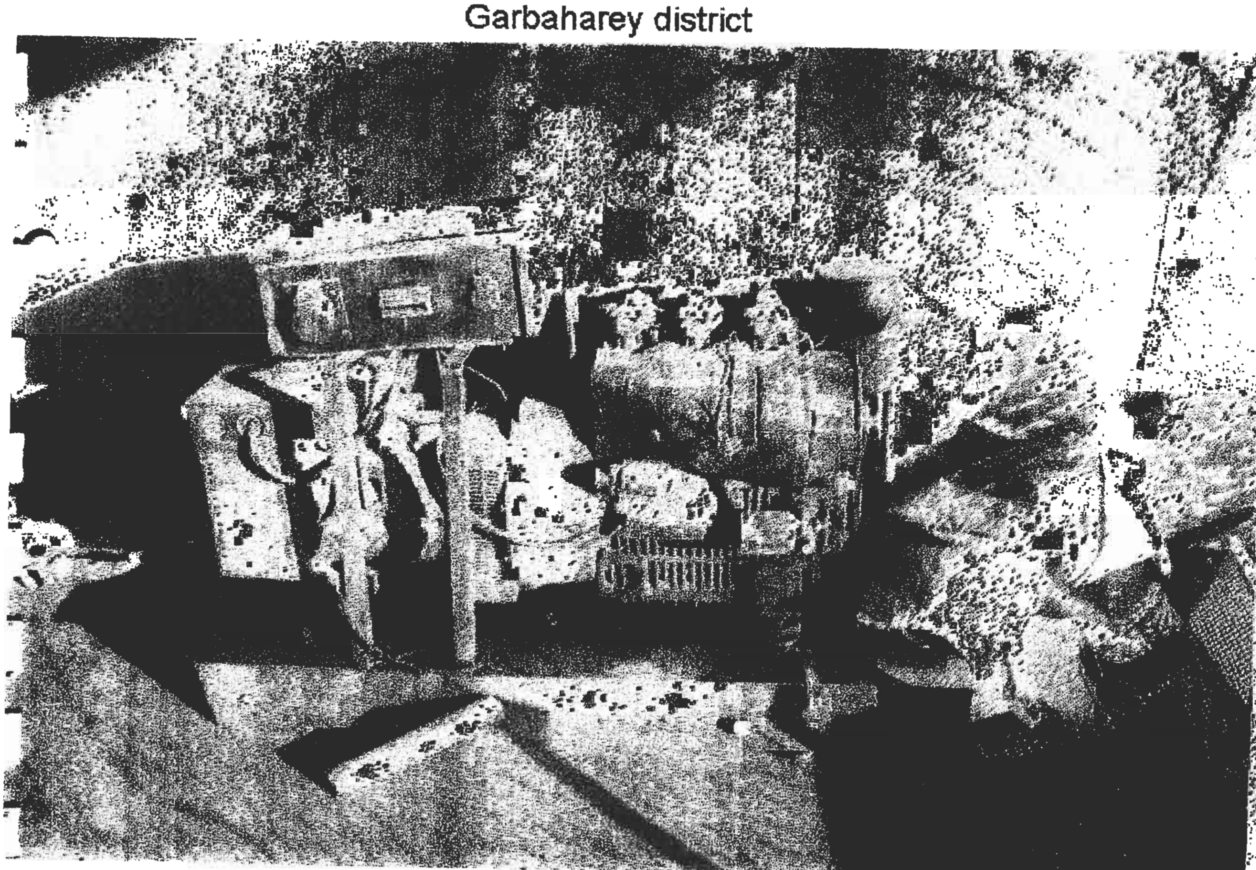
No	Selected Bore holes	GPS	Population	No of well	Condition	SWL (m)	T.depth (m)	Inside diam. (m)	NGO Involved	Job to be performed
1	Khadiijo Xaaji	GPS N:03 37 48 4 E:041 41 42 4	a) no of families Permanent 200 b) no Of families Nomadic -3500-4000	N.1	Bad					**Full project** **Without Water tank** **and animal trough and engine room**
2	Dhamase	GPS N: 03 09 15 7 E:041 20 11 4	a) no of families Permanent 1000 b) no Of families nomadic-12000	N.1 N.2	a) N1 Fair b) N2 bad					**Rehapilitation of two Bhs** **Full project**
3	Ceel Guduud	GPS N:02 59 36 6 E:041 5706 8	a) no of families Permanent 500 b) no Of families Nomadic 5000		a) Good				unicef	**New Water tank 45-70mc**
4	Ceel Cadde	GPS N:03 02 08 2 E:041 52 06 1	a) no of families Permanent 830 b) no Of families Nomadic 12000		a) Good				unicef	**No suggestion**
5	Tuulo Barwaaqo	GPS N:03 30 05 7 E:042 09 37 8	a) no of families Permanent 1000 b) no Of families Nomadic 6000		a) Good				unicef	**No suggestion**
6	Maykaareebay	GPS N.03 26 47 4 E:042 16 09 5	a) no of families Permanent 300 b) no Of families nomadic3000		a) Fair				unicef	**Needs deep well 31m** **Diameter 1.5m**

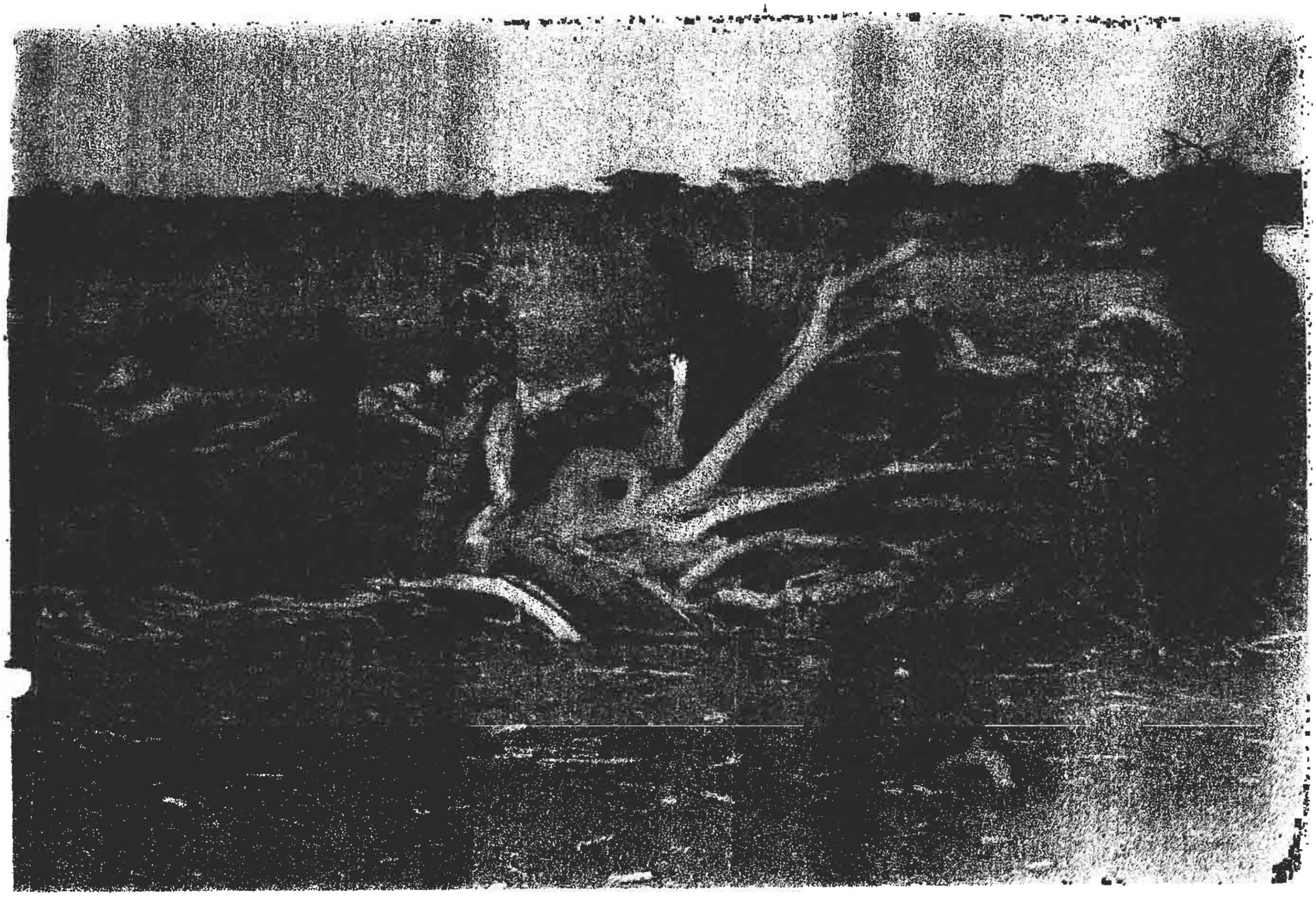
APPENDIX 10

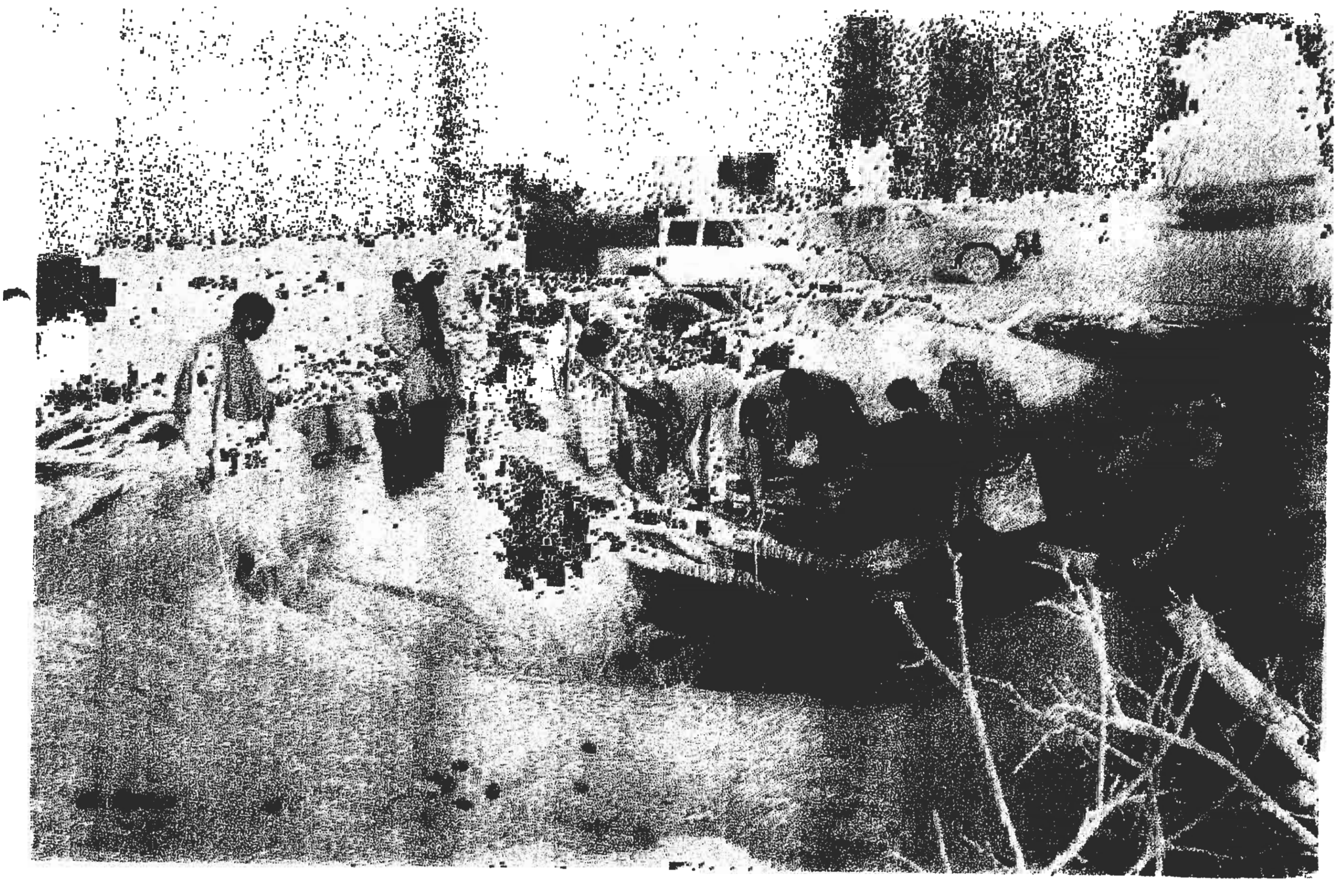
SELECTED PHOTOGRAPHS



Ceel Cade borehole
Garbaharey district







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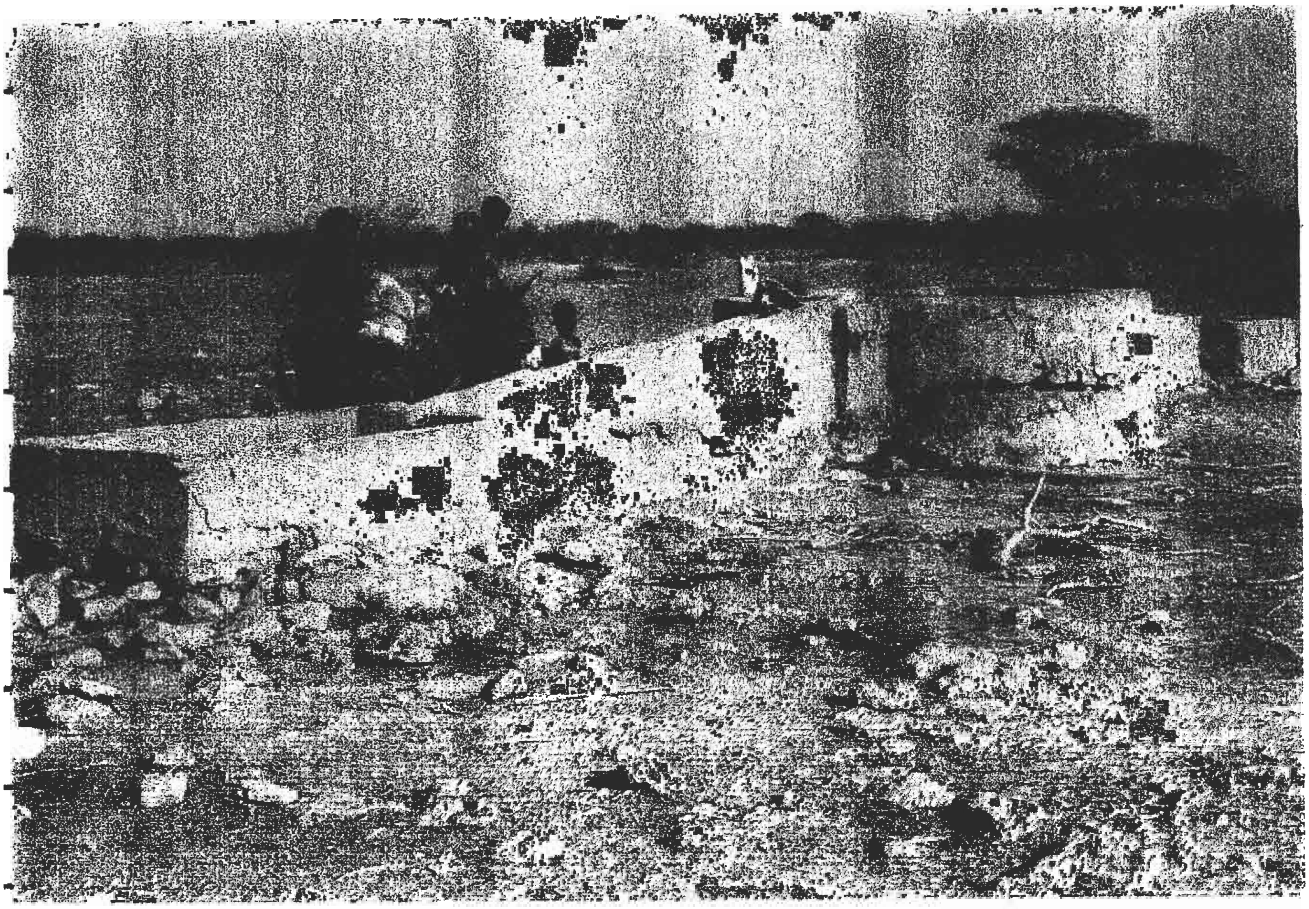
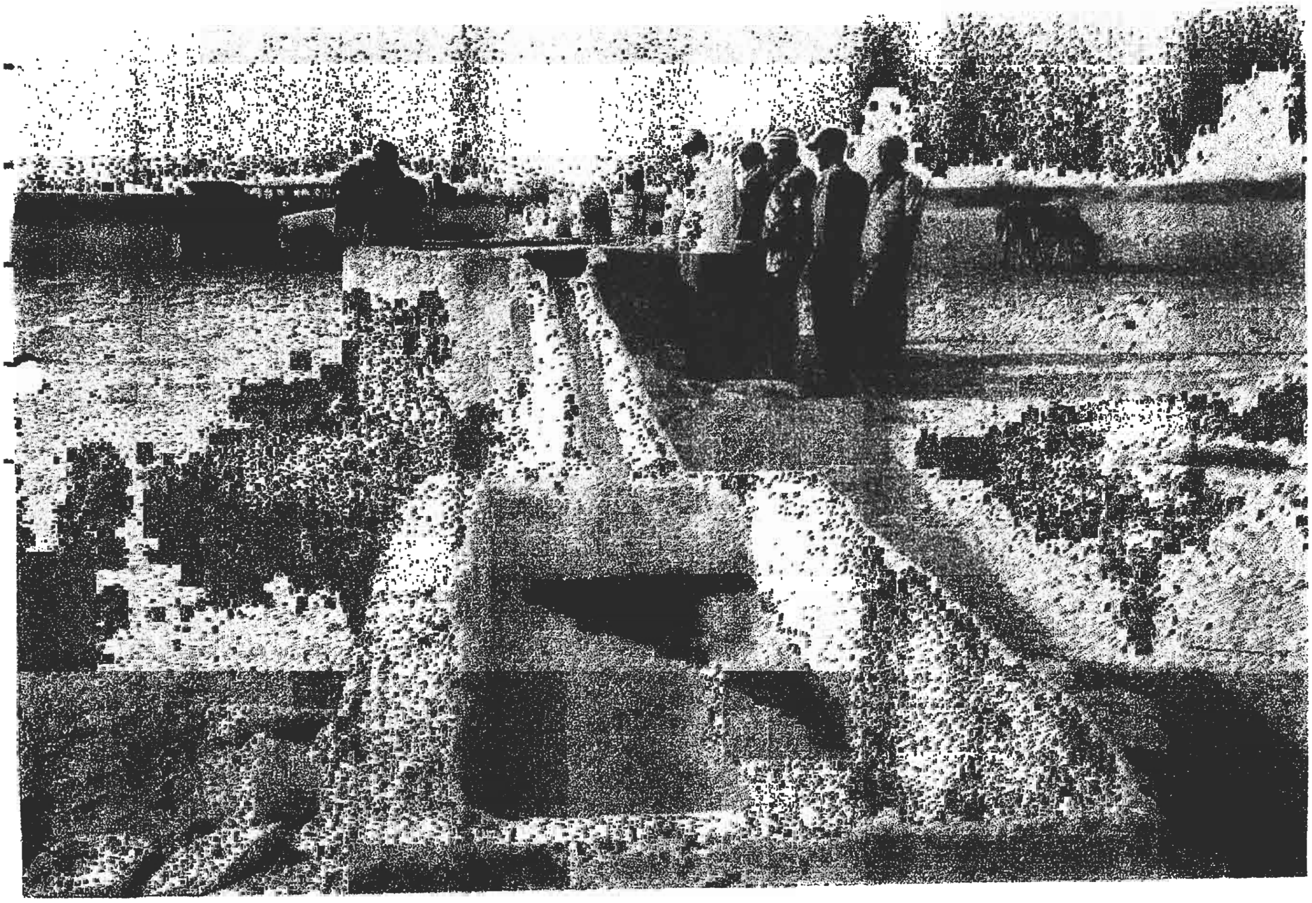
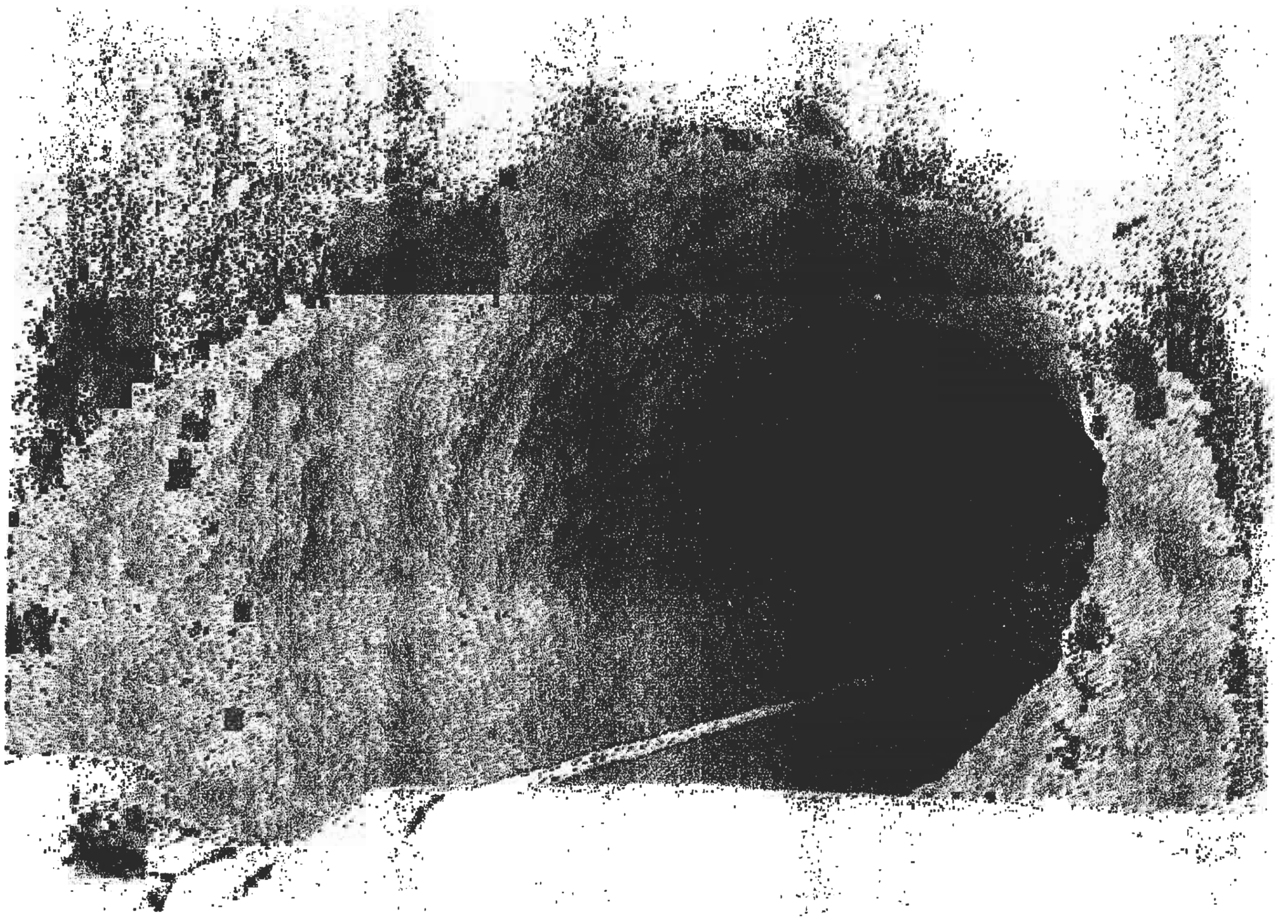


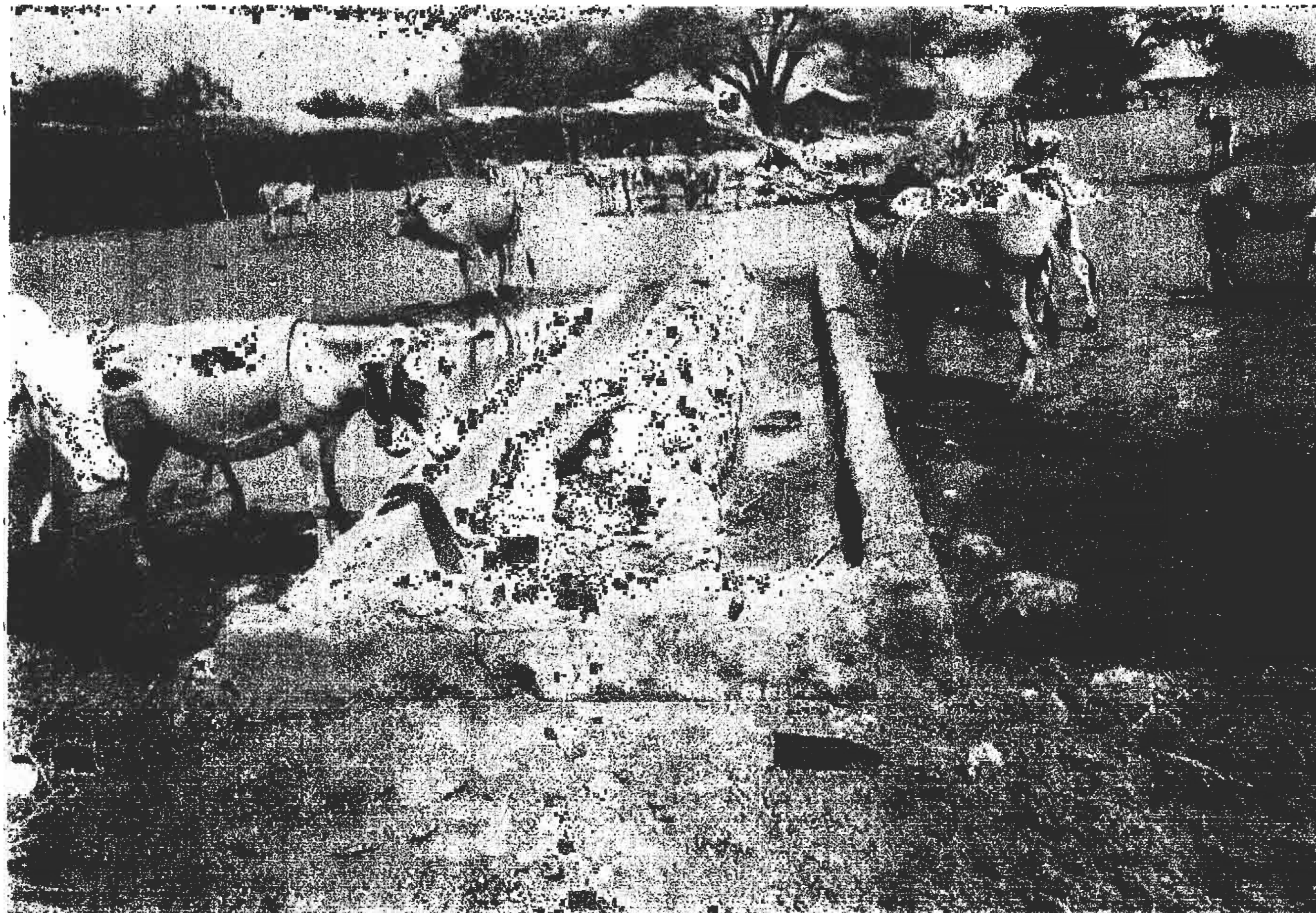


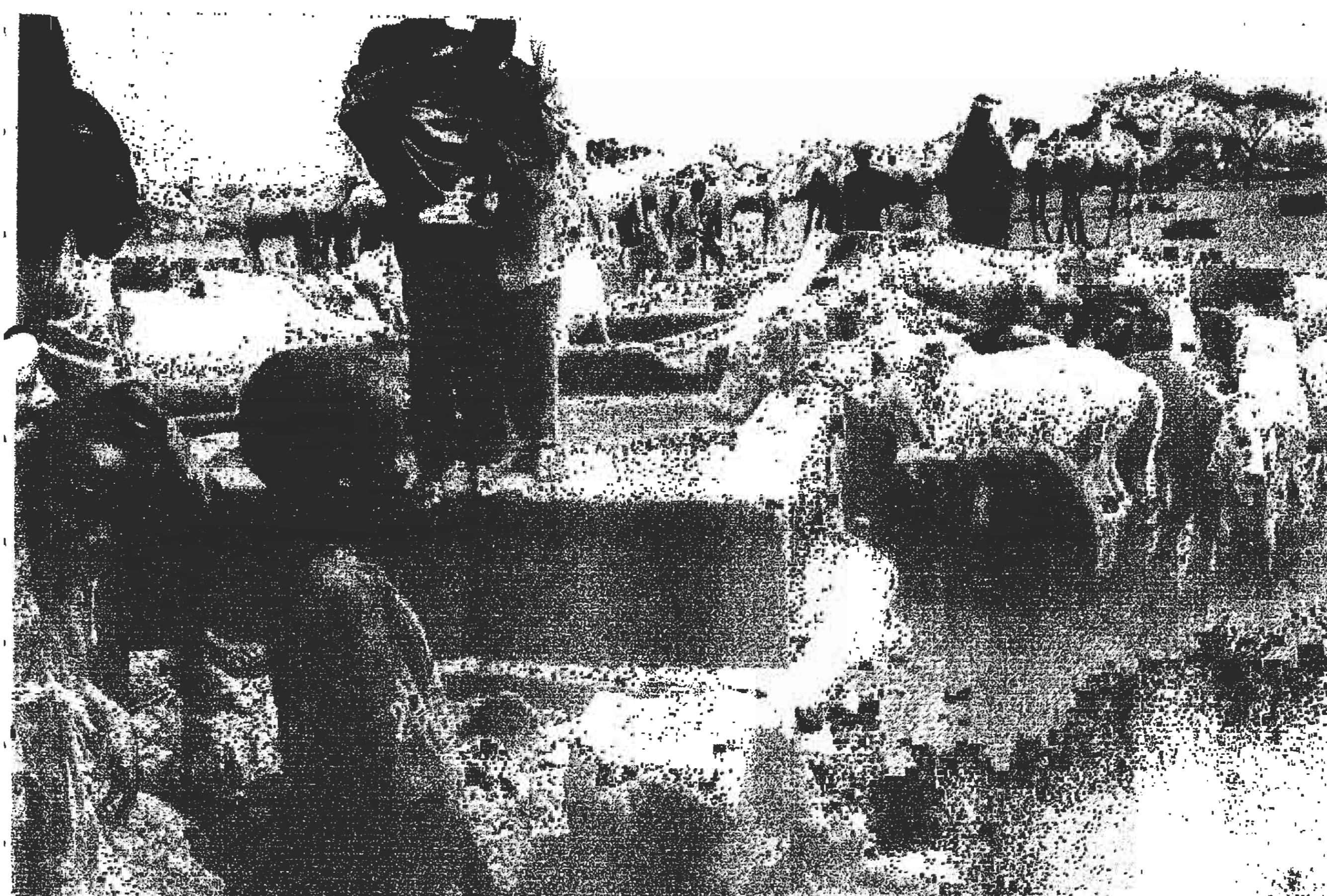
Sinu Jeif (Gedo Region

22 of January 2002

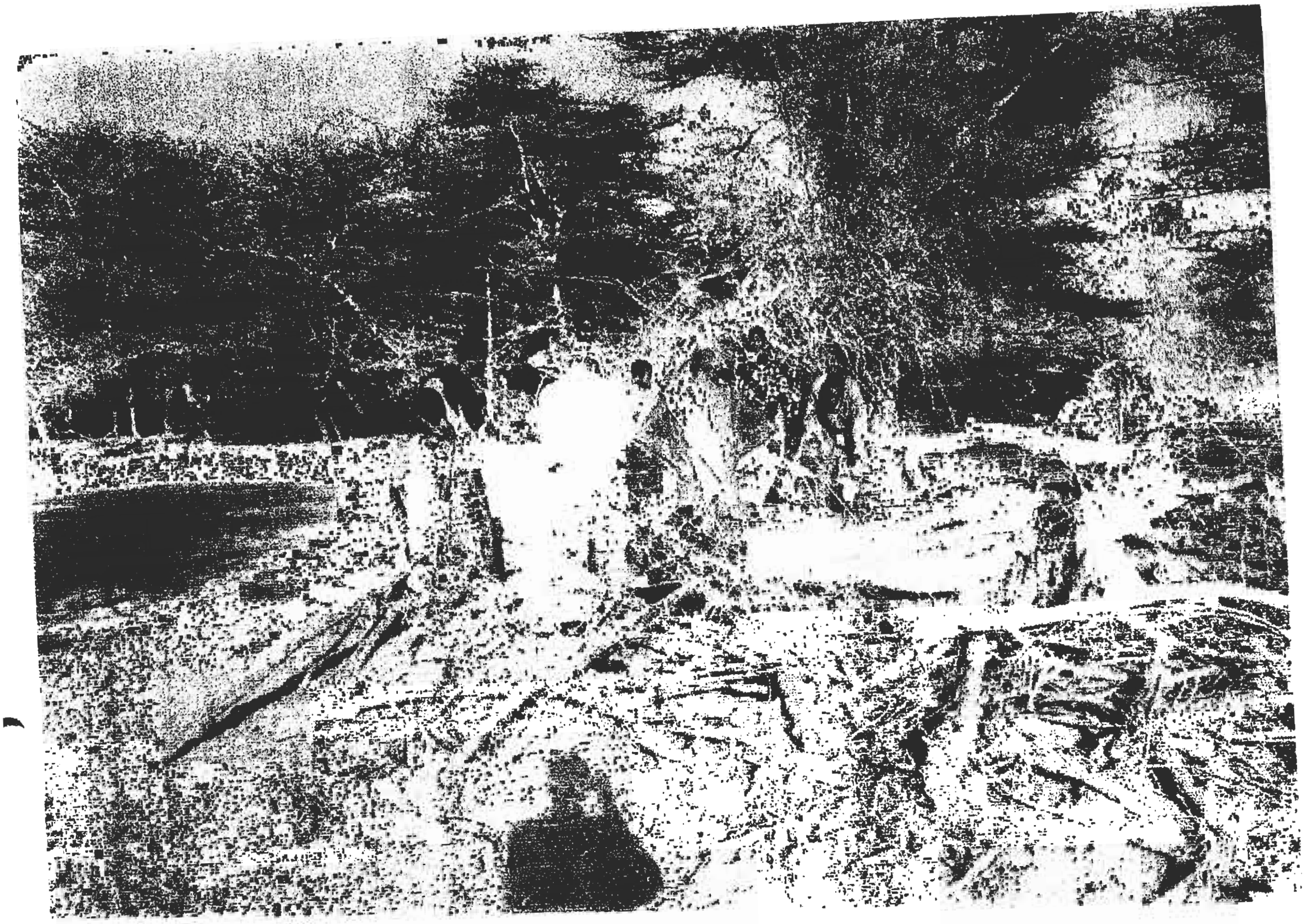
El Add shallow well
Bardere district



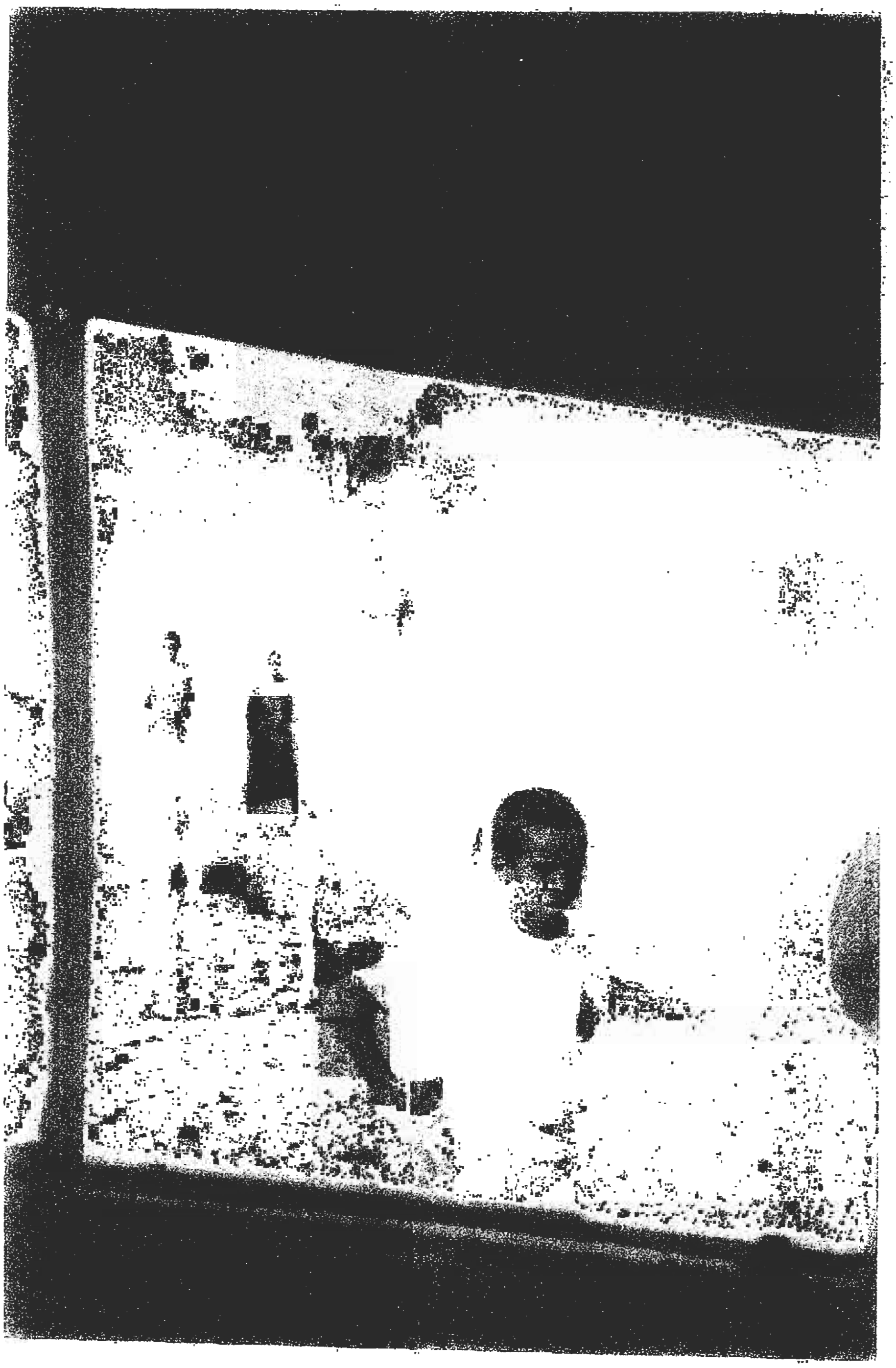




[illegible], GEDO REGION)
23 of JANUARY 2002



Luuq (Gedo Region)



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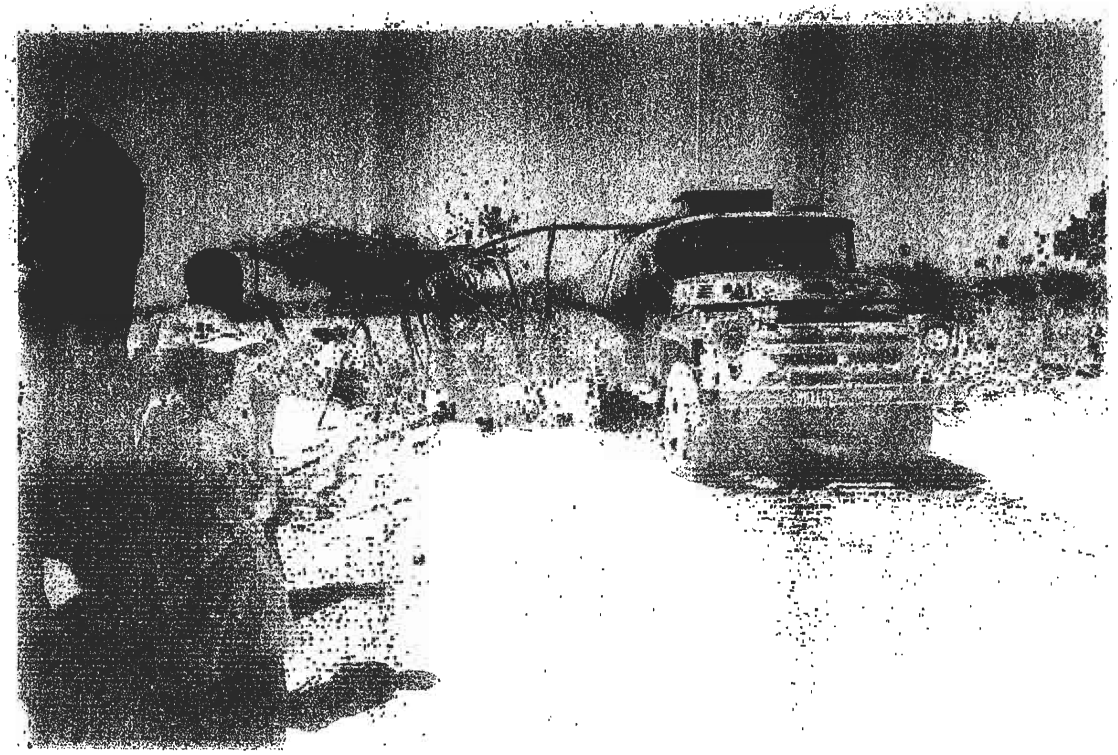
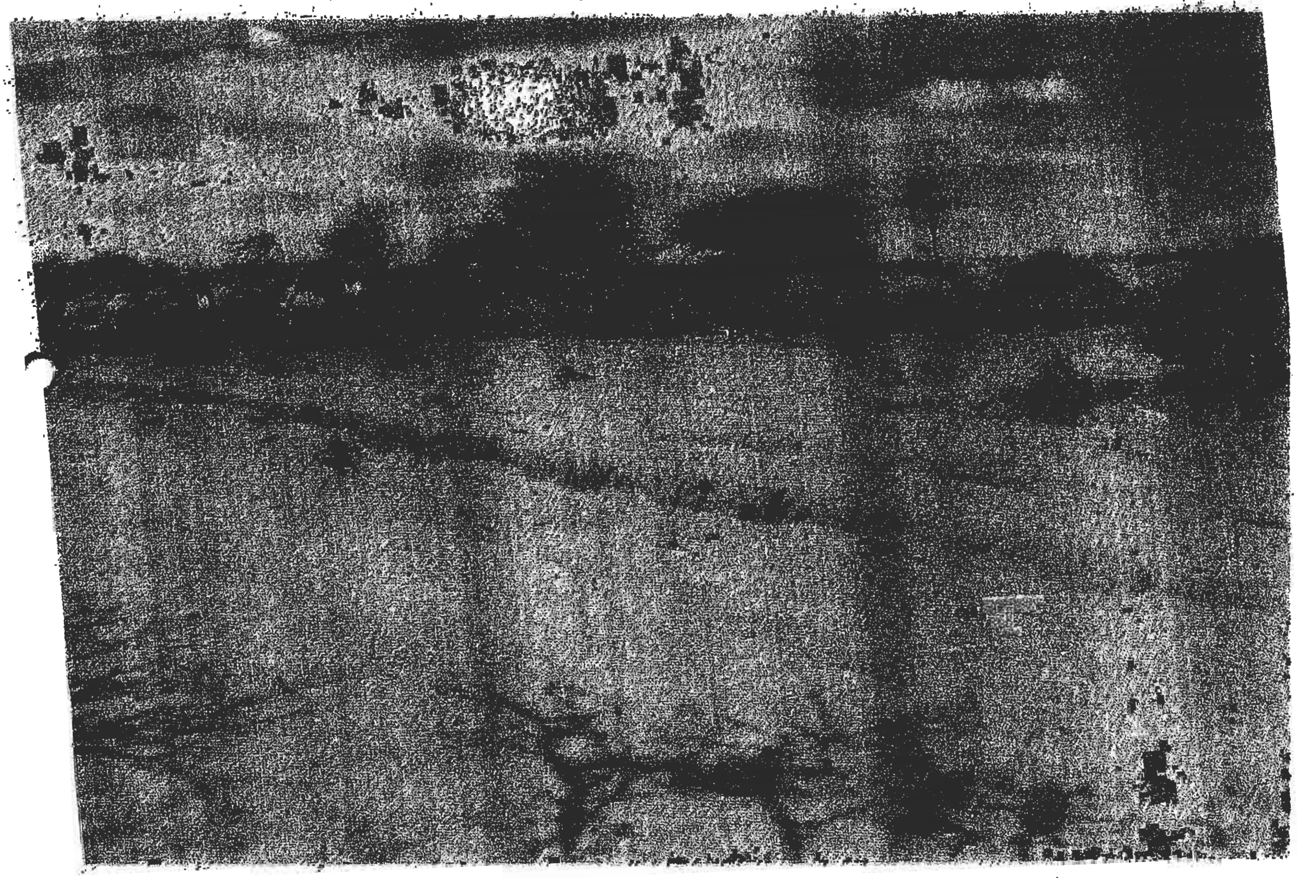
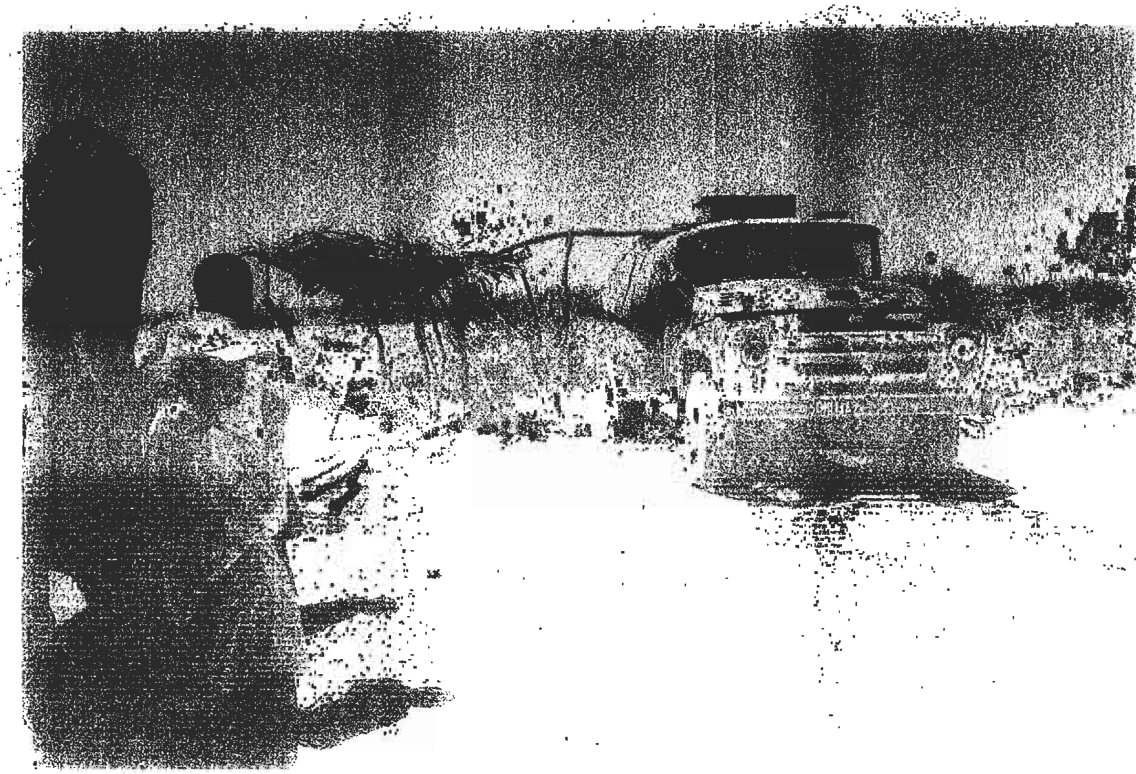
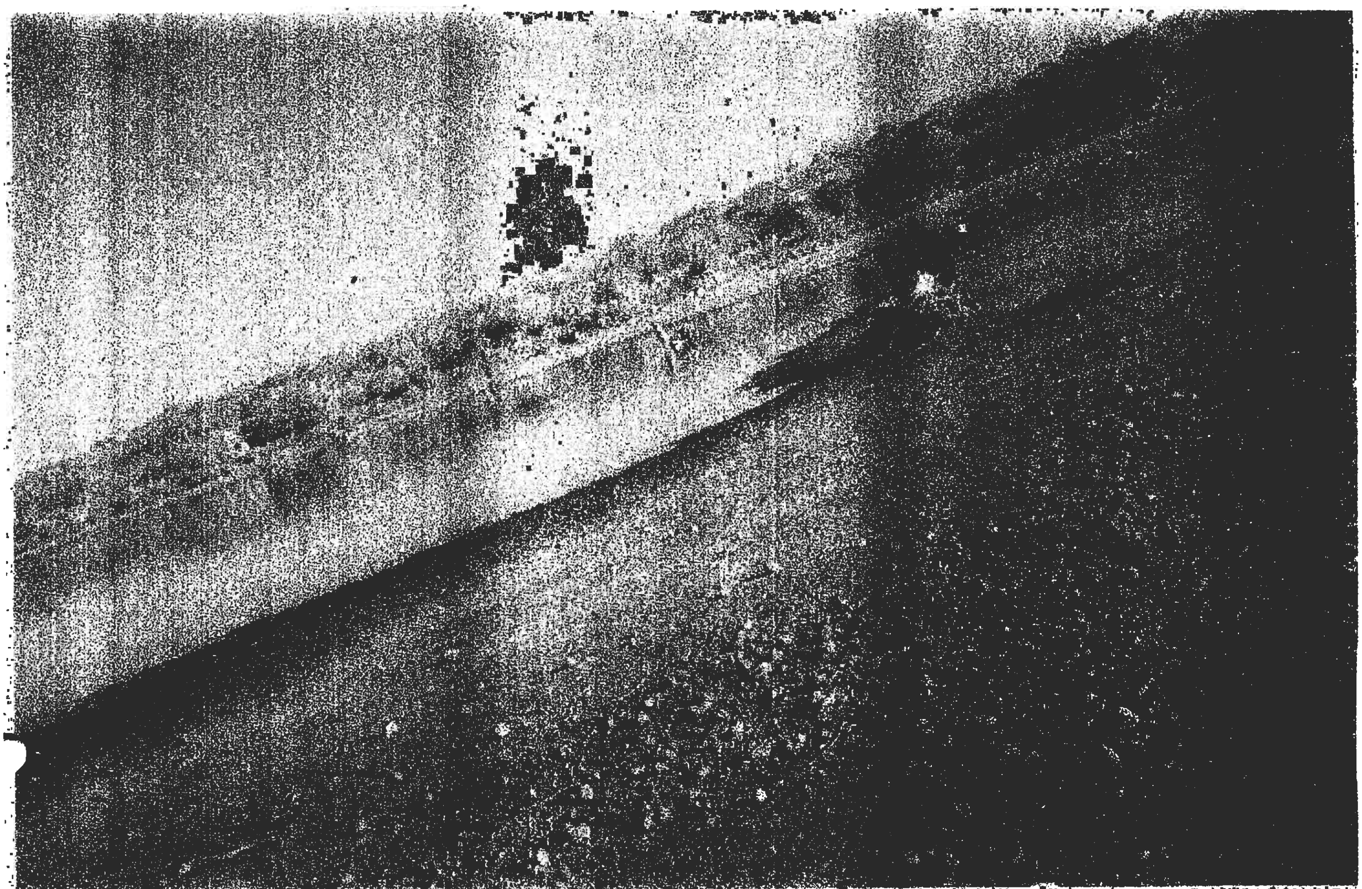




Luaso (Gearo Region)





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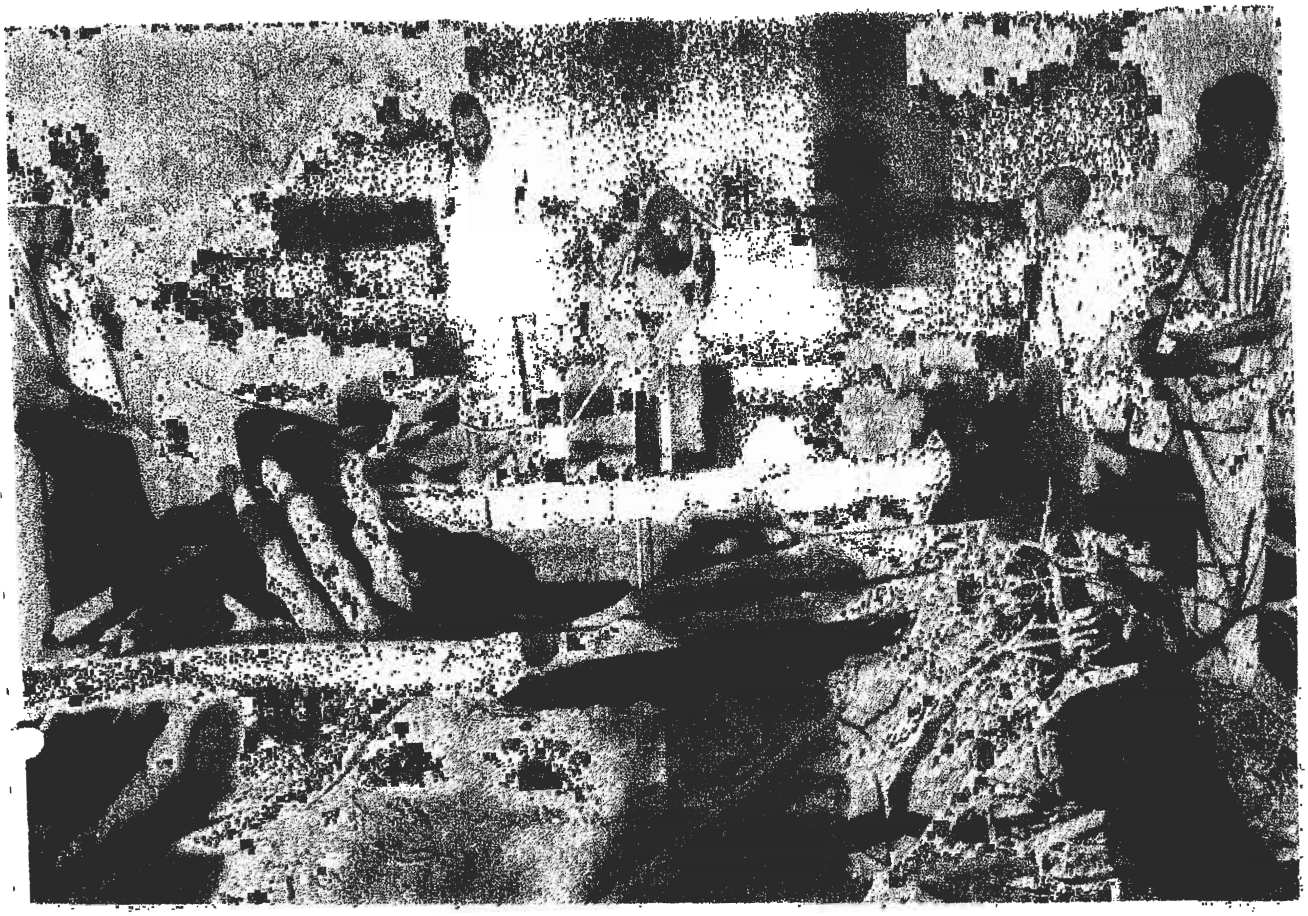
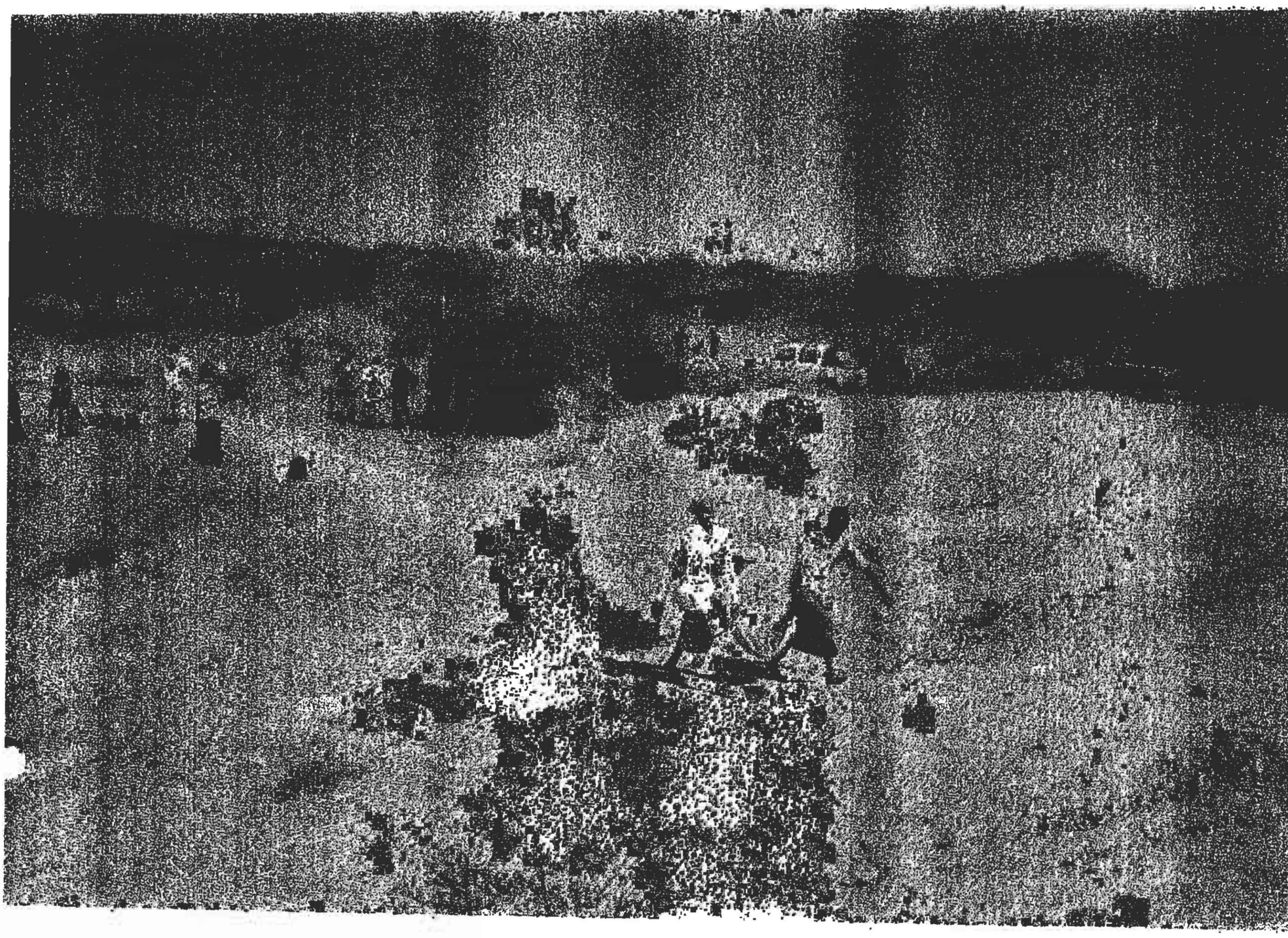
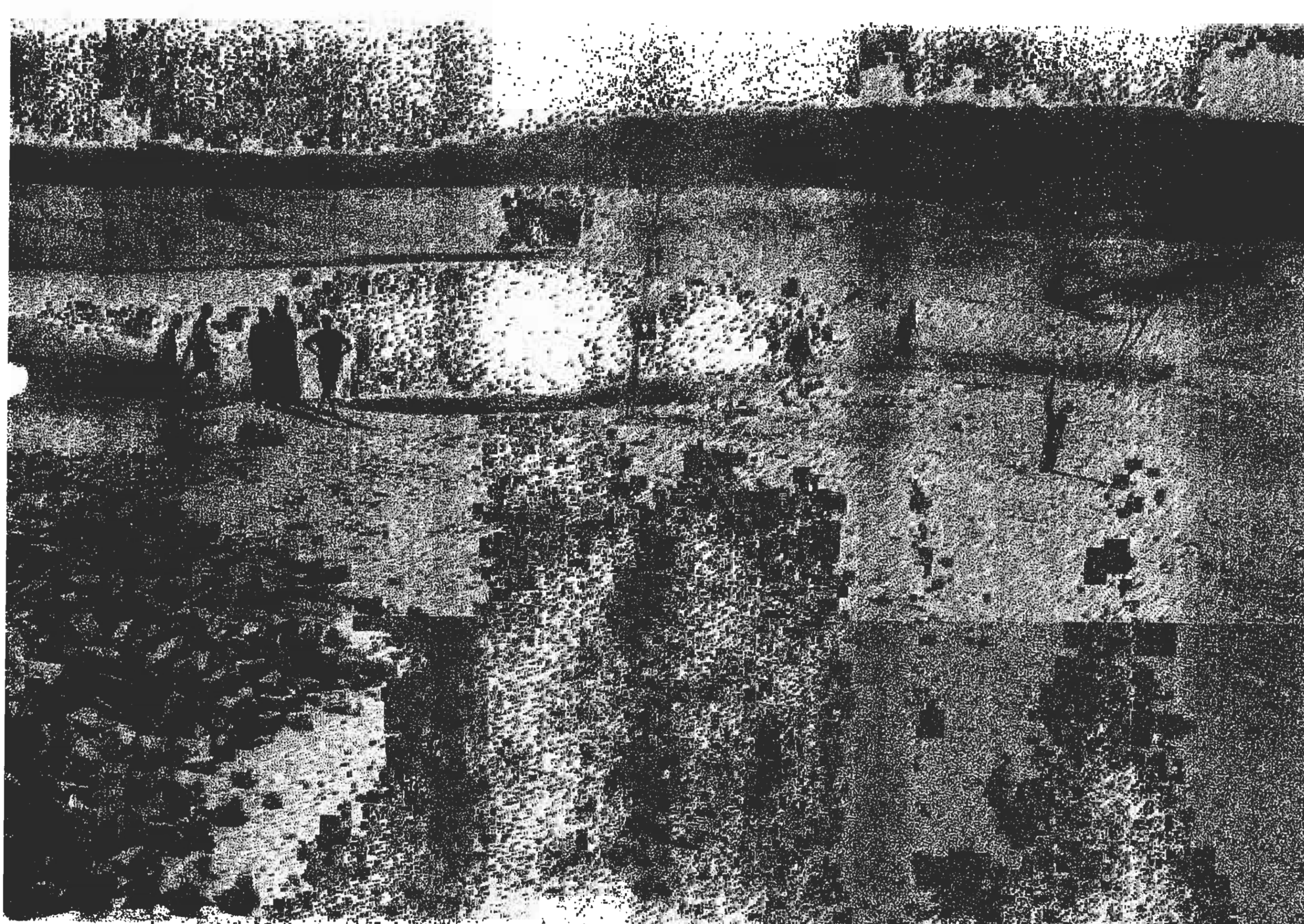


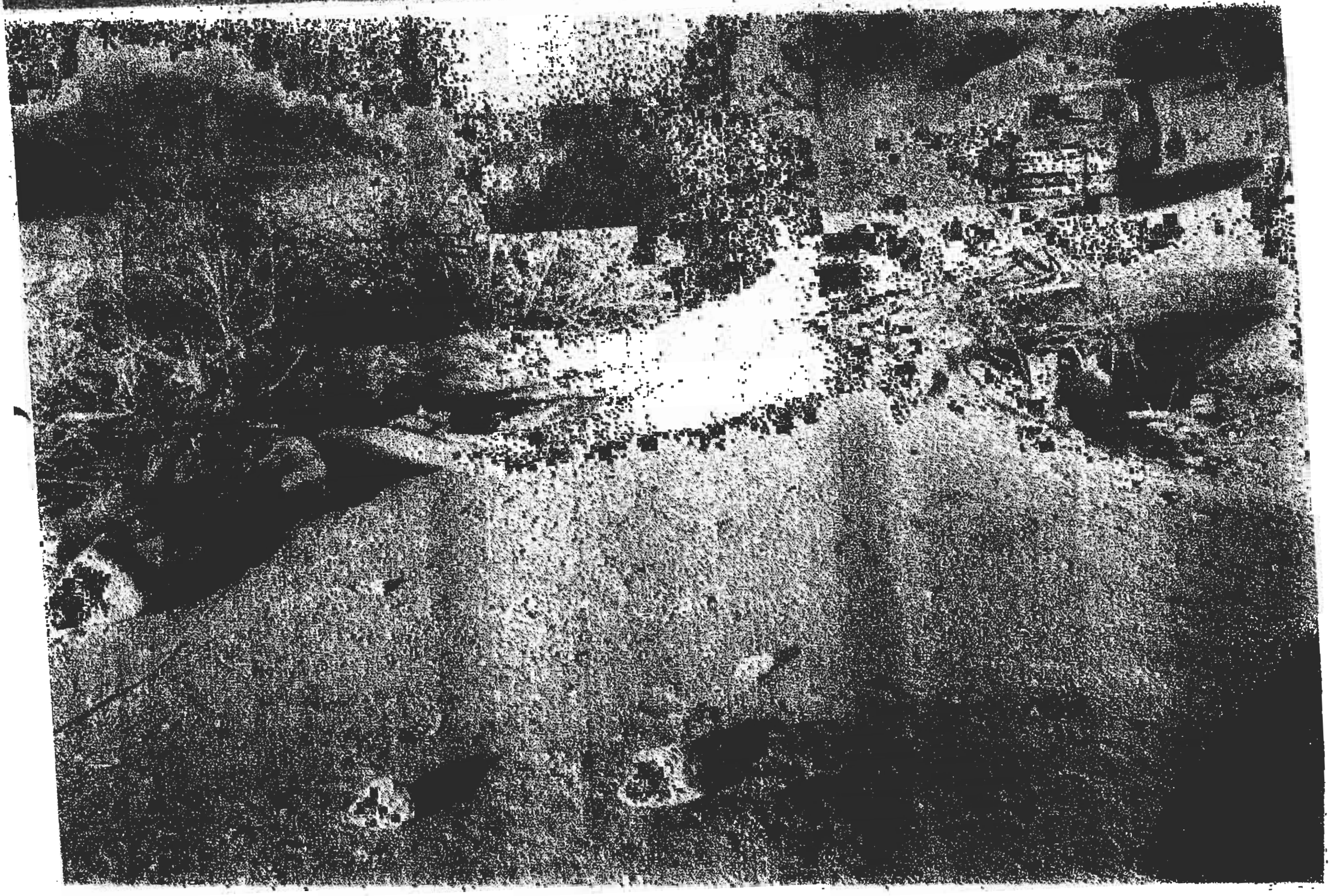
GARSAL, IGEDO BE[illegible]
29 of JANU[illegible]





NWS Da[illegible] (Cairo Reg[illegible]

[illegible] of January, [illegible]



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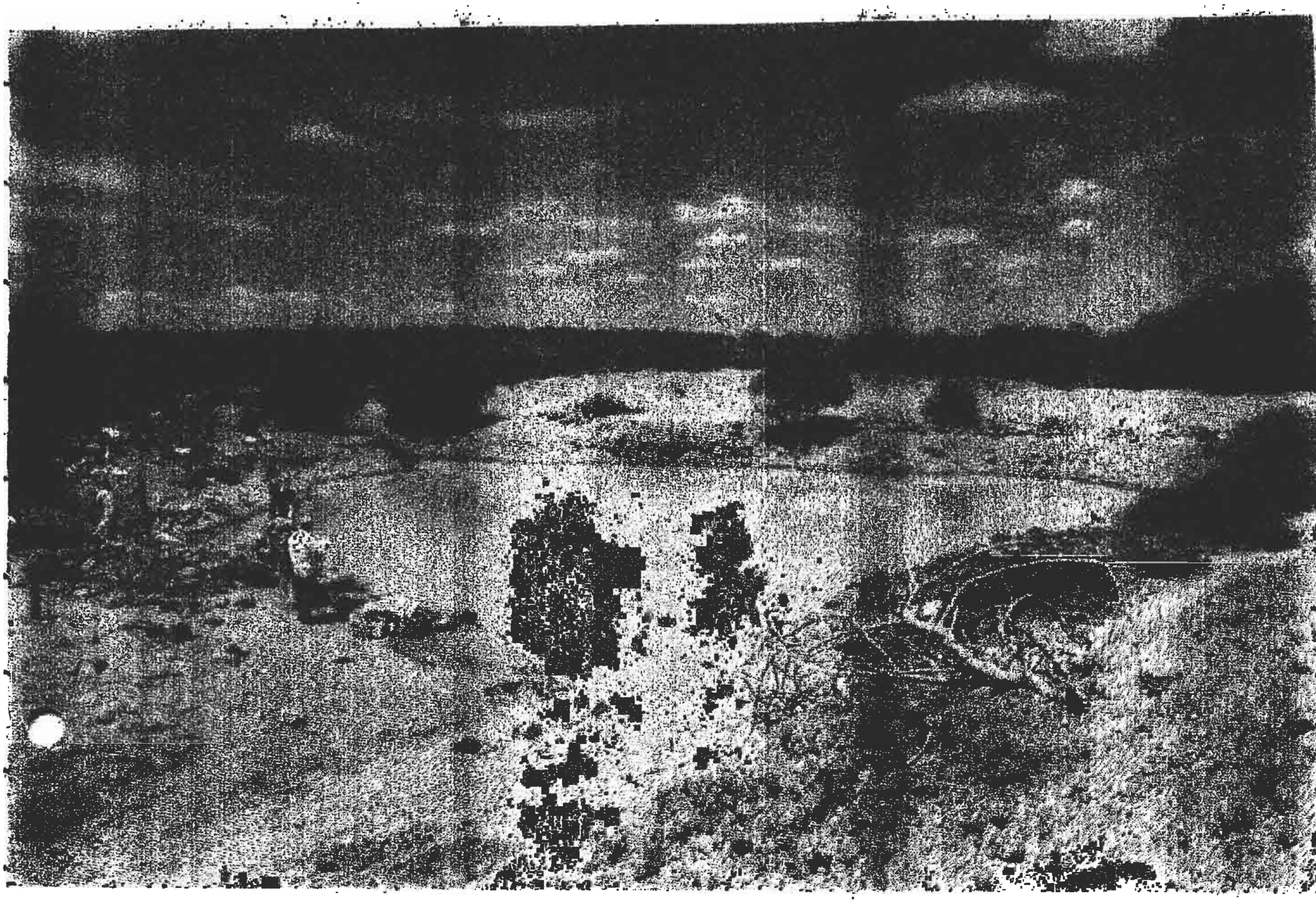
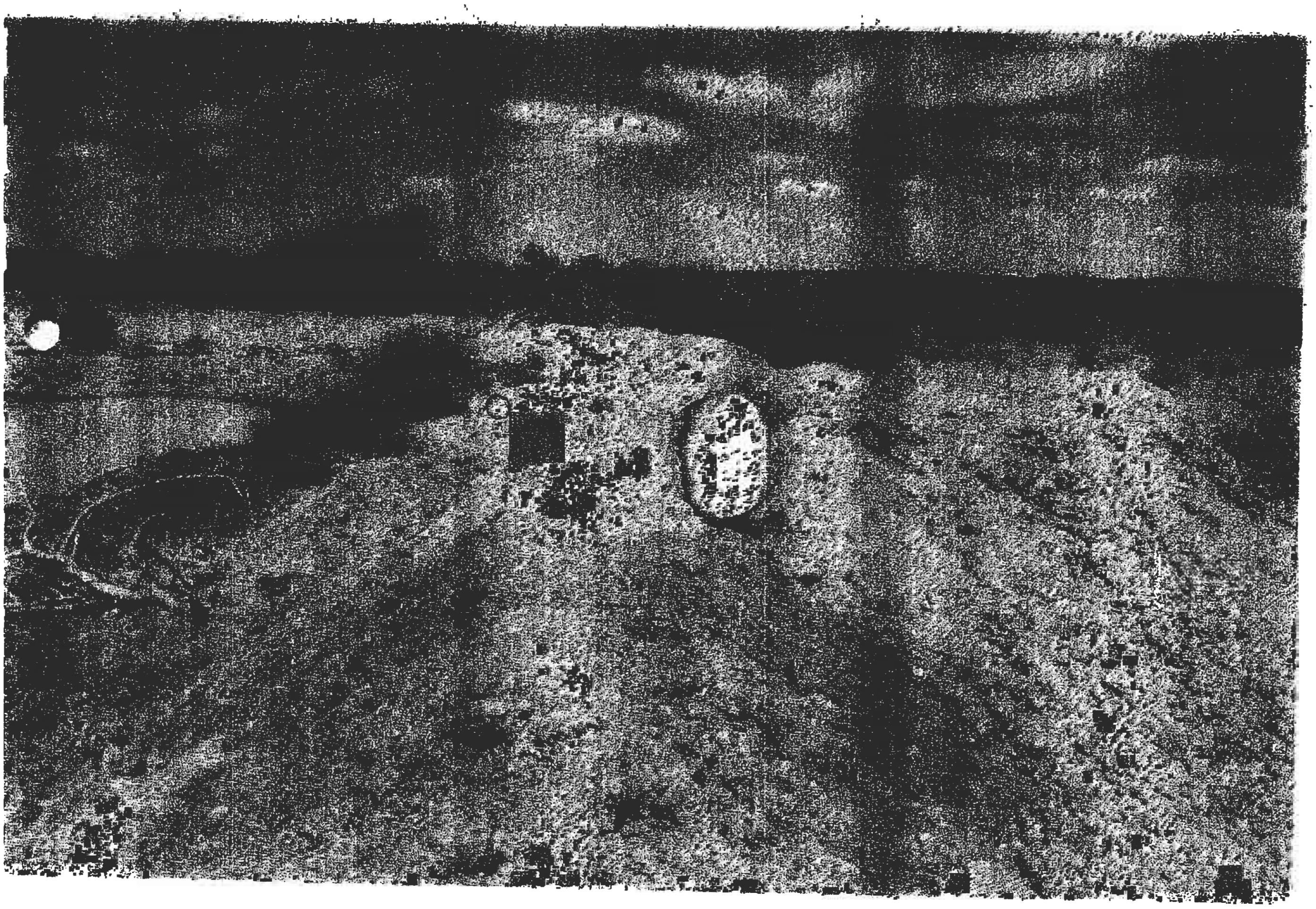
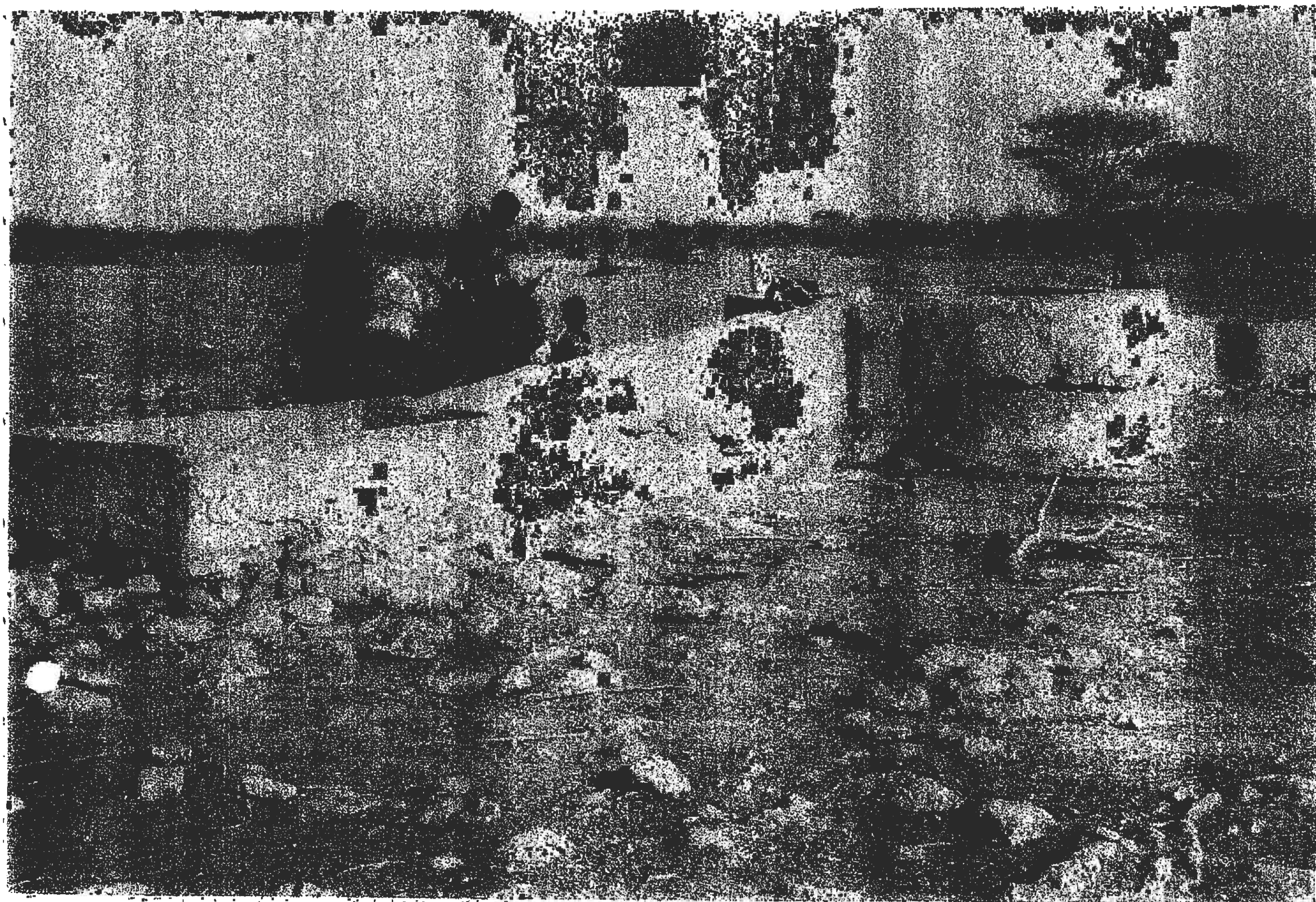
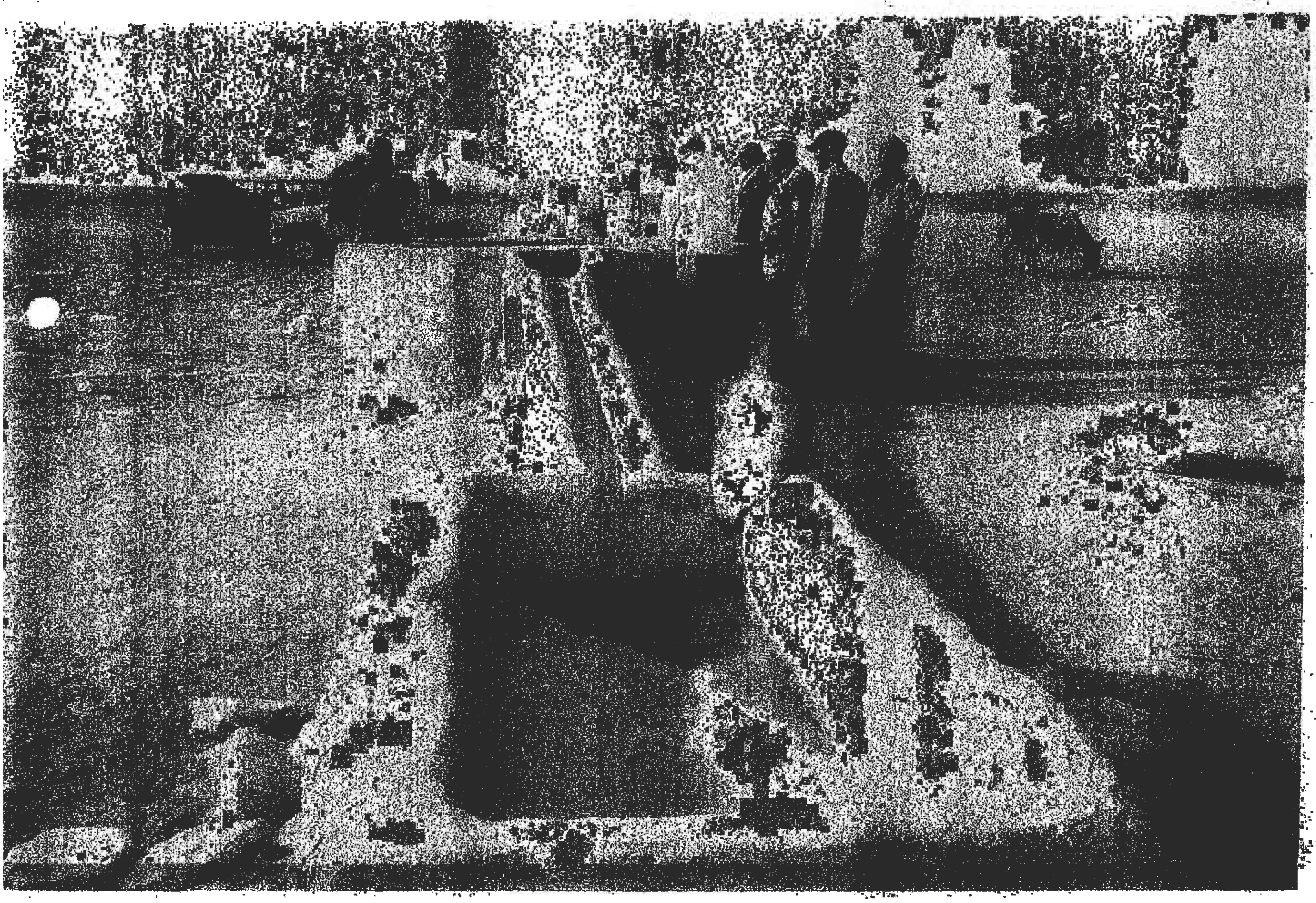
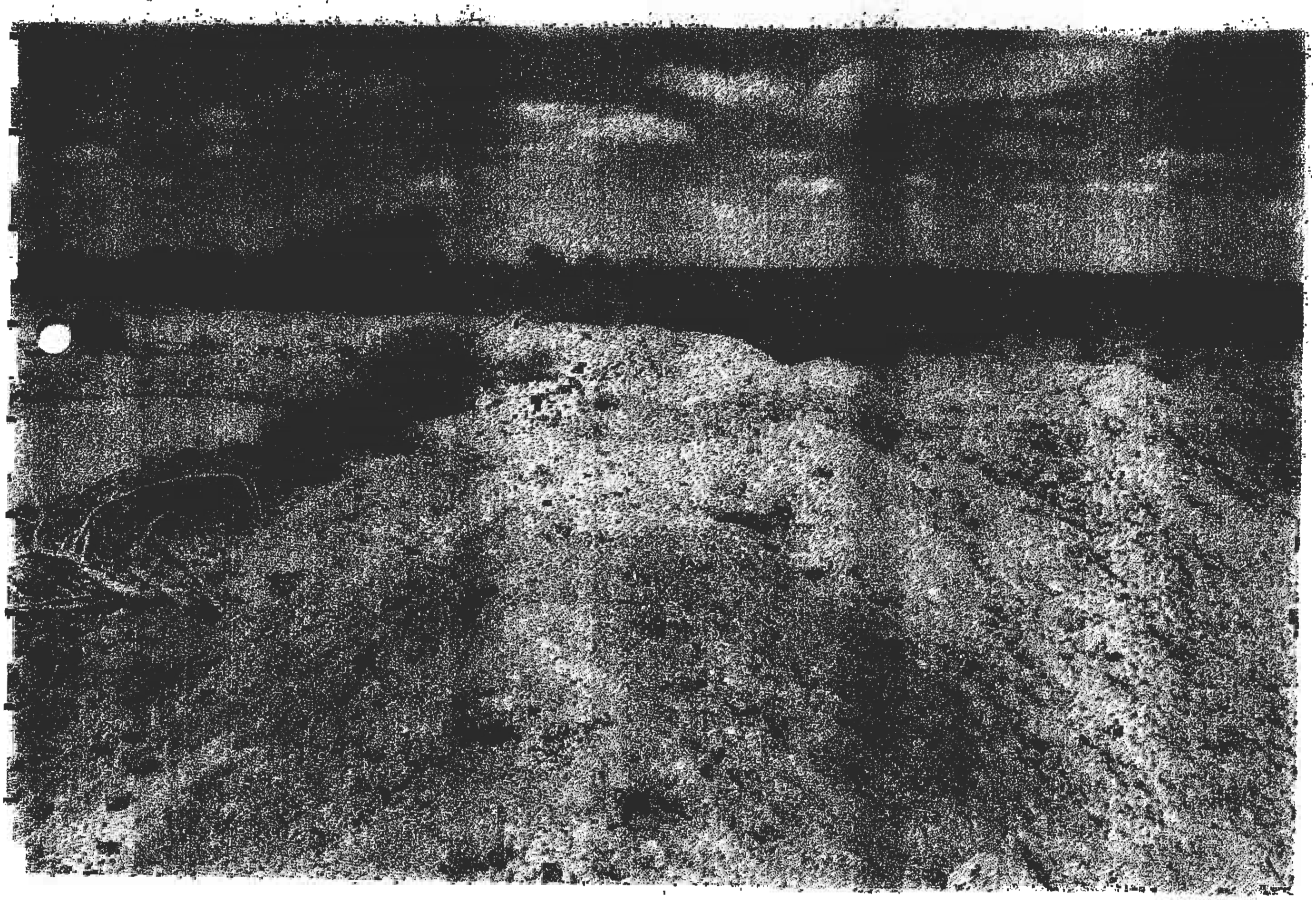




IAAZA MAGHEERA

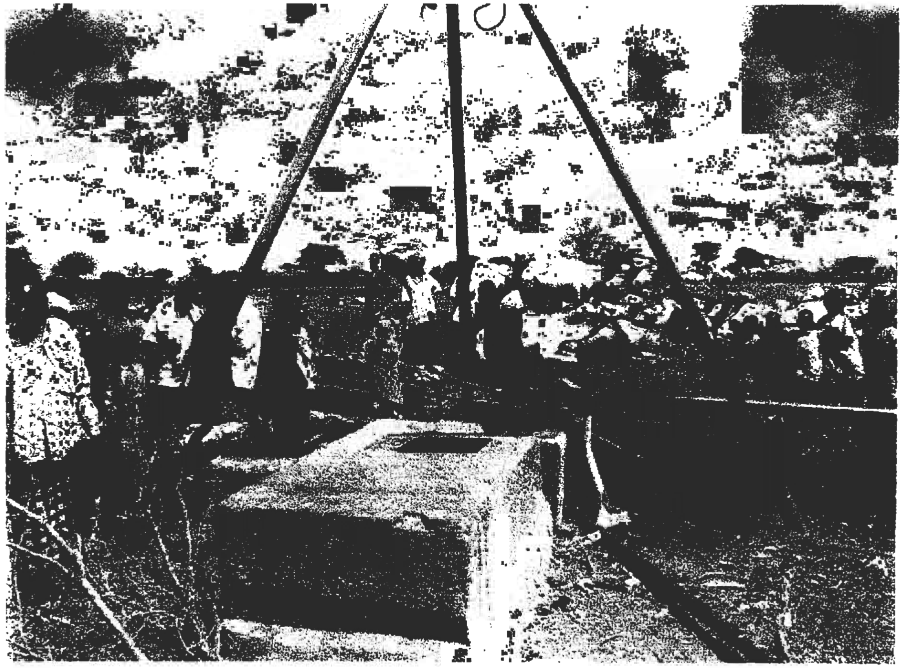


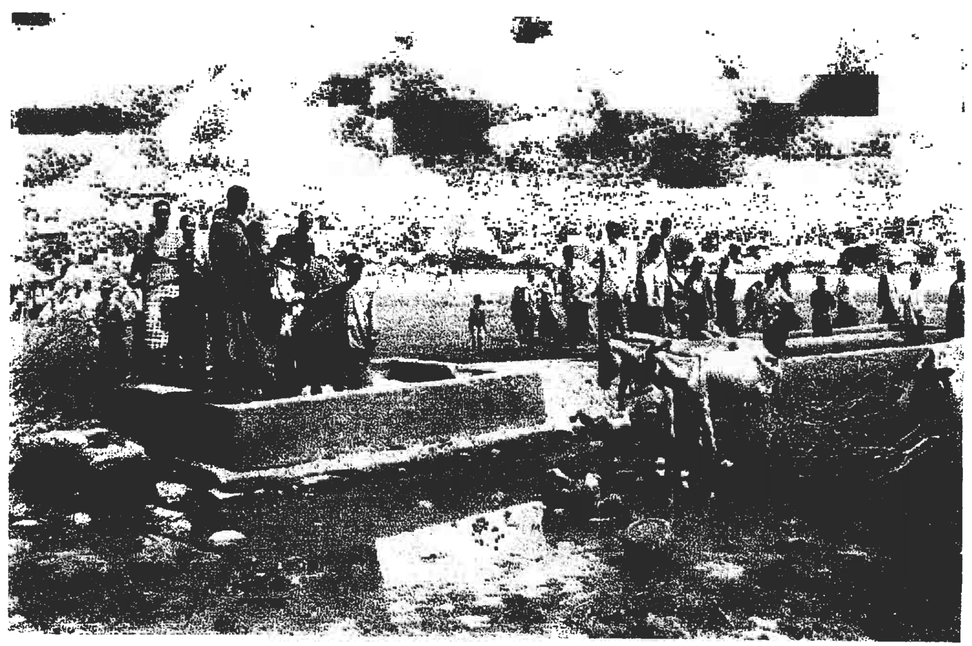




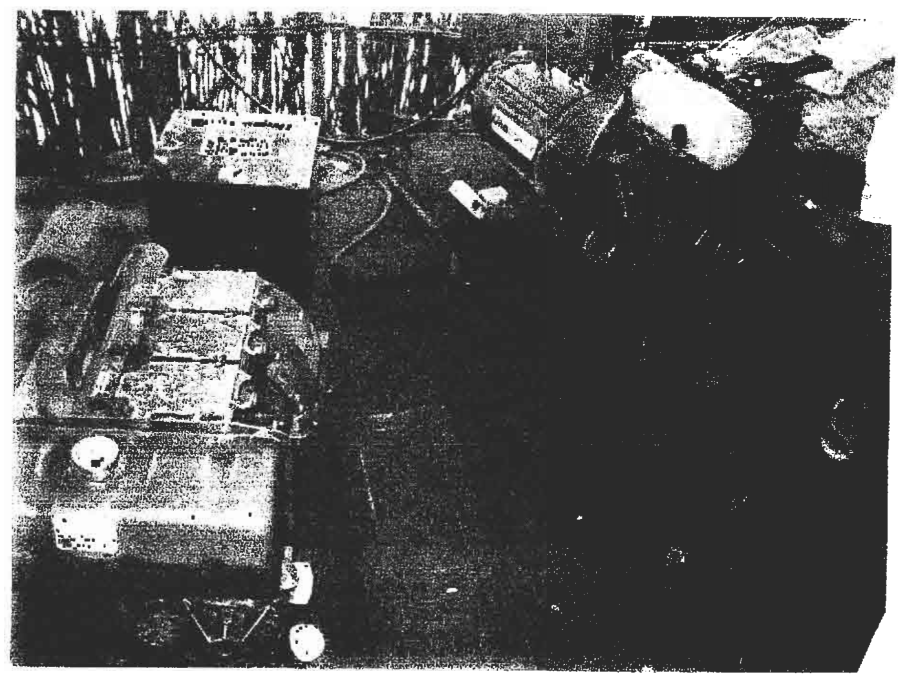
HARA MADHEERA . Gedo Region]

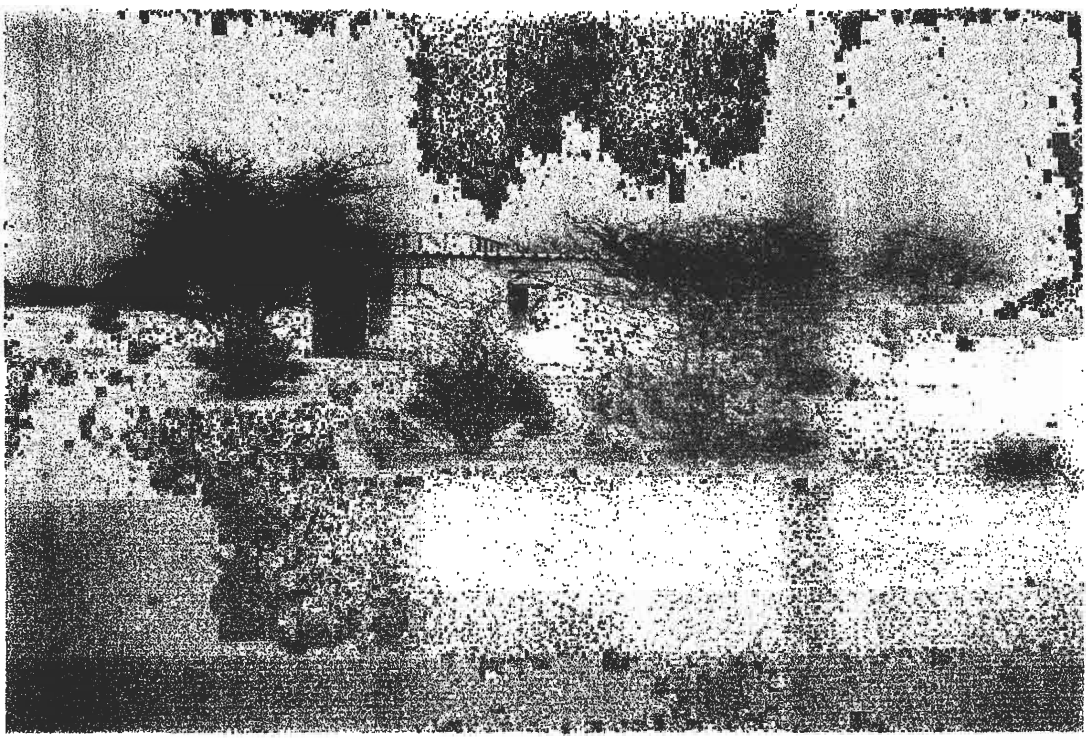
CEEL - G[illegible]





Damase borehole
Belet Xawo district





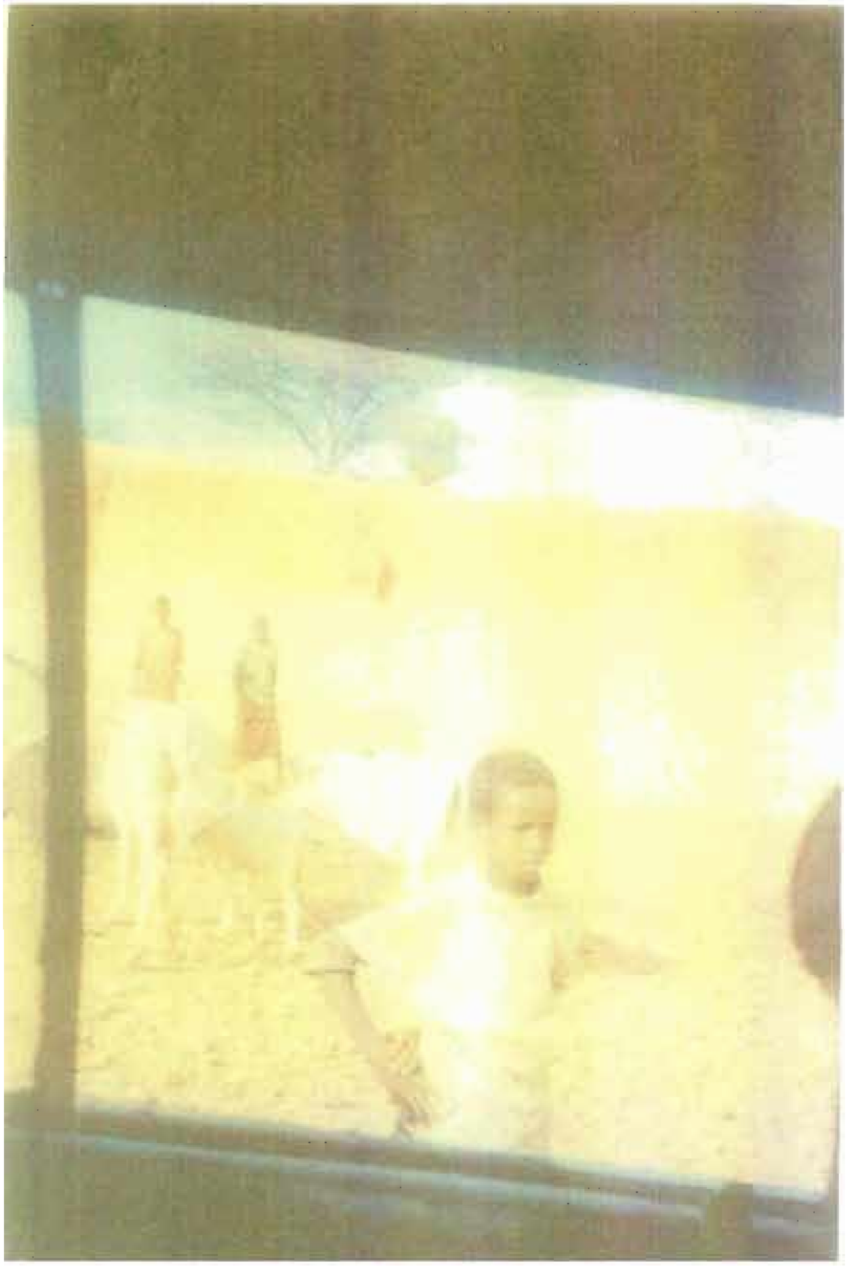
Ceel Cade borehole
Garbaharey district

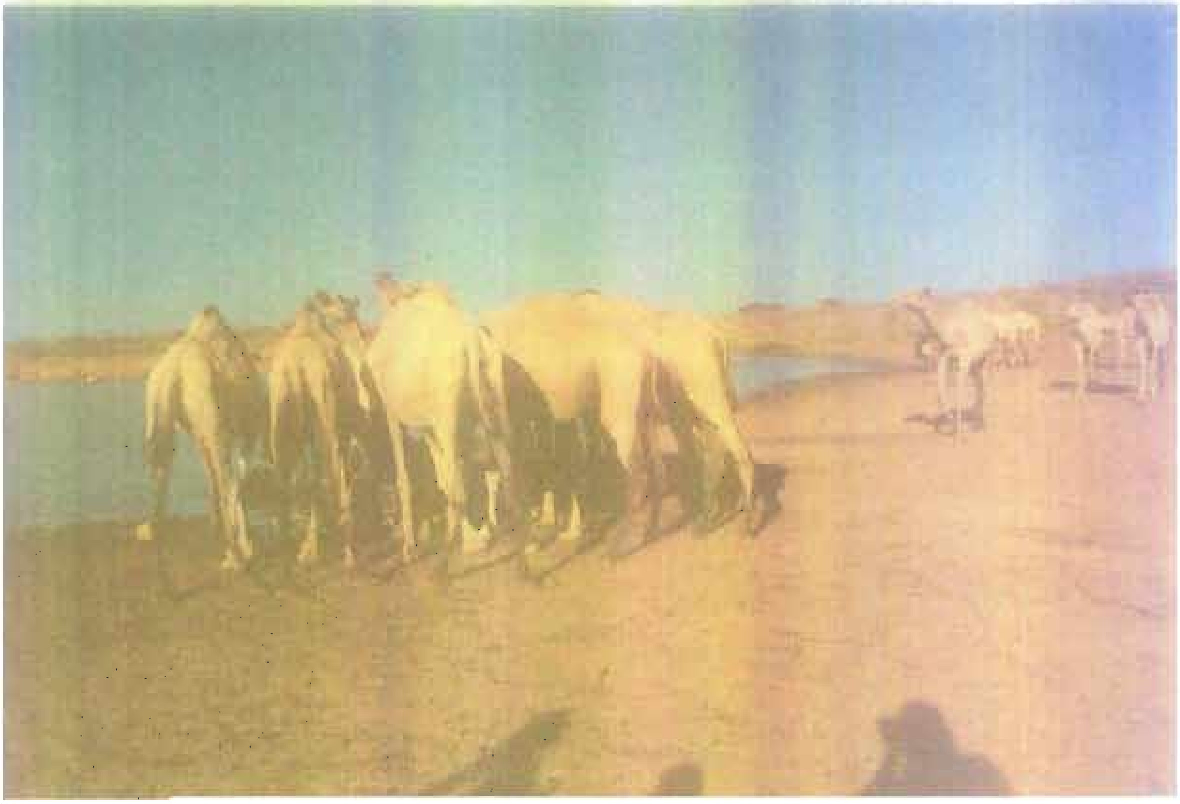
Siinujiif (Gedo
22 of January 2003

El Add shallow well
Bardere district

Shamnan (Gode Region)
23 of January 2002

Dunsa / Gedo Re...





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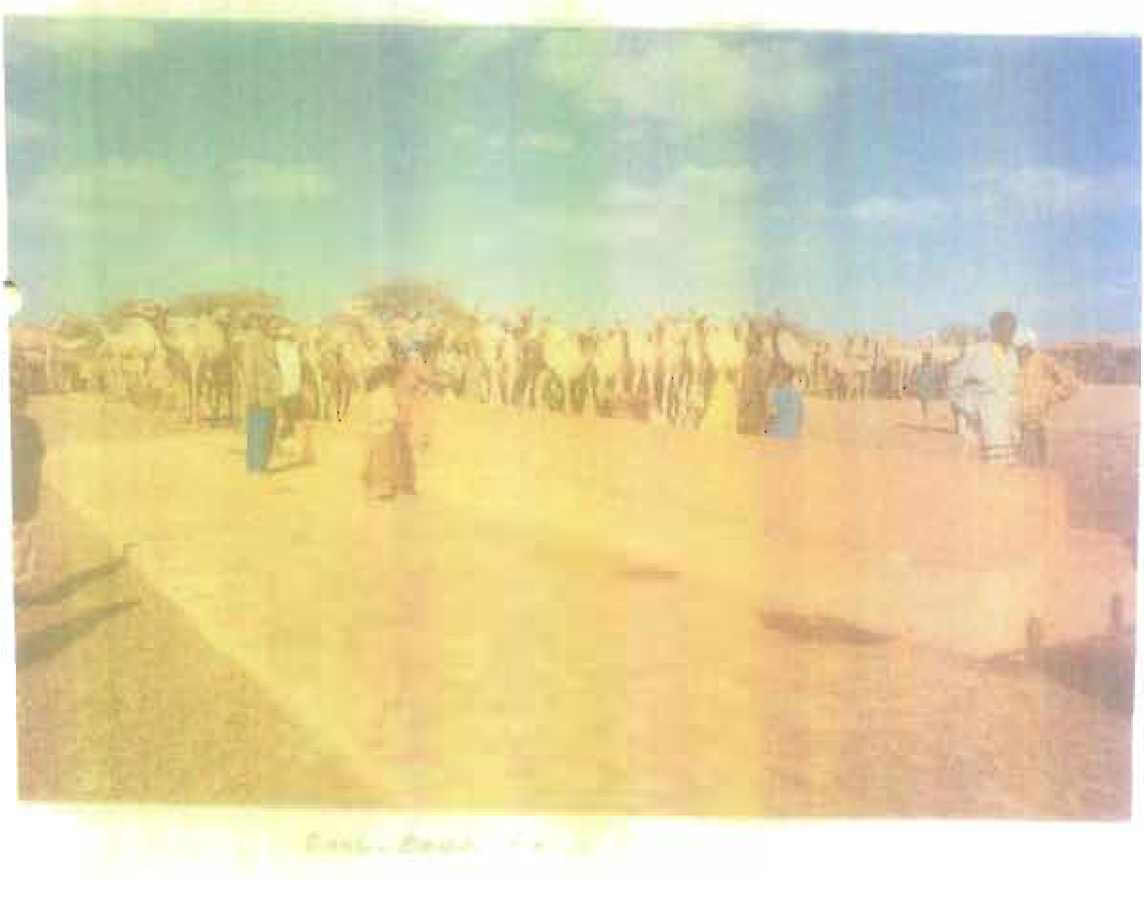
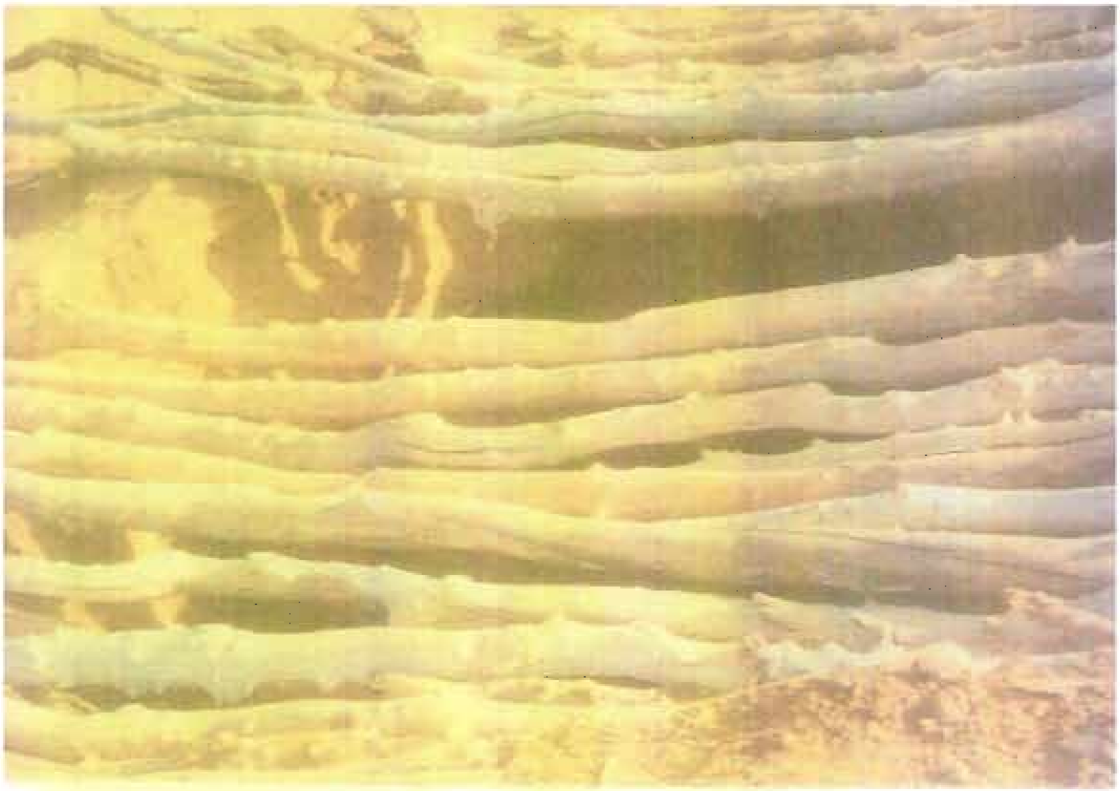
20 of January [illegible]





[illegible]
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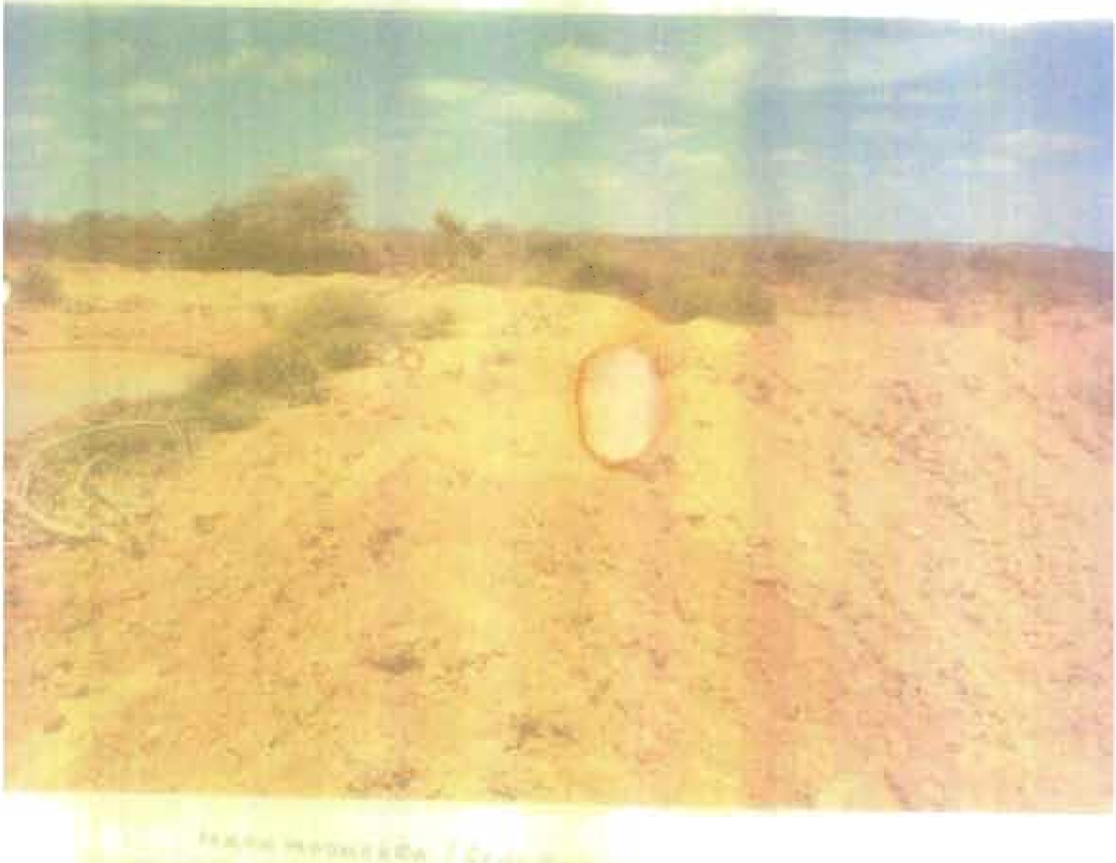

Cool – [illegible]

Damase borehole
Belet Xawo district