SOCIALIST ETHIOPIA

THE URGENT GROUNDWATER DEVELOPMENT PROJECT

FINAL REPORT

March, 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

PREFACE

It is with great pleasure that I present to the Government of Socialist Ethiopia this report on the Urgent Groundwater Development Project.

This report has been compiled by the Japan International Cooperation Agency (JICA) based on the request of the Ethiopian Government to the Japanese Government.

JICA dispatched to Ethiopia a survey team headed by Mr. Shinichi Yoshikawa from January 1985 to January 1986.

The team conducted a survey in consultation with the officials concerned of the Ethiopian Government and was engaged in the construction of model water supply facilities.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will contribute to future development of the project and to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Ethiopian Government for their close cooperation extended to the team.

March 1986

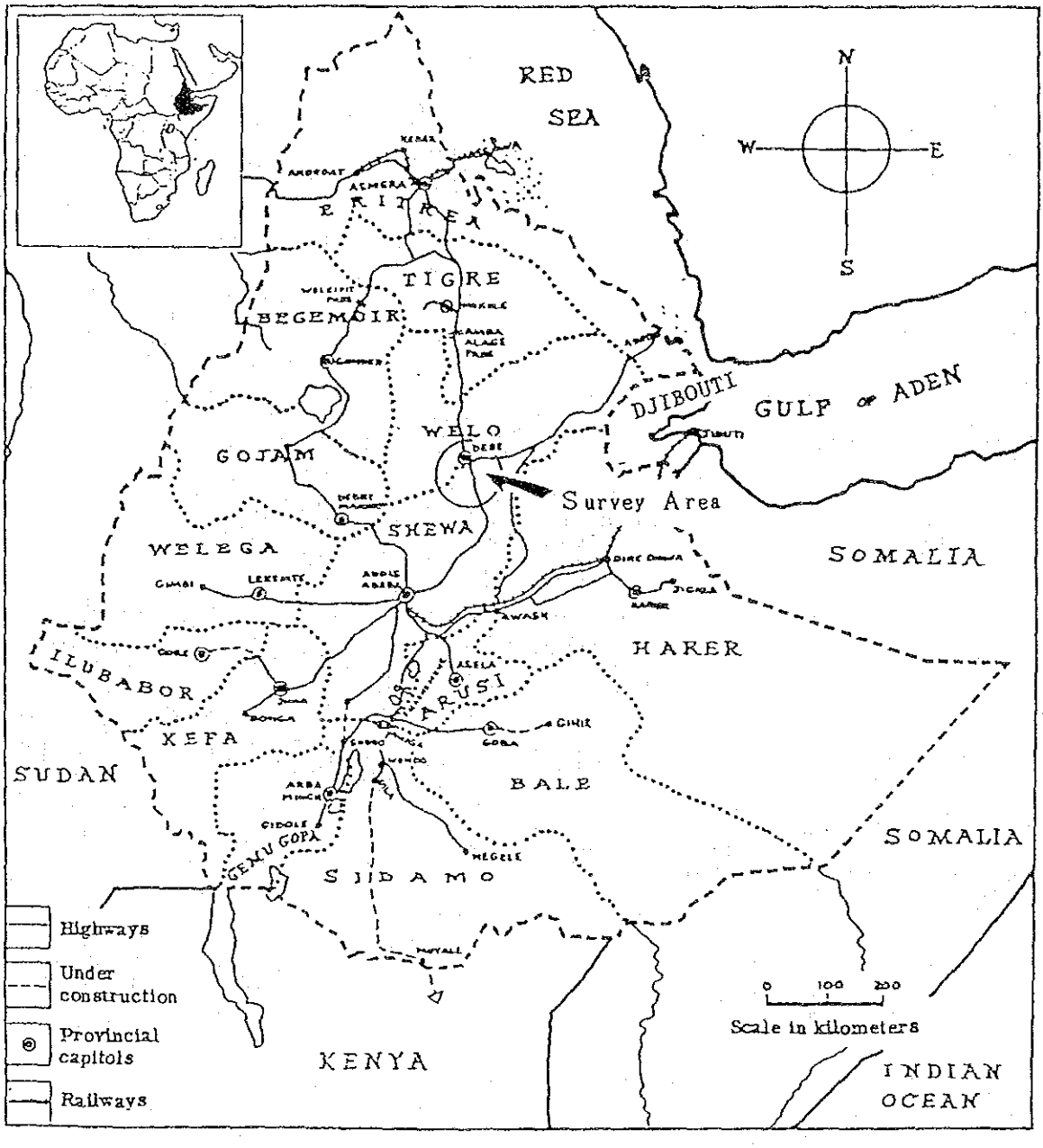
Keisuke Arita

KEISUKE ARITA

President

Japan International Cooperation Agency

SOCIALIST ETHIOPIA



Survey Area

SUMMARY

The Government of Japan determined to offer urgent aid to these drought affected people and areas from the point of humanity, as when Mr. Abe, the Minister of Foreign Affairs had visited Socialist Ethiopia in November 1984, the country had been attacked by drought and famine.

Considering that, Japan International Cooperation Agency (JICA) Planned and implemented a Program of development of water resources (ground water development) as an urgent subject for the supply with steady living water.

The project started from procurement of relating equipment and materials at the end of December 1984, then specialists dispatched, a selection of the project sites, and the construction of water supply facilities and finally the water supply has been actually in operation five sites.
The out line of the project is as follows;

1 Period of Survey
January 28, 1985 - March 15, 1986

2 Scope of Survey
From the northern area of Shewa region to the southern area of Wello region.

3 Contents of Survey
Study on social condition, subsurface geological survey (hydrogeological survey), test well drilling, construction of model water distribution facilities at (1)Karakoro (2)Chirete (3)Degan (4)Kembolcha (5)Tchaffa weledi

The area between northern shewa region and southern Wello region if comparatively lowland with 1,200 - 1,500 m in altitude. Damage by critical drought in 1984 in this area was particularly big, thus many farmers were affected to foll the victim.
This investigation aims at water supply to the relief centre that is performing relief activities in this area, together with acquirement of living water for inhabitant, as well as it can be utilize in future drought time in this area.

On the other hand, number of group from the aid granting organization of many countries are also operating their works in this country. Their numbers become to 43 groups as end of May, 1985.

The investigation was carried out between March and October, 1985, which included the condition and scale of relief centre, as well as social condition of the perimeter in 34 sites.

Finally, based on the access, degree of emergency and future potentiality, nine sites out of them were selected by turn for study on feasibility of groundwater development and appropriateness for the construction of water distribution facilities.

(1) Harbu (2) Karakoro (3) Chirete (4) Degan (5) Kamise
(6) Tisa Balima (7) Dessie (8) Kembolcha (9) Tchaffa Weledi

Summary of the result of hydrogeological survey at each site is as follows;

(1) Harbu (Wello)

Electrical prospecting was carried out at four places in this area. Underground geological structure is unconsolidated formation of upper part upto the depth of 120m, which is considered to be an interbedded formation of sand, gravel and clay, and the deeper part is considered to be Tertiary bedrock.
Aquifer is unconsolidated sand gravel formation of upper part.

In this area, EWWCA constructed three wells, two of which are 2 l/s, and another one is 11.4 l/s yields.

(2) Karakora (Shewa)

Electrical prospecting was performed in five places here.
Geological structure of underground is classified generally into three formation.
Main aquifer is the second formation, but the weathered zone of bedrock of the third formation in considered to have potentiality of groundwater.
The depth of groundwater development will be 70 - 80 m, taking the weathered zone as the object which, however, can not be expected much for groundwater potential because of narrow water catchment area.

(3) Chirete (Wello)

Electrical prospecting was carried out at five sites.
Underground geological structure is mainly classified into four formations.

The aquifer is sand and gravel layer of second and third formations.
According to the existing well, the layer for taking water is to be sand formation within 10 - 40 m at the depth of 51 m.
In this place, the third formaiton is to be the object with target of 120 m.

(4) Kamise (Wello)

Electrical prospecting was performed at four places with the result that the underground geological structure is mainly classified into three formations.

Main aquifer is sand gravel formation of the third.
The depth upto the bedrock is 50 - 70 m in the sorrounding area of shelter and 110 m in the adjacent area of E-5, from which it's infered that it has a considerably slope.

According to the data of existing well, as the permeability coefficient is 4.91 x 10^{-3} cm/s, this aquifer is considered to have good permeability.

(5) Tisa Balima (Wello)

Electrical prospecting was performed at four places.
Underground geological structure, according to resistivity, is mainly classified into five formation.

Aquifer is sand and gravel layer of the second as the main and the next is the third one, which, however, is inferior than the second one.
The fourth and fifth layer are bedrocks, especially the fourth, compared with the fifth, is judged to be the crushed clastic rocks, therefore, in case of groundwater development being carried out in this area, it's desirable to survey the fourthe formation as the object.
In this area, there are a well with yield of 5 L/s at the depth of 67 m and a shallow well at the slope of terrace along Ashawa river, which utilizes groundwater in sand gravel formation of the second one.

(6) Degan (Wello)

Electrical prospecting was carried out at five places.
The underground geological structure, by resistivity , is classified into three Layers.

First and second layer are equivalent to the hill deposits, which thickness is controlled by the surface shape of bedrock, i.e. the depth to the bedrock is presumed to be 20 - 40 m near E-1, 2,3,5, but in the vicinity of E-4, it's analyzed to be about 60 m.
This area is difficult in groundwater potential.
First and second layer are considered to be equivalent to the hill deposits. Both layers consist of mainly clay layer with sand & gravel and have bad permeability.

In this area, the object is to be fissure water in Tertiary bedrock.
Since a certain groundwater potential is expected probably in a boundary of the hill deposit and bedrock, in the vicinity of E-4 is desirable for the object point of test boring, where the upper surface likes valley.
In this place, there is a well with yield 2 l/s, which water catchment point is supposed to be within Tertiary formation.

(7) Dessie (Wello)

Electrical prospecting was performed in two sites in surrounding area of the transit chelter. Underground geology of lava plateau can not absolutely be classified, but in analyzing of the existing well' data, which is classified into four formations.

Relative height between electrical prospecting point No.1 and No.2 is about 30 m. Lava formation of both points is linked.
In the third layer groundwater potential is expected.
Below fourth layer, as the resistivity is considerably higher than upper formation, existence of hard lava is considered.

In the perimeter of this transit shelter, there are two city wells. In the light of these wells data, it can be described that groundwater layer is infered to be fissure water generated in fractured zone of the third layer.
Groundwater in this plateau is not existed in the basalt itself, but in the fractured rocks. The larger scale of fractured zone, the larger amount of groundwater potential. For instance, existing well No.3 is 15 l/s in yield and existing well at NO.2 point of electrical prospecting is 10 l/s. In the perimeter of shelter, this second formation is the object for groundwater development.

(8) Kembolcha (Wello)

Electrical prospecting was performed at three sites in the perimeter of SCF centre. From the result of prospecting upto 150 m deep, boundary with the bedrock cann't be grasped. Resistivity of upper lakes and terrace deposit is low and classification of formation is difficult.
Generally, resistivity of this deposit is less than 10 -Ω m.
There are many records of performance of well drilling in the basin.
In case of groundwater reaching 60 m, it flows out, which means that it has a pattern of confined groundwater.
The formation bearing this confined water is Fine sand grain layer with shell fragment, which is, reportedly, widely spreaded evenly.

(9) Tchaffa Welede (Wello)

Electrical prospecting was performed at five sites in the perimity of town.
Underground geological structure is classified mainly two.

There are two wells in this area, one of which is a shallow well of 7 m deep and subsurface groundwater is its' object, and another one is 37 m deep, which withdraw water from the weathered zone of bedrock.
It's desirable for groundwater development to take both of groundwater of subsurface layer and weathered zone, but the former one is easily affected by seasonal change.

Plan of Water Supply

As to the selection of proposed project site, at the beginning, only relief centre was aimed to be the object, because of that high degree of emergency, but at the latter part, future problem and future contribution for the local people were taken into consideration.

In selection of these proposed sites, determination was made on the understanding of the following matters.

(1) Social Condition of Relief Centres and surrounding area
(2) Condition of water utilization (Perimeter of Relief Centre)
(3) Emergency and future prospect

Judging these matters collectively, evaluation was given from the order of high degree of emergency Items of evaluation are as follows;

1. Degree of water demand
2. Access
3. Groundwater potential
4. Social condition
5. Future prospect
6. Others (Security condition, other Agency's well drilling Plan)

These evaluation items was examined with the result of determination of selection of the following five sites;

Karakoro, Chirete, Degan, kembolcha, Tchaffa Weledi.

As the result of pumping test on the drilled test well, yield of each area is as follows;
Karakoro(Well depth..80.5m): 1.01/s, Chirete(w.d. 126.5m): 3.01/s, Degan(w.d. 55.0m): 1.01/s, Kembolcha(w.d. 92.5m): 6.01/s, and Tchaffa Weledi(w.d. 38.0m): 3.5 1/s

In the construction of the facilities, Test boring was preceded, because of the problem whether supply can meet water demand, the facilities were constructed based on such result.
If the future maintenance and control of the facilities is concerned, for economic responsibility, based on the cost of water of 5 cent per 30 1. and water consumption of 30 1. per day per capita, cost of water per 1.0 1 is to be 0.16 cent.

On the basis of the above, 0.39 cent in Karakoro, 0.13 cent in Chirete, Degan 0.39 cent and 0.11 cent in Tchaffa Weledi.

Proposal for Operation Plan of Facilities

For the facilities to be used effectively and effect restored to the areas greatly, it is necessary to consider the established system of maintenance and control together with economic aspect. Here the future utilization of the facilities is proposed.

(1) Karakoro and Chirete

In case of only Karakoro facilities, as the local population must bear much economic obligation, it's considered to be more effective for the operation that this facilities will be connected by pipe with Chirete's facilities in future for uninformalization.
In such a case, Karakoro facilities will be deemed to be a standby one, because of its' high maintenance cost, thus Chirete well is to be mainly operated.

(2) Degan

A handpump has been installed, which needs regular maintenance as the imparative matter.

(3) Kembolcha

At this site, a comparative study was carried out as to the both cases, such as in case of the use of generator and another one was in case of having reliance upon electricity replaced with the former one.
As the result of the above, in case of generator, cost of water will be 0.06 cent, while in case of power plant it will be 0.74 cent. In consideration of future maintenance and control, the power plant is expected to be effective.

(4) Tchaffa Weledi

There is a state farm naming the "Tchaffa State Farm" in this area and the annual budget relating to the facilities is summed up 666,390 birr.
For the maintenance cost of existing generator, 4,500 birr a year is summed up, which is accounted for 12.33 birr per hour. In case of new generator, 14.26 birr per hour, about 5,200 birr a year, therefore, the facilities can be sufficiently maintained and controlled in view of the financial capacity of this farm.

Finally, it's important for the maintenance and control of the facilities to grasp operation condition always in order to establish system to be able to act soon at an emergency time. Especially, for control of well, check for water level, discharge rate, voltage and currency is very important.
In case of normal operation of well being unavailable owing to drawdown, decrease of yield and increase of sand discharge, it's necessary to recover the well capacity by rehabilitation.

On the other hand, the equipment and materials relating to this project were transfered as they were to RRC of Ethiopia and technical tranfer was executed too.
Hence, it is necessary for RRC in development of this project and demonstration of the fruits of technical transfer to continue, enforce and improve this system as much as possible, and to endivour to establish own system for future drought that may happen again.

Supply of Equipment and Materials relating to Project.
All the equipment and materials relating to this investigation were supplied under the Japanese Government's grant aids, amounting total ¥407 Million Yen (Birr 3.39 M).

This amount involves such contents as the equipment and materials for well construction including drilling rigs, mud pumps, drilling tools, casing pipes (total 660 m) and screen pipes (total 165 m), and instruments for survey. Further, as to the equipment and materials for the facilities construction, the following items are included, such as generator (8 units), submersible motor pump (8 sets), water tank 50 m^3 5 units, macinery house 5 bldgs and pipes (total 3,900 m). Furthermore, the equipment and materials for living including four units of container house and etc., which reached 1,200 m^3 in weight, and two units of large truck, two units of pickup have been included too.

Further, the breakdown of expenses paid for the implementation of this project is as follows;

	Yen	Birr
- Expenses for survey	¥ 47,000,000	(392,000)
- Cost of Construction of Model Water Distribution Facilities	¥152,000,000	(1,266,000)
Karakoro	(40,000,000)	(333,000)
Chirete	(32,000,000)	(267,000)
Degan	(7,000,000)	(58,000)
Kembolcha	(39,000,000)	(325,000)
Tchaffa Weledi	(34,000,000)	(283,000)
- Cost of Supplied Equipment and Materials	¥154,000,000	(1,282,000)
Drilling Rig, materials	(130,000,000)	(1,083,000)
Spare parts	(24,000,000)	(199,000)
- Overall Administration Cost.	¥ 54,000,000	(450,000)
Total	¥407,000,000	3,390,000

Note:

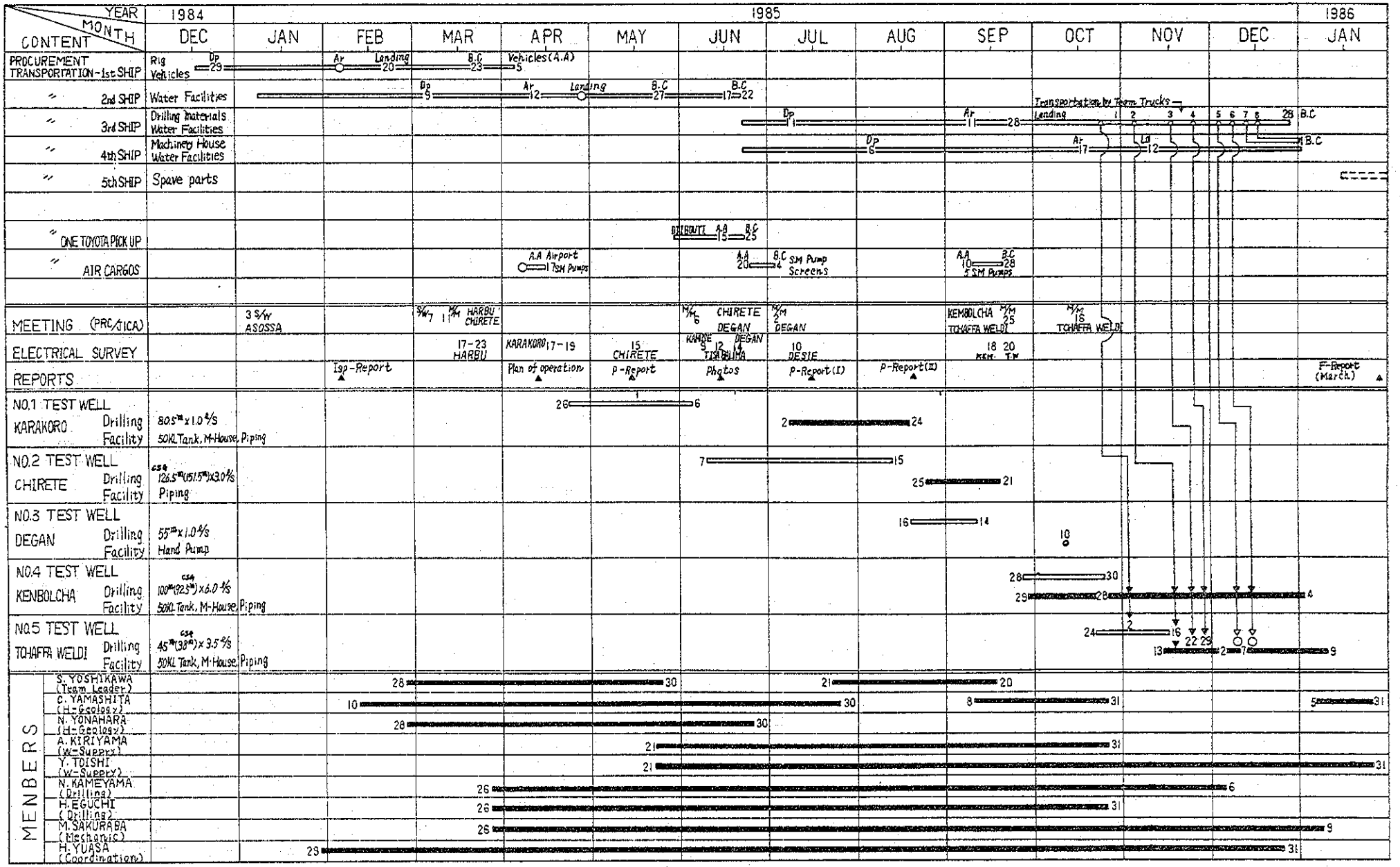
(1) Cost of survey consists of the expenditure concerning to the study on socio-economic, selection of project site, geography/geology and utilization of facilities.

(2) Cost of construction of model water distribution facilities includes cost of well construction.
Further, in these construction cost the installed generator and water tank, as well as the equipment and materials are involved.

(3) The drilling rig and materials in the cost of supplied equipment and materials mean the cost of the same other than the equipment and materials installed or consumed in the facilities construction.

(4) Exchange rate applied: Birr 1.00 = Yen 120 (on Mar. '85)

TABLE-PROCESS OF PERFORMANCE



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The Government of Japan determined to offer urgent aid to these drought affected people and areas from the point of humanity, as when Mr. Abe, the Minister of Foreign Affairs had visited Socialist Ethiopia in November 1984, the country had been attacked by drought and famine.

Considering that, Japan International Cooperation Agency (JICA) Planned and formed a Program of development of water resources (ground water development) as an urgent subject for the supply with steady living water.

This project, at first, had been carried out in Assosa region, in the south-western area of the country, in accordance with the resettlement plan which Socialist Ethiopia had been carrying out. However, for the later conditions of Ethiopia, the object area was changed to another area from the northern Shewa region to the southern Wello region where there are a large number of drought affected people and has a high degree of water demand.
The project started from procurement of relating equipment and materials at the end of December 1984, then specialists dispatched, a selection of the project sites, and the construction of water supply facilities and finally the water supply has been actually in operation five sites. In the meantime, as to the contents of the project, its condition of progress and result were reported as Progress Report I and II.

In addition, JICA Study Team carried out the project attempting the technical transfer to the engineers of R R C (Relief and Rehabilitation Commission), the enforcement organization of Ethiopia.

This report summarizes these details and also proposes the future plans for maintenance and administration, the operation system, etc.
Every data obtained and supplied equipment and materials relating to this investigation are collected in the APPENDIX.

2. OUTLINE OF SOCIALIST ETHIOPIA

2.1 Basic matter

Ethiopia lies in the north-eastern area of African Continent in what is called the "Horn of Africa", within the range of 3° to 8° in the north latitude and in longitude 33° to 48° E.

The area of this country is about 123,000 km^2 (three times that of Japan). This country consists of many variety of tribes including Amhara, Oromo, Tigray and Wulage that are inhabiting in the highland, and in the lawland, Ogaden region Somali, and in Afar lowland Afar are inhabiting.
As for the political regime, the revolution government that was established by the military revolution in 1974 is still controlling, and which adopts a socialism system headed by Major Mengiest as the Chairman. In the north, Eritorea region and in the west, Ogaden region, Tigray People Liberation Flont (TPLF), Eritrea People Liberation Flont (EPLF) and West Somalia Liberation Flont (WSLF) have been setting out the separation independent movement from Ethiopia. The prolonged civil wars among them have been continued. The area with these active guerila operation is in a critical security condition, but in the other area the security condition is steady.
Ethiopia is divided into 14 Regions.

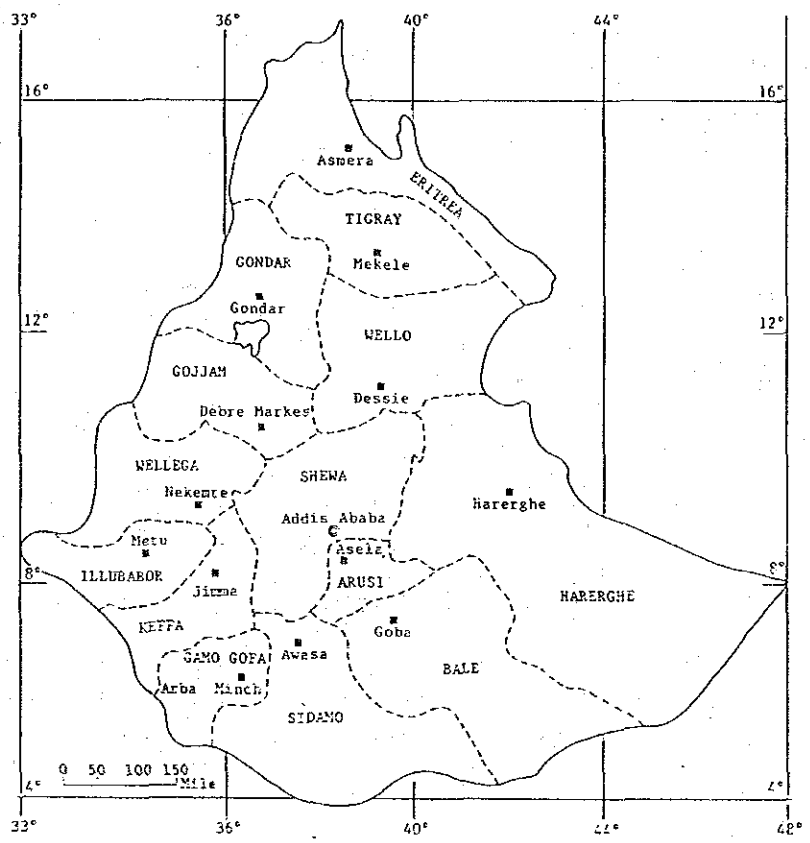


Fig. 1 Regional Map of Ethiopia

2.2 Summary of topography

This country's topographic characteristic is that 2/3 of the overall country land are covered with highlands with the altitude of 1,000 ~ 4,600 m. The highlands is divided to three zones by the Rift Valley and river ravine.

(1) Northern Mountains

This is the highest zone in Ethiopia, where the highest peak of this country, Ras Dashen (4620 m) is located. This mountains extends from Eritrea to Tigray and Gojjam regions in the north, and to Addis Ababa in the south, and in the west it's adjacented to lowland of Sudan. In the eastern side, it's adjacented to Rift Valley with steep cliff.

Blue Nail River that is No. 1 river in this country flows from Lake Tana in this mountains, dissecting this zone, making steep ravine, and runs to ward Sudan.

(2) South western Highlands

This zone is situated in the south-western part bounded by the Blue Nail. The erosion by river is not so significant compared with that of the northern part. The altitude is not high like the northern part, but the eastern side near the Rift Valley is more than 2,500 m in hight. In this zone, mainly Wellega, Illubabor and Keffa regions are situated.

(3) South eastern Highlands

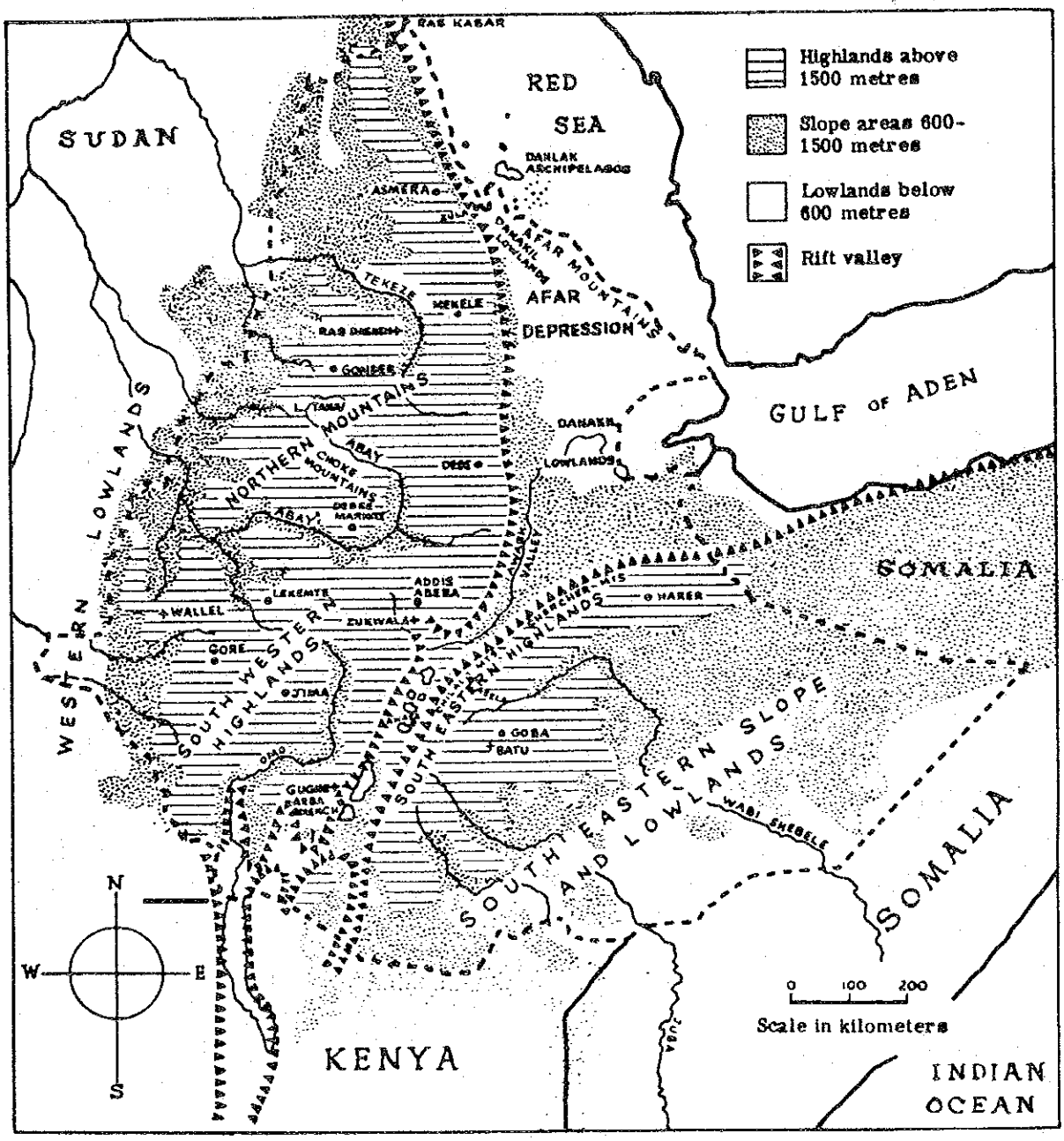
This highlands is in the eastern side bounded by the Rift Valley. Generally, in comparison with the northern mountains, the extension is narrow, in the western side, it contacts the Rift Valley with steep cliff, while in the eastern side, the altitude reduces gradually toward Somalian side with gentle slope. In this zone, Harerghe, Arusi and Sidamo regions are situated.

The lowlands surrounding the highland are (1) the lowland along the Rift Valley (2) western lowland (3) south eastern

slope. The Rift Valley tends to the south-west, Kenyan direction. In this lowland, there are, from the south, Chamo, Abaya, Shala, Abiata, Langano and Ziway lakes in series. In the northern lowland, Afar area has a place with - 100 m from the sea level. The western lowland that contacts the southern part of Sudan, to which Gambela region of Illubabor region corresponds. The south eastern slope that is the one that inclindes from the south eastern highland to the north western Somalia, which is called the Ogaden area.

The rivers dissect these highland zones, flowing down to the lowland belongs to the water system of either Nile or Rift Valley or Webi Shebele. The Nile water system includes rivers dissecting the western highland zone bounded by the Rift Valley, which is particularly represented by the Blue Nile that flows from Tana Lake.
The Rift Valley water system includes rivers that flow down in the lowland of Rift Valley and most of them flow in to lakes, not reaching the ocean. Among them, Awash river is the representative one. The Webi Shebele water system is a river system that flows down in the south eastern slope. Most of them vanish within the continent.

Fig. 2 Higlands and Lowlands



2.3 Summary of geology

The basement of Ethiopia consists of pre-camblian metamorphic rock, which is a part of shild zone in the world. These rocks are comprised of Shist, Granite and Gneiss and are the country rock of mineral deposit. The outcrop of these basement appear in the regions of Eritrea in the north, Wollega and Keffa in the southwest, and Sidamo in the south. In the upper part of the basement, sandstone, gypsum and limestone deposited thickly by marine transgression and marine regression. The distribution of these rocks of the mezoic era can be seen in Ogaden of Harerghe region in a part of Tigray region and in the ravine which is made from the volcanic rock land dissected by the Blue Nile.

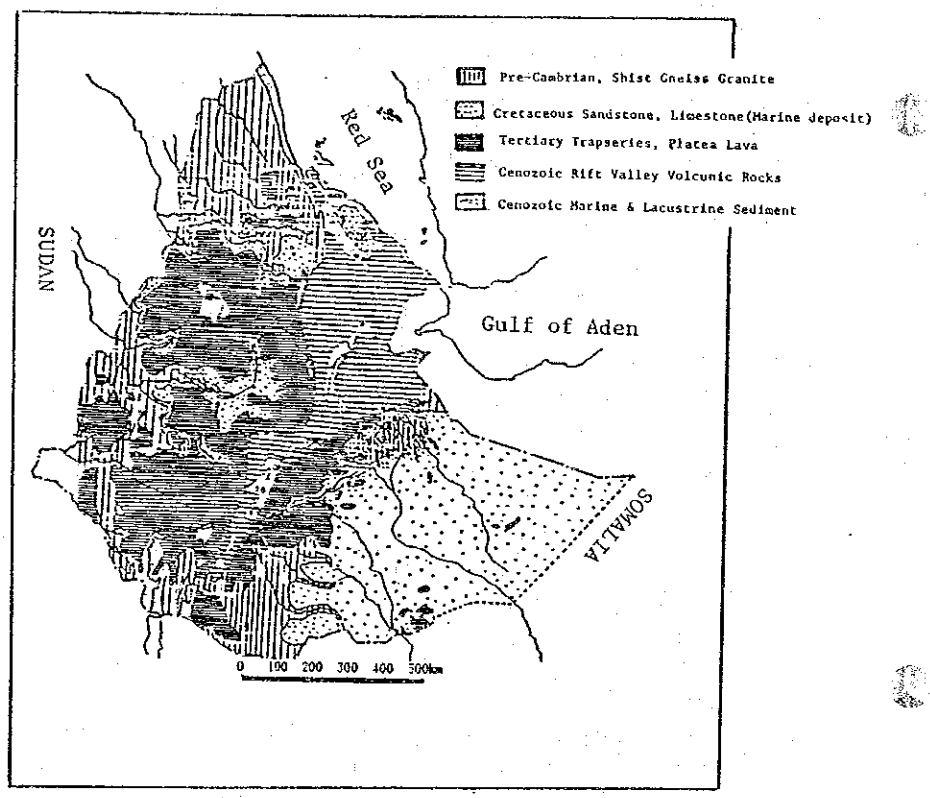


Fig. 3 Geological Map of Ethiopia
(by Kazmin, 1975)

In the Oligocene epoch of Tertiary volcanism became active and huge volume of alkali basalt belched up with the result

of rocks aforementioned being overlain by the thickness of 2,000 - 3,000 m of lava plateau.

The baslts made by the series of volcanism is called the "Trap Series" that consists of the complex of various rocks such as alkali basalt, clastic rock, tuff and ryorite.

This series is divided, according to the time of activity, to Ashangi formation and Magdala formation. After this, at the beginning time of Miocene, separation of continental crust begun and tholeitic basalt was extruded. This crust separation, in the end of Pliocene, was bounded in the western side by the normal fault to form the structure of the Rift Valley zone.

As mentioned above, the Geology of Ethiopia is distributed from Pre-Cambrian to the unconsolidated sediment of the Quaternary which deposit in the lowland of Rift Valley, but the present topography of this country was formed by the volcanic rocks of the Tertiary Trap Series, by which the highland zone was formed.

2.4 Meteorology

Season of Ethiopian highland through the year is divided into the rainy season and dry season.

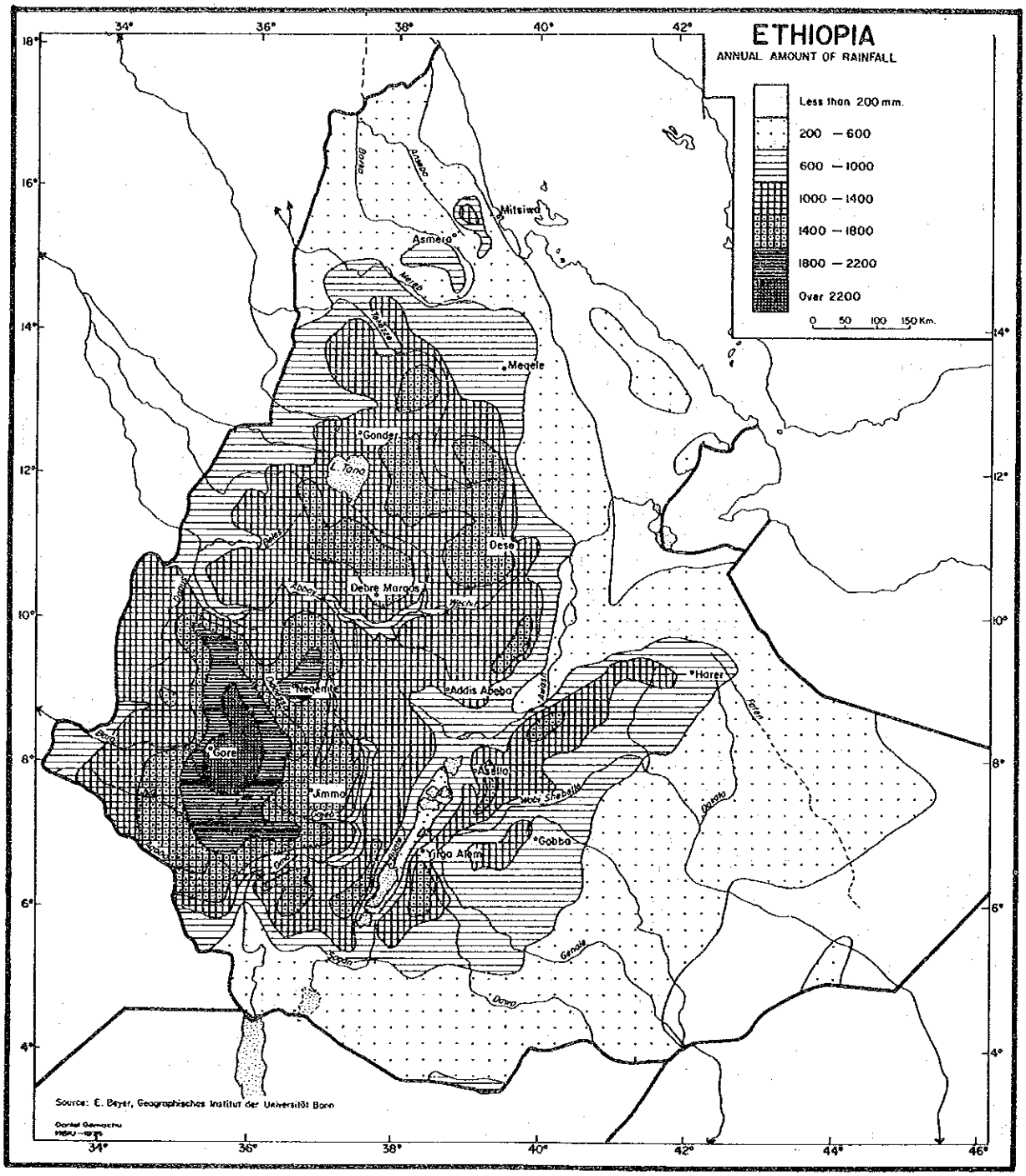
The rainy season is further divided into the less rainy season (February - May) and much rainy season (June - Septemer). Dry season is from October to January.

The above is a general trend, but in such areas as Illubabor, Keffa, Sidamo and the western part of Gamo Gofa, continuously rain falls between March and the middle of September, especially this area has much annual precipitation, which is recorded 1,400 - 2,200 mm. Generally, annual precipitation is 1,400 - 1,800 mm in highland with topographically altitude more than 2,500 m and 1,000 - 1,400 mm at 600 - 2,500 m in allitude.

Precipitation in Dankil (Afar) area, Ogaden area and lowland along Red Sea is 200 mm.

Fig. 4 shows precipitation distribution in this country.

Fig. 4 Annual Amount of Rainfall



3. PROCESS OF PROJECT

Ethiopia lies in the north-east area of African Continent in what is called the "Horn of Africa." The area of this country is about 1,230,000 Km^2 (three times that of Japan), the population is estimated at 42,000,000 ('84) and when exactly classifying, the number of tribes are said to be more than one hundred.

The country is divided in two sections, the north-east heights and the south-west heights, by the Rift Valley, the great graben zone which runs from the north-east to south-west region. The altitude of the Rift Valley is -150 - +1,500 m and scattered along the Rift Valley are lakes of various sizes. Lake Tana in the center of the northern region is the source of the Blue-Nile. The heights, called Abisiniya plateau, has an altitude of about 2,000 - 3,000 m and its annual precipitation is 1,200 - 2,400 mm, 80% of which is concentrated in the rainy season between June and September. In the dry season between October and February fine weather lasts and in the northern region Rift Valley it seldom rains throughout the year.

During the great drought before and after 1970, it was reported in September 1973 that 2 million people faced famine and the dead from starvation numbered at least 500,000. This became the outset that Emperor Haile Selassie I abdicated in the revolution in September 1974 and the Empire of Ethiopia which had gloried in 3,000 years of history was changed to the present Socialist Government.

However, after the great drought which had attacked six nations in Northern Africa in half a century, the chronic shortage of water and food menaced the lives of millions of people. Then precipitation around 1984 decreased and the great drought came again. In September 1984, the drought affected people in Ethiopia numbered 6 - 7 million. In December that same year there was one instance when more than a hundred people died in one relief camp during one night.

Relief activities by various countries and organizations were performed while time the Government of Japan delegated Mr. Abe the

Minister of Foreign Affairs and he inspected relief centers for drought affected people in the northern region and pledged the aid for the development of underground water in the country.

According to this, Japan International Cooperation Agency (JICA) dispatched a Study Team On January 6th,1985 for a preliminary survey aiming to make an urgent plan of living water by the ground water development to aid the drought affected people.

At the time of the preliminary survey, an objective area for survey of the ground water development was said to be at a point about 100km to the south from Addis Ababa. However, as the Government of Ethiopia set forth a plan which was to move the drought affected people in the northern region to the southwestern region, JICA Study Team make field reconnaissance in the settlement place drought affected people migration places in Assosa and Ganbela regions as well as they extended the reconnaissance to the Bati relief center in the north-east. After the said survey JICA fixed a plan of ground water development for the Assosa region (dated Jan. 3 '85 S/W).

However, RRC later requested a survey of ground water development in drought affected people relief centers (shelters) in northern Shewa and southern Wello regions to determine which had the highest degree of emergency for living water.

JICA accepted this request anew and entered into a "Scope of Works" with the Ethiopia Relief and Rehabilitation Commission (RRC) (March 7, 1985). Successively after the field reconnaissance, it was determined in the minutes of a meeting dated March 11, to study shelters in Harbu and Chirete. Another 3 sites were to be selected from the northern Shewa and southern Wello region (between Debre.Berhan and Dessie) and the base camp of the Study Team was to be constructed in the RRC garage in Kembolcha.

However, since the arrival of equipment and materials (drilling rigs, vehicles and so on) had been delayed unexpectedly, Ethiopian Water Works Construction Authority (EWWCA) was compelled to set out well drilling itself which was urgently needed to cope with the

shortage of water in Harbu shelter. Therefore, after reconnaissance the JICA Study Team changed the program again and selected as the No.1 test well drilling point Karakoro (shelter) in the village of Chirete.

Afterwords the conditions of drought affected people improved gradually and each shelter began to reduce, with the good progress of survey schedule and time passage in the latter part of the project, however, it became difficult to select the points of test drilling and investigation. Progress in the survey of shelters in order of degree of emergency was made and finally five well drillings were completed. The last, No. 5 test well drilling was completed on November 16, 1985.

No.1 test well ----- Karakoro
No.2 test well ----- Chirete
No.3 test well ----- Degan
No.4 test well ----- Kembolcha
No.5 test well ----- Tchaffa Weledi

On the other hand, as the arrival at the site of equipment and materials for the water distribution facilities was delayed, the trucks of the study team was sent to Assab, 450 km from here, over eight times and as a result of such effort for receiving such equipment and materials, those finally reached the site on January 1st, 1986. Afterward, all the water distribution facilities were completed on 9th January.

4. OUTLINE OF PROJECT

The outline of the Project is as follows:

1 Period of Field Survey
January 29, 1985 - January 29, 1986

2 Scope of Survey
From the northern area of Shewa region to the southern area of Wello region (S/W dated March 7) Between Debre Berham and Dessie (M/M dated March 11)

3 Study of Social Conditions
Study of social conditions in 34 sites
Study of relief activities and environmental conditions mainly by hearing and field reconnaissance

4 Geological Survey
Survey by electrical prospecting in 9 sites to search possibilities of ground water potential.

Harbu, Karakoro, Chirete, Degan, Kemisee, Tisa Balima, Dessie, Kembolcha, Tchaffa Weledi

5 Construction of Water Distribution Facilities
Based on the result of the above survey 34 sites for the Project were selected and construction of water distribution facilities in 5 sites, after investigation of test well and water distribution began.
(1) Karakoro (2) Chirete (3) Degan (4) Kembolcha
(5) Tchaffa Weledi

6 Supply of Equipment and Materials Related to the Project
Equipment and materials related to the wells
Equipment and materials related to facilities

7 Personnel Composition in Project

Ethiopia

Maj. Mulugeta Kebede	Head, Eng & Tech, Service Dept. RRC
Ato. Ephrem Guade	Head, Water Supply Sec. RRC
Ato. Getnet Kebede	Counterpart for the Project
Ato. Abel Debebe	ditto

Japan

Mr. Shinichi Yoshikawa	Team leader. Socio-Economy
Mr. Chifumi Yamashita	Sub-Team Leader. Hydrogeology
Mr. Nobuo Yonahara	Hydrogeology & Electrical Prospecting
Mr. Akihiro Kiriyama	Water Supply Planning Water Supply Facilities
Mr. Yohichi Toishi	Water Supply Facilities
Mr. Noboru Kameyama	Well Drilling
Mr. Hitoshi Eguchi	Well Drilling
Mr. Masakatsu Sakuraba	Mechanics
Mr. Hitoshi Yuasa	Coordination

5. WATER RESOURCES OF ETHIOPIA

5.1 Conditions of Water Supply

It is difficult to explain the present conditions of water supply of Ethiopia in a word, therefore it is generally said that the people who are supplied with sanitary drinking water make up less than 20 % of the population in the cities and only about 5 % in the rural areas. Large-scale water supply facilities are diffused in less than five cities such as Addis Ababa, the capital. According to data by Addis Ababa Water Supply Authority, the consumption volume of water per person per day is 80 liters. However, actual consumption is much lower, less than 30 liters. While in rural areas the water conditions are extremely inferior, inhabitants are supplied with water through rivers, springs and simple water supply facilities constructed in the villages.

Originally, the country has suffered from a chronic shortage of water, and recently the drought which attacked Wello and Tigray regions in 1973, 74 claimed 200,000 human lives and damaged thousands of cattle. The next great drought, which attacked early 1984, spread throughout the country, both in the highlands and lowlands, and the water level of rivers decreased. Also various damages such as the drying-up of springs and shallow wells, ground water recession reducing of ground water, etc., occurred. Although there are about 1,000 water supply boreholes, it is supposed that the influence of this drought has especially affected the lowlands. Two hundred wells, which is equivalent to 20 % of the total, have lowered their capacity because of shortage of parts or maintenance. Another 150 wells have been decreasing the amount of water by groundwater recession and 50 more wells cannot operate because there are no pumps, generators, etc.

Water resources of Ethiopia are influenced by topography, geology and meteorology, and property of surface water sources and underground water differs depend on the location.

Surface Water Sources;

Although the Ethiopian highlands are the source of water supply in the "Horn of Africa", at most places it's not utilized enough. One of the reasons why it cannot be utilized is the rivers run through deep ravines. Another reason is the pattern of precipitation through the year is irregular and the change of flow amount in the dry season is extremely great. Further, in the north-western plateau and the Rift Valley, which occupy one third of the country, there are a few rivers because the annual rate of precipitation is small. Also as most main springs are located along cliffs, access to them is very difficult. However, the south-western highlands which have many woods are blessed with rain and can be expected to be useful in future surface water sources development.

Ground Water Sources;

As the quality of ground water, same as the surface water is influenced by topography and geology, the conditions of geology must be grasped on ground water investigation. In the eastern, southern and western areas, the stratum, which is rather recent, has been eroded and various kinds of metamorphic rocks of the old Precambrian distribute. At these places where old rocks distribute ground water is limited at fissured and upper weathering zones. In the south-eastern area which is limestone and sandstone zones of the Mesozoic area, lies the aquifer bearing good quality of water. In the volcanic areas which form the highlands, fissured and fractured zones consist a favorable aquifer. The ground water in the Rift Valley is hot and high in density of flouride. The lacustrine deposit, alluvium and sedimentary layer within the Rift Valley are a more favorable aquifer, which is an object of groundwater development.

5.2 Organization of Water Resources Development and Development Plans

Based on the need of water resources development, the Government established the National water Resources Commission in 1981. and under the commission 3 Authorities and 1 Agency were set up. The roles and allotments are as follows:

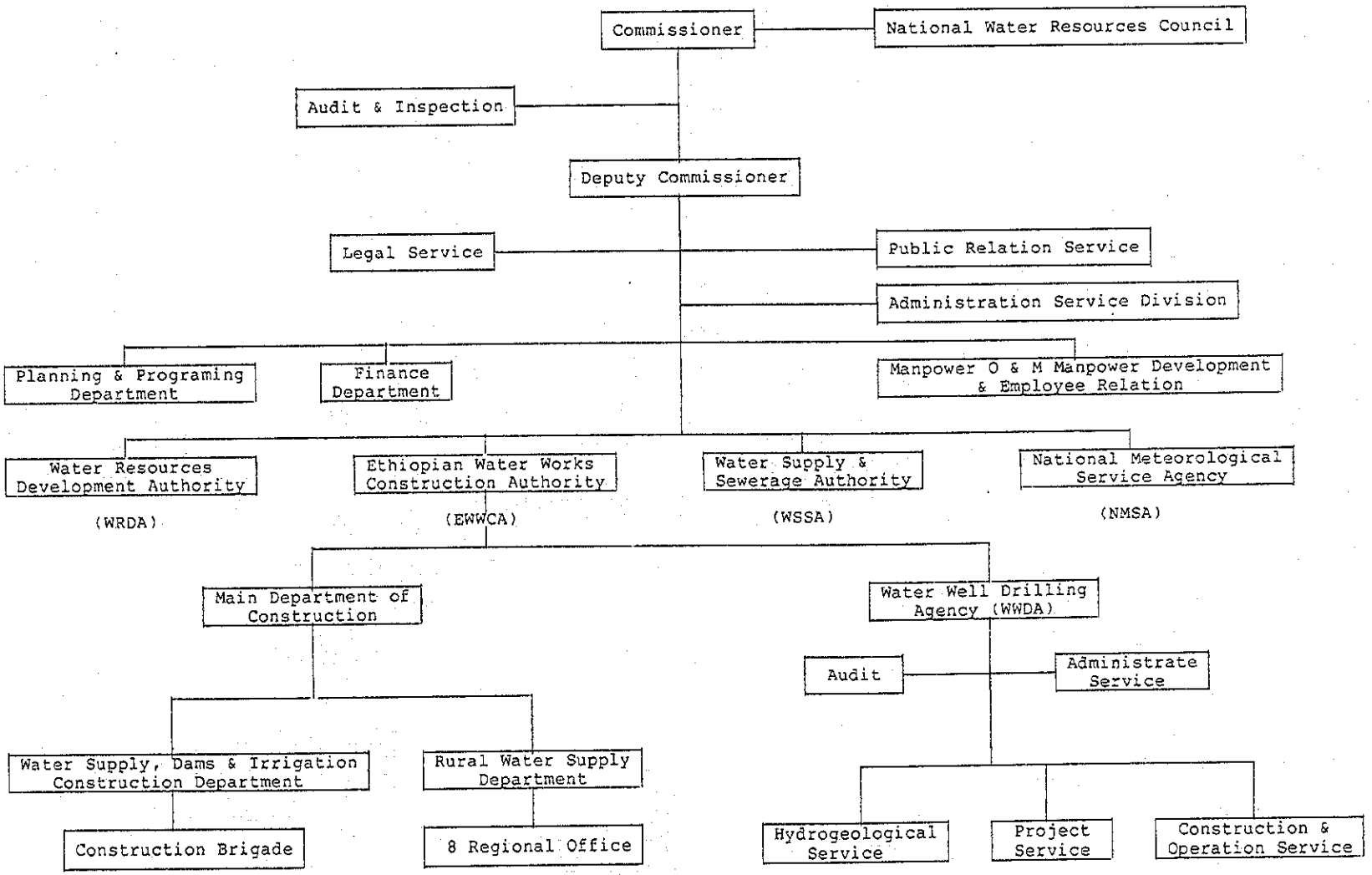
The water Resources Development Authority
(WRDA)
Established in 1981, forms plans related to water resources and monitors the activities of all irrigation projects

The Ethiopian Water Works Construction Authority
(EWWCA)
Established in 1980, carries out general constructions related to water resources and has 8 branches covering the whole country.

The water Supply and Sewerage Authority
(WSSA)
Established in 1981, forms plans of water supply facilities and sewage systems. It also operates water supply facilities in cities and rural areas and maintains and controls them.

The National Meteorological Service Agency (NMSA)
Established in 1980, surveys and studies weather conditions.

Fig. 5 Organization Chart of National Water Resources Commission



EWWCA is operated on the National budget but WWDA, which is under it, is operated individually on a commercial base. This WWDA was established by grant aid from the Japanese Government and a yen loan from the Overseas Economic Cooperation Fund (OECF).

While EWWCA constructs water supply and water sources facilities in various areas, WWDA, which is a contractor takes systems like well owners, administrating them. In the rural area, Farmer's Association operates and administrates simple water supply facilities. They collect the fee, 30 liters (equivalent to a water pot) for 5 cents (about 6 yen) and devote it to the operation expense. EWWCA which has 8 branches in the country operates, maintain and controls hand-dug wells and local water supplies. However, as equipment and materials for construction and vehicles they run short, the operation is not fully utilized. Incidentally, as drilling machines, only 11 machines have been repaired in each section within the past 10 years. The remaining 27 rigs have not been repaired in the past 15 - 30 years and are no longer working properly.

From these matters, the National Water Resources Commission has fixed the following water supply program:

(1) Repairing and maintenance of water supply facilities which are left in the drought areas because of shortage of parts will be carried out.

(2) Deep wells which are not used in the drought areas because of shortage of pumps or generators will be fully restored.

(3) Wells will be rehabilitated aiming to increase the yield.

(4) Existing facilities such as relief centers will be increased to cope with the increasing number of people who pour into to the centers from the drought affected areas.

(5) New facilities will be constructed in resettlement places for the people who have moved from the drought areas. The National describing Water Resources Commission is planning such project as describing in the table below of rehabilitation and control of the existing facilities as well as planning of new project for development of deep wells (bore hole), shallow tube wells, hand dng wells, springs and surface flow water for the sake of resolution of these problems.

Table 1 Proposed Project components

Item No.	Project Description	Type of Facilities	No. of scheme	Population to be served
1	Additional source for towns and villages affected by influx of drought affected people	Bore hole	60	150,000
2	Replacement for dried wells	- ditto -	150	375,000
3	Deeping of dried wells	- ditto -	50	125,000
4	New water Sources in drought affected areas	- ditto - Hand dug and shallow tube wells	185 625	462,500 156,250
5	Water sources for relief and rehabilitation centers	Bore hole, Hand dug wells spring tapping surface water development	105 625 120 110	262,500 156,250 300,000 275,000
6	Repaire & Maintenance of existing rural water supply systems in drought affected areas including completion of partially constructed systems	Bore hole Hand dug wells	283 300	707,500 75,000

6. BACKGROUND OF INVESTIGATION

6.1 General Condition

In the country which had been affected by the chronic water shortage, it seldom rained during Belg season in 1984. Although farmers sowed seeds, the seeds didn't grow and cattle didn't thrive. Then they experienced a great blow. As a result the agricultural yield was reduced to 40 % of that of an ordinary year. The yield of crops, especially that of grain, was desperate in those regions, Wello, Tigray, Eritrea and northern Shewa where the damage from drought was tremendous. The shortage of grain naturally reflected in the price. The price of Teff, which is the staple food, soared abnormally. The following table shows the transition of Teff prices from 1983 - 1985. In the regions most affected by drought damage, the price rose 2 to 3 times in this period.

Table 2. Transition of Teff Price

Market (Region)	Price of Teff in Birr/gt				
	1983	1984	1985		
	Dec.	Dec.	Jan.	Feb.	Mar.
Assela(Arssi)	63	110	117	134	NA
DeDre Markos(Gojam)	44	61	60	65	61
Akari(Shewa)	71	144	154	165	173
Awassa(Sidamo)	70	100	100	140	170
Dessie(Wello)	88	216	209	235	264
Nekemte(Wellega)	58	95	125	132	130
Gonder(Gonder)	54	96	109	109	125

*NA - Not Available

In Kiremt season following Belg season, the weather was still unsteady resulting in serious damage even extending into the regions of Harerghe, Sidama, Gamo Gofa and Eastern Gonder. The regions of Gojjam and Bale are usually the surplus producing districts of Maize and Sorgham, but even here agriculture was influenced by drought damage. As the result, the rural district, whose population is 88% of all the population, had a shortage of food. People sold seeds, cattle and household goods to ward off hunger. However this only met an immediate need. They quickly spent all the money and were

finally forced to leave their land and poured into cities to become refugees. This caused a large number of people to die. Farmer affected by damage in the harvest season reached 10,750,660 in the whole country and among them the number of people who needed aid by the end of 1985 was estimated at 7,923,150. The following table shows the number of such affected people in each region.

Table 3. Number of People needing assistance

Region	Number of people needing assistance
Wello	2,587,420
Tigray	1,429,390
Eritrea	827,000
Shewa	851,830
Harerghe	875,080
Sidamo	532,500
Gamo.Gofa	106,330
Gonder	363,000
Gojjam	76,120
Bale	192,870
Arssi	81,610
Total	7,923,150

April, 1985

The remaining 2,827,510 people expected to receive aid through the local distribution system. The following table shows the number of people who need aid between June and December.

Table 4. Number of People likely to be affected

Region	Number of people likely to be affected
Wello	309,960
Shewa	480,420
Harerghe	869,120
Gonder	497,240
Gamo.Gofa	172,950
Arssi	138,890
Gojjam	87,460
Sidamo	142,990
Wellega	23,420
Keffa	29,000
Illubabor	73,350
Bale	2,710
Total	2,827,510

April, 1985

Whether it rains or not during Belg rain season has a great effect upon the agricultural yield of this country , espe-

cially that of the highlands such as Wello, Bale, and northern Shewa, which forms 50 % of the annual yield, as well as Arssi, Tigrai, Sidamo, and Gamo Gofa. Belg season, in northern Wello, Tigrai and Shewa, which usually starts in January, did not begin until early March this year. In those regions seeds were short and there was no existing livestock so, the condition was serious. The following Table 5. shows the number of people being supplied with foods in each district of Wello region where damage from the drought was serious. For example, at the Food Distribution Center in the village of Degan in August, dry powder such as wheat flour, dry milk, cornmeal, etc., was distributed once a month which amounts to 15kg per person per month (5 people in a family x 15 = 75kg). Before the wet season (April - May) a large number of people gathered at the distribution center, but following the wet season (after September) the numbers decreased. It can be supposed that the effect of food supply had been improving during the wet season and they were able to begin supporting themselves.

6.2 Actual Condition of Relief Activities

Facing such a critical situation, at Ethiopia side, RRC has carried out positive activity and at the same time it has received the relief goods from foreign countries, which was contributable in establishment of supply system for the affected area.

A considerable numbers of group from the aid granting organizations of many countries are also operating their works in various area of this country.

Such groups from non governmental organizations are operaing their relief activities under RRC's control.

Their numbers became to forty-three groups as of the end of May, 1985, whose list and main activities are shoen in the following table 6.

Table 5 Distribution Centers & Number of Beneficiaries in Wello Region

30th June, 1985

No.	Awaraja	Name of Center		Population in the Center				Distance from Dessie
		Woreda	Kebare	Age 0 ~ 6	Age 7 ~ 15	Age over 16	Total	
1	Ambasel	Ambasel	Tis Abalima	19,880	22,415	39,209	81,504	45
		Tehuludeiay	Hayke	38,650	39,720	71,262	149,632	30
		Werebabo	Arabati	9,670	11,210	20,770	41,650	90
		"	Bistimma	8,175	11,270	19,555	39,000	47
2	Wadela. Delan	Delanta	Wogel Fena	33,210	36,430	65,360	135,000	98
		Wadela Delanta	Kon	12,640	14,250	25,760	52,650	262
3	Wore.menu	Tenfa	Aj-Bar & Lanna Mariam	55,540	59,692	97,250	212,482	123
		Legambo	Gebban Akesta	10,120	11,251	22,059	43,430	78
4	Kallu	Bati	Bati	16,729	18,320	29,951	65,000	65
		Kallu	Harubu	21,163	21,960	39,877	83,000	46
		Kallu	Degan	17,622	19,520	38,770	75,912	48
		Eseygola	Kemise	8,620	9,772	12,568	30,960	70
		Dewoi	Bora	8,750	10,620	19,630	39,000	102
		Arfuma	Chirete	5,620	7,214	11,973	24,807	87
		Elbuko	Gobeya	17,620	19,522	38,070	75,212	70
5	Yeju	Gubalafto	Woldia	13,210	14,530	26,950	54,690	120
		Haberu	Merssa	12,511	15,060	22,529	50,100	90
		"	Sirinka	5,816	7,270	15,997	29,083	110
		Gubalafto	Harra	12,327	14,230	25,185	51,742	145
		Haberu	Gerrana	6,230	7,340	41,658	55,228	80
		"	Suneka	17,251	19,620	37,905	74,776	150
6	Ray	Alamta	Alamata	35,556	44,445	97,781	177,782	200
		Kobbo	Kobbo	26,169	32,712	71,967	130,848	170
		"	Gobya	8,600	10,750	23,650	43,000	140
7	Dessie. Zuriy	Kutaber	Kutaber	3,019	33,231	58,573	94,823	23
		Dessie Zuriya	Teleyayen	240	300	660	1,200	52
			Mitikolo	-	-	-	-	-
			Hatrbi	14,231	15,230	28,339	57,800	28
			Gerado & Ayata	10,065	11,077	19,524	40,666	65
8	Lasta	Bugyra	Lalibela	48,339	22,130	31,980	102,449	300
		Mekit	Felakit	912	11,730	20,420	33,062	-
		Gedan	Huya	-	-	-		-
9	Awussa	Awussa	Assayta	5,120	6,230	9,650	21,000	285
		Mile	Mile	2,520	2,650	6,200	11,370	165
		Dubte	Dubte	1,520	1,640	3,240	6,400	225
		Elidar	Elidar	345	4,120	8,430	12,895	335
10	Wag	Wofela	Korem	26,187	51,925	130,029	208,141	220
		Sekota	Sekota	-	-	-		-
11	Borena	Debre Sina	Mekane Selam	-	-	-	-	-
		"	Wogdi	6,523	5,297	21,200	33,020	-
		Kelella	Kelella	5,703	5,451	14,802	25,956	143
		Saynet	Ajbar	11,771	12,131	27,420	51,322	-
12	Woreyelu	Legehida	Lalane	6,290	7,052	12,036	25,378	93
		Jama & Woreyelu	Woreyelu	3,259	4,953	6,675	14,887	80
	Total			567,723	674,270	1,314,864	2,556,857	

Table 6 Actual Condition of Relief Activities

30 May, 1985

No. Name of Agency	Types of Activity	Station (Site) Name	Region
1 Christian Relief & Development Association (CRDA)	1 Intensive feeding 2 Take home sup. ration 3 Medical 4 On site general feeding	Shewa Robit	Shewa
	1 Intensive feeding 2 Take home sup. ration 3 Medical 4 On site general feeding	Jewha	"
	ditto	Ataye	"
	ditto	Majete	"
	"	Kara Koro	"
	"	Senbet	"
	1 Medical 2 Mother & Child health	Robe	Bale
	Others: Shewa (5)	Sidam (3)	
2 Irish Concern	1 Intensive feeding 2 Supp. feeding 3 Medical	Harbu	Wello
	1 Supp. feeding 2 Water supply	Kemise	"
	1 Intensive feeding 2 Supp. feeding 3 Medical 4 Water supply	Chirete	"
	Others: Sidamo Region (5)	Gondar Region (2)	

3	World Vision International Ethiopia	Medical Feeding Agricultural packages	Alamata, Bugna, Tenta Alamata 4 others Alamata 3 others	Wello " "
		Various development	Shewa(7), Sidamo regio (7), Gojam(3), others	
4	Society of International Missionaries(SIM)	Feeding program Medical program Dry ration distribution	Sidamo(2) Gamo Goffa(2)	
5	Ethiopian Catholic Secretariate	Medical Feeding Dry ration distribution	Tigray(12), Eritrea(6) Sidamo(17). Shewa(10) Wello(1), Arssi(1) Hareghe(1)	
6	Missionaries of Charity	1 Assist mentaly handicapped 2 Home for dying destitute 3 Orphanges	Addis Ababa Dire Dawa Jijiga Jima Alamata	Shewa Hareghe " Keffa Wello
7	Medicins Sans Frontieres(Fr)	Medical	Korem Kobo	Wello "
8	The Lutheran World Federation	Rehabilitation Medical	Hareghe(1), Illubabor (1) Eritrea(2), Wello(1) Shewa(1)	
9	Care-Ethiopia	Computer Programming Intensive feeding Dry ration distribution	RRC Hareghe(34)	
10	Catholic Relief Service	1 Food distribution, Medical supplies, non-food commodities(tents, blanket) Dry ration distribution	Hareghe(4), Tigray(1) Gondar(3) Shewa(5) Sidamo(1) Tigrai(6) Eritrea(14)	

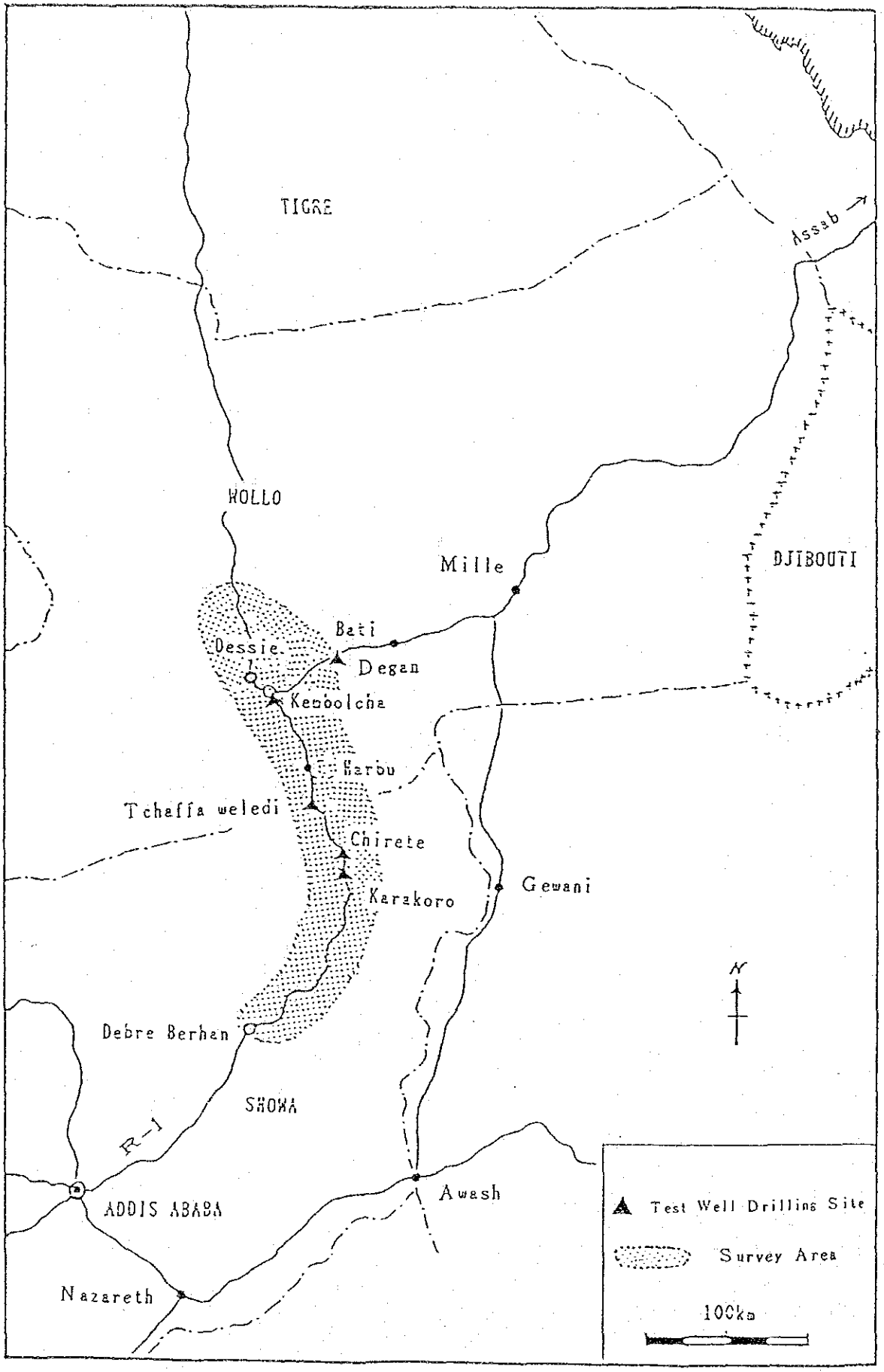
11	Malteset Hospitaldients-- Austria	Medical	Axum	Tigray
12	Save the Children Fund(U.K.) SCF(UK)	Intensive feeding Medical Take home sup.ration	Kolem Kobbo Bulbula Others Hareghe	Wello " " Bale
13	Ethiopian Evangelical Church Mekane Yesus (EECMY)	Feeding Dry ration distribution	Wello(13), Tigrai(2) Shewa(1)	
14	OXFAN	Supp. feeding Take home sup.ration Water supply	Bora, Wegel Tena Anthokia, Chirete, Kemise, Bora, Harbu, Kembolcha, Bati, Mille Bulbula, Ajbar, Kubo, Alamata, etc.	Wello Wello
15	Food for the Hungry Inter-national	Medical, Feeding Seed distribution	Gondar(1) Shewa(2)	
16	Philadelphia Church Mission	Medical, Feeding Dry ration dist. Water development	Shewa(1) Sidamo(2) Gamo Gofa(2)	
17	Air Serv. International	Provision of air craft and crew Payment of all operating costs	Sidamo	
18	Baptist Mission of Ethiopia	Dry ration dist. Medial Seed grain dist. Veterinary	Shewa	

19	German Emergency Doctors	Intensive feeding Supp. feeding Medical	Lalibela Arb Gebeya	Wello Gondar
20	Ethiopian Orthodox Church	Medical, Feeding	Hyik Mekele	Wello Tigray
21	Jesuit Relief Service	Intensive feeding Medical	Gossa Wellecha	Sidamo "
22	Medicins Sans Frontieres (Belgium)	ditto	Idaga Hamous	Tigray
23	Japan 24 Hour TV Charity Committee	ditto	Sirinka	Wello
24	Africa--Ethiopia	Relief Aid Medical	Mekele	Tigray
25	Japan Inter-National Volunteer Center (JVC)	Feeding Medical	Ajibar	Wello
26	Enfants Sans Frontieres	Medical Intensive feeding	Meteka	Harerghe
27	Menshen Fur Menshen	Resettlement & Relief Program	Becho, Burie Halu & Mettu Erer	Illuba-bore Harerghe
28	Action Inter-national Contre La Faim (AICF)	Medical Feeding	Rama	Tigray
29	Swiss Evangeli-cal Nile Mission	Feeding, Medical School for disableet	Addis Ababa Tedele	Shewa

30	Terre Des Hommes Lausanne (Switzerland)	Take home supp. ration Medical Children's village	Jari	Wello
31	Church of Christ Mission	Medical Feeding	Tenkaka	Shewa
32	Mennonite Mission	Medical	Ghinnir	Bale
33	Norwegian Church Aid (NCA)	General distribution Feeding Water development	Arba Minchi Robie Robe	GamoGofa Bale "
34	Secours Populaire Francais	Medical	Chanka	Wellega
35	Save the Children Federation(USA)	Supp. feeding Dry ration distribution	Yifatna Timuga	Shewa
36	German Agro Action	Store construction	Gondar, Harerghe	
37	Norwegian Save the Children (Redd Barna)	Intensive feeding Medical Water supply Dry ration distribution	Sidamo(3) GamoGofa(1) Bale(1)	
38	Swedish Save the Children (Redd Barrer)	Cash for work	Korga	Shewa
39	Terre Les Hommes Netherlands	Conbalescent home	Addis Ababa	Shewa
40	Adventist Development and Relief Agency	Seed distribution Dry ration distribution	Shewa (3), Eritrea (1) Sidamo (1) Tigray (1)	

41	Kale Heywot Church Develop-ment Program	Relief program Development program	Shewa, Sidamo Eritrea
42	SOS Kinderdorf International	Children village	Harerghe, Tigray Eritrea, Sidamo
43	American Joint Distribution Committee	Health Center Construction	Teda Gondar

Fig. 6 SURVEY AREA

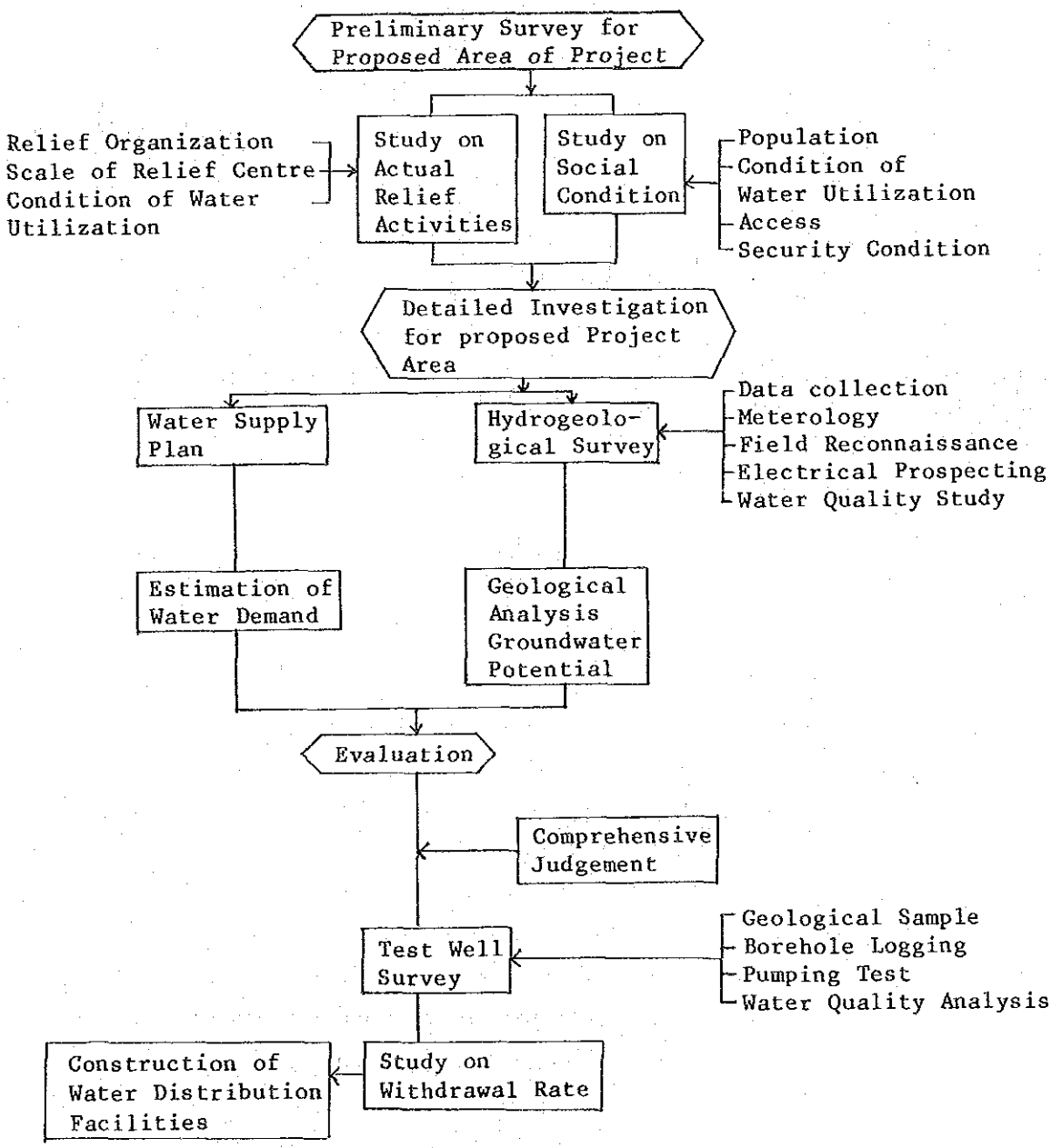


7. FLOW OF INVESTIGATION

The area between northern Shewa region and southern Wello region is comparatively lowland with 1,200 - 1,500 m in altitude. Damage by critical drought in 1984 in this area was particularly big, thus many farmers were affected to be victims.

This investigation aims at water supply to the relief centre that is performing relief activities in this area, together with acquirement of living water for the future for inhabitant in this area.

Fig. 7. Flow of Investigation



8. CONDITION OF INVESTIGATION AREAS

The area from the northern Shewa region to the southern Wello region consists of lowlands which rise 1,200 - 1,500 m above sea level. The drought in 1984 caused big damage especially in this area and a great number of people were affected by it. From the end of 1984 various relief organization from other countries entered this area and have been performing their relief operations. Main organizations are as follows:

1 Christian Relief & Development Association (CRDA)
Jehwa, Ataye, Majete, Karakoro, Senbete, Fursi

2 Irish Concern
Harbu, Kemise, Chirete

3 World Vision
Antsokia

4 Save the Children Fund (U.K.) SCF
Kembolcha, Dessie

5 Ethiopian Red Cross
Bati, Degan

Also RRC which is the Ethiopian relief organization, set up the Food Distribution Center in a tie-up with those organizations and now distributes food regularly. The JICA Study Team selected sites proposed to the project and upon deliberation with RRC constructed water distribution facilities from May '85 to January '86. The proposed site reached 34 sites where field reconnaissances and actual condition investigations by hearing were done. The next table shows the list of the sites proposed. Among them were 11 sites in Shewa region and 22 sites in Wello region. In this area, though hamlets along the National Highway Route 1 are in comparatively favorable condition with water sources and accessibility, those into the mountains are hardly accessible, especially during the wet season, and lot of places become isolated without transportation.

Finally, based on the access, degree of emergency and future potentiality, nine sites out of them were selected by turn for study on feasibility of groundwater development and appropriateness for the construction of water distribution facilities.

(1) Harbu (2) Karakoro (3) Chirete (4) Degan
(5) Kamise (6) Tisa Balima (7) Dessie (8) Kembolcha
(9) Tchaffa Weledi

Fig. 8 Route Map

(Distance from Addis Ababa)

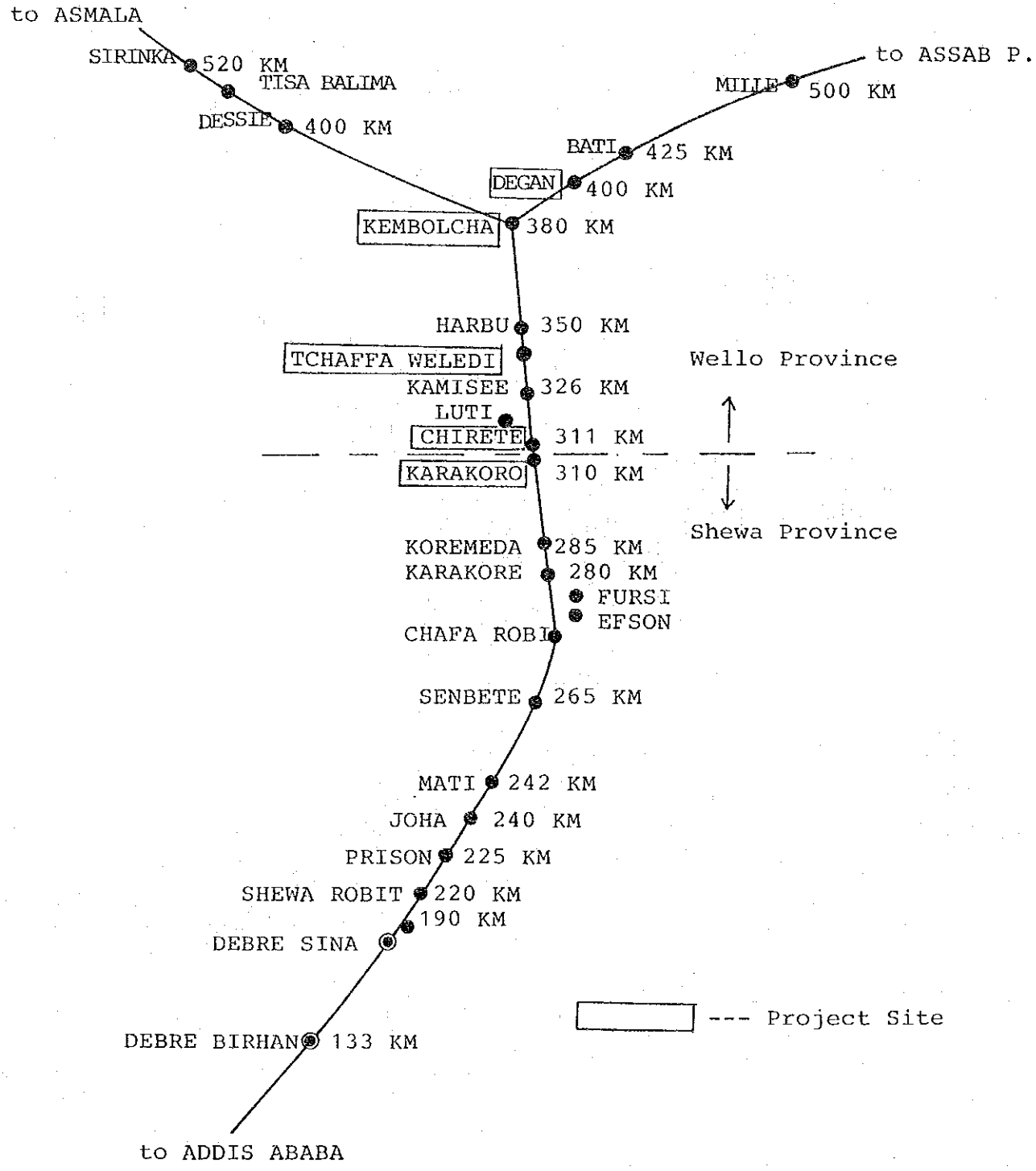


Table 7 Sites Proposed by Project

Mar.- Oct. 1985

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organi-zation	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potenti-ality of ground Water	Evaluation	Judgement
1	MATI (Wello)	242 km	RRC	Mar/85	Canada Kingston	Mar/85	500	Many vacant tents 2245	Wet 3620	Medical	Some houses 1 well 1 water-tower		Hot area no infor-mation	A few in-habitants little future demand	X
2	SANBETE (Shewa)	265 km	RRC	May/85	CRDA	Nov/84		(40 prns)	Dry 7000		1 well tank-4 kl		Tertiary hill low	Sufficient water supply	X
3	KOREMEDA (Shewa)	285 km	JICA	May/85	Irish Concern	Apr/85	150	1700 prns			1 deep well 1 shallow well		Alluvial high	Sufficient water supply	X
4	KORAKORO (Shewa)	310 km	RRC	Apr/85	Irish GOAL	Nov/84	5	150 prns	Dry 6000	Feeding medical	Carried from Chirete	JICA No. 1 well	1 l/sec SWL -25.45 m DWL -42.00 m	Insufficient water supply for shelter	No.1 well
5	CHIRETE (Wello)	311 km	RRC	Apr/85	Irish Concern	Jun/85	15	Night Shelter 80-100	Wet 350 Dry 3500	Feeding medical	1 shallow well 1 deep well - 1.5 l/sec	JICA No. 2 well		Insufficient water supply for shelter in the future supply for inhabitants	No.2 well
6	LUTI (Wello)	W. 6 km from Kamisee	RRC	Jun/85			No shelter		Dry in Karakoro, Chirete				Lowlands	No shelter	X
7	EFESON (ATAYE) (Shewa)	275 km S. of Karakoro	RRC	May/85	CRDA	Nov/84		25-30	Dry 6000		Inhabitants - 5000 prns 1 deep well		Tertiary hill low	Rivers inferior access	X
8	FURSI (Shewa)	N.E 8 km of Karakoro	CRDA RRC	May/85 Jul/85	Canada	Mar/85	4	150	Wet 2500 Dry 17000		No well use spring		Mountain very low	Access im-possible well dril-ling impossible	X

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organi-zation	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potenti-ality of Ground Water	Evaluation	Judgement
9	KAMISEE (Wello)	326 km (before Chirete)	RRC	Jun/85	Irish Concern	Waiting for per-mission	In planning	Object 5000 children	Dry 5000		Inhabitants - 7000 New well 150 dia x 70 m x 5 l/sec Old well - dia x - m x 3 l/sec	Electric pros-pecting 5 places	High	Inferior access in rainy season sufficient water supply after center opens ?	
10	HARBU (Wello)	350 km	RRC	Mar/85 May/85	Irish Concern	Nov/84	(Mar 600) May 390	6000		Relief center	Inhabitants - 3500 prns 2 wells 3 tanks	New well 11 l/sec	Alluvial very high	EWWCA On con-struction of water supply facility	X
11	KEMB-OLCHA (Wello)	380 km	RRC	May/85	RRC	Nov/84	Moved most tents to Dessie in June	(80 - 90 tents 4343)		Main transit shelter	3 wells in town 24 kl tank lorry		Alluvial very high	Sufficient water supply in transit center	X
12	DEGAN (Wello)	400 km E. 20 km of Kemb-olcha	RRC	Jun/85	Ethiopian Red Cross	Plan of opening early July	In planning		Wet 500 (10000 W) Dry 76000 (Degan area) Wet 1292t Dry 129t 1421t/m	Feeding	Inhabitants 700 - 800 150 dia x 100m x 2 l/s 8.5 kl tank (Total 76,000 in Degan & Gilba)	Electric pros-pecting at 5 points JICA No. 3 well	Tertiary volcanic rocks	After center opens, 1 well drilling will be necessary	No.3 well
13	BATI (Well)	E. 45 km of Kemb-olcha	RRC	Feb/85 May/85 Sep/85	RRC Red Cross	Oct/84	500	Apr 20935 May 15600	Unknown	Relief center	3 deep wells	EWWCA Under drilling new well	Tertiary hill	Water suffi-ces for people	X
14	MILLE (Wello)	E. 120 km of Kemb-olcha	RRC			Unknown				Relief center		Plan by EWWCA		Social conditions are inferior	X

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organization	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potentiality of ground Water	Evaluation	Judgement
15	DESSIE (Wello)	N. 3 km of Dessie RRC 400 km	RRC	May/85 Jul/85	SCF/ RRC	Moved from Kembol-cha May/85	246	Capacity 5000 Present 800 Back to the farms program on propul-sion (moved 8000 around Sep. 7		Transit	3 wells in town 1.79 m x 15 l/s 2.89 m x 10 l/s	Electric prospect-ing at 4 points	Tertiary hill	Population in transit shelter changes widely	X
16	TIS ABA LIMA (Wello)	N. 52 km of Dessie 510 km	RRC	Jun/85	EECMY	Unknown	No night shelter		Dry 10000	Feeding	1 well 5 l/s (No money for fuel) Supplied by shallow well and spring			Water is supplied sufficiently	X
17	SIRI-NKA (Wello)	N. 110 km of Dessie 510 km (2 hours by Car)	RRC	Jul/85 Aug/85	NGO NTV-24 Hrs			200	Feeding medical 12000 prns Dry 60000 - 70000 15 Farm-er's Asso-ciations in Ambasa and Yage regions	Relief center	Inhabitants more than 2000 Spring from river bed 300 l/m No water supply facilities Carried by 4kl tank lorry from Weldedi, 100 km N. of Dessie 300 l carried by hand	Existing well plumb-ed by EWWCA	Tertiary hill (in-ferior to Kobbo's)	To transfer is impossi-ble Plumbing made by EWWCA Out of S/W	X
18	KOBBO (Wello)	N. 170 km of Dessie 570 km (3 hours by car)	RRC	Jul. 85 Aug. 86	MSF, SCF EECMY, CRC, RRC	New shelter planned to be opened in early Sep.	15 irons worked shelters on con-struction (by Israel)	14000 m^2 area 2000 prns planned At pres-ent MSF-medi-ca 250 children SCF-1500 (3500-2000 dis charge)	Dry,object 12000 EECMY-aged 6-14 2000-22000 (environs) CRC-1097 (dry 17517) RRC-dry 113,000 ration 50 kg/m)	Relief center (larger than Harbu's)	Inhabitants12,000 (120000 in en-virons) 1 well under river bed 60-70m, 11 l/s 150 kl tank (both supplied by W. Germany) New 40 kl tank) oxfan	EWWCA	Tertiary (basin in moun-tains) Access easy	New well has been constructed by EWWCA Social con-ditions are inferior Out of s/w	X

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organi-zation	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potenti-ality of Ground Water	Evaluation	Judgement
19	BULB-ULO (Wello)	N. 25 km of Dessie E. 13 km of Haik 438 km	RRC	Jul/85	SCF	Jan/85	10	2250 prns		Relief center	Spring and shallow well 6.5 m. 25 kl/d	Shallow well	Outcrop of basalt low	Difficult access Objective site for shallow well	X
20	DEBEL	Unknown	RRC												X
21	HARA (Wello)	565 km from Addis 22 km from Weledi	NTV 24 Hrs		NTV 24Hrs	No fixed			Dry & Wet	Relief	76000 prns in the eastern area		Unknown	Inferior social conditions Guerrilla zone	X
22	GARADO (Wello)	4 km from Dessie	RRC	Sep/85	RRC	No fixed	4-5	200-300	Unknown	Transit	Surface flow water springs. Shallow wells Hand pump	EWWCA	Marsh area	Very diffi-cult access Rapid-slope	X
23	KARINA (Wello)	N. 10 km from Kembolcha	RRC	Sep/85	RRC				Unknown	Food distribu-tion	Deep in valley		Narrow valley Small village on the cliff	Unsuitable for deep well. Suitable for shallow well.	X
24	TCHA-FFA WELEDI (Wello)	350 km before Harbu	RRC	Sep/85	RRC				Dry ration for 54690		Town population 4500 1 shallow well (7 m) and 1 ex-isting well (38 m) for agri-culture	Drilled 78.5 m but demo-lished because of 1 l/s Electric prospe-cting at 5 pts	Depth to the base about 40 m	Large water amount can't be expected High water demand	No. 5 well
25	ABISHA AGELU (Wello)	370 km before Kembolcha	RRC	Sep/85	RRC						Small village Earth dam on construction springs, rivers		Outcrop of baserock zone	Low ground water poten-tiality	X

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organi-zation	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potenti-ality of Ground Water	Evaluation	Judgement
26	MITE-KORO (Wello)	2 km from Kembolcha	RRC	Sep/85							On the mountain Well for military camp		Base-rocks outcroped	Low under-water poten-tiality	X
27	XELEM MEDA (Wello)	N. 5 km from Dessie	RRC	Sep/85	RRC						Marsh area Springs and rivers		Suitable for hand-dug shallow well	Access is impossible	X
28	BERAS GOBA (Shewa)	30 km from shewa-Robit enter from the town	RRC	Sep/85	RRC									Difficult access	X
29	YAELAN KEBELE (Shewa)	Enter to the left between Shewa-Robit and Joha	RRC	Sep/85	RRC									Difficult access	X
30	ADABELA	Fursi area	RRC	Sep/85	RRC									Difficult access	X
31	KEMB-OLCHA (Wello)	380 km	SCF RRC	Sep/85	SCF (U.K)	Sep/85	Site on ex-transit shelter	1200 prns expand in the future Tents 23	300-400 serious patients	Relief center	Town population 18000-20000 in 6 Kebares	WWDA 96m well near the site Electric prospe-cting at 3 pts	High ground water poten-tiality	High water demand High prior-ity of emergency	No. 4 well
32	FUGNAN Denbi (Shewa)	S.115km from Kembolcha plus 6km	RRC	Oct/85					Food distri-bution for 1500		River water		Low ground water potenti-ality	Difficult access	X

No.	Name of Site	Distance from Addis	News Source	Survey Time	Relief Organi-zation	Date of Opening	Number of Tents	Number of People	Number of Feeding Objective Dry Wet	Type of Shelter (Transit etc.)	Social Condition (population) Condition of Water Supply	EWWCA Plan of Well Drilling	Potenti-ality of Ground Water	Evaluation	Judgement
33	WERE-LENCHA (Shewa)	Near Sanbate	RRC	Oct/85										Access impossible	×
34	KARA-GEGEBA (Shewa)	200 km from Addis	RRC	OCT/85							1500 in environs		In mount-ains	Along National Highway route No.1 but low Ground water potentiality	×

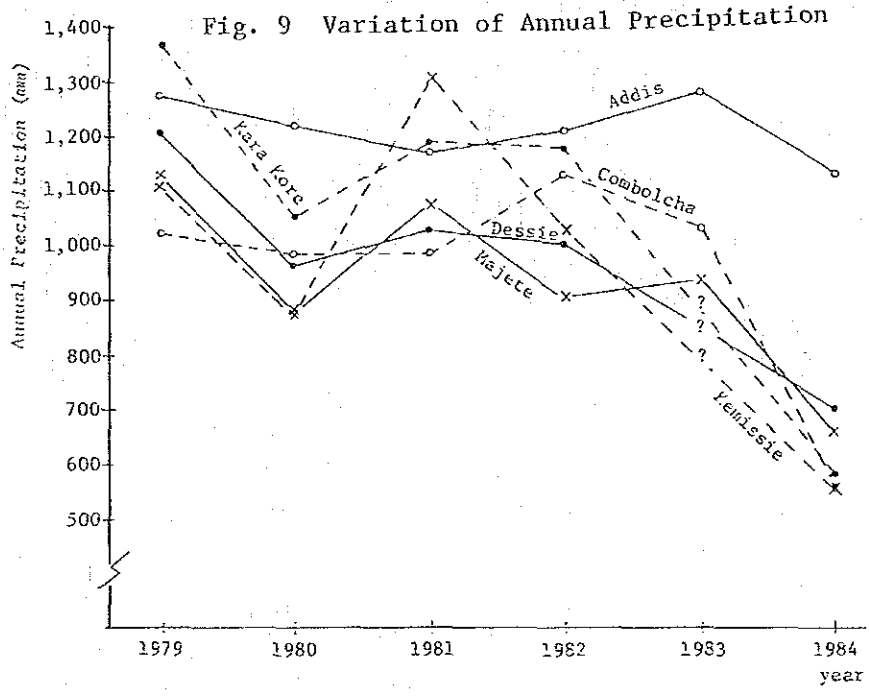
9. HYDROGEOLOGICAL SURVEY

9.1 Meteorological condition

The past six years meteorological data (from 1979 to 1984, especially amount of rain fall) was received from the Meteorological Bureau of Ethiopia.
In Ethiopia, a meteorological station is set in each region. The data received this time was come from one of them, which is situated in a place between Addis Ababa and Dessie.
The data of 1985 is still under preparation, which seems to be unavailable for official anouncement at this moment.

Variation of annual precipitation
Figure 9 shows a time system Variation of annual precipitation in the representative site in this investigation area. The average precipitation in Addis Ababa is more or less 1,200 mm, which is almost steady one, but in the investigation area, particularly, precipitation in 1984 was abnormally little, which indicated about 50% of the ordinary year of about 1,000 mm. The altitude of Dessie is almost same as Addis Ababa, however, 1984 experienced an abnormally less precipitation, from which, it is learnt that 1984 was an abnormal drought year.

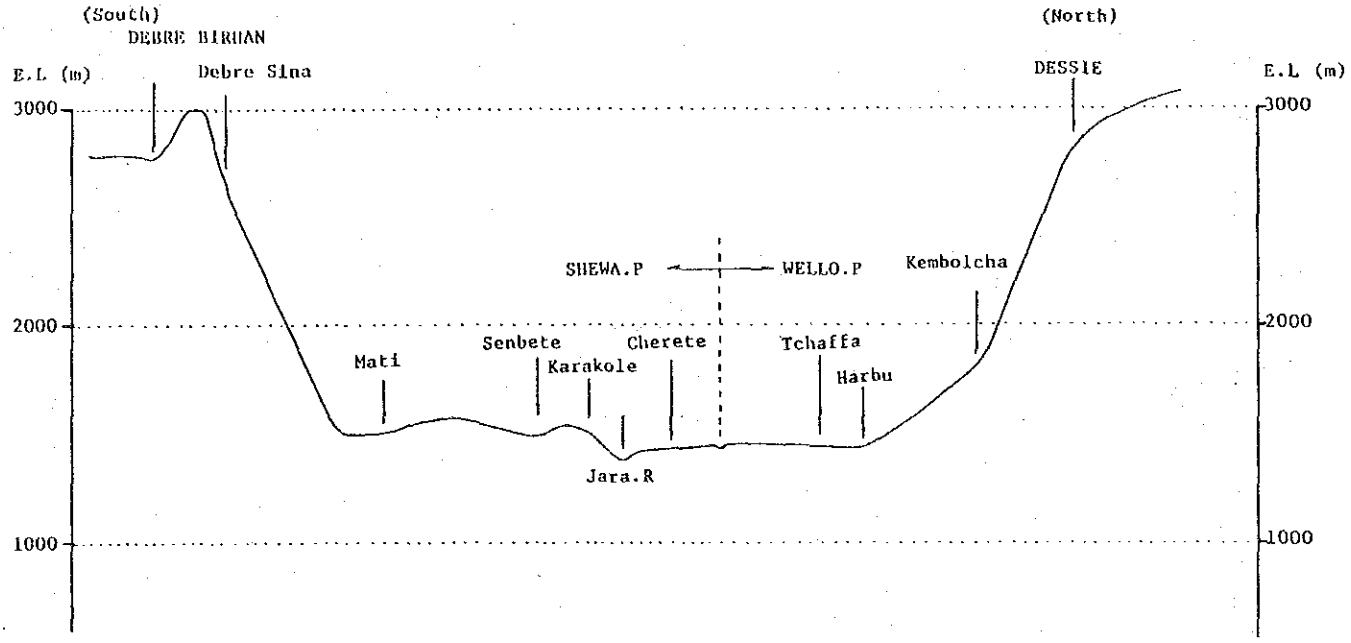
Fig. 9 Variation of Annual Precipitation



9.2 Topography

This area is classified into two regions in regime.
Debre Birhan - Karakoro belongs to Shewa region and the north of the area where Borkena river weaves largely eastward belongs to Wello region.
This area belongs to the nortern mountanous zone with many undulations topographically. The area between Debre Birhan and Debre Sina is highland with altitude of 2,000 - 3,000 m, but the level from Debre Sina is lowered with steep cliff and the area between Mati and Harbu is comparatively flat with altitude of 1,600 - 1,400 m.
Judging from the cross section of the eastwest direction, between Mati and Kembolcha, the altitude of the east side is 1,600 - 2,000 m and the western side is 2,500 - 3,500 m of mountains.
Therefore, water system of rivers on this area belongs to Rift Valley system. There are seen man rivers in the investigation area, among of which, particularly big ones are, from the north, Borkena, Jara, Gerbi and Kebena. These rivers flow out to Rift Valley side in the east without stagnation in the basin, which is said to be the river flowing out.
Especially, Borkena river, flowing from around Dessie, runs from the north to the south in the basin, and consequently, flow out from near the border of Wello with Shewa region to the east.
Tese rovers. in Rift Valley, join with Awash river and flow in Abe lake. There is no flow other than these rivers, excepting a number of wadi that carry water only in the rainy season or rain time. Some of them form a ravine with relative height of more than 10 m.
There is no lake with water stagnation always in the investigation area, but at the concentrated heavy rain fall, some stagnate for a while in the lowland and afterward, in a dry season, it flows out, or it will be evporated to disappear.

Fig. 10 Topographical Cross Section in the Project Area



9.3 Geology

Geology of the investigation area is divided mainly into, two, which one is volcanic rock of the Cenozoic in the lower layer and the upper is unconsolidated sediment of the quaternary of the Cenozoic.

The lower volcanic rock is classified to the volcanic rock (Ashangi formation) that belongs to the so called "Trap Series" of the Paleogene - Miocene, Thertiary and to the volcanic rock (Magdala formation) of the Miocene, Tertiary - the Pleistocene, Qaternary that are distributed in the adjacent area of Debre Birhan - Debre Sina. In this area the volcanic rock (Ashangi formation) belonging to the Trap Series is extensively distributed.

Table 8 shows the geological stratigrphy in the object area of investigation.

Trap Series is the general name of the series of vocanic rocks that spurted in large scale from the Rift Valley (fault

formed this zone). The rock facies are mainly alkali basaltic volcanic rock and clastic rock, and the rock other than the intrusion of rhyorite, coarse grain of baslat sheet, acidic rock and gabbro - diabase can be seen.
The rock facies of Ashanigi formation is similar to the above mentioned. Further, its' upper formation is tuff, which is said to be a composition of lacustrime sediment including lignite, acidic volcanic rock and conglomerate. Magdara formation is narrow and small in the investigation area. This formation is distributed extensively in the south of Adis Ababa, especially near the extension of the Rift Valley. The rock facies is mainly Phyorite that is acidic rock, volcanic trachyte, gabbro and crushed basalt are included.

The thickness of Ashangi formation is very thick, which reaches 200 - 1,200 m, but the Magdara formation is 180 - 500 m that depend on the place.
These volcanic rocks are divided into acores of sheet by the volcanism.
The relative hight between kembolcha and Dessie is about 1,000 m, along National Route No.1 almost continuous outcrop of Ashangi formation can be seen, which are divided into at least 20 sheets of volcanic rock.

Table 8 Stratigraphic Classification

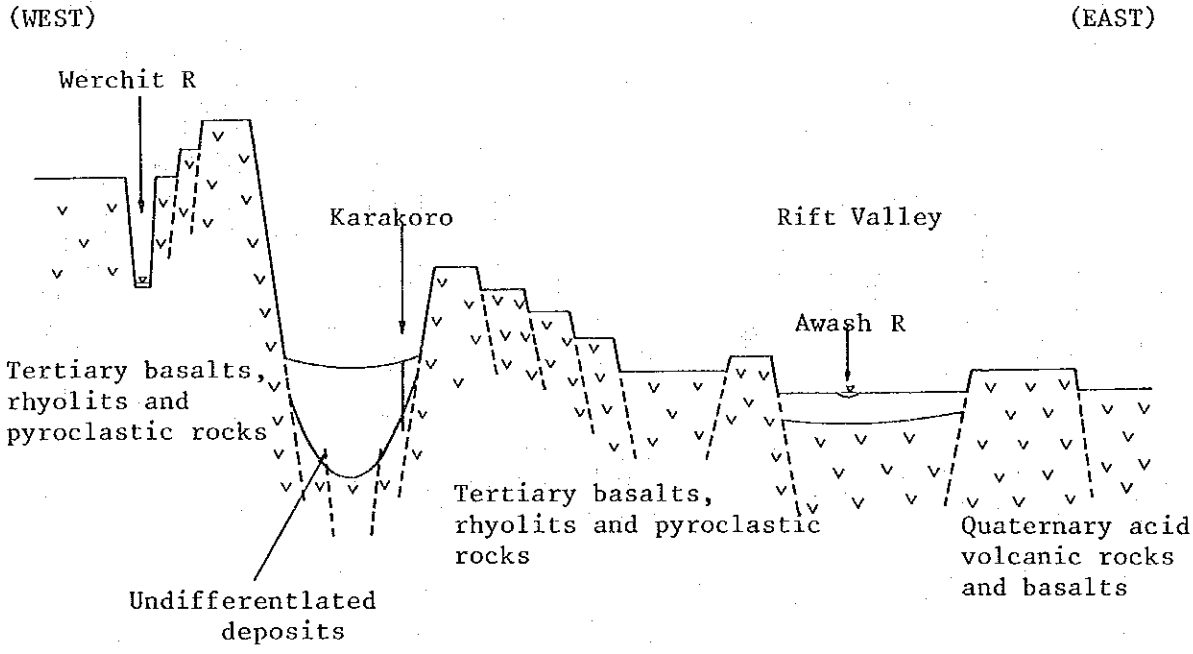
Age			Columner	Mark	Bedding name	Rock phases
CENOZOIC	Quartarary	Pleistocene Holocin		Q	Undefferentl-lated deposits	·Clay ·Gravel ·Silt ·Sand
	Tertiary	Miocine		Nm	Magdara group	·Rhyolites ·Trackytes ·Rhyolitic and trakytic tuffs ·Ignimbrites agglomelates basalts
				Pga	Ashangi group	(upper) ·Lacustrine deposits ·Acid rolanic ·Conglomerates
				(a)		·Alkali banalt and tuffs (rare rhyolites) ·Doleritic sills ·Gabbro-diabase intrusives
		Paleocine		(b)		

These volcanic rocks form not only mountains surrounding the basin, but form the bedrock of the Quaternary sediment in the basin. The unclassifed sediment in the upper formation seems to have been formed between the Pleogene and Holocene, Quaternary.
This formation is comprised of boulder, gravel, sand, silt and clay, part of which contains shell fragment.

These formations occur in shigle body, but are comparatively complicated and a series deposit and metempsychsis are unknown. Observing the outcrop of this formation along the river in the basin, clay continuing from subsurface can be seen. From the columnar section of the test well in karakoro site, it can be judged that clay is main body upto almost 30 m from the ground level.

Most part of this area is situated in the lowland within the basin, but this basin seems to have been formed as the result of volcanic rock plateau becoming block caused by normal fault along the Rift Valley.
Highland in the east of basin is about 2,000 m in altitude, which is lowered gradually, in block, toward the Rift Valley in the east.

Fig. 11 Schematic Profile



9.4 Groundwater Potential and General of Water Quality

Groundwater potential in this area under the condition of toptography and geology foregoing is considered that it can be divided into the groundwater in the highland between Debre Birhan and Debre Sina, and another one is in the Rift Valley (Lowland).

In the former case, groundwater is mainly fissure water inside the crack of volcanic clastic rocks of the Trap Series or in the basalt, while in the Latter case, the main is groundwater in unconsolidated deposit of the Quaternary. In the latter case, of course, groundwater in volcanic rock of the Quaternary can be considered, but if groundwater development is planned, it will be easy to treat the upper deposit as the main aquifer.
In hydrological comparision of the former one and the latte's, the latte's is supeior.
Figure and table show the compiled pH. comductivity of the surface water and groundwater in the area, from Jara, Shewa region to Kembolcha (80 km).

As the result of this measurement, surface water is generally less than 400 μs/cm, while groundwater indicates a value more than that, from which increase of soluble component can be seen. Further, groundwater in shallow well shows more than 600μs/cm, while groundwater in deep well shows 40 - 500 μ s/cm, which seems to be a characteristic.
pH in every case shows a standard value, 7 - 8.

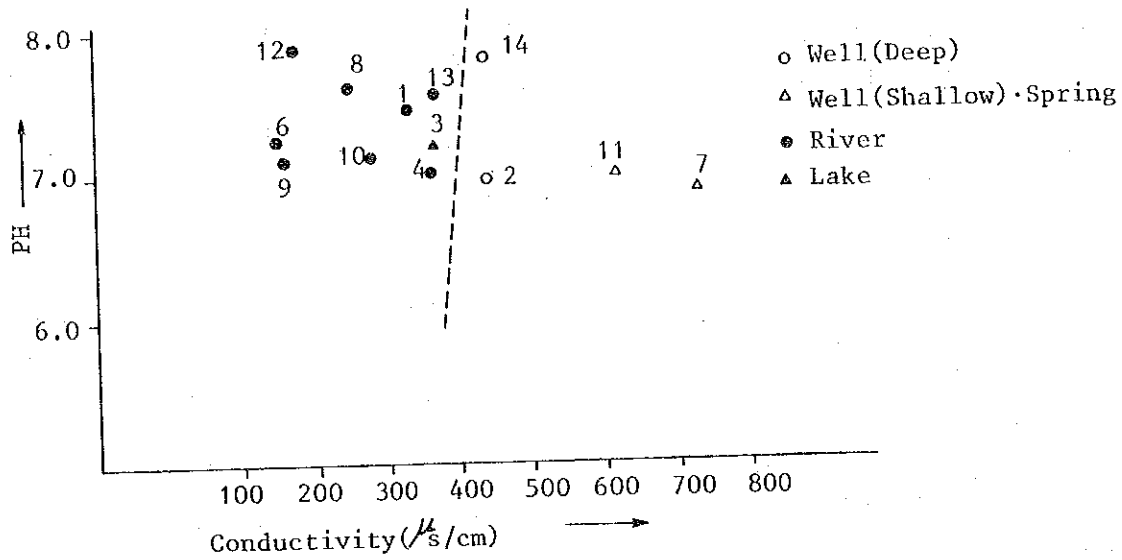


Fig. 12 Relation of pH and Conductivity

Table 9 Survey of Water Quality

Number	Location		Type of water	Temperature (℃)	pH	Conductivity (μs/cm)	*Corrected Conductivity (μs/cm)
	Province	Point					
1	Shewa	Jara	Jara. River	24.8	7.46	330	330
2	Wello	Chirete	Well(Deep)	24.5	6.96	440	440
3	〃	Jimete	Lake	30.3	7.20	408	367
4	〃	〃	Borkena.R(L)	24.9	7.03	360	360
5	〃	〃	Hot spring	59.2	7.32	20,000<	—
6	〃	Kanro	River	23.1	7.25	135	153
7	〃	〃	Well(Shallow)	25.2	6.76	730	730
8	〃	〃	River	31.8	7.60	278	250
9	〃	Kamise	River	22.9	7.10	105	158
10	〃	Milamile	Borfena・R(M)	24.8	7.12	281	280
11	〃	Koladi	Spring(?)	29.5	6.98	671	617
12	〃	Harbu	Harbu.R	23.6	7.88	173	177
13	〃	Kembolcha	Borfena.R(U)	21.2	7.55	337	370
14	〃	〃	Well(Deep)	21.1	7.80	414	455

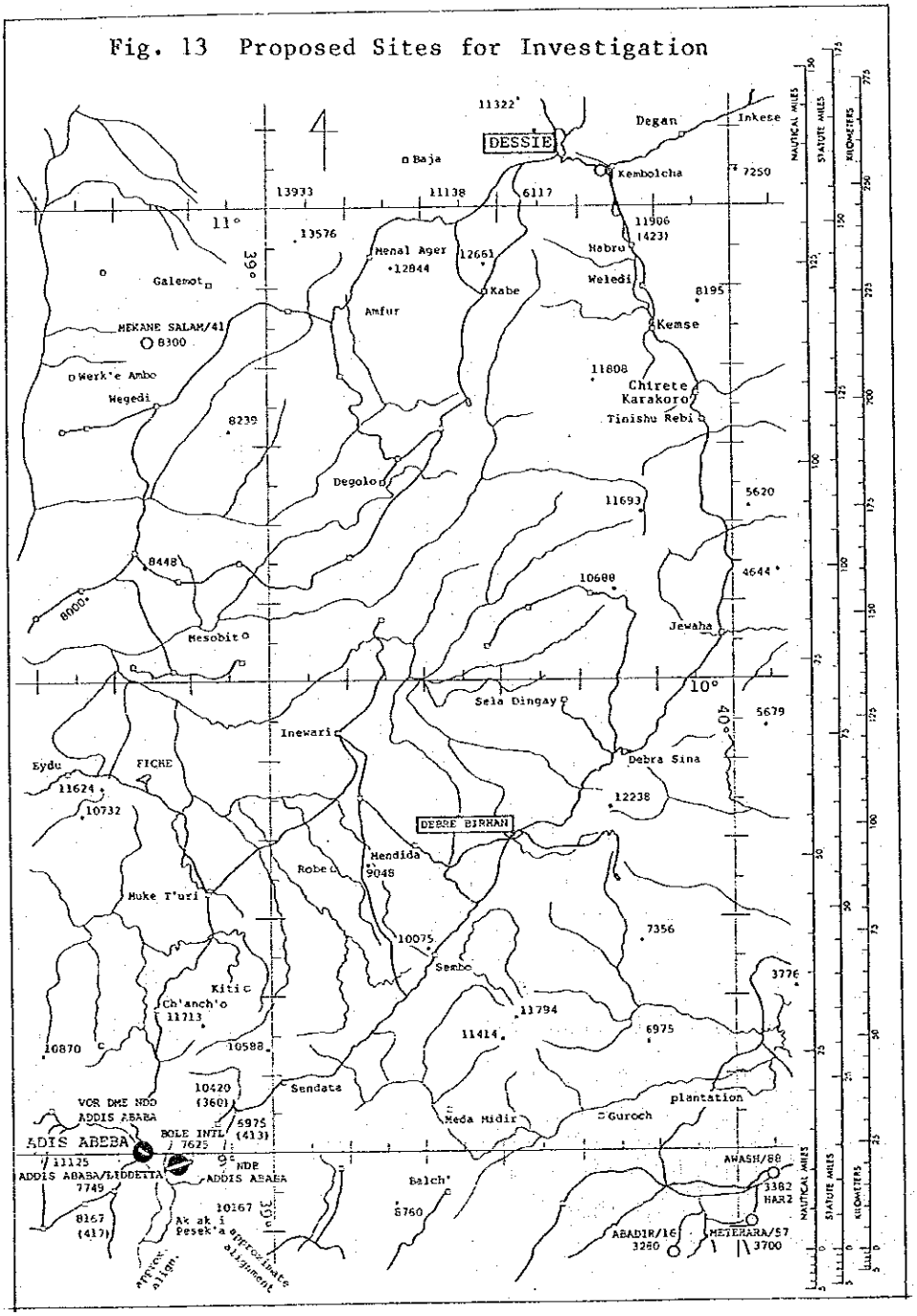
(* 25°C Conversion)

9.5 Electrical Prospecting

As the result of study on emergency, future potentiality and access out of social condition investigation, the proposed area was selected by turn and groundwater research was carried out there.

In such research, the geological analysis was performed by means of surface electrical prospecting to analize as to the potentiality for the groundwater development.

Fig. 13 Proposed Sites for Investigation



(1) Harbu (Wello)

Topography

Harbu is situated in the Rift Valley with altitude about 1,500 m which is 350 km north of Addis Ababa. Both sides have mountains of 2,500 - 3,000 m class.

Geology

The geology is formed by the Tertiary volcanic rocks (basaltic lava, tuff) at the lower part and the Quaternary unconsolidated deposit of upper part.

Electrical Prospecting

E.P. was carried out at four sites in this area. Prospecting Underground geological structure is unconsolidated layer of the upper part upto the depth of 120 m, which is considered to be an interbedded layer of sand, gravel and clay, and the deeper part is considered to be the Tertiary bedrock.

Groundwater Potential

Aquifer the upper unconsolidated sand gravel potential layer. In this area, EWWCA constructed three wells, two of which are 2 l/s and another one is 11.4 l/s yields.

(2) Karakoro (Shewa)

Topography

Karakoro is situated in 310 km north of Addis Ababa with altitude of about 1,400 m, which is similar to Harbu in Rift Valley that extends from north-north-west to south-south-west. In the east-south of this area, a small mountain stands out in the basin, which makes the lowland narrow, and there is an volcanic cone, which limits the catchment area of groundwater.

Geology

Form the lower part, the Tertiary volcanic rock lies and bedrock is rhyolite, and unconsolidated sand, gravel and clay cover the upper part.

Electrical Prostecting

E.P. was performed at five points.
Geological structure of underground is classified generally to three layers.

First layer...surface soil-upto 5m deep, resistivity 9 - 90Ωm
Second layer..clay, sand, gravel-20-60m deep, resistivity 6-19.1Ωm
Third layer...rhyorite-resistivity 24.6-136Ωm

Groundwater Potential

Main aquifer is the second layer, but the weathered zone of bedrock of the third layer is considered to have potentiality of groundwater. The depth of groundwater development will be 70-80m, taking the weathered zone as the object which, however, can not be expected much for groundwater potential because of narrow water catchment area.

(3) Chirete (Wello)

Topography

Chirete is situated in 311 km north of Adis Ababa, neighbouring with Karakoro, with altitude of about 1,300 m, which is more flat than Karakoro area.

Geology

The geological structure is same as Karakoro, but the upper unconsolidated layer has thick deposit.

Electrical Prospecting

E.P. was performed at five points.
Underground geological structure is mainly classified to four layers.

First layer...surface soil upto 5.0m deep resistivity 3.1-8.0 Ωm
Second layer..sand, gravel-30-40m deep resistivity 6.9-18.8 Ωm
Third layer...sand, gravel & partly clay depth abt.120m
resistivity 1-20.8Ω m
Fourth layer..volcanic rock-depth more than 120m
resistivity 15.2-85Ω m

Groundwater Potential

The aquifer is sand and gravel layer of the second and third layer.
According to the existing well, the layer for taking water is to be sand layer within 10-40m at the depth of 51m.
In this site, the third layer is to be the object with target of 120m.

(4) Kamise (Wello)

Topography

This site is narrow in the east and the west, which is lowland extending to north-north-west south-south-east with altitude of about 1,400m.

Geology

As to the geology of this area, the Tertiary volcanic rock is bedrock, in the upper part Quaternary unconsolidated layer deposits.

Electrical Prospecting

E.P. was performed at four points with the result of the underground geological structure being mainly classified to the following three layers.

First layer...Predominant clay layer-depth 20-40m
Second layer..Predominant sand gravel layer-depth 50-110m
resistivity 4-19Ω m.
Third layer...Bedrock-resistivity 22-50Ω m.

Groundwater Potential

Main aquifer is sand gravel layer of the third. The depth upto the bedrock is 50-70m in the surrounding area of shelter and 110m in the adjacent area of E-5, from which it seems to have a considerably slope.
According to the data of existing well, as the permeability coefficient is 4.91×10^{-3} cm/s, this aquifer is considered to have good permeability.

(5) Tisa Balima (Wello)

Topography

This site is situated in 52 km north of Dessie, which is the basin surrounded by the mountains of 2,000 3,000 m high and the altitude of this area is about 1,500 m. Kite river and Ajawa river run in the basin. Kite river flows from the south of the basin to the north throungh the basin and Ajawa river from the basin to join with Kite river. Topography of the basin, which shows fun confirigation in the mountain side, forms terrance with approaching Kite river.

Geology

Geology of this area is, from the lower, the Tertiary volcanic rock, the Tertiary-Quaternary volcanic rocks, which are capped by the Quaternary unconsolidated layer.
The Tertiary volcanic rock is equivalent to Ahangi formation

of Trap Series, which mainly consists of alkali basalt. The Tertiary-Quaternary volcanic rocks, which are younger than Trap Series and are equivalent to Magdara formation, and consist of rhyorite and tarchyte with mainly acidic volcanic rock. The Quaternary unconsolidated layer with river deposit is conposed of sand, gravel and clay.

Electrical Prospecting

E.P. was performed at four points.
Underground geological structure, according to resistivity, is mainly classified into the following five layers.

First layer...Clay dominant-depth: 0 - 5m,
resistivity: 30 - 50Ωm
Second layer..Sand & gravel dominant-
resistivity: 30 - 50Ωm
Third layer...Clay dominant-depth: 60 - 80m,
resistivity: 11 - 38Ω m
Fourth layer..Volcanic rock (bedrock)-depth: 110 - 120m,
resistivity: 18 - 29Ω m
Fifth layer...Volcanic rock-resistivity: 46.5Ω m

Groundwater Potential

Aquifer is sand and gravel layer of the second as a main and the next is the third, which, however, is inferior than the second.
The fourth and fifth layers are bedrocks, especially, the fourth, compared with the fifth, is judged to be the crushed clastic rocks, therefore, in case of groundwater development being carried out in this area, it's desirable to survey the fourth layer as the object.
There are two wells in this area, one of which has a yield of 5 l/s at the depth of 67m, and another one is a shallow well at the slope of the terrace along ajawa river, which withdraw groundwater from sand gravel layer of the second layer.

(6) Degan (Wello)

Topography

This site is situated on the hill with altitude of 1,400 m, which contacts the mountain slope with altitude of more than 2,000 m in the north and the west. Eastward, this hill reduce gradually the altitude. Kilt river forms a terrace, dissecting the area from the northwest to southeast.
Geology in this area is composed of the Tertiary volcanic rock beneath and the upper Quaternary unconsolidated formation. The Tertiary volcanic rock is equivalent to Ashangi formation of Trap Series, which consists of mainly alkali basalt and tuff, and partly accompanying with rhyorite.
The JQuaternary deposit is equivalent to the hill deposit, consisting of sand, gravel and clay.

Electrical Prospecting

E.P. was performed at five points.
The underground geological structure is classified, by resistivity, into the following three layers.

First layer...Sand, gravel with clay-depth: abt.10m.
resistivity: 10 - 50Ω m
Second layer..Clay with sand, gravel-depth: 20 - 60 m
resistivity: 5 - 21Ω m
Third layer...Volcanic rock-resistivity: 17 - 60Ω m

First and second layers are equivalent to the hill deposits, which thickness is controlled by the surface shape of the bedrock, i.e. the depth to the bedrock is presimed to be 20 - 40m near the E-1,2,3,5, but in the vicinity of E-4, it's interpreted to be about 60m.

Groundwater Potential

This site is difficult for groundwater potential. potential
First and second layers are considered to be equivalent to the hill deposits. Both layers consist of mainly clay layer

with sand and gravel with low permeability.
In this area, the object is to be fissure water in the Tertiary bedrock.
Since a certain groundwater potential is expected, probably, in a boundary of the hill deposits with bedrock. The vicinity of E-4 is desilable for the object site of test boring, where surface of bedrock looks like a valley. There is a well with yield of 2 l/s at the depth of 100 m in this place, which, probably, position of catchment will be the Tertiary formation.

(7) Dessie (Wello)

Topography

This is the capital of Wello region, situated in 23 km north of kembolcha, and on a high Land with 2,300 - 2,400m altitude that is almost same as Addis Ababa's.
The southern side of this city is lowered with relative height 700m to Kembolcha side and northward the altitude being reduced gradually.
Borkena river flow from this city southward.

Geology

Geology forming highland is equivalent to Trap Series and Ashangi formation.
Lithofacies is mainly basalt and trachyte, rhyorite and tuff are present.

Electrical Prospecting

E.P. was performed at two points in the surrounding site of the transit shelter. Underground geology of lave plateau can not absolutely be classified, but in analyzing of the existing well' data, which is classified to four layers.

First layer...Surface soil & weathered clay-depth abt. 15 m, resistivity 10Ω m
Second layer..Basaltic lava-depth abt. 30m,

resistivity 11 - 26Ω m

Third layer...Fractured zone of basalt-depth 60 - 70 m,
resistivity 20Ω m

Fourth layer..Basaltic lave-resistivity 40Ω m

Relative height between electrical prospecting point No.1 and No.2 is about 30m. Lava formation of both points is linked. In the third layer groundwater potential is expected. Below fourth layer, as the resistivity is considerably higher than upper layer, existence of hard lava is considered.

Groundwater Potential

In the perimeter of this transit shelter, there are two city wells. In the light of these wells data, it can be described that groundwater layer is infered to be fissure water generated in fractured rocks. The larger scale of fractured zone, the larger amount of groundwater potential.
For instance, existing well NO.3 is 15 1/s in yield and existing well at No.2 point of electrical prospecting is 10 1/s. In the perimeter of shelter, this second layer is the object for groundwater development.

(8) Kembolcha (Wello)

Topography

Kembolcha is situated in the extremely north of Rift Valley linking to Karakoro - Chirete - Kamise - Harbu, which is 380 km north of Addis Ababa, being a basin between mountains with altitude of 1,780 m.

Geology

Borkena river and other several rivers flow in this area. these small rivers carry sand, gravel and clay to make thick sedimentation. The thickness of basin deposit is said to be more than 200 m. The bedrock is the basalts that form the mountain surrounding this basin.

Electrical Prospecting

E.P. was performed at three points in the perimeter of SCF centre. From the result of prospecting upto 10 m deep, boundary with the bedrock cann't be grasped. Resistivity of upper lakes and terrace deposit is low and classification of layer is difficult. Generally, resistivity of this deposit is less than 10Ωm.

Groundwater Potential

There are many records of performance of well drilling in the basin. In case of groundwater reaching 60 m, it flows out, which means that it has a pattern of confined groundwater. The formation bearing this confined water is Fine sand grain layer with shell fragment, which is, reportedly, widely spreaded evenly.

(9) Tchaffa Weledi (Wello)

Topography

Tchaffa Weledi is situated in Rift Valley with altitude of about 1,500 m, being 350 km north of Addis Ababa. This site is topographically similar to Harbu site.

Geology

Geology of this site seems to be same as Harbu site, but according to the well drilling data of EWWCA, unconsolidated sedimentary formation is clay in dominant. The bedrock is rhyorite and partly, tuffbreccia is present.

Electrical Prospecting

E.P. was performed at five points in the perimity of town. Underground geological structure is calssified mainly two.

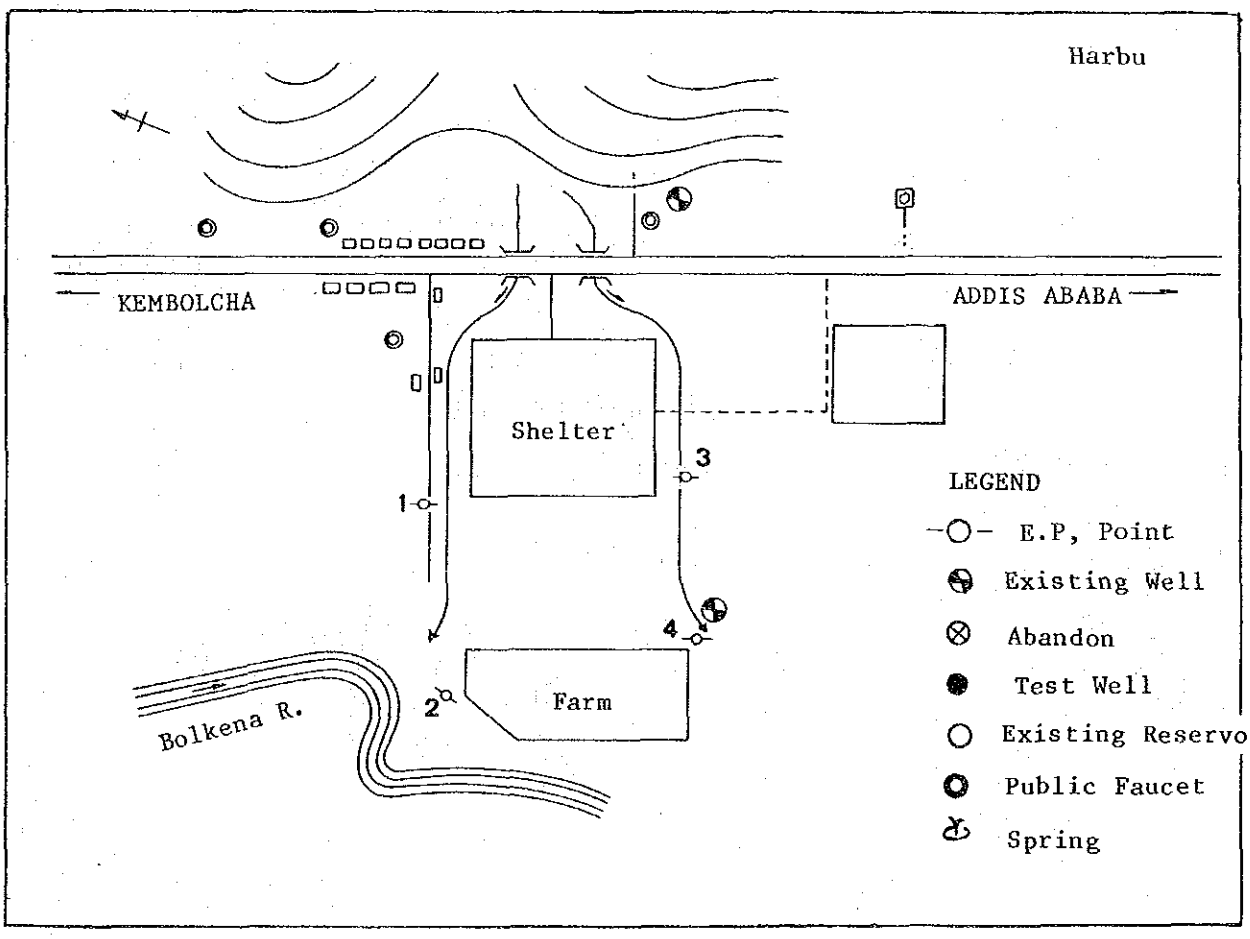
First layer ..... Interbedded layer of sand, gravel and clay
depth 40 - 120,
resistivity 9 - 20Ωm

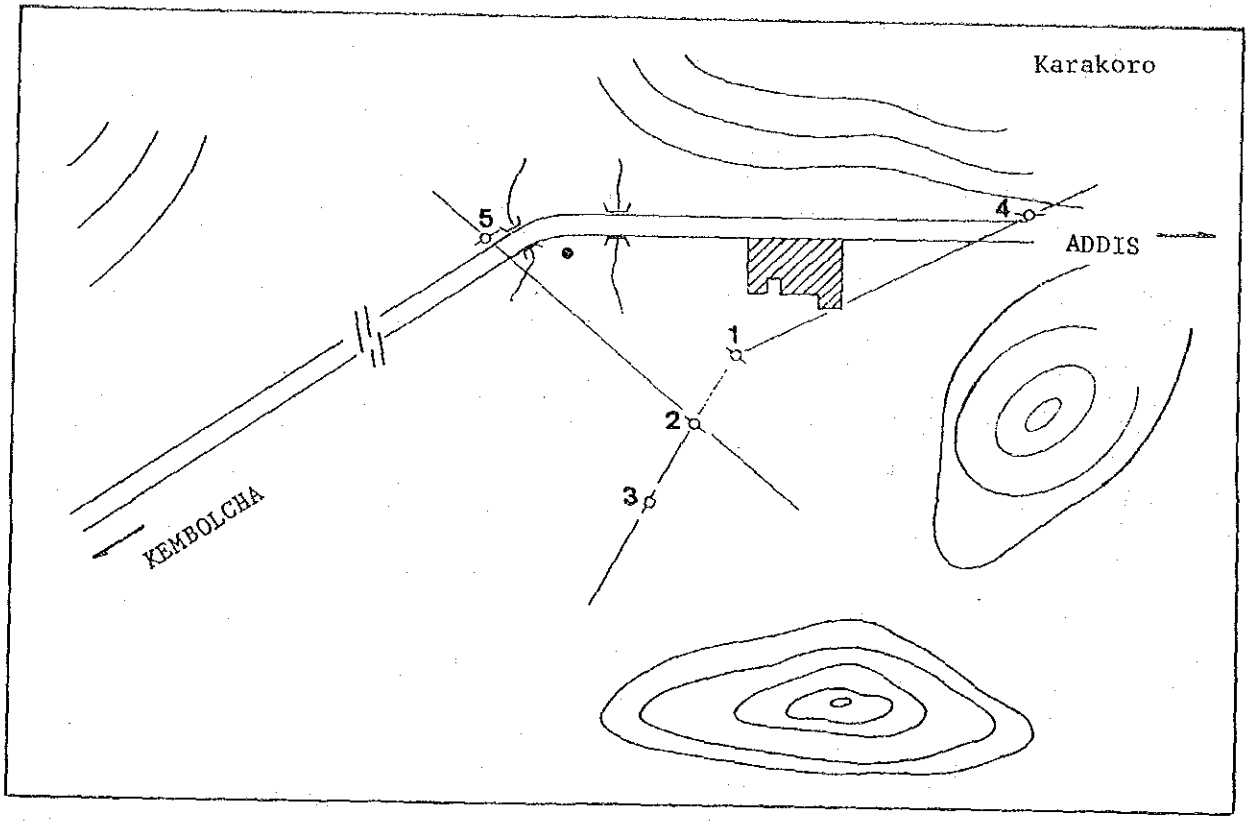
Second layer ..... Volcanic rock, Resistivity over 20Ωm

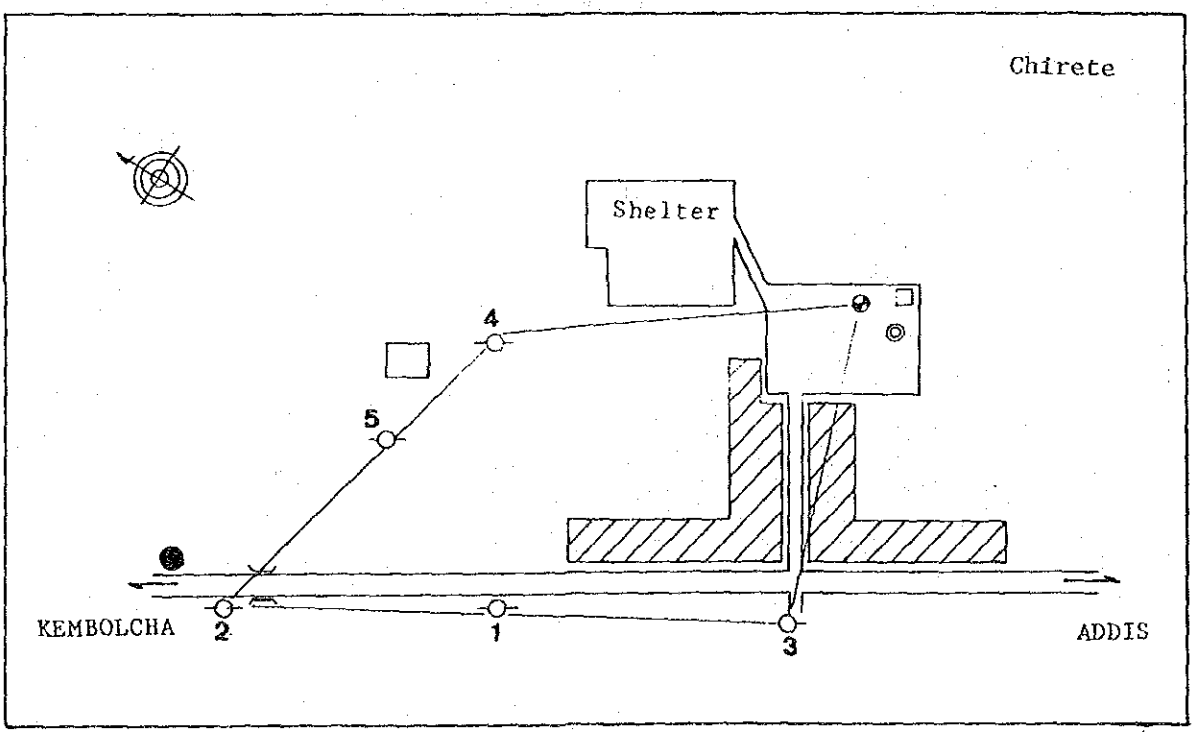
Groundwater Potential

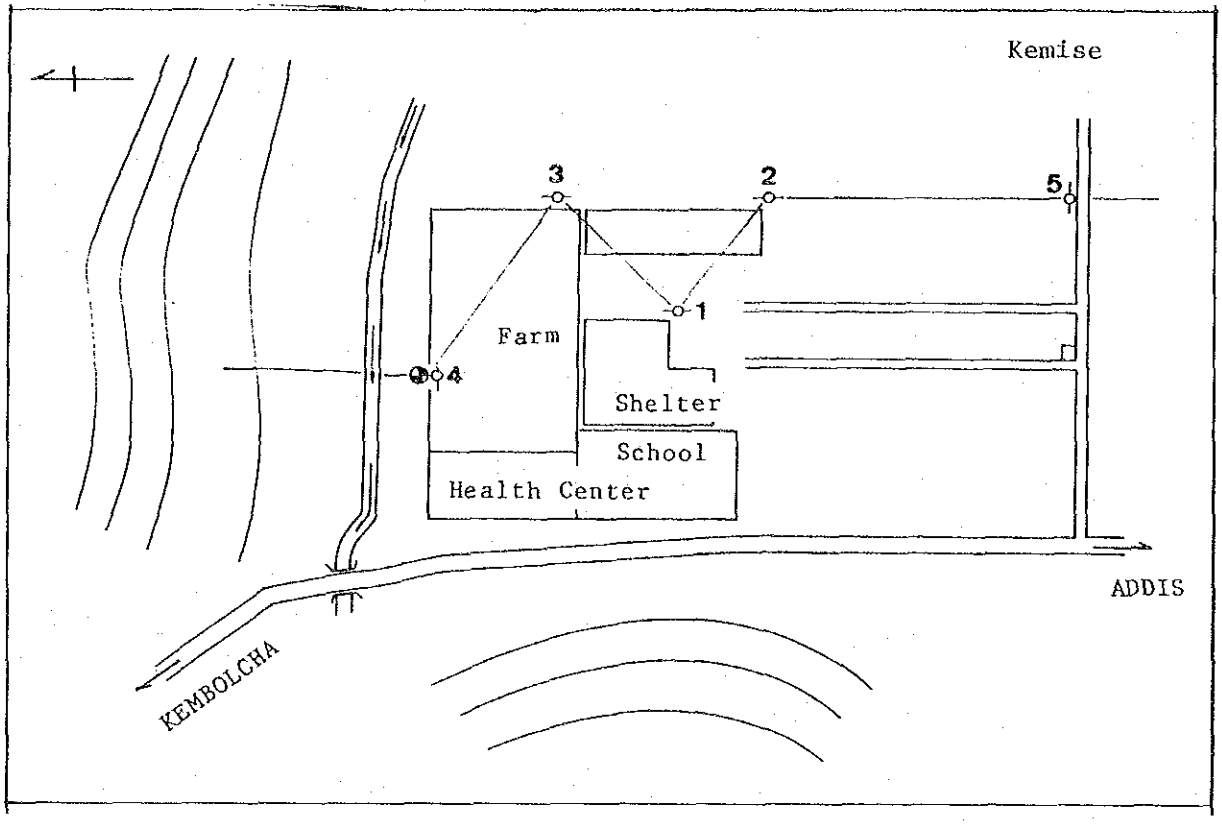
There are two wells in this site, one of which is a shallow well of 7 m depth and subsurface groundwater is its' object, and another one is 37 m depth, which withdraw water from the weathered zone of bedrock. It's desirable for groundwater development to take both of groundwater of subsurface layer and weathered zone, but the former one is easily affected by seasonal change.

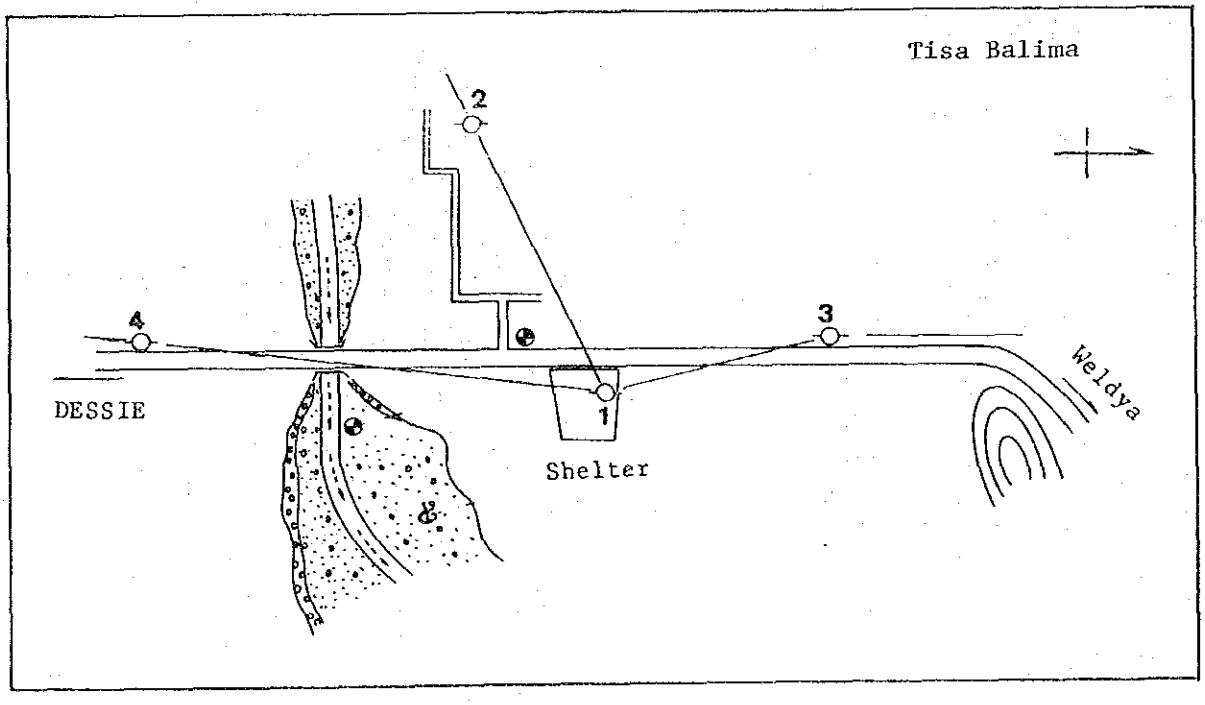
Fig. 14-1 Electrical Prospecting Points

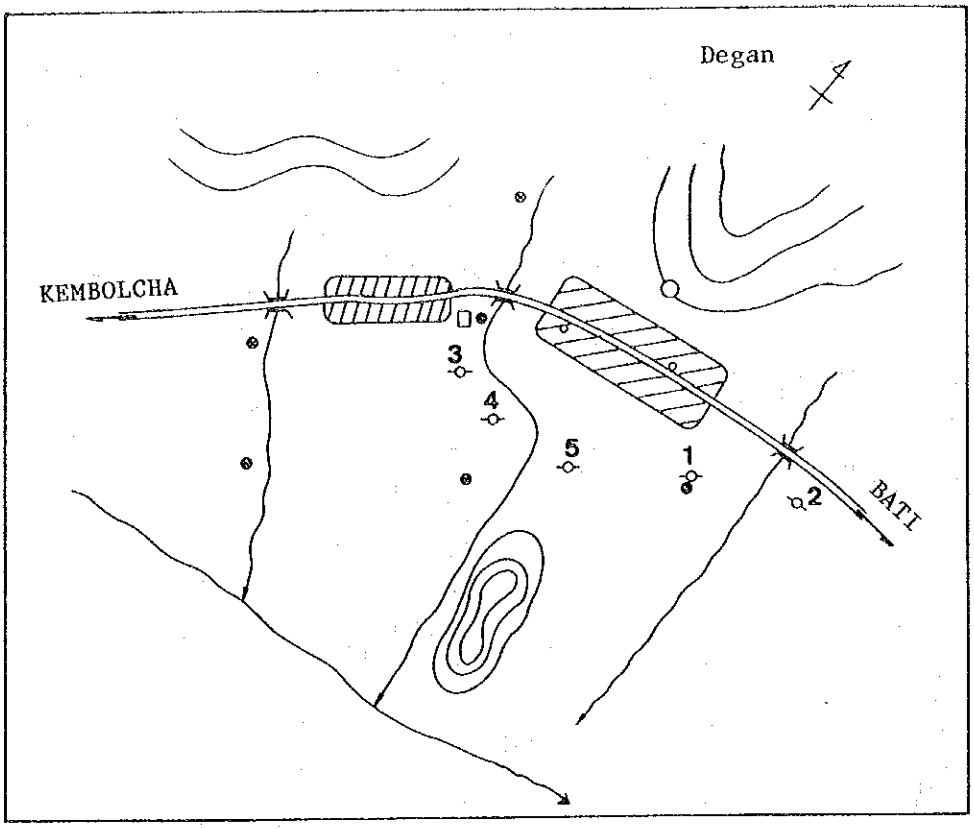


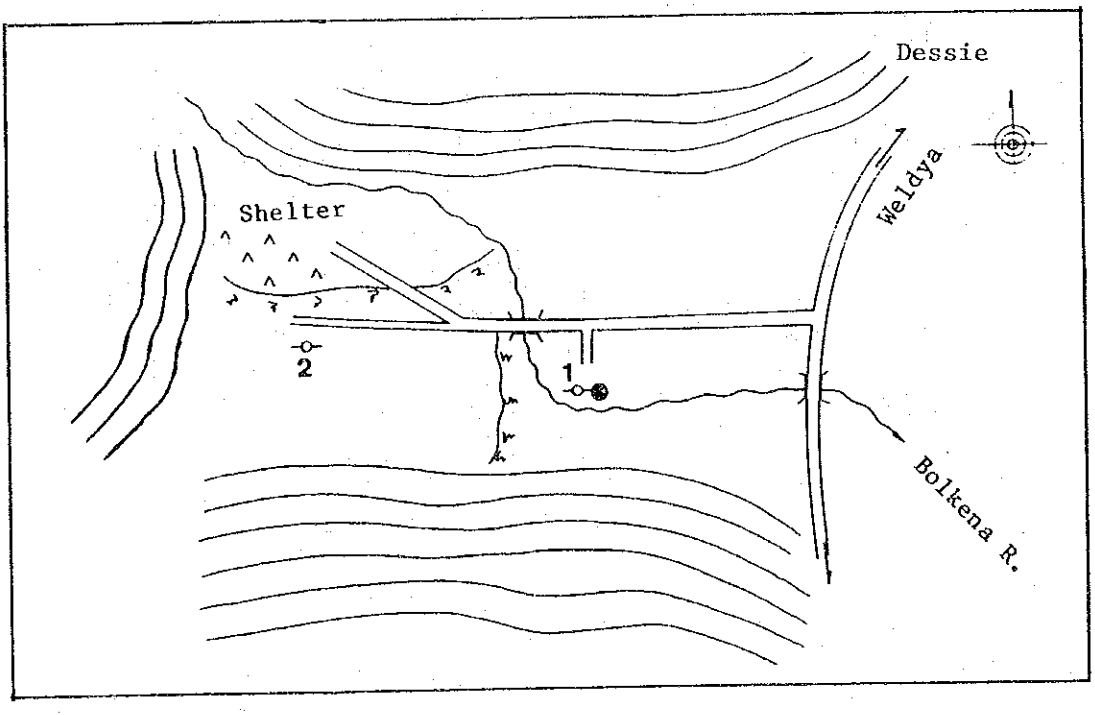

Karakoro
5
4
ADDIS
1
2
3
KEMBOLCHA

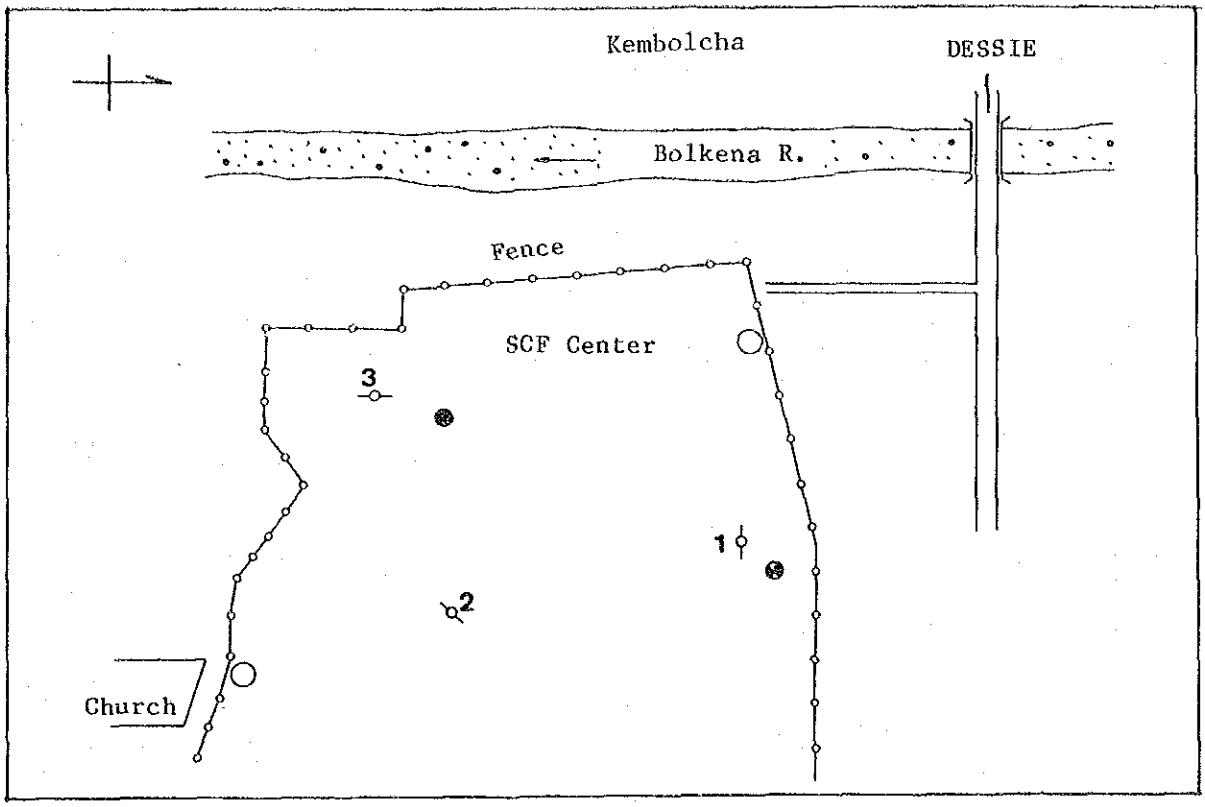

Chirete
Shelter
4
5
KEMBOLCHA
2
1
3
ADDIS

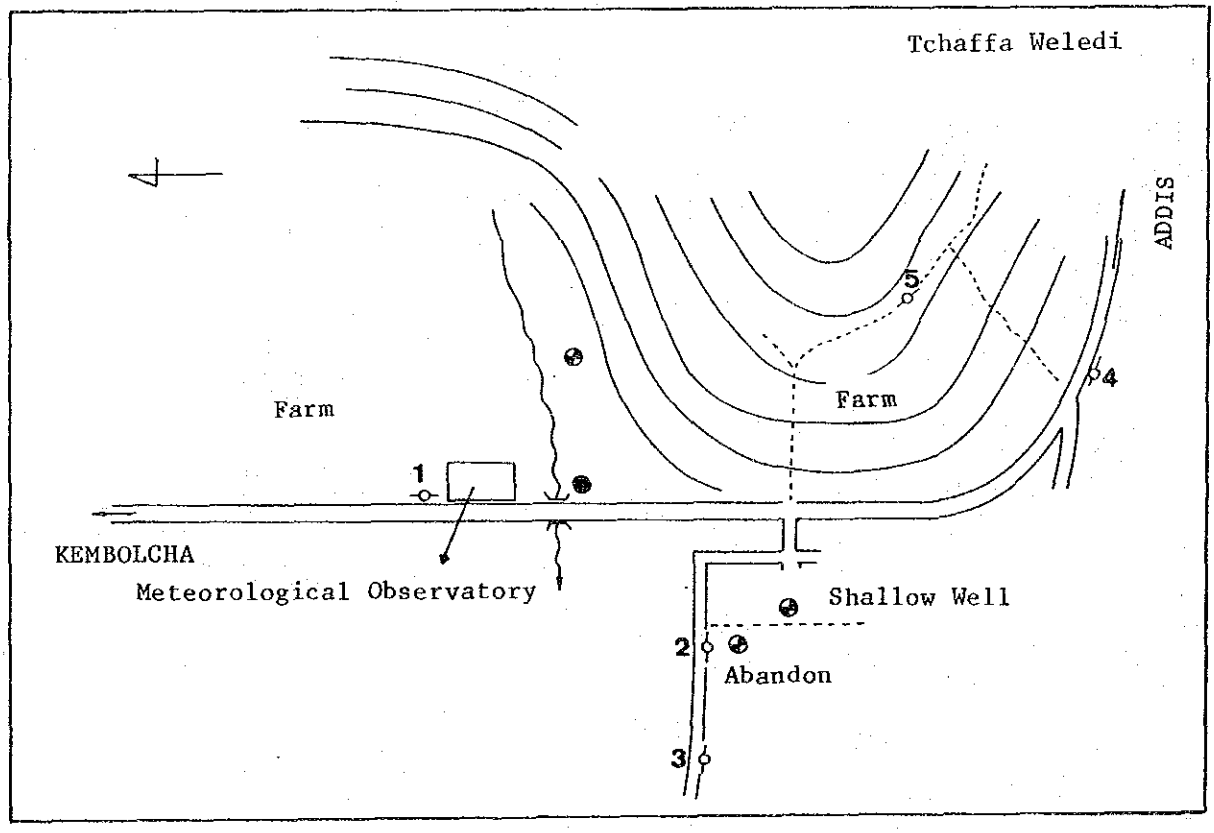

Kemise
3
2
5
1
Farm
4
Shelter
School
Health Center
ADDIS
KEMBOLCHA


Tisa Balima
2
4
3
Weldya
DESSIE
1
Shelter


Degan
KEMBOLCHA
BATI
1
2
3
4
5


Dessie
Shelter
Weldya
Bolkena R.
1
2


Kembolcha
DESSIE
Bolkena R.
Fence
SCF Center
3
1
2
Church

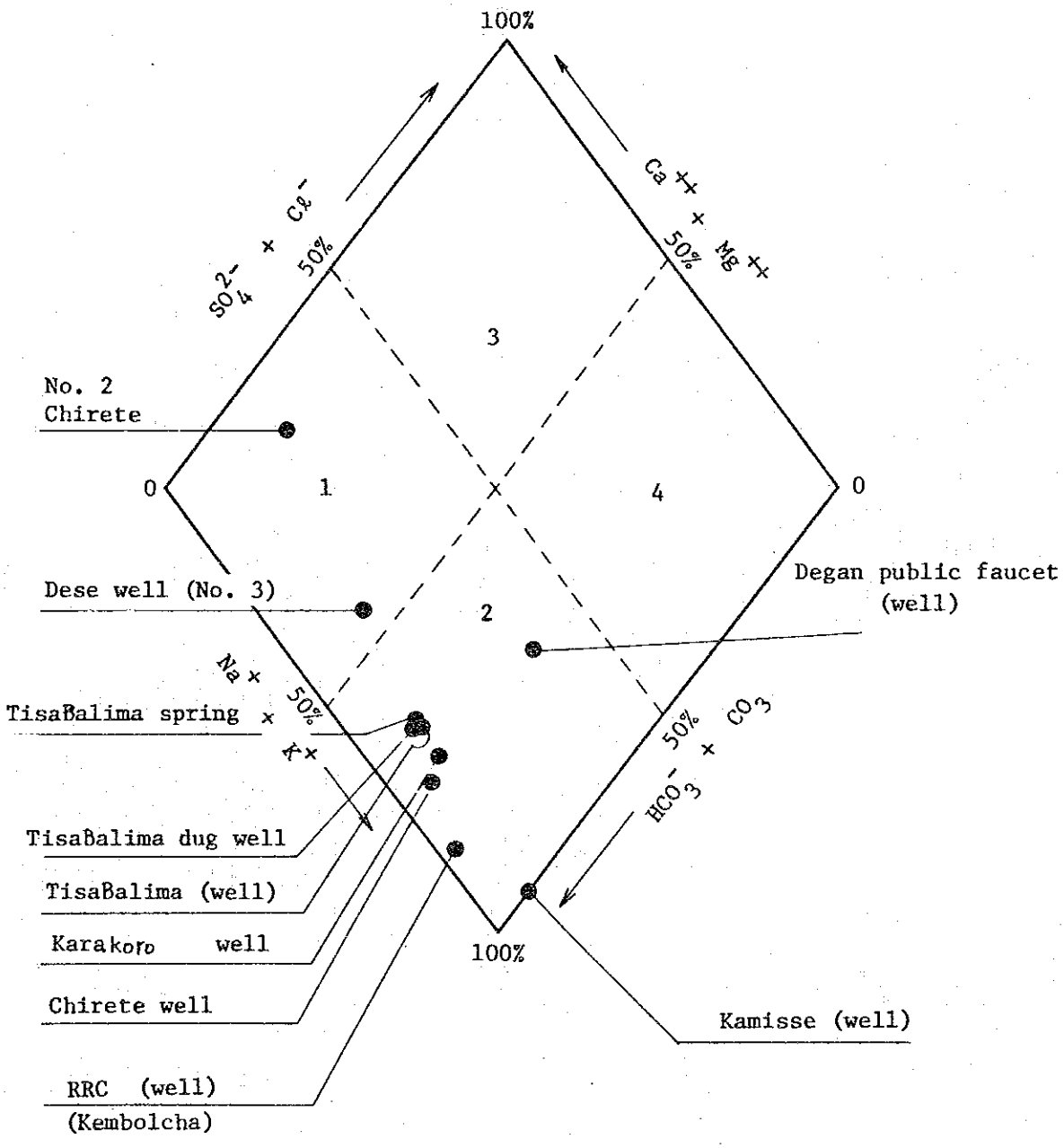

Tchaffa Weledi
ADDIS
5
4
Farm
Farm
1
KEMBOLCHA
Meteorological Observatory
Shallow Well
2
Abandon
3

9.6 Water Quality Study

The result of water quality analysis is to be indicated collectively.
The figure shows water quality component of groundwater.
Type 1 of water is calcium cabonate type, which is general type of fresh water.
Type 2 is sodium carbonate type, which is generally softened groundwater, and stagnant groundwater is mainly this type.
Type 3 is non calcium carbonate type that is compound of mainly Ca.Mg and So4.Cl and belong to permanent hard water.
Type 4 is non sodium carbonate type, which is sea water or volcanic water.

Groundwater in this area almost belongs to type 2, but although groundwater in Degan belongs to same type, some point is different, which means probably groundwater in Degan is fissure water in volcanic rock (bedrock) and it's infered that groundwater in the other area is due to the difference of groundwater in sedimental formation.
Further, groundwater in Dessie belongs to type 1, which is different from the others in property. It's infered that since it's under the environment with comparatively good water circulation, groundwater recharge is in the superior condition than the others.

Fig. 15 Key Diagram



10. Water Quality Analysis

Table

	Location / Head	KaraKoro Test well No.1	Chirete Exting well	Chirete Test well No.2	TisAbaLima Exting well	TisAbaLima Dug well	TisAbaLima spring	Kamisse Exting well	Degan Exting well	Kemboicha RRC well	Dese Exting well No.3
1	Atmosphere Temperature	33.8℃	—	33.0	32.0	33.2	33.0	30.5	33.5	25	
2	Water Temperature	28.8℃	—	25.8	34.9	23.0	21.6		29.2	23.5	
3	Ammonia Nitrogen	0.06mg/ℓ	0.01>mg/ℓ	0.3	0.01>mg/ℓ	0.01>mg/ℓ	0.01>mg/ℓ	0.01>mg/ℓ	0.01>mg/ℓ	0.01>mg/ℓ	0.06mg/ℓ
4	Nitrate Nitrogen+ Nitrite Nitrogen	1.06	1.0	2.3	1.9	1.7	1.5	0.7	0.2	0.1>	1.7
5	Chloride Ion	8.8	5.6	37	5.5	5.7	4.8	13	101	2.9	5.0
6	Potasuue permangan-ate consumed	5.0>	5>	20<	5>	5>	5>	20<	5>	5>	5>
7	Total Colonies	0			3	3	100<		1		40
8	Coliform group	detection			detection	detection	detection		detection		detection
9	Cyanide Ion	0.01>	0.01>	0.01	0.01>			0.01>	0.01>		0.01>
10	Mercury	—									
11	Organophosphate	—									
12	Copper	0.05>	0.1>	0.05	0.1>	0.1>	0.1>	0.05>	0.1>		0.1>
13	Iron	2.5	0.1>	2.0	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>
14	Manganese	0.2	0.1>	0.6	0.1>	0.1>	0.1>	2.8	0.1>	0.1>	0.1>
15	Zinc	0.1>	0.27	0.2	0.53	0.17	0.13	0.5	0.8		0.05
16	Lead	0.2	0.5	2.4	2.5	0.1>	1.1	3.8	1.2		0.70
17	chromium (VI)	0.01>	0.01>	0.01<	0.01>	0.01>	0.01>	0.01>	0.01>		0.01>
18	Cadmium	—									
19	Arsenic	—									
20	Fluoride	—									
21	Hardness	69 $CaCO_3$	71	333	121	95.0	104	1.0>	170	48	130
22	Total Residue	—									
23	Phenols	—									
24	Surface-active ogents (anionic)	—									
25	pH Value	6.2 (28.2℃)	7.5 (33.8℃)	6.4 (18.5℃)	7.85 (34.9℃)	7.1 (23.0℃)	7.1 (21.6℃)	7.8 (23.1℃)	7.1 (29.2℃)	8.8 (23.5℃)	7.3 (23.7℃)
26	Odor	non	non	non	non	non	non	non	non	non	non
27	Taste		non		non	non	non	non	non	non	non
28	Color	2	1		1	1	1	1	1	1	1
29	Turbidity	1.5	1		1	1	1	1	1	1>	1>
30	Calcium Hardness	54	55	260	70	00	68.0	1.0>	108	2.8	48.0
31	Calcium	21.6	22.0	104	30.4	24.0	27.2	1.0>	43.2	11.2	19.2
32	Magnesium Hardness	15.0	16.0	73	45.0	35.0	36.0	1.0>	62.0	15.0	82.0
33	Magnesium	3.7	3.9	17.7	10.9	8.5	8.7	1.0>	15.1	3.6	19.9
34	Potassium	2.9	4.9	5.3	4.2	1.0	0.2	9.5	0.8	3.0	0.8
35	Sodium	70.8	70.6	21.6	96.1	77	85.8	228	208	94.3	46.2
36	Total Alkalinity	198	210	300	310	225	255	455	365	247	190
37	Sulfate Ion	19.0	15.0	34	15.0	25	23.0	43.0	81.0	5>	28.0
38	Phosphrous Ion	0.05>	0.23	0.05	0.22	0.38	0.38	0.17	0.05	—	4.0
39	Nitrite nitrogen Ion	0.02	0.03	0.06	0.01	0.01	0.08	0.07	0.01>	0.01>	0.01>
40	Nitrate nitrogen Ion	4.6	4.2	10.0	8.5	7.5	6.4	2.88	40.0	0.13	5.5
41	Ammonium Ion	0.08	0.1>	0.4	0.1>	0.1>	0.1>	0.1>	0.1>	0.1>	0.09

10. PLAN OF WATER SUPPLY

The sites proposed of the project, at the beginning being considered with RRC selected relief centers as object areas which were in critical condition. However, after the wet season the conditions of the society and agriculture indicated a favorable turn, and the relief centers began to reduce. Therefore the selection of the sites proposed became more difficult. In the latter part of the project, the scope of object areas was extended considering the future and the inhabitants' benefit. The selection of these sites proposed was determined considering the following matters.

1 Social Conditions of Relief Centers and Surrounding

2 Conditions of Water Supply (Relief Centers and Surrounding)

3 Degree of Emergency and the Future Prospect

Judging collectively these contents, from the order of high degree of urgency, evaluation was given.
Evaluation items are as follows:

1 Degree of Water Demand ----- sufficient, insufficient

2 Access ----- circumstances in wet season, conditions of roads

3 Groundwater Potential ----- possibility of ground water development
(collection of existing data and surveys by Electric Prospecting)

4 Prospect ----- future system of maintenance and control

5 Others ----- condition of public order, well drilling plans of other organization and so on.

Examining these evaluation items, the following places have been selected as proposed sites.

1	KARAKORO (April '85)	2	CHIRETE (June '85)
3	DEGAN (July '85)	4	KEMBOLCHA (September '85)
5	TCHAFFA WELEDI (October '85)		

The following table is the selection list as to each proposed site.

Table 11. Sites Proposed by Project (Short list)

Sites Proposed by Project Short List (Exact Investigation)						
Name of Site Proposed	Distance from Addis	Outline of Relief Center			Social Conditions of Environs	
		Relief Organization	Character, Scale, Substance of Center	Condition of Water Utilization	Population, etc.	Conditions of water utilization
HARBU	North 350 km	Irish Concern	Opened Nov. 84 Medical, wet feeding center. 6,000 people (May, 85) Dry ration for 83,000 people	63 m^3 water tank in the center Water supply facilities	Town population 3,500	3 existing wells (EWWCA) 2 l/s x 2 wells 11.4 l/s x 1 wel, (newly constructed)3 public hydrants
KARAKORO	North 310 km	Irish Goal	Opened Nov. 84 Medical, wet feeding center. 150 people Dry ration for 6,000 people	No water supply 4,800 l/day carried by hand from Chirete village	Village population 350	No water sources, no supply facilities Getting water from Chirete village
CHIRETE	North 311 km	Irish Concern	Opened Jan. 85 Medical, wet feeding center. 80-100 People, Wet feeding for 1,750, Dry ration for 24,807	10 kl tank in the center Irregular water supply from Chirete village	Village population 2,000	1 existing well (EWWCA) 51 m x 1.5 l/s Shallow well (hand pump) Both are frequently out of order and difficult to use customarily
DEGAN	North 400 km	Ethiopian Red Cross	Plan to open Jul. 85 (in June) Plan of wet feeding for 500, dry ration for 10,000	Water supply will be needed after center opening	Village population 850 Including environs 76,000	1 existing well (EWWCA) 150 dia x 100 x 2 l/s 8.5 kl tank in the village water supplied twice/day. Use surface flow water in rainy season
KAMISEE	North 326 km	Irish Concern	Be in preparation to open (waiting for permission) Plan of medical, wet feeding center Object 5,000 children Dry ration for 30,000	5 kl tank in the center, water supply facility, Plan of piping from town water supply	Town population 7,000	2 existing wells (EWWCA) old well 3 l/s new well 150 dia x 70 m x 5 l/s 60 m^3 water store tank
TISA BALIMA	North 452 km	EECMY	Feeding center Dry ration for 50,000	Piping water from water supply facility in village (simple facility)		1 existing well (EWWCA) 5 l/s 12 kl tank Inhabitants use spring and shallow wells
DESSIE	North 400 km	RRC	Transit shelter Capacity of 5,000 Reduced to 800 at Jul. 9	Piping water from city water supply	City population 78,000	Water sources 3 existing wells Total 30 l/s 2 springs

Sites Proposed by Project Short List (Exact Investigation)						
Name of Site Proposed	Distance from Addis	Outline of Relief Center			Social Conditions of Environs	
		Relief Organization	Character, Scale, Substance of Center	Condition of Water Utilization	Population, etc.	Conditions of water utilization
KEMBOLCH	North 380 km	SCF	Opened Sep. 85 Plan of medical, wet feeding center, 300-400 people Object 1,200 children	No water sources in the site Plan of 10 kl tank construction Use 30-40^3/day day	City population 18,000 - 20,000	Many wells for industry and agriculture in the city. Inhabitants get water from them or use surface flow water
TCHAFFA WELEDI	North 350 km	RRC	No relief center Dry ration for 55,000	Need water for dry rationed people	Town population 4,500 Including environs 6,000	1 shallow well (7 m) for ordinary inhabitants 1 well (38 m) for agriculture Use surface flow water in rainy season

(NOTE)
EECMY: Ethiopian Evangelical Church Mekane Yesus
RRC : Relief and Rehabilitation Commission
SCF : Save the Children Federation (U.K)
ETCA : Ethiopian Transport Construction Authority
PA : Farmer's Association

(NOTE)
Provided:
Amount of Water Demand ..... 30l/day per person
Operation time of Generater ... 6 hours/day
Judgement : o ... High, Good
△ ... Middle, Normal
X ... Low, Bad

Sites Proposed by Project Short List (Exact Investigation)

Name of Site Proposed	Evaluation: Water Demand (water supply conditions, balance)	Access (Roads, Rainy season)	Potentiality of Ground Water	Maintenance and Administration of Facilities	Plans of Other Organizations, Social Conditions	Total Judgement	Judgement	Order of Test-well
HARBU	Amount of water demand (per day) Center 180,000 l Town 105,000 l Amount of water supply 332,640 l ✕	Hard in rainy season △	Electric prospecting at 4 points High potential water in upper ○ Sedimentary layer	Administrated by relief organization ○	New well was constructed by EWWCA △	Water is sufficient at present, after a new well was constructed.	✕	-
KARACORO	Amount of water demand (per day) Center 4,800 l Village 10,500 l Amount of supply (per day) is short Carried by people ○	Along roads possible even in rainy season ○	Electric prospecting at 5 pts. Upper Sedimentary layer is thin & low Potential water △	Administrated by relief organization. Plan be transferred ○	No plan. Social conditions good ○	Water is insufficient in both center and village. Absolute amount of water is short. Demand of water is high	○	1
CHIRETE	Amount of water demand (per day) Center 3,000 l Village 60,000 l Amount of water supply (per day) 32,400 l about 30,000 l short ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Ground water deposits in upper Sedimentary layer (aquifer) ○	ditto ○	No plan. Social conditions good ○	About 30,000 l/day is short. Existing well is time-worn tremendously. Demand of water is high	○	2
DEGAN	Amount of water demand (per day) wet feeding 15,000 l Village 25,500 l Amount of water supply (per day) 43,200 l almost ±0 ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Aquifer is lower volcanic rocks Ground water deposits is a little △	ditto ○	No plan ○	At present, water is sufficient only in town. After center opens, water will be short. Demand of water is high	○	3
KAMISEE	Enough supply to the town by newly constructed well ✕	No places for well drilling along roads Impossible in rainy season △	Electric prospecting at 5 points. Aquifer is in upper Sedimentary layer Potentiality of ground water is high ○	Administrated by relief organization ○	New well was constructed by EWWCA △	At present, water is sufficient only in town. After center opens, it is question.	△	-
TISA BALIMA	Inhabitants don't use well facilities because of economic burden, but use shallow wells or springs and are satisfied ✕	Along roads possible even in rainy season ○	Electric prospecting at 4 points. Aquifer is in Sedimentary layer Potentiality and possible even in lower volcanic rocks △	Heavy expenses burden on people ✕	No plan. out of the S/W △	Well facilities are administrated individually by relief organization	✕	-
DESSIE	If people are more than the shelter's capacity, water is short. Change of populaion is great, impossible to estimate the future water demand ○	Good ○	Electric prospecting at 2 points. Aquifer is at fissured zone basaltic rocks ○	Administrated by relief organization ○	Transit shelter Difficult to drill because of hard rocks △	The center is transit shelter. Population has reduced and now water is sufficient.	✕	-
KEMBOLCHA	Amount of water demand center 30,000-40,000 l water supply, carried by water lorry ○	Hard to carry into the center in rainy season △	Electric prospecting at 3 points possible in ○	Administrated by relief organization. Plan to be transferred to town ○	No plan. Though it is ETCA well but can't be used ○	There are no water sources in the center. Demand of water is high.	○	4
TCHAFFA WELEDI	Amount of water demand (per day) Town 135,000 l Water supplied twice per day by shallow wells ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Ground water in the most upper Sedimentary layer possibility of decreasing in dry season. △	Administrated by F.A ○	Though a well 150dia x 80m had been constructed by EWWCA, was abolished for the water amount was 1 l/s ○	Existing well does not suffice for absolute water amount. After population increases water will be definitely short.	○	5

Sites Proposed by Project Short List (Exact Investigation)

Name of Site Proposed	Evaluation: Water Demand (water supply conditions, balance)	Access (Roads, Rainy season)	Potentiality of Ground Water	Maintenance and Administration of Facilities	Plans of Other Organizations, Social Conditions	Total Judgement	Judgement	Order of Test-well
HARBU	Amount of water demand (per day) Center 180,000 l Town 105,000 l Amount of water supply 332,640 l ✕	Hard in rainy season △	Electric prospecting at 4 points High potential water in upper Sedimentary layer ○	Administrated by relief organization ○	New well was constructed by EWWCA △	Water is sufficient at present, after a new well was constructed.	✕	-
KARACORO	Amount of water demand (per day) Center 4,800 l Village 10,500 l Amount of supply (per day) is short Carried by people ○	Along roads possible even in rainy season ○	Electric prospecting at 5 pts. Upper Sedimentary layer is thin & low Potential water △	Administrated by relief organization. Plan be transferred ○	No plan. Social conditions good ○	Water is insufficient in both center and village. Absolute amount of water is short. Demand of water is high	○	1
CHIRETE	Amount of water demand (per day) Center 3,000 l Village 60,000 l Amount of water supply (per day) 32,400 l about 30,000 l short ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Ground water deposits in upper Sedimentary layer (aquifer) ○	ditto ○	No plan. Social conditions good ○	About 30,000 l/day is short. Existing well is time-worn tremendously. Demand of water is high	○	2
DEGAN	Amount of water demand (per day) wet feeding 15,000 l Village 25,500 l Amount of water supply (per day) 43,200 l almost ±0 ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Aquifer is lower volcanic rocks Ground water deposits is a little △	ditto ○	No plan ○	At present, water is sufficient only in town. After center opens, water will be short. Demand of water is high	○	3
KAMISEE	Enough supply to the town by newly constructed well ✕	No places for well drilling along roads Impossible in rainy season △	Electric prospecting at 5 points. Aquifer is in upper Sedimentary layer Potentiality of ground water is high ○	Administrated by relief organization ○	New well was constructed by EWWCA △	At present, water is sufficient only in town. After center opens, it is question.	△	-
TISA BALIMA	Inhabitants don't use well facilities because of economic burden, but use shallow wells or springs and are satisfied ✕	Along roads possible even in rainy season ○	Electric prospecting at 4 points. Aquifer is in Sedimentary layer Potentiality and possible even in lower volcanic rocks △	Heavy expenses burden on people ✕	No plan. out of the S/W △	Well facilities are administrated individually by relief organization	✕	-
DESSIE	If people are more than the shelter's capacity, water is short. Change of populaion is great, impossible to estimate the future water demand ○	Good ○	Electric prospecting at 2 points. Aquifer is at fissured zone basaltic rocks ○	Administrated by relief organization ○	Transit shelter Difficult to drill because of hard rocks △	The center is transit shelter. Population has reduced and now water is sufficient.	✕	-
KEMBOLCHA	Amount of water demand center 30,000~40,000 l water supply, carried by water lorry ○	Hard to carry into the center in rainy season △	Electric prospecting at 3 points possible in ○	Administrated by relief organization. Plan to be transferred to town ○	No plan. Though it is ETCA well but can't be used ○	There are no water sources in the center. Demand of water is high.	○	4
TCHAFFA WELEDI	Amount of water demand (per day) Town 135,000 l Water supplied twice per day by shallow wells ○	Along roads possible even in rainy season ○	Electric prospecting at 5 points. Ground water in the most upper Sedimentary layer possibility of decreasing in dry season. △	Administrated by F.A ○	Though a well 150dia x 80m had been constructed by EWWCA, was abolished for the water amount was 1 l/s ○	Existing well does not suffice for absolute water amount. After population increases water will be definitely short.	○	5

11. TEST WELLS

Test well was started from Karakoro site as the first well and was completed at the last No.5 well of Tchaffa Weledi.
The result is as the following table.

Table 12. Result of Test Boring

Item / Sites	Diameter (mm)	Depth (m)	Position of Strainer m - m (length m)	Pumping Test				Specific Yield $m^3/d/m$
				Static W.L. (m)	Dynamic W.L. (m)	Yield L/S	Coeff-icient of Aquifer	
Karakoro	150	80.5	36.5-64 69.5-75 (30)	25.53	50.28	1.0	Transmis-sivity 1.15×10^{-5} m^2/s permeabi-lity coeff-icient 3.84×10^{-5} cm/s	3.49
Chirete	150	126.5	22.0-27.5 93.5-121.0 (30)	7.28	36.95	3.0	$3.70-10^{-5}$ 1.48×10^{-4}	8.73
Degan	150	55.0	23.0-34.0 45.0-50.5 (15)	31.0	43.12	1.0	$1.32-10^{-5}$ $2.64-10^{-4}$	7.12
Kembolcha	150	92.5	27.0-30.0 49.0-54.5 65.5-71.0 76.5-87.5 (30)	1.28	29.6	6.0	1.94×10^{-4} 6.4×10^{-4}	18.30
Tchaffa Weledi	150	38.0	3.8-31.3 (25)	4.37	11.55	3.5	2.92×10^{-4} 1.45×10^{-3}	42.11

Note: *Figure within a parenthesis indicates length of strainer* inserted.

As the result of pumping test, yield in each site is that Karakoro-1.0 1/s, Chirete-3.0 1/s, Degan-1.0 1/s, Kembolcha 6.0 1/s and Tchaffa Weledi-3.5 1/s. In the basis of these yield, the following plan of facilities was made.

12. CONSTRUCTION OF WATER DISTRIBUTION FACILITIES

The completion of water distribution facilities is not only to ensure living water of relief centers, but also to greatly benefit the inhabitants, as well as it can be utilize in future drought time. Before the facilities construction, a test well was made to determine whether the water supply met the amount of water demanded. After getting the results of the test well, the facilities were constructed. Also considered was the future maintenance and control, and whether they could bear the expenses to maintain and control the facilities. After these two matters (amount of water demand and expenses borne) had been examined, the facilities were constructed. As for expenses borne, the water rate was determined based on 5 cents per 30 liters. When the amount of water use is based on 30 liters per person per day, the cost of water is 0.16 cents per 1 liter.

(1) KARAKORO

1) Amount of Water Demand (per day)

Relief Center	4,800 liters
Village	10,500 liters
Total	15,300 liters

2) Amount of Supply

At relief center carried by hand (water jar) at present.

3) Balance

There are no water source facilities, provided they bear expenses after these facilities being transferred to them in the future.

1 Amount of Water Demand (necessary amount)
In case of inhabitants 350 persons,
amount of use 30 liters/person (maximum amount),
30 liters x 350 = 10,500 liters/day

2 Available amount of water supply by test well
1.0 liters/s

3 Necessary operation time of generator (operation of submersible motor pump) to supply 10,500 liters/day
2.91 hours

4 Consumption volume of fuel per generator operation time
1.9 liters (maximum amount by specifications and test result)

5 Cost of Fuel
0.75 birr/liters (1 birr = 120 yen)

6 Cost of Operation Maintenance per day
0.75 x 19 x 2.91 = 41.46 birr

7 Cost of Water per liter
41.46/10,500 = 0.39 cents

Though in this case, they will have to bear great expenses to maintain and control in the future considering the degree of present emergency and the matter in which the relief center will bear expenses, the water distribution facilities were built and 50kl-tank, pipes and public hydrant were constructed in the center.

(2) CHIRETE

1) Amount of Water Demand (per day)

Relief Center		3,000 liters
Village		60,000 liters
	Total	63,000 liters

2) Amount of Water Supply (per day)

From 1.5 liters/s by ability on one existing well
(6 hours operation)
32,400 liters

3) Balance (Shortage about - 30,000 liters)

Provided the facilities are transferred to them in the future,

1 Amount of water demand (per day)
Provided the inhabitants number 2,000,
60,000 liters

2 Available amount of water supply from test well
3.0 liters/s

3 Operation time of generator
5.5 hours

6 Cost of operation maintenance per day
78.37 birr

7 Cost of water per liter
0.13 cents

By this, they will be able to maintain the facilities in the future and its effect restored to in this site will be great. As there had already been an existing tank of 10KL here, a 50KL tank was not constructed. Pipes to the center tank and pipes within the center were laid.

(3) DEGAN

Here, a feeding center was supposed to be opened early in July, however, the circumstances became better and the plan was suspended in the end of August. The balance between supply and demand here at the time of the Center opening planned is as follows on the center opening plan.

1) Amount of Demand (per day)

Relief Center	15,000 liters (plan)
Village	25,500 liters
Total	40,500 liters

2) Amount of Supply

2.0 liters/s capacity of one Existing Well
(6 hours operation)
43,200 liters

3) Balance

Though it is +3,000 liters at present,
in case the number of settlers increase,
it will be short.

In case water distribution facilities are constructed here, the cost will be as follows:

1	Amount of water demand (per day) In case the inhabitants number 850,	25,500 liters
2	Available amount of water supply by test well (completed in September)	1.0 liter/s
3	Operation time of generator	7 hours
6	Cost of operation maintenance per day	99.75 birr
7	Cost of water per liter	0.39 cents

In this case, if the facilities are constructed, people here will not be able to bear the running cost of such as fuel. Therefore because of the suspension of the relief center construction and their expenses burden, the water supply plan by means of Submersible Motor Pump was suspended but a Hand Pump was to be installed.

(4) KEMBOLCHA

The population of Kembolcha is estimated to be about 18,000 - 20,000. People are supplied with water from rivers and existing wells, and the water distribution facilities are not fully equipped in this city. Here a relief center was abruptly planned to be constructed, and because there was no water source facility in the center, it was selected as a place of the project.

In the center, the water consumption per day is planned 30,000 - 40,000 liters.

Available amount of water supply by test well	6.0 liters/s
Operation time of generator	1.8 hours
Cost of maintenance (per day)	25.65 birr

(5) TCHAFFA WELEDI

Though this site has no relief centers, it is considered as the center of food distribution. There are an estimated 4,500 inhabitants, but water source facilities are short. One shallow well is used for public water, the absolute amount of water is short.

1) Amount of Water Demand (per day)
Provided the inhabitants number 4,500...135,000 liters

2) Amount of Supply
One shallow well (7 m)

3) Balance
The water amount changes seasonally and steady water supply is impossible. In case water facilities are constructed, the cost will be as follows:

1	Amount of water demand (per day)	135,000 liters
2	Available amount of water supply by test well	3.5 l/s
3	Operation time of generator	10.7 hours
6	Cost of operation maintenance per day	152.61 birr
7	Cost of water per liter	0.11 cent

By this the facilities will be able to be maintained here and the effect of this construction will be great. Here, a 50 KL-tank was constructed together with pipes.

Next table shows cost of water in each site aforementioned.

Table 13. Cost of Water in Each Facility

Site / Item	Karakoro	Chirete	Degan	Kembolcha	Tchffa Weledi
Water demand (L/d)	10,500	60,000	25,000	40,000	135,000
Water supply capacity (L/s)	1.0	3.0	1.0	6.0	3.5
Maintenance cost for operation (fuel cost birr/d)	41.46	78.37	97.75	25.65	152.61
Cost of Water cent/L	0.39	0.13	0.39	-	0.11

(Note) Standard unit cost 0.16 cent/L
Based on the cost of water 5 cent/30 L and water consumption per day per person: 30 L

As mentioned above, in five sites, facilities have been constructed meeting each condition and were all transferred to Ethiopia on January, 27th 1986. The scales, capacity and so on at each facility are summarized on the following table.

Table 14. Summary of Impementation works

Name of Project Site	Location Distance from Addis	Name of Region	Test Wells							Water Distribution Facilities			Present Condition & Maintenance, Administration Model Water Supply Facility	
			Diameter (mm)	Depth (m)	Place & Length (m) of Strainer	Pumping Test				Scale of Facility	Type & Place of Pump	Period of Investigation	Present Condition	Maintenance Adm. & Future Use
						Static Water Level	Dynamic Water Level	Amount of Pumping	Hydraulic Coefficient					
KARAKORO	North 310 km	SHOWA	150	80.5 m (reached rock 55.9 m)	36.5 - 4 m 69.5 - 75 m (30 m)	25.53 m	50.28 m	1.0 l/s	Transmissibility (I) 1.15×10^{-5} m²/s Permeability (K) 3.84×10^{-5} cm/s	∘50 kl water tank ∘350m long pipeline ∘Machinery house ∘68 KVA Generator	Submersible motor pump EBARA 65BHS 30-18.5 (66.0m)	Test drilling 4/26-6/6 '85 Facility 7/2-8/24 '85	Under relief center Plan to be transferred to FA in the future	
CHIRETE	North 311 km	WOLLO	150	126.50 (buried to 151.5m)	22.0-27.5 93.5-121.0 (30 m)	7.28	36.95	3.0	T 3.70×10^{-5} K 1.48×10^{-4}	∘750m long pipeline ∘Machinery house ∘68 KVA Generator	Submersible motor pump EBARA 65BHS 30-18.5 (80.0)	6/7-8/15 8/25-9/21	- ditto -	
DEGAN	North 400 km	"	150	55.0 (valcanic rocks from 17.6m)	23.0-34.0 45.0-50.5 (15 m)	31.0	43.12	1.0	T 1.32×10^{-5} K 2.64×10^{-4}	∘No water-supply facility ∘Installed hand pump	Hand pump NSB-100HL-W (44.0)	8/16-9/14 10/16-12, 11/9	Transferred to FA Cost will be high, if Submersible motor pump is installed	
KEMBOLCH	North 380 km	"	150	92.50 (buried to 100.m)	27.0-30.0 49.0-54.5 65.5-71.0 76.5-87.5 (30 m)	1.28	29.60	6.0	T 1.96×10^{-4} K 6.5×10^{-4}	∘50 kl water tank ∘311 m long pipeline ∘Machinery house ∘68 KVA Gnt	Submersible motor pump EBARA 65BHS 30-18.5 (60.0)	9/28-11/5 9/28 -	under SCF	
TCHAFFA WELEDI	North 350 km	"	150	38.0 (buried to 45.0m)	3.8-31.3 (25 m)	4.37	11.55	3.5	T 2.92×10^{-4} K 1.45×10^{-3}	∘50 kl water tank ∘Pipeline ∘Machinery house 68 KVA Gnt	Submersible motor pump EBARA 50BHS 22-11	10/24-11/18 11/13	Plan to be transferred to SCF	

13. PRESENT CONDITION AND FUTURE UTILITIZATION OF FACILITIES

The construction of facilities has been finished upon the completion of test run. Some of them are still being used by the relief agencies, but the rest hasn't been transfered yet. Table 15 is a summary accounting for the conditin since then of the utilization of facilities and the condition of the perimeter.

Table 15. Present Condition and Future Utilization of Facilities

	KARAKORO	CMIRETE	DEGAN	KEMBOLCHA	TCHAFFA WELEDI
Condition of Relief Center	150 pacients admitted (as of Apr/85) 45 pacients & families (100 psn) (100 psn) admitted (as of 25/1/86) Day nation is continued. This will be closed end March.	80-100 pacients admitted and 350 supplied with food (as of Apr/85) 70 pacients and families (50 psn) admitted (as of 25/1/86) This closure is not determined.	500 as the object supplied with food (as of Jun/85) Ethiopian Red Cross continues Dry ration	300-400 pacients admitted, about 1,000 infants supplied with foods a day (Sept/85) 150 admitted, 400 infacts/day supplied will foods (as of 25/1/86)	
Condition of Facilities & Water Utilization	Twice a day-3.5hrs operation Water utilization $10m^3/d$ supplied to Centre & villagers	Once a day-1.5hrs operation Water utilization $10m^3/d$ supplied to only Centre	200-300 psn/d using handpump, about 9,000 l/d	Once a day-1.0 hrs operation Supply to only Centre	
Maintenance Cost (Gas Oil Comsumption)	60 l/5 days 9 birr/d	25 l/4 days 4.6 birr/d Operation time: Total 77 hrs.		25 l/2 days 9.3 birr/d	
Future Control	After closure, it will be transfered to F.A., but EWWCA is tobe responsible for maintenance	Same as Karakoro	RRC	RRC will maintain 2 years time, afterward municiparity will be over as a plan.	
Capacity of Water Supply (per day)	Suppliable:21,600l Population to be supplied: 720	Suppliable:64,800l Population to be supplied: 2,160		Suppliable:129,600l Population to be supplied: 4,320	Suppliable:75,600l Population to be supplied: 2,520

14. OPERATION PLAN OF FACILITIES

For the facilities to be used effectively and effect restored to the sites greatly, it is necessary to consider the established system of maintenance and control together with economic aspect. Here the future utilization of the facilities is proposed.

(1) Karakoro and Chirete

In case of only Karakoro facilities, as the local population must bear much economic obligation, it's considered to be more effective for the operation that this facilities will be connected by pipe with Chirete's facilities in future for making them one unit. In such a case, Karakoro facilities will be deemed to be a standby one, because of its' high maintenance cost, thus Chirete well is to be mainly operated. In this case;

1)	Water demand (per day)	70,500 L
2)	Yield	3.0 L/s
3)	Operation time a day	6.52 hr
4)	Maintenance cost per day	92.91 birr
5)	Cost of water per littre	0.13 cent

For the utilization in future of both site's facilities as one unit, which will be more effective, the following three methods are to be planned.

1) Karakoro well operation is to be suspended, instead water pipe is extended from Chirete well for storaging water in the tank at Karakoro (unification of facilities)

2) This idea is similar to 1), but in this case, Karakoro well is to be treated as an emergency one, thus the submersible motor pump here is reserved and hand pump is to be installed instead without delivery of water from Chirete well.

3) In case of deversion 10 KL tank at the relief centre of Chirete to be other, water will be sent to the existing tank in village and operation is to be carried out alternately.

In future, some, either 1), 2), or 3) will be selected. Chirete well is considered to be sufficiently maintained, because of its' capacity.

(2) Degan

A Hand Pump is installed in Degan. Here, the maintenance of the Hand Pump is important.

(3) Kembolcha

Kembolcha consumes much water, because of the large population. At present, the water distribution facilities are under the control of SCF and soon the facilities is supposed to be used by RRC that has a plan of using them at least 2 years continuously from now on.
At Kembolcha, the German Team, now, carries out the municipal water work facilities project, which is supposed to be transfered to the municipality in the furture.

As the municipality possess an electric power plant, the present generator is expected to be displaced by the said facilities. In the comparative study on the said both facilities, the future maintenance and control are hereby studied. In this case, assumedly, 10,000 people that is a half of the total population in the city is to be an object supplied with water.

1) In case of generator;
Average water supply/day: 30L x 10,000 = 300,000 L
Water supply/h: 300,000 L/24 = 12,500 L/h.
Operation time of pump: If well capacity is 6 L/s
12,500/6 x 3,600 = 0.58 hrs.
Fuel cost: 0.75 Birr x 0.58 x 19 = 8.27 Birr
Population/hr. for water supply: 12,500/30 = 416 person

Expenses to be borne/person: = abt. 2 cents

Water cost/L: = 0.06 cents

2) In case of electric power plant;

Average water supply/day: = 300,000 L

Water supply/h: = 12,500 L

Operation time of pump: = 0.58 hrs.

Electric consumption: = 12.76 kw

(pump capacity is 22 kw)

Electric rates (3 phase): As 24 cents/kw,

0.24 x 12.76 = 3.06 Birr

Expenses to be borne/person: = 0.74 cents

(This is less than a half of that of generator)

Water cost/L: = 0.02 cents

	Generator	Electric power plant
Average water supply/d	300,000L	300,000L
Water supply/h	12,500L	12,500L
Operation time of pump	0.58h	0.58h
Runing cost	8.27Birr	3.06Birr
Water cost/L	0.06cents	0.02cents
Expenses/person	1.09cents	0.74cents

The above table shows a comparison of each item.

Even though the generator is being utilized, it's considered that the facilities can be used, but itwill be more effective to replace the generator by the electric power plant.

It's learnt that if the electric power plant is completed the construction cost would have become more than 20,000 Birr in case of 100 m entrance lead being laid.

The difference of runing cost between the generaor and the electric power plant is 125.04 Birr per day, thus, 20,000/125.04 = abt.160 days, which means that 20,000 Birr can be amortized in 160 days.

(4) Tchaffa Weledi

There is a state farm, naming the "Tchaffa State Farm" in this site. The facilities is to be totally transfered to the

said farm. Hitherto, 4,500 inhabitants live in this area, but at harvest time, seasonal workers increase the number by 2,500 man, thus, water supply cann't meet such increased demand. The existing water source facilities are a drilled well with 38 m depth and a hand dug well with 7 m depth. The former one is utilized mainly by persons concerning the farm in 5 hours pump operation a day and the latter's is for domestic use for inhabitants in twice pump operation per day, but the absolute quantity for the inhabitants is short.

The state farm sums up a year budget for the existing facilities as follows;

Budget relating to all the state farm:	2,000,000. birr
Budget for technical sector (incl. administration charge for water sources facilities):	666,390. birr
Maintenance cost for pumps:	2,000. birr

A generator is responsible for power supply to the facilities in the farm. Operation time of this generator is 6,570 hrs. a year, of which for the water sources and lighting are 2,080 hrs. The electric rate per hour is 12.33 birr and maintenance cost for the generator per year is summed up 4,500 birr. In the preceding clause 12, the maintenance cost for the new facilities' generator is 152.61 birr a day, 14.26 birr per hour, which is accounted for about 5,200 birr a year by increase of 700 birr. According to a manager of technical sector, such expensescan be borne within the total budget without any problem, therefore the state farm can be considered to maintain the facilities sufficiently in a normal condition.

15. SYSTEM OF MAINTENANCE AND CONTROL

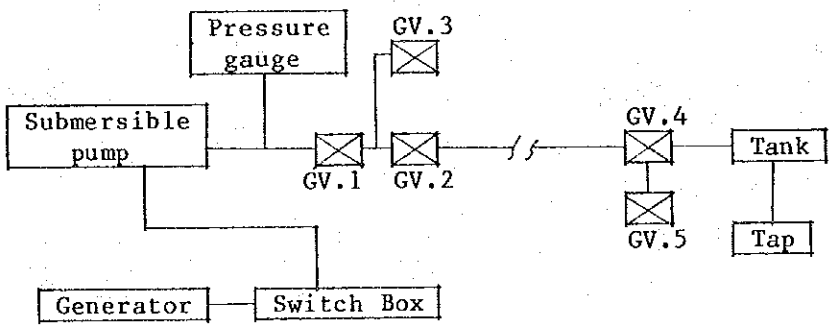
15.1 Operation Control

At each facility, if its handling is erred, unexpected accident can happen. Here, special attention items concerning basic handling in operation are to be mentioned. Handling of the special attention items should be strictly kept.

1. KARAKORO

In this site, a well of 150 mm diameter and 80.50 m depth, connected with a 50 KL-tank within the center is placed. A submersible motor pump is installed at the depth of 66.0 m. Here, it is important that the water level should not become lower than 60 m on pumping. Therefore the following operation is necessary.

(1) Method of Operation



1 Set the generator ON at 400V. 50HZ

2 Set the switch ON

3 Adjust the pressure at 28 kg/cm^2 by GV.2 watching the pressure gauge. At this time GV.1 and GV.4 should certainly be opened, but GV.3 and GV.5 should be closed.

4 To stop the submersible motor pump, turn OFF the switch, then turn OFF the generator.

(2) Items of special attention

1 In operating, always adjust the pressure gauge at 28 kg/cm^2 and watch. If the pressure gauge shows a drop, immediately turn OFF the switch. Reoperating should not be Started for at least 8 hours.

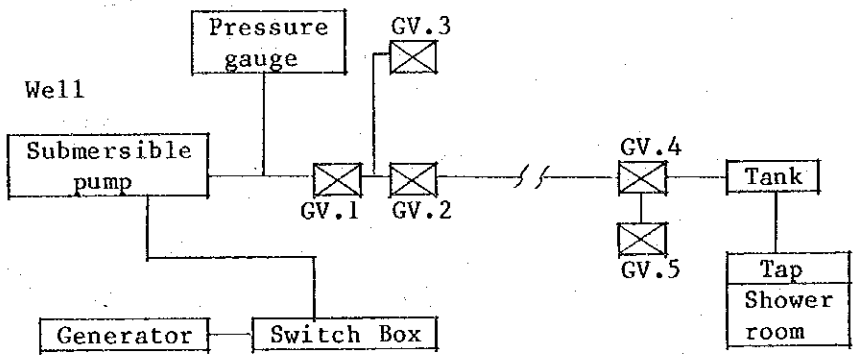
2 Ensure from time to time that the generator shows 400V, 50HZ in operating

Also before operating, be sure to check the amount of fuel, radiator water and engine oil, and filth conditions. If anything is wrong, consider how to cope with it in accordance with the instructions.

2. CHIRETE

In this area, a well of 150mm diameter and 126.50m depth, connected with a 10KL-tank within the center is placed. A submersible motor pump is installed at the depth of 88m but when the amount of water becomes over 3.0 liters/s, the water level will fall abruptly, and special attention is required. Therefore the operating should be carried as follows.

(1) Method of Operation



1 Set the generator ON at 400V. 50HZ

2 Set the switch ON

3 Adjust the pressure at 24 kg/cm^2 by GV.2 watching the pressure gauge. At this time GV.1 and GV.4 should certainly be opened, but GV.3 and GV.5 should be closed.

4 To stop the submersible motor pump, turn OFF the switch, then turn OFF the generator.

(2) Items of special attention

1 In operating, always adjust the pressure gauge at 24 kg/cm^2 and watch. If the pressure gauge shows a drop, immediately turn OFF the switch. Reoperating should not be started for at least 8 hours.

2 Ensure from time to time the generator shows 400V. 50HZ in operating.

Also before operating, be sure to check the amount of fuel, radiator water and engine oil, and the filth condition. If anything is wrong, consider how to cope with it in accordance with the instruction.

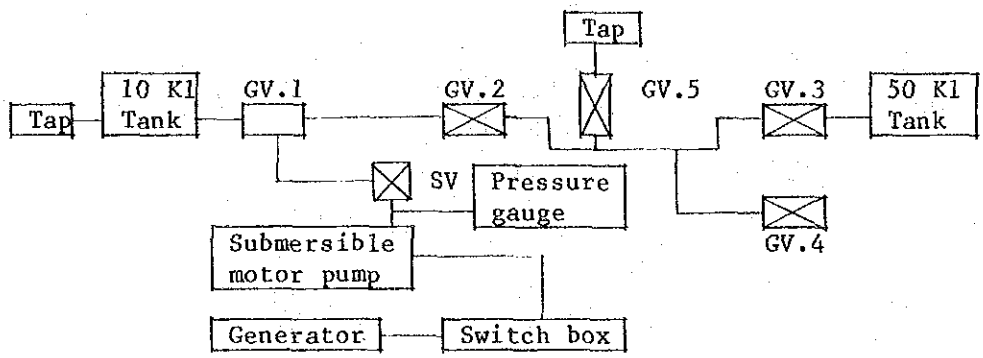
(3) Others

1 The tap in the shower room can be used only when the water tank is nearly full. (Because of water pressure drop.)

3. KEMBOLCHA

In this area, a well of 150 mm diameter and 92.50 m depth, and a 50 kl tank that is connected with it are placed. A submersible motor pump is installed at the depth of 40 m.

(1) Operation method



1. Set the generator ON at 400 V, 50 Hz.

2. Set the switch ON.

3. Adjust the pressure at 20 kg/cm^2 by SV, watching the pressure gauge. At this time, GV.2 and GV.3 should certainly opened, but GV.1, GV.4 and GV.5 should be closed.

4. stop the submersible motor pump, turn off the switch, then turn off the generator.

(2) Items for special attention

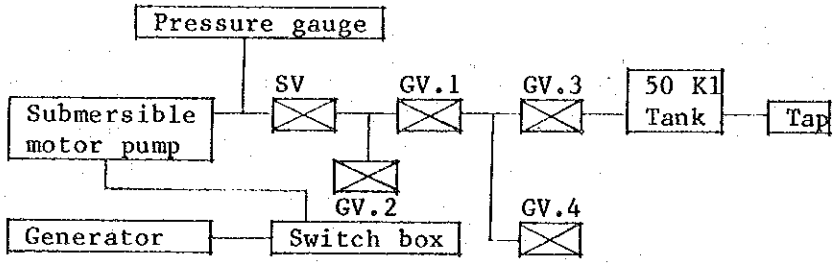
1. In operation, the pressure gauge always is to be adjusted at 20 kg/cm^2 with watching.

2. It must be ensured from time to time that the generator shows 400 V, 50 Hz in operation. Also before operating, be sure to check the amount of fuel, radiator water and engine oil, and filth conditions. If anything is wrong, consider how to cope with it in accordance with the instructions.

4. Tchaffa Weledi

In this area, a well of 150 mm diameter and 38 m depth, and 50kl tank connected with it are installed. The submersible motor pump is erected at the position of 33 m.

(1) Operation method



1. Set the generator ON at 400 V, 50 Hz

2. Set the switch ON

3. Adjust the pressure at 16 kg/cm^2 by SV, watching the pressure gauge. at this time GV.1 and GV.3 should certainly be opened, but GV.2 and GV.4 should be closed.

4. Stop the submersible motor pump, turn off the switch, then turn off the generator.

(2) Items for special attention

1. In operaion, the pressure gauge always is to be adjusted at 16 kg/cm^2 with watching. If the pressure gauge shows a drop, switch shall be immediately turned off. Reoperation shall not be started for at least 8 hours.

2. It must be ensured from time to time that the generator shows 400 V, 50 Hz in operation. Also before operating, be sure to check the amount of fuel, radiator water and engine oil, and filth conditions. if anything is wrong, consider how to cope with it in accordance with the instructions.

15.2 Guide for Maintenance and Administration

To grasp the usual operation condition of the facilities and to establish the system which can deal with emergencies swiftly are very important for securing the long-range safety of the facilities. For this reason the reinforcement of control system is necessary. Well facilities can easily be damaged seriously. For this well control, the following items are important.

(1) Water Level

Check the static water level when not pumping and the dynamic water level on pumping. The extreme drop of water level tends to connect with pump trouble. Therefore, monitoring of the pressure gauge and the measurement of water level should be done regularly (for instance once a day) and be recorded.

(2) Yield

Although a flow meter has not been installed in each facility, as mentioned in 10.1 it can be determined by the pressure gauge.

Karakoro well	28 kg/cm^2
Chirete well	24 kg/cm^2
Kembolcha well	20 kg/cm^2
Tchaffa Weledi well	16 Kg/cm^2

(3) Voltage and Current

Pay special attention to the voltmeter and galvanometer on the switch box. If it shows abnormal increases or decreases, operation should be stopped immediately

The following table 16 is a form of check list for well control.

Table 16. Check List for Well Control

No.

Check List for Well control

Location _____ Completion _____
Casing Diameter ____ mm Depth ____ m
Pump No. Rated Current ____ A

Date	Water Level		Pump Pressure (kg/cm^2)	Current (A)	Voltage (V)	Remarks
	Static (m)	Dynamic (m)				

When the ordinary operation of a well becomes impossible because of water level drop, water amount decrease or sand amount increase it will be required to rehabilitate and rejuvenate the well.

In this case the following matters should be practiced as a countermeasure.

Rehabilitation:

The contents of this work will be practiced in order of sand dredging, induction, and brushing. (Compare the change of water level and water amount before and after the rehabilitation)

(1) Buried Sand Dredging

As buried sand will usually be the cause of the decrease of yields and damage to the pump, it should be immediately removed. For this work, doing by Bailer is general.

(2) Induction

This induction is intended to recover the yield and is usually managed by Swapping.

(3) Brushing

This is the work which purifies the inside of the well. (removing scales)

After practicing this in such order, pumping up to and evacuating muddy water, the work will be completed.

16. PROPOSAL

This project was implemented by the Japanese Government for Ethiopia for the purpose of securing water for living in emergencies. The equipment and materials related to this project were transfered to RRC as they were and technical transfer was also executed.

Proposal;

1) Storage of the relating equipment and materials
At present, all the quipment and materials are being stored in RRC warehouse in Kembolcha. As the list of these eqipment and materials is described in Appendix, it's very important to read through the instruction mannual carefully and to practise the habitual maintenance and adjustment.

2) Establishment of system
JICA Study Team have carried out this project under such five systems as hydrogeology, well drilling, facility, transportation (vehicle) and machinery maintenance. Hence, it's considered that RRC will have to continue and enforce/improve this sytem as much as possible in order to develop this project and demonstrate the result of technical transfer.

APPENDIX

List of Documents Collected

Scope of Work

Minutes of Meeting

List of Persons Concerned

APPENDIX

List of Documents Collected

Publication

1. Relief and Rehabilitation Commision (RRC)

    1) Drought Situation in Ethiopia and Assistance Requirements 1984/85 October, 1984

    2) Review of the Current Drought Situation in Ethiopia December, 1984

    3) Current Situation & Future Prospect april, 1985

    4) Location of Ongoing Activities of Nom - Covernmental Organizations Operating in Ethiopia under the Auspies of the Commission May, 1985

    5) 1986 Food supply Prospect (Crop and, Livestock Dependent Food Supply systems) 1st Report September, 1985

    6) Review of Drought Relief and Rehabilitation Activities for the period December 1984 - August, 1985 Assistance Requirements October, 1985

2. Central Statistical Office

    1) *Ethiopia Statistical Abstract* 1982

    2) Result of the Survey of Manufacting Industries 1973 E.C. (1980/81 G.C.) June, 1983

    3) Transport and Communications Statistic March, 9815

    4) Average Retail Prices of Goods and Services in Rural Area by Region (May 1981 - April 1982) (August 1981 - April 1982) May, 1985

    5) Report on the Results of the 1981 Demographic Survey June, 1985

    6) Report on the Rural Health survey (1982/83) Vol.1 October, 1985

3. Office of the Population and Housing Census Commission

    1) Ethipoia 1984 Populatin & Housing Census Preliminary Report. September, 1984 Vol.1

4. National Water Resources Commission

    Water Supply Scheme for Drought Affected Population of Ethiopia (Assistance Requirement) December, 1984

Literature
==========

1. Geology : Groundwater

   1) Mineral Survey in Two Selected Areas in Ethiopia Photogeological Survey Vol.1 United Nations Development Programme 1969

   2) Mineral Survey in Two Selected Areas Technical Report Vol.1 Text United Nations Development Programme 1972

   3) Geological Groundwater Investigation in Wello and Tigrai by Gebretsadik Eshete Megmure Hailemeskal B.J. Last May, 1976

   4) Hydrogeology of South Afar and Adjacent Areas Ethiopia. Supported Interpretation of LANDSAT Imagery. 1983 International Institute for Aerial Survey and Earth Sciences (ITC) Enshede, The Netherlands December, 1983

   5) Geological Map of Ethiopia Explanation of the Geological Map of Ethiopia by V.KAZMIN 1973

2. Hydro-Meteorology

   1) Aspect of Climate and Water Budget in Ethiopia by DANIEL GAMACHU Addis Ababa University 1977

   2) Topographic Map

      1/1,000,000
      ADDIS ABABA, MIZANTEFERI, METU, AWASA
      1/250,000
      NC36-3,4,7,8,11,12
      NC37-3,7,11
      1/50,000
      BAMBESI, KELEM, HAROJIWEDO, GARAARBA, BEGI, CHEMODABUS, KEMSHMANDO, BENGUWA

   3) Administrative Region Map
      Wellega 1/250,000 Wello 1/500,000

Scope of Work

for

The Urgent Groundwater Development Project

in

Socialist Ethiopia

Agreed upon between

Relief and Rehabilitation commission

and

Japan International Cooperation Agency

in

Addis Ababa

on

March 7, 1985

(NOTE)

As to the Scope of Work, it had to be retyped, because of the original paper being unclear, and the part for signature is being adhered with the original paper's.

AGREEMENT

Between

The Relief and Rehabilitation Commission of Socialist Ethiopia, (hereafter referred to as the RRC) on the one part,

and

Japan International Cooperation Agency (hereafter referred to as JICA) of the other part; whereas the parties hereto entered into an agreement signed in Addis Ababa on March 7, 1985 concerning a project of assistance in Ground Water Development Scheme.

It is hereby agreed between the parties hereto as follows: -

I. INTRODUCTION

In view of the consultations between the Minister for Foreign Affairs of Japan, Mr. Shintaro Abe, and the leaders of the Government of Ethiopian on the occasion of Mr. Abe's visit to Ethiopia, the Government of Japan has decided to conduct the Urgent Ground Water Development Project (hereinafter referred to as the Project).

Accordingly, JICA, the offical agency responsible for implementation of technical cooperation programme of the Government of Japan, will undertake the project in close cooperation with RRC and authorities concerned of Ethiopia.

II. OBJECTIVE OF THE PROEJCT

The objective of the Project shall be to formulate and implement a grond water development plan for driking water for drought victims.

III. OUTLINE OF THE PROJECT

1. Project Area

   North Show and Sough Wollo Administrative region. Target area shall be determined on the basis of preparatory field surveys.

2. Components of the Project

   1) Data collection

   2) Preparatory field surveys

      a. Geophysical survey (Electirc Prespecting)
      b. Test boring

3. Implementation Work

   1) Several test wells

   2) Water distribution facilities

4. RECOMMENDATION

   1) Well operation

   2) Well maintenance

IV. DURATION OF THE PROJECT

From the end of January to November 1985 (10 months) tentatively.

V. COMPOSITION OF THE ETHIOPIAN COUNTERPART PERSONNEL AND JICA TEAM

Ethiopian Counterpart Personnel: -

- Hydrogeology
- Water supply
- Well drilling
- and others

Engineering and Technical Service Department of RRC will work in partnership with JICA Team.

JICA Team:

- Water supply planning
- Hydrogeology
- Well drilling supervision
- Water Supply facilities
- Mechanics

VI. UNDERTAKING

For the smooth implementation of the project, the RRC and JICA shall take necessary measures set forth in the APPENDIX, attached herewith.

VII. CONSULTATION

RRC and JICA shall consult with each other in respect of any matter that may arise from or in connection with the project.

APPENDIX

I. OBLIGATIONS OF THE RELIEF AND REHABILITATION COMMISSION

To facilitate smooth conduct of the Proejct the RRC shall take necessary measures: -

(1) To secure the safety of the JICA Tema

(2) To assign counterpart personnel

(3) To exempt the members of the JICA Team from taxes, duties, fees and other charges on equipment, machinery and otehr materials brought into Ehiopia for the conduct of the Project

(4) To secure permission for the implementation of the Project

Note: "detail items" are shown in the adjoining page

II. OBRIGATIONS OF JICA

For the implementation of the Project, JICA shall take the following measures: -

(1) To dispatch, at its own expense, the JICA Team to Ethiopia

(2) To provide the equipment and machineries necessary for the implementation of the Project

(3) To hand over the machineries to RRC on expiry of Project period

DETAIL ITEMS

1. To arrange smooth customs clearance and transportation of equipment and machineries necessary for the Project. (Transportation charges shall be borne by JICA)

2. To issue permission for procurement of materials to be used for implementation work and/or to issue the letter of request to other agencies concerned, if necessary. (Cost shall be borne by JICA)

(1) Fuel	: approx.	6,000 litre/month
(2) Machine oil	: approx.	200 "
(3) Cement	: approx.	7,000 kg/site
(4) Sand	: approx.	5 m^3/site
(5) Gravel	: approx.	5 m^3/site

3. To provide fenced space for Base Camp at Project site or its vicinity. Required area will be about 1,000 m^2.

4. To arrange workers (Cost shall be borne by JICA)

(1) Driver	: 3 persons
(2) Worker for geoelectrical prospecting	: 5 persons
(3) Worker for test well drilling	: 6 persons
(4) Worker for construction of distribution facilities	: 10 persons
(5) Worker for mechanical maintenance	: 2 persons

Signed: _____ Signed: _____

On behalf of Relief and Rehabilitation Commission

Mr. HIROSHI IHARA
On behalf of Japan International Cooperation Agency

Date: _____ Date: _____

ATTENDANT LIST

Ethiopian Side: -

Taye Gurmu	-	Deputy Commissioner, RRC
Mulgeta Kebede	-	Head, Eng. & Tech. Service Dept., RRC
Ephraim Guade	-	Water Supply Section, RRC

Japanese Side: -

Mr. Hiroshi Ihara	-	Head, the second development division, the social development Co-operation Dept.
Mr. Shinichi Yoshikawa	-	JICA Team
Mr. Chifumi Yamashita	-	JICA Team
Mr. Jinichi Yuki	-	Embassy of Japan
Mr. Masaharu Wada	-	Embassy of Japan
Mr. Akio Komazawa	-	JICA

MINUTES OF MEETING

Relief and Rehabilitation Commission (RRC) and JICA study team held a discussion upon the items hereunder, regrading the conclusion of the agreement on the Scope of Work dated 7th March 1985.

1) JICA study team outlined the working schedule and the formation of the team for the project. (Appendix I)

2) JICA study team have decided the following shelters as sites proposed for the preparatory study after the investigation of the target areas where RRC suggested.

HARBU / CHIRETE

The rest of the three sites will be decided from the shelters located in Northern Shewa and Southern Wollo region (between Debre Berhan and Dessie).

3) JICA study team have found it suitable to allocate the project base camp within the compound of RRC in Kembolcha.
RRC will provide every possible assistance to the base camp and members of the team, such as the use of land for the camp, supply of water and the safety of the members.

4) It is appeared to be very difficult to hire a vehicle, namely four wheel drive pick-up, for a long term in Ethiopia.

5) RRC requested to send the counterparts, who work in the project, to Japan after the completion of the project. It is to learn more deeply for the operation of equipment, technical knowledge of drilling works and the construction of water supply system.

SIGNED: _____ SIGNED: S. Yoshikawa

Ephrem Guade
Head of
Water Supply Section
Relief and Rehabilitation
Commission

Shinichi Yoshikawa
Team Leader of
JICA Study Team

DATE: MARCH 11, 1985

MINUTES OF MEETING

Relief and Rehabilitation Commission (RRC) and JICA Study Team held a discussion and confirmed the items hereunder.

1) That Chirete has been decided as No. 2 well site based on the preliminary survey after the discussions between RRC and JICA Study Team.

2) That, at present, the nominated sites for No. 3 well are Luti, Degan, Kemisee and Tisa Balima. However, the final decision on No. 3 well site will be made by making selection from among the above mentioned sites by 25th June after the survey and discussions between RRC and JICA Study Team.

3) That the rest of the well sites will be selected principally from the sites as said in 2) above by the middle of July after further discussions between RRC and JICA Study Team.

SIGNED : _____ SIGNED : C. Yamashita.

Mulugeta Kebede (MAJ.)
Head of Engineering & Technical Service Department

Head of
Engineering & Technical
Service Department
Relief and Rehabilitation
Commission

Chifumi Yamashita
Sub-Team Leader
JICA Study Team

DATE : 06/06/85

MINUTE OF MEETING

Relief and Rehabilitation Commission (RRC) and JICA Study Team held discussions and confirmed the follwings;

1) RRC and JICA Study Team agreed that No. 3 well site shall be at Degan.

2) The rest of the well sites shall be decided by the middle of July after further discussions between two sides.

SIGNED : _____ SIGNED : C. Yamashita.

MULUGETA REBEDE (MAJ)
Engineering & Technical
Service Department

Mulugeta Rebede

Head of
Engineering & Technical
Service Department
Relief and Rehabilitation
Commission

Chifumi Yamashita

Sub-Team Leader
JICA Study Team

DATE : 2nd July, 1985

MINUTES OF MEETING

Relief and Rehabilitation Commission (RRC) and Japan International Cooperation Agency (JICA) held discussions and confirmed the followings;

1. Project Sites

   1) No. 4 well site shall be at Kembolcha.

   2) No. 5 well site (the last site of the Project) shall be selected from the following four sites,

      Chaffa Weledi

      Kara Gegeba

      Fugnan Denbi

      Were Lencha

   The decision shall be made by 7th October in this year at the latest.

2. Transportation

   JICA requested RRC to take necessary measures for the quick transportation of equipment and machineries which have already embarked for Ethiopia.

3. Equipment and Machineries

   1) RRC requested JICA to transfer the equipment and machineries provided for the implementation of the Project after the termination of the Project

2) RRC also requested JICA to provide equipment and machineries for the smooth follow-up of the Project, which will be carried out by RRC.

SIGNED : _____ SIGNED : _____

Taye Grumu
TAYE GURMU
Deputy Commissioner

Deputy Commissioner

Chifumi Yamashita

Acting Team Leader
JICA Study Team

The P.M.G. of Socialist Ethiopia
Relief & Rehabilitation Commission

Witness : _____ Witness : _____

MULUGETA KEBEDE (MAJ.)
Head, Engineering & Technical
Service Department

Teruyoshi Kumashiro

Head of
Engineering & Technical
Service Department
RRC

Team Leader
JICA Coordination Team

Date : 25th September, 1985

ATTENDANTS LIST

RRC :

Ato Taye Grumu	-	Deputy Commissioner
Maj. Mulugeta Kebede	-	Head, Eng. & Tech. Service Dept.
Ato Ephrem Guade	-	Head, Water Supply Sec.
Ato Getnet Kebede	-	Counterpart for the Project

JICA :

(4)

Mr. Chifumi Yamashita	-	Acting Team Leader, JICA Study Team
Mr. Hitoshi Yuasa	-	Member, JICA Study Team
Mr. Teruyoshi Kumashiro	-	Team Leader, JICA Coordination Team (Development Cooperation Div.) Ministry of Foreign Affairs
Mr. Takao Toda	-	Member, JICA Coordination Team (2nd Development Survey Div.) JICA

(2)

MINUTES OF MEETING

Relief and Rehabilitation Commission (RRC) and JICA Study Team held discussions and confirmed the following;

No.5 well site shall be at Tchaffa Weledi.

SIGNED : _____ SIGNED : C. Yamashita

Mulugeta Kebede (M.S.)
Head, Engineering & Technical Service Department

Mulugeta Kebede
Head of
Engineering & Technical
Service Department
RRC

Chifumi Yamasnita
Acting Team Leader
JICA Study Team

DATE : 16 October, 1985

MINUTES OF MEETING

Relief and Rehabilitation Commission (RRC) and Japan International Cooperation Agency (JICA) held discussions and confirmed the followings.

1. Reports

(1) JICA Study Team submitted to RRC Draft Final Report on Jan. 8, 1986, which was basically accepted by RRC.

(2) Final Report shall be sent to RRC within two (2) months after the termination of field survey. This Report shall include all the salient results of the Study.

2. Equipment and Machineries

(1) In response to the request by RRC, JICA shall transfer to RRC the Equipment and machineries provided for the implementation of the Study after the termination of field survey.

(2) The list of the above equipment and machineries shall be prepared by the JICA Study Team.

(3) As for the spareparts which are to arrive at Asab Port or at Addis Ababa Airport after the termination of field survey, PRC shall be responsible for smooth inland transportation, on which Embassy of Japan shall be kept informed.

Signed: TAYE GURMU DEPUTY COMMISSIONER

Taye Gurmu
Deputy Commissioner

Witness:

Mulugeta Kebede (Maj.)
Head of Engineering & Technical
Service Department

Signed: C. Yamashita

Chifumi Yameshita
Acting TEam Leader
JICA Study Team

Witness: 戸田隆夫

Takao Toda
Coordinator
JICA EDQ

Date: 27th Jan. 1986.

Attendants list

R.R.C.:	
Ato Taye Gurmu	Deputy Commissioner
Maj. Mulugeta Kebede	Head, Eng. & Tech. Service Dept.
Ato Ephrem Guade	Head, Water Supply Sec.
JICA:	
Mr. Chifumi Yamashita	Acting Team Leader, JICA Study Team
Mr. Takao Toda	Coordinator JICA HDQ
Embassy of Japan:	
Mr. Katsumi Otani	First Secretary

List of Persons Concerned

RRC: (Relief and Rehabilitaiton Commission)

Ato Taye Gurmu	Deputy Commissioner
Maj. Mulugeta Kebede	Head, Eng. & Tech. Service Dept.
Ato Ephrem Guade	Head, Water Supply Sec.
Ato Getnet Kebede	Water Supply Sec.
Ato Abel Debebe	- ditto -
Ato Hailu Wolde Senbete	Regional Representative RRC Dessie
Ato Gulme	RRC Dessie
Ato Kebede Beyene	Head Settlement Adm. & coop, Sec. Dessie
Ato Bellete Ergetie	Field Superviser overall Adm.
Ato Ketema Feyie	Kembolcha regions work shop RRC Chief and Rehabilitation Commission
Ato Damena Makonen	Regional Representative RRC, Addis Ababa
Ato Berhanu Deressa	Aid Coordinator RRC
Ato Getaneh Argan	- ditto -
Ato Tefe Wassen	- ditto -

EWWCA: (Ethiopian Water Works Construction Authority)

Ato Abela	Head, Rural Water Supply construction Dept.
Ato Ahmed Omer	Head, Eng. Service
Ato Yohanez Simon	Head, Rural Water Supply Sec. Wello
Ato Yetnayet Negussei	Rural Water Supply Sec. Wello Hydrogeologist.

Irish Concern

Mr. Raymond cleary Assistant Field Director

Irich Goal

Dr. Catherine

SCF (UK)

Mr. David Alexandria

Dr. Aroop

Dr. Michail Peuy

JICA Study Team

Field members:

Ato	Tudesse	Asfew	Drilling
Ato	Sissay	Hunde	"
Ato	Ashalew	Teshome	"
Ato	Hussen	Abedela	"
Ato	Mathius	Giruma	"
Ato	Getuchew	Wolde	Construction
Ato	Asafer	Abeder	"
Ato	Solomon	Haile	"
Ato	Wubshet	Million	"
Ato	Megullusa		"
Ato	Kassa	Segaru	Mechanics
Ato	Sellas	G/Michail	"
Ato	Semen	Negeyu	"

Driver:

Ato	Kassa	G/Michail
Ato	Telahune	Kidane
Ato	Getahune	Sahele
Ato	Admass	Deneke

WWDA: (Water Well Drilling Agency)

Dr.	Tessafai	

MTSC: Maritime and Transist Services Corporation)

Ato	Nigusse Demissie	Manager

NTO : (National Tour Operation)

Ato	Kiros Tekle	Head, Tours & Safari

Ethiopia Red Cross

Ato	Teferra Shiawl	Secretary General

Relief Transport Unit

Ato	Aragan Fetene	Head
Ato	Gebrebatik H. Mariam	Deputy Manager

Mapping Agency

Ato	Asfan Fanta	General Manager

Tchaffa State Farm

Ato	Kinduye Alemahu	Head, Technical Sec.
Ato	Aneneh Getachew	Head, Agricultural Sec.

Kembolcha Municipality

Ato	Ismail Wuru	Master Program for Re-development of Kembolcha

Karakoro Kabare

Ato	Ahamed Hassan	Secretary