BASIC DESIGN STUDY REPORT
ON
THE RURAL WATER SUPPLY PROJECT
IN
THE REPUBLIC OF GHANA

FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Ghana, the Government of Japan decided to conduct a basic design study on the Rural Water Supply Project and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Ghana a study team headed by Mr. Yukitoshi Suzuki, Industrial Water Division, Facilities Department, Waterworks Bureau, Yokohama City, from September 30 to October 27, 1985.

The team had discussions with the officials concerned of the Government of Ghana and conducted a field survey in Northern, Brong Ahafo and Western regions in Ghana. After the team returned to Japan, further studies were made and the present report has been prepared.

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

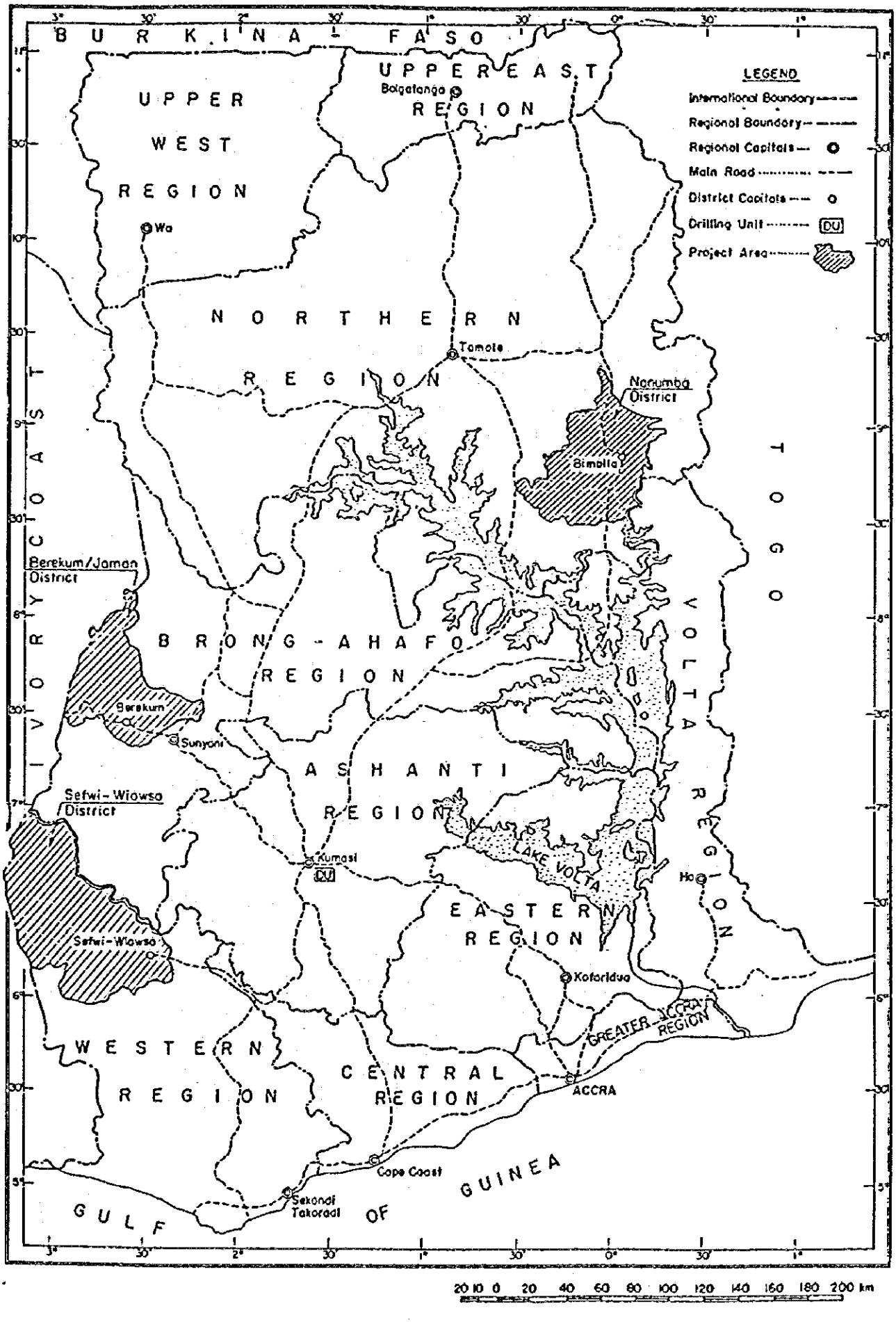
I wish to express my deep appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

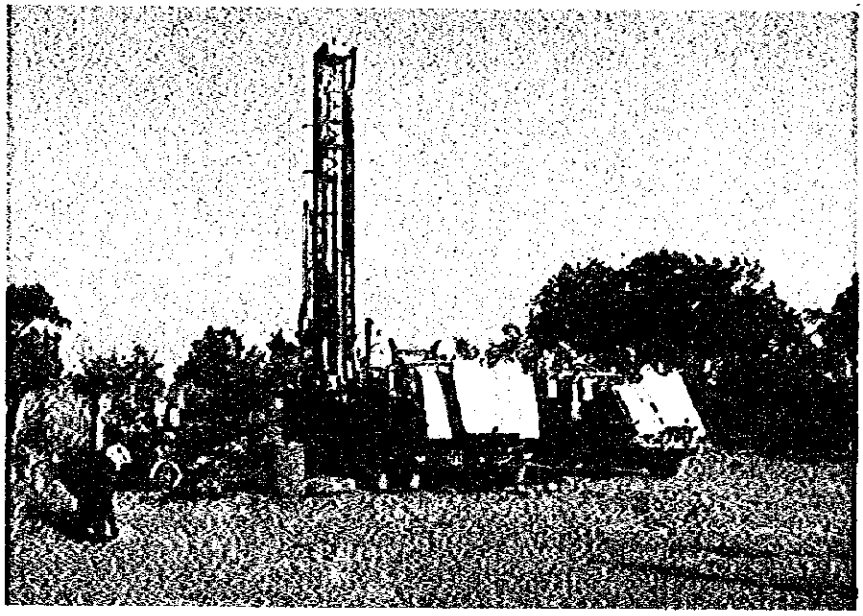
February, 1986

Keisuke Arita

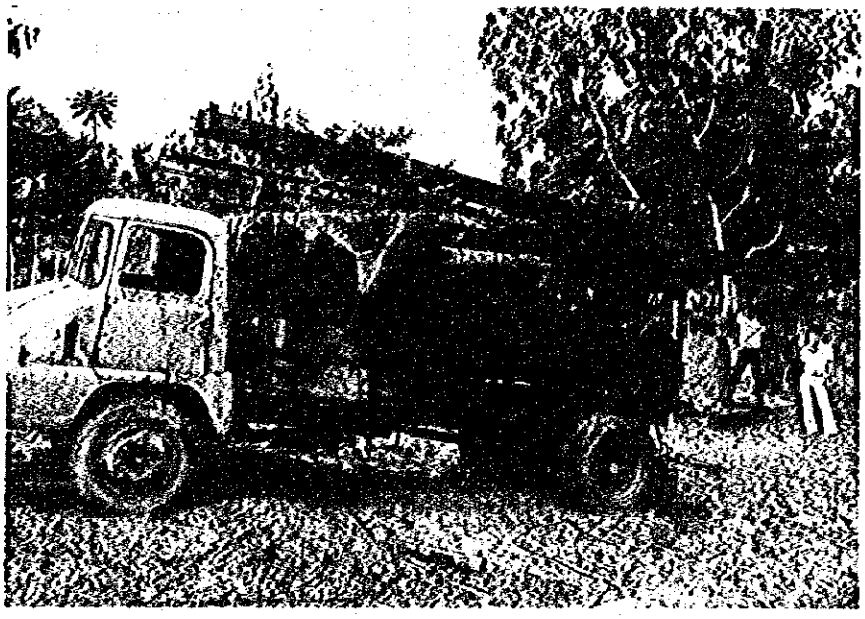
Keisuke Arita
President
Japan International
Cooperation Agency

LOCATION MAP OF THE PROJECT AREAS

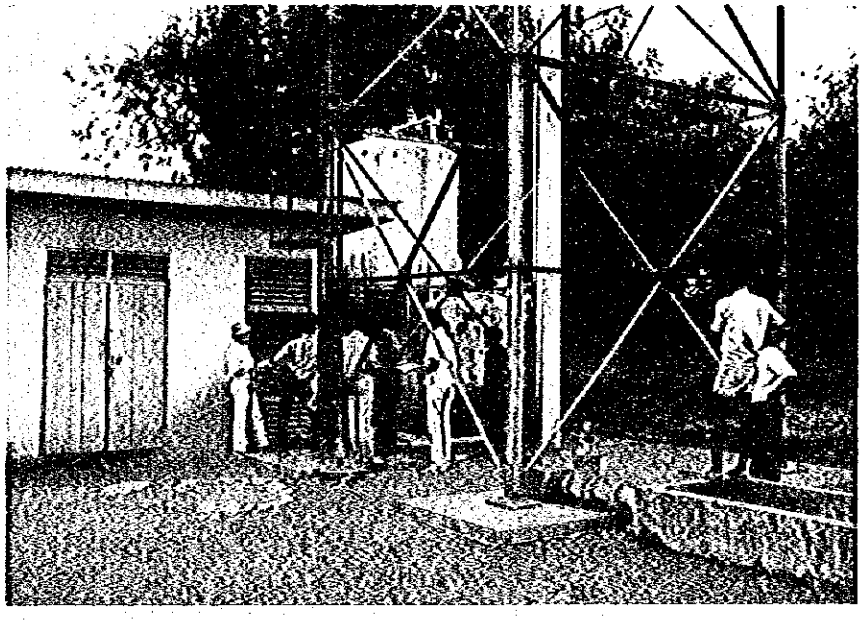




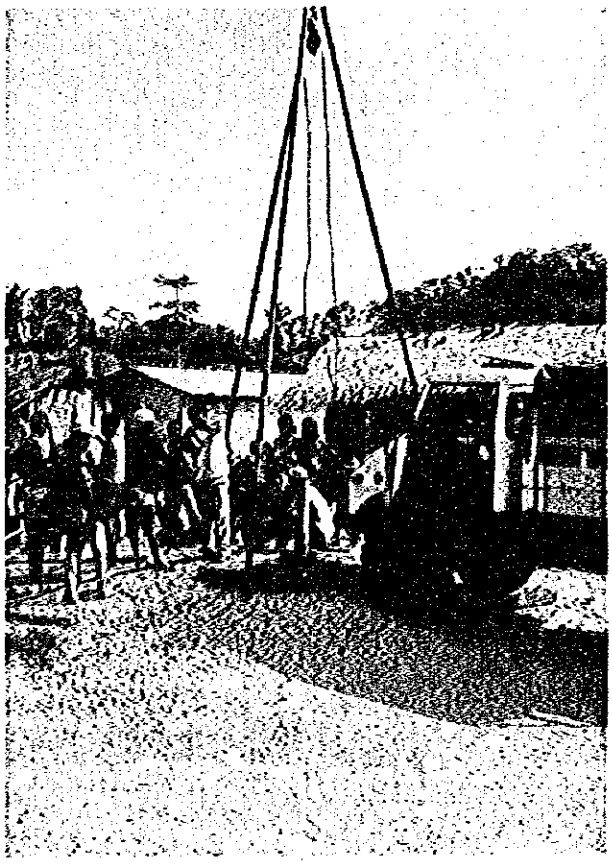
Rotary drilling rig at work (TH60)
— at Buipe, Northern Region —



Percussion rig at work (22RW)
— at Duasi, Ashanti Region —



Time-worn Treatment Facility
— at Goaso, Brong Ahafo Region —



Repairing scene of hand-pump
by GWSC's maintenance crew
— at Domesase, Central Region

Pumping scene at Nkrakwanta, Northern Region
(India Mark II)

A scene of domestic water source at Nanumba District

Basic Design Study Report on The Rural Water Supply Project
in The Republic of Ghana

CONTENTS

Attached Documents

ABBREVIATIONS

ATMA	Accra-Tema Metropolitan Area
CBS	Central Bureau of Statistics
CIDA	Canadian International Development Agency
CSIR	Council for Scientific and Industrial Research
ECG	Electric Corporation of Ghana
E/N	Exchange of Notes
GOG	Government of the Republic of Ghana
GOJ	Government of Japan
GTZ	Gesellschaft fur Technische Zusammenarbeit
GWSC	Ghana Water and Sewerage Corpotation
IGIS	Ingenieur Gesellschaft fur Internationale Planwungsaufgaben
ISD	Information Service Department
JICA	Japan International Cooperation Agency
MFEP	Ministry of Finance and Economic Planning
MH	Ministry of Health
MWH	Ministry of Works and Housing
NORRIP	Northern Region Rural Integrated Development Programme
OCP	Onchocersiasis Control Programme
PNDC	Provisional National Defence Council
UNDP	United Nations Development Programme
UNICEF	United Nations International Children's Emergency Fund
URWSP	Upper Region Water Supply Programme
WEDC	Water and Waste Engineering for Developing Countries
WHO	World Health Organization

SYMBOLS

mm	milimeter(s)
cm	centimeter(s)
m	meter(s)
km	kilometer(s)
in or "	inch(es) (=25.4 mm)
sqm or m^2	square meter(s)
sqkm or km^2	square kilometer(s)
cum or m^3	cubic meter(s)
MCM	million cubic meter(s)
l	liter(s)
gal	gallon(s) (=4.546 l)
°	degree(s)
lcd	liter(s) per capita per day
gcd	gallon(s) per capita per day
l/d	liter(s) per day
l/hr	liter(s) per hour
l/min	liter(s) per minute
g/min	gallon(s) per minute
μS/cm	micro-Siemens per centimeter
¥	Japanese Yen(s)
¥M	million Japanese Yen(s)
$	US Dollar(s)
$M	million US Dollar(s)
¢	Ghanaian Cedi(s)
¢M	million Ghanaian Cedi(s)

SUMMARY

The Republic of Ghana (hereinafter referred to as Ghana), located almost in the middle of the coastal area along the Gulf of Guinea in the West Africa, has the national land area of about 239,000 km^2 and the population of about 12.21 million (as of 1984).

Ghana belongs, in total, to a tropical climatic area which has dry and rainy seasons, however, the area is subdivided into two major climatic sub-regions; an equatorial climatic region with two rainy seasons in a year along the coastal area, and a tropical continental climatic region with sole rainy season in northern area.

The topography of the country is mostly flat, consisting of several plateaux with different elevation and plains. Considerable abundance in raifall has developped well many river basins including the Volta and others in the country. The geology is formed basically with Pre-Cambrians and their overlayers of Paleozoics, Mesozoics and some Cenozoics, and is subdivided into 10 hydro-geological regions according as their characteristics and structure or hydrological conditions. The hydrogeological regions with promising aquifers both in shallow and deep layers are found in the Togo Buem and the Birrimian zones in the northwest, while the regions with dominant deep aquifers are in the northwest Birrimian, the Middle Voltaian in the mid-west, and the Tertiary in the coastal area, and the regions with promising aquifers only in the shallow layers are found in the Lower Voltaian in the mid-south and the Granites found sporadically in the southwest. The groundwater found in the northwest is generally contained only in local aquifers.

The Ghana Water and Sewerage Corporation (hereinafter abbreviated as GWSC) under the Ministry of Works and Housing is totally responsible for the water supply administration and particularly responsible for the development of water supply to both

the urban and the rural areas, sewerage drains/treatment, and the operation and maintenance of the related facilities and organization, and also for necessary water quality control.

Although the GWSC holds the right to operate and manage the organization on the independent basis, it has faced crisis of bankruptcy in its finance due to decrease in collected charge resulting from shortage of collectors and O & M staffs, increase in number of facilities, and unraised rate of water tariff.

The GWSC has the Drilling Unit in its organization, which specializes the groundwater development by borehole drilling; however, it has been suffering from its time-worned equipment/ devices and shortage in spare parts/materials. The operation and maintenance of the water supply facilities are carried out under the responsibility of those three offices of the GWSC Headquaters, Regional Offices and the Central workshop. Actually, however, such O and M service system has not functioned effectively due to shortage in spare parts by unfavourable foreign exchange reserve, short staffing with skillful engineers and inactive organization for the works.

The GWSC has established the administrative standards to supply water by pipe-borne water supply system with the urban towns having population more than 2,000, by borehole facilities equipped with hand-pumps with those communities having population between 400 and 2000, and by providing ponds or hand-dug wells with those communities having population less than 400. The GWSC has been administering 208 water supply systems throughout the country to supply water with about 3.6 million people, approximately 20 percent of the total population of 12 million. The water supply capacity by these facilities, although nominally about 182 MCM per annum, has been estimated actually at 159 MCM only per annum, about 87 percent of the nominal capacity, due to inefficient time-worned facilities. Actually, the local urban areas have been suffering from ineffective

and seriously insufficient water supply since the beginning of 1970s due to drastical doubling in population.

On the other hand, the rural areas have been so poorly provided with water supply facilities as to drive women and children into heavy labour of water fetching and to cause frequent occurrences drinking water-borne diseases. Consequently, the rural inhabitants had to bear considerably heavy burden of medical expenditure. The survey by the Ministry of Health revealed that the occurrence rate of water-borne diseases such as Guinea-worm infection, dysentery, diarrhea, hepatitis, etc, sums up annually 44/1000 persons.

Since early 1970s, the GWSC has installed about 10,600 water supply facilities including 700 boreholes with hand-pumps in the rural areas, and coincidentally, has been positively trying to invite the international cooperation. As a result, since 1974 some 5,600 borehole facilities with hand-pumps have been constructed in total throughout the country as of 1985, by the cooperations from Canada, West Germany, Catholic International Fund, and World Bank.

The national policy for water sector is involved in "Economic Recovery Program" (1984 - 1986), "Five-year Rehabilitation and Development Programme" (1984 - 1989) and etc. The rural water supply scheme in the Economic Recovery Programme aims to alleviate the burden of medical expenditure and of heavy labour for water fetching of the local people, so that labour forces can be utilized in farming works. Most ($105 M) of the allocation ($155 M) of the investment to the Social Service Sector is planned to be used for this water supply scheme. The Five-year Rehabilitation and Development Programme consists of rehabilitation of the existing facilities, their capacity expansion and extension, completion of the on-going projects, construction of new rural water supply systems, and expansion and strengthening of the GWSC's administrative and management system. The proposed investment to this Programme is 145 million dollars, about 91 million dollars

(63%) of which will be covered by foreign currency.

The GWSC has formulated a rural water supply project for further improvement of water supply condition in the rural area based on the said five year programme, and requested the grant aid to the Government of Japan through the Ministry of Finance and Economic Planning of Ghana.

The request consisted of two schemes; the scheme-I and II. The scheme-I covered the procurement of equipment and materials required for completion of three on-going water supply projects in Brong Ahafo Region, for rehabilitation of 37 time-worned facilities in Brong Ahafo and Western Regions and the procurement of equipment, materials and vehicles required for strengthening the GWSC Drilling Unit. And the scheme-II covered the grant aid with equipment and materials required for construction of 120 to 130 borehole facilities with hand-pumps in Nanumba District of the Northern Region together with equipment and materials for O and M of those facilities and dispatch of Japanese engineers for the technical guidance of O and M.

In response to the said request, the Government of Japan has decided to conduct a basic design study on the Project. Based on the decision, the Japan International Cooperation Agency (hereinafter referred to as JICA), an official executing agency of international cooperation programmes by the Government of Japan dispatched a Basic Design Study Team (hereinafter referred to as Survey Team) to Ghana for 28 days from 30th September to 27th October 1985.

The Survey Team had discussions with the officials concerned of the Government of Ghana and conducted a field survey in the Project areas, an inspection of facilities concerned and collection of data available.

The Government of Ghana has, through the discussions, excluded the former two components of Scheme-I in the initial request; completion of the on-going projects and rehabilitation of time-worned facilities, because they would be realized only to poorly function if only the equipment and materials would be supplied on the basis of the request, and furthermore, the more detailed plan and design data would be required to be included in the grant aid.

The outline of the plan and request confirmed through the discussions between the Government of Ghana and the Survey Team are as follows;

Outline of the Plan: To construct about 440 borehole facilities with hand-pumps in the selected three areas of Nanumba in the Northern, Berekum/Jaman in the Brong Ahafo and Sefwi-Wiawso in the Western Region, to improve the rural water supply conditions. (The GWSC is to be an execution agency for the Project implementation.)

Outline of the Request:
(1) To procure the equipment required to implement the Project
(2) To construct 120 of borehole facilities with hand-pumps.

While the both parties confirmed that the GWSC desired to have transfer of technology in various fields of the Project implementation from Japanese engineers/experts through the construction work, and the GWSC should recruit personnel for the implementation by their own expenses.

The Study Team, after returned to Japan, conducted the Basic Design Study on water supply and facility plan, selection of equipment and materials, rough estimation of the Project cost, O & M plan, etc., as well as the examination of the Project based on the field survey.

In accordance with the GWSC's proposal and data on the number of communities as objectives, their population predicted for 1989, and the standard of the 400 beneficiaries per borehole, the proposed boreholes in the Project were re-allocated. In the Project, 15 lit.cd and 6,000 lit./day are taken as the design water demand and as the standard pumping rate per borehole respectively, while 300 lit./hr of yield is taken as the criteria of successful borehole. The boreholes in the Project are to be drilled to average 50 m in depth (min. 30m, max. 70 m). Appurtenant facilities and manual pumps for deep borehole type are to be properly equipped.

The aforesaid design factors can determine the work volumes to be required for the Project as follows.

District	Proposed No. of Boreholes	Boreholes to be Drilled	No. of Dry Holes	Drilling Depth (m)	Casing Length (m)
Nanumba	159	245	86	12,250	7,950
(Japanese Cooperation)	(120)	(185)	(65)	(9,250)	(6,000)
Berekum/Jaman	143	191	48	9,550	7,150
Sefwi-Wiawso	164	219	55	10,950	8,200
Total	466	655	189	21,750	23,300

Resulting from the study on work plan in taking into consideration climatic conditions, labour regulation/customary rule and sundays/national holidays, the following optimum organization for the construction works is pland out; three siting, an earthwork, a borehole test, three drilling, and two civil work parties. The numbers of the Ghanaian staffs and workers to be required for

successful implementation of the Project are 22 GWSC staffs and 67 extra workers, 89 persons in total. With such composition of the working parties, it will take about 41.6 months (about 3.5 years) as an actual construction period.

The grant aid of Japan for the Project implementation involves a procurement and transportation of major equipment, dispatchment of seven engineers for the cooperation to the construction work concerned to the said 120 borehole facilities including a procurement of materials required, and a consultancy services including a dispatchment of three supervising engineers. The Japanese engineers would transfer technologies such as management of the project, siting, borehole drilling and test, construction of borehole facilities, installation of manual-pump, O & M of equipment and facilities, etc., in Nanumba District through the actual construction work with Ghanaian staffs during the dispatched period of about 12 months.

The equipment and materials to be procured in the Project are to be as follows;

		No. of Units
(1)	Truck-mounted Drilling Rig	3 units
(2)	High Pressure Air-compressor	3 "
(3)	Cargo Trucks	9 "
(4)	Light Vehicles for Transportation of Personnel and Materials	14 "
(5)	Bulldozer	1 unit
(6)	Borehole Test Equipment	1 set
(7)	Geophysical Prospecting Equipment	3 sets
(8)	Engine Welder	2 units
(9)	Concrete Mixer	2 "
(10)	Permanent Casing Pipe	6,600 m
(11)	Manual-pumps	140 units
(12)	Workshop Instruments	1 set
(13)	Radio Communication system	1 unit
(14)	Camping Equipment	1 unit

The Government of Ghana should be responsible and bear the costs for successful mobilization of the necessary Ghanaian staffs and workers throughout the Project period, procurement and supply of the construction materials excepting those under the grant aid, and other procedures required to implement the grant aid programme of Japan. The expenditure to be borne by the Ghanaian Government will be about 159 million Cedis (about 529 million yen) for the period from the commencement to the completion of the Project.

The Japanese cooperation to the Project under the grant aid will take about 22 months in total commenced on the E/N between both Governments; 9.5 months for procurement/transportation of equipment and materials, 12 months for the cooperation of construction work by the dispatched engineers, and 0.5 month for re-arrangement and hand-over the equipment.

The GWSC should be fully responsible for practising O & M services for the borehole facilities, drilling rigs, supporting equipment/devices, and vehicles. The O & M shall be under the responsibility of each Regional Office of the GWSC by services through the Hand-pump Maintenance Center to be newly provided in the three districts, while those for the equipment/instruments are under the Drilling Unit of the GWSC. Construction of the new Hand-pump Maintenance Centers will cost about 20.8 million Cedis and the annual operational costs of these centers will be about 5.5 million Cedis.

The direct benefits generated from the Project are to alleviate the heavy burden of medical expenditure of the rural inhabitants through mitigating the high suffering rate of water-borne diseases (44 cases to 1,000 inhabitants), in particular, the infant mortality by diseases at digestive system, to remarkably alleviate the heavy burden of women and children for water fetching, and to stabilize and level up the rural life.

On top of the above, it is expected to accrue the ripple effects to utilize the labour forces to be released from water fetching to the other productive labours and contribute to development of the regional or national economy, and to strengthen the solidarity of the rural communities as a whole. In other respect, the durable equipment to be supplied under the Japanese grant aid will be so sufficiently operative as to drill more than 2,000 boreholes even after completion of the Project. The effective operation of these equipment with the latest technology and knowledge to be transferred from the Japanese engineers will allow the rural water supply improvement to be realized effectively and urgently. In addition to the effects in socio-economy and human needs, there will be strengthening of the relationship expected between the two countries as one of the major effects, and therefore, the Project can be considered quite feasible as a grant aid programme.

The successful implementation of the Project will require the Ghanaian authorities concerned to pay due attention to the following facts; 1) the Ghanaian authorities concerned should make the effective and efficient budget for procurement and supply of the equipment and materials as to ensure smooth progress of the Project after the second implementation year, 2) the equipment and materials to be procured and supplied by Japanese grant aid should not be concurrently used in any other works than the subject Project until its completion, 3) the proposed O & M staffs for the facilities should be engaged in the construction works as many as possible, 4) the Project beneficiaries should be educated on the public-health as early as possible, and 5) the Ghanaian authorities concerned should consider to establish the village-basis Borehole Committees (provisional name) as early as possible.

CHAPTER 1. INTRODUCTION

The GWSC has been in charge of the drinking water supply of Ghana. The GWSC has supplied the pipe-borne water to urban areas through the 208 facilities and to rural areas through about 6,000 borehole facilities. However, the mean water supply spread rate over the nation is nominally as low as 30 percent (by GWSC data).

Due to age, iadequate maintenance system and non availability of spare parts because of scarcity of foreign exchange, many of the existing supply systems, especially in the rural area, have been left as not maintenanced for these 20 years, and now, more than 60% of rural water supply systems are eigher malfunctioning or else not functioning at all. The most of rural population holds their daily life under the very poor public health condition utilizing untreated potable water sourced from streams, ponds and rain, and then suffered from very high occurence of water-borne diseases. These high occurence rate of disease and heavy and longtime fetchig work of water lose the home labour capacity and obstruct the farming and further the development of the country.

With regard to such condition, the GWSC requested the Government of Japan through the Ministry of Finance and Economic Planning of Ghana to provide a grant aid which places the key points on the provision of equipment and materials for the rehabilitation of the time-worn water supply facilities and the construction of boreholes.

The Government of Japan has examined the request, and decided to conduct the basic design survey on the Project. Japan International Cooperation Agency has, based on the decision, dispatched a Basic Design Study Team headed by Mr. Y. Suzuki, Industrial Water Supply Division, Bureau of Water Supply, Yokohama City, to Ghana for 28 days from 30th September to 27th October, 1985.

The Study Team has made a series of discussions on the content of request with the related officials of the Government of Ghana, the field inspection on the present situation of water supply and water supply facilities and other conditions and collection of data and information concerned to the Project.

The matters basically agreed with Ghanaian party through the discussions are concluded in the Minutes of Discussions dated 14th October, 1985 signed between Mr. Suzuki, Leader of the Study Team and Mr. T.B.F. Acquah, Acting Managing Director, GWSC.

The member list of the Study Team, the itinerary of survey, the Ghanaian organizations and related officials contacted by the Team, the copy of Minutes of Discussions and the list of collected data are attached to the end of this report as Appendices 1, 2, 3, 4 and 5 respectively.

Basing upon the said survey, the Study Team has carried out, after their return to Japan, the examination of feasibility of the Project, the design of water supply facility, the selection of equipment and materials necessary for the implementation of Project, the preliminary estimate of Project cost, planning of operation and maintenance and so forth.

This report describes the results of the above-mentioned serial basic design study.

CHAPTER 2. BACKGROUND OF THE PROJECT

2-1. General Condition of Ghana

(1) Geographic features

The Ghana situated almost in the middle of the coastal area along the Gulf of Guinea in the West Africa, has a national land area of about 239,000 km^2, and adjacent to Ivory Coast at the west, Togo at the east, Blukinafasso at the north, and the Gulf of Guinea at the south.

(2) Society

The Ghana has administrative division consisting of 10 Regions and 141 Districts. The locations of the Regions and their capitals are shown in the location map attached to the Report at the first page.

According to the population census (CBS, 1984), Ghana has the population of 12,206,000 and has shown an annual growth rate of 2.6 percent since 1970. The population and growth rate for each Region are shown in Appendix 6. The census revailed that the population of urban cities/towns with a population 5,000 or more in 1984 was about 31 percent of total population. Appendix 7 shows the population distribution in both the urban and the rural areas for each region.

The people of Ghana can be divided into various tribes, of which large tribes are Ga, Ebe, Akam, Mamprusi, Dogomba, etc.

(3) Politics and administration

Ghana is a republic which became independent from British administration in 1957, the first in the West African countries.

Since December, 1981, through four political changes in government after the independence, the Provisional National Defence Council (hereinafter referred to as PNDC), a political power, has governed Ghana. The PNDC Government has put emphasis on decentralization of its administrative authority to local councils as one of the political target and made an effort to integrate the functions of the branches/representative offices of the central governments into local councils.

The local administrative organization is divided into three level councils; region, district, and area-town-village. The councils of the regions and the districts consist of the organization shown in Figure 2-1-1, representing the central government, and coordinate in activities of the area-town-village councils. The PNDC assigns the Secretary and Under-secretary of the regions and districts councils.

(4) Industry and Economy

The industry of Ghana is based on a bounteous natural resources and supported by agriculture, mining, and forestry mainly developed in the south. Cocoa, among the agricultural products, accounts for 30 percent of the total world production and has a share of 70 percent in the total exports of Ghana. The second largest export item is timber, followed by mining products such as gold, diamond, bauxite, and manganese. The electric power, generated at the Akoson dam of the Volta river, has been supplied to Togo and Benin.

Since 1970s , the economy of Ghana has been dull. The agricultural production, which is the most important sector of Ghanaian economy, has hardly increased; the manufacturing industry has been operated with less capacity than nominal capacity of the facilities; and the transportation system has suffered from an extraordinary shortage in facilities and means.

Sluggish export trade has caused the foreign exchange resources to reach the bottom, and the import has been extremely prevented in such materials, equipment, heavy machines, spare parts, and fertilizers. The operation and maintenance of social infrastructure has been neglected without repair. Chronical shortage in foreign exchange also has raised inflation rate higher and far lowered employment rate than before.

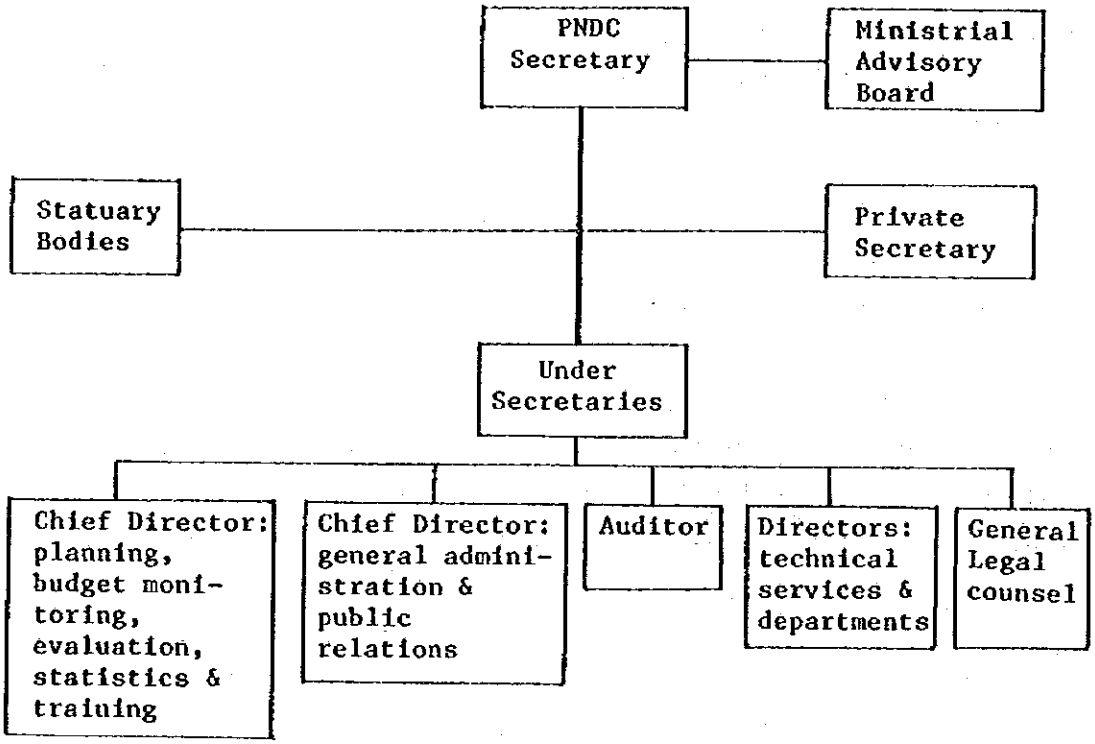
These conditions resulted in a decrease in GNP per capita by 25 percent during five years from 1978 to 1982, and a level down in living standard of the people.

Furthermore, in 1983, a severe drought and large scale forest fire caused most cocoa plantations to be drastically destroyed and the agricultural production reduced. And in January in the same year, repatriation of more than one million Ghanaian from Nigeria worsened the national economy.

Since the Government of Ghana had avoided the devaluation of Cedi, the actual rate reached several ten times to the official rate (2.25 Cedis to 1.0 US Doller) early 1983. The PNDC Government, in considering of these serious economic status, formulated the Economic Recovery Programme (1984/86). In 1983, as one of the action of the said Programme, the Government devalued the rate of Cedi to the doller to 20 Cedis per Doller, and has adjusted it according to the actual rate since then. As of October, 1985, the rate to 1.0 Doller was 60 Cedis. The effect of the said Programme has been gradually developed, so that the economy of Ghanaian has shown a sign of turn favorable .

The economic indices of Ghana are shown in Appendix 8.

Figure 2-1-1. Organization of Regional and District Administration in Ghana



(ISD, 1983)

(5) Economic Policy

The Government has undertaken the Economic Recovery Programme which includes one year of preparation period in 1983 and three-year implementation period from 1984 to 1986. The priority policies of the Programme are given as follows:

- To reform prices and restore production incentives
- To arrest a runaway rate of inflation
- To realign interest rates
- To reduce the budget deficits
- To establish the proper priorities for the allocation of scare foreign exchange resources

The fund for the programme is allocated as shown in Table 2-1-1, and the foreign fund of 2,100 $M occupies 51 percent of the total demand of 4,100 $M including ODA.

Table 2-1-1. Financing of the Economic Recovery Programme

(US$ million)

	1984-86	1984	1985	1986
Domestic Sources	2,015	410	680	925
Foreign Exchange	739	179	230	330
Cedi counterpart	1,276	231	450	595
External Sources	2,135	465	770	900
O.D.A.	1,455	305	500	650
Official non-concessional	378	118	145	115
Private loans & transfers	302	42	125	135
Total	4,150	875	1,450	1,850

The sectoral allocation of the fund, shown in Table 2-1-2, accounts for 37 percent of the total and is allocated to the rehabilitation of physical infrastructure, mainly of roads, ports and harbors, and communication, followed by fossil fuels (32 percent), agricultural and industrial production (16 percent), export oriented sector including cocoa the Ghana's largest export item, mining product, and timber (11 percent), and finally social service sector (4 percent).

Table 2-1-2. Economic Recovery Programme; Sectorial Allocation

(US$ million)

	1984-86	1984*	1985-86*
Export oriented Sectors	473(11.4)	132	341
Cocoa	174	55	119
Mining	314	15	125
Timber	159	62	97
Other Productive Sectors	672(16.2)	161	511
Agriculture	244	59	185
Manufacturing	428	102	326
Physical Infrastructure	1,538(37.1)	238	1,300
Fuel and Power	1,312(31.6)	238	1,019
Social Sectors	155(3.7)	51	104
Total	4,159(100.0)	875	3,275

* The numerical values for 1984 are actual values, and those after 1985 are reviewed values with the actual results in 1984.

2-2. Physical Environment

2-2-1. Topography and Geology

(1) Topography

Ghana stands almost half way on the stretch of African west coast opening to the Gulf of Guinea, with a rectangular area of about 238,539 km^2, between 1°12'E and 3°15'W in longitude and from 4°45'N to 11°11'N in latitude.

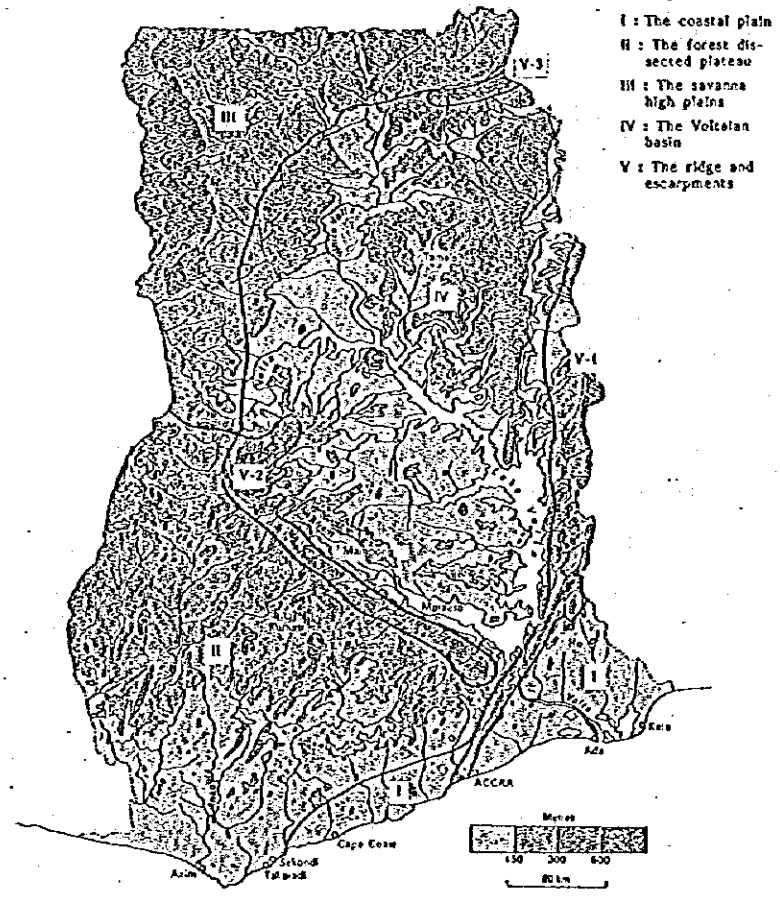
Most of the country consists of a series of plateau surfaces and plains at different elevations. Fig.2-2-1 shows the patterns of relief in the country, and the following physiographic regions may be distinguished: (1) the coastal plain, (2) the forest dissected plateau, (3) the savanna high plains, (4) the Voltaian sandstone basin, and (5) the ridges and escarpments bordering the Voltaian sandstone basin. These are explained briefly as follows.

a) The Coastal Plain

This is the low and flat land, broad in the east and west along the coast. The plain may be divided into two broad sections; the southeast coastal plains east of Accra, and the plains west of Accra.

The southeast coastal plains extending in both sides of the Volta are very flat and carry only a few isolated hills. While the west coastal plains show different characteristics; the land is not flat but rather undulating.

Fig. 2-2-1 Physiographic regions

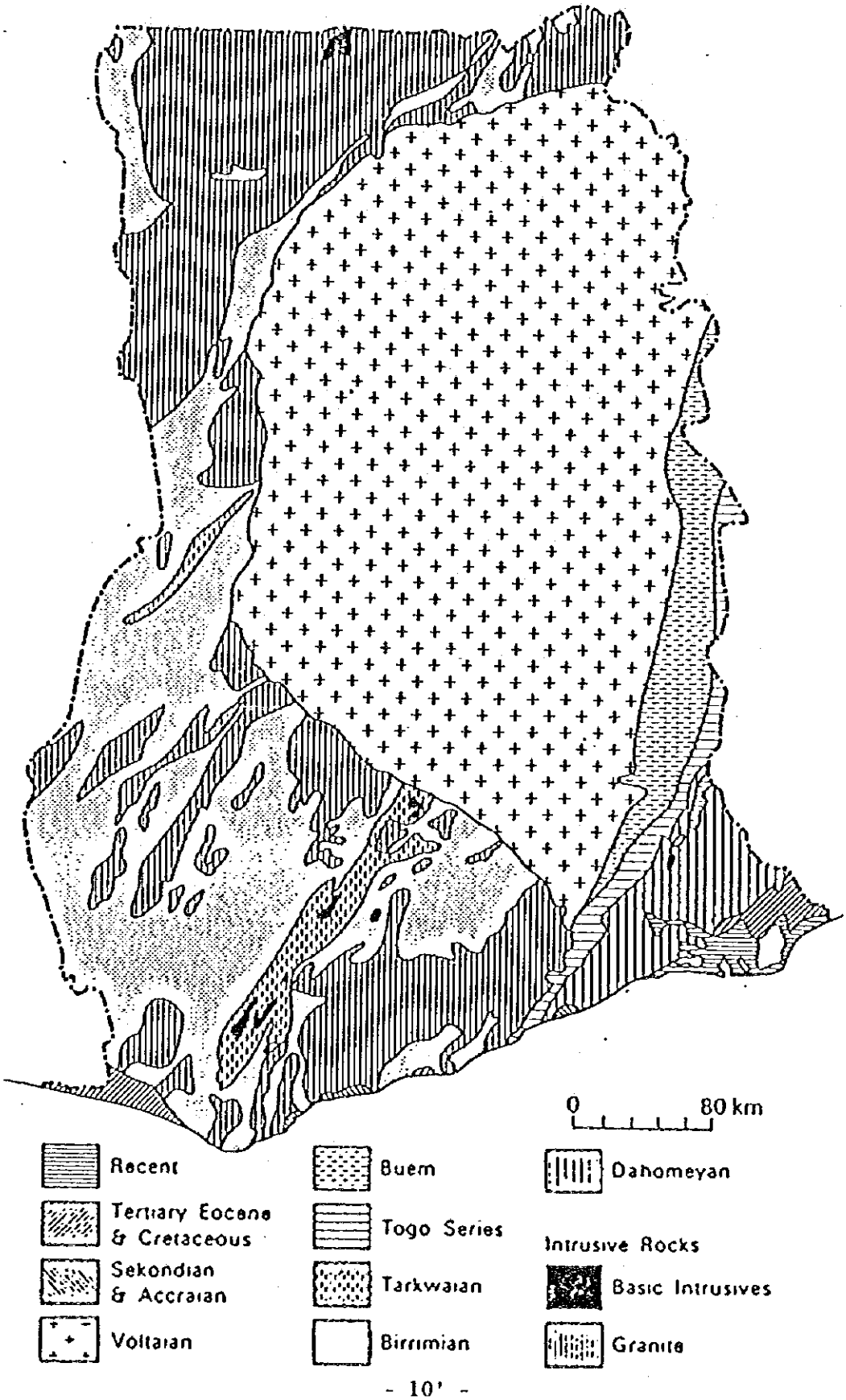


b) The Forest-dissected Plateau

The land is a plateau with an altitude between about 240 and 300 meters above sea level, covered by dense rain forest. The heavy rainfall in the region and consequent forest vegetation which prevents sheet erosion can explain the strong dissected nature of the plateau.

Erosion is restricted mainly to the river channels which cut up the plateau surface, but the plateau still remains a peneplain feature, obscure though. Within the region, hills composed of somewhat hard rocks are rounded and stand about 60 - 90 meters of relative height as residual hills.

Figure 2-2-2 Geological Map of Ghana



c) The Savanna High Plains

The plains occupy the northwest corner of the country. Since much of the erosion in this region is by sheet flooding, the topography is more gently rolling than that of the forest dissected plateau. The average height of the high plains is between 180 and 300 meters above sea level. Standing here and there on the plains are small rounded residual hills resulted by the selected erosion.

d) The Voltaian Sandstone Basin

The basin occupies almost a half of the territory of Ghana. It is made up of gently bedded or flat-bedded sandstones, shales, and mudstones which, generally speaking, are easily eroded. The result is an almost flat and extensive plain which is between 60 and 150 m in that part of the basin south of the west-east flowing Black Volta, and up to about 180 m above sea level in that part north of the river. But immediately to the west of the Oti river the sandstones are resistant and stand out as a north-south range of hills with height between 180 m and 300 m above sea level.

e) The Ridges and Escarpments Bordering the Voltaian Sandstone Basin

The captioned ridges and escarpments comprise following three sub-regions;

e-1. Akwapim-Togo ranges ... The fold mountains forming the eastern boundary of the Voltaian basin and separating the coastal plain into two parts, the east and the west.

e-2. Southern Voltaian plateau ... The plateau, made up of the horizontal layers of sandstone, marks the southern boundary of the Voltaian basin.

e-3. Gambaga escarpment ... It is also made up of horizontal layers of sandstone, and marks the northern limit of the Voltaian basin forming both north-facing and south-facing escarps.

(2) Geology

The land of Ghana stands on the eastern margin of the West Africa Stable Craton. Geologically the land is built of several formations of different ages, overlying Pre-Cambrian, the basement of the area (see Fig. 2-2-2). These are listed below mentioning from the base to the upper with brief explanations.

Pre-Cambrian

a) The Dahomeyan formation ... early Pre-Cambrian, the oldest in the country, consisting of gneisses and schists, distributing at inland of the east coastal plain.

b) The Birrimian formation ... mid Pre-Cambrian, consisting mainly of phyllites and schists and some of metamorphic lavas at upper portion, spreading throughout the rain forest area.

c) The Tarkwaian formation ... mid-late Pre-Cambrian, consisting of schists, sandstones, quartzite and phyllites, folded, scattering in the rain forest area as residual hills.

d) The Togo series ... mid-late Pre-Cambrian, consisting of heavily folded sedimentary rocks and their metamorphosed versions, forming an eastern half of the Akwapim-Togo Ranges.

e) The Buem formation ... late Pre-Cambria, being made up of folded sedimentary rocks, forming a western half of the Akwapim-Togo Ranges.

Palaeozoics

a) The Voltaian formation ... covers throughout the vast Voltaian basin (nearly two-fifths of the surface area of Ghana), consisting of flat bedded or horizontal sandstones, shales, mudstones, and limestones.

b) Secondian
Accraian ... late Palaeozoic, distributing only a few places on the coast, consisting of sedimentary rocks.

Mesozoics

a) Upper Cretaceous rocks ... consisting of sandstone, shale and limestone, distributing at the extreme ends of the coast associated with the Eocene rocks.

Cenozoics

a) Eocene rocks ... Tertiary, sedimentary rocks covering the Cretaceous rocks mentioned above.

b) Quaternaries ... consisting of clay, loose sand, and gravel deposited by rivers at their mouths (the main one is at the mouth of the Volta and around the Keta lagoon)

Intrusive Rocks

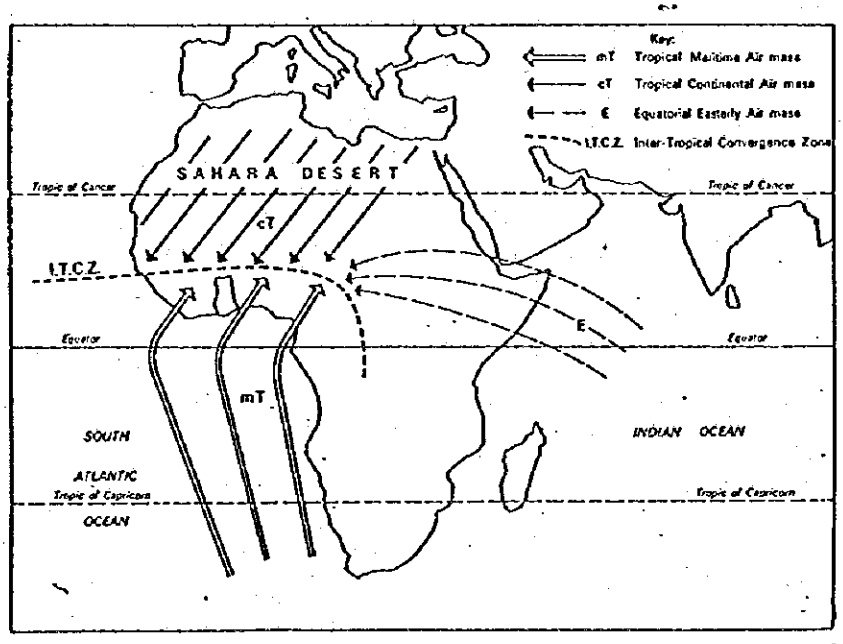
a) Granites ... extensive masses of granites, associated with the Birrimian formation in the rain forest and Savanna areas.

b) Basic Intrusives ... distributing as a few small patches of the land, associated with the Tarkwaian formation.

2-2-2. Climate and Hydrogeology

The climate of the Western Africa Coastal Countries is directed by the relative dominance between two air masses; the hot and dry tropical continental air mass (cT) originated in the heart of the Sahara-Arabian Desert and the wet tropical maritime air mass (mT) originating in the South Atlantic Ocean (see Fig. 2-2-3).

Fig. 2-2-3. Air Masses and Their Source Regions



The wind blowing from the cT, the north-east trade, is called as "harmattan" and it is a symbol of dry season, while the south-west monsoon blowing from the mT carries a rainfall. The third air mass is recognizable in Ghana; the equatorial easterly (E). The cT, the mT and the E form a Inter-Tropical Convergence Zone (I.T.C.Z.) on the western Africa, and the movements of I.T.C.Z., northward or southward, causes seasonal change of weather condition.

In these general situations, the climate of Ghana has considerable local variation for its northern and southern parts, although Ghana belongs to a tropical climate region with dry and wet seasons as a whole (see Fig.2-2-4 and 2-2-5).

Fig.2-2-4. Mean Annual Temperature

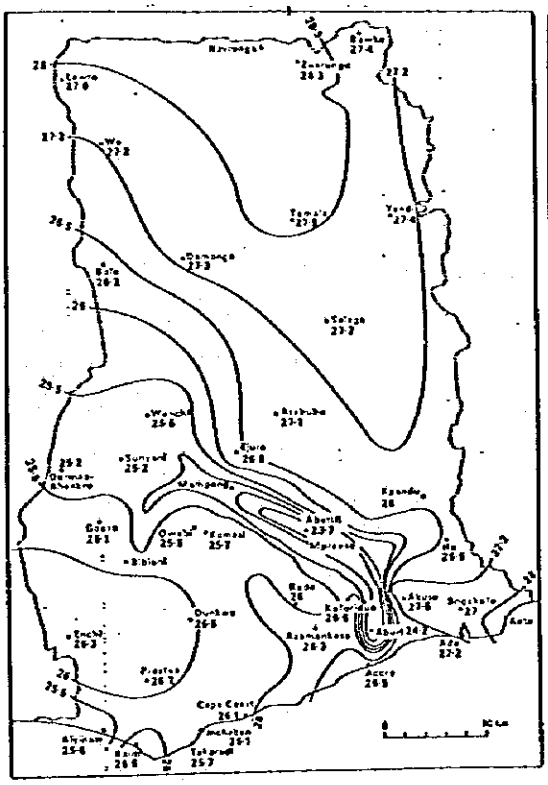
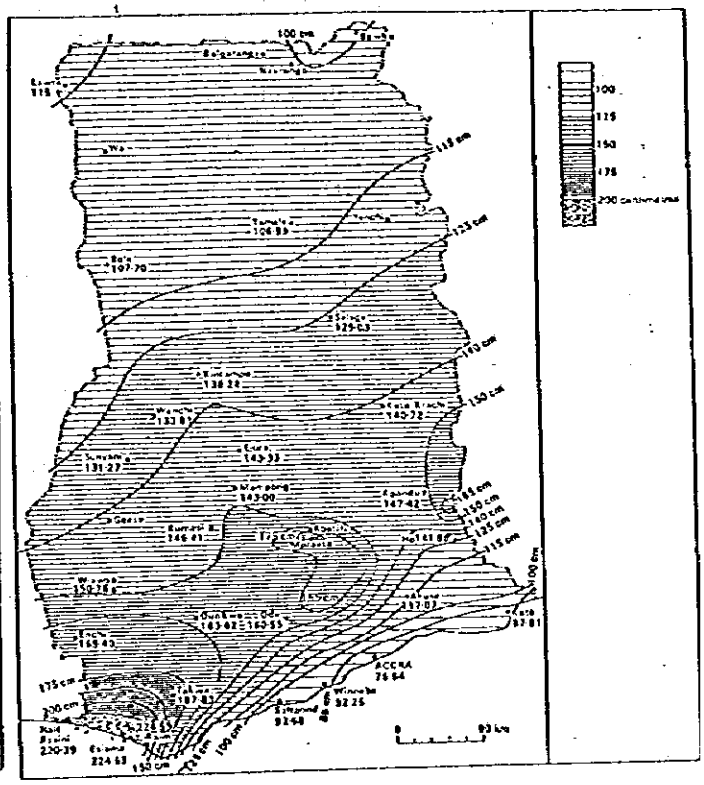


Fig.2-2-5. Mean Annual Rainfall



Thus the climate of Ghana is subdivided into four climatic regions; (1) South-western Equatorial, (2) Dry Equatorial, (3) Wet Semi-Equatorial, and (4) Tropical Continental or Savanna, as shown in Fig.2-2-6.

These climatic regions are briefly explained below.

a) South-western Equatorial

This is the wettest climatic region in Ghana. The rainfall regime is the double maximum type (June and October). Mean

annual rainfall is above 1,900 mm and, on the average, no month has less than 250 mm of rain. The highest mean monthly temperature is about 30°C (in March and April) and the lowest one is about 26°C (in August). Average monthly relative humidities are not less than 70% through a year. A typical station for this climatic region is Axim (see Fig. 2-2-7).

b) Dry Equatorial

This region is the driest in Ghana, the mean average rainfall is between about 740 and 890 mm per annum. This climatic region also has two rainfall maxima; but the dry seasons are more marked. Temperatures are almost the same as in the south-west equatorial climatic region. But the highest average monthly relative humidity in this region does not exceed 75% and the lowest is about 60%. A typical station for this climatic region is Accra (Fig. 2-2-7).

c) Wet Semi-Equatorial

As in the cases of the first two climatic regions, there are two rainfall maxima, but the mean annual rainfall is between 1,250 and 2,000 mm. However, unlike those in the south-western equatorial climatic region, the dry seasons in the wet semi-equatorial climatic region are quite sharp or pronounced. But temperatures and relative humidities are as in the south-western equatorial region. A typical station for this climatic region is Kumasi.

d) Tropical Continental or Interior Savanna

This region covers almost a northern half of the country including the vast Volta basin and the Savanna high land.

The true tropical continental climate is found in the area north of Salaga. It has a single rainy season from May to October followed by a prolonged dry season. The mean annual rainfall is about 1,000 to 1,150 mm. Mean monthly temperatures vary from about 36°C in March to about 27°C in August. Relative humidities are high during the rainy season (70 to 90%) but may fall to as low as 20% during the dry season. A typical station for this climatic region is Zuarungu (see Fig.2-2-7).

South of Salaga, the climate is a modified from of the tropical continental (a little low temperature and two rainfall maxima).

Fig.2-2-6. Climatic Region

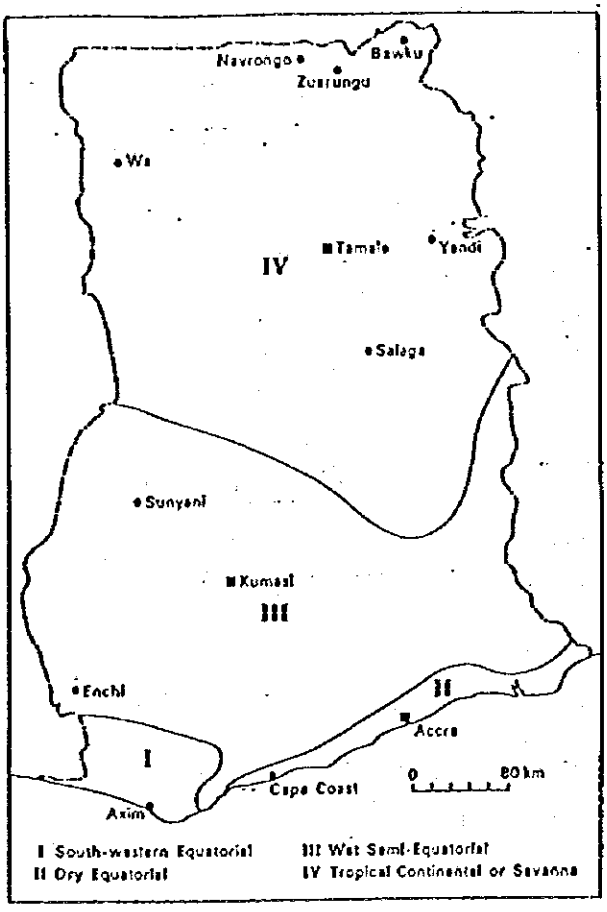
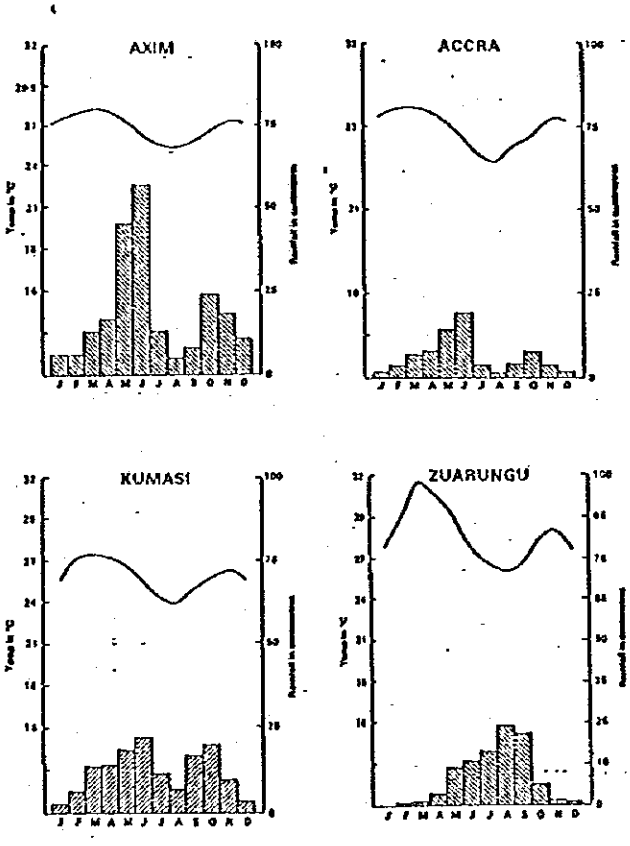


Fig. 2-2-7. Typical Climatic Conditions

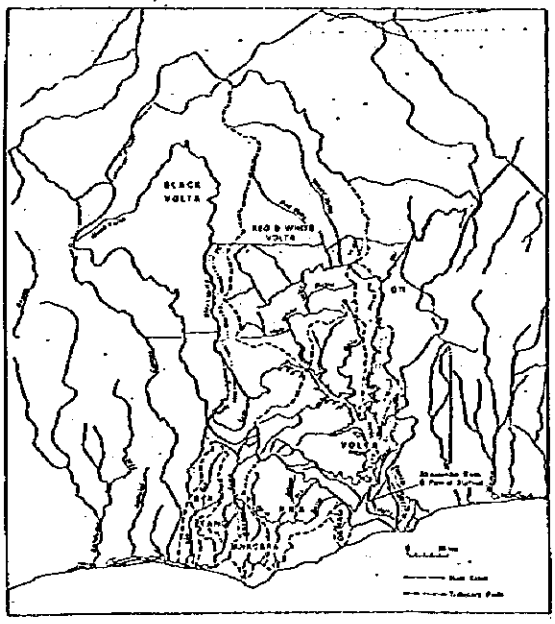


Because of considerable abundant rainfall, many rivers and their basins have been developed well. By far the longest river is the Volta, and within its basin lies nearly three-forths of the total land surface area of the country. However, the Volta originates in the border mountain range between Ivory Coast and Blukinafaso (the Black Volta), and its total river basin covers the area more than twice of the share within Ghana. This huge basin can be subdivided into smaller basins belonging to the Black Volta, the White Volta, the Oti, and the Volta which here refers to the continuation of the Black Volta downstream from the confluence with the white Volta (see Fig. 2-2-8).

The flow of the Volta is now regulated to some extent by the vast artificial Volta lake, the second largest in the world that is formed behind the dam at Akosombo.

In the closed forest there are following major rivers found: the Tano, the Ankobra, and the Pra, all of which have their sources within the forest and flow roughly north-south into the areas. All these rivers are still actively working to enlarge their basins at the expense of others by capturing more tributaries.

Fig. 2-2-8. Major River Basins

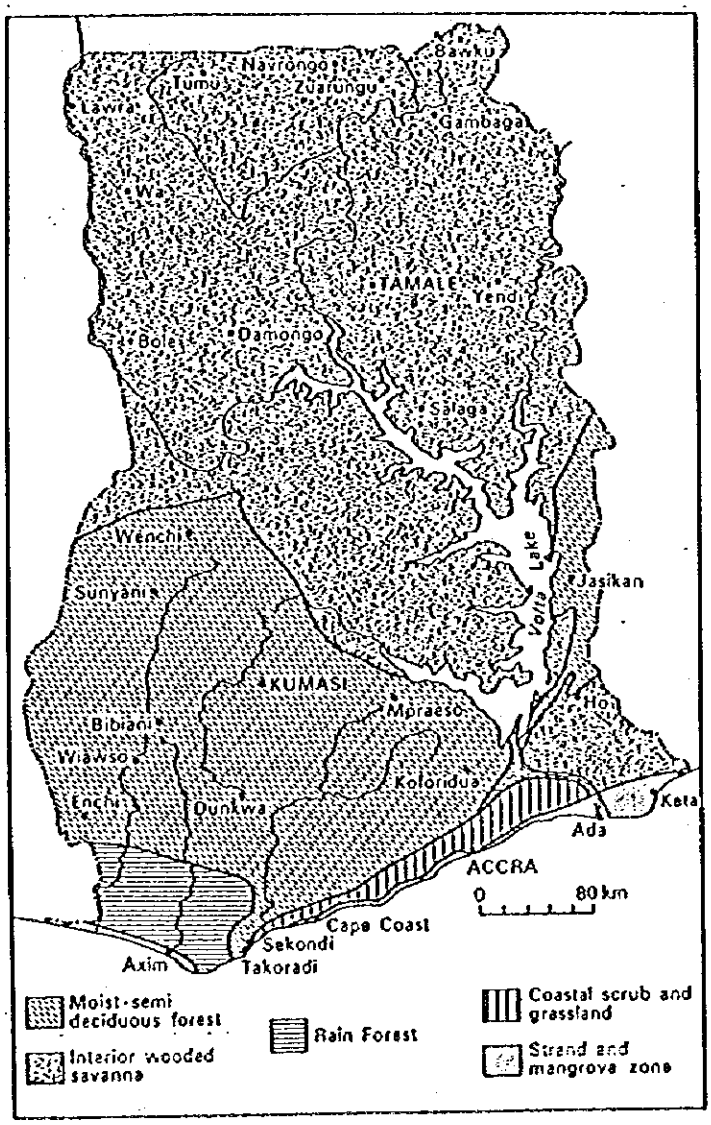


2-2-3. Vegetation and Soils

(1) Vegetation

Vegetation forms an important part of the physical environment and helps greatly in the definition of the resources and character of an area. The vegetation condition of Ghana is subdivided into following five types, almost corresponding to the climatic regions (see Fig.2-2-9).

Fig. 2-2-9. Vegetation Types



a) The Rain Forest

It lies in the south-western equatorial climatic region. The high temperatures and the heavy rainfall (above 1,900 mm) which is well distributed throughout the year promote very rapid plant growth. The forest looks luxuriant and every green all the time.

The rain forest consists of three layers or strata of trees. They are referred to simply as the upper, the middle and the lower layers. The upper tree layer consists of scattered trees, between 35 and

45 m high. They normally have wide crowns. The lower tree layer consists of numerous trees with narrow closely packed crowns. Immediately below this layer is the undergrowth with the ground vegetation which consists of low young trees and seedlings and herbs.

b) Moist Deciduous Forest

This occurs in the wet semi-equatorial climatic region where the annual rainfall is between 1,250 and 1,750 mm and the dry season are more clearly marked. The forest contains most of the country's valuable timber trees.

Although the moist deciduous forest does not differ much in appearance from the rain forest, it is distinguished by the fact that many of the trees in its upper and middle layers exhibit deciduous characteristics during the long dry season when the influence of the harmattan is greatly felt.

c) Interior Wooden Savanna

The wooden or tree savanna only occurs in parts of tropical continental climatic region of Ghana. Although its boundaries are not permanent, at present it constitutes the single largest vegetation zone in Ghana covering an area of about 170 km^2.

Only trees such as the baobab, the dawa dawa, the acacias and the shea tree which have adapted to this environment are found in this vegetation zone. They are few and widely scattered except along the margins of the moist deciduous forest where the trees often grow quite close together.

d) Coastal Scrub and Grassland

This type of vegetation occurs in the dry equatorial climatic region. This is the belt which receives the least amount of rain in Ghana (between 740 and 890 mm in annual rainfall).

Today, at it consists of dense scrub without grass west of Accra, and mainly grass with isolated patches of scrub and an occasional tree east of Accra. Baobab and nim trees are quite common and in the wetter parts (east of the Volta) fan palms and wild oil palms are also to be found in large numbers.

e) Mangrove Forest

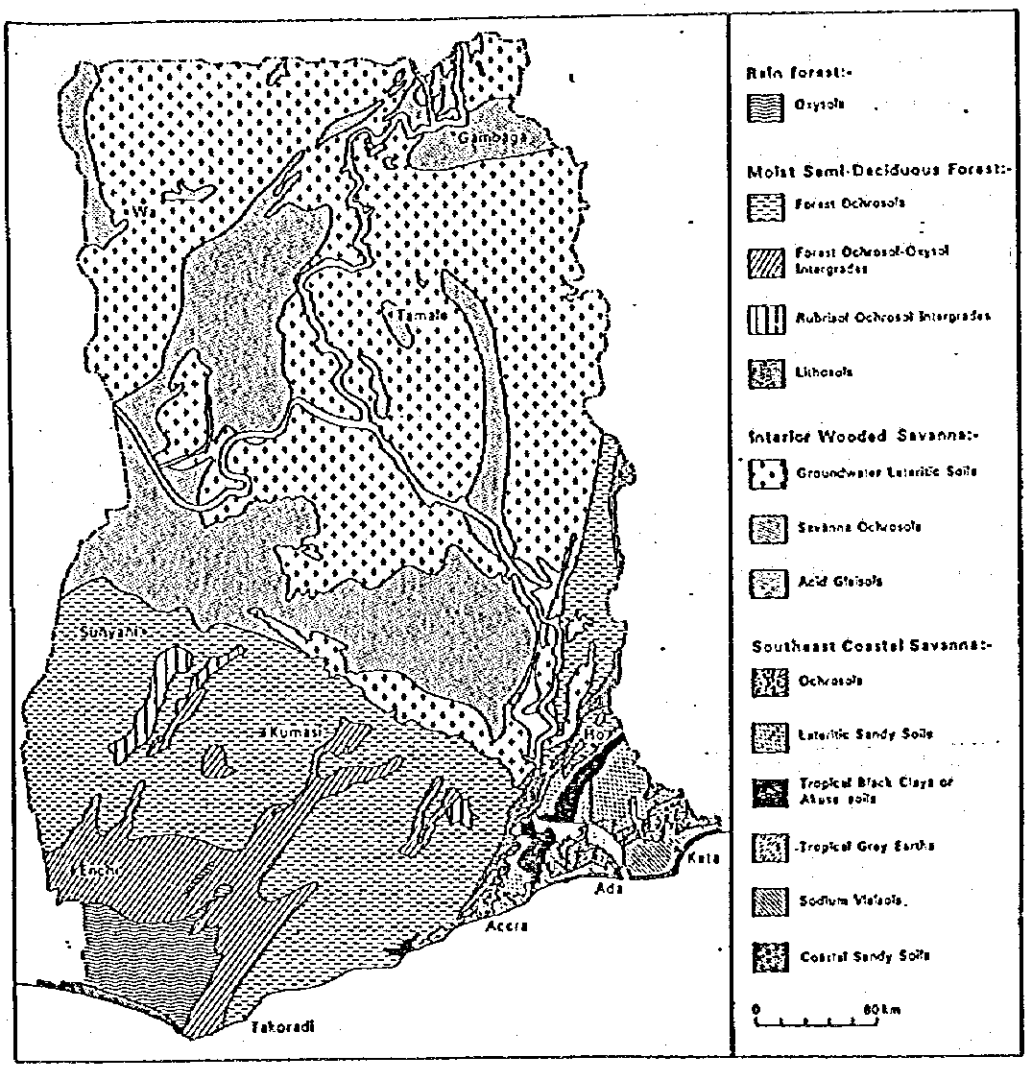
The mangroves are found along the coastal lagoons where the soil is waterlogged and salty. The mangrove trees grow to a height of between 12 and 15 m and are closely packed and green in appearance throughout the year.

(2) Soils

Soils are another important element of the physical environment as well as geology, relief and drainage, climate and vegetation mentioned so far. Among them, geology, climate and vegetation are the most significant factors affecting the nature of soils.

Since the geology, climatic regions and vegetation types are generally confirmable each other, the soils in Ghana are classified into four major soil groups (and several subgroups) corresponding to the vegetation types. These are (a) Rain Forest Series, (b) Moist Semi Deciduous Forest Series, (c) Interior Wooded Savanna Series, and (d) Southeast Coastal Savanna Series, as shown in Fig.2-2-10.

Fig.2-2-10. Major Soils of Ghana



2-2-4. Hydrogeology

Generally, a hydrogeological condition is highly influenced by characteristics and structure of basic geology and climate of the area. In Ghana, the hydrogeological regions and their characteristics are very similar to the local geological condition, because the climatic regions of the country are mostly confirmable to the geological regions.

As shown in Fig.2-2-11, the land of Ghana is divided into 10 hydrogeological regions, and they are briefly explained below.

Region 1. North and northwest region of granite and subsidiary Brirrimian metamorphics. Poor dry season surface supplies. Shallow groundwater scanty. Suitable for boreholes of yield 15 to 75 l/min and for superficial storage both at carefully selected localities.

Region 2. Voltaian quartzites and shales, flat-lying. Poor to fair dry season surface supplies. Shallow groundwater scanty; not generally suitable for boreholes. Superficial storage at selected localities recommended.

Region 3. Voltaian quartzites, flat-lying. Fair to good dry season surface supplies and shallow groundwater. Boreholes not generally suitable. Superficial storage (e.g. collecting boxes), and wells recommended.

Region 4. Voltaian shale and mudstone, flat-lying. Very poor dry season surface supplies; shallow and deep groundwater scanty. Not suitable for wells or borehole. Superficial storage recommended.

Region 5. Voltaian arkoses and shales, latter folded in east of area. Poor dry season supplies away from Volta, Oti and Obosum rivers. Shallow groundwater scanty but borehole prospects fair to good.

Region 6. Togo and Buem quartzites, phyllites and mudstones; highly folded and well jointed. Surface supplies fair to good. Borehole prospects good.

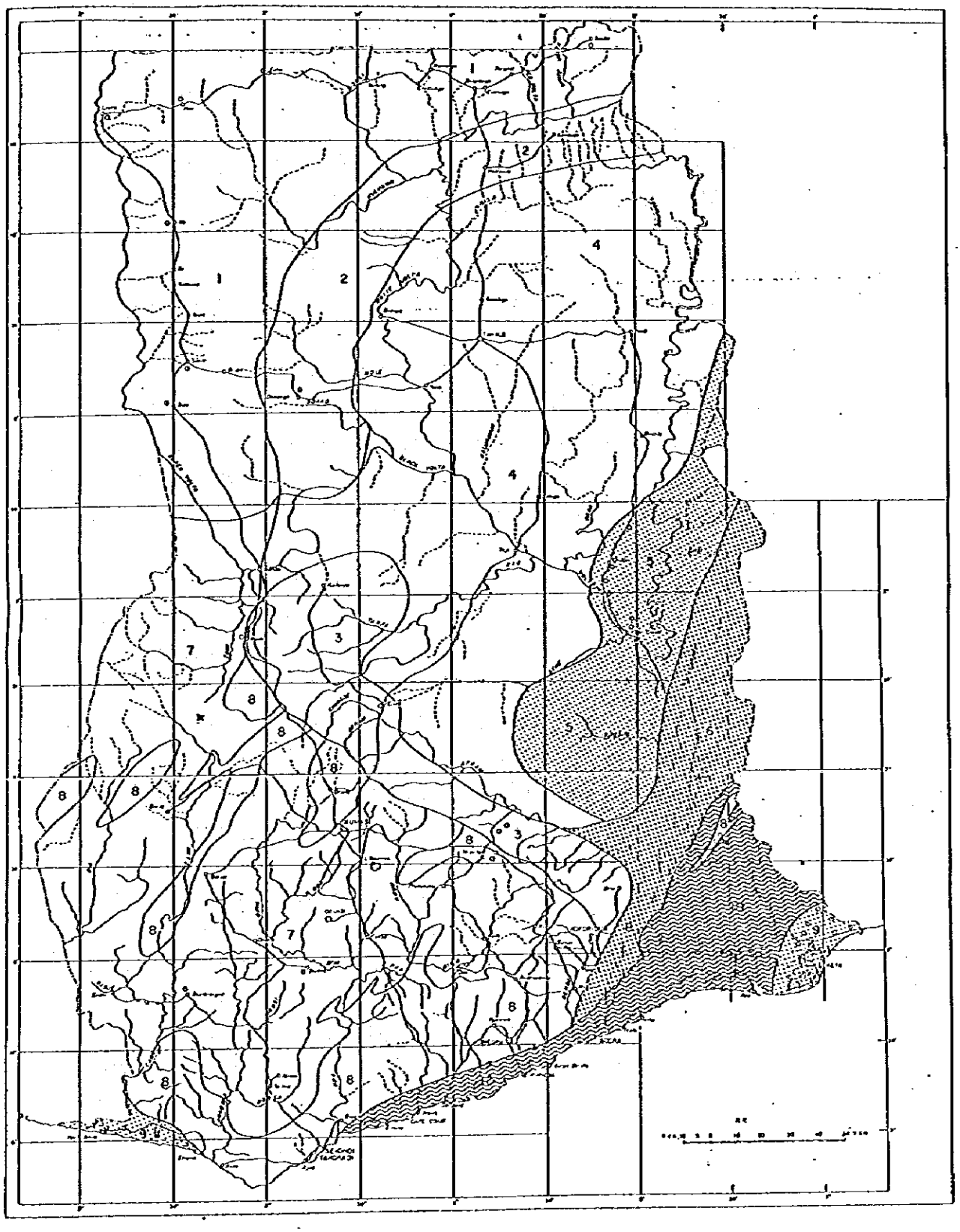
Region 7. Birrimian schists, phyllites, greenstones and greywackes; highly folded. Surface supplies and shallow groundwater fair to good. Borehole prospects fair to good especially where quartz veining abundant.

Region 8. Granite and granitic gneisses. Surface supplies fair to good. Shallow groundwater fair to good. Not generally suitable for boreholes. Wells and superficial storage recommended.

Region 9. Southeastern and Southwestern Cretaceous and Tertiary sediments. Surface supplies and shallow groundwater poor to fair. Borehole prospects very good well-defined aquifers.

Region 10. Dahomeyan acid and basic gneisses, sediments of the Volta delta, and coastal savanna zone. Very poor dry season surface supplies. Shallow and deep groundwater scanty and where present unpalatable. Boreholes not suitable. Superficial strange recommended.

Fig. 2-2-11. Hydrogeological Regions



2-3. Present Situation of Water Supply

2-3-1. Administrative Organization of Water Sector

(1) GWSC

The GWSC which was created by ACT 310 in 1965 under the Ministry of Works and Housing, is the most significant institution in the water supply sector. It is directly charged with responsibility for development, operation and maintenance and water quality control of urban and rural water supplies and for sewerage and sewage disposal.

Figure 2-3-1 shows the organization of the GWSC. The GWSC is basically a decentralized organization with each of its Regional Offices having responsibility for the operations and cost recovery in each Region, within controls and standards set by its Headquarters in Accra.

The GWSC's number of employees grew to about 8,000 by 1983, its qualified staff shrank to one-third of those employed a decade previously. This shortage of the right staff and inadequacy of operative and senior staff training, while the number of water systems were increasing, together with inadequate levels of tariffs since 1979 in order to generate funds for satisfactory operations and maintenance, have debilitated and bankrupted the organization.

Table 2-3-1 shows the balance table of the GWSC for 1985. The revenue mainly from the water rate is only 470 ¢M. On the other hand, the facility operating cost such as personnel, electric power, and chemical cost is 1,470 ¢M, more than three times of that revenue. The expenditure including the repayment and interest of the debt is 1,530 ¢M, i.e., a shortage of balance of 1,060 ¢M. With a subvention of 240 /M from the Government, a deficit of about 820 ¢M is estimated.

In order to assist the Government of Ghana the World Bank (IDA) provided a credit of SDR 11.8 million, in 1983, to rehabilitate the Kpong/Tema/Accra pipeline which was indanger of complete failure. Furthermore, the Credit provides for emergency spare parts and vehicles as well as institutional strengthening. The latter is by way of funds for 30-man years of technical assistance and to finance a full organization and management study. The technical assistance (the management improvement programme), including redefining relations with the Government revising the organization structure and design of new personnel, training and accounting systems was commenced in 1984 for completion in two years at which time the Credit would finance further technical assistance to help the GWSC with its transformation.

Figure 2-3-1. Organization of GWSC

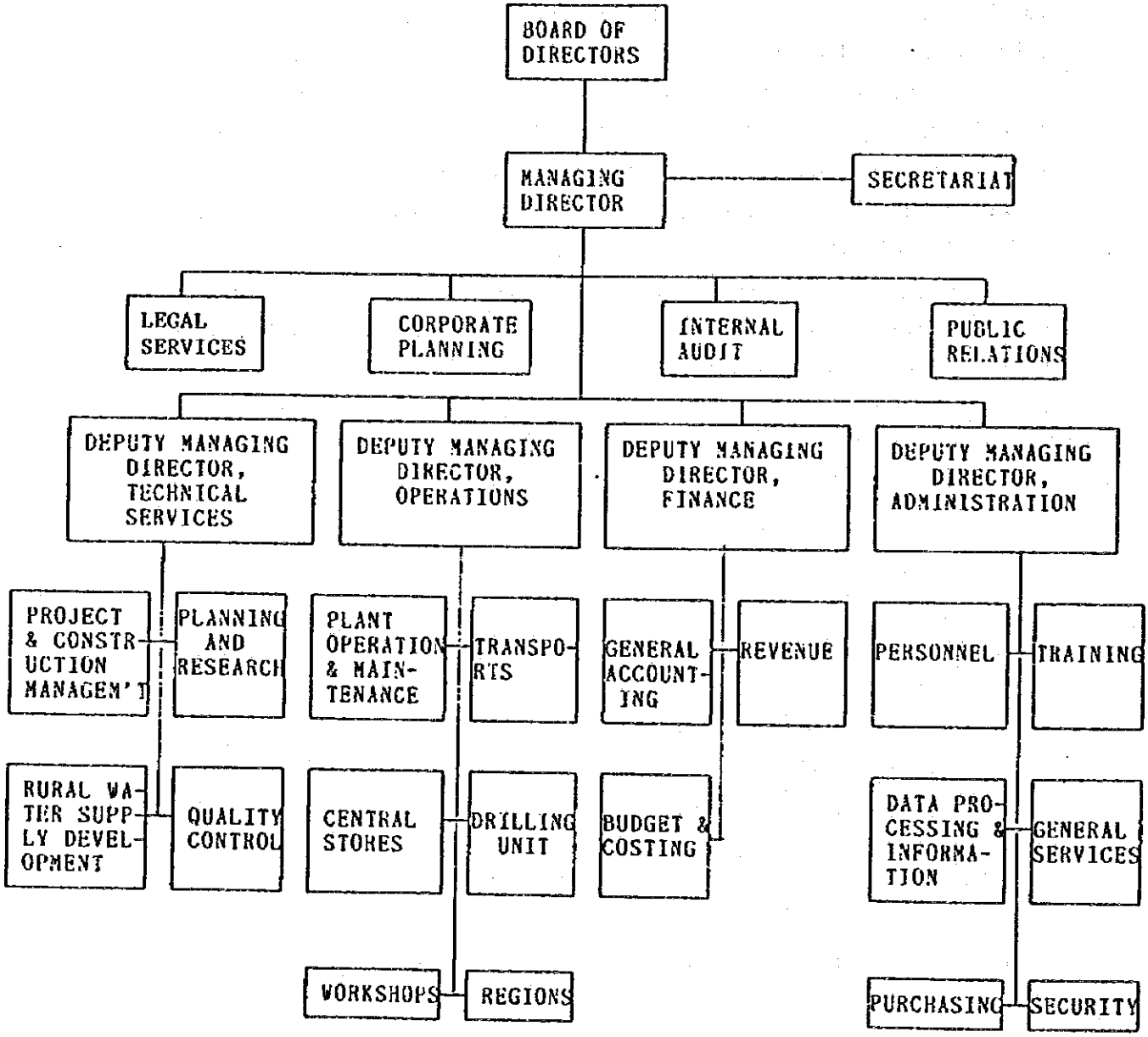


Table 2-3-1 Income Statement Forecast of GWSC for 1985

(¢M)

Operating Data		
(1)	Production (million gal)	36,720
(2)	Sales (- do -)	20,800
Revenue		
(3)	Sales of water	403
(4)	New connections	2
(5)	Miscellaneous	67
(6)	Sub-total	472
Expenses		
(7)	Personnel	414
(8)	Electricity	291
(9)	Transport (hired)	58
(10)	Other contractual	137
(11)	Chemicals	270
(12)	Fuels and lubricants	104
(13)	Other commodities	101
(14)	Sub-total (operating expenses)	1,375
Debt Service		
(15)	Principal reports	69
(16)	Interest	86
(17)	Total cash expenses (14)+(15)+(16)	1,530
(18)	Operating losses (17)-(6)	1,058
(19)	Government subvention	242
(20)	Cash shortfall	816

(GWSC: Public Expenditure Review)

(2) Drilling Unit

The GWSC has a Drilling Unit which specializes in the groundwater development. The Drilling Unit has its head office at Kumasi in Ashanti Region and has carried out the groundwater development mainly by boreholes over the past 20 years.

The Drilling Unit now has been staffed in 25 staffs, 51 staffs for drilling and workshop, and 13 auxiliarys staffs, totalling 89 members.

The table 2-3-2, 2-3-3 show the list of the drilling rigs and supporting vehicles owned by the Drilling Unit.

Table 2-3-3 List of present Drilling Unit Vehicles

No.	Vehicle type	Model	Condition
1	Truck	Hino/FF173-S	Good
2	- ditto -	- ditto -	- ditto -
3	- ditto -	- ditto -	- ditto -
4	- ditto -	Layland	A little good
5	- ditto -	Berllet	Bad
6	Light vehicle	Toyota	A little good
7	- ditto -	Nissan	- ditto -

Reportedly, the Drilling Unit has nine drilling rigs, most of which are deteriorated and only six of which are operated now. The actual drilling results of the Drilling Unit for the last two years are shown in the table below.

Table 2-3-2. Drilling Rigs and Their Supporting Transport (Drilling Unit)

Drilling Rig No.	Type	Maker	Model	Date Commissioned	Condition	Supporting Transport	Date Commissioned	Capacity (ton)	Conditione
1	Rotary	Mayhew	1500	1974	Fair	Mack	1974	15	Poor
2	Rotary	Cyclone	TH60	1974	Poor	Mack	1974	15	Poor
2	Percussion	Rustn*	22RW	1948	Poor	Leyland	1975	7	Fair
9	Percussion	Rustn*	22RW	1953	Poor	Berliet	1976	3	Fair
13	Percussion	Rustn*	22RW	"	Very poor	Hino	1984	7	Good
18	Percussion	Rustn*	60RL	1962	Fair, but prime mover is poor	Hino	1984	7	Good
19	Percussion	Rustn*	60RL	"	Fair	Hino	1984	7	Good
20	Percussion	Rustn*	60RL	"	Poor	Hino	1984	7	Good
30	Percussion	Rustn*	22RW	1972	Fair	Leyland	1981	10	Fair

* Ruston Bucyrus

Table 2-3-4 Actual drilling results of Drilling Unit for last two years

	Boreholes drilled Percussion	Boreholes drilled Rotary	Total	Successful boreholes	Successful rate
1983	16	108	124	57	* 40%
1984	9	124	133	113	* 85
Total	25	232	257	170	av. 66

The Drilling Unit has a workshop and a warehouse at Kumasi. Table 2-3-5 shows the equipment and tools owned by the workshop.

Table 2-3-5 List of Existing Equipment and Tools of Workshop, Drilling Unit

No.	Classification	Capacity	Quantity
1	Electric Welder		2
2	Mobile Gravity Crane	5-ton	1
3	Blacksmith Hearth		1
4	Battery Charger	10 A	1
5	Portable Lathe		1
6	Air-Compressor		1
7	Hydraulic Press	30-ton	1
8	Table Grinding Machine		1
9	Engine Hoist		1
10	Floor Jack		1
11	Valve Grinder		1
12	Slothing Machine		1
13	Piller Drilling Machine	Medium size	1
14	Coupling Forming Machine	for P.V.C.	1
15	Gas Welder Outfit		1
16	Others		1

*) Reportedly, the difference results came from the fact that the drilling was carried out at the central area of communities until 1983, while at the valleies remote from communities in 1984.

The Drilling Unit has assigned seven hydrogeologist, who have performed the siting, supervision, casing design of boreholes, etc. However, since they have no scientific measures such as geophysical prospecting equipment for siting, they have faced difficulty that the successful rate of borehole drilling can hardly be increased.

(3) Maintenance and operation system

Responsibility for operation and maintenance of water supply installations falls on three bodies at different organizational levels: the Head Office, the Regional Offices and the Central Workshops.

The Head Office attends to the policy making, guidance and coordination aspects of O & M.

Responsibility for actual operation and maintenance of GWSC water supply facilities lies with the individual regions which, in theory, enjoy some measure of organizational independence. Organizationally, the region contains a regional head office, regional stores and workshops, and district centres, the numbers of which are governed by the size of the region and type and number of water supply systems. The region is headed by a manager, who is responsible for all activities, including administration, collection of fees for sale of water, and construction of new projects. The regional manager is assisted by a regional engineer, who is directly in charge of operation and maintenance of water supply installations.

There are three types of workshops serving the GWSC systems:

- Central workshops (the term is used here to include both the Central Workshop in Tema and the Base Workshop in Kumasi)
- Regional workshops
- District workshops

The workshops are described below. In addition to the above facilities, it should be borne in mind that there are also workshops attached to most of the large scale facilities.

The Central Workshop in Tema and the Base Workshop in Kumasi provide repair services, including those requiring a high level of skill, as well as general repairs of all types to all GWSC water facilities. Both workshops are equipped with tools and machinery for metal working and machining. In addition, they operate mobile workshops, which are staffed by skilled personnel and which cover large areas of the country. Both workshops also maintain a central store containing spare parts for pumping and electrical equipment.

The Central Workshop in Tema serves the Greater Accra, Central, Eastern and Volta Regions. It also provides all regions with electrical services, including electric motor repairs such as winding, drying and lacquering. While the Base Workshop in Kumasi serves the Ashanti, Brong-Ahafo, Northern, Upper East, Upper West and Western Regions. It does not undertake electrical repairs, these being handled by the Central Workshop in Tema.

The Regional workshops have evolved into the repair centers for the entire regions, and attend to all the region's needs, including those relating to vehicles, carpentry, buildings, etc. The Regional workshops also provide routine and preventive maintenance for the water supply systems. However, effective maintenance is hampered by the shortage of trained manpower, the poor condition of tools, and lack of spare parts and vehicles.

The District workshops were originally intended to assist in carrying out mainly routine and preventive maintenance for GW* and PP* systems, as well as to some degree for MCT* systems. However,

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GW: Groundwater system, PP: Package treatment plant system,
MCT: Medium capacity conventional treatment plant system.

only some of the district workshops initially planned have been established so far, and these are both ill-equipped and understaffed.

The absence of a systematic operation and maintenance regime is one of GWSC's severest problems. The condition is a result of a number of factors arising from Ghana's economic situation, among them lack of spare parts and equipment owing to financial difficulties and problems in obtaining import licences, lack of planning and organization, and a dearth of qualifies personnel.

The Head Office, the Regional Offices and the Central Workshops which have responsibility for operation and maintenance of water supply installations have neither been able to cope with basic O & M functions nor coordinate activities with each other. The result is steady deterioration of equipment and facilities, and an unreliable water supply. The responsibility for activities of the Head Office lies in the hands of the Chief Engineer. However, since the Chief Engineer is also responsible for numerous other affairs, such as construction of new water supply schemes, transportation, etc., he is unable to devote sufficient time to organization of O & M functions, The system is thus characterized by an absence of organized planning and policy making on the basis of records and record analysis at Head Office level and by ad hoc decision making for solving of immediate problems.

In the region level, limited resources, lack of adequate infrastructure and untrained manpower have made systematic planning and organization of O & M activities extremely difficult. There has thus been no systematic planning and programming of O & M, and although annual programmes have been prepared, they are inapplicable in view of the limited resources. As a result, much equipment in the systems remains idle, while haphazard repair of equipment has forced the regional engineer to be constantly travelling between the various water supply systems.

Regional workshops, with the exception of the one in ATMA, are poorly equipped and housed in unsuitable structures. Spare parts in regional stores are scarece, and no proper inventory is maintained. Only some of the district workshops originally planned exist, and these have hardly any equipment and only limited manpower.

Table 2-4-5 shows the deployment of the personnel for the maintenance/operation and repair shop except for the head office for each region.

(4) The O & M system for the borehole facilities with hand-pumps

Maintenance of water supply systems, like other aspects of GWSC's operations, has been traditionally administered by autonomous Regional Headquarters.

Early in the 1970's the formation of District Offices with workshops and stores attached was initiated in the Regions, to improve the maintenance facilities for the water supplied in the rural areas. But the workshops and maintenance crews at the Districts have almost always concentrated on the maintenance and repairs of pipe-borne water supply systems. As a result the hand-pump systems commissioned by the Drilling Unit were left un-attended to, and most of them have fallen into disuse.

To forestall the non-maintenance of their systems, both URWSP and the 3,000 Well Drilling Programme introduced the setting up of well maintenance units as a major part of the projects. The strategy involved the re-organization and strengthening of existing GWSC facilities in the Regions to meet the increased maintenance needs related to the projects' installations.

The basic concept of the maintenance programme for each project is for regular inspection and preventive maintenance of each pump with major repair or replacement on an as-required basis.

Table 2-3-6 CWSC Personnel Deployment for Each Region

	Ashanti	Brong Ahafo	Central	Eastern	Greater Accra	Northern	Upper East	Upper West	Volta	Western	Tema	Kumasi	Total
Water Supply Systems	315	182	153	155	318	69	151	84	318	172	-	-	1,917
Regional and District Workshops	11	30	85	16	62	20	27*		35	18	-	-	304
Central Workshops	-	-	-	-	-	-	-	-	-	-	82	89	171
Total	326	212	238	169	380	92	262*		344	190	82	89	2,392

(G W S C)

* For Upper East and Upper West Regions together.

Inspectors riding motorcycles regularly visit each pump to ensure it is operating, liaise with the pump-users on site and pump maintenance and make necessary above-ground repairs. Service crews in trucks capable of complete field servicing of the pumps fix pumps when the Inspector was unable to repair, either because he did not have the correct part with him or because the pump unit required removal from the borehole. The two separate functions by the pump inspectors and the service crews are coordinated and operated as one. Both maintenance organizations had the common aim of performing practical servicing and repairs of the hand-pumps, boreholes, and maintenance vehicles, and the training of Ghanaian personnel to undertake the maintenance operation on their own in future.

(5) Water charges system

The GWSC establishes the stepped water tariff as shown in Table 2-3-7. The maximum rates are charged to the beneficiaries receiving water and sewerage services in the ATMA area (Metropolitan area) such that 44 Cedis/1000 gallons is charged for industrial use with 260 Cedis/month as minimum charges, and 30 Cedis/1000 gallon for domestic use with 90 Cedis/month as minimum charges. The minimum rate, 24 Cedis by the month is charged to the beneficiaries using a stand pipe in the region or district capitals. The own tap utilizers without meters and stand pipe utilizers in the areas other than district capitals are not charged. An extra charging system according to the water quantity used is also not applied to this system.

The GWSC water charges revenue has been decreased year by year because of such causes as the unstable facility function due to shortage of spare parts, irregular water supply due to unstable fuel supply, impossibilities of failed water meter renewal, and lack of meter-check and charges-collecting personnel. The average tariff for the total water supply quantity in 1984 was only about 20 Cedis/1000 gallons.

In an estimation for 1985, the water quantity for which water rate can be charged will be 20,800 million gallons (100 million m^3), 57 percent of the water supply quantity 36,700 million gallons (170 million m^3), and the charges revenue will only be 400 million Cedis.

Table 2-3-7 Water Tariff

	ATMA Area	Secondi/ Takoradi & Kumasi	Regional/ District capitals	Other areas
Non-domestic,				
(1) Metered house or premises with water & sewerage services,	44/260	-	-	-
(2) Metered house or premises with water services only,	36/220	36/220	24/145	22/130
Domestic Premises,				
(3) Metered house or premises with water & sewerage services,	30/ 90	-	-	-
(4) Metered house or premises with water services only,	22/ 70	22/ 70	20/ 60	18/ 60
(5) Unmetered house or premises with water services only,	0/ 60	0/ 60	0/ 40	-
(6) House or premises without private connections.	0/ 30	0/ 30	0/ 24	-

Notes: (1) The numerator is water charge per 1000 gallons.
(2) The denominator is minimum charges or flat rates per month.
(3) All rates are in Cedi.

(Water Charges Regulation, 1984)

2-3-2 General water supply circumstances

(1) Outline

For the provision of portable water for domestic and industrial purposes, the GWSC utilizes both surface and groundwater resources. The groundwater-based water supplies may be by means of boreholes fitted with hand-pumps for communities of less than 2,000 people at a ratio of one well per 400 persons, or by mechanized boreholes for centers of population over 2,000. For the communities of less than 400 people, water sources such as hand-dug wells or small reservoir are to be utilized.

(2) Municipal water supply

The GWSC operates some 208 piped water supply systems in the ten Regions of Ghana, and supplies water to 3.6 million inhabitants, 30 percent of the total population 12 millions.

Ghana has 135 urban towns with a population 5,000 or more, of which 132 towns are served by 77 water supply systems. The facilities of the three remained towns are now under construction. Among 208 water supply systems including the local towns with a population 2,000 or more, 105 facilities use the mechanized boreholes and 99 facilities are based on the surface water as a water source.

Table 2-3-8 and 2-3-9 show the number of facilities for each type and their operation rate. Table 2-3-10 also shows the number of facilities for each Region and their operation rate.

As shown in Table 2-3-11, the nominal water supply capacity by these facilities is 182 MCM per year. Since the 1970's, these facilities have been operated with few spare parts imported due to an extreme shortage of the reserve in foreign exchange. Sixty

percent of the these facilities have deteriorated, resulting in a reduced capacity or non functioning. This means that the actual water supply quantity now is only 157 MCM per year, 87 percent of the nominal capacity. If these facilities are not properly rehabilitated, the water supply capacity is estimated to decrease to 112 MCM per year, 62 percent of the nominal capacity in five years hence. Since, in actual fact, the water utilizing population has doubled after the early 1970, the water supply circumstances at local towns in particular becomes seriously worse.

Table 2-3-8 The Number of Facilities for Each Type and Their Operation Rate

Type of System	Systems					Pumping Units				
	No.	Operative Units	%	Inoperative Units	%	No.	Operative Units	%	Inoperative Units	%
GW	105	73	70	32	30	187	103	55	84	45
PP	65	30	46	35	54	111	32	29	79	71
MCT	23	22	96	1	4	124	93	75	31	25
HCT	11	10	91	1	9	112	79	71	33	29
BS	4	4	100	-	-	11	5	45	6	54
Total	208	139	67	69	33	545	312	57	233	43

Notes: GW; Groundwater system,
PP; Package treatment plant system,
MCT; Medium capacity conventional treatment plant system,
HCT; High capacity conventional treatment plant system,
BS; Booster station system.

Table 2-3-9 Water Supply Capacity and Actual Water Supply Quantity

Type of System	Design Discharge m^3/hr	% of Total	Actual Discharge m^3/hr	% of Design Discharge	Power Rating* Total kW	%	E C G kW	%	Local kW	%
GW	2,039	8	1,196	56	2,771	100	361	13	2,410	87
PP	938	4	537	57	2,282	100	71	3	2,211	97
MCT	2,284	9	1,938	85	5,609	100	1,214	22	4,395	78
HCT	19,507	79	18,597	95	37,682	100	33,020	88	4,662	12
BS	18	-	18	100	1,744	100	1,211	69	533	31
Total	24,786	100	22,286	90	50,088	100	35,877	72	14,211	28

* Including standby units

Table 2-3-10 Water Supply Capacity and Actual Water Supply Quantity for Each Region

Region	No.	Discharge (m^3/hr) Design	Actual	Power Supply (kW) E C G	Local
1. Ashanti	28	3,408	2,676	2,982	1,587
2. Brong-Ahafo	28	818	577	9	3,398
3. Central	14	2,123	1,698	1,715.5	1,475
4. Eastern	36	1,473	1,209	1,912.8	1,585
5. Greater Accra*	4	13,000	13,000	22,576	544
6. Northern	16	1,111	1,025	3,684	2,408
7. Upper East	15	493	243	-	1,206
8. Upper West	13	197	123	34	372
9. Volta	32	442	231	1,042	-
10. Western	22	1,421	1,293	2,633	594
Total	208	25,786	22,286	35,877.3	14,211

* Including sewage system

Table 2-3-11 GWSC Water Supply Capacity and Restoration Effect by Rehabilitation Work

(MCM/year)

	Current facility capacity (nominal) (1)	Current actual water supply quantity (2)	Reduced capacity without rehabilitation work (3)	Rehabilitation work effect: Resoration capacity (4)=(1)-(2)	Rehabilitation work effect: Prevented reduced capacity (5)=(2)-(3)	Rehabilitation work effect: Total (6)=(4)+(5)
Metropolitan area, Kumasi, Second/ Takorade areas	123	118	91	5	27	32
Other large and medium scale systems	32	27	14	5	13	18
Small scale system	27	14	7	13	7	20
Total	182 (110.0)	159 (87.4)	112 (61.5)	23 (12.6)	47 (25.8)	70 (38.5)

(GWSC: Five-year Rehabilitation and Development Programme)

(3) Rural water supply

The spread of the rural water supply facilities in Ghana was of poor level, so that the women and children labour consumed for fetching water was enormous, the disease occurence rate due to untreated drinking water was extremely high, and the medical expense burden of the local inhabitants was not light.

The GWSC Drilling Unit constructed about 1,500 boreholes completed by steel pipes with 150 to 250 mm diameter until 1960's, and most of them has been utilized for water supply by mechanized pumps. Now, most of these boreholes installed by steel pipe are said to be non-functional due to screen corrosion.

In the 1970's, considering the importance of the rural water supply, the GWSC decided to construct the boreholes installed by plastic pipes with a small dia. of 100 to 150 mm (called shallow borehole) with hand-pumps for rural inhabitant. Up to now, the GWSC has independently completed about 700 such boreholes.

The rural water supply facilities constructed by the GWSC number in 10,633 as of 1985, as shown in Table 2-3-12.

Table 2-3-12 Local Water Supply Facilities (as of 1985)

Dug well	9,482
Borehole (with hand-pump)	700
Reservoir	98
Weir intake	353
Total	10,633

(4) Water-borne Diseases

With 33 areas over the whole nation sampled to be investigated, the Ministry of Health investigated the occurrence of water-borne diseases which hospitals and clinics examined during five years 1964 to 1968.

Although the investigated results are not always satisfactory such that the data for a specified year is absent or the report on a specified disease in a specified area is unavailable, an annual mean numbers of the occurrences reported are arranged as shown in Table 2-3-12.

This data, which was obtained more than 18 years ago and somewhat old, covers the large cities or local towns as the investigated areas and the water supply circumstances has not remarkably improved since that time, so that the data can be considered to be still effective now.

Comparing this data with the population in 1970 at the investigated areas, for the object population 2,758,000, the occurrences are an annual mean value of 122,000, which means that the occurrence rate is such an extremely high rate as 44 persons per 1,000 persons. With respect to region classification, the highest rate area is the Northern Region (116 persons), followed by the Ashanti Region (100 persons), the Eastern Region (83 persons), and the Central Region (70 persons).

With respect to disease classification, the highest percent disease is the unspecified diarrhea disease which accounts for 62 percent of total diseases, followed by schistosomiasis (14 percent), bacillary dysentery (8 percent), and infectious hepatitis (6 percent).

Guinea worm infections and schistosomiasis, relating to the

Table 2-3-13 Number of Disease Outbreaks Resulting from Water in Ghana (Mean Value during 1964 to 1968)

Investigated areas	Total population (1970)	Bacterial dysentery	Amebic dysentery	Unspecified diarrhea symptoms	Weil's disease	Typhoid/ Paratyphoid	Tularemia	Guinea worm infectious symptoms	Schisto-somiasis disease	Infectious heptatitis	Total	Symptoms occurence rate (per 1000 persons)
Greater Accra region												
(1) Accra	636,067	253	234	11,009	-	312	1	32	332	417	12,590	19.8
Eastern region												
(2) Kohoridoa	69,776	528	109	2,987	65	120	-	120	1,110	305	5,344	76.6
(3) Enusawamu	69,289	512	331	407	73	146	-	136	1,224	415	3,242	46.8
(4) Somania	62,357	636	293	3,542	18	44	-	128	1,925	791	7,377	118.3
(5) Enukaukau	84,850	177	161	558	-	92	-	59	415	379	1,841	15.8
(6) Akiokum	78,797	369	348	1,117	7	128	-	151	930	317	3,367	42.7
Subtotal	365,069	2,222	1,242	8,611	163	530	-	594	5,604	2,205	21,171	58.0
Central region												
(7) Capecoast	70,729	27	19	4,736	-	37	-	179	533	107	5,638	79.7
(8) Saltpond	11,800	43	75	202	-	12	-	24	10	69	435	36.8
(9) Dankua	15,400	-	10	357	-	3	-	2	360	29	761	49.4
Subtotal	97,929	70	104	5,295	-	57	-	205	903	205	6,834	69.8
Western region												
(10) Seconde/Tacorade	160,368	964	57	671	-	50	-	271	403	87	2,503	15.6
(11) Tarukua	14,700	16	11	647	-	18	-	28	179	564	1,463	99.5
(12) Akimu	53,138	167	12	517	-	108	-	111	175	79	1,169	22.0
(13) Sefipasso	5,600	5	3	-	-	28	-	12	250	20	318	56.8
Subtotal	234,356	1,152	83	1,835	-	204	-	422	1,007	750	5,453	23.3
Ashanti region												
(14) Mamupong	55,923	1,128	22	2,296	-	-	-	62	134	91	3,733	66.8
(15) Beguwai	34,496	-	-	492	-	-	-	600	293	-	1,385	40.1
(16) Conongo	25,138	39	7	1,312	-	78	-	2	180	634	2,252	89.6
(17) Kumasi	260,300	145	60	19,921	-	194	-	82	4,664	253	25,319	97.3
Subtotal	375,857	1,312	89	24,021	-	272	-	746	5,271	978	32,689	87.0
Brong-Ahafo region												
(18) Sunyani	60,344	393	-	516	-	200	-	12	134	87	1,142	18.9
(19) Wenchi/Kintampo	98,091	577	-	491	-	52	-	15	215	35	1,385	14.1
(20) Atebubu	59,101	448	-	402	-	10	-	17	165	10	1,052	17.8
(21) Goaso	44,931	239	-	382	-	17	-	8	73	18	737	16.4
Subtotal	262,467	1,657	-	1,591	-	279	-	52	587	150	4,316	16.4
Northern region												
(22) Tamare	98,560	640	200	9,700	-	6	-	1,651	1,832	202	14,231	144.4
(23) Saraga	73,029	-	10	3,710	-	6	-	148	82	116	4,072	55.8
(24) Gambago	85,736	271	57	5,080	-	34	-	291	71	984	6,788	79.2
(25) Damongo	40,784	248	118	829	-	9	-	362	32	524	2,122	52.0
(26) rende	56,753	527	210	2,748	-	59	-	503	108	292	4,447	78.4
Subtotal	354,862	1,686	595	22,067	-	114	-	2,955	2,125	2,118	31,660	89.2
Volta region												
(27) Ho	37,938	139	212	-	-	25	-	142	85	14	617	16.3
(28) Ketekurachi	107,541	5	8	-	-	19	-	30	260	44	366	3.4
(29) Hohoe	14,800	763	47	9	55	31	-	35	49	169	1,158	78.2
(30) Sagakofe	58,897	216	165	50	3	45	-	132	136	40	787	13.4
(31) Keta	27,404	291	52	22	-	36	-	54	64	27	546	19.9
Subtotal	246,580	1,414	484	81	58	156	-	393	594	294	3,474	14.1
Upper region												
(32) Volgatanga	95,010	200	78	1,217	-	53	-	285	739	185	2,757	29.0
(33) Wa	90,049	202	71	191	-	16	-	146	258	42	926	10.3
Subtotal	185,059	402	149	1,408	-	69	-	431	997	227	3,683	19.9
Total	2,758,246	10,168	2,980	75,918	221	1,988	1	5,830	17,420	7,344	121,870	44.2

The Ministry of Health: This data is based on the diseases data (1970) resulting from water supply and water. The population is the value in 1970 according to the population census report (1984).

surface water such as river and marsh water, provide a possibility of infection when the habitants have access to such water, so that they indirectly relates to the water supply itself. The nationwide occurrence rate (98,398 cases) of such digestive system diseases directly relating to the drinking water as dysentery, diarrhoea symptoms, cyphoid, and hepatitis is still high rate, 36 persons per 1,000 persons.

2-3-3. National policy on water supply

(1) Outline

Economy development policy of Ghana includes the "Economic Recovery Programme (1984 - 1986)" planned in 1983, which indicates the positioning of water supplies sector through the national policy. The GWSC further formulated the "Five-year Rehabilitation and Development Programme (1985 - 1989)" under the guidance of the World Bank. For the Northern Region where an area to be covered by the Project, the Northern Region Rural Integrated Programme (NORRIP) has been enforced.

The above policies are described as follows:

(2) Policy on water sector in the Economic Recovery Programme

The priority policy of the water supply sector in the Programme is the extension of local water supply and the rehabilitation of existing deteriorated facilities. The strategy of rural water supply intends to allocate the labor force consumed for fetching water to agricultural production together with to reduce the burden of medical expenses by healthy water supply.

The fund allocation to water supplies sector, shown in Table 2-3-14, accounts for most of the allocation to social service sectors.

Table 2-3-14. Economic Recovery Programme; Water Supplies Sector

	$M	¢M
Rehabilitation (rural)	5.22	59.00
Rehabilitation (cities & urban)	38.76	239.88
On-going projects (completion)	26.92	297.25
Materials for completion	34.50	
Total	105.40	596.13

(3) Five-year Rehabilitation and Development Programme (1985-1989)

a) Outline

In the view of the water supply condition described in the previous section, the GWSC formulated the "Five-year Rehabilitation and Development Programme" in which the priority in policy is given mainly to the rehabilitation of existing deteriorated facilities.

The programme consists of the five major categories as follows:

i) Rehabilitation of existing systems
ii) Capacity expansion and extension
iii) Completion of on-going projects
iv) New rural water supply system
v) Extension and strengthening of the GWSC's administration system such as:

- Planning, research, technical assistance
- Water meter, billing and revenue collection facilities
- Vehicles, drilling rigs, radio communication facilities, etc.
- Workshops, stores, office, etc.

The Programme features the policy which does not approve a new project except for new rural water supply facilities regarded as

important in the Economic Recovery Programme, and gives priority to the completion of the on-going project and to the rehabilitation of existing facilities over the expansion or extension of existing facilities. Table 2-3-15 shows the investment schedule of the Programme.

For a required total project cost 222$M, in the Programme, 145$M will be invested with an achievement ratio of about 65 percent expected. The allocation of the investment accounts is such that 49 percent of them is first allocated to the completion of the on-going projects (51 projects in the whole nation), followed by the rehabilitation of existing facilities (128 projects, 24 percent), administration system (14 percent), rural water supply (36 projects, 11 percent), and then expansion and extension (47 project, 3 percent). Table 2-3-16 shows the number of projects for each Region and projects.

Table 2-3-16. GWSC Five-year Rehabilitation and Development Programme, Number of Project for Each Region

Region	Rehabilitation	Expansion	Completion	Local Water Supply
Ashanti	14	6	7	6
Brong Ahafo	9	15	7	8
Central	13	3	2	2
Eastern	35	-	9	3
Greater Accra	5	-	5	-
Northern	15	10	10	7
Upper	5	5	4	6
Volta	17	3	3	2
Western	5	5	4	2
Total	128	47	51	36

b) New rural water supply system

In the Five-year Rehabilitation and Development Programme, the new construction of rural water supply system consists of the following:

Table 2-3-15. Investment Schedule of GWSC Five-year Rehabilitation and Development Programme

(Unit: Million US Dollars)

Item	Required Total Project Cost			Total Project Cost for Five-year Programme			Achievement Ratio	Investment Schedule													
								1985			1986			1987			1988			1989		
	LC	FC	Total	LC	FC	Total	%	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total	LC	FC	Total
ehabilitation of Existing Facilities	17.0	28.3	45.3	12.2	21.9	34.1	75.3	1.8	5.0	6.8	4.1	10.9	15.0	2.3	2.7	5.0	2.4	1.3	3.7	1.8	2.0	3.6
xpansion and Extension of Facility Capacity	21.6	7.3	28.9	2.3	1.6	3.9	13.5	-	-	-	-	-	-	-	-	-	-	-	-	2.3	1.6	3.9
ompletion of Facilities Already Undertaken	36.7	65.6	102.3	20.4	50.3	70.7	69.1	2.1	3.4	5.5	5.7	8.4	14.1	4.4	12.2	16.6	4.6	13.0	17.6	3.6	13.3	16.9
ew Local Water Supply	18.8	5.8	24.6	11.5	4.0	15.5	63.0	-	-	-	0.6	0.3	0.9	3.5	1.3	4.8	3.7	1.2	4.9	3.7	1.2	4.9
dministration System	7.9	13.2	21.1	7.9	13.0	20.9	99.1	2.2	1.6	3.8	1.6	3.2	4.8	1.8	3.8	5.6	1.4	3.2	4.5	0.9	1.2	2.1
Total	102.0	120.2	222.2	54.3	90.8	145.1	65.3	6.1	10.0	16.1	12.0	22.8	34.8	12.0	20.0	32.0	12.1	18.7	30.8	12.1	19.3	31.4

ote: LC: Local currency FC: Foreign currency

(G W S C)

- Construction of hand-dug wells for local communities with a population less than 400
- Construction of borehole facilities with hand-pumps for communities with a population 400 to 2,000.

Hand-dug Well Programme

There are at present about 40,000 rural communities without safe water supply in the country. While some of these communities fall within the 400-2,000 population range and therefore qualify for hand-pump boreholes under GWSC's planning criteria, most of them have less than 400 inhabitants, and will therefore not qualify for hand-pump boreholes.

Attention is being re-directed to the construction of hand-dug wells for these communities. At present a programme code-named "Improvement in Drinking Water and Sanitation" is being undertaken in a joint effort between Ghana Government and UNDP in this respect. The programme is being undertaken in the Central and Volta Regions, by personnel drawn from GWSC, Department of Community Development and the National Service Secretariat. As a pilot project 10 Nos wells may be sunk for each of the 10 Regions of the country.

A project cost of 4.2 ¢M is appropriated for 100 wells with 40 feet depth.

Borehole with Hand-Pump Programme

In the borehole with hand-pump programme, the construction of total 2,245 boreholes facilities including an international cooperation such as 170 boreholes by UNICEF and 455 boreholes by CIDA have been projected. Table 2-3-17 shows the construction programme for each region.

Table 2-3-17. Five-year Rehabilitation and Development Programme (1985-1989)
Borehole with Hand-Pump Programme

Region	Area	Number of Communities	Population (1990)	Number of Borehole	Cooperation Party (period)
Ashanti	North area	66	80,000	210	Unsettled
Brong Ahafo	Whole area	148	227,000	610	Unsettled
	Atebubu	62	35,000	111	UNICEF (1986-1987)
Eastern	North area	44	39,000	129	Unsettled
	Afram Plain	25	29,000	59	Unsettled (1986-1987)
Volta	Northern area	61	85,000	202	Unsettled
Western	Whole area	67	83,000	217	Unsettled
Northern	Eastern Dagomba	100	-	167	CIDA (1986-1989)
	Western Mamprusi	68	-	111	CIDA (1986-1989)
	Buipe	-	-		CIDA (1986-1989)
	Nanumba	54	42,000	130	Unsettled
Upper	Whole area	118	-	149	CIDA (1986-1989)
Public Facilities	-	-	-	132	
Total				2,245	

The construction cost per borehole facility is estimated at local currency 300,000 Cedis and foreign currency 2,000 US Dollars.

(4) Northern Region Rural Integrated Programme (NORRIP)

a) Outline

NORRIP has been created as a Planning Institution for the Northern Region of Ghana. Prime functions include producing regional, sectoral (programme), district plans, and designing projects for the Northern Region. Another important function is to strengthen regional and project planning processes and institutions.

NORRIP's development philosophy, is designed as a realistic response to the existing situation. It stresses small scale initiatives based on appropriate technology to increase productivity and the delivery of basic needs based on the principles of self-help and self-reliance. The plan identifies key leverage points for short-term developmental actions. This philosophy has resulted in the designation of villages and areas that should be able to absorb and respond to immediate developmental initiatives. In the longer term the development strategy advocates a process whereby development would spread to other areas in the region and to other institutions, particularly those of Government.

The strategy stresses the need for increased productivity mainly in agriculture but also in processing/manufacturing so that local funds will be available to finance the delivery of basic needs.

The strategy reflects development at three levels; regional level, local levels, and district and sub-district level.

At the local level of development, three specific types of sub-district areas have been identified (see Fig. 2-3-2):

i) Integrated development areas: These are settled areas where potential exists for in-situ development and delivery of basic needs.
ii) Critical areas: In these areas, action must be taken immediately because of critical bio-physical characteristics (e.g. erosion, desertification).
iii) Settlement areas: These are areas where considerable agricultural potential appears to exist but where, for a variety of reasons, little settlement has occurred to date.

Regionally, ten priority development programmes have been identified as listed below.

i) A hunger gap programme designed to minimize the problems associated with lack of food between harvests;
ii) A portable water programme;
iii) Primary Health care;
iv) Agricultural initiatives designed to deliver agricultural services and create an integrated extension service;
v) A transportation package designed to construct, maintain and rehabilitate bush tracks, feeder roads and arterials;
vi) Settlement infrastructure programmes and projects;
vii) Conservation-oriented initiatives;
viii) A buffer system programme consisting of fuel storage, inventories of spare parts, and plant and machinery pools to make the region more self-sufficient and less dependent on inputs from the south;
ix) Educational packages designed to create learning systems oriented toward the key regional development initiatives that have been identified in the plan; and

x) A community self-reliance package designed to assist villagers in helping themselves.

Sectors for development also covers the following:

i) Agriculture
ii) Development of social economic system (preservation of health, education, and development of community)
iii) Social infrastructure (water supply, transportation, communication, and energy)

Figure 2-3-3 shows the regional development strategy except for agricultural sector.

(b) Development Strategy on water supply sector

The items at which the water supply sector aims are:

i) To provide safe domestic water for all people in the Northern Region by improving existing system and by developing new systems and supplies.
ii) To develop and manage water resources to supply other needs such as animal husbandry, aquaculture, irrigation, hydro-electric power, industry, etc.
iii) To ensure reliability of water supply through education programmes, supply of input, user responsibility and self reliance, etc.
iv) To increase awareness concerning appropriate waste disposal methods.

In order to accomplish these comprehensive targets, the subjects to be developed are divided into the following two large items which will be individually planned and implemented.

A. For Domestic Supplies

a) eventually, all villagers and urban people in the Northern Region,
b) in the shorter term, villages with 200-1,500 population requiring safe portable water; in the medium run, villages with 50-200 population requiring safe portable water,
c) the residents of larger centres, including Tamale.
d) any groups in newly developing areas.

B. For Other Purposes

a) In animal husbandry:
   ° Villagers or communities with livestock or livestock potential on an individual need basis
b) In Irrigation Projects:
   ° Farmers involved in small irrigation projects.
c) In Industrial Production:
   ° Entrepreneurs or managers as per special requests with preference to agri-industries and essential goods manufacture (soap, food processing, etc.)

(c) Development strategy of Nanumba District

As shown in the previous Figure 2-3-2, the Nanumba District is one of the better agricultural areas and is known as the 'yam exporter' of the Northern Region. This is one of the most poorly served districts in terms of governmental and NGO services. Attracting qualified staff to this area will be difficult due to the lack of basic amenities.

In concrete terms, the development will be separately implemented in the following three strategies:

Figure 2-3-2. Development Areas of Area Level

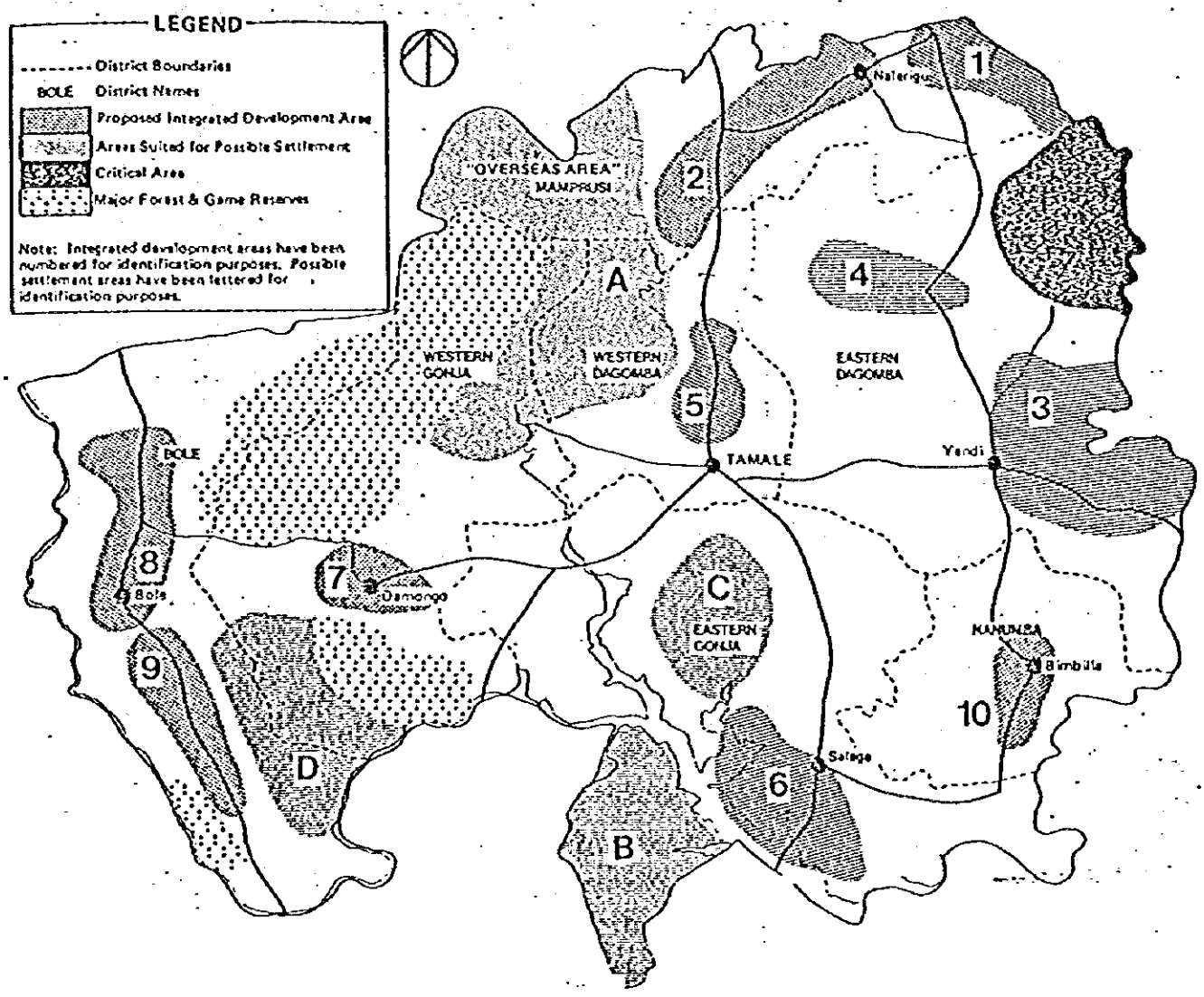
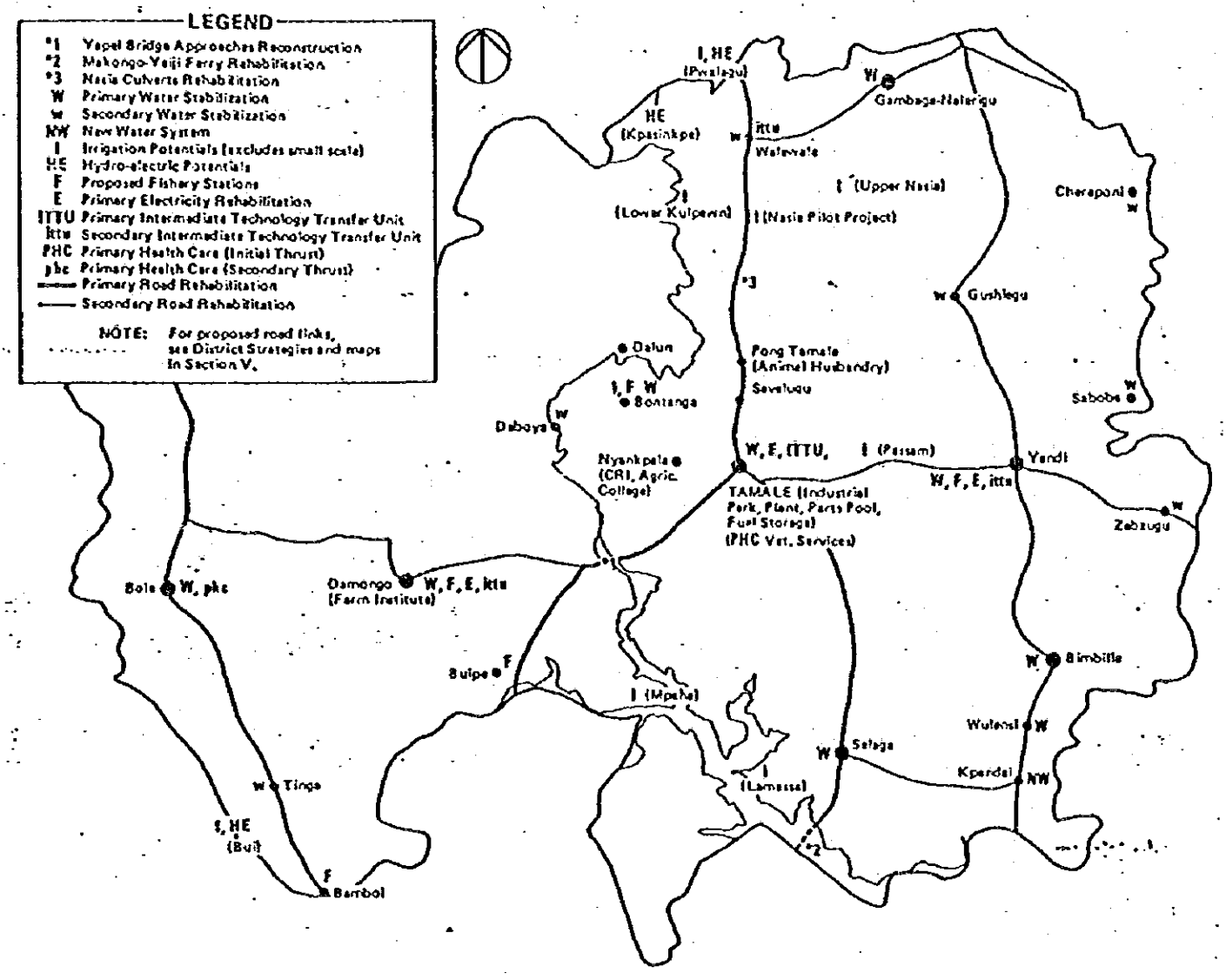


Figure 2-3-3. Development Strategy of Regional Level



SECTOR	RESPONSIBLE INSTITUTION, AGENCY	DISTRICT PRIORITY	ACTION SEQUENCING
AGRICULTURE	MIN. OF AGRIC.	* * *	INVESTIGATE ADDITIONAL POTENTIAL FOR YAM INDUSTRY →
	FISHERIES	* *	INVESTIGATE FISHING POTENTIALS
	IDA	* *	INVESTIGATE IRRIGATION POTENTIALS
	MIN. OF AGRIC.	* * *	DEVELOP FUNCTIONAL PACKAGES
SOCIO-ECONOMIC-INSTITUTIONAL	MFEP(NORRIP), MIN.HEALTH	* * *	SUPPORT MISSION CLINIC AT CHAMBA AND HEALTH CLINIC AT BIMBILLA →
	MFEP(NORRIP), GES	*	SUPPORT TEACHER TRAINING COLLAGE AND SECONDARY SCHOOL AT BIMBILLA →
PHYSICAL INFRASTRUCTURE	GWSC	* * *	REHABILITATE WULENSI - BIMBILLA WATER SYSTEM
	"	* *	EXPAND WULENSI - BIMBILLA SYSTEM →
	"	* * *	BOREHOLE DEVELOPMENT →
	GHA, VRA	* *	IMPROVE FERRY CROSSING OVER L.VOLTA
	MRH (FEEDER ROADS DIVISION)	* *	IMPROVE/MAINTAIN N-S AND E-W ROAD LINKS , REHABILITATE DAKA RIVER CROSSING →

NOTE 1: This is not a linear scale; it is meant to imply sequencing only. No specific lengths of time are implied.
NOTE 2: Priorization is internal to the District and is not directly related to the Regional Priorizations of the previous charts.

Table 2-3-18 NANUMBA DISTRICT DEVELOPMENT STRATEGIES

A. Agriculture Strategies

i) Yam production increase programme
ii) Inland fishery programme (river Ochi and lake Volta)
iii) Irrigation programme

B. Socio-eonomic Infrastructure Strategies

i) Institutional development
ii) Health
iii) Education

C. Physical Infrastructure Strategies

i) Roads
ii) Rural water supply
iii) Piped water (Bimbilla, Wulensi)

Table 2-3-18 shows the priority of these programmes and the implementating agencies who are to be responsible to the programme.

2-3-4. Present situation of international cooperation for Local Water Supply

The GWSC actively enlisted an international cooperation in order to epochally improve the rural water supply condition. With the Upper Region Water Supply Project cooperated by Canada as the start, since 1974, the GWSC has completed total more than 5,600 borehole facilities with hand-pumps.

The situation of the rural water supply development under international cooperation is as follows:

(1) Upper Region Water Supply Project (URWSP, 1974 to 1981)

The first of the major donor-country projects was the URWSP sponsored by the Government of Canada through CIDA. The URWSP (1974-81) resulted in the completion of 2388 4in. diameter hand-pump boreholes distributed by districts in the Upper Regions.

In addition, 296 GWSC boreholes existing before the beginning of the project were rehabilitated and fitted with new hand-pumps.

The project also completed some boreholes for mechanization. A total of 113 6in. and 8in. diameter boreholes were drilled across the Upper East and West Regions.

As a follow up of the completion of the rural water supply systems, a Maintenance Unit, a "Water Utilization Project" and a "Responsibility and Educational Programme" were introduced in the Region in that order, to cater for the facilities and are still being financed by CIDA.

(2) 3000 - Well Drilling Programme (1978 to 1984)

The Federal Republic of Germany through Kfw, sponsored the 3000 Well Drilling Programme for the provision of 3000 4in. diameter boreholes fitted with hand-pumps in Southern and Central Ghana during the period 1978-1984. The distribution of the boreholes by Regions is as follows:

Ashanti - 1,052	Brong Ahafo - 101	Central - 358
Eastern - 561	Volta - 336	Western - 592

The wells were fitted with INALSA Mark II (2250) and MOYNO (750) hand-pumps. A Consultant was also hired to plan and set up a Maintenance Organization to take care of the wells, for a period of three years after the installation of the pumps.

When the drilling works of the 3000 Well Drilling Programme was

nearing completion, the Government in March 1983 indicated its intention to extend the programme, to drill a further 1500 wells.

(3) Catholic Church Drilling in Brong-Ahafo

In 1984, the National Catholic Secretariat undertook the drilling of boreholes for the rural people under the cooperation of the Catholic International Misereor of West Germany, and had completed total 163 borehole facilities until April, 1985.

(4) Drilling for Volta Region Agriculture Development Programme (VORADEP)

As a part of the operations on VORADEP, a World Bank Programme, 90 successful boreholes have been completed in the Krachi district of Voltage region in June, 1985.

The actual results of the above international cooperation are summed as shown in Table 2-3-19.

Table 2-3-19. Boreholes with hand-pump by international cooperation (as of 1985)

Cooperation nation/ agency	Region	Number of Borehole	Implemented Period
Canada	Whole Upper region	2,388	1974 - 81
West Germany	Six Central and Southern regions	3,000	1978 - 85
West Germany Catholic Secretariat	Greater Accra region	163	1984 - 85
World Bank	Volta region	90	1984 - 85
Total		5,641	

(5) International cooperation expected to be implemented

Additionally, the international cooperation projects under implementation or near to undertaking are as follows:

° UNICEF Assistance in Rehabilitation of Existing GWSC Wells

UNICEF-Ghana in March 1984 submitted a proposal to the GWSC, offering to assist in the rehabilitation of 250 of these boreholes in the Western, Brong Ahafo, Eastern and Volta Regions. UNICEF is to provide inputs like new engines and spare parts for vehicles, uPVC casings and India Mark II hand-pumps for the project. The GWSC is to provide equipment and personnel to undertake the rehabilitation.

The operation started early in March 1985 in the Attebubu District of the Brong Ahafo Region, and is expected to last until the end of 1986.

° NORRIP Drilling - Northern Region

Based on the results of a test-drilling programme in the Northern Region during 1981 - 82 using staff and equipment of the Upper Region Water Supply Project, it has been decided to undertake a borehole drilling project in the Northern Region as a part of NORRIP. It is estimated to drill about 350 boreholes to be fitted with hand-pumps, and a number of mechanisable boreholes. The programme is scaled to take off late in 1985 or early in 1986, and will be funded by the Canadian Government through CIDA.

° UNICEF Assistance in Drilling for Health Centres

As a further assistance to the GWSC, UNICEF intends to drill about 200 No. hand-pump boreholes at Health

Centres/Hospitals/Clinics in the Eastern and Brong Ahafo Regions. It is planned to undertake this programme soon after the UNICEF Rehabilitation project now under way is nearing completion, again using the Drilling Unit's equipment and personnel.

° Indian Loan Project

Under a Ghanaian-Indian Loan Agreement, 4 rotary rigs with supporting logistic equipment have been bought from India for rural water supply development in Ghana. All items except the 4 rigs have already arrived in Ghana. The Government has directed that the equipment be used by the Field Engineers' Regiment of the Ghana Army, to undertake drilling operations alongside the activities of other drilling organizations in the country. Meanwhile, the GWSC Drilling Unit has mounted a training programme for the Army personnel, to prepare them to take over the "Indian" rigs.

2-4. Outline of the Request

2-4-1. Process of the Request

(1) Contents of the Initial Request

The request of the Government of Ghana consists of two schemes as referred from the letter No. PR.01/11/Vol. 2/211 and the letter No. PR.01/11/Vol. 2/40, dated 2nd May 1984 and 7th May 1984, respectively.

a) The first scheme

The first scheme (hereinafter referred to as "Scheme-I") is composed of the following four (4) conponents for Brong Ahafo and Western Regions:

i) Completion of on-going projects in three rural communities in Brong Ahafo Region

- Target communities are Kukuom, Dwenen and Nkrakwanta.
- Boreholes have been already drilled, and the equipment and materials such as submersible pumps, generators, elevated tanks, etc. are required.
- Construction work shall be done by the GWSC under their own budget.
- A total population of 15,000 people will be benefited from the project.

ii) Rehabilitation and stabilization of 37 existing systems

- These systems were installed in the late sixties and they often broke down because of age.
- The proposal is to replace the faulty plants and equipment with new ones such as pumps, generators, etc.
- The installation of the plants and equipment shall be done by the GWSC under their own budget.
- These systems are classified into two types based on the sources of water -- some 21 groundwater systems and 16 surface water systems.

iii) Strengthening of the GWSC Drilling Unit

- The Unit, based in Kumasi, implements the groundwater development by drilling and equipping the boreholes with hand-pumps or mechanised pumps.
- Presently, almost all of the drilling equipment are inoperable due to old age and lack of spare parts.

- The requests consist of drilling rig and four (4) servicing rigs to strengthen the ability of the unit.

iv) Transportation

- The GWSC faces also severe problems in transporting materials, plant and equipment.
- Proposal is to purchase two (2) articulations and twelve (12) pick-ups.

b) The second scheme

The second scheme (hereinafter referred as "Scheme-II") is a project to construct about 120 to 130 boreholes fitted with hand-pumps for some 60 communities in the Nanumba District, Northern Region. The project consists of two components -- the first component is to be the actual construction work of boreholes and installation of pumps, and the second component is to entail the setting up a Maintenance Support Program for the sustenance of the water supplies provided by the first component.

The proposal for Japanese Assistance is consisted of equipment for both components mentioned above, and a dispatch of Japanese experts also for both components.

The list of requirement for these two schemes are shown in Table 2-4-1 and 2-4-2, respectively.

Table 2-4-1. Material and Equipment List Required in Scheme-I

	Item	Quantity
1)	Submersible pumps (Head 150 to 300 ft; capacity 1,000 to 5,000 gph)	50 sets
2)	Centrifugal or reciprocating pumps (Head 200 ft; capacity, 2,000 gph)	36 "
3)	Generators (10 kva to 50 kva)	50 "
4)	Diesel engines (10 Hp)	12 "
5)	Generating sets (22 to 30 Hp, for package plants)	24 "
6)	Drilling rig (with complete accessories)	1 "
7)	Service rigs	4 "
8)	Articulators (30 ton)	2 "
9)	Pick-ups (500 kg load)	12 "
10)	2-year spare parts for above items 1) through 9)	1 L.S.
11)	Elevated water tank (10,000 gallons, steel make) and piping	3 sets
12)	Others (freight and insurance)	1 L.S.

Table 2-4-2. Material and Equipment List Required in Scheme-II

	Item	Quantity
1)	Drilling rig (Truck-mounted and head-driving type rotary drilling with down-the-hole hammer, capable of drilling to 200 m)	2 units
2)	Air compressor (trailer-mounted, capacity 750 lit/min at 290/300 psi operating pressure)	2 "

3)	Portable electric logging system and water-meter	2	"
4)	8-ton cargo truck with crane (left-handled, lifting capacity 3 ton)	2	"
5)	Water rolley (left-handled, 1,500 gallons capacity)	2	"
6)	Jeep, Station wagon (diesel engine)	2	"
7)	Jeep, Pick-up-type (long body, diesel engine)	2	"
8)	Electric welding set (diesel-engine generator attached)	2	sets
9)	Camping equipment	2	"
10)	Casing pipe (P.V.C., equivalent to 6,000 m)	1	L.S.
11)	Screen pipe (P.V.C., equivalent to 2,100 m)	1	"
12)	Water analysis kit	2	sets
13)	Hand-pumps (Moyno or Helecal-screw type)	120	units
14)	Spare parts covering above thirteen items	1	L.S.
15)	8-ton truck (transportation of materials and equipment)	1	unit
16)	Jeep, Pick-up type (long body, diesel engine)	2	"
17)	Jeep, Station wagon (diesel engine)	1	unit
18)	Motor bicycle (125 cc)	3	units
19)	Workshop equipment	1	L.S.
20)	Spare parts for above five items	1	L.S.
21)	Technical assistance (3 persons x 2 years)	72	man/month
22)	Contingencies	1	L.S.
23)	Technical assistance (3 persons x 1 year)	36	man/month

(2) Result of Field Inspection

The result of the field inspection made by the Study Team in connection with each scheme shown in the initial request is as follows.

a) Scheme I - i

Among the three districts of Kukuom, Nkrakwanta, and Dwemnen, the former two communities were inspected.

Only boreholes were drilled there (three in Kukuom and two in Nkrakwanta) and nothing other construction has been started.

In Kukuom, a hand-pump was fitted to the existing borehole, but it was out of order and not in use at present. Water test was made by a near borehole (Test No.1), but water was found problematical because the borehole is shallow.

In Nkrakwanta, one of the two boreholes was left opened and found contaminated just before reuse. The other one is installed with a hand-pump and used by villagers now, but it also is shallow and contains much iron, thus being problematical in the water quality too. (Test No.2)

At any rate, it is not recommendable that the existing boreholes are used as they are, and accordingly the projects must be commenced from the siting and the new drilling of boreholes; this is being judged to be a new construction project.

The planning data of the three projects obtained from the GWSC is shown at Appendix 14.

b) Scheme I - ii

In connection with the 37 rehabilitation projects plan, eight project areas were inspected (including similar facilities). They are;

Brong Ahafo Region: Goaso, Gensusu*
Western Region: Wasso-Akropon, Dompin, Sefwi-Berkwai, Awaso, Sefwi-Wiawso, and Demesase.

(Marked with * are similar facilities and underlined are the groundwater type).

What can be said commonly to the surface water type in each facility inspected is that the water source is unstable in almost all facilities, that the water pumps are short of capacity or out of order, that the packaged treatment plants are not at satisfactory work, that the water sources are polluted with bacteria (refer the test Nos. 3 to 7 at Table 2-4-3), and the like.

While the groundwater type is fair in the water quality (test No.4), but the pumping capacity of all were short. In addition, they are time-worn because neither renewal nor expansion work has been made for the last twenty years or so. The water sources, water pumps, treatment plants, reservoirs, drainage pipings, etc. are short of capacity for all potential users to be supplied water because of no spare pumps and engines available and increase in users by more than 100 percent.

In other words, it cannot be expected to produce sufficient effect only by rehabilitating the water supply facilities and considerable scale of expansion shall be accompanied.

There are, they said, many water supply systems in Brong Ahafo of which they desire to change the water source from surface water to groundwater because of unstable or running dry water source, although the direct inspection by the Team has not taken place at

the time.

As stated above, the rehabilitation and stabilization plan of the existing facilities can not be achieved only by providing the equipment and materials required by the GWSC, and it is thought that the original function cannot be restored unless the change or stabilization of the water source, replacement of treatment plants and elevated water tanks, and further expansion and extension will be carried out in parallel, and it was impressed that most of them must be subjected to fundamental investigation and survey.

Details of this plan obtained from the GWSC are shown in Appendixes 15 and 16.

c) Scheme I -iii and -iv

At the visit of Drilling Unit in Kumasi, discussion meeting with Acting Drilling Engineer, Chief Driller, and Hydrogeologist was held, and the workshop and storage belonged to Drilling Unit were inspected.

At that time, a personnel list and an equipment list owned by the Drilling Unit were required, and the usage of drilling rig (1 unit), service rigs (four units), and vehicles (two trailer trucks and twelve pick-up trucks) described in the initial request was interviewed by the Team.

The drilling rigs owned by the Drilling Unit at present are nine in number, but only six of them are available for actual use. Such drilling rigs are now engaged in the borehole maintenance project under the cooperation of UNICEF mentioned before or in the borehole drilling which is not belonged to a special project.

In addition, among the present water supply facilities in local towns those whose water sources rely on the groundwater, many time-

worn boreholes (most steel pipe casings installed in 1960's are found corrosive) require re-drilling, those whose water sources rely on unstable surface water require such a drilling to change the water source from surface to groundwater. It will be the real intention that the drilling required would be operated chiefly for such purposes.

Service rigs and pick-up trucks are desired to be used also for rehabilitation work of boreholes, but desired to be used chiefly for installation and maintenance (replacement work in most cases) of hand-pumps.

In addition, it is said that a 30-ton trailer truck is planned to be used for the transportation of the rehabilitation equipment (pumps, engines, etc.) for the existing water supply facilities in local towns. Furthermore, as a desire of the Drilling Unit, it was proposed that the equipment and materials for the workshop of the Drilling Unit be furnished.

d) Nanumba District (Scheme II)

In Nanumba District of the Northern Region, three communities were inspected, and interviews with inhabitants and water tests were made; and further in Bimbila, the capital of Nanumba District, existing water supply facilities sourced by surface water reservoir was inspected.

In this district, there are only two mechanized water supply facilities including the said one, and almost all the people utilize the surface water such as river, pond, etc. without relying upon wells or boreholes.

As a result of interview with the inhabitants, it was told that they had considerable amount of rain this year and the rainy season was just over, so that they felt rather easy to fetch water because

there is a water source nearby (about 2 km). However, normally in a dry season it is common for them to fetch water 4 to 5 km apart; and what is worse, they have to go a water source to draw water more than 10 km apart and that several times a day.

Fetching water is usually the job of housewife or a young girl, bringing a bucket of about 20 liters capacity with her, four or five times a day in average.

On the other hand, the water source which was said good in quality and quantity this year was a small stream and was found contaminated with bacteria as a result of test (Test Nos. 8 through 11). In addition, many injured children by Guinea worms were found in communities; furthermore, it was heard that water-borne disease or parasites having hosts in the water source such as Onchocerciasis, Schistosomiasis, etc. are prevailing.

Table 2-4-3 shows a result of water quality test conducted by the Study Team in the field.

(3) Details of Discussion

As a result of discussions about the contents of the request between the Study Team and the GWSC staffs, the priority order of Ghana-side in each scheme included in the initial request is, following the Five Year Rehabilitation and Development Program, the rehabilitation of aged facilities (Scheme I-(ii)), completion of on-going projects (Scheme I-(i)), and rural water supply project by construction of borehole facilities with hand-pumps (Scheme II); and a consensus that the reinforcement of the function of Drilling Unit is indispensable for the implementation of any scheme was confirmed.

Concerning to the Scheme I-(i) and (ii), however, it was revealed that the original functions of each facilities would not be recovered by the means of only replacement of equipment or materials

required, and a fundamental re-examination of the plans themselves including studies on water source, beneficiaries, design of facilities, etc. was necessary to have them be an objective of grant aid assistance programme, as a result of the field survey by the Study Team.

On the basis of the result, the Ghanaian party decided that the schemes for completion of on-going projects and rehabilitation of aged facilities be exempted from the request of this time and accordingly fixed up to the request of cooperation for the projects in connection with Scheme I-(iii) and (iv) and Scheme II.

The Ghanaian party stated that the equipment and materials required in the Project be used for new drilling of hand-pump equipped boreholes for the rural water supply and re-drilling of aged boreholes of the local town's water supply facilities.

As a concrete operation plan, the GWSC proposed the construction of about 440 boreholes with hand-pumps in total (modified to 445 boreholes later, subject to details for Appendix 10) consisting of 120 holes in Nanumba District of the Northern Region (modified to 130 holes later), 144 holes in Berekum/Jaman District of Brong Ahafo Region, and 171 holes in Sefwi-Wiawso District of Western Region.

The Ghana-side further showed a request consisting of a provision of equipment and materials required for the implementation of the Project and a construction of 120 borehole facilities out of the above mentioned 440 boreholes by the Japan-side cooperating with the GWSC's staffs to ensure the transfer technology.

The cooperation request for the construction of boreholes is a substitute for the engineers dispatchment covering 108 man/month in connection with the construction and O & M of the boreholes facilities in the initial request. The Ghanaian party strongly requested that a radio communication system, bulldozer for

preparation of the borehole drilling site and access road, vehicles for transporting the bulldozer, and equipment and tools for the hand-pump maintenance centers scheduled to be installed at each district be added to the provision of equipment and materials. The minutes of discussions (Appendix 4) as a result of the discussions was signed and exchanged on October 14 by Mr. Suzuki, the Leader of the Study Team and Mr. T.B.F. Acquah, the Acting Managing Director, GWSC.

2-4-2. Contents of the Request

The contents of the Ghana-side request in the final confirmation in accordance with the minutes of discussions are as follows.

(1) Objectives of the Project and the Project Areas

The objectives of the Project are to construct some 440 boreholes equipped with manual pumps and to provide the necessary equipment for borehole drilling in the rural area in order to develop healthy portable water supply and to improve the standard of living of the rural population.

The Project area is to be the following three district; (refer to the Location Map on the head of this Report)

1. Nanumba District of Northern Region
2. Berekum/Jaman District of Brong Ahafo Region
3. Sefwi-Wiawso District of Western Region

(2) Requests of the Government of Ghana

A. Provision of equipment necessary for the implementation of the Project

a.	Truck-mounted drilling rig	3 units
b.	High pressure air-compressor	3 units
c.	Cargo truck with crane	4 units
d.	Water lorry	3 units
e.	Pick-up type light vehicle	6 units
f.	Station wagon type light vehicle	6 units
g.	Camping facility	1 set
h.	Geophysical prorspecting equipment	1 set
i.	Borehole test equipment	1 set
j.	Water analysis kit	1 set
k.	Radio telephone system	1 set
l.	Equipment and tools for workshop	1 set
m.	Equipment and tools for hand-pump maintenance center	1 set
n.	Earth-moving equipment (bulldozer)	1 unit
o.	Manual pump	140 sets
p.	Spare parts covering above items	1 set

Note: The Ghanaian party has expressed their strong desire that manual pumps to be provided be of GWSC's standard types.

B. Construction of 120 boreholes and appurtenant facilities inclusive of supply of construction materials and installation of manual pump sets.

Note: The Ghanaian party has expressed their strong desire that the technical personnel of the GWSC participate in the Project works to ensure technology transfer from the Japanese personnel related to the Project in the various fields of the Project implementation such as project management; borehole siting, drilling and testing; manual pump installation; and maintenance of equipment, manual pump and borehole facility.

Table 2-4-3. Water Test Result

No.	Investigation Spot		Objective	Remark	Water Quality			Bacteria Investigation	
					Temp. °C	pH	Electric Conductivity μS/cm	Colon Bacilli Group (No.of colony)	General Bacteria gation (")
1	KUKUOM	Brong-Ahafo Region	Groundwater	Handpump Well	26.0	6.06	225	2/5	none
2	NKRAKWANTA	"	"	"	24.8	7.12	375	-	-
3	GOASO	"	Surface Water	Water source of facilities	26.0	6.64	125	Oveall	79
4	GENSUSU	"	Groundwater		27.5	6.25	105	1/5	none
5	DOMPIN	Western Region	Surface Water	"	24.4	6.86	66	50	15
6	AWASO	"	"	"	24.9	6.91	61	-	-
7	SFWI-WIAWSO	"	"	"	23.7	7.40	197	30	11
8	BINCHERATANGA	Northern Region	"	Water left drawn	30.9	6.65	39	Overall	20
9	"	"	"	Stream	32.8	6.75	42	marks	13
10	"	"	Ggroundwater	Artesian	28.4	7.38	53	-	-
11	BIMBILA	"	Surface water	Water source of facilities (pond)	34.0	6.13	201	-	-

		°C		
Average	Surface water	26.7	6.70	104.4
	Groundwater	28.1	6.76	189.5

CHAPTER 3. OUTLINE OF THE PROJECT AREAS

3-1. Administrative Regions and Population

Administratively, the three Project areas belong to Northern, Brong Ahafo and Western Regions respectively. These regions are further divided into 12 to 13 district level administrative units; local councils or urban councils, and each target Project area is one of these local councils respectively.

Table 3-1-1 shows a number of district level administration units and populations of related regions and target districts (refer Location Map of the Project Areas at the head of the Report).

Table 3-1-1. Populations of Related Areas

Region	No. of Councils	Population of Region*	Council	Population of Councils*
Northern	12	1,162,645	Bimbila LC**	91,072
Brong Ahafo	13	1,179,407	Berekum/Jaman	165,352
Western	12	770,087	Sefwi-Wiawso	99,344
Total	37	3,112,139		355,768

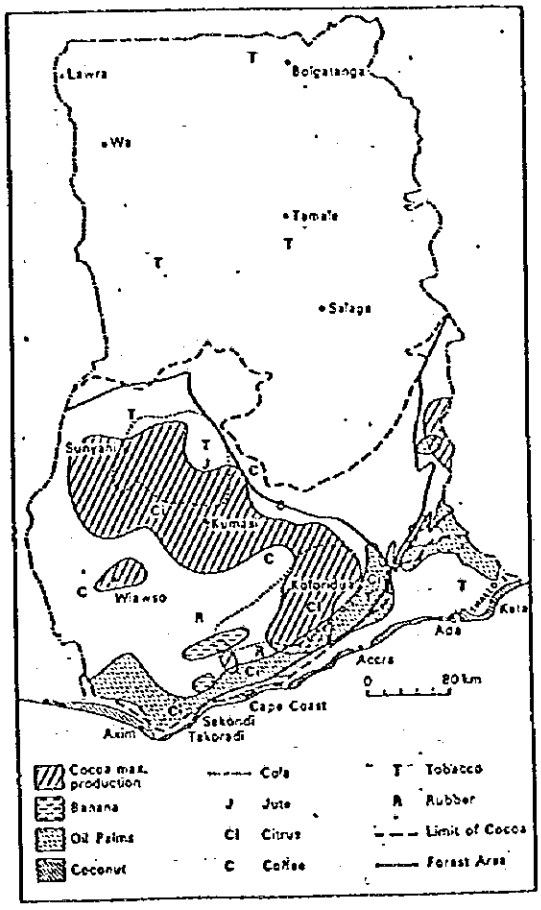
* : Population Census 1984, CBS

**: Nanumba District

3-2. Geography and Socio-Economy

The land of Ghana can be divided into 11 geographical regions and they are also socio-economical regions coincidentally (see Fig.3-2-1). The Project areas, which are hatched in the figure, situate in following three geographic regions respectively; (1) The middle belt, (2) The cocoa forest, and (3) The pioneer fringe.

Fig. 3-2-1. Geographical Regions



(1) The Middle Belt

Nanumba District, belongs to this region. The middle belt is the most extensive geographic region covering a part of Upper Region on the north and a part of Ashanti and Eastern Regions on the south, centering the Volta lake.

The most important feature distinguishing the middle belt of Ghana is the low population density. Also, the middle belt is the least developed part of the country and is marked by the absence of motorable roads over extensive areas.

Because of a hard soil condition, livestock-farming is rather prevailing than agriculture in this area; the most of cattle in Ghana are feeded in the region and more northern part. Within these circumstances, only the area centering Bimbila, Nanumba District, is well known as "yam exporter" of the Northern Region, because of its favorable soil condition.

(2) The Cocoa Forest

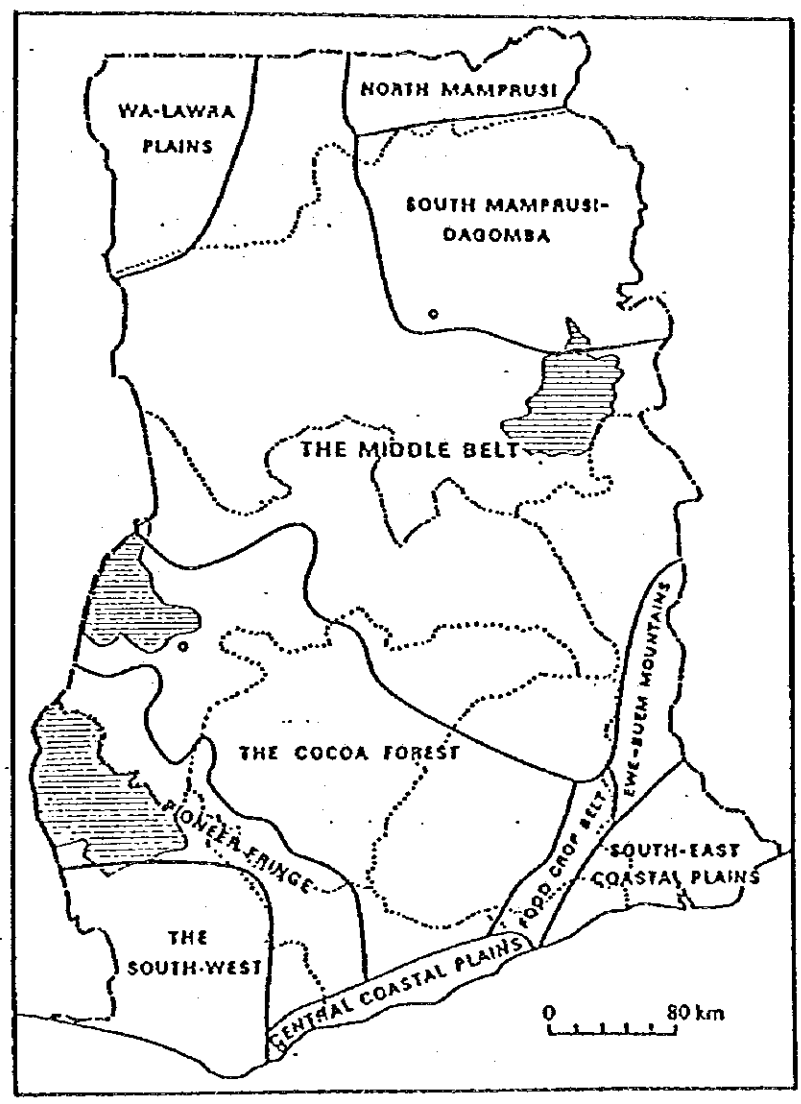
The second Project area, Berekum/Jaman District belongs in this region. As is name implies, the region is the chief producer of the country's most valuable cash crop, cocoa. The region has roughly the shape of a rectangle, and lies across the northern half of the main forest zone, with its long axis in a southeast-northwest position. The area thus covered includes portions of Eastern Region, Central Region, Ashanti and roughly the southern two-thirds of western Brong Ahafo (see Fig. 3-2-1).

Its importance as the country's chief producer of cocoa is not the only distinguishing characteristic of the region. Population density is another: it is fairly high, though not uniformly so, throughout the region, reaching over 115 persons per km^2 partly. There is a third distinguishing feature of the region: most of the large and important towns in the forest zone as a whole are to be found in the region.

Of the primary economic activities in the region, cocoa cultivation is by far the most important. Besides this, the region is also well known for its kola trees which yield another of the country's agricultural exports, kola nuts. Other cash crops in the region are rubber, coffee, tobacco and jute, while the lower end of the region is the domain of oil palm tree which either grows wild or is cultivated (see Fig.3-2-2).

However, the target Project area, Berekum/Jaman District which belongs to this rather blessed region though, is situated at its northwest end where is mostly mountaneous area bordering with Ivory Coast, and left as low socio-economic situation.

Fig. 3-2-2. Distribution of Commercial Crops



(3) The Pioneer Fringe

Between the southwest and the cocoa forest regions is the pioneer fringe, a broad belt of land stretching in an arc from northwest to southeast. The name pioneer fringe itself suggests that the region is little developed and it is this general lack of economic development which forms the most important characteristic

of the region. Others are the small number of roads and other means of communication, the small number of towns or large settlements and the generally low population density. The region is still being opened up.

Recently, as communications improved, so cocoa farmers moved in. Besides cash crop farming the only major occupation in the region is timber-logging. Many the large timber concessions in the closed forest are located in the region. Dunkwa, Wiawso, Mim are developed as the centers for timber industry and communication.

Sefwi-Wiawso District, the third Project area, is situated at the west end of this pioneer fringe also bordering with Ivory Coast. The district is still in far low socio-economic situation among the other districts in the generally little developed pioneer fringe, mainly because of its geographical situation.

3-3. Physical Environment

(1) Climate

Nanumba District of Northern Region belongs to the tropical continental, and both Berekum/Jaman District of Brong Ahafo Region and Sefwi-Wiawso District of Western Region are situated in the wet semi-equatorial region climatically.

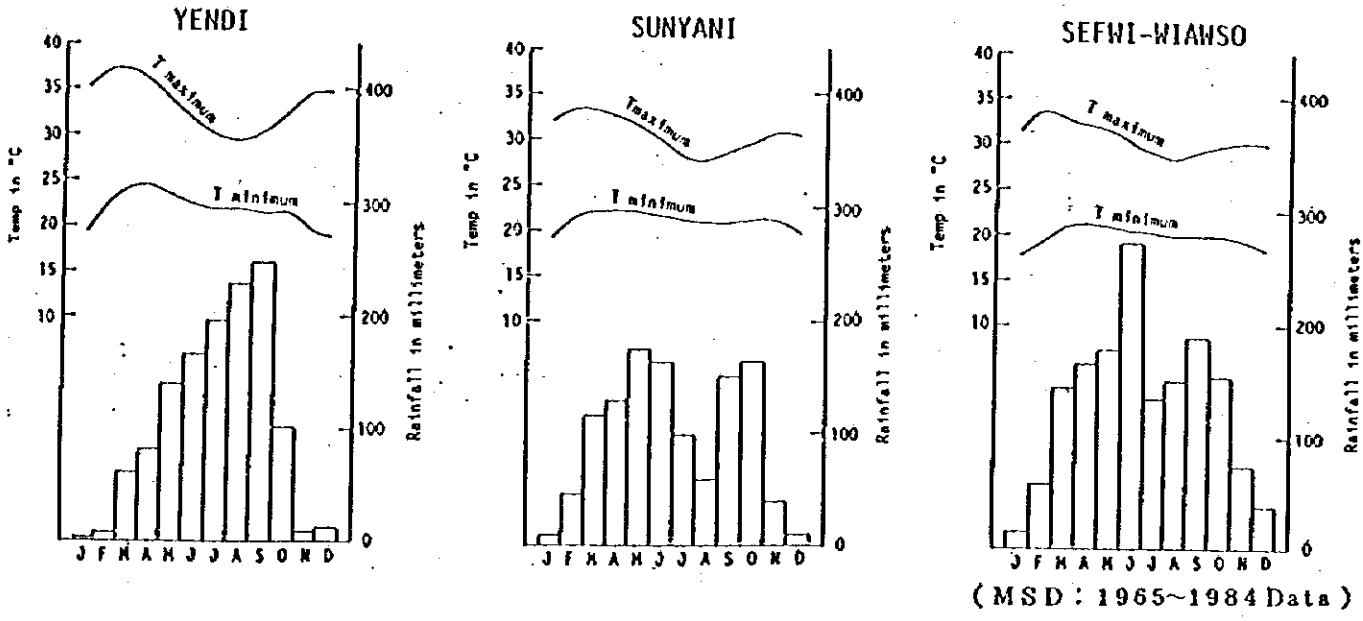
Tropical continental climatic region has a single rainy season and clearly defined dry season. The mean annual rainfall is 1,150 to 1,250 mm, the mean monthly temperatures are low, ranging from about 30°C in March to about 24°C in August. Relative humidities are heigher in the rainy season but may fall to less than 50 percent during the dry season.

The wet semi-equatorial climatic region has two rainfall maximum, and the mean annual rainfall is between about 1,250 and

2000 mm. The first rainy season is from May to June, and the second rainy season is from September to October. They dry seasons in this region are quite sharp or pronounced. The mean monthly temperatures vary from 30°C to 26°C, and average monthly relative humidities are ranging from about 80 percent in rainy season to about 70 percent in dry season, not so much different throughout a year.

Fig. 3-3-1 shows typical climatic stations respective of the three project area; Yendi immediate north of Nanumba District, Sunyani immediate east of Berekum/Jaman District, and Sefwi-Wiawso in the Project area.

Fig. 3-3-1. Climate of the Project Areas



(2) Vegetation

As mentioned before, the vegetation of Ghana is divided into five types just corresponding to the climatic regions; Moist Semi-deciduous Forest, Interior Wooded Savanna, Rain Forest, Coastal Scrub and Grassland, and Strand and Mangrove Zone. Nanumba District belongs to the Interior Wooded Savanna, and the other two areas belong to the Moist Semi-deciduous Forest (see Fig. 2-2-9, previous chapter).

The Savanna within Ghana is modified from the typical Continental Savanna extend more interior than Ghana because it has rainfall enough to grow up trees more dense than the typical Savanna. The Moist Deciduous Forest occurs in wet semi-equatorial climatic region. The forest contains most of the country's valuable timber trees. Although the Moist Deciduous Forest does not differ much in appearance from the Rain Forest, it is distinguished by the fact that many of the trees exhibit deciduous characteristics during long dry season.

(3) Topography and Geology

a) Northern Region and Nanumba District

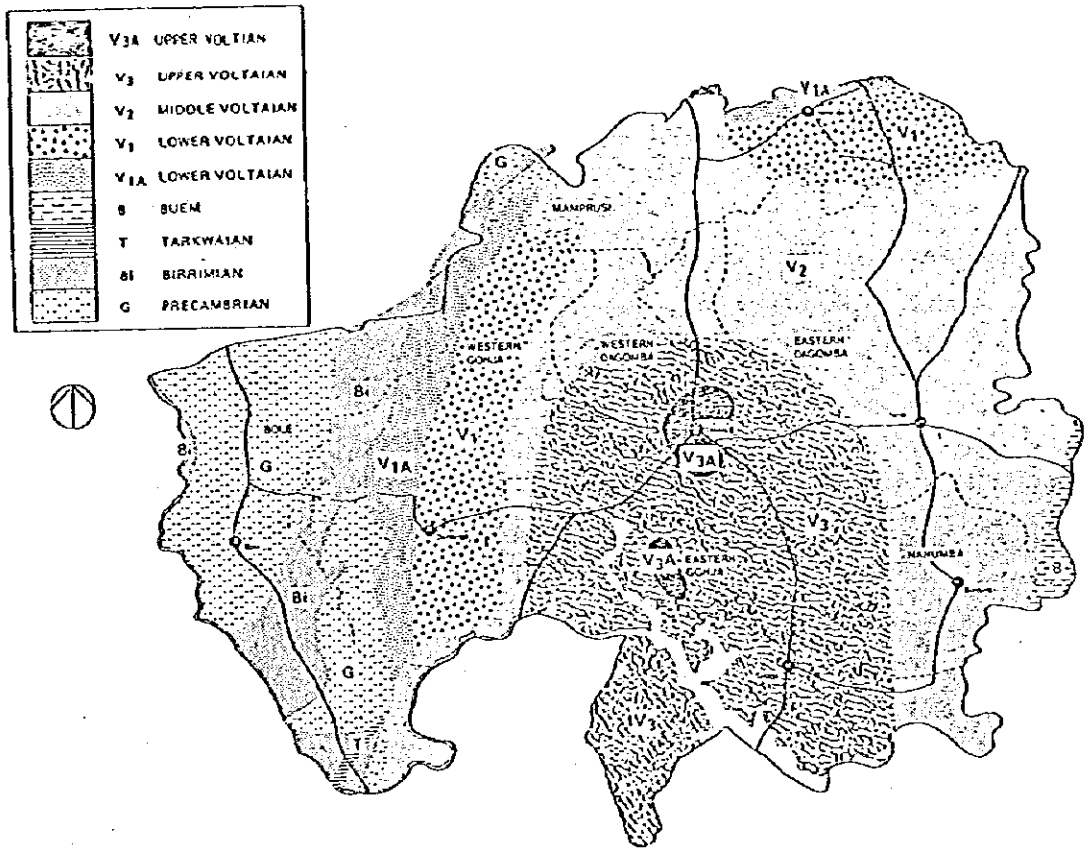
The most of the area of Northern Region lies within the Volta Basin and only its western end covers the Savanna High Land. Nanumba District situates at southeastern margin of the vast Northern Region, bordering with the Volta Region partly.

The area of Nanumba District is flat and relatively high land which forms a part of north-south range of hills, restricted both sides by the Oti and the Daka river. Ground surfaces of the land are considerably flat or very gently rolling with height between 200 and 300 m above sea level, and are cut into several blocks by east-west flowing tributaries of above mentioned rivers.

The geology of the Region can be divided into two main sharp contrasts. The Pre-Cambrian Basement in the west and the Voltaian Sedimentary Basin ever the central and eastern parts of the Region (see Fig. 3-3-2).

The Pre-Cambrian Basement rocks consists of granitic intrusives and metamorphic rocks referred to as the Birrimian. The granitic rocks are mostly granits, granodiorites, and granite geisses with pegmatic, aplitic and quartz veins and dykes. The Birrimian consists of phyllite, schists, sheared conglomerates, quartzites and metavolcanies.

Fig. 3-3-2. Geology of Northern Region



The Voltaian Sedimentary Basin has been subdivided into the Lower (V1A, V1), Middle (V2) and Upper (V3A, V3) zones based on the lithology of the rocks. The Lower Voltaian consists of base sandstone with overlying shales (V1A) constituting the base of the Voltaian, overlain by feldspathic and quartz sandstones, alternating with shale and siltstone layers with limestone intercalating. The Middle Voltaian consists of alternating grey, green or brown shales, siltstones, sandstones and greywackes. Some limestone, conglomerate and evaporates (salt, calcium phosphate) occur at the Base. The Upper Voltaian is subdivided into two units (V3 and V3A) with sandstone, arkeses and conglomerates.

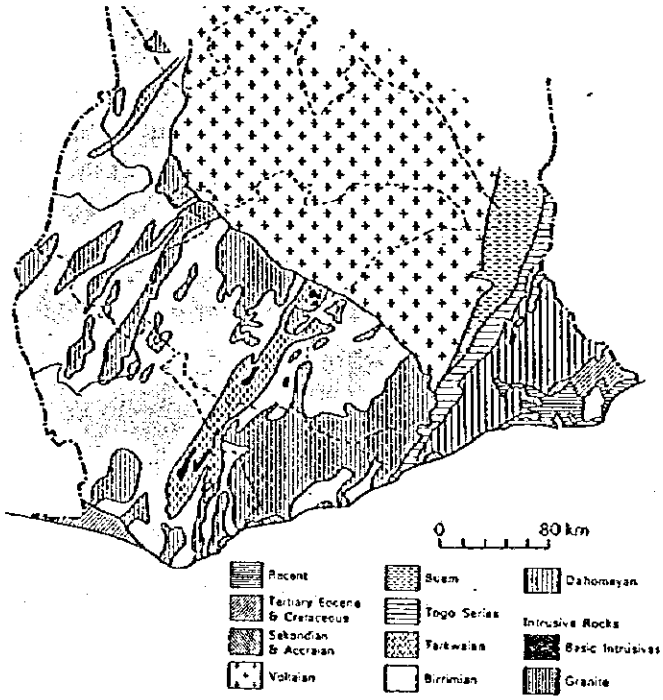
b) Brong Ahafo Region and Berekum/Jaman District

The wide and east-west extending Brong Ahafo Region covers the Forest Dissected Plateaux and Savanna High Land at its western part and the Volta Basin at its central and eastern parts.

Berekum/Jaman District situates on the mountainous western margin of the Region, bordering with Ivory Coast. The area is included in the Rain Forest Dissected Plateau climatically and physiographically. The plateaux with elevation from 300 to 600 m above sea level are strongly dissected by several rivers but form rather flat tops, and still remain peneplain feature as a total summit level. Dissecting valleies are deep and their bank slopes are very steep, they have a flat bottoms though.

In the western part of the Brong Ahafo Region including the Project area, Pre-Cambrian the Basement of the area crops out directly. While the central and eastern parts of this Region is underlain by the Voltaian, Palaeozoic in age. Pre-Cambrian rocks in Ghana consists of Dahomeyan, Birrimian, Tarkwaian, Togo series, and Buem Formations, and Intrusive Rocks. Among them, the Birrimian occupies the area mainly and the Tarkwaian overlying the former partly (see Fig. 3-3-3).

Fig. 3-3-3. Geology of Central and Southern Ghana



The Birrimian Formation covers more than three-fourths of the closed forest zone. So far it has been, economically, the most important geological formation in Ghana since it contains all the minerals exported from the country. The formation is subdivided into Lower Birrimian which consists of such metamorphosed sediments as phillites and schists, and the Upper Birrimian which is the younger of the two and consists of rocks of the Lower Birrimian as well as metamorphosed lavas. The Birrimian formation as a whole was folded along a southwest-northeast axis, that is, the folds followed a southwest to northeast trend.

The Tarkwaian formation originally consisted of sediments eroded from the Birrimian and deposited in a shallow narrow basin, and then folded along the same axis as the Birrimian. The formation consists of schists, sandstones, quartzites and phillites. A few small patches of land within the area covered by the formation consists of plutonic or volcanic rocks.

c) Western Region and Sefwi-Wiawso District

The whole area of Western Region belongs to the Rain Forest Dissected Plateau physiographically. The area of this region is prolonged north-south in contrast with Brong Ahafo Region. The Project area situates at the northern end of the Region bordering with Ivory Coast on the west and with Brong Ahafo Region on the north and east.

Sefwi-Wiawso District, which belongs to the Rain Forest Dissected Plateau though, is situated at the southern end of the Wet Semi-equatorial climatic region and the forest is very dense. The rivers near around the project area cut up the plateaux deeply and form considerably wide vallies with very steep bank slopes. Elevations of these plateau surfaces are not so high; mostly less than 300 m above sea level.

The rocks in the Western Region belong to the Pre-Cambrian Basement Complex. These consist of granitic rocks intruded into much older metamorphosed rocks referred to as the Birrimian and the Tarkwaian. The Project area is underlain by the Birrimian mostly as the same to Berekum/Jaman District, but the granitic rocks also crop out here and there within the area.

The granitic rocks are mostly granites, gronodiorites and granite-gneisses, with pegmatitic and quartz veins and dykes. The Birrimian consists of phyllites, schists, greywackes, quartzites and metavolcanics as mentioned already.

(4) Hydrogeology

The land of Ghana is, as mentioned before, subdivided into 10 hydrogeological regions (see Fig. 2-2-11, previous chapter). Among three Project areas, Nanumba District belongs to No.4; upper Voltaian region, and the rests; Berekum/Jaman and Sefwi-Wiawso

Districts, are occupied by No.7, Birrimian hydrogeological region mostly, in this general division. Followings are more detail discriptions for hydrogeological conditions of the project areas.

a) Nanumba District

Nanumba District, which is included in the upper Voltaian hydrogeological region in the nation wide classification though, is underlain by the middle Voltaian (V2) mostly and by the upper Voltaian (V3) at its western margin, to the exact (see Fig. 3-3-2).

The middle Voltaian consists of grey to green silty and quartz sandstones. They have produced very good yields from fractured and other week zones within the rocks. Maximum yields of 900 l/min have been obtained from the quartz sandstones south of Yendi. Yields from the silty sandstones range from 9 to 136 l/min, and the siltstones, mudstones and shales have given low yields averaging about 14 l/min. Where fractures have been encountered in these rocks, higher yields have been obtained. The average depth to water in these rocks is about 21 m.

The upper Voltaian consists of sandstones, quartzitic and feldspathic sandstones. The sandstones of this unit are fairly hard, and relatively less productive compared to the sandstones of V2. Yields ranging from 5 to 200 l/min have been recorded in this unit. The high yields have come from fractures and week zones in the sandstones and siltstones. The average yield for this unit is about 27 l/min.

The lower Voltaian, which does not crop out within Nanumba District though, consists of mainly sandstones and they have been the principal aquifers with the water bearing zones being the fractures in the rocks. Yields as high as 270 l/min have been obtained.

The sandstones, quartzites, mudstones, siltstones and conglomerates of the Voltaian Sedimentary Basin are relatively less decomposed compared with the Pre-Cambrians. The bedrock occurs at shallow depths overlain by a few meters of laterite and clay material. The aveage depth of decomposition in these area is about 6 meters. The soft shales are however deeply weathered.

b) Berekum/Jaman and Sefwi-Wiawso District

The total areas of both Districts are occupied mainly by the Birrimian hydrogeological region and partly by Granite region as mentioned before. These regions are called as Pre-Cambrian Basement Hydrogeological Region totally, and the most dominant aquifer in Ghana.

Rock weathering within the Pre-Cambrian rocks is generally deep. The granites, granodiorites, phyllites and schists have been extensively decomposed into clay and loos sand grains, thus creating secondary porosity for groundwater storage. The depth of decomposition averages about 30 m.

The granites and granodiorites are the principal aquifers, with the water bearing zones being the moderately decomposed zones overlying the fresh rock. In this zone, the less resistant mineral, such as feldspar and mica are decomposed leaving loose quartz grains to act as aquifers. Yields as high as 450 l/min have been measured where pegmatite, aplite and quartz veins have been encountered in this zone. The underlying fresh rocks have also encountered the yields from the decomposed zones where fractures have been encountered. The granite gneisses, phyllites and schists have produced less water from their decomposed zones. However, where these rocks have been fractured or intruded by quartz and pegmatite veins, the yields have been high. In summary, the potential of the Pre-Cambrian basement rocks can be said as good for groundwater development, however, the depths of boreholes may be deep because the main aquifers are in the lower part of the deep decomposed zones.