BASIC DESIGN STUDY REPORT
ON
THE RURAL WATER SUPPLY PROJECT (PHASE-II)
IN
THE REPUBLIC OF GHANA

March 1990

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 has decided to conduct a basic design study on the Project for Rural Water Supply (Phase-II) and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Ghana a survey team headed by Mr. Akira KONO, First Africa Division, Middle Eastern/African Bureau, Ministry of Foreign Affairs, from November 26 to December 17, 1989.

The team exchanged views with the officials concerned of the Government of the Republic of Ghana and conducted a field survey at the Project Site. After the team returned to Japan, further studies were made and the present report was 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.

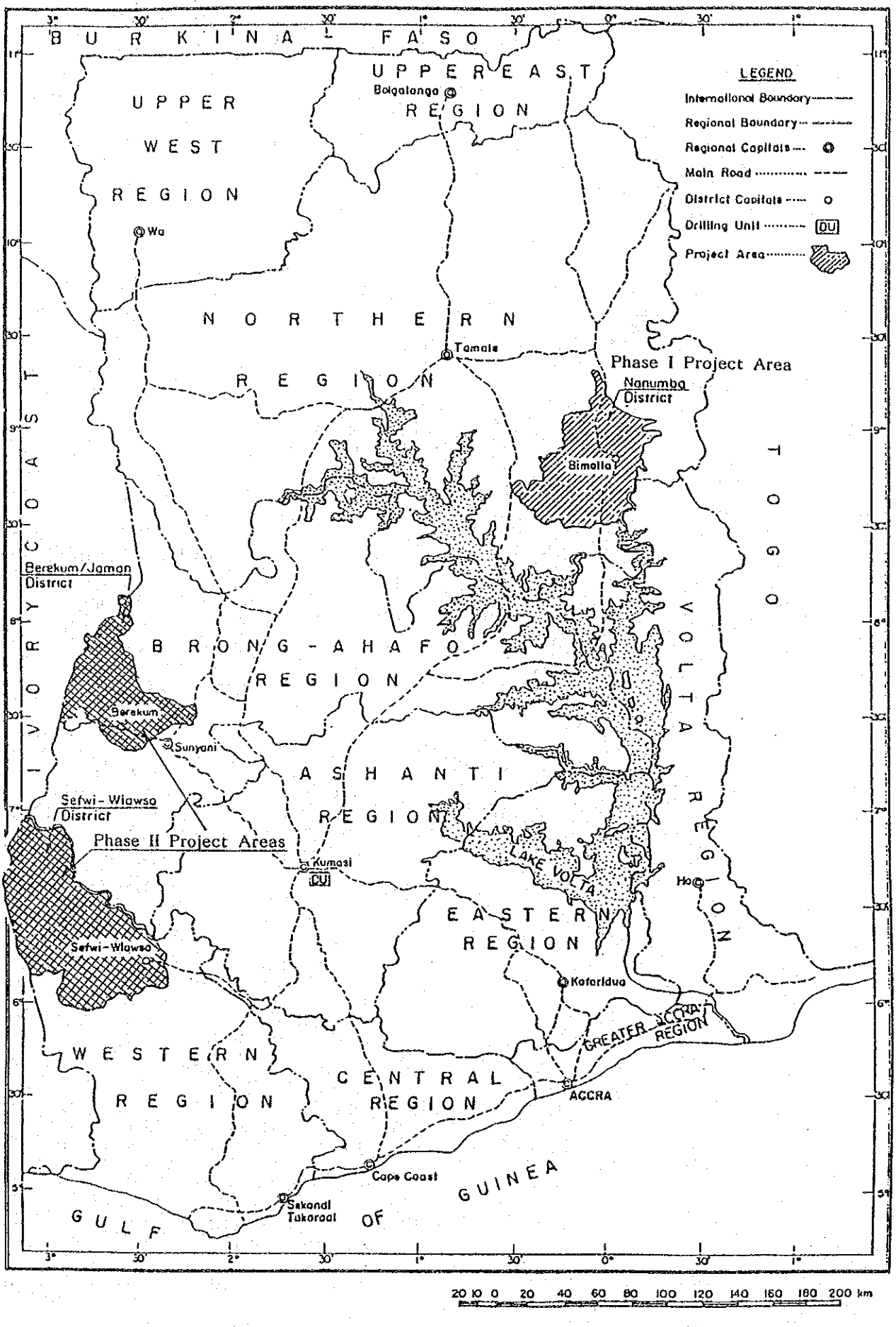
I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Ghana for their close cooperation extended to the team.

March, 1990

Kensuke Yanagiya

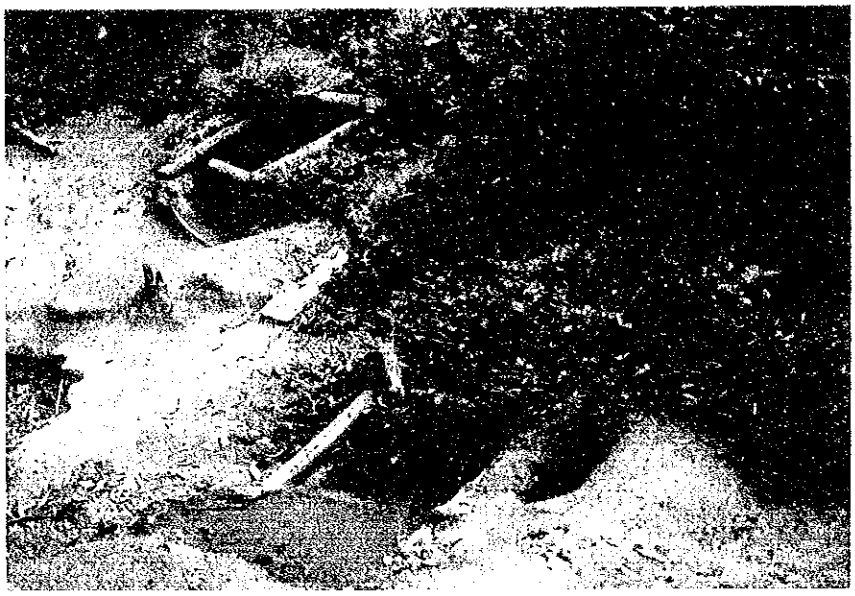
Kensuke Yanagiya
President
Japan International Cooperation Agency

LOCATION MAP OF THE PROJECT AREAS



既存水源（湧水地下水）
西部州
－クウェメ・タウィクロム村－

Current water source
(Spring-water at
Kwemetawiakrom,
Western Region)



同上（地表水水源）
西部州
－アサフォ村－

-ditto-
(Surface water at
Asafo, Western Region)

水質試験を行う
調査団員

Water Quality Test
by the Team member

水を運ぶ少女達
(西部州、
セフィ・ビバソ郡にて)

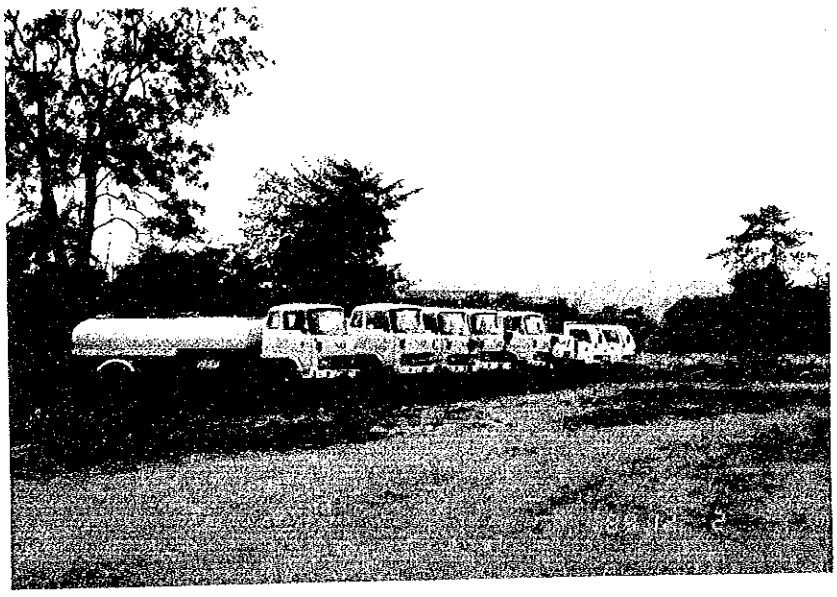
Girls fetching water
(at suburb of Sefwi-
Wiawso)

ジャーマン郡 ドロボ市
郊外に移動した
ベースキャンプ

Project Base Camp
(at Drobo, Jaman Dist.)

ベースキャンプに集合した
フェーズIで調達された
車両類

Vehicles provided under
the Phase-I Project



SUMMARY

The Republic of Ghana (hereinafter referred to as Ghana) lies almost in the center of the countries along the Gulf of Guinea (the West Africa Coast), having a national land area of about 239,000 km^2 and a population of about 13.6 million (as of 1988).

The Ghana Water and Sewerage Corporation (hereinafter abbreviated as GWSC) under the Ministry of Works and Housing (MWH) is responsible for water supply administration and for development of water supply to both urban and rural areas, sewerage drain/treatment, the operation and maintenance of the related facilities and organization, and so forth.

GWSC has formulated the administrative standards to supply water by pipe-borne water supply system for the urban towns with a population of more than 2,000, by borehole facilities equipped with hand-pumps for those communities with a population between 500 and 2,000, and by providing ponds or hand-dug wells for those communities with a population less than 500. GWSC has been administering 208 water supply systems throughout the country to supply water for about 4.0 million urban people, approximately 30% of the total population of 13.6 million. While for the rural population, which comprises 65% of the total population, only 40% is provided with water. It means about 5.0 million rural people do not have access to good drinking water.

In 1985, the Government of Ghana formulated and launched the "Five-year Rehabilitation and Development Programme (1985-1989)" under the National Economic Recovery Programme (ERP) to rehabilitate the existing facilities and to develop the rural water supply systems. Under the condition, GWSC requested the Government of Japan, through the Ministry of Finance and Economic Planning of Ghana (MFEP), to provide a grant aid which places the key points on the provision of equipment and materials for the rehabilitation of time-worn water supply facilities and the construction of borehole facilities. Then, Japan International Cooperation Agency (JICA) conducted a Basic Design Study based on the decision of the Government (The Project Phase I).

The Government of Japan, with respect to the result of the Study, decided to cooperate in the Rural Water Supply Project, which will construct 466 borehole facilities in 147 communities, for a rural population of 205,000 at Nanumba (Northern Region), Berekum/Jaman (Brong Ahafo Region), and Sefwi-Wiawso District (Western Region). In fiscal 1986, JICA executed grant aid of 889 million yen for the Project including provision

of drilling rigs, construction equipment and materials, as well as consultancy and expertise services for 120 out of 159 borehole facilities with hand-pumps to be constructed in Nanumba District, Northern Region. After the completion of Japanese cooperation, GWSC continued the Project works and thus completed 159 borehole facilities with hand-pumps in Nanumba. Thereafter, GWSC has removed the base camp to Jaman District, one of the remaining Project Areas, to initiate the borehole drilling at the area.

Recently, ERP has been shifted to its phase-II stage. On the occasion, GWSC has formulated the "6000 Drilled Wells Programme" (1987-1991) under the new national policy to promote the extension of the rural water supply systems, and launched the Programme with positive international assistance and NGO's activities.

Thus, the Government of Ghana again requested grant aid from Japan for the Phase-II Project to construct the remaining 307 borehole facilities in the said two areas urgently. In response to the request, JICA sent a Project Formation Study Team to Ghana in April, 1989, to examine the contents of the request. Based on the Study, the Government of Japan decided to conduct the basic design study on the Project Phase-II. Based on the decision, JICA dispatched a Basic Design Study Team to Ghana from 26th November to 17th December 1989. The Study Team held a series of discussions on the contents of the request with the related officials of the Government of Ghana, conducted field inspections in the Project areas, and collected data/information concerning the Project.

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

- Outline of the Plan:

  To construct 307 borehole facilities with hand-pumps for the five districts in Brong Ahafo and Western Regions, to improve the rural water supply conditions (Japan cooperates in construction of 166 borehole facilities).

  Major dimensions of the borehole facilities are one facility per 400 population, 15 lcd of water demand, 6000 lit/day of standard withdrawal, 300 lit/hr of minimum successful yield, and average 50m of borehole depth.

- The Project Areas:

  The Project areas and planed borehole facilities are shown below.

Project Areas	Former*	Boreholes	Japanese cooperation
Berekum	Berekum/Jaman	43	-
Jaman		100	83
Juabeso-Bia	Sefwi-Wiawso	89	11
Sefwi-Wiawso		72	72
Bibiani-Anhwiaso-Bekwai		3	-
Total		307	166

* : subdivided into five districts in 1988.

- Equipment and Materials:
  - (A) for borehole construction
    - a. Spare parts for Phase-I equipment 1 LS
    - b. Rotary drilling rig 1 unit
    - c. Air-compressor 1 unit
    - d. Supporting vehicles 1 LS
    - e. Borehole test equipment 1 LS
    - f. Siting equipment 1 LS
    - g. Hand-pump 353 units
    - h. Casing and Strainers 1 LS
  - (B) for District Maintenance Centers
    - a. Servicing rig 3 units
    - b. Motorcycle 9 units
    - c. Workshop tools 2 sets
    - d. Spare hand-pumps and parts 1 LS

Expenses to be borne by the Ghanaian government are estimated at 25 million yen. The implementation of the Project will take 3.5 months for the detail design and 12 months for the cooperation on the borehole construction.

The direct benefits generated from the Project are 1) to alleviate the heavy burden of medical expenditure of the rural inhabitants through mitigating the high occurrence rate of water-borne diseases, in particular, infant mortality by digestive disease, 2) to remarkably alleviate the heavy burden of women and children for water fetching, and 3) to stabilize and raise the level of rural life. Furthermore, the equipment to be procured under the Project will be sufficiently operative after completion of the Project. The effective operation of the equipment, as well as the latest technology and knowledge to be transferred through the Project, will help to realize the improvement of rural water supply in the country. Thus, the Project should be quite feasible as a Japanese grant aid programme.

For the successful implementation of this Project, it is recommended that the Ghanaian authorities concerned pay attention to the following points; 1) 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, 2) the proposed O&M staffs for the facilities should be engaged in the construction works as much as possible, 3) the Project beneficiaries should be educated on public health as early as possible, 4) the Ghanaian authorities concerned should consider to establish and extend the Village Level Operation and Maintenance (VLOM) Programme as early and efficiently as possible and so forth.

The Rural Water Supply Project (Phase-II)
Basic Design Study Report

CONTENTS

ABBREVIATIONS

AfDB	: African Development Bank
Ag.	: Acting
ATMA	: Accra-Teme Metropolitan Area
BCR	: Benefit Cost Ratio
BIAO	: Bilateral Assistance Organization
BTP	: Baptist Church
CBS	: Central Bureau of Statistics
CCCE	: Caisse Central de Co-operation Economique
CIDA	: Canada International Development Agency
CSIR	: Council for Scientific and Industrial Research
DMD	: Deputy Managing Director
DTH	: Down-the-hole Hammer
ECG	: Electric Corporation of Ghana
EM	: Electro-magenetic (prospecting or equipment)
E/N	: Exchange of Notes
EOJ	: Embassy of Japan
ERP	: Economic Recovery Programme
FC	: Foreign Currency or Foreign Cost
F/S	: Feasibility Study
FTBN	: Finance to be negotiated
GE	: Geo-electric (sounding or equipment)
GOG	: Government of the Republic of Ghana
GOJ	: Government of Japan
GSD	: Geological Survey Department
GTZ	: Gessellschaft fur Technische Zusammenarbeit
GWSC	: Ghana Water and Sewerage Corporation
IDA	: International Development Association
IGIP	: Ingenieur Gesellschaft fur Internationale Planwung-saufgaben
IRR	: Internal Rate of Return
ISD	: Information Service Department
JICA	: Japan International Cooperation Agency
KfW	: Kreditanstalt fur Wiederaufbau
LC	: Local Currency or Local Cost (Cedi)
MD	: Managing Director
MFEP	: Ministry of Finance and Economic Planning
MLGRD	: Ministry of Local Government and Rural Development
MOH	: Ministry of Health
MSD	: Meteorological Service Department
MWH	: Ministry of Works and Housing
NGO	: Non-Governmental Organizations
NORRIP	: Northern Region Rural Integrated Programme

NSS	: National Service Secretariat
ODA	: Official Development Assistance
PIP	: Public Investment Programme
PNDC	: Provisional National Defense Council
RCC	: Roman Catholic Church
SAP	: Structural Adjustment Programme
SD	: Survey Department
SOE	: State Owned Enterprises
UK	: United Kingdom
UNDP	: United Nations Development Programme
UNICEF	: United Nations Children's Fund
URWSP	: Upper Region Water Supply Project
VLOM	: Village Level Operation and Maintenance
VORADEP	: Volta Region Agricultural Development Programme
WHO	: World Health Organization
WSRP	: Water Sector Rehabilitation Project
WVI	: World Vision International

SYMBOLS

in or "	: inch(es) = 25.4 mm
sqm or m2	: square meter(s)
sqkm or km2	: square kilometer(s)
cum or m3	: cubic meter(s)
MCM or mcm	: million cubic meter (s)
gal	: gallon(s) = 4.546 lit.
°	: degree
lit.cd	: liter(s) per capita per day
gcd	: gallon(s) per capita per day
gpm	: gallon(s) per minute
¥	: Japanese Yen(s)
¥m	: million Japanese Yen(s)
$	: US Dollar(s)
$m	: million US Dollar(s)
₵	: Ghanaian Cedi(s)
₵m	: million Ghanaian Cedi(s)
pcs	: pieces
L.S	: Lump sum
KVA	: kilo-volt-ampere
μS/cm	: micro-Siemens per centimeter

CHAPTER 1. INTRODUCTION

The provision of good drinking water for the Ghanaian population is a major social and health objective of the Government. The Ministry of Works and Housing (MWH) is responsible for the administration of the water sub-sector while the Ghana Water and Sewerage Corporation (GWSC) is responsible for the development and distribution of pipe-borne and other sources of good drinking water throughout the country.

In 1985, the Government of Ghana formulated and launched the "Five-year Rehabilitation and Development Programme (1985-1989)" under the National Economic Recovery Programme (ERP), to rehabilitate the existing facilities and to develop the rural water supply systems. Under the condition, the GWSC requested the Government of Japan, through the Ministry of Finance and Economic Planning of Ghana (MFEP), 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 borehole facilities. The Government of Japan, in response to the request, decided to conduct a basic design study on the Project, and entrusted the study to the Japan International Cooperation Agency (JICA). <The Project Phase-I>

The Government of Japan, with respect to the result of the Study, decided to cooperate in the Rural Water Supply Project which intends to construct 466 borehole facilities at Nanumba (Northern Region), Berekum/Jaman (Brong Ahafo Region), and Sefwi-Wiawso District (Western Region). In fiscal 1986, JICA executed grant aid of 889 million yen for the Project including provision of drilling rigs, construction equipment and materials, as well as consultancy and expertise services for 120 out of 159 borehole facilities to be constructed in Nanumba District. After the completion of Japanese cooperation, GWSC continued the Project works ceaselessly and completed 159 borehole facilities in Nanumba under its direct management.

Recently, ERP has been shifted to its phase-II stage. On the occasion, GWSC has formulated the "6000 Drilled Wells Programme" (1987-1991) under the new national policy to promote the extension of the rural water supply systems, and launched the Programme receiving positively the international assistance and NGO's activities. Thus, the Government of Ghana again requested grant aid from Japan for the Phase-II Project to construct the remaining 307 borehole facilities in the said two areas urgently.

Responding to the request, JICA sent a Project Formation Study Team

to Ghana to examine the contents of Request. And based on the Study Report, the Government of Japan decided to conduct a basic design study on the Project Phase-II. Based on the decision, JICA dispatched a Basic Design Study Team headed by Mr.A. KONO, First Africa Division, Middle Eastern/Africa Bureau, Ministry of Foreign Affairs, to Ghana from 26th November to 17th December 1989.

The Study Team held a series of discussions on the contents of the request with the related officials of the Government of Ghana, conducted field inspections in the Project areas, and collected data and information concerning the Project. The matters basically agreed upon with the Ghanaian party through the discussions are contained in the Minutes of Discussions dated 12th December 1989, signed by Mr. A. KONO, Leader of the Study Team and Mr. T.B.F. Acquah, Managing Director, GWSC.

After their return to Japan, the Study Team carried out a feasibility study of the Project, designed water supply facilities, selected equipment and materials necessary for the implementation of Project, made a preliminary estimate of Project costs, planned the operation and maintenance and so forth, based on the survey.

This report describes the results of the above-mentioned serial basic design studies. List of the Study Team, Itinerary of the Team, List of related Organization and Officials, and copy of the Minutes of Meeting are attached to the Report as Appendix 1, 2, 3 and 4 respectively.

CHAPTER 2 BACKGROUND OF THE PROJECT

2-1. Background of the Project

The lack of potable water supply to such a large population of the rural communities (65%) adversely affects the health and quality of life of millions of rural dwellers, and hence their economic productivity. The importance of potable water supply in national socio-economic development cannot be over-emphasized. In Ghana, where approximately 70% of the entire population live in the rural areas, which are also the centers of agricultural production, the health of the rural dwellers is the wealth of the nation.

It is therefore in the interest of national economic growth, among other things, that potable water be made available to as many more rural communities as possible within a reasonable period of time. Approximately 60% of the rural population of Ghana does not as yet have access to potable water. Their sources of water include streams, ponds, rivers, etc., which are invariably polluted and hence lead to a high incidence of water-borne and water-related diseases such as guinea worm, cholera, diarrhea, schistsomiasis, malaria, and other endemic diseases. Agricultural productivity is impaired and the national medical expenditure increases as a result of these diseases. Useful man-hours and energy are also wasted in traveling long distances to fetch water from the streams and rivers. It is foreseen that these efforts will require an accelerated programme of the magnitude such as to cover 5.0 million rural people within the shortest possible time.

Thus, the provision of good drinking water for the Ghanaian population is a major social and health objective of the Government. The Ministry of Works and Housing (MWH) is responsible for the administration of the water sub-sector while the Ghana Water and Sewerage Corporation (GWSC) is responsible for the development and distribution of pipe-borne and other sources of good drinking water throughout the country. Figure 2-1-1 and 2-1-2 show the organizations of GWSC Headquarters and Area/Regional Offices.

GWSC recognizes the aforementioned severe situation of the rural inhabitants and has thus proposed two major rural water supply programmes, namely:

(i) 10,000 Hand Dug-well Programme, dubbed "Operation Dry Throat" for small rural communities with a population below 500.

Figure 2-1-1.

GHANA WATER AND SEWERAGE CORPOLATION
HEAD OFFICE ORGANIZATION

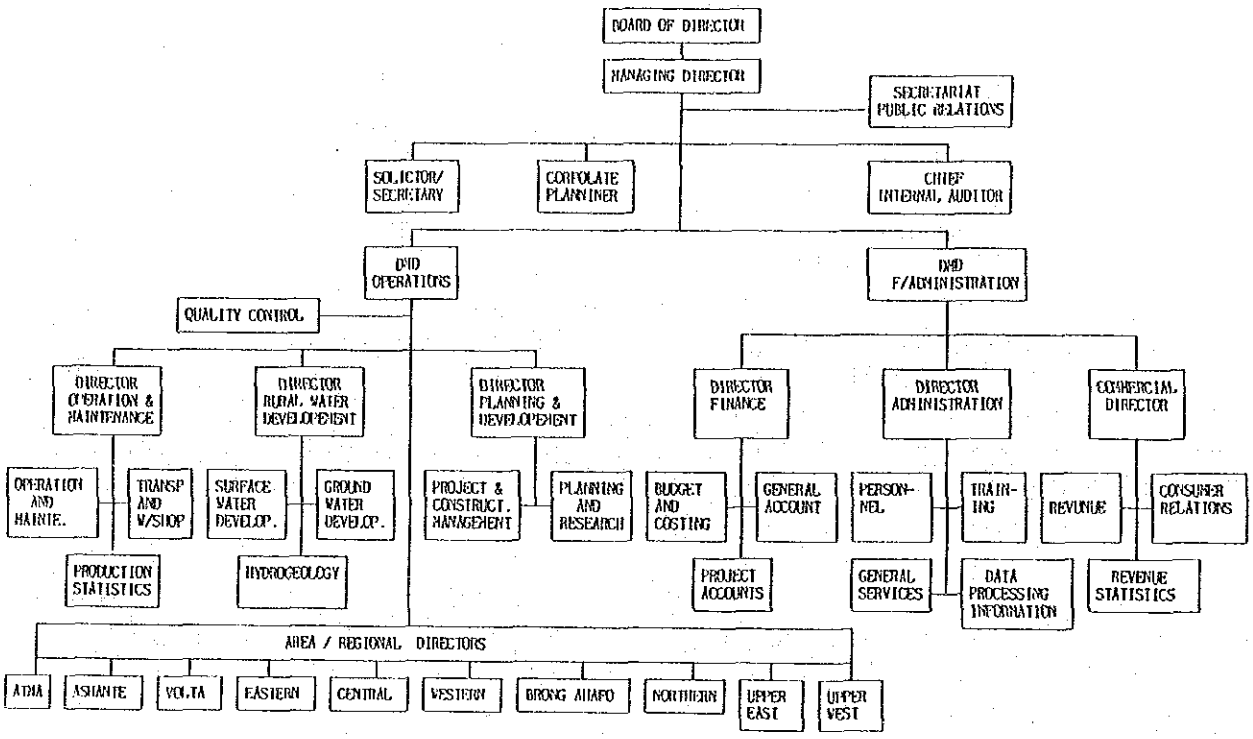
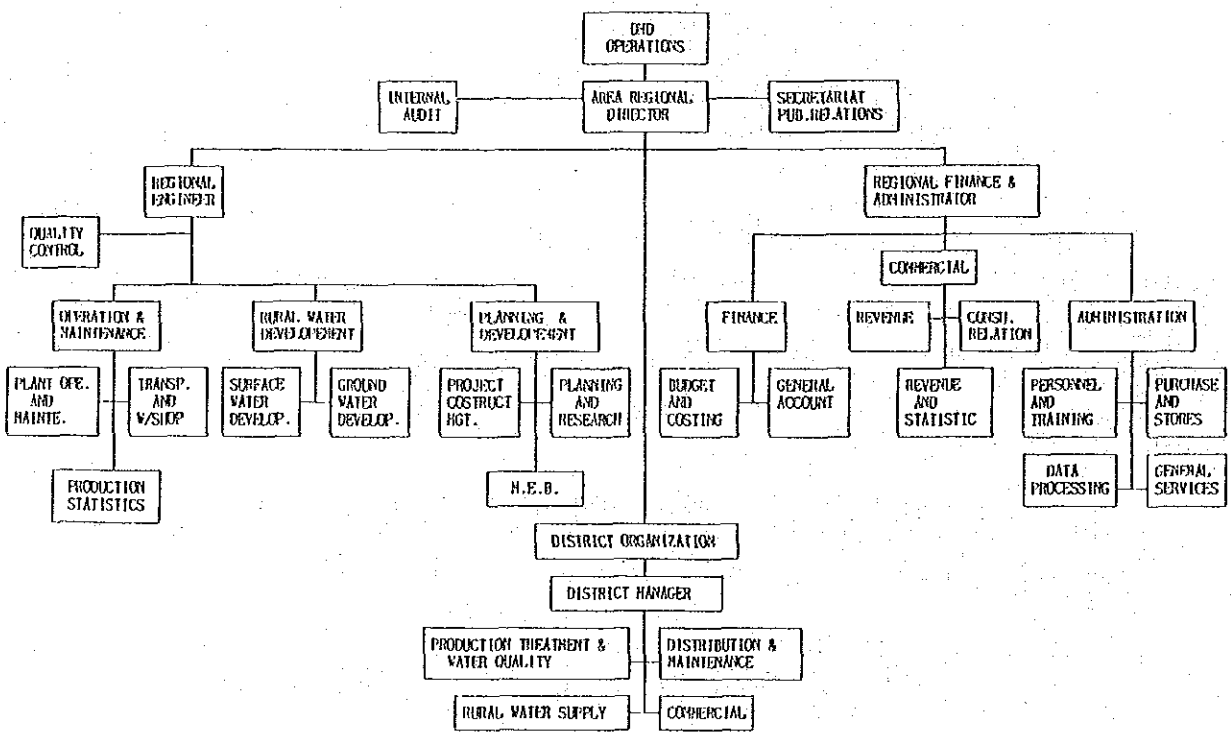


Figure 2-1-2.

GHANA WATER AND SEWERAGE CORPOLATION
REGIONAL/DISTRICT ORGANIZATION



(ii) 6,000 Drilled Wells Programme, referred to as "Operation Sparkling Groundwater" is aimed at providing potable water to communities within the population range 500 - 2000.

The two programmes are intended to bridge the gap in water supply coverage between the urban and the rural areas. The latter is seen as a continuation of the Corporation's broad strategy for meeting the total demand of the population range 500 - 2,000 with provision for 250 - 300 people to a well, along one of the highest priority national project; "Rural Water Supply Scheme II (WTR 008/86)" under Public Investment Programme (PIP).

"6000 Drilled Well Programme" has been initiated widely and positively, receiving the international assistance and non-governmental assistance activities shown in Table 2-1-1 and Figure 2-1-3. The Project Phase-I was assigned as a component of the Programme, and the request for the Project Phase-II has also been done to further promote the Programme.

2-2. Outline of the Request

The request of the Government of Ghana to Japan on the Project was made through MFEP in April 1989. By the letter, the request was consisted of supplemental borehole construction materials, equipment and tools for District Maintenance Center, additional drilling rigs (percussion type rigs) and consultancy/expertise services with construction materials.

The details of the requested equipment, materials and services are shown in Appendix-5 at the end of the report.

On 24th May 1989, GWSC sent a letter to JICA with a revised request on the Project in response to the discussions with and recommendations by the Project Formation Study Team sent by JICA in April. The major item revised in the request was changing the type of drilling rigs from a percussion type to a rotary type. The latest list of equipment and materials requested by the letter is attached as Appendix-6, and further, the comparison table of the requests and the results of the study is shown as Table 3-2-1 (next Chapter, section 3-2).

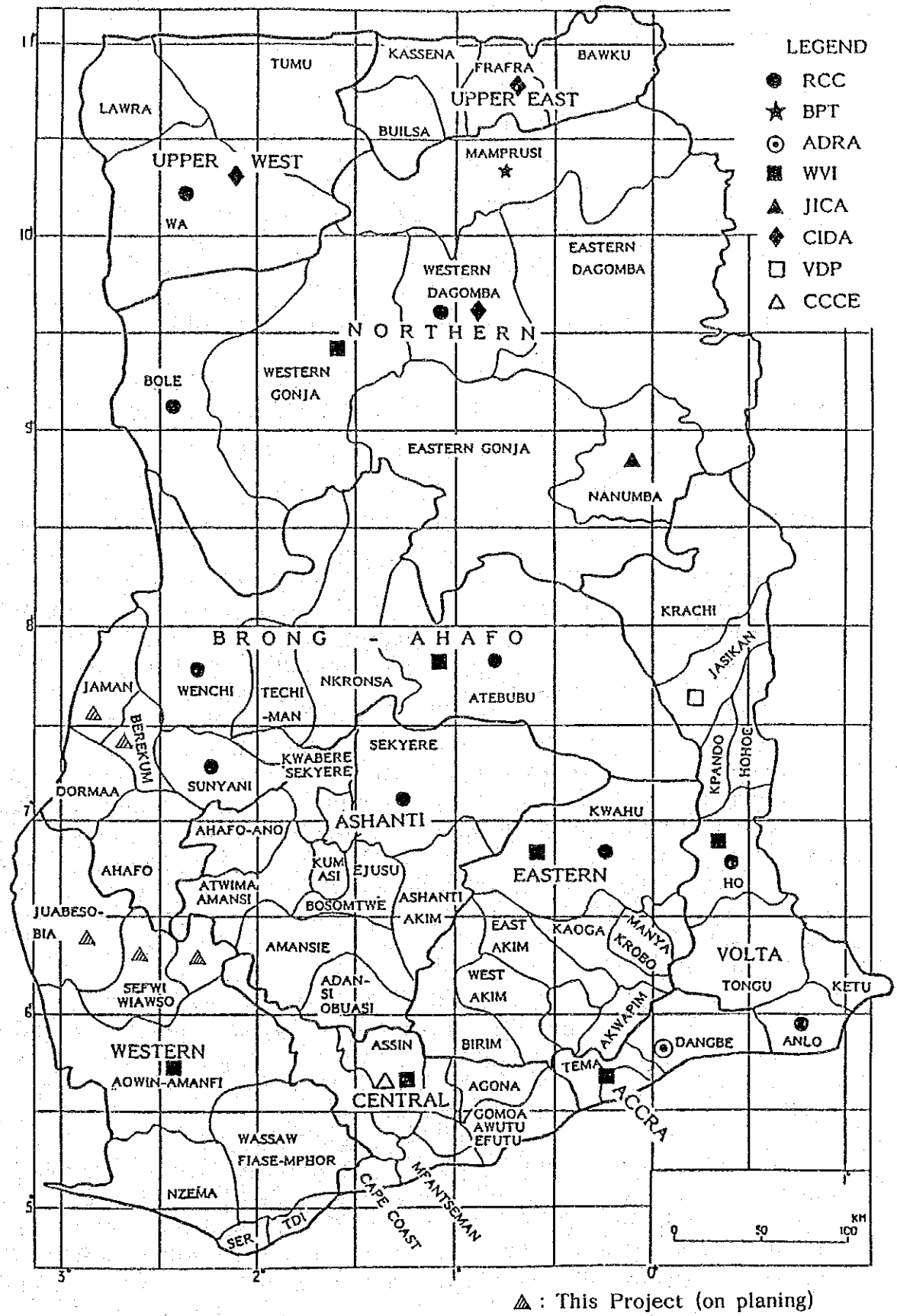
Table 2-1-1

6000 DRILLED WELLS PROGRAMME
IMPLEMENTATION SCHEDULE

REGION	No. of Wells to be Drilled					TOTAL
	1987	1988	1989	1990	1991	
Ashanti	40 RCC	40 RCC	60 RCC	60 RCC		200
Brong-Ahafo	225 RCC	170/25 RCC/WVI	50/25/143 RCC/WVI/JICA	50/25 RCC/WVI	50/25 RCC/WVI	788
Central		25 WVI	25 WVI 300 CCCE	25 WVI 300 CCCE	25 WVI 300 CCCE	1,000
Eastern	30 RCC	25 WVI	50/25 RCC/WVI	50/25 RCC/WVI	25 WVI	1,000
			256	257	257	
Greater Accra	20 WVI	25/10 WVI/ADRA	25/17 WVI/OTHERS	25 WVI	25 WVI	147
Northern	156/30 RCC/JICA	90/100/50/25 JICA/CIDA BPT/WVI	100/25/50/39 CIDA/WVI BPT/JICA	100/25/50 CIDA/WVI BPT	25 WVI	865
Upper East/ West	65 RCC	70 RCC	40	35		210
Western	10 WVI	25 WVI	25/82 WVI/JICA	25/82 WVI/JICA	25 WVI	882
			203	203	202	
Volta	24/120/8 RCC/VDP/WVI	25 WVI	25 WVI	25 WVI	25 WVI	1,000
			249	249	250	
TOTAL	728	705	1,814	1,611	1,234	6,092

NB:
- RCC - Catholic Church (including Wench, village water project in Brong-Ahafo)
- BPT - Baptist Church
- ADRA - Adventist
- WVI - World Vision (Ghana) International
- JICA - Japan International Cooperation Agency
- CIDA - Canadian International Development Agency
- VDP - Voradep
- CCCE - Caisse Central de Co-operation Economique
- OTHERS - Include Unicef, Danish, Dutch, Romania etc.

Figure 2-3-4. INTERNATIONAL COOPERATION IN GHANA



▲ : This Project (on planing)

2-3. Outline of the Project Areas

2-3-1. Socio-economic Situation

Administratively, the Project area of the former Berekum/Jaman District in Brong Ahafo Region was sub-divided into two districts as Berekum and Jaman Districts, and the former Sefwi-Wiawso District in Western Region was divided into following three districts in 1988; Juabeso-Bia, Sefwi-Wiawso and Bibiani-Anhwiaso-Bekwai Districts.

The land of Ghana can be divided into 11 geographical regions, and they are also socio-economical regions coincidentally (refer to the figure 2-3-1).

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

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

However, the target Project area, the former Berekum/Jaman District, which belongs to this rather blessed region, is situated at its northwest end where it is mostly mountainous area bordering with the Republic of Ivory Coast, and has been left in a low socio-economic condition.

The second Project area, the former Sefwi-Wiawso District, belongs to the "Pioneer Fringe" (see Fig. 2-3-1). The region lies between the Southwest and the Cocoa Forest regions, a broad belt of mountainous or hilly 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.

Figure 2-3-1 Socio-Economic Regions

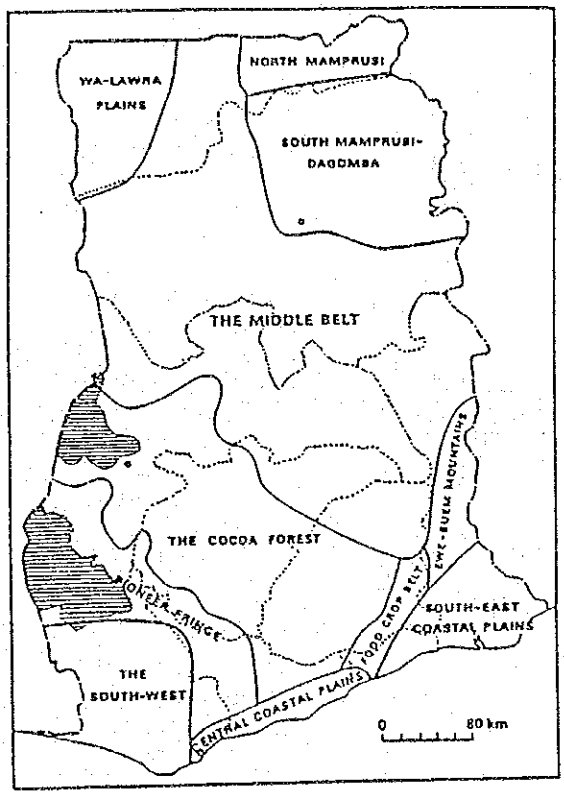
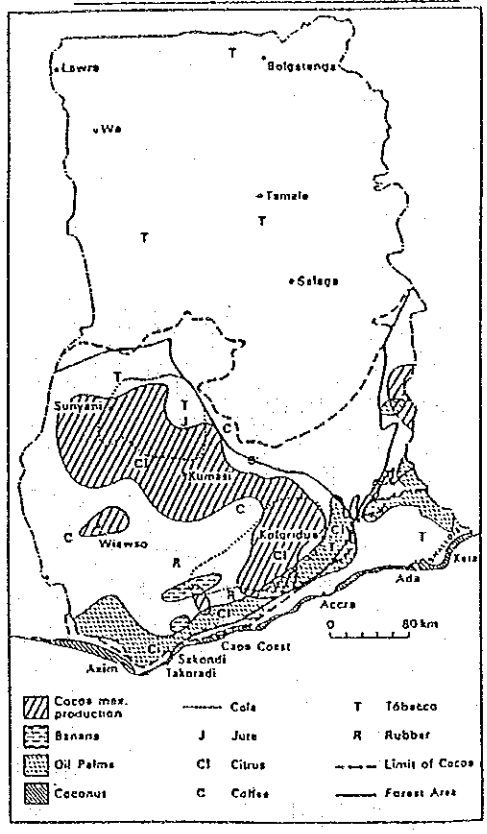


Figure 2-3-2

Distribution of Commercial Crops



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.

Juabeso-Bia, Sefwi-Wiawso, and Bibiani-Anhwiaso-Bekwai Districts are situated at the west end of this pioneer fringe, also bordering with Ivory Coast. The districts are still in far low socioeconomic situation among the other districts in such generally little developed pioneer fringe, mainly because of its geographical situation.

2-3-2. Physical Environment

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

Berekum and Jaman Districts are in the mountainous western margin of the Region bordering Ivory Cast. The area is included in the "Rain Forest Dissected Plateau" climatically and physiographically. The plateaux with elevation from 300 to 600m above sea level are strongly dissected by several rivers but form rather flat tops keeping a pene-plain feature as a total summit level. Dissecting valleys are deep and their bank slopes are very steep, although generally they have flat bottoms.

In the western part of the Brong Ahafo Region including the Project area, Pre-Cambrian, which is the basement of the country, crops out directly. The Pre-Cambrian rocks in Ghana consists of Dohomeyan, Birrimian, Tarkwaian, Togo Series, and Buem Formations in descending order of age. Among them, the Birrimian occupies the area mainly and the Tarkwaian overlying the former partly.

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 export-ed 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 lava. The Birrimian formation as a whole 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, sandstone, quartzites and phillites. A few small patches of land within the area covered by the formation consists of plutonic or vol-canic rocks (refer to the Geological Map of Ghana in Appendix-12).

The whole area of the Western Region belongs to the Rain Forest Dissected Plateau physiographcally. The area of this region stretches north-south, in contrast with the Brong Ahafo Region. The Project areas are situated at the northern end of the Region bordering Ivory Coast on the west and Brong Ahafo Region on the north and east.

The Project areas; Juabeso-Bia, Sefwi-Wiawso and Bibiani-Anhwiaso-Bekwai Districts, which belong to the Rain Forest Dissected Plateau, are situated at the southern end of the Wet Semi-equatorial climatic region, and the forest is very dense. The rivers near the Project area cut up the plateaux deeply and form considerably wide valleys with very steep bank slopes. Elevation of these plateau surfaces are not very high; mostly less than 300m above sea level, however, the road condition is very poor because of an abandance of rain, dense forest and steep land slopes.

The rocks in the Western Region belong to Pre-Cambrian Basement Complex. The Project areas are underlain by the Birrimian mostly, as the same situation with the former Berkum/Jaman District, but the Granitic rocks also crop out here and there within the areas.

The Project areas are situated in the "Wet Semi-equatorial" region climatically, and the mean annual rainfall around the area is between about 1,250 and 2,000mm. The region has two rainfall maximums in a year at June and October. Mean monthly temperature is about 25° C and average monthly relative humidities are 60 to 70% in the dry season, and 70 to 80% in the rainy season.

Hydrogeologically, the Project areas are occupied mainly by the Birrimian hydrogeological region and partly by the Granite region (refer to Figure 2-3-3). These regions are called "Pre-Cambrian Basement Hydrogeological Region" overall, which has the most dominant aquifers in Ghana. However, a rock weathered zone in the group is generally deep; the depth of decomposition averages about 30m, sometimes 40m.

The Birrimian hydrogeological region mainly consists of such metamorphosed sediments as phyllites, schists, greenstones and greywackes. The region, as a whole, was highly folded and intruded by quartz vein everywhere. In the region, although the decomposed zone contains groundwater, the underlying fresh rock also forms dominant aquifers in fractures or quartz veins at its upper portion. The yields in the region are generally high; reaching more than 300 lit/min at the fractured or quartz vein zones.

The rocks in the Granite region are also deeply weathered, and usually the water bearing zones are found at the moderately decomposed zones overlying the fresh part of rock. Underlying fresh rocks have also encountered the high yields when they have joints, fractures or intruded pegmatite veins at their upper portions. Yields as high as 400 lit/min have often been measured at such aquifers.

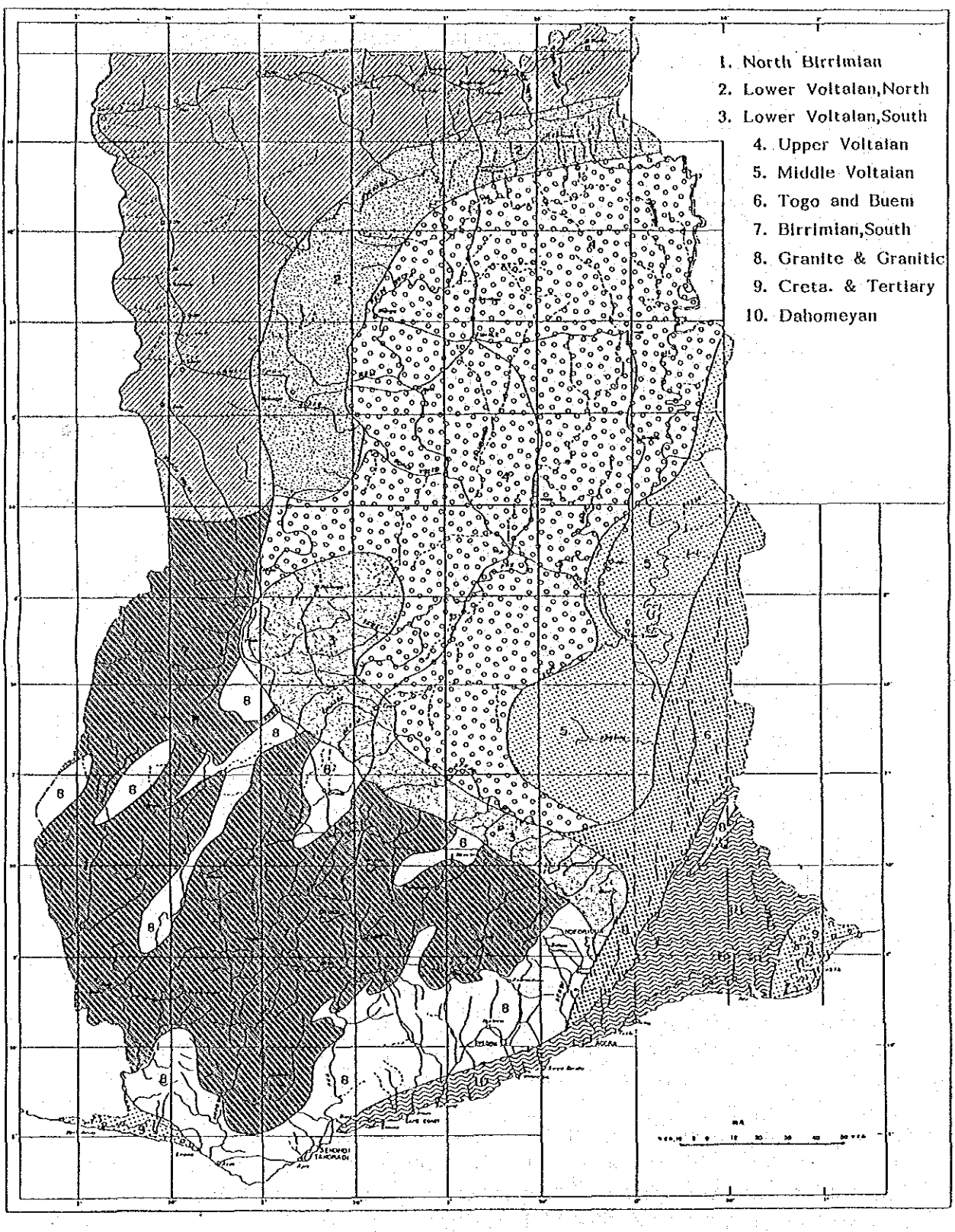


Figure 2-3-3 Hydrogeological Regions of Ghana

As mentioned so far, the potential of the Pre-Cambrian basement rocks can be said to be as good for groundwater development, however, the depth of boreholes may be deep because the main aquifers are in the lower parts of the deep decomposed zones.

On the other hand, the water quality in the Pre-Cambrian hydrogeological region is not always favorable, rather troublesome more or less. Because of the characteristics of the layers and its water bearing system, groundwater in the region usually contains some chemical components, mainly heavy metal ions. Furthermore, most groundwater around there indicates an acid character, ranging in pH value from 6.5 to 5.5, and sometimes 5.0. The situation was not paticularly serious for human health in a direct sense, but caused secondary pollution by rusted iron in the boreholes. The actual records on the water qualities measured at existing boreholes in the related areas are shown in the Appendix together with Water Quality Designation of WHO and Japan (Appendix-9 and 10).

CHAPTER 3. OUTLINE OF THE PROJECT

3-1. Objectives and Contents

The objectives of the Rural Water Supply Project (the original Project) were to construct 466 boreholes equipped with manual pumps and to provide the necessary equipment for the borehole drilling in the rural area having no suitable water supply system at present, in order to develop a healthy potable water supply and to improve the standard of living of the rural population, and further to contribute toward the development of the local economy and to the national economy.

The original Project area was following three districts;

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

The Project was phased in two stages for the implementation as the Project Phase-I and the Phase-II, and the Project Phase-I has been implemented under Japanese grant aid.

The first grant aid of Japan; summed to 889 million yen, for the Project implementation involved procurement and transportation of major equipment, dispatching of seven engineers for the cooperation in 120 borehole facilities construction, including procurement of materials required, and a consultancy service including the dispatching of three supervising engineers.

The equipment and materials procured under the Project Phase-I were shown below;

		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)	Hand-Pump	140 units
12)	Workshop Instruments	1 set
13)	Radio Communication System	1 "
14)	Camping Equipment	1 unit

The objectives of the Project Phase-II are to construct 307 boreholes equipped with hand-pumps and to provide the necessary equipment and materials for borehole construction and maintenance in the rural area, in order to develop healthy potable water and to improve the standard of living of the rural inhabitants, which are the same as those for the Phase-I.

The Project area for Phase-II is to be the following five districts according to administrative modification by the Government:

1) Berekum District, and
2) Jaman District of Brong Ahafo Region
   (above two are the former Berekum/Jaman District)
3) Juabeso-Bia District,
4) Bibiani-Anhwiaso-Bekwai District, and
5) Sefwi-Wiawso District of Western Region
   (above three are the former Sefwi-Wiawso District)

The location of these Project areas is shown as the LOCATION MAP OF THE PROJECT AREA at the front of the Report.

3-2. Study and Examination on the Request

The original request from the Government of Ghana through MFEP consisted of a) equipment and materials for borehole construction, b) equipment and materials for the District Maintenance Centers, c) two sets of Percussion Drilling Rigs, and d) consultancy and expertise services. Later, GWSC sent a revised request to JICA through the Embassy of Japan in Ghana, in response to the discussions with and recommendation by the Project Formation Study Team dispatched by JICA in April 1989.

Table 3-2-1 shows contents/quantities of each item requested in the latest request, together with the quantity (and items) formulated through the Study. The major differences between these two are a) number of additional drilling rig (item 1-3) and b) supporting vehicles and materials for District Maintenance Centers.

Basically, the following examination on the request shall be done based on the latest request (revised one) taking the Study Team's recommendations into an account.

Table 3-2-1.

Equipment and Materials requested for Phase II Project

Item No.	Descriptions	Requested	Studied
1.	EQUIPMENT & MATERIALS		
1-1.	For the Borehole Construction:		
1-1-1.	Casing materials 4"x4m	3377 units	3100 units
1-1-2.	Strainer -ditto-	1689 units	1100 units
1-1-3.	Hand-pump	354 units	353 units
1-1-4.	Supplemental drilling tools	1 lot	1 lot
1-1-5.	Spare parts for supplied equipment	3 years	2 years
1-1-6.	-ditto- for geophysical and E.M equipment	1 lot	1 lot
1-1-7.	Mud-agencies	1 lot	1 lot
1-1-8.	Equipment for Borehole Test	-	1 lot
1-1-9.	Equipment for Siting	-	1 lot
1-2.	For the District Maintenance Centers:		
1-2-1.	Servicing rig	3 units	3 units
1-2-2.	Pick-up truck (4WD)	3 units	-
1-2-3.	Workshop equipment & tools	2 lots	2 lots
1-2-4.	Hand-pump	30 units	30 units
1-2-5.	Hand-pump cylinders	30 units	30 units
1-2-6.	Submersible pump	3 units	-
1-2-7.	Diesel generator	3 units	-
1-2-8.	Motor Cycles	9 units	9 units
1-2-9.	Spare parts for above	3 years	2 years
1-2-10.	Air-compressor	-	3 units
1-3.	Additional Drilling Rig		
1-3-1.	Truck mounted rotary drilling rig	2 units	1 unit
1-3-2.	Standard accessories & tools	2 lots	1 lot
1-3-3.	High-pressure Air-compressor	2 units	1 unit
1-3-4.	Cargo truck (8 ton capacity)	2 units	1 unit
1-3-5.	Station Wagon (4WD)	2 units	1 unit
1-3-6.	Pick-up trick (4WD)	2 units	2 units
1-3-7.	Truck mounted water lorry	2 units	1 unit
1-3-8.	Spare parts for above	3 years	2 years
2.	SERVICES		
2-1.	Consultancy Services		
2-1-1.	Services for the procurement	4 M/M	7 M/M
2-1-2.	Supervising Engineer	12 M/M	11.5 M/M
2-1-3.	Hydrogeologist	12 M/M	6 M/M
2-2.	Expertise Services		
2-2-1.	Senior Mechanical engineer	24 M/M	11.5 M/M
2-2-2.	Senior Driller	24 M/M	16.0 M/M
2-3.	Construction Materials		
2-3-1.	Contractor's equipment	1 lot	1 lot
2-3-2.	Camping and Transport	1 lot	1 lot
2-3-3.	Materials for construction (fuels, oils, cement, etc.)	1 lot	1 lot

Equipment and Materials for Borehole Construction

On the equipment and materials for Borehole Construction at first, item 1-1. consisted of two categories; a) borehole construction materials for remaining 307 borehole facilities, and b) spare parts for supplied equipment under the Project Phase-I.

For the category a), casing, strainer, and mud agencies shall be procured in Japan and the quantities shall be automatically calculated from the total drilling length. Mud-drilling agencies such as Bentnite and CMC, however, shall be examined again from the viewpoint of efficiency and cost/volume/performance. Hand-pump may be procured from a third country, but it must fit the new standard of GWSC, and further, the underground structures of hand-pump shall be any kind of stainless type because of an acid groundwater quality.

Equipment supplied under the Phase-I Project, including the siting equipment, have been on-site more than two years and are actually working now. Although they have been maintained very well by the Project staff, most of the spare parts for them have been used. The spare parts for equipment, including geophysical equipment, should be provided for at least two years operation (until the end of all construction works under the Project).

Equipment and Materials for District Maintenance Center

This item consists of a) workshop equipment and tools and b) supporting vehicles including servicing rigs. The former shall be of the same contents and quantities as those procured under the Phase-I Project (for Nanumba District).

Servicing rigs are the main equipment of the item, and are studied prudently from the cost/performance viewpoint because a typical servicing rig is very costly. Hand-pumps and their cylinders, which are provided as spare pumps when a hand-pump fitted is under repair, are newly requested. Spare hand-pumps are requested for maintenance works, however, the adequate number of spare hand-pumps in each Maintenance Center shall be studied. Supporting vehicles, which were pick-up trucks originally and revised to both pick-up trucks and motorcycles, will also be examined carefully to determine whether both types are necessary, and if not, which type is more suitable.

Submersible pumps and diesel generators were included in the revised request mainly for borehole developing work. For this purpose,

a combination of air-compressor and air-pipe is much simpler, more portable and more economical.

Services

Because geological and hydrogeological conditions of the Project areas are quite different from those of Nanumba District (Phase-I Project area), GWSC requested consultancy and expertise services on the cooperation for construction of borehole facilities under the Project.

The Project areas, Western and Brong Ahafo Regions, are underlain by Pre-Cambrian basement complex, in contrast to Paraeozoic sedimentary rocks in Nanumba District, so the siting theory and drilling method must be different from the ones they leaned and practiced at the Phase-I Project, e.g. full mud-drilling is required in the areas. Further, the setting of District Maintenance Center at each Project area is one of the major Project components.

Thus, a hydrogeologist and a supervising engineer as the consultancy services, and senior drillers and mechanic engineers in the field of expertise services shall be required on the cooperation for borehole construction in the areas. The period and work volume of the cooperation shall be studied in line with the contents of technology transfer and implementation schedule.

Additional Drilling Rig(s)

Tow percussion rigs in the original request, then two rotary rigs in the revised one, both with standard accessories and tools, were requested by GWSC.

Necessity of additional drilling rig depends on the Project period (the critical pass of the actual Project works is always drilling work). However, it must be considered from the economical point of view too, whether it can be effectively operative or not by GWSC's own budget after completion of the Project, because it will be procured under the Japanese grant aid programme.

For the work schedule, the completion of Project works will be delayed until the late third year in the case that only the equipment already supplied are mobilized. Primarily, the request from the Government of Ghana for Japanese assistance has been done aiming to arrest

the further delay of the Project. GWSC already gave up progressing the Project on schedule (to be completed by the end of this year, but still intends to complete the Project by the end of the second year by when the superior national project of "6000 Drilled Wells Programme" shall be completed.

Considering this situation, although it is very hard to complete all Project works by the end of 1991, at least one additional drilling rig shall be supplied to complete the works within the planned period, or not long after the targeted completion time .

With regard to the financial burden for GWSC, it is concluded that GWSC can bear the expenses for operation (and maintenance) of the supplied rigs after completion of the Project, because GWSC's financial base was already improved under ERP Phase-II, GWSC itself adjusted and rehabilitated the organization and its capacity on the new development programmes, and further, the rural water supply scheme was appointed as one of the "Super-core" Projects; the first priority national project in PIP. It is quite conceivable that GWSC shall continue their own programme for rural water supply along the national development plan, using the supplied drilling rigs by Japanese grant after completion of the Project.

Based upon the examination mentioned above, it is appropriate to supply another one or two drilling rig(s) under the Project. However, it shall be reasonable to supply one drilling rig from the general consideration on the adequate Project implementation term, mobilization capacity of the various staffs, and the economical situation of GWSC which has just recovered from a severe decline.

In the case of four drilling parties, the critical pass shall be shifted to Borehole Test work, so another set of borehole test equipment should be supplied to provide two borehole test parties.

3-3. Project Description

3-3-1. Execution Agency and Operational Structure

The main body to execute the Project is to be the GWSC.

The GWSC shall secure the personnel required for the implementation of the Project, procure materials necessary for the implementa-

tion of the Project other than those procured by Japan, and bear the expense incurred therein.

Because the Project areas expand over two regions, it is desired that the direct responsibility of this Project be borne not by regional office of GWSC but by the Drilling Unit. The Headquarters and each regional office of GWSC shall support the Drilling Unit in connection with the implementation of this Project.

On the basis of the annual implementation plan of this Project, the GWSC Headquarters shall make efforts to continue securing the annual budget including the foreign currency allowance for the procurement of import materials and to support each Regional Office concerning coordination between the Drilling Unit and Regional Office and between the Regional Office and government agencies concerned. The division directly responsible for the Project shall be the "Rural Water Development Division" (refer to Table 2-1-1, previous Chapter).

Each Regional Office shall support the Drilling Unit for communication or coordination with local councils and communities and operate a District Maintenance Center, and has a responsibility to O&M for the completed borehole facilities. The organization of each Regional Office is shown in Section 2-1 Table 2-1-2, and the offices associated with the Project are Brong Ahafo and Western Regional Offices.

The organization and staffs of the Drilling Unit is shown as Figure 3-3-1. As shown in the table, the Drilling Unit has already established an individual work section for the Project, so that the section can be directly in charge of the Project implementation. The field operation structure shall be organized systematically with the staff of the section almost the same as for the Phase-I Project (refer to the Figure 3-3-2, shown at next page).

3-2-2. Plan of Operation

a) The Project is to construct 307 borehole facilities equipped with hand-pumps for the rural people in the former Berekum/Jaman District and Sefwi-Wiawso District in Brong Ahafo and Western Regions, aiming to provide healthful potable water economically to the inhabitants.

b) The Project shall be planned linking in with the "6000 Drilled Wells Programme" (1987-1991) of GWSC.

Figure 3-3-1

GHANA WATER AND SEWERAGE CORPOLATION

DRILLING UNIT ORGANIZATION

TOTAL ESTABLISHMENT = 91

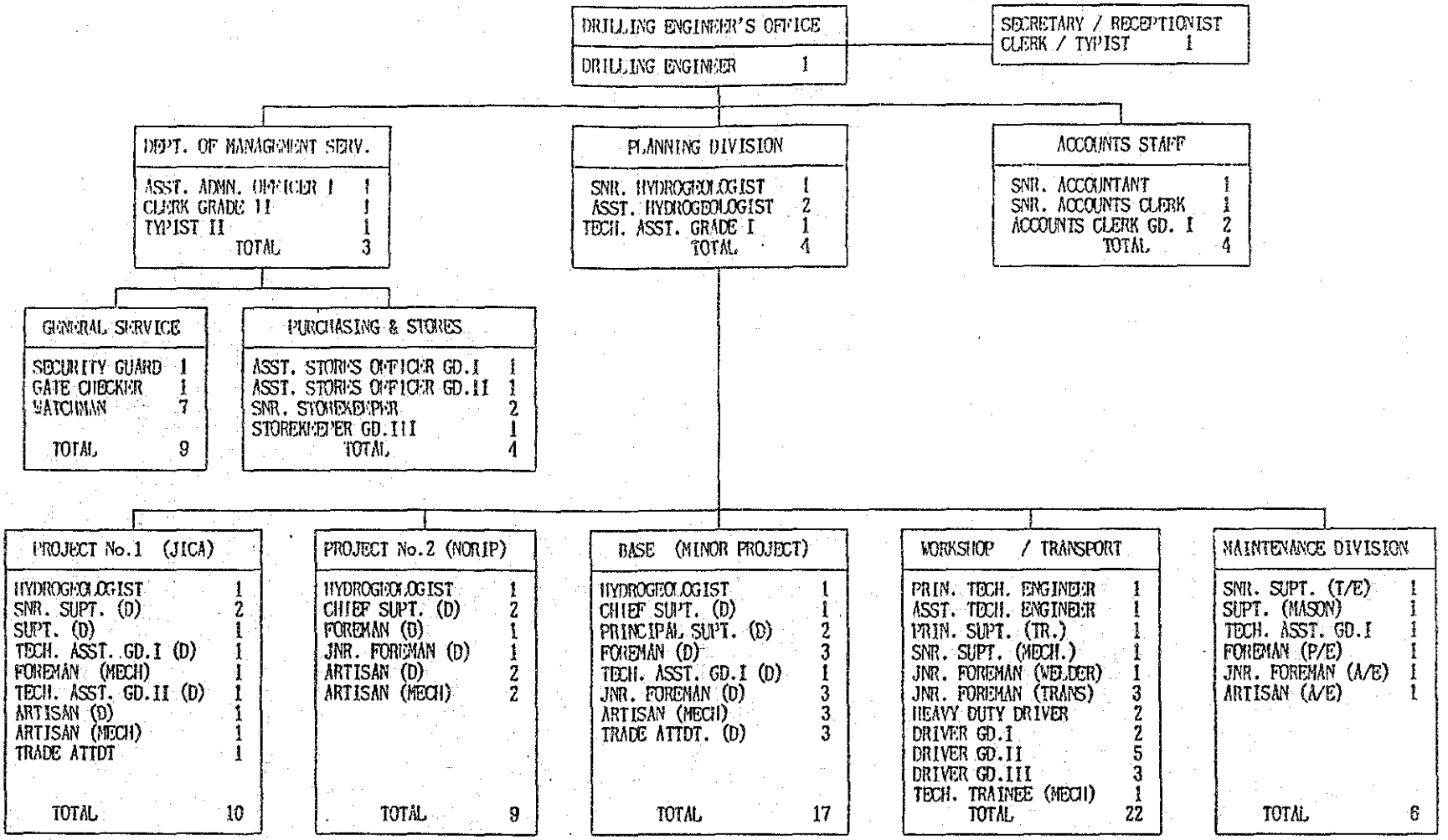
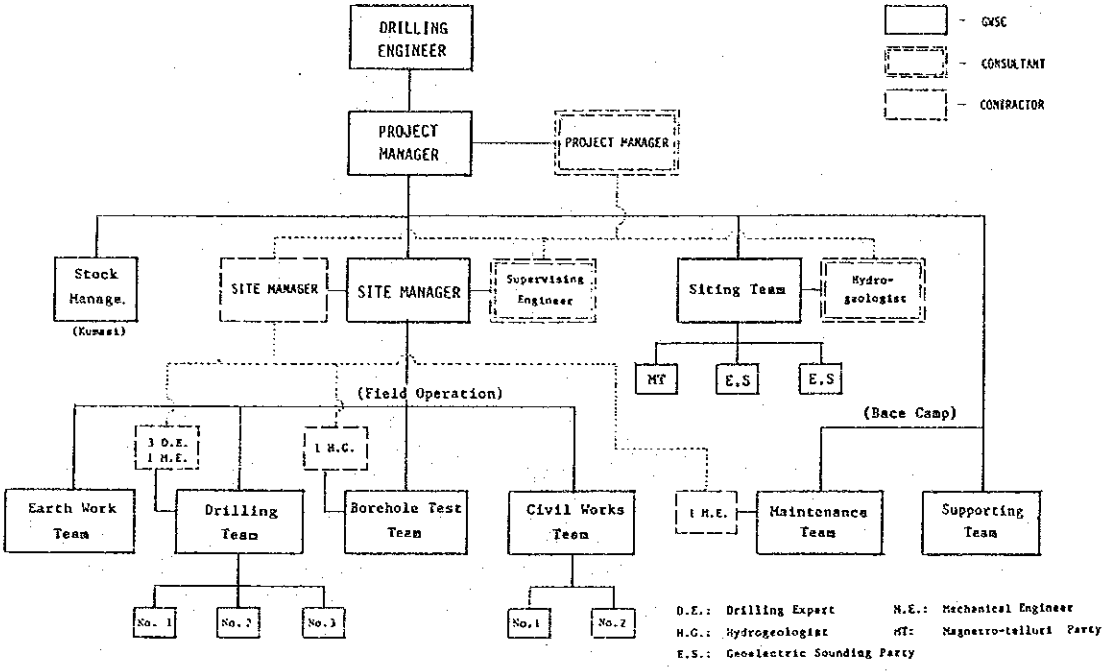


Figure 3-3-2

FIELD WORKS ORGANISATION FOR RURAL WATER SUPPLY PROJECT



c) The target communities of the Project are to be those having a population of more than 400 as of 1990; 82 communities (about 98,000 people) in the former Berekum/Jaman and 65 communities (about 67,000 people) in the former Sefwi-Wiawso District, for a total of 147 communities with 165,000 people.

d) Design water demand is to be 15 lit.cd, standard and maximum pumping rate are to be 6000 and 9000 lit./day respectively.

e) Criteria of borehole allocation is as follows;

Communities with	400 - 599 population	: 1 borehole
"	600 - 999 "	: 2 boreholes
"	more than 1000 "	: additional 1 borehole per 400 people exceeding the population above.
"	more than 2000 "	: 5 boreholes

f) Borehole facilities are to be equipped with hand-pump and appurtenant facilities such as concrete slab, drain conduit, etc. are to be installed to keep the facility clean and healthy.

g) The construction will be commenced at the former Berekum/Jaman

District followed by the former Sefwi-Wiawso District.

h) The Project is planned based on the premise that the following Japanese grant aid programme will be implemented;

i) Provision of spare parts and equipment/materials for borehole construction (for 307 facilities),
ii) provision of equipment and materials for District Maintenance Centers (for three Centers), and
iii) Provision of services for the implementation of the Project (for 166 out of 307 borehole constructions).

3-3-3. Location and Condition of Project Site

Location of the Project areas is shown in the "Location Map of the Project Areas" at the front of the Report. The target communities are scattered widely in the five Project areas, and the locations of these communities are attached in Appendix-8, together with a detailed list of the target communities (Appendix-7).

As shown in the location map, most of the target communities are located along the main road except some small communities, so driving a car and transporting materials will be rather easy in the dry season. However, the areas in the Wet Semi-Equatorial climatic region have a considerably abundant rainfall and a long rainy season. Therefore, the utmost care must be paid to transportation just before and after the Shut-Down period.

Other physical conditions on the Project areas, especially geological and hydrogeological situations, are already explained in the previous section (Chapter 2, Section 2-3).

3-3-4. Outline of Equipment and Materials

Major equipment and materials required for the implementation of the Project are listed below;

Borehole Construction Materials

a) Casing materials
b) Strainers
c) Hand-pumps
d) Supplemental drilling tools

e) Mud-drilling agencies
f) Fuel and lubricants
g) Cement*
h) Gravel and sand*
i) Others*

* : these are available in Ghana

Spare parts

a) Spare parts for drilling rigs and vehicles
b) Spare parts for geophysical equipment

Additional Drilling Rig

a) Rotary type drilling rig
b) Standard accessories and tools for DTH drilling
c) Standard accessories and tools for rotary drilling
d) High-pressure air-compressor
e) Supporting vehicles
(Cargo-truck, pick-up, station wagon, water lorry, etc.)
f) Borehole-test equipment and tools
g) Mobile radio telephone system
h) Spare parts for above

Equipment and tools for District Maintenance Center

a) Servicing rigs
b) Supporting vehicles
c) Workshop equipment and tools
d) Spare hand-pump and cylinder
e) Air-compressor and pipe
f) Spare parts for above

3-3-5. Operation and Maintenance Plan

In the Project, the operation and maintenance services will be rendered to the borehole facilities, drilling rigs and the related supporting equipment/vehicles. The GWSC shall be responsible for carrying out the O&M services as it has been practicing at present.

Drilling Unit

The Drilling Unit of the GWSC is fully responsible for operation and maintenance of the drilling rigs, their supporting equipment and vehicles that are or will be supplied for the Project implementation by the Government of Japan.

The equipment/tools and spare parts provided by Japan in the Project shall be delivered to the workshop or warehouse of the Drill-

ing Unit, and the Drilling Unit should be responsible for adequate stock control and their utilization.

In other respects, since the provision of the spare parts as Japanese aid in the Project will be limited in kinds and quantity, those which will be required additionally for the successful completion of the Project and for effective operation and maintenance after completion of the Project shall be procured and supplied by the GWSC at its own expense.

Regional Offices

The O&M services for the respective borehole facilities in the Project area shall be the responsibility of each Regional Office of GWSC, and a District Maintenance Center shall be established at each Project area. The Maintenance Centers shall be responsible for O&M services for the hand-pump of the boreholes, and the Drilling Unit of GWSC shall repair any serious breakdown of the borehole facilities in response to requests from each Center through Regional Offices.

District Maintenance Center

The staff of the District Maintenance Center should be employed in the following way, but it is desirable to assign those who would be engaged in the construction works of the borehole facilities to the civil work party.

a).	Chief of the Center	1 person
b).	Head of maintenance crew	1 "
c).	Crew member	3 "
	TOTAL	5 persons

The chief of the center should be responsible for general administration of the center, regular inspection of the facilities especially their exposed portions, the operation of them, and the collection of maintenance fees and claims made by beneficiaries, etc. And when any trouble is found with the facilities, the chief shall dispatch the repair group to the site along with his judgment of the trouble, and furthermore, shall maintain an inventory of the spare parts to facilitate stock control.

The maintenance crew should repair trouble and replace the parts for maintaining effective water supply according to the instructions given by the chief of the Center.

The Maintenance Center shall provide the workshop for repairing mainly the hand-pumps and the warehouse to store the spare hand-pump as well as the necessary spare parts, and also a servicing rig and three motorcycles shall be deployed with the Center for hand-pump repairing and regular patrol or inspection.

The Center shall be equipped with the following building, equipment and vehicles to the extent of the basic design;

a) Building of the Center (40 m2) consisting of office, workshop and warehouse.	1 building
b) Vehicles	
Servicing rig	1 unit
Motorcycles	3 units
c) Spare hand-pumps	10 units
d) Spare cylinders	10 units

Operation and Maintenance Cost

Summing up the maintenance costs (the basis and calculation are attached in Appendix), the total operation and maintenance cost for the District Maintenance Centers are estimated below. In the estimation, however, the consideration on a contingency as an allowance for the price escalation during the construction period is not involved.

(a). O&M cost until completion of construction

Construction cost	₵2,000,000.-	
Equipment/materials	₵ 0.-	(to be supplied)
TOTAL	₵2,000,000.	

(b). Annual O&M cost after completion

Remuneration	₵ 1,898,136.
Building	₵ 150,000.
Equipment/materials	₵10,135,400.
Fuel	₵ 1,707,400.
TOTAL	₵13,890,940.-

Among them, the cost for equipment and materials will be of a foreign currency portion and the rest are of local currency.

CHAPTER 4. BASIC DESIGN

4-1. Design Policy

The Project is Phase-II of the Rural Water Supply Project already commenced by GWSC with Japanese grant aid. Project areas are five districts which were two districts in a former administrative division, and are situated in the most remote area bordering to Ivory Coast. The physical conditions such as geology, vegetation, climate, etc., of the districts are quite different from those of the Phase-I Project area.

Since the Project would be implemented under grant aid from the Government of Japan, the same as the Phase-I Project, institutional limitations of the aid system ought to be a premise for the basic design.

The basic design for the Project is, therefore, to be conducted under the following basic policy and concept taking the aforesaid conditions of Ghana, Project areas and system of Japanese aid into account;

(1) to conform with the Phase-I Project because the Project shall be the consequent Phase-II stage.
(2) to meet the national policy, regulations and criteria of water supply sector of Ghana.
(3) to design a standardized and economical facility applicable for all Project areas.
(4) to make the construction plan taking the regional climatic condition and present situation and customary work system of the Drilling Unit of GWSC into account.
(5) to select the equipment and materials from views of not only economy but applicability and availability for farther rural water supply schemes by the Government of Ghana.
(6) to provide those equipment and materials indispensable to implement the Project in addition to those requested, provided they fit the purpose and object of the grant aid.
(7) to formulate the dispatching plan of Japanese experts based on the conception that the major tasks of those experts are to complete the technology transfer in the different physical conditions than the Phase-I area so that the Ghanaian staff can make a plan and conduct project works by themselves throughout the country.

4-2. Study and Examination on Design Criteria

(1). Criteria of successful boreholes

The maximum pumping capacity of the standard hand-pump is 900 lit/hr and the efficiency concerned with the pumping head and operation is usually fixed as 70% (WHO standard), it means usual pumping rate of standard hand-pump shall be of 630 lit/hr or less. Then, the standard borehole facility in the Project is available for a pumping rate of 6,000 lit/day (in day time) normally, which means the required yield capacity of borehole will be enough with 600 lit/hr.

However, it is not always reasonable economically and administratively to discard all boreholes whose yield is less than 600 lit/hr. This is because, if the water sources is remote enough or extraordinarily unhealthy, even a borehole which fails to reach the standard yield will not be so unavailable.

In this Project, therefore, a borehole whose yield is 300 lit/hr and over available for covering a water supply population of 200 is decided to be successful. However in such case of low yield borehole, additional boreholes would be considered (count as a half borehole).

(2). Successful rate of boreholes

The successful rate of existing boreholes in the related two regions are summarized as follow, based on the actual drilling records of "3000 Wells Programme" and GWSC's own drilling in the Project area (Tab. 4-2-1);

Table 4-2-1. SUCCESSFUL RATE OF EXISTING BOREHOLES

Region	Number of drilling	Number of success	Number of dry hole	Successful rate	Remark
Brong Ahafo	126	84	42	0.67	In case 3 gpm and over are successful
Western	513	383	130	0.75	
Total/Average	639	467	172	0.73	

Because the geological and hydrogeological conditions of the Project areas are almost same as these of the above-listed areas, the

design successful rate of boreholes is to be 0.75 based on the data.

(3). Number of boreholes to be drilled

Taking into consideration the number of borehole facilities allocated to each Project area and the successful rate of borehole drilling in the foregoing section, the proposed number of boreholes to be drilled in each area is shown in the table below;

Table 4-2-2 NUMBER OF BOREHOLES

Region	District	Allocated Boreholes	Successful rate	Boreholes to be drilled
Brong Ahafo	Berekum	43	0.75	58
	Jaman	100	"	134
Western	Juabeso-Bia	89	"	119
	Sefwi-Wiawso	72	"	96
	Bibiani-A.-Bekwai	3	"	4
TOTAL / AVERAGE		307	0.75	411

(4). Borehole design depth

Borehole depth of existing hand-pump equipped borehole facilities are summarized in Table 4-2-3.

Table 4-2-3.

EXISTING BOREHOLE DEPTH

Region	GWSC		3000 WELLS		AVERAGE	
	Number	av.Depth	Number	av.Depth	Number	av.Depth
Brong Ahafo	20	47.0m	76	54.0m	96	52.5m
Western	-	-	50	36.6	50	36.6
TOTAL	20	47.0	126	47.1	146	47.1

As shown in the table, the average depth of hand-pump equipped boreholes in the related regions was 47.1m. Further, the minimum depth of borehole is to be more than 30m to prevent the facility from pollution by domestic water, and boreholes more than 70m deep are not suited to the hand-pump equipped facility.

Thus, the borehole depth is designed to be more than 30m and less than 70m, 50m on average, which is the same as the conditions designed in the Phase-I Project.

(5). Quantities of drilling and casing

The total linear lengths of borehole drilling and casing by the area are estimated as shown in Table 4-2-4.

Table 4-2-4. LENGTH OF DRILLING AND CASINGS

Districts	Total Drilling Length	Casing		
		Total Length	Blank	Screen
Berekum	2,900 m	2,150 m	1,634 m	516 m
Jaman	6,700	5,000	3,800	1,200
Juabeso-Bia	5,950	4,450	3,382	1,068
Sefwi-Wiawso	4,800	3,600	2,736	864
Bibiani-A.-Bekwai	200	150	114	36
TOTAL	20,550	15,350	11,666	3,684

(6). Siting

Most groundwater in the Project area is contained in a thick weathered rock zone and/or cracks and joints at the uppermost parts of fresh rock, in contrast with the Phase-I area in where groundwater is contained at fissures or cracks in the hard rock. Accordingly, the main points of groundwater investigation shall be directed to grasp the depth of weathered zone and the configuration of fresh rock surface.

In consideration of the above-mentioned situation, this Project also introduces the following siting method but different investigation strategy;

a) Analysis of Landsat imagery,
b) Interpretation of aerial-photo,
c) Electromagnetic prospecting, and
d) Geoelectric prospecting.

4-3. Design of Facilities

The drilling depth of designed boreholes varies from 30m to 70m, and is 50m on average.

The hand-pump installed in the borehole must have a pumping capacity of 900 lit/hr at maximum according to the water supply plan, and the cylinder diameter of this class hand-pump is usually 50 - 90 mm. Consequently, the minimum diameter of permanent casing shall be 100 mm, and thus, the minimum drilling diameter shall be 150 mm.

The geological condition of the Project area suggests that a decomposed and collapsible layer lies down to the depth of around 30m. Therefore, temporary casing works to prevent holes collapsing during drilling is required. In this case, a drilling diameter of 216 mm is needed to insert the temporary casing with more than 172 mm of diameter which can pass the 150 mm diameter bit through.

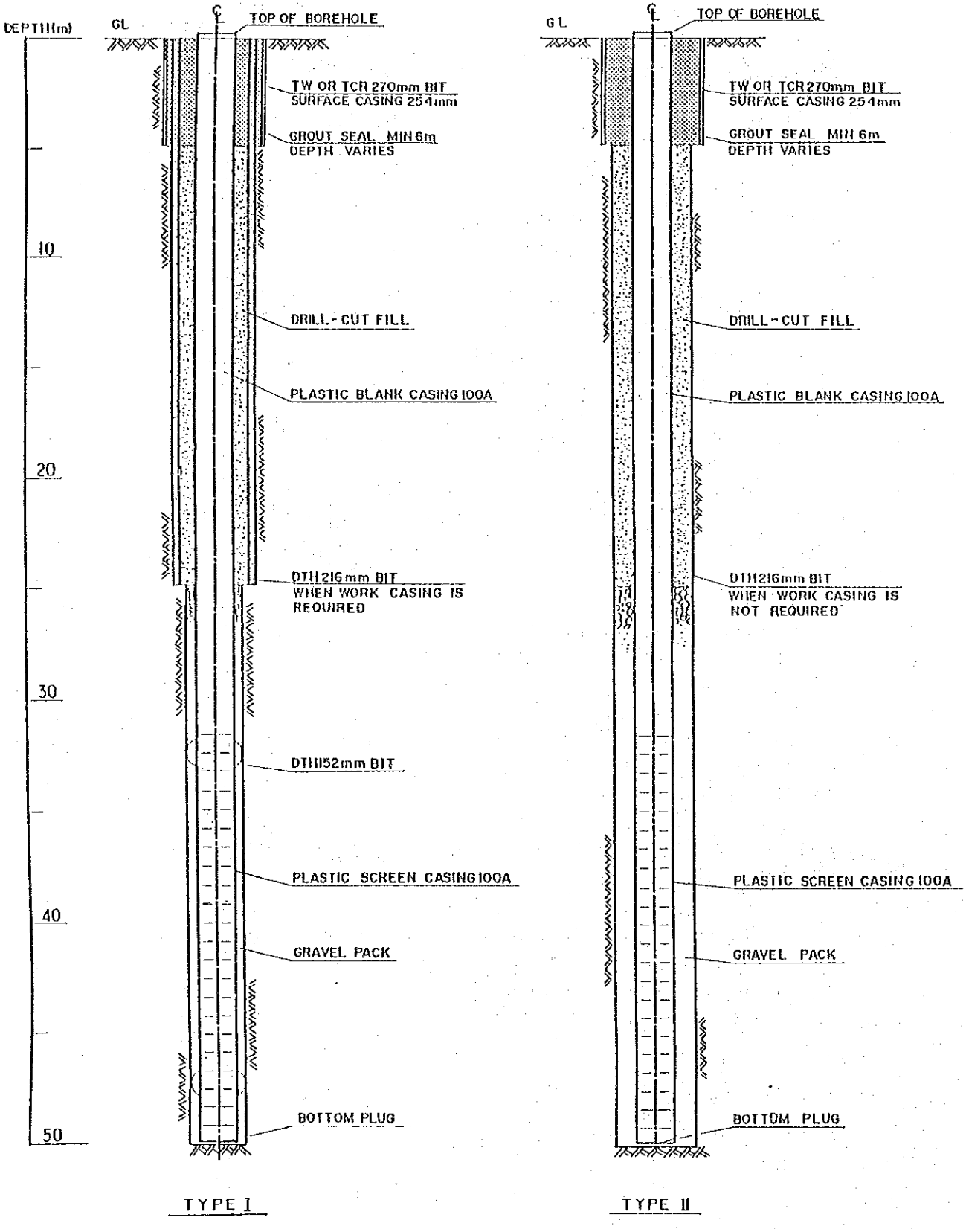
In the case where there is very thin weathered zone at the drilling site, there is no need to use a temporary casing so the 216 mm drilling can be continued to the bottom of the hole.

Thus, two types of borehole are designed as shown in the figure 4-3-1, although the boreholes belong to the Type-II structure are estimated as few as 20% of total drilling.

As appurtenant facilities which prevent boreholes from being polluted by waste water, such as concrete slab, drainage conduit, cattle waters, fence, laundry, etc., are desirable. However, the former two facilities and drain pit are planned according to the actual condition and tradition of Ghana in the Report, and the other facilities are expected to be provided by beneficiaries themselves in future as the necessity arises.

The concrete slab is 2.0m by 2.0m, and the drain pit is set at a point about 7m apart from the center of borehole connected by the concrete drain conduit. Design of the facilities is shown in Fig.4-3-2.

Figure 4-3-1 Design of Borehole



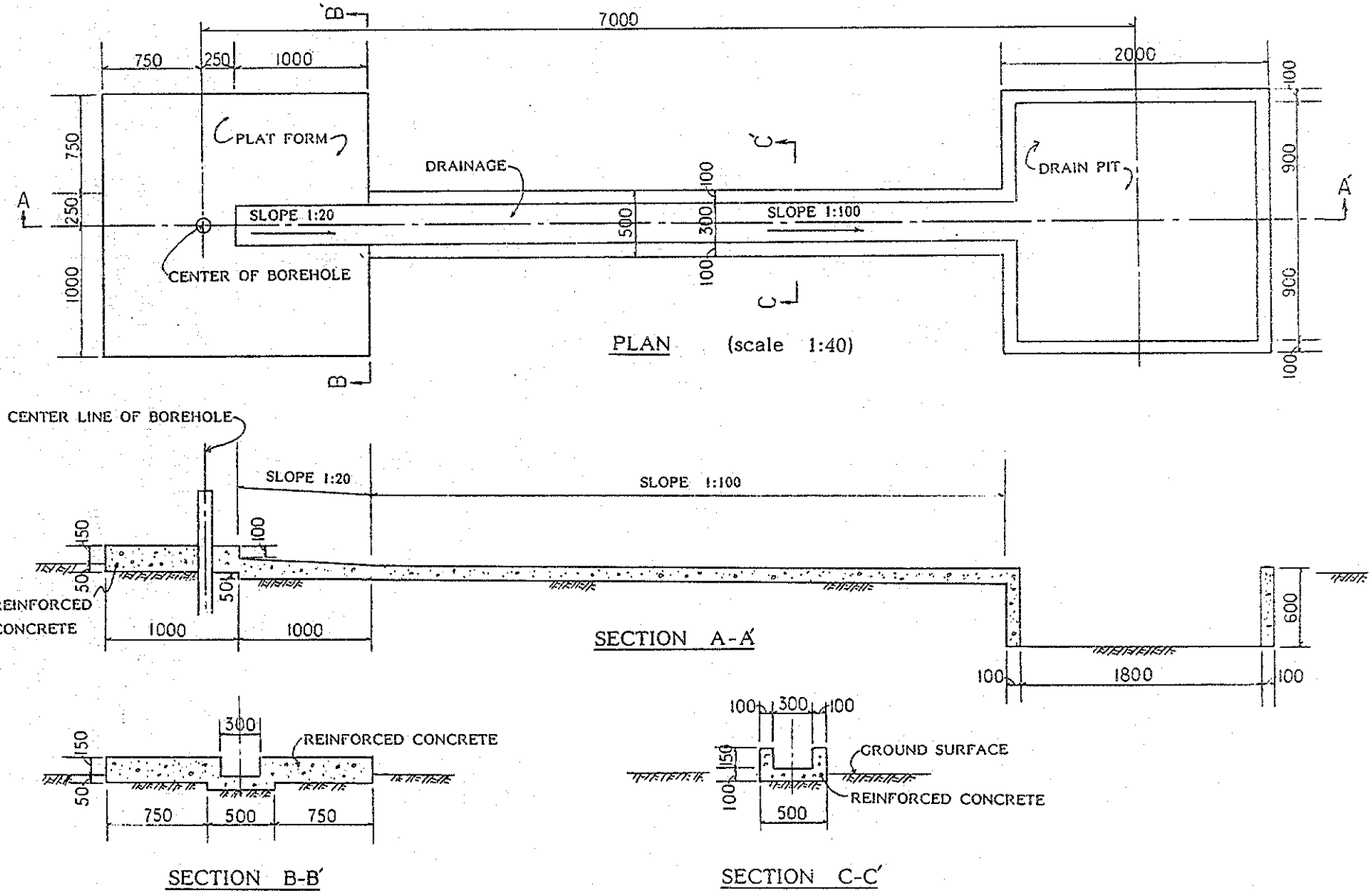


Figure 4-3-2 Desiogn of Appurtenant Facility

4-4. Construction Plan

4-4-1. Construction Basis

(1). Basic policy

The Project is to be under the in direct management of GWSC, and Phase-I of the Project has been already implemented. However, the work progress is seriously delayed in the total implementation schedule, and now it cannot be expected to complete all project works within the original project implementation term (by the end of 1990). Under the situation, the work plan studied herein should be the most efficient one to complete all of the remaining project works within the shortest time possible.

(2). Quantities of construction

The quantities of construction for the Project implementation are summarized as the table 4-4-1.

Table 4-4-1. SUMMARY OF CONSTRUCTION WORKS

District	Required Bore-holes	Drilling Length (m)	Casing Length (m)
Berekum	43	2,900	2,150
Jaman	100	6,700	5,000
Juabeso-Bia	89	5,950	4,450
Sefwi-Wiawso	72	4,800	3,600
Bibiani-A.-Bekwai	3	200	150
TOTAL	307	20,550	15,350

(3). Organization for the construction

The constructing work for hand-pump equipped borehole facilities is sub-divided into eight sectors as described below. The work of each sector shall be carried out by professional and individual working parties for smooth and effective progress of the construction (refer to Fig.3-3-2 in the previous Chapter).

a). Project management
b). Site management

c). Siting
d). Earth work
e). Drilling
f). Borehole test
g). Civil work
h). Maintenance

(4). Working days

Working days in a year for the construction work is estimated as follows, in accordance with customary work conditions and the climatic environment of Ghana.

- Working conditions	8 hours per day 6 days per week 30 days of national holiday per year, including X'mas and Easter holidays
- Climatic condition	6 weeks of shut-down per year (mid. Aug. - Sep.)

By the above-mentioned condition, total holidays and shut-down period in a year are to be 118 days as calculated below;

Weekly holiday	52 week x 1 day	= 52 days
National holiday		= 30 days
Shut-down period	6 week x 6 days	= 36 days
TOTAL		118 days

Thus, the annual working day is estimated as 247 days (365-118=247), and it is converted to 20.6 working days per month. (Average working day in a month excluding the Shut-down period is about 22.8 days).

4-4-2. Works Progress

The works progress of the aforementioned works sectors shall be studied herein as a base to formulate a construction schedule.

(1). Siting

Siting work is to be carried out by field reconnaissance survey

and by geophysical explorations such as electromagnetic (E.M) prospecting, geoelectric resistivity sounding, etc., as well as pre-study of Landsat Image, aerial photo and topo-maps.

A hydrogeologist reconnoiters the proposed borehole sites (about 5 sites per day) including the access routes, and points out the E.M prospecting field of about 0.25 km^2 (500m x 500m). The field is prospected by E.M within a half day on an average, and six detail survey points are selected out. These detail survey points are prospected by geoelectric resistivity sounding and the final drilling site is pointed out. It takes about 0.6 day on an average.

Accordingly, the siting work takes about 1.0 day per site, provided one E.M party and two geoelectric resistivity parties are mobilized. Farthermore, it will be converted to average progress rate of about 1.4 days when the successul rate of 0.75 is taking into consideration.

(2). Earth Work

The sites requiring the arrangement or repair of access route are approximately one-fourth of total drilling sites. The earth work volume to be removed per site is presupposed as 600 m^3 (200m x 3m x 1m), and a bulldozer of D41A-3 class, which was supplied under the Phase-I Project, is to be adopted in the earth work.

The work capacity of the bulldozer can be calculated by the following formula;

$$Q = (60 \times q \times E)/Cm$$

Q : hourly work capacity (m^3/hr)
q : unit capacity (m^3)
E : workability
Cm: cycle time (hr)

Given that a 10-ton bulldozer as mentioned above will be used, and that a rather hard overburden such as laterite will be removed, the work capacity per hour is calculated as follows;-

$$Q = (60 \times 2.19 \times 0.55)/1.36$$
$$= 53.14 \ m^3/hr$$

Then, work time for each site is to be approximately 11.3 hours (600/53), and the average work time for bulldozer work is to be 3.0 hours because three-fourths of the sites do not require the earth work (11.3 x 1/4).

Therefore, the total time required for the earth work is to be 4.5 hours (0.6 days), including 1.5 hours for mounting/dismounting the bulldozer and moving in and out time besides the above mentioned work time. And it is converted to average progress rate of 0.8 day/site, because the successful rate of borehole drilling is 0.75 (0.6÷0.75=0.8).

(3). Drilling

Drilling time for the designed boreholes as shown in Fig.4-3-1 is calculated below, provided the drilling and other work speeds of:

- 6 m/hr for rotary drilling by 270 mm bit.
- 6 m/hr for rotary drilling by 216 mm bit.
- 10 m/hr for air-hammer drill by 152 mm bit.
- 12 m/hr for 254 mm casing work.
- 15 m/hr for 191 mm casing work.

Then, the work time required to drill in is;

ø270 mm rotary drilling	6 m ÷ 6 m/hr	= 1.0 hr
ø216 mm rotary drilling	24 m ÷ 6 m/hr	= 4.0 hr
ø152 mm airhammer drilling	20 m ÷10 m/hr	= 2.0 hr
ø254 mm casing work	6 m ÷12 m/hr	= 0.5 hr
ø191 mm casing work	30 m ÷15 m/hr	= 2.0 hr
TOTAL		9.5 hr

Since the work time in a day is 8.0 hr, the pure drilling work takes about 1.2 days. Consequently, the work day required to complete one borehole is estimated as follows;-

- moving in, erection and preparatory works	1.0 day
- drilling	1.2 days
- geoelectric logging, casing, gravel-packing and developing	1.5 days
- dismounting, moving out	0.5 day
TOTAL	4.2 days

In the case of dry holes, the required work day is to be 2.7 days because whether it is dry or successful has been judged during the drilling and following casing, gravel-packing and developing works can be neglected. And in the case of Type-II drilling, it can be expected to drill out a little earlier than the Type-I, however, the consideration on this matter will be negligible because the volume of this type drilling will be very little. Thus, the total average progress rate of drilling is calculated as 5.1 days/successful borehole as shown below.

(4.2 days x 3 sites + 2.7 days x 1 site) ÷3 sites = 5.1 days

(4). Borehole Test

Borehole tests, i.e. pumping test and water quality test, take 1.5 days as estimated below:

a). Pumping test	
- moving in/out	0.5 day
- pumping test	0.5 day
sub-total	1.0 day
b). Water quality test	
- water quality test	0.5 day
TOTAL	1.5 days

(5). Civil Work

Civil work for completion of borehole facilities takes 2.0 days per borehole as estimated below:

- moving in/out	0.3 day
- basing, form & reinforcing	0.7 day
- concrete works	0.5 day
- pump installation	0.5 day
TOTAL	2.0 days

(6). Moving of Base Camp

The Project areas in Brong Ahafo Region (former Berekum/Jaman District) and in Western Region (former Sefwi-Wiawso District) are more than 100 km apart, therefore, the Base Camp is to be set up at each Project area. The Base Camp is already set up at Drobo, Jaman District, so it will be removed to the Project area in the Western Region within the implementation period.

For the removing of Base Camp, from Brong Ahafo to Western Regions, two weeks (14 days) will be required.

(7). Withdrawal

After the completion of all Project works, the Base Camp must be wound up and withdrawn to the Drilling Unit, Kumasi, together with all equipment, vehicles and remaining materials. It will take about three weeks (0.7 months) including the transportation.

4-4-3. Construction Schedule

(1). Total work plan

The total work plan is estimated based on the basic work days of each sector mentioned above. Table 4-4-2 shows total work days for each sector to complete the quantities shown in the table 4-4-1, in the condition that only the equipment already supplied under the Phase-I Project are mobilized and the works progress by GWSC in these two years is neglected.

As shown in the table, the critical pass of works among all project works shall be Drilling Work and it will take about 26 months. Then, the total implementation term will be about 27.4 months adding 0.5 month for Base Camp moving, 0.2 month for final Borehole Test (1.5 days) and Civil Work (2.0 days), and 0.7 month of withdrawal, it means about 2.3 years.

Table 4-4-2. Total Work Plan

Sectors	Work Volume	Work Party	Progress Rate	Required Period days	months
Siting	307	1	1.4	430	20.0
Earth Work	307	1	0.8	246	12.0
Drilling	307	3	5.1	522	26.0
Borehole Test	307	1	1.5	534	22.4
Civil Work	307	2	2.0	461	14.9
Camp Moving	1	all	14.	14	0.5
Withdrawal	1	all	21.	21	0.7

(2) Works Progress by GWSC

Presumably, the equipment and materials to be provided under the Project will arrive at Ghana at the end of the first year and the actual Project works start in the early second year, even if the official procedures on the Project are undertaken most smoothly (the implementation schedule will be discussed in the following section).

However, GWSC has already removed the Base Camp for the Project in Jaman District after completion of the Phase-I Project at Nanumba, and initiated certain Project works, diverting construction materials from other projects. As for the field survey term by the Study Team (December

1989), they drilled-over 20 successful boreholes (but did not complete them as borehole facilities because of a lack of hand-pump).

Furthermore, GWSC and Drilling Unit have planned to drill 40 more boreholes during the 1990 fiscal year, as well as 60 points of siting work, also diverting tentatively the materials from the other projects such as German Aid Programme or UNICEF.

Thus, the actual work volume, at the time when the Project works will be commenced under Japanese assistance, will be 247 holes of drilling and 307 facilities for a civil work.

(3). Construction Schedule

Based on the aforementioned examinations and studies, such as the quantity of total construction works, works progress rate, etc., the total construction schedule is formulated as Table 4-4-3 and illustrated as Figure 4-4-1.

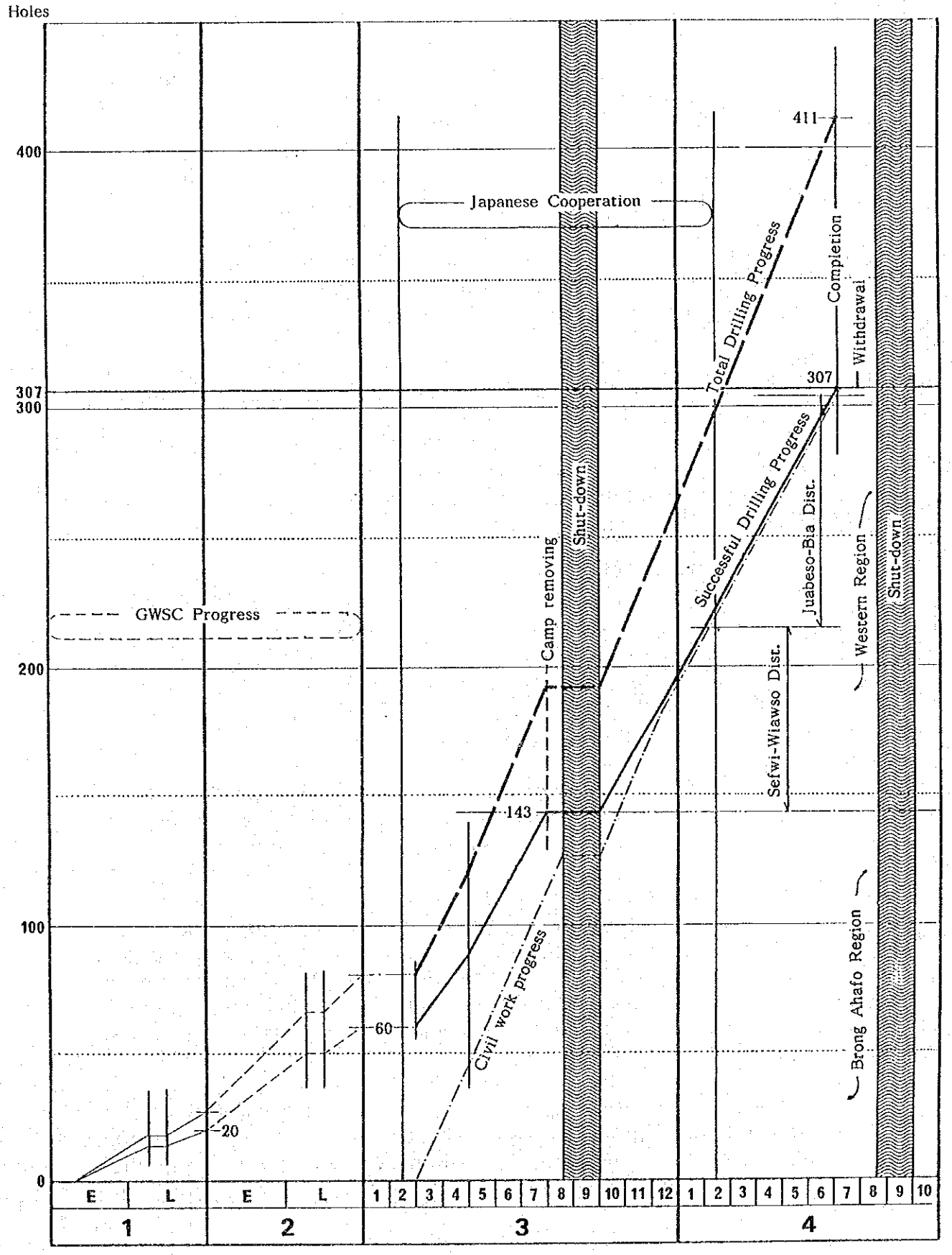
As shown in the figure and the table, all of the Project works will be completed in the middle of the fourth year (1992), even though the successful rate of drilling will be at 0.75 as designed. If the rate is improved to the same rate as Phase-I, the delay from the end of the third year will be minimal. The siting work will take a little longer than the drilling work, therefore, the Japanese hydrogeologist will be dispatched to accelerate the siting work earlier than the other experts concerning to the construction works.

Table 4-4-3. Construction Schedule

Sectors	Work Volume	Work Party	Progress Rate	Required days	Period months
Siting	247	1	1.4	346	16.8
Earth Work	247	1	0.8	197	9.6
Drilling	247	4	5.1	315	15.3
Borehole Test	247	2	1.5	185	9.0
Civil Work	307	2	2.0	461	14.9
Camp Moving	1	all	14.	14	0.5
Withdrawal	1	all	21.	21	0.7

Figure 4-4-1.

CONSTRUCTION SCHEDULE



(4). Japanese Cooperation on Construction

The Project includes cooperation on the construction works by Japanese experts to transfer technology through the actual construction works, complementary to the Phase-I Project.

Although the details shall be described later, the Japanese cooperation period will be just enough to complete the technology transfer, and the quantity of construction works subject to cooperation from Japan will depend on the cooperation term. The required technology to be transferred to the Ghanaian staffs through the Project are mainly on drilling in the collapsible layer, and on operation and maintenance of equipment.

For the drilling, transfer of technology on mud-drilling to the existing drilling parties is expected to be completed within two months (the period to drill about 50 holes) if Japanese experts teach them one to one. However, it will take about a half year to teach such technology to the three parties by only one Japanese expert. And for the newly organized party, it will need one full year to transfer the technology from the beginning by another Japanese expert.

In the Project, repairing and replacement of parts of the rigs and other equipment will be emphasized for technology transfer by the mechanical engineer on operation/maintenance aspect. Although it will take rather a long time to transfer all technology on repair or replacement of rig or vehicle parts, the transfer of most of these techniques to Ghanaian staffs can be expected through full one year of cooperation, including an intensive maintenance period in the rainy season.

Based on the discussions, the minimum required technology will be transferred to Ghanaian staffs through at least one year of cooperation, although the request from GWSC was for two years' cooperation.

Of the one year cooperation period, one month, 0.5 month for preparation at the beginning and 0.5 month for moving the Base Camp, must be excluded from the construction period, so the cooperation period on the actual construction works will be 11.0 months. And if the Japanese cooperation were to start when the Project materials arrive in Ghana, only the existing three rigs are available in the construction works for the first two months.

As mentioned before, it takes 4.2 days and 2.7 days to drill a successful borehole and dry hole respectively (refer to Table 4-4-2). It means that an average 16 boreholes and 21 boreholes can be drilled by three and four drilling rigs respectively, therefore, a total of 221 holes (166

holes of successful) are expected to be drilled in the eleven months (by three rigs during the first two months and by four rigs through the remaining nine-month period).

Thus, the quantity of Japanese cooperation on the construction works is to be as follows;

Boreholes drilling (successful drilling)	166 holes	8,300m
Siting	for 6 months	
Civil works	for 11 months	
Maintenance	for 11 months, and	
Supervising of all works sectors for 11 months.		

4-5. Equipment Plan

4-5-1. Selection of major Equipment and Materials

(1). Equipment and materials required

In the implementation of the Project, two categories of major equipment/materials are required, namely, equipment and materials for borehole facility construction including additional drilling rig and equipment, and materials for the District Maintenance Centers. The major equipment and materials in those are listed below.

For Borehole Construction

a). Major equipment
- i). Drilling rig
- ii). High-pressure air-compressor
- iii). Supporting vehicles
- iv). Engine welder
- v). Borehole test equipment
- vi). Siting equipment
- vi). Radio-telephone system
- vii) Spare parts for the above and equipment already supplied

b). Major Materials
- i). Hand-pump
- ii). Casing and strainer
- iii). Mud-agencies
- iv). Fuel and lubricants
- v). Cement
- vi). Sand and gravels

For District Maintenance Centers

- i). Servicing rig
- ii). Vehicles
- iii). Workshop tools
- iv). Spare parts for above
- v). Spare hand-pump and parts

(2). Selection of major equipment

The equipment is selected in the following sections:

Equipment for Borehole Construction

a). Drilling rig

As mentioned in the construction schedule, an additional drilling rig will be required. The rig should be the same type as the one supplied under the Phase-I Project from the viewpoint of conformability with the existing equipment and the geological condition of the Project area.

Thus, the rig shall be a truck-mounted rotary rig with DTH, and the drilling capacity shall be a maximum of 150m at a drilling diameter of 150mm.

b). High-pressure Air-compressor

The highpressure air-compressor is necessary to drive the air-hammer and air-circulation. As for the air-hammer drive, the air-pressure capacity of the compressor is to be 17kg/cm2 or more, with an air delivery of 21m3/min or more.

Same as the one supplied, the compressor must be trailer-mounted considering the transporting condition of the site.

c). Supporting Vehicles

In line with four drilling and two borehole test parties, the following additional vehicles will be required.

i. Cargo truck

Cargo truck of eight-ton payload capacity is necessary to transport drilling tools such as drill pipes, casings, drill bit, etc.

A crane of three-ton capacity is to be mounted to the truck to handle heavy steel pipes during the works.

ii. Water lorry

A water lorry will be required because four drilling rigs will be operating at the same time and most of the drilling will

be mud-drilling. The lorry shall be of 6.5m3 capacity, which is the same as the one supplied under the Phase-I.

iii. Light Vehicles

To support the additional drilling party, a station wagon for mobilization of personnel and a pick-up truck for materials and equipment transportation will be necessary.

While, for the new borehole test party is also to be procured with one pick-up truck.

d). Borehole Test Equipment

In addition to that already supplied, the following equipment is required for Borehole Test Party;

- Auto-recording electric logger
- Submersible motor pump
- Diesel generator
- Water meter
- Water analysis kit

e). Siting equipment

One set of new E.M equipment shall be procured in the Project because the existing one has already passed its mechanical life time. Besides the E.M, two sets of Landsat Imageries covering the Project areas and a stereoscope for air-photo interpretation are required.

f). Radio-telephone system

For the additional drilling party, at least one mobile telephone station must be provided.

g). Camping facility

The size of each party for drilling and borehole test works will be increased under the Project, therefore, camping facilities for these additional personnel are required.

h). Spare parts

Since the spare parts for the existing equipment supplied under

the Phase-I Project have been used already, spare parts for all equipment including the ones to be supplied this time shall be provided.

The volume of spare parts must be enough for at least two years operation, when GWSC's own efforts after completion of the Project are taken into consideration.

Equipment for District Maintenance Center

a). Servicing rig

For routine maintenance of borehole facilities, a servicing rig or an alternative will be required for each District Maintenance Center.

In the Project, instead of the special servicing rig, a cargo truck of 4-ton payload capacity with 2-ton crane shall be selected as an alternative from the consideration of performance, availability, easiness of operation and economy. And for the borehole developing, a combination of air-compressor and air-hose shall be equipped to each truck.

b). Vehicles

For patrolling the borehole facilities to check their condition and for collecting the maintenance fee from the communities having a borehole facility, three motorcycles shall be provided instead of a light vehicle from the consideration of mobility and O/M cost.

c) Tools

One set of workshop tools has already been supplied to the District Maintenance Center at Nanumba. So two sets of workshop tools with the same contents as the previous one shall be provided for District Maintenance Centers at the former Berekum/Jaman and Sefwi-Wiawso Districts.

(3). Selection of major materials

a). Hand-pump

Recently, GWSC decided that its standard hand-pump would be the "India Mark-II", and intends to unify all hand-pumps under GWSC's management to the type. The hand-pump to be procured under the Project, therefore, should be "India Mark-II", which is not produced in Japan.

Furthermore, GWSC has already started to change the riser pipe and rod of the existing boreholes from galvanized iron to stainless steel because of acidic groundwater around Brong Ahafo and Western Regions. In this connection, the hand-pump to be provided under the Project should be stainless type, at least for the underground structures. Spare hand-pumps to be delivered to the Maintenance Center are also involved in the consideration.

Quantity of hand-pumps shall include a 15% allowance for boreholes counted as 0.5 boreholes (a half well) and for breakdowns or accidents during transportation and handling.

b). Casing and Strainer

Permanent casing pipe shall be of PVC pipe with 100mm (4") diameter, the same as the one supplied under the Phase-I, from the viewpoint of easiness and stainlessness. Strainer pipe (screen pipe) shall also be of PVC, and the volume of the strainer shall be 30% of total casing length.

The quantity of the pipe shall include an additional 10% as spares in case of loss during transportation and handling.

c). Mud agencies

Agencies for drilling liquid, especially for mud-drilling-water in the rotary drilling method, are required for drilling works. Volume of the agencies shall be enough for 12,350m of rotary drilling and 8,200m of air-percussion drilling. In the Project, chemical agencies which make the developing work easy and efficient shall be selected.

4-5-2. Specifications

Specifications and quantities of equipment and construction materials to be procured are described below, based on the examinations mentioned before:

(1). Equipment/Materials for borehole construction

(a). Drilling rig 1 set

i). Borehole specification
Drilling diameter : 270 - 152 mm
Drilling depth : ave. 50m, max. 150m
Casing diameter : 100 mm (4")

ii). Drilling type
Both mud-circulate rotary and air-hammer drill

iii). Rig
Truck-mounted type
Truck : Water-cooled diesel engine, left-hand drive
Drilling capacity : 3-1/2" drill pipe x 150m
Mud-pump : 500 lit./min

iv). Standard accessory and consumables
Drill pipes, shock absorbers, bits, drill color, stabilizer, handling tools, water swivel, manifolds, wire ropes, fishing tools, down-the-hole hammer and bit (6" - 8"), tools, work casings (7", 10"), portable water tanks, and others.

(b). High-pressure Air-compressor 1 set

Trailer-mounted
Capacity : 17 kg/cm2 x 21 m3/min or more
Accessory : line-oiler, injector, high-pressure delivery hose, etc.

(c). Cargo truck with crane 1 unit

i). Truck
Engine : Water-cooled diesel engine
Type : Left-hand drive
Payload : 8 ton

ii). Crane
Loading : 3 ton

(d). Water lorry — 1 unit

i). Tank capacity : 6.5 m3
ii). Truck
Engine : Water-cooled diesel engine
Type : Left-hand drive

(e). Light vehicle — 1 unit

Engine : Water-cooled diesel engine
Type : Station wagon type, 4 x 4, left-hand drive, long body

(f). Light vehicles — 2 units

Engine : Water-cooled diesel engine
Type : Pick-up type, 4 x 4, left-hand drive, long body

(g). Engine welder — 3 sets

Diesel engine
DC max. 240 A
AC max. 8 KVA, 200 V/50 Hz
with Welding bar (4mm) 50 kg, tools and accessory

(h). Permanent casing pipe — 1 L.S

i). Material : Polyvinyl Chloride
ii). Diameter : Outer 114mm, inner 100mm
iii). Connection : Socket and paste
iv). Unit length : 4m
v). Screen : Slit type, perforation 5%
vi). Quantity : Blank pipe - 12,400m (3,100pcs)
Screen pipe - 4.400m (1,100pcs)
Socket - 4,200pcs
Bottom plug - 340pcs
Paste - 1 L.S

(i). Hand-pump — 353 sets

i). Type : Manual type
ii). Yield : 15 lit./min, 40m Head
iii). Casing diameter : 100mm
iv). Accessory : Pump head, withdrawal pipe, etc. (parts underground must be stainless type)

(j). Radio telephone system — 1 sets

Mobile station
Power output : 25W
Accessory

(k). Electric logger — 1 set

Measurement : Resistivity and S.P
(long. normal and micro)
Record : Auto-recording
Cable : 100m with cable dram
Standard accessory

(l). Pumping test equipment — 1 set

i). Submersible pump (100 lit./min, 60m H, 50mm pipe)
ii). Diesel engine generator (50 Hz, 220 V, 10 KVA)
iii). Water meter (100m cable, 1 set)
iv). Standard accessory

(m). Water analysis kit (for 500 samples) — 1 set

i). Type : Portable type for field measurement
ii). Items of analysis : Turbidity, color, odor, taste, consumption of KMnO4, pH, nitrate, ammonia-N, nitrite-N, Cl, Cr, total hardness, chloride, bacteria, colon bacillus.

(n). Siting equipment — 1 L.S

i). Electric-magnetic prospecting equipment
portable type, 200m of prospecting depth
ii). Landsat Imageries
covering the two Project areas
each three theme analysis
iii). Stereoscope
Handy type

(m). Agencies — 1 L.S

i). Mud-circulation agencies (chemical type)
ii). Foaming agency

(o). Spare parts — 1 L.S

i). Spare parts for supplied equipment (for 2 years operation)
ii). Spare parts for supplied geophysical equipment (-ditto-)
iii). Spare parts for newly supplied equipment (-ditto-)

(p). Camping facility 1 L.S

i).	Tent (for 6 men)	(4 sets)
ii).	Camping bed	(16 sets)
iii).	Temporary shower bath, toilet unit	(3 units)
iv).	Wiring/piping materials	(1 LS)
v).	Others	

(2). Equipment and Materials for District Maintenance Center

(a). Servicing rig (Cargo truck with crane) 1 unit

i). Truck

Engine	: Water-cooled diesel engine
Type	: Left-hand drive
Payload	: 4 ton

ii). Crane

Loading	: 2 ton

(b). Motorcycle 9 sets

Engine	: 125 - 175 cc
Type	: Off-load type with carrying bag

(c). Hand-pump 30 sets

Type	: Manual type
Yield	: 15 lit/min, 40m Head
Casing diameter	: 100 mm
Accessory	: Pump head, withdrawal pipe, etc. (parts underground must be stainless type)

(d). Cylinder of Hand-pump 30 sets

Same type as above

(e). Air-compressor 3 sets

Type : stationary type

Capacity : 7 kg/cm2, 3.0 m3/min or more
Accessory : delivery hose (1", 100m), and standard accessory

(f). Workshop equipment and tools 2 sets

each set includes;

1.	Vice	1 no
2.	Wrench set (Hexagonal)	1 set
3.	Driver set	2 sets
4.	Pipe wrench	1 pair
5.	Spanner set	1 set
6.	Hammer	1 set
7.	Chisel	1 set
8.	Wood hammer	3 nos
9.	Portable pipe threading machine	1 set
10.	Pipe cutter	1 set
11.	Monkey wrench	1 set
12.	Calipers	1 no
13.	Steel scale	1 no
14.	Tape measure	2 nos
15.	Portable electric drill	1 set
16.	Saw	2 sets
17.	Pliers	1 no
18.	Wire brush	10 nos
19.	Brush	10 nos
20.	Sling wire	2 nos
23.	Sand paper	1 set
24.	Handing grinder	1 set
26.	Bolt clipper	1 no
27.	Water pump pliers	2 nos
28.	Tool box	2 nos
29.	Electric saw	1 set
30.	Electric grinder	1 set
31.	Engine welder	1 set

DC welder - max. 200A
AC generator- output max. 3.2 KVA
with diesel engine, standard accessory,and
welding rod (6mm, 59kg)

(g). Spare parts 1 L.S

i). Spare parts for equipment mentioned above (1 L.S)
ii). Packing for hand-pump cylinder (1000 pcs)

4-6. Implementation Plan

4-6-1. Implementation System

(1). Apportionment of the Government of Ghana and Japan

Undertaking of the Government of Japan

a). Procurement, transport and hand-over of the major equipment and materials.

b). i. Dispatching of the construction engineers and transfer of technology to the Ghanaian staff, and
ii. Procurement of the local materials for the construction of 166 borehole facilities.

c). Design and supervising services covering the items mentioned above including a dispatching of concerned engineers.

Undertaking of the Government of Ghana

a). To complete the Project throughout.
b). To provide the necessary number of Ghanaian personnel for the Project implementation and to bear all the expenses.
c). To bear all expenses necessary for the Project other than those to be borne by the Japanese grant,
d). To acquire land space and the right-of-way for the Project works.
e). To ensure the tax exemption and customs clearance at a port in Ghana of import equipment and materials supplied under the Japanese grant for the Project.
f). To ensure the exemption of taxes and duties on all personal goods, equipment and effects which are to be brought into Ghana by Japanese personnel related to the Project.
g). To do everything possible to secure the safety of Japanese personnel related to the Project during their stay in Ghana.
h). To accord Japanese personnel related to the Project such facilities as may be necessary for their entry and/or re-entry into Ghana and stay therein for the Project.
i). To bear the following commissions to the Japanese foreign exchange bank for the banking services based upon the Banking Arrangement;
(1) advising commission of the Authorization-to-pay,

(2) payment commission.

j). To maintain and use properly and effectively the equipment and borehole facilities provided under the Japanese grant and to arrange and secure necessary budgets and personnel for the maintenance and operation, after the takeover of those equipment and facilities.

(2). Executive agency

The executive body for the Project is to be GWSC, and the construction works shall be undertaken by GWSC force account basis.

GWSC shall construct the borehole facilities with the personnel mobilized under their own responsibility, and the equipment and materials both procured at their own expense and provided under the grant aid assistance of Japan. Further, GWSC shall establish District Maintenance Centers, strengthen the repairing functions of each Regional Office and Drilling Unit, and operate and maintain the borehole facilities completed and equipment appropriately.

Besides those, GWSC shall make necessary measures for the grant aid programme of Japan, such as Exchange of Note (E/N), Bank Arrangement, tax exemption, etc., in cooperation with the Government agencies concerned.

(3). Field Operation System

Sectors of construction work and working parties required for the Project implementation as well as their major tasks are described below.

a). Project Management (one party)
- Coordination and communication with the government agencies concerned,
- Coordination and communication with the communities concerned,
- Management of the total construction programme,
- General supervision of the construction sectors,
- Siting,
- Judgment of the successful borehole,
- Recording of the Project implementation,
- Management of the personnel,
- Stock management of the stand-by equipment, materials and spare parts,
- Accounting, and
- Others.

b). Site Management (One party)
- Management of the Base Camp,
- Management of the borehole sites,
- Management and coordination of each construction sector,
- Stock management of the construction materials,
- Procurement and delivery of the local construction materials,
- Management of the personnel engaged in the construction works,
- Recording and reporting the construction works, and
- Others.

c). Siting (one group with 3 geophysical prospecting crews)
- Pre-studying the borehole sites,
- Geophysical prospecting and analysis,
- Judgment of the proposed site and reporting to the Project Manager,
- Selection of the access route,
- Judgment of the earth work quantities,
- Instruction the borehole sites and access routes to the earth work party, and etc.

d). Earth work (one party)
- Arrangement of the access routes and borehole sites.

e). Drilling (four parties)
- Drilling the boreholes,
- Electric logging of the drilled boreholes,
- Casing, gravel packing and developing the boreholes.

f). Borehole Test (two parties)
- Pumping test,
- Water quality analysis,
- Analysis of the borehole tests above mentioned and reporting to the Project Manager.

g). Civil work (Two parties)
- Construction of appurtenant facilities for the completed boreholes,
- Installing the hand-pump.

h). Maintenance of equipment (two parties)
- Daily maintenance of equipment and vehicles, and
- Repairing the equipment and vehicles.

i). Operation and maintenance (one party for each district)
- Regular check of the borehole facilities,
- Repairing broken down facilities, and
- Collecting the maintenance fee.

j). Stock managing (at Drilling Unit)
- Managing of the stand-by equipment and the stock of spare parts in the warehouse of Drilling Unit, Kumasi.

(4) Ghanaian personnel plan

Ghanaian personnel to be engaged in the Project implementation totals up 116 persons (105 persons are fully assigned to the field works), covering all construction sectors mentioned above. The remuneration and wages for the Ghanaian workers are to be borne by GWSC.

The allocation of personnel to the each construction sector is shown in Table 4-6-1.

Table 4-6-1. GHANAIAN PERSONNEL PLAN

Profession / Sector	Base camp	Siting	Drilling	Borehole test	Earth work	Civil work	Maintenance	Total
Project Manager	(1)							- (1)
Site Manager	1							1
Hydrogeologist		3		2				5
-ditto- Assistant		3		2				5
Mech. Engineer			1				(1)	1 (1)
-ditto- Assistant			2				(1)	2 (1)
Civil Engineer					2	1		3
Driller Chief			4					4
Assistant Driller			4					4
Stock clerk	(2)							- (2)
Accounter	1							1
Sub-Total	2 (3)	6	11	4	2	1	(2)	26 (7)
Foreman					2	1		3
Driver (heavy)			8			2		10
Driver (light)	2							2
Typist/secretary	1							1
Cook	2							2
Guard/watcher	2		4	2	1	1		10
Labour	2	12	16	8	8	5	(4)	51 (4)
Sub-Total	9	12	28	10	11	9	(4)	79 (4)
T O T A L	11 (3)	18	39	14	13	10	(6)	105 (11)

(5). Consultant services

The consultant will make a contract with the GWSC for following consultant services immediately after the Exchange of Notes for the grant aid assistance to the Project.

a). Preparation of detail design and tender documents for the procurement of equipment and materials and for the construction works to receive cooperation from the Japanese government,

c). Witnessing and advising on the negotiation between the Government of Ghana and the successful bidders,

d). Supervising of procurement and transport the equipment and materials, and supervising of dispatched Japanese engineers,

e). Transfer of technology including siting technique, and

f). Others.

(6). Supplier

The contracted supplier shall procure the equipment and materials specified in the contract, transport them to the site designated by GWSC, dispatch the engineers to Ghana for the contacted period, and procure the local materials required to construct the 166 borehole facilities.

4-6-2. Japanese Cooperation on Construction Works

(1). Dispatching plan of Japanese Engineers

Japanese engineers join with the Ghanaian staff to cooperate in the construction for one year under the Grant Aid System. Dispatched Japanese engineers transfer the technology, especially for the following items according to the characteristics of new Project areas, to the Ghanaian personnel through the actual works, as well as advising and assisting them to enable smooth and effective Project implementation.

a). Borehole siting,
b). Design of borehole facilities,
c). Site Management,
d). Drilling by rotary rig with mud-water,
e). Borehole test,
f). Maintenance and management of rigs, supporting equipment and vehicles,
g). Stock management of equipment and materials, and
h). Installation, maintenance and management of hand-pump.

To achieve the above-mentioned objectives, the Government of Japan will dispatch the engineers shown in Table 4-6-2 at Japan's own expense.

Table 4-6-2. JAPANESE ENGINEERS AND PROFESSION

Field	Profession	Sectors in charged of	Person
Design and & Supervision	Hydrogeologist	Siting	1
	Supervising Engineer	Supervising, Design of borehole	1
Sub-total			2
Cooperation for construction	Drilling Engineers	Drilling	2
	Mechanical Engineer	Maintenance and management of equipment, Stock management	1
Sub-total			3
TOTAL			5

Scope of work for the Japanese engineers dispatched are to be as follows:

A. Design and Supervising Group (Consultant)

a). Supervising Engineer

i. Advising, assisting and transferring technology to the Ghanaian Project Manager and Site Manager for the items concerning Project managing, borehole construction and supervising such as;

- Management of the implementation schedule,
- Supervision of the construction,
- Design of boreholes,
- Supervision of borehole test,
- Supervision of appurtenant facility construction and installation of hand-pumps,
- Recording the Project implementation, etc.

ii. Supervising the tasks of Japanese engineers concerned with the construction works.

b). Hydrogeologist

i. Advising, assisting and transferring technology to the Ghanaian staff in charge of borehole siting for the items such as;

- Selection of borehole sites,
- Geophysical prospecting and analysis,
- Judgment of proposed borehole sites and reporting technique,
- Selection of access routes,
- Instruction of earth work to the work party con cerned, etc.

B. Engineering Group (Contractor)

a). Drilling Engineer

i. Advising, assisting and transferring technology to the Ghanaian staff for the items concerning drilling such as;

- Handling and operation of the drilling rig and supporting equipment,
- Drilling technology, especially mud-drilling,
- Casing and gravel packing,
- Developing of borehole,
- Recording and reporting the work record, etc.

b). Mechanical Engineer

i). Advising, assisting and transferring technology to the Ghanaian staff for the items concerning maintenance of the equipment and stock management such as;

- Daily maintenance and management of the rigs, supporting equipment and vehicles,
- Stock management of the stand-by equipment and spare parts,
- Maintenance and managing of the hand-pumps,

ii. Procurement of local materials and delivery to the borehole site.

4-6-3. Implementation Schedule

The Project will actually start when the Exchange of Notes is mutually confirmed by the Governments of Japan and Ghana. Then GWSC should immediately conclude a contract with the Japanese consulting firm for services of designing and supervising of the Project. After the contract is signed, the Consultant should prepare the detailed design and the tender document for Japanese suppliers regarding the