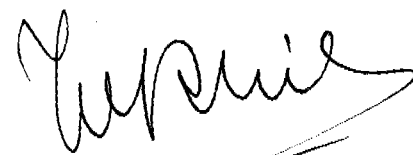


024

GH. AC 68

U. N. SPECIAL FUND—WORLD HEALTH ORGANIZATION



DRAFT

LIBRARY
International Reference Centre
for Community Water Supply

DESIGN PHASE
OF THE
WATER SUPPLY AND SEWERAGE WORKS
FOR THE
ACCRA-TEMA METROPOLITAN AREA, GHANA
PROGRESS REPORT No. 1

CONSULTING ENGINEERS:
TAHAL CONSULTING ENGINEERS LTD.
in Association with
ENGINEERING SCIENCE, INT. LTD.

TEL AVIV
APRIL 1968
P. N. 831

824 GH. AC 68 -
540

U. N. SPECIAL FUND—WORLD HEALTH ORGANIZATION

824
GH. AC 65

540

Faint, illegible text, possibly a stamp or handwritten note.

DESIGN PHASE
OF THE
WATER SUPPLY AND SEWERAGE WORKS
FOR THE
ACCRA-TEMA METROPOLITAN AREA, GHANA
PROGRESS REPORT No. 1

CONSULTING ENGINEERS :
TAHAL CONSULTING ENGINEERS LTD.
in Association with
ENGINEERING SCIENCE, INT. LTD.

TEL AVIV
APRIL 1968
P. N. 831

C O N T E N T S

	<u>Page</u>
INTRODUCTION	
<u>PART A - WATER SUPPLY</u>	1
1. WATER REQUIREMENTS	1
a. General	1
b. Present Supply Situation	1
c. Water Consumption in 1966 and 1967	3
d. Revised Water Demand Forecast	8
2. REVISED FIRST STAGE DISTRIBUTION SYSTEM	17
a. General	17
b. Town Planning	18
c. Water Requirements	19
d. Adequacy of Supply Sources and of Conveyance Facilities	19
e. Accra Distribution System	21
f. Tema Distribution System	22
g. Central Area Distribution System	23
3. REVISED SECOND STAGE DISTRIBUTION SYSTEM	24
a. General	24
b. Town Planning	25
c. Water Requirements	25
d. Adequacy of Supply Sources and of Conveyance Facilities	26
e. Accra Distribution System	27
f. Tema Distribution System	30
g. Central Area Distribution System	31

CONTENTS (Cont'd)

	<u>Page</u>
4. WEIJA DAM	32
5. CONSTRUCTION PROGRAMME	
a. Construction Programmes Considered in the Feasibility Study	33
b. First Stage Construction Programme	33
c. Second Stage Construction Programme	34
d. Contract Documents	36
6. PROGRESS MADE	37
a. Work Programme	37
b. Distribution System Design	37
c. Work on Distribution System - May 1967 to April 1968	39
d. New Weija Dam	40
e. Reservoirs	42
f. Treatment Plant	42
g. Densu River Flow Measurements	43
h. Water Analyses	44
i. Leakage Survey	44
j. Contract Documents	45
k. Staff	45

CONTENTS (Cont'd)

	<u>Page</u>
<u>PART B - SEWERAGE</u>	48
1. RECENT SEWERAGE SCHEMES IN THE ACCRA AREA	48
a. General	48
b. Existing Korle Bu Hospital Scheme	48
c. Existing Ministries Scheme	49
d. Proposed Police Barracks Scheme	49
e. Proposed High Street Area Scheme	50
f. Position of Existing and Proposed Schemes in Accra Phase I Scheme	50
2. REVISED ACCRA PHASE I SCHEME	52
a. Present Development Trends at Accra	52
b. Change in the Scope of the Accra Phase I Scheme	52
c. Relocation of Pumping Station Sites	53
d. Pumping Stations to Serve Low Areas Near the Coast	54
e. Design Capacity of Phase I Scheme	54
f. Flexibility of Sewerage Proposals	54
3. CENTRAL ACCRA SCHEME	56
a. General	56
b. Description of Scheme	56
c. Interim Disposal Arrangements	57
d. Changes From Immediate Implementation Measures	58
4. WEST TEMA SCHEME	60
a. Present Development Trends at Tema	60
b. Doxiadis Report on Urgent Amelioration Works	60
c. Future Treatment Plant Site and Submarine Outfall Location	61

CONTENTS (Cont'd)

	<u>Page</u>
5. CONSTRUCTION PROGRAMME	62
a. Construction Programme Considered in the Feasibility Report	62
b. Revised Construction Programme	62
c. Contract Documents	63
6. PROGRESS OF WORK	66
a. Design Procedure and Programme	66
b. Topographic Surveys	66
c. Sewer Layout and Design	67
d. Soils Investigations	67
e. Site Acquisition and Wayleaves	68
f. Ocean Investigations	68
g. Contract Documents	68
h. Staffing	69

CONTENTS (Cont'd)

Page

LIST OF TABLES

Table 1	Population and Water Consumption - Accra	3
Table 2	Population and Water Consumption - Tema	5
Table 3	Annual Water Consumption by Sectors - Tema	5
Table 4	Metropolitan Area Peak and Average Day Consumption in 1967	7
Table 5	Daily Water Consumption - Accra	8
Table 6	Revised Water Demand Forecast - Accra	11
Table 7	Average Daily Consumption - Tema	11
Table 8	Peak Day Consumption - Tema	12
Table 9	Revised Water Demand Forecast - Tema	14
Table 10	Metropolitan Area Water Demand Forecast	16
Table 11	Accra Tema First Stage - Water Requirements	19
Table 12	First Stage Supply According to Revised Design Curve	20
Table 13	Accra Tema Second Stage Water Requirements	26
Table 14	Metropolitan Area Second Stage Distribution and Sources of Supply - 1978	27

CONTENTS (Cont'd)

Following
page

LIST OF FIGURES

Figure 1	Design Peak Day Water Demand	9
Figure 128R	Accra - Main Dist. Grid - 1st Stage	20
Figure 131R	Tema - Main Dist. Grid - 1st Stage	21
Figure 129R	Accra - Main Dist. Grid - 2nd Stage	26
Figure 132R	Tema - Main Dist. Grid - 2nd Stage	29
Figure 2	Revised Development Programme	32
Figure 204R	Accra Sewerage General Project Plan	51

I N T R O D U C T I O N

Progress Report No. 1 presented herewith has been prepared in pursuance of the Agreement dated December 27, 1967, between the World Health Organization (WHO) and Tahal Consulting Engineers Ltd. This Report is being submitted, as agreed, to the Advisory Panel, for discussion at the meeting to be held in Accra in June 1968.

Work in Accra was officially commenced with the signing of the said Agreement, but the Tahal office in Accra actually began work on the Project in May 1967.

Under the provisions of the Agreement, Tahal has submitted in March 1968 a report on the New Weija Dam (P.N. 828). That report should be read as part of the present Progress Report.

The object of the present Report is, as defined in the Agreement, to furnish a summary of a review of the Master Plan and Feasibility Study and to recommend any modifications of previous proposals, data and criteria, to be applied in the design work.

The report is divided into two parts: Part A - Water Supply, and Part B - Sewerage. The progress of work under each part is reported at the end of that part.

PART A

WATER SUPPLY

1. WATER REQUIREMENTS

a. General

Water demand forecasts for the Accra-Tema Metropolitan Area (minimum, design and maximum) were determined in the Master Plan* and the Feasibility Study** on the basis of the best data available at the time on population growth, water consumption and development programmes. Under the Feasibility Study the minimum demand forecast was revised taking into account a slowdown in the growth of water consumption as a result of the decision of the Ghana Government to abandon the seven-year development plan and concentrate instead in the near future on the stabilization of the country's economy.

In the present report, the forecasts made in the Feasibility Study will be analysed in the light of actual water consumption and domestic and industrial development which has taken place in Accra and Tema since 1966.

b. Present Supply Situation

During the period 1965-1967 the water works in the Accra-Tema Metropolitan Area were considerably improved. The First Stage scheme constructed by Messrs. Stepri (commenced in December 1966) has increased the daily capacity of the supply sources at Kpong to 32 mgd, out of which 14 mgd (or more) will be supplied to Tema, but not more than 18 mgd to Accra.

* Master Plan for Water Supply and Sewerage, Accra Tema Metropolitan Area, Engineering Report Tahal and E-S, P.N. 481, October 1965.

**Feasibility Study, P.N. 652, November 1966.

A 10 mg reservoir at Tema, together with a 42" dia. main, have improved the previously poor supply situation in the town.

In Accra a 10 mg reservoir, as well as a booster station for the two pressure zones - high and medium - each with a 2 mg reservoir, have superseded the interim measures provided in 1965 to allow for the increasing water consumption in the capital.

The present supply to Accra from the Weija Water Works (including the obsolete old works and the excess lime treatment reservoirs) is about 9 mgd. A report prepared by Tahal in 1967 (P.N. 804) calls for a comprehensive rationalization of the Weija Water Works in order to restore its capacity to 13 mgd. The conveyance of the full supply of 13 mgd to Accra, however, will be possible at present with the aid of the Odorkor Booster Station built in 1965. X

During 1967, 15 miles of pipelines forming part of the First Stage main distribution system, were constructed and put into operation in Accra and Tema. Secondary and tertiary mains were laid and house connections made mainly in Tema, and only to a limited extent in Accra during this period.

In many parts of Accra, consumers are still drawing their water from public standpipes. New areas have been developed in western Accra beyond the First and Second Stage boundaries (as defined in the Feasibility Study) and no adequate water supply has been provided in them.

Subdivision of the Accra distribution system into pressure zones, although not yet completed, has already improved the flow conditions in some areas of deficiency.

The metering system for water supplied to consumers is still inadequate. Moreover, due to poor maintenance, the parts of the system already provided are deteriorating.

Considerable improvements have been made in the master metering provisions at the headworks at Kpong and at the Weiija Water Works, as well as at the Tema and Accra terminal reservoirs. Flow recording units and remote control systems have been installed in these works.

c. Water Consumption in 1966 and 1967

(1) Accra

Accra population and water consumption figures for the period 1961 to 1967 are given in Table 1 below.

TABLE 1
POPULATION AND WATER CONSUMPTION - ACCRA

Year	Population*	Total annual consumption (mg)	Average daily consumption (mgd)	Average per capita consumption (gpd)
1961	390,000	2,640	7.25	18.5
1962	410,000	2,931	8.05	19.5
1963	430,000	3,120	8.55	19.8
1964	460,000	3,440	9.45	20.5
1965	500,000	4,129	11.30	22.5
1966	530,000	5,400	14.80	27.9
1967	562,000	5,708	15.64	27.9

* mid-year figures

file

The population figures given in Table 1 have been estimated on the basis of the growth rates adopted in the Feasibility Study as no census or sample survey of the population of the Area have been carried out since 1960.

The average daily per capita consumption figures were computed using the annual recorded consumption and the estimated population for the middle of the corresponding year. The actual figures may differ considerably from those shown in the above Table, depending on the actual population figure for each year.

In 1967 a new Venturi meter was installed at the Weija Water Works for metering the total water supply from Weija to Accra. Together with the new metering system that commenced operating at Tema in December 1966 the supply to Accra during 1967 can be considered to have been reasonably accurately recorded.

The relatively steep increase in consumption during the period 1966-1967 may be attributed to the commissioning of the new First Stage Works in December 1966. Annual water consumption in Accra by sectors of consumption is not available for that period; it is known, however, that no significant industrial development took place in Accra during 1966 or 1967 and therefore very little of the increase can be attributed to industry.

(2) Tema

Table 2 shows population, total daily, daily per capita and total annual consumption figures for Tema for the period 1961 to 1967.

TABLE 2
POPULATION AND WATER CONSUMPTION - TEMA

Year	Population*	Total annual consumption (mg)	Average daily consumption (mgd)	Average per capita consumption (gpd)
1961	29,000	385	1.05	35.5
1962	34,000	525	1.44	42.5
1963	40,000	851	2.33	59.0
1964	48,000	940	2.58	54.0
1965	56,000	1,450	4.00	71.5
1966	64,000	1,530	4.20	65.0
1967	73,000	1,770	4.85	67.0

* Mid-year figures

In this Table, average per capita consumption has been calculated on the same basis as described above for Accra.

Annual water consumption in Tema by the domestic, public, commercial and industrial sectors, for the period 1961 to 1967, is shown in Table 3.

TABLE 3
ANNUAL WATER CONSUMPTION BY SECTORS - TEMA
(mg)

Year	Domestic	Public and commercial	Industrial	Total
1961	269	49	67	385
1962	350	108	67	525
1963	596	118	137	851
1964	436	296	208	940
1965	681	361	410	1,452
1966	792	300	438	1,530
1967	838	356	576	1,770

The growth of total water consumption in Tema has declined in the years 1966 and 1967 in comparison with the growth in 1965, despite the fact that more water was available in those years than in 1965. Domestic consumption grew steadily but at a declining rate, while public and commercial consumption fell below the level of 1965. The reasons for this are not known. Erroneous meter readings resulting from the poor condition of most of the domestic block master meters could be one explanation. The decline in public and commercial consumption could be attributed to the decrease in construction of public, commercial and industrial buildings.

Computation of the amount of water supplied to Tema since 1967 is based on the metered flow from Kpong to Tema, less the metered flow to the Accra terminal reservoir, and less the estimated flow through the Nungua (Central Area) mains.

This computation method has proved to be reliable, since its figures are in fair agreement with the total measured supply to the various sectors.

The total industrial consumption, as calculated from consumers' meters, agrees roughly with the figure of total industrial consumption arrived at by subtracting domestic, public and commercial consumption from the total metered supply to Tema. Thus, the figures for industrial consumption can be considered fairly accurate.

An increase of 40 percent in Tema industrial consumption is indicated between 1965 and 1967, although the town's industrial development has slowed down since 1966.

(3) Peak Day and Peak Hour Consumption

Peak day water consumption in Accra and Tema for the year 1967 was determined on a percentage basis by relating the average daily consumption in the maximum month to the average daily consumption throughout the year.

A comparison of peak day and average day consumption figures for Accra and Tema in 1967 is given in Table 4.

TABLE 4
METROPOLITAN AREA PEAK AND AVERAGE
DAY CONSUMPTION IN 1967

Town	Peak, day consumption* (mgd)	Average day of the year (mgd)	Ratio (percent)
Accra	16.70	15.64	107
Tema	6.50	4.85	134

* Taken as average day of maximum consumption month.

Taking into account the daily fluctuations during the maximum month of consumption in Accra, and the industrial consumption component in Tema, which in the future will represent a considerable part of the total consumption, it can be concluded that the ratio of 120 percent of the peak to the average day in the year adopted in the Feasibility Study as a long-term design criteria for the Metropolitan Area is justified.

Peak hour consumption for the years 1966 and 1967 could not be obtained on the basis of master meter readings, since the measured flow also included the water used for filling the storage reservoirs during peak hours.

During the leakage survey conducted by Tahal in 1967 in two pilot areas, the peak hour demand in one of the areas was found to be 85 percent higher than the average demand and in the other area 75 percent higher. The pilot surveys were carried out in high grade residential areas, where high peak demand could be expected.

Due to the lack of new data, it is proposed to retain for the peak hour consumption the figure of 180 percent of the average hourly demand of the average day, as adopted in the Feasibility Study.

d. Revised Water Demand Forecast

(1) General

In the Feasibility Study a set of three peak day consumption curves was established as a basis for flexible design to be adapted to actual needs. The curves were: maximum and minimum forecast curves and a selected design curve, as shown in Figure 105F, Volume One of the Feasibility Study.

(2) Accra

Table 5 gives the actual consumption in Accra for the years 1966 and 1967 as compared with the corresponding figures forecast in the Feasibility Study.

TABLE 5
DAILY WATER CONSUMPTION - ACCRA

Year	Minimum forecast*		Maximum forecast*		Design curve		Actual consumption		
	Ave.	Peak	Ave.	Peak	Ave.	Peak	Ave.	Recorded peak day	Calculated peak day
1966	9.3	11.2	12.9	15.5	11.6	13.9	14.8	-	17.8
1967	10.20	12.2	14.2	17.0	12.9	15.5	15.64	16.7	18.8

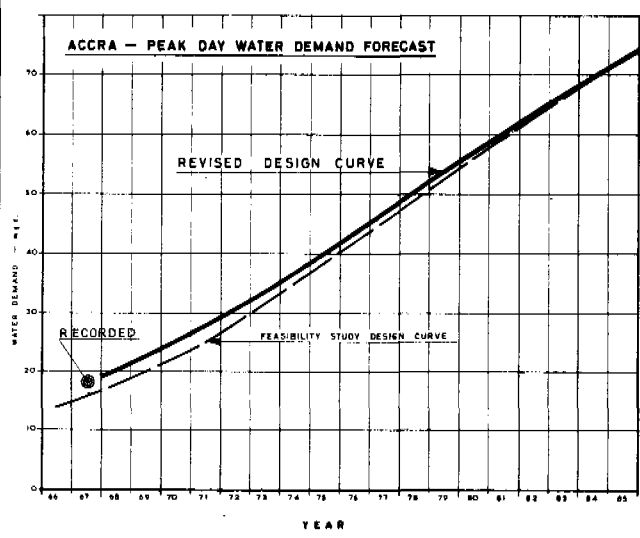
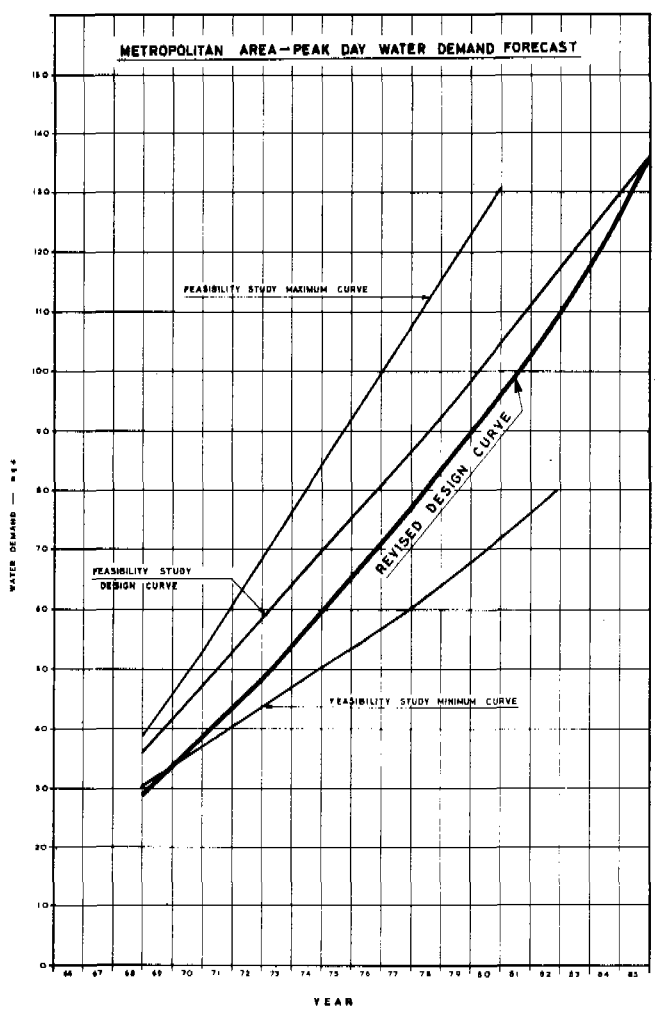
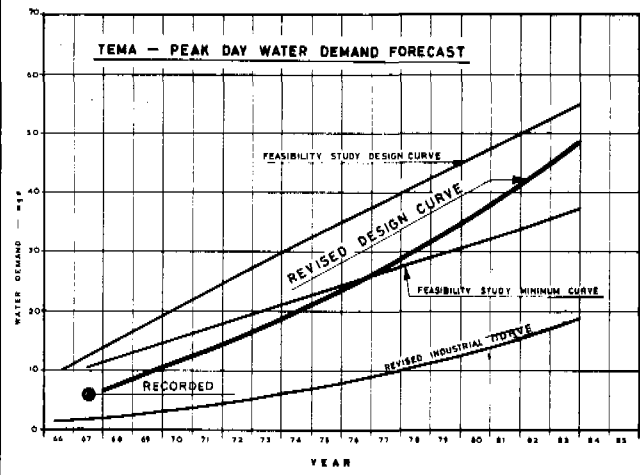
* Based on mid-year population figures

From the above Table it can be seen that the actual 1966 and 1967 average figures exceed even the maximum forecast, whereas the recorded peak day consumption in 1967 (average day of maximum month) remained slightly below the 1967 maximum forecast peak day figure. This can be regarded as a temporary increase in consumption resulting from ample quantities of water made available by the commissioning of the First Stage System. These high figures of actual consumption cannot be regarded as an indication of a new and higher trend in consumption, since the actual increase in total consumption between 1966 and 1967 was 6 percent, compared to the rate of eleven percent in the design forecast. However, the minimum figures given in the Feasibility Study can now justifiably be disregarded.

1966?

In the past two years rapid housing development has taken place in the western part of Accra. A large number of houses, built mainly by private owners, occupy areas located west of Tessano and Kaneshie, as well as west of Link Road. These new developments have expanded beyond the boundaries of Accra as assumed for the First and Second Stages.

Initially, the north-western part of this area was included in the Second Stage programme, while the south-western part was included in the Third Stage development programme. It is now estimated that within the First Stage programme in western Accra, an area of 1,000 acres will be developed by the Ghana State Housing Corporation at Dansoman, while privately owned buildings will be located on a area approximately 4,000 acres, with the density of building increasing gradually. At the end of the Third Stage, ^{the} whole area in western Accra is expected to be fully developed, as assumed in the Feasibility Study.



ACCRA-TEMA & METROPOLITAN AREA DESIGN PEAK DAY WATER DEMAND; 1968 TO 1985

Figure 1 shows two curves for the Accra consumption forecast, the lower curve representing the design forecast as defined in the Feasibility Study, and the upper curve representing the revised design forecast. For the revised design forecast it is assumed that the development in western Accra replaces other development programmes indicated in the Feasibility Study for the First and Second Stages, as a result, the two curves gradually merge.

Nevertheless the revised design curve for Accra lies slightly above the feasibility study design curve for the first years. This is a reflection of the irregular nature of actual consumption growth, which does not follow a smooth continuous curve. The initial jump is explained by the high unsatisfied potential demand existing in Accra, which was reflected in an immediate increase in consumption upon the commencement of operation of the First Stage scheme. It is further assumed that the temporarily high increment in the demand will be balanced by a lower average rate of consumption growth in the future, compared with the rate given in the Feasibility Study for the design curve. This lower rate is already apparent in the figures for 1966 and 1967. For the years beyond 1980 there are no better data available than those given in the Feasibility Study. Consequently, the revised design curve has been drawn to join the Feasibility Study design curve in the early eighties.

The following Table summarizes the revised consumption forecast to be used for design for the period 1967-1985.

TABLE 6
REVISED WATER DEMAND FORECAST - ACCRA
(mgd)

Year*	Water Demand	
	Average day	Maximum day**
1967	15.64***	16.70***
1970	22.0	26.4
1980	48.4	58.0
1985	61.6	73.9

* End of year figures

** Design peak-day demand on the basis of 120 percent of the average daily demand

*** Figures computed from existing records.

(3) Tema

The following Tables 7 and 8 give the actual consumption figures for the years 1966 and 1967 and compare them to the forecast figures of the Feasibility Study.

TABLE 7
AVERAGE DAILY CONSUMPTION - TEMA
(mgd)

Sector	Minimum forecast*		Maximum forecast*		Design curve		Actual consumption	
	1966	1967	1966	1967	1966	1967	1966	1967
Domestic	-	2.48	-	-	2.36	2.58	2.18	2.30
Public and Commercial	-	0.74	-	-	0.73	0.74	0.82	0.97
Industrial	-	5.83	-	-	5.26	6.85	1.20	1.58
T o t a l	7.7	9.05	8.80	10.4	8.35	10.17	4.20	4.85

* Mid-year figures

TABLE 8
PEAK DAY CONSUMPTION - TEMA
(mgd)

Year	Minimum forecast*	Maximum forecast*	Design curve	Actual consumption	
				recorded	calculated
1966	9.23	10.60	10.00	-	5.03
1967	10.82	12.45	12.19	6.50	5.83

* Mid-year figures

From the above Tables it can be seen that the actual amounts of water consumed in 1966 and 1967 were below even the minimum forecast given in the Feasibility Study. This is due to the rate of industrial development which was much slower than anticipated. The rate of consumption growth in the domestic, public and commercial sectors was, however, close to the design forecast.

Industrial development is, in fact, the principal factor in the growth of water demand in Tema. In the Feasibility Study the design forecast was based on the Seven Year Plan, and the minimum forecast assumed a certain slowing down of industrial development. Total water consumption in Tema in the past two years was much below this minimum forecast, and a revised forecast is therefore warranted.

The revised forecast shown in Table 9 is based on a survey conducted by Tahal in 1967 and early 1968, and on the following criteria obtained from the Ministry of Economic Affairs:

- (i) Ghana industrial production should achieve, in the long run, an annual growth rate of 10 percent;
- (ii) The Government's policy for the future is to achieve a progressive increase in the production of existing industries;
- (iii) Although the general tendency is to decentralize industrial development, it is believed that Tema will continue to be an attractive location for new industrial undertakings due to its available facilities and services (harbour, railway, access roads, electricity, water, etc.);
- (iv) The following annual rates of growth should be adopted for Tema industrial production: 20 percent for the first 5 years; 15 percent for the next 5 years, decreasing to 10 percent after ten-twelve years.

With regard to the domestic, public and commercial water consumption forecasts, the analysis of present consumption and the housing programme of the Tema Development Corporation give fairly accurate indications that future demand will be close to the Feasibility Study design forecast.

The revised water demand forecast for Tema will accordingly be based on the assumption that:

- (i) Domestic, public and commercial demand will follow the Feasibility Study design forecast.
- (ii) Industrial water demand will increase in proportion to the assumed growth of industrial production.

Figure 1 shows the revised industrial demand curve and the revised total design demand curve for the peak day in Tema. It also shows the initial design and minimum curves of the Feasibility Study. The revised design curve represents a summation of the

revised industrial demand figures with the domestic, public and commercial water requirements as in the design forecast of the Feasibility Study.

Table 9 shows industrial and total daily demand as recorded in 1967 and as per the revised forecast for 1970 and 1980.

TABLE 9
REVISED WATER DEMAND FORECAST - TEMA
(mgd)

Year*	Peak day industrial demand	Average daily demand	Total peak day demand**
1967	1.9	4.85***	6.5***
1970	3.62	10.00	12.0
1980	14.00	31.60	38.0

* End of year figures

** Design peak day demand taken as 120 percent of the average daily demand

*** Figures computed from existing records

(4) Metropolitan Area

Figure 1 shows the revised design curve for the Metropolitan Area total peak day water demand, as well as the original minimum, design and maximum curves of the Feasibility Study.

The revised design curve for the Metropolitan Area shown in Fig. 1 is a summation of the separate revised design curves for Accra and for Tema described above. It is proposed to proceed

with the completion of the First Stage and with the Second Stage of the Project according to this revised curve.

The development of the water supply scheme for the Metropolitan Area involves a sequential decision process; in each stage of development the basic assumptions of previous stages must be re-examined and revised in the light of the actual results of earlier steps.

At present the short-term development programme for water supply is being studied, and a decision on the construction programme of the Second Stage will have to be taken. In this study, the effect of the irregular rate of consumption growth on the short term development programme cannot be overlooked. This effect was not taken into account during the Feasibility Study and the long-term consumption forecast made was drawn as a continuous smooth curve.

For Accra this irregularity was demonstrated in the marked increase of consumption upon ample water being made available by the commissioning of the First Stage works; in Tema an irregularity resulted from the sudden slowdown of industrial programmes; and, in the Central Area, it was caused by the cancellation of most development programmes. All these have been analyzed for the revised design curve.

It can be seen that the revised design curve returns to the original design curve in the eithties. For the period beyond 1980 there are no better assumptions than those adopted in the Feasibility Study. However, on analyzing the sensitivity of the revised design curve, one can see that any deviation above or below the forecast beyond 1980, has very little effect on the revised design curve during the Second Stage period terminating in mid-1978.

For the revised design curve it is assumed that the Central Area, which at present consumes 0.5 mgd, will not undergo further development before 1980. If development does nevertheless materialize, it will replace other development programmes within the existing boundaries of Accra and Tema.

Table 10 shows the average and peak day demand as actually recorded in 1967 and as per the revised forecast for 1970, 1980 and 1985.

TABLE 10
METROPOLITAN AREA WATER DEMAND FORECAST

Year*	Revised design figures	
	Average day	Peak day
1967	20.91**	23.7**
1970	32.42	38.90
1980	80.42	96.50
1985	113.60	136.00

* End of year figures

** Recorded figures

2. REVISED FIRST STAGE DISTRIBUTION SYSTEM

a. General

The distribution system proposed for Accra and Tema in the Feasibility Study are shown on Drwgs. 128F and 131F respectively. The First Stage according to the Feasibility Study was to have been completed at the end of 1971 on the basis of the design curve to supply 50 mgd during peak days.

As will be shown further on (Section 5 - Construction Programme), the Second Stage Scheme could commence operating at the earliest, at the beginning of 1974. At that time the Metropolitan Area demand on peak days would be about 53 mgd.

Urban expansion in Accra has now extended in its western part beyond the boundaries assumed in the Feasibility Study. On the other hand, most of the development programmes for the Central Area have been cancelled.

In Tema a slowdown in the industrial development has taken place, whereas the development of communities has been spread beyond the boundaries of the First Stage assumed in the Feasibility Study.

In view of the above changes, the distribution system will have to be revised and kept in line with the revised water demand forecast.

The design criteria laid down in the Feasibility Study, Volume One, Chapter VI, remain pertinent and have been used in the revised design.

b. Town Planning

(1) Accra

So far, there is no approved Master Town Planning Scheme for the development of the town.

The newly developed area in western Accra which has expanded beyond the boundaries demarcated in the Feasibility Study for the First and Second Stages, complies only partially with the relevant town planning schemes. Except for the North Kaneshie and Dansoman housing schemes, the remainder consists of private dwellings, mainly of medium and low grade, forming groups of houses. For the time being there are no road layouts in this area, and complications are experienced in the design and laying of pipelines.

(2) Tema

Town planning schemes for Tema are available and are being updated by Messrs. Doxiadis to meet new and changing needs.

The intended number of housing units will be built in general accord with the estimates given in the Feasibility Study. However, part of the construction work will take place in communities 8,9,10,11 and 12, which were originally due for development only in the Second and Third Stages. Buildings of houses in the above communities will commence prior to the completion of development of the existing communities 4,5,6 and 7. Community 3 will not be developed during the First Stage.

(3) Central Area

The construction of a satellite city is the only programme which is still valid for the Central Area. Other schemes such as for the Science City, Teshie and Nungua have been postponed or cancelled altogether.

c. Water Requirements

Table 11 below shows the First Stage water requirements for Accra and for Tema, on average and on peak days. These requirements are based on the revised design curves.

TABLE 11
ACCRA TEMA FIRST STAGE - WATER REQUIREMENTS*
(mgd)

Year	A c c r a**		T e m a	
	Revised forecast		Revised forecast	
	Average day	Maximum day***	Average day	Maximum day***
1970	22.0	26.4	10.0	12.0
1971	24.5	29.4	11.7	14.0
1972	26.6	32.0	13.6	16.3
1973	28.8	34.5	15.4	18.5

* End of year figures

** Accra, including Central Area

*** Maximum day demand taken as 120 percent of average day demand

d. Adequacy of Supply Sources and of Conveyance Facilities

During the First Stage, 53 mgd can be supplied to the Metropolitan Area, after the Weija Water Works are improved to supply 13 mgd and the Kpong Water Works are extended to produce 40 mgd.

Table 12 below shows distribution of water according to areas of supply during the First Stage, if demand follows the revised design curve.

TABLE 12
FIRST STAGE SUPPLY ACCORDING TO REVISED DESIGN CURVE

Area of Supply	After Weija W.W. improvement			After Kpong W.W. extension		
	Available supply sources			Available supply sources		
	Weija	Kpong	Total	Weija	Kpong	Total
Accra	13.0	17.0	30.0	13.0	21.0	34.0
Tema	-	14.5	14.5	-	18.5	18.5
Central Area	-	0.5	0.5	-	0.5	0.5
Total	13.0	32.0	45.0	13.0	40.0	53.0

The Weija Water Works can deliver the 13 mgd to Accra through the existing 21", 16", 14" and 12" parallel mains running from Weija to Accra, with the support of the Odekor booster operating on the 21" main.

The Tema booster station will be capable of delivering 18 mgd to Accra through the 32" rising main, with 2 units in operation, and 21 mgd with 3 units in operation.

Tema can be supplied directly from the Tema Terminal through the 42" gravity main.

The Central Area can also be supplied from the Tema Terminal through the 16" and the 9" gravity mains.

e. Accra Distribution System

Fig. 128R shows the revised supply boundaries of Accra, the existing mains, and the mains proposed for the First Stage.

The capacity of the First Stage main distribution grid is 31.5 mgd and will suffice to meet the requirements up to the end of 1972, provided the demand conforms to the revised design curve. Since the Second Stage Scheme cannot be completed before the end of 1973, part of the Second Stage mains will have to be completed towards the end of 1972, subject to the same proviso that demand follows the revised curve.

The Accra distribution system will be divided into four pressure zones; high (H.P.Z.), medium (M.P.Z.), low (L.P.Z.), and an enclaved zone (E.Z.) within the Low Pressure Zone, as shown on Drwg. 129F in the Feasibility Study, Volume Two. The development of the Enclaved Zone, scheduled in the Feasibility Study for implementation in the Second and Third Stages, will be advanced so as to permit supplying part of the newly developed area in western Accra.

The mains for the high and medium pressure zones will remain as proposed in the Feasibility Study.

To supply water to the high areas of the Enclaved Zone (elevations 70 ft to 150 ft O.D.), the Odorkor booster will be operated to deliver water through the 21" main from Weiija. To control the pressure produced by the booster, a pressure regulating valve (P.R.V.) will be installed on the 21" main at Winneba Road and Ring Road junction. The P.R.V. will maintain the required head established by the booster for the Enclaved Zone and will reduce the pressure downstream as much as is needed to permit a supply from the Accra Terminal to the Low Pressure Zone. During hours of low demand, the Odorkor booster will not be in operation, and the high areas of the

Enclaved Zone will be supplied by gravity directly from the Weiija clear water tank.

New 21", 15" and 12" mains will be laid in the Enclaved Zone. The mains will be fed through the existing 21" main running from Weiija. The connection should be downstream of the Odorkor booster.

The part of the Low Pressure Zone situated east of Liberation Road will be controlled by the Mile 4 Reservoir, as proposed in the Feasibility Study.

The central part of the Low Pressure Zone will be supplied directly from the Accra Terminal Reservoir. Towards the end of the First Stage, a new 15" main will be laid parallel to the existing 21" and 16" mains running from Mile 4 Reservoir to Central Accra. This new main was initially provided for the Second Stage, but if consumption increases according to the revised curve, its provision will be advanced.

The low laying areas in the newly developed portion of western Accra will be part of the Low Pressure Zone. These areas will be supplied by the existing 12" and the proposed 15" mains running along Link Road.

f. Tema Distribution System

Fig. 131R shows the revised development boundaries and main distribution system of Tema.

In the area of domestic supply, the distribution system shown on Fig. 131R conforms partly with that shown on Drwg. 131F (First Stage) and partly with that shown on Drwg. 132F (Second Stage) in Volume Two of the Feasibility Study. It should be noted

that while the provision of some of the mains intended for the First Stage is now postponed to the Second Stage, other mains designed for the Second Stage are now advanced to the First Stage. This is in line with the actual development of the communities in Tema.

Secondary and tertiary grids will be constructed for all communities, according to the actual development of the areas.

Due to reduced industrial consumption, Community 2 can still be supplied by gravity during the First Stage, so that the proposed booster station and elevated tank for Community 2 can now be assigned to the Second Stage. Furthermore, it is now no longer necessary for the 48" main from the Tema Terminal reservoir and the 16" main along Chemu Lagoon to be laid in the First Stage.

g. Central Area Distribution System

The new housing scheme and the existing villages of Teshie and Nungua will be supplied in the First Stage from Tema Reservoir.

The two lines, 16" and 9", running to Nungua and continuing from there as 12" and 9" lines respectively to the Labadi reservoir can supply the First Stage requirements of the Central Area by gravity flow.

A distribution system will be provided for the new housing scheme, while existing communities will continue to draw their water mainly from standpipes.

3. REVISED SECOND STAGE DISTRIBUTION SYSTEM

a. General

The distribution grids proposed for Accra and Tema in the Feasibility Study are shown on Dwg. 129F and 132F respectively, in Volume Two of that study.

The capacity of the Accra-Tema supply system during the Second Stage will remain unchanged at 80 mgd, and will meet the requirements up to mid-1978, if demand follows the revised design curve. Modifications in the original programmes and revisions in the proposed network are, however, necessary, in view of the changed circumstances enumerated below.

(1) In respect of the First Stage, it is now envisaged that building activities in western Accra will extend beyond the boundaries of the Second Stage assumed in the Feasibility Study.

(2) In the Central Area, as already mentioned, most of the construction programmes have been cancelled.

(3) In Tema, industrial progress will continue at a slower pace than assumed in the Feasibility Study. On the other hand, the building up of communities will spread beyond the boundaries assumed for the Second Stage.

The design criteria set out in the Feasibility Study, Volume One, Chapter VI, remain pertinent and have been used unaltered in the revised design.

b. Town Planning

(1) Accra

In addition to the expansion of building in western Accra beyond the Second Stage boundaries, referred to above, it is also assumed that slum clearance will be started during the Second Stage. This is, however, likely to be undertaken on a somewhat reduced scale.

(2) Tema

According to information provided by the town planning authorities, new communities will be developed during the Second Stage to the west of the existing Communities 10, 11 and 12. At the same time, the existing communities will reach further or completed development. Community 3 is also included for construction in the Tema Development Corporation's programme.

Light industries are expected to be set up along the Accra-Tema motorway; other new industries will be developed in the Industrial Area.

(3) Central Area

There are no development plans for the Central Area during the Second Stage, except for the Satellite City.

c. Water Requirements

Table 13 below shows the Second Stage water requirements for Accra and for Tema, on average and on peak days. These requirements have been estimated in accordance with revised design curves.

TABLE 13
ACCRA-TEMA SECOND STAGE WATER REQUIREMENTS*
(mgd)

Year	A c c r a**		T e m a	
	Average day	Peak day***	Average day	Peak day***
1974	32.5	39.0	17.5	21.0
1975	35.5	42.5	19.7	23.6
1976	38.4	46.0	21.6	26.0
1977	41.2	49.5	24.1	29.0
1978	44.1	53.0	26.4	31.6

* End of year figures

** Accra - including Central Area

*** The peak daily demand is taken as 120 percent of the average daily demand

d. Adequacy of Supply Sources and of Conveyance Facilities

During the Second Stage, 80 mgd could be supplied to the Metropolitan Area as follows: 40 mgd from the Weija Water Works extended according to the Second Stage programme, and 40 mgd from the First Stage Works at Kpong.

Table 14 below shows the distribution of water in the Second Stage, based on the revised design curve:

TABLE 14
METROPOLITAN AREA SECOND STAGE DISTRIBUTION
AND SOURCES OF SUPPLY - 1978
(mgd)

Location served	Supply course		
	Weija	Kpong	Total
Accra	40.0	19.5	49.5
Tema	-	29.5	29.5
Central Area	-	1.0	1.0

The combined capacity of 80 mgd of the Second Stage sources will suffice up to the middle of 1978, if demand follows the revised design curve. The supply mains and distribution systems are designed for this capacity.

e. Accra Distribution System

The accompanying Fig. 129R shows the revised boundaries of the Accra Second Stage supply area and the revised main distribution system.

The Accra distribution system will be divided into three pressure zones, high (H.P.Z.), medium (M.P.Z.) and low (L.P.Z.). The Enclaved Zone in Western Accra, as proposed for the Second and Third Stages, will be part of the Low Pressure Zone.

To supply the high area in Western Accra (70 to 150 ft O.D.), which will form an integral part of the Low Pressure Zone, two 15" A.C. mains will be provided: one will be laid south of the Winneba road and will run parallel to the 15" main proposed for the First Stage;

the other will be laid north of the Winneba road, branching off the proposed 34" main which runs along the Accra-Tema Motorway.

To support the south-western part of the Low Pressure Zone and to bring more water to the newly developed area in Western Accra, new 18" and 15" mains will branch off the 48" supply main from the McCarthy Reservoir.

The major contribution of water for the increased demand in the Low Pressure Zone during the Second Stage will be made by the new 34" and 30" mains, now proposed to be laid along the new Motorway, and not along Winneba and Ring Roads as previously planned and shown on Dwg. 129F in the Feasibility Study.

These mains will connect the 48" supply main from the McCarthy Reservoir with the central and southern parts of the Low Pressure Zone through the existing and new 24" and 21" main along Nsawam Road.

The new 34" and 30" mains will also deliver water to the Mile 4 Reservoir through a new 24" main to be laid along the Motorway, and through the existing 32" main.

With the new location of the 34" and 30" mains along the Motorway, the 16" main proposed in the Feasibility Report for the Second Stage to run along Winneba Road and along Ring Road from Winneba Junction to the Independence Av. Junction will no longer be required.

Minor changes are proposed in the layout of the eastern part of the Low Pressure Zone. These changes derive from adaptation to field conditions and coordination with the future road network.

The revised distribution system for the Second Stage, as shown on Fig. 129R and described above, provides, at no additional investment, a system which is flexible enough to accommodate the wide range demand fluctuations in forecast for this stage.

Other advantages offered by the revised layout are as follows:

- (i) During emergencies, in case of insufficient supply from the Tema Terminal, water can be delivered from the McCarthy Reservoir to the Accra Terminal for the Medium Pressure and High Pressure Zones, or from the Accra Terminal to the Low Pressure Zone, whereas the supply from Weiija is low.
- (ii) Elimination of the Enclaved Zone as a separate pressure zone.
- (iii) The mains along the Motorway will provide shorter secondary grids for the future development area in North Accra.
- (iv) Laying the larger 34" and 30" mains along the Motorway is a far simpler operation than laying them along the crowded Winneba Road, where four large mains already exist.

During the Second Stage, the Accra Low Pressure Zone will be controlled by the McCarthy Reservoir (T.W.L. 300'); static pressure in this zone will be lower than during the First Stage, when the Weiija Clear Water Tanks (T.W.L. 347') will control the system. In order to control the Accra Low Pressure Zone at maximum TWL 300 ft O.D., separate inlet and outlet pipes will be provided between the reservoir and the supply main at the McCarthy Reservoir. Furthermore, to reduce undesirable high pressures during off-peak hours, there will be a continuous controlled flow between the McCarthy and the Mile 4 Reservoirs.

f. Tema Distribution System

The Second Stage Development boundaries and the revised main distribution system for Tema are shown on the accompanying Fig. 132R.

A new 40" main will have to be laid parallel to the existing 42" main, from the Tema Reservoir to the northern boundary of the Industrial Area.

In the area of domestic supply, the distribution system shown on Fig. 132R conforms with that shown on Dwg. 132F in Volume Two of the Feasibility Study.

The main grid for the Second Stage will also supply the secondary grid to be laid within the area scheduled for development west of Communities 10,11 and 12.

The booster station and elevated tank initially proposed for the First Stage will have to be constructed to serve Community No. 2.

In view of the uncertainties regarding location of industry and type of industrial consumers, it is found economical to construct, during the Second Stage, a 21" main to the east of the Oil Refinery instead of the 40", 38" and 30" main proposed in the Feasibility Study and shown on Dwg. 132F. A parallel 38"-36"-32" main will have to be laid after five or six years.

The Tema Steelworks have a smaller output than previously planned, and also use a recirculation system for water supply. Consequently, the 14" main on the northern side of the factory, proposed in the Feasibility Study, will not be needed during the Second Stage.

g. Central Area Distribution System

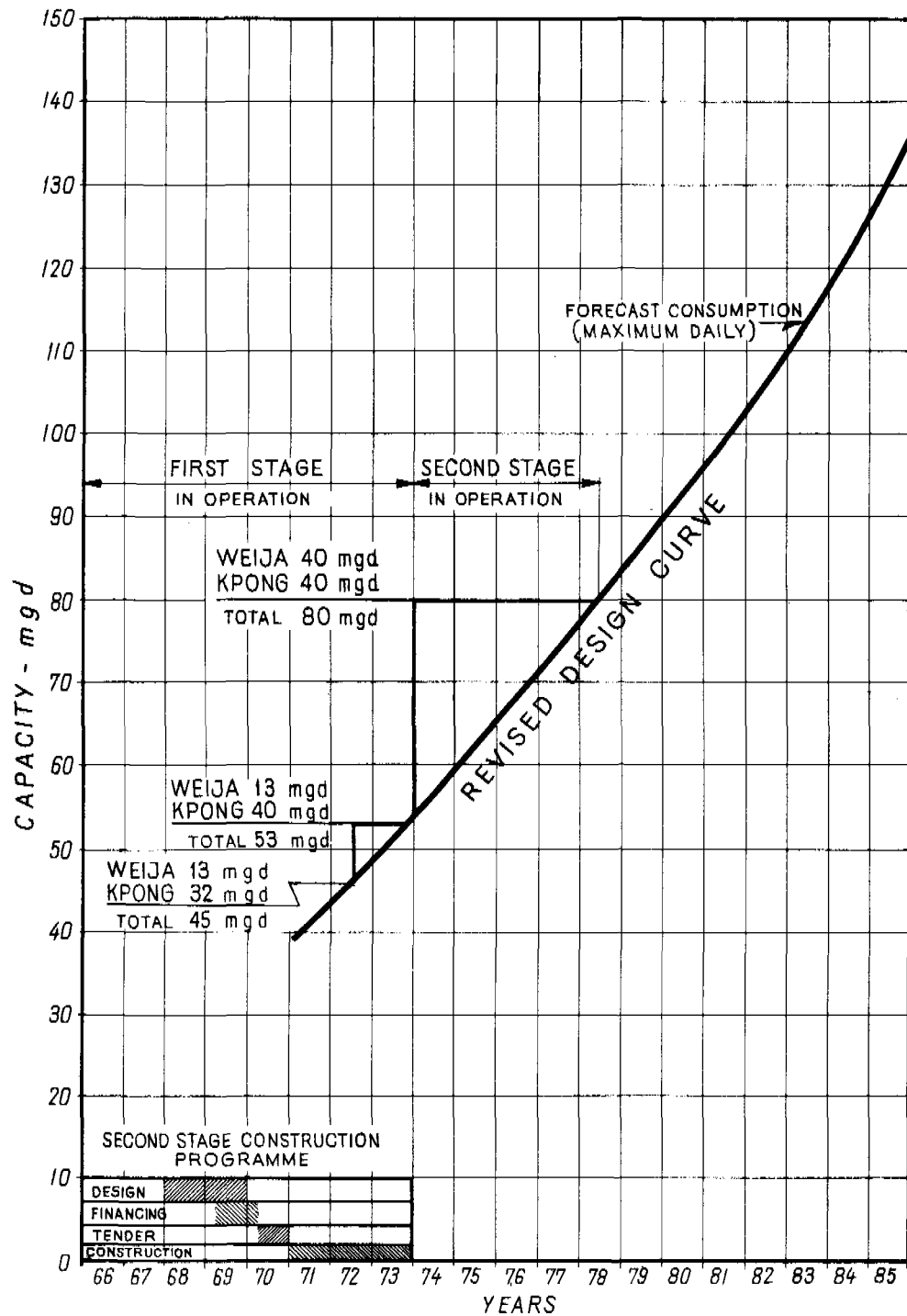
If consumption remains within the limits assumed in this report, only secondary and tertiary mains need be laid for the Central Area. During peak days and peak hours, the Nungua Booster, with a capacity of 2.0 mgd, should be operated on the 16" main.

In case of emergency, water can be conveyed to the Central Area from the Accra Medium Pressure Zone Reservoir through the 12" and 9" mains. Provision of the 14" main proposed in the Feasibility Report, branching off the 32" main along the Motorway, can thus be postponed to the next stage.

4. WEIJA DAM

A report on the new Weija Dam (P.N. 828) was submitted to WHO in March 1968. The report contains a new hydrological study on the Densu River and makes recommendations on the storage capacity required in the Weija impounding reservoir to provide water for both municipal and irrigation needs.

In the report two alternatives dam height were indicated. The lower dam can provide storage for municipal demand only, whereas the higher dam can provide sufficient storage for the combined municipal and irrigation demands. According to the agreement of December 1967 between WHO and TAHAL (Article 2.3.1), WHO is to advise TAHAL with-
in three months of the date of submittal of the report, which dam height is to be adopted in the design.



REVISED DEVELOPMENT PROGRAMME

FIGURE 2

5. CONSTRUCTION PROGRAMME

a. Construction Programmes Considered in the Feasibility Study

Two alternative construction programmes were considered in the Feasibility Study for the Second Stage Scheme. The first programme was to extend over a period of five years (including time needed for design, financing and tendering) and was devised for construction in a single phase. The second programme took into account the recent slow-down in economic development in Ghana, and was planned for a minimum forecast of consumption. This second programme was elaborated for implementation in two phases and was to take up a period of thirteen years.

In view of the revised demand forecast and the fact that design has commenced as late as 1968, the construction programmes set out in the Feasibility Study are no longer realistic and call for revision.

b. First Stage Construction Programme (See Fig. 2)

The combined capacity of the existing Kpong Water Works and the Weiija Water Works (after completion of its renovation programme), i.e. 45 mgd, would be sufficient to meet demand until early 1972, according to the revised design forecast. The Weiija work renovation programme, which has already been started, should be completed to bring up the Weiija Works capacity to 13 mgd.

Since the Second Stage scheme cannot be completed before 1974, the only practical way to meet the growing demand would be to increase the capacity of the Kpong Water Works, from the present 32 mgd to the original design capacity of 40 mgd. The necessary extension should be completed during 1972, thus bringing up the combined

capacity of the Weija and Kpong water works to 53 mgd.

The main grids of the Accra and Tema distribution systems have been designed for 31.5 mgd and 14.7 mgd respectively, and will be capable of meeting the anticipated demand in 1972 according to the revised design forecast. These distribution systems will be provided during the period of 1968 to 1971. To supply the ultimate First Stage capacity of 53 mgd, part of the Second Stage mains will have to be completed towards the end of 1972.

40 + 13
45 + 8

2/1968

A request to finance the cost of the foreign currency portion of the Accra First Stage distribution system was submitted in February to the Aid to Ghana Group. If the requested finance is provided, construction can commence in 1968. To make this possible, it has been decided to complete by September 1968 the design and tender documents for the Accra First Stage distribution system.

c. Second Stage Construction Programme

Examination of Fig. 2 shows that the Second Stage scheme would be required by the end of 1973 to meet the revised design demand forecast, and that the scheme should be constructed in a single phase.

The works required for the Second Stage are those described in the Feasibility Study, Chapter IX. The only departures are the revised distribution system for the entire Metropolitan Area and a higher dam at Weija (should this be approved by the Ghana Government).

A lead time of about 6 years is still available to bring the Second Stage scheme into operation at the beginning of 1974 according to the revised design curve. The design of the scheme was commenced in January 1968 and will be completed in December 1969. Negotiations for financing the scheme will have to commence not later than the beginning of 1969, and an agreement with a financing agency will have to be finalized early in 1970. The call for tenders will immediately

follow and an agreement with the accepted contractor should be ready by the end of 1970. Construction is to commence at the beginning of 1971 and should be completed by the end of 1973.

A period of three years is required for the construction of the Weija New Works, the McCarthy Reservoir and the supply mains from Weija to Accra. The completion of this programme according to schedule will provide the Weija Water Works with an additional capacity of 30 mgd at the end of 1973.

Any alteration in this programme means a shortage in the supply to Accra if consumption follows the revised design curve.

It should be noted that during the period of 1971 to 1974 Accra will depend, for obtaining a sufficient and continuous supply, on a single pump at the Odorkor Booster station and on the operation of the Tema booster without a standby unit. It is therefore recommended that first priority be accorded to the construction of 42" supply main from Weija to the McCarthy Reservoir, as this will eliminate the necessity of operating the Odorkor Booster for so lengthy a period. Thus, the 13 mgd from Weija would be conveyed to Accra by gravity flow through the 42" main.

The design for the Tema Terminal Reservoir provides for one reservoir of 25 mgd consisting of two compartments; the first compartment will be required during the Second Stage when Tema consumption exceeds 13 mgd - the existing storage capacity - and it is recommended that it be built together with the Second Stage scheme. Construction of the second compartment can be postponed until required at a later stage.

The Main Grid Distribution System will be constructed gradually over the period 1971-1975. Secondary and tertiary mains will be laid throughout the period of the Second Stage, in accordance with the actual development of demand areas or as required by local conditions.

d. Contract Documents

The following proposals for the subdivision of contract documents is in accord with the construction programme described above. It is assumed that funds for the different stages will be made available at the appropriate times.

- (1) One set of contract documents will be prepared for the First Stage distribution system for Accra and another for Tema.
- (2) Contract documents for the complete Second Stage works will be prepared for one single phase of construction.

The Second Stage works will however be split into a number of contracts and for each separate documents will be prepared. The documents will contain provisions for a combined tender, wherever this would be to the advantage of the scheme, as well as for separate tenders.

6. PROGRESS MADE

a. Work Programme

A work programme for the Government service was submitted in January 1968 in conformity with article 3.7 of the Agreement between WHO and TAHAL of December 1967. ||

b. Distribution System Design

(1) Main Distribution System

Design work on the Accra and Tema Main Distribution System commenced in May 1967, with the revision of basic data relating to town planning programmes and water demand forecast.

On the strength of the revised data, and after preliminary field work and coordination with the relevant authorities, a revised scheme was drawn up for the Main Distribution of the First and Second Stages.

Individual sections of the Main Distribution System are being designed in the following sequence:

- (i) Preliminary investigation for determining the appropriate alignment.
- (ii) Contact with Town Planning, City Council, Army Public Works and other authorities to secure the necessary space for services.
- (iii) Communication with promoters of other services (electricity, telephone etc.) to ascertain location of existing and proposed underground cables, pipelines etc. so as to avoid mutual interference.
- (iv) Selection of final route and survey of proposed alignment, including collection of all pertinent field data necessary for the design.

- (v) Plotting and tracing of plan and longitudinal section of surveyed alignment.
- (vi) Detailed design of proposed main with due regard to its integration in the existing distribution system.
- (vii) Soil investigations along proposed alignment.
- (viii) Production of final contract drawings.
- (ix) Drawing up Bill of Quantities.
- (x) Application for wayleaves and easements. 2

(2) Secondary Distribution System

The secondary distribution grid is designed on the basis of proposed town planning layouts, where such layouts are available. Owing to the lack of final road alignments and designs, it has been found impracticable as yet to set out the lines of the secondary grid on the ground.

The situation was considered at a meeting held by TAHAL with representatives of WHO, G.W.S.C., Town Planning and other authorities in Accra on January 31, 1968. It was then agreed that the secondary grid design be prepared in the form of drawings and should include the following information:

- (i) Layout of 6" and 8" mains on the basis of proposed road layouts.
- (ii) Tentative location of mains within the strips reserved for the proposed roads.
- (iii) Location and size of connections to existing and proposed distribution systems.
- (iv) Location and size of valves, hydrants etc.
- (v) Standard details for the construction of secondary mains.

- (vi) Bills of quantities based on approximate length of pipelines and number of fittings.
- (vii) Complete specifications for the construction of secondary mains.

c. Work on Distribution System - May 1967 to April 1968

(1) Survey

Preparatory field work, including collection of information and coordination with the relevant authorities, was completed in the period under review in respect of 80 miles of lines in the main distribution system for Accra and Tema First and Second Stages.

Survey of proposed alignments for 65 miles of mains was completed.

(2) Preparation of Drawings

The plotting of 65 miles of surveyed alignments, including plans and longitudinal sections and all pertinent details was completed.

Basic maps for developing areas and communities for Accra and Tema were received in part from the Town Planning Department and from the Tema Development Corporation.

A comprehensive 1:10,000 scale map, for use as key map for the distribution system, is now under preparation by Town Planning Department.

(3) Design of Mains

Design criteria for transmission mains and distribution system grids were elaborated.

Hydraulic calculations, load and flow diagrams, were completed for the revised main distribution system and analyzed,

*role of
G.W.S. e*

together with alternative schemes, by computer. Static calculations for asbestos-cement and steel pipes under internal and external loads were made and criteria for design worked out for the entire project.

Standard details for the installation of asbestos-cement and steel pipes ranging from 4" to 32" in size, covering the requirements of the First Stage scheme were prepared. These include thrust blocks, valve chambers, air valves, hydrants, washouts, connections, drain crossings, stream crossings, road and railway crossings, etc. The detailed design of 20 miles of mains was also completed.

d. New Weiija Dam

For the report on the New Weiija Dam (P.N. 828) submitted in March 1968, as reported in Section 4 above, a new topographical map of the dam site to the scale of 1:500 was prepared. In addition, the existing map 1:1,000 scale map was revised. Field preparations such as siting of boreholes, pits etc., were also made for the commencement of the subsoil investigations.

The subsoil investigations contractors, Foundation Engineering (Overseas) Ltd., arrived from Lagos, Nigeria, with all their necessary equipment and transport and commenced work after the contract between the Government of Ghana (represented by the Co-Manager, Mr. K.M. Addison) and Foundation Engineering (Overseas) Ltd., had been signed on February 29, 1968.

The following works have been carried out to date by the said contractors.

(1) Diamond Drilling

Thirteen boreholes drilled in the Weiija dam site.

(2) Augering X

Six auger holes, downstream of the proposed spillway completed.

(3) Test Pits

The first test pit completed on the right embankment.

(4) Borrow Area

Two adequate borrow areas located for further detailed investigations downstream of the proposed dam.

(5) Geological Section

Provisional geological sections plotted for the proposed dam axis and the spillway.

(6) Laboratory Samples

Samples from dam axis and borrow area collected for shipment to the Contractors' central laboratory in Lagos.

The investigations are proceeding under the supervision of Tahal's soil and geological experts.

A topographical map of the Impounding Reservoir area to the scale of 1:10,000 was drawn.

Full investigations of the cost involved in making good the damage that will be caused when the artificial lake is formed behind the new dam at Weiija, was carried out, as a number of villages, roads and lands in the area of the proposed Impounded Reservoir will be affected. X

A rough estimate of the cost of bush clearing in the reservoir area was made on the strength of information obtained from the Ministry of Forestry.

From the first results of the subsoil investigation in the dam area two main alternatives for the dam axis were elaborated. Furthermore, some preliminary sketches for weirs, embankments, retaining walls etc., for the two alternatives were prepared.

e. Reservoirs

All necessary information regarding the location of the operational reservoirs at McCarthy (10 mgd), M.P.Z. (2 mg) and Tema (25 mg) reservoirs were collected. Surveys of the reservoir areas and detailed plotting were also completed.

Final topographical maps for the design of the reservoirs were prepared as follows:

- 1:500 map for the McCarthy 10 mg reservoir
- 1:500 map for the M.P.Z. 2 mg reservoir
- 1:500 map for the Tema 25 mg reservoir

Preliminary design for the above reservoirs was commenced.

f. Treatment Plant

A new topographical map for the Weija Treatment Plant to the scale of 1:500 was prepared. In addition, a similar new map showing the position of the test pits for subsoil investigation was completed.

*investigations
in existing
plants
(rate of
filtration)*

A detailed subsoil investigation was carried out by the Geological Survey and a final Report drawn up.

A meeting was held between Tahal and the Ghana Water and Sewerage Corporation in connection with the facilities to be provided at the water and sewage pumping stations and treatment works.

g. Densu River Flow Measurements

In December 1967 some hydrological investigations were made on the Densu River at the existing Weiija Dam site, as well as at points downstream of the dam.

These investigations related to the following matters:

- (i) Establishment of stage-discharge relationship for the flow downstream of the dam.
- (ii) Determination of the coefficients of discharge for the spillway gates in the existing Weiija Dam.
- (iii) A study of the effects of tides on the flow in the river downstream of the dam.

The investigations were followed in January 1968 by the preparation of a 'Water Balance' for the Weiija Reservoir for the past period of December 1966 to December, 1967.

Detailed reports on all the above studies have already been submitted.

to whom?

Towards the end of February 1968, two self-recording gauges were installed at the gauging stations of Nsawam and the Densu Bridge (on the Accra-Winneba Road). It is hoped that the gauge at the latter station will provide additional information on the tidal effects on the river downstream of the dam.

In order to determine the tail-water level for the design of the new dam, staff gauges were recently installed at four different locations downstream of the dam. Observations will be made simultaneously at these four gauges during the coming wet season.

Daily staff-gauge readings were taken at the Weiija, Nsawam and Manhia gauging stations throughout the period under review.

All previous hydrological studies on the Densu River were summarized in the report on the New Weiija Dam of March 1968 (P.N. 828).

h. Water Analyses

(1) Raw Water

Monthly analysis records for the Densu River raw water, covering the period March 1965 to January 1968, were received from the Chemist, Water Control Laboratory, Weiija. All samples for the analyses had been taken from the raw water tanks which feed the "Candy" and the "Pintsch Bamag" plants. Since February 1968, samples have been taken from the raw water tanks, as well as from the impounding reservoir (at depths of 6 feet and 12 feet) for fortnightly analysis.

(2) Settled, Filtered and Final Water

The office of the Area Manager, Accra-Tema Area Management, has furnished records of the results of analysis on the "settled", "filtered" and "final" water for each of the three treatment plants at Weiija (The "Old Works" is now abandoned).

(3) Bacteriological Examination

Records of bacteriological examinations of water from both the Weiija Treatment Works and the Accra Distribution system have been received from the Accra-Tema Area Management.

i. Leakage Survey

Two pilot areas which contain 10-15 miles of mains were surveyed in preparation for the selection of equipment, programming and manning of the leakage survey. Detailed report on the results and procedure of work were submitted.

For whom?

On the arrival of Mr. Ditkovsky from TAHAL headquarters, two meetings between TAHAL and the Area Management were held to coordinate the necessary steps in connection with the leakage survey. Reports on the meetings were submitted by Mr. C.B. Burgesson - Water Quality Control Engineer of the Area Management.

All the leakage survey equipment and instruments in possession of the Area Management were properly checked and prepared for future use.

The leakage survey team began with the checking of valves, hydrants etc. in the selected areas of James Town and Ussher Town.

A detailed report on the general preparations in the leakage survey area and a list of manpower requirements were submitted. *by whom*

j. Contract Documents

The non-technical sections of the Contract Documents such as General Conditions of Contract, Parts I and II, Instructions to Tenderers, Form of Tender, Form of Bond etc. have been drafted and will shortly be submitted to the Ghana Water and Sewerage Corporation for comments and approval.

k. Staff

The water supply studies are being directed by Mr. B. Wenderow, Director, Foreign Operations, TAHAL.

During the period of January to April 1968, the Consultants' staff employed on the water supply project consisted of Mr. T. Baron, Branch Manager, Mr. S. Neuman, Professional Engineer, Mr. M. Angel, Senior Surveyor.

Mr. T. Baron left Ghana on February 22, 1968, on completion of his tour of service and handed over to Mr. A. Bassan who arrived on January 24, 1968. A

Mr. B. Wenderow the Project Manager of the Water Supply, arrived for the meeting held on January 31, 1968, with WHO representatives.

The Project Engineer for the Water Supply Project, Mr. N. Perla, also paid a visit to Accra where he stayed for a period of one month to familiarize himself with local conditions, and to prepare the work programme for the Consulting Engineers' and for the Government's Services. 2

The following members of the Consultants' staff also came to Ghana for various periods in connection with the Water Supply Project:

- Mr. A. Ditkovsky, Professional Engineer (Water) arrived on March 12, 1968, for a period of one year, and will be in charge of the leakage survey.
- Mr. N. Hlasbalg, Geological Engineer arrived on February 22, 1968, for a period of about two months to supervise the subsoil investigations on the Weiija Dam Site.
- Mr. S. Nirenblatt, Professional Engineer, Designer of the dam embankments and dam foundations, arrived on March 23, 1968, for a period of about three months.
- Mr. B. Aisentstein, Chief Geologist of TAHAL, arrived on April 16, 1968, for a period of about two weeks in connection with the subsoil investigations for the Weiija Dam.

Two Engineers assigned to the Water Supply Project by the Ghana Government are Mr. D.K. Nsowah; Mr. P.A. Kubi.

In addition, draughtsmen, office personnel and other supporting staff, together with facilities for office and field work have been provided by the Ghana Government.

Overall project direction from the TAHAL head office is given by Mr. A. Wiener, Director General, assisted by Mr. E. Balaban, Deputy Director General, Mr. P.H. Doron, Deputy Director General, Mr. B. Wenderow, Project Manager, Mr. E. Dubinsky, Assistant Director Foreign Operations, and Mr. N. Perla, Project Engineer.

PART B

SEWERAGE

1. RECENT SEWERAGE SCHEMES IN THE ACCRA AREA

a. General

Since the preparation and completion of the Feasibility Report, three small individual sewerage schemes have been constructed: one includes sewer extensions to serve the Korle Bu Hospital, the second serves part of the Ministries area, and the third provides for extensions to the existing sewerage system at the University of Ghana at Legon to serve the newly constructed University building. Two small sewerage schemes have been planned, one to serve the Police Barracks in Cantonments Road, and the other to serve existing commercial properties in the High Street Area. In addition, extensions have been proposed to the existing sewage treatment plant serving the military area at Burma Camp. Of these, only four schemes are of any significance to the design of the Accra Phase I sewerage scheme and are outlined in the following paragraphs.

b. Existing Korle Bu Hospital Scheme

Korle Bu Hospital has its own sewerage system and small treatment plant which discharges effluent into Korle Lagoon. In recent years considerable extensions to the Hospital have taken place without a corresponding extension to the sewage treatment plant, with the result that the sewage treatment plant has become overloaded and is no longer adequate for the Hospital's needs.

An extension of the northern main sewer has been completed, which brings the flow from the northern part of the Hospital area to the junction of Guggisberg Avenue and Ring Road, where, together with the flow from the southern main sewer, it gravitates to a small

treatment plant adjacent to Korle Lagoon. Construction is presently under way to provide additional treatment units. Primary treatment is to be provided for all flows and secondary treatment for a part of the flow with chlorination of the primary effluent discharged to Korle Lagoon. These measures have been undertaken in an attempt to minimize the present public health hazard due to the inadequacy of the present arrangements and to restrict the pollution of Korle Lagoon from this source. However these improvements to the sewerage arrangements will not eliminate the nuisance and are intended only as temporary measures until the sewerage scheme for Accra becomes operative.

c. Existing Ministries Scheme

A sewerage scheme has recently been constructed to serve the southern part of the Ministries area between Rowe Road and the 28th February Road, and temporary accommodation used by several Ministries which are located to the south of the 28th February Road. The flow from the southern part of the Ministries area gravitates to a point between the Ghana Water and Sewerage Corporation building and the Volta River Authority buildings. From this point the main sewer turns south to cross the 28th February Road and then runs along the west side of the Black Star Square. At about 500 feet from the beach the main sewer turns west and gravitates to a small treatment plant located near the previous beach headquarters of the Ghana Water and Sewerage Corporation. Sewage treatment consists of an extended aeration plant from whence the effluent flows to an existing surface water drain which discharges over the beach into the sea. X

d. Proposed Police Barracks Scheme

A sewerage scheme has been proposed to serve the Police Barracks in Cantonments Road. A main sewer would be laid along-

side the Klotey Stream to the east of Cantonments Road. A second main sewer starting north of the Ring Road - Cantonments Road roundabout, would be laid eastwards from Cantonments Road alongside a tributary drain to Klotey Stream. The two sewers would meet at the junction of the tributary drain and Klotey Stream and the flow would then gravitate to an existing small sewage treatment plant situated on the east side of Klotey Stream and adjacent to Ring Road. The existing treatment plant serves a Government housing estate situated to the south of North Labone Estate.

e. Proposed High Street Area Scheme

A small sewerage scheme has been proposed to serve the following properties located in the High Street, Bank of Ghana, Ghana Commercial Bank, Standard Bank of West Africa Ltd., Barclays Bank D.C.O., Compagnie Francaise de l'Afrique Occidentale and the Ghana National Trading Corporation. These properties would be connected to branch sewers which would drain to a main sewer to be laid in the High Street between the Ghana Commercial Bank and Lutterodt Street. The location of the sewage treatment plant has not been finally decided but two alternative sites have been proposed, one on the coast west of the UTC compound and the second on the coast to the east of the UTC compound. Sewage treatment at each alternative site would consist of a small aeration plant. The effluent from either treatment plant would discharge to the sea.

Why these small installations?

f. Position of Existing and Proposed Schemes in Accra Phase I Scheme

The individual collection system serving the Korle Bu Hospital will be retained and connected at suitable points to the proposed Phase I sewerage system via a gravity sewer draining to Pumping Station C. The temporary sewage treatment facilities would be abandoned.

The sewers serving the Ministries area would be retained but the flow would be diverted in the vicinity of the Black Star Square to Pumping Station 2. The sewers downstream of the diversion point would be retained and the flow in these sewers would be diverted from the small sewage treatment plant to a pumping or ejector station to be located adjacent to the existing sewage treatment plant which would then be abandoned.

The proposed sewers to serve the Police Barracks in Cantonments Road have been sized to provide for the future Phase I sewage flows and therefore this scheme, if carried out in the near future, could easily be incorporated into the Phase I scheme and the existing treatment plant abandoned.

The proposed collection system to serve the commercial properties in the High Street could be retained and incorporated into the Phase I proposals provided the sewers were of adequate capacity. This will be investigated during the course of the present design work. The sewer from High Street to the proposed treatment plant would be abandoned together with the sewage treatment plant.

Who has planned these links?

2. REVISED ACCRA PHASE I SCHEME

a. Present Development Trends at Accra

During the last two years extensive development of Accra has taken place to the west of the city and now extends to the West Accra submarine outfall site. This westerly development is primarily individual private development with Government housing estates being constructed at Dansoman and North Kaneshie. Development has also taken place to a lesser extent at the Airport Residential Estate to the north-east of Accra, and at East Cantonments to the east of Accra. However, all development is within the Master Plan boundaries and consequently does not affect the sizing of any of the main trunk sewers in the Phase I area which will eventually be extended into these areas. Development within the Phase I area has generally been confined to the construction of office building within the commercial and Ministries areas.

b. Changes in the Scope of the Accra Phase I Scheme

The extent of the Phase I sewerage scheme for Accra is indicated on Figure No. 204R and is basically the same as presented in the Feasibility Report. However there have been a few slight modifications to the boundaries as described below.

The new Continental Hotel situated on the Airport Road will be included in the Phase I area.

The existing Korle Bu Hospital area has its own collection system and so the branch sewers for the Hospital area will be omitted from the Phase I scheme. X

Pumping Station D together with the main sewer D5 - Pumping Station D through the Hospital area, will not be required until it is desired to serve the areas upstream of point D5. This pumping

station and the main sewer line will therefore be omitted from the Phase I proposals.

In addition, areas to the south and to the west of the Korle Bu Hospital known as Construction Zones 1 and 12 respectively in the Feasibility Report, will not now form part of the Phase I proposals. These areas are classed as redevelopment areas and consist of domestic dwellings. However the proposed main trunk sewer which passes through Construction Zones 1 and 12 along the old Winneba Road to Pumping Station A will be retained. These areas can thus be easily sewered at any time in the future as and when redevelopment proceeds. The other areas in Accra which are classed as redevelopment areas contain the majority of commercial and business properties and it was considered proper to retain these in the Phase I scheme.

c. Relocation of Pumping Station Sites

It has been necessary to relocate the site for Pumping Station G to a position south-west of its original position shown in the Feasibility Report. This was necessary because the location of the Pumping Station G site interfered with proposals of the Railway Authority to redevelop the Accra Railway Station. The changing of the site for Pumping Station G does not affect the Phase I proposals.

The site for Pumping Station No.1 is located in an area that is quickly becoming built-up. The present site has been developed since the site was chosen and the pumping station is now located at the rear of newly built properties. Another site will be located in the area if the present site is not acceptable to all the interested parties.

The sites for the other pumping stations remain unchanged.

d. Pumping Stations to serve Low Areas near the Coast

In order to serve properties to the south of High Street and 28th February Road it is necessary to provide two small pumping or ejector stations near the coast. As mentioned previously one of these small stations known as the Area Beach Station would receive the flow from the temporary accommodations used by several Ministries. The flow to this station would be pumped to a sewer laid in 28th February Road which would gravitate to Pumping Station C. The second small station known as the High Street Station would serve properties located between High Street and the beach. The flow to this station would be pumped to a sewer laid in High Street also draining to Pumping Station C.

e. Design Capacity of Phase I Scheme

The Phase I scheme for Accra will provide for a total average flow of 15 mgd. This flow is the estimated Phase I - 1985 average sewage flow as presented in the Feasibility Report. The intercepting sewer along the eastern side of Korle Lagoon and the sewer along the coast to Chemu Lagoon will be sized for the Phase I - 1985 peak flows. Pumping mains and pumping equipment will also be designed for the Phase I - 1985 peak flows. Main trunk sewers and branch sewers will however be designed for the estimated Accra year 2000 peak sewage flows.

f. Flexibility of Sewerage Proposals

The sewerage proposals for the Accra Phase I scheme form the basis of a much larger sewerage system to serve the whole of Accra, and the Phase I scheme has been provided with built-in flexibility to provide future sewerage service for most of Accra by simple, straightforward sewer extensions. The capacity of the scheme can thus be increased as and when the Phase I - 1985 flow

is reached by increasing pumping capacity as required, providing additional pumping mains, and laying the planned parallel sewers along the eastern side of Korle Lagoon and along the coast to Chemu Lagoon.

Because of the extensive development that has taken place in Accra it will obviously be desirable, on completion of the Accra Phase I scheme, to extend sewerage service to these developments at an early date. The proposed housing development at Dansoman can be drained via several main trunk sewer extensions. These are sewers A7-A1, D7 - Pumping Station D, E5 - Pumping Station E, and a sewer laid in Winneba Road draining to Pumping Station E. It will also be possible to serve part of the Cantonments and East Cantonments areas to the Sewer H13 - Pumping Station 1 until the capacity of this station is reached.

3. CENTRAL ACCRA SCHEME

a. General

In late 1967, TAHAL-ES were requested by the GWSC to prepare a short report and feasibility study on a relatively small sewerage scheme forming the initial construction stages of the Accra Phase I system. This scheme was called the Central Accra Scheme and was eventually submitted to the Ministry of Economic Affairs. In February 1968, the Central Accra Sewerage Scheme was considered for possible international financing by the "Aid to Ghana" group of countries. At the time of writing the decision of the "Aid to Ghana" group of countries is not known. X

b. Description of Scheme

The proposed Central Accra Sewerage Scheme forms part of the Phase I sewerage proposals as previously described and the extent of the proposed system as well as the Phase I scheme is indicated on Fig. 204R. The figure shows the routes of the main and trunk sewers only; individual branch sewers are not known. ?

The extent of the Central Accra Scheme has been determined on considerations of cost, topography, the Phase I construction programme and the final disposal of sewage. The area served by the system covers some 1850 acres which is 26 per cent of the Accra Phase I total sewerage area.

A main sewer would be laid along Independence Avenue from Point F14 to F12 to receive the flow from residential properties in part of East Ridge and West Ridge areas. The Ridge Hospital and the Ambassador Hotel would also be served. The sewer would continue from F12 through the main business and commercial areas of Central Accra to join the Korle Lagoon interceptor at Point F9 near the Hansen Road Bridge. The business and commercial properties in this area would be connected to the sewerage system.

A main sewer would be laid from Point F6 in High Street through Ussher Town and James Town to join the Korle Lagoon interceptor at Point F4. The Korle Lagoon interceptor would gravitate along the route of the Accra Harbour Railway from Point F9-F4-F1 to Pumping Station C.

The flow from the Ministries area and the remaining properties in East Ridge, including State House, the Race Course and the Sports Stadium would gravitate to Pumping Station 2 located near Black Star Square from whence the flow would be pumped along Rowe Road to discharge into the sewer F12A-F12 at Point F12A.

Properties to the south of 28th February Road and High Street would drain to two small pumping or ejector stations from whence the flows would be pumped to sewers laid in 28th February Road and High Street respectively and gravitate to Pumping Station C.

After submission of the Central Accra Sewerage proposals the GWSC requested that consideration should be given to extending the scope of the proposed scheme to include Korle Bu Hospital. The additional costs involved in this extension are presented separately later in this report.

c. Interim Disposal Arrangements

Ultimately disposal of sewage from the Phase I sewerage area would be to the ocean via a large diameter submarine outfall located to the west of Accra at Chemu Lagoon. It is possible that construction of this submarine outfall would not take place for several years and an interim solution to the disposal problem is therefore needed. Mobil Oil Ghana Ltd. own two submarine oil pipelines, one 12-inch diameter, the second 10-inch diameter, both located near the outlet to Korle Lagoon near the site of Pumping Station C. The pipelines are each about 12,000 feet in length. Discussions

have been held with Mobil Oil Ghana Ltd. with a view to utilizing these pipelines for sewage disposal to the ocean, and Mobil Oil Ghana Ltd. have indicated that they are prepared to negotiate for the release of these pipelines. The 12-inch diameter pipeline has been abandoned by Mobil Oil Ghana Ltd. and can be made available immediately but the 10-inch diameter pipeline is still in use and the decision to abandon this line will be made at a later date. *Why?*

The condition of these two pipelines will be investigated during the sea outfall investigations prior to further negotiations with Mobil Oil Ghana Ltd. It will be impracticable to use the full length of the pipelines for sewage disposal and the 12-inch diameter pipe will be cut at a length of about 4,000 feet from shore and flow tests will be carried out on this section of the line to determine the flow characteristics of the pipe.

The actual capacity of the interim disposal arrangements will be determined from the results of the flow tests. However preliminary calculations show that for the 12-inch diameter pipe a discharge of between 2.0 mgd and 3.0 mgd can be expected depending upon the condition of the pipe. The combined discharge capacity of the 10-inch and 12-inch diameter pipelines would be between 3.5 mgd and 5.0 mgd. These figures assume that the length of the pipelines would be about 4,000 feet off-shore.

d. Changes from Immediate Implementation Measures

As presented in the Feasibility Report the Phase I area was divided in 12 construction zones plus the area of Korle Lagoon and priorities for these zones were considered in relation to existing and future conditions. For the Central Accra Scheme the construction priorities have been modified.

The Central Accra Scheme consists of part of the Phase I first year construction programme namely the southern section of

the immediate implementation proposals for the relief of pollution of Korle Lagoon, the full second year construction programme which includes Construction Zones 3 and 4, and part of the third year construction programme namely Construction Zone 5.

These changes from the original Phase I Construction Programme as presented in the Feasibility Report are due to:

- (i) the limited capacity of the proposed interim disposal facilities which make it impracticable to pump out of the Nima Culvert
- (ii) financial considerations in that the area now proposed includes the business and commercial areas which have the ability to connect immediately to the sewerage system and pay for the service provided.

Waters + sewerage rates

4. WEST TEMA SCHEME

a. Present Development Trends at Tema

Recent investigations into the proposed residential and commercial development at Tema show little change from previous development forecasts. For industrial development the situation is different in that development is not proceeding at the same pace as previously anticipated. This is primarily due to a general slow-down in the development of the economy of Ghana and is reflected in the present forecasts of industrial development and anticipated industrial water use.

On this basis the revised water demand forecast during the initial years of development is less than the design forecast used in the Feasibility Report. By 1985 the water requirements based on each forecast are identical. Taking into account the uncertainties in any development forecast it was decided not to change the design data as presented in the Feasibility Report for the Tema Phase I sewerage proposals. Originally the capacity of the Phase I proposals would have been exceeded by 1976 but based on the present forecasts the capacity of the Phase I proposals would not be exceeded until a later date.

b. Doxiadis Report on Urgent Amelioration Works

The rapid increase in development over recent years has increased the total sewage flow to the existing sewerage system at Tema. This has resulted in the situation where the existing Pumping Station 3 is grossly overloaded and the existing 27-inch diameter sewer to the detention tank is running at full capacity. In 1967 Doxiadis Associates prepared a report on urgent amelioration works to relieve the overloading of the present sewerage system.

2

Their recommendations include the installation of the fourth sewage pump at Pumping Station No. 3, the construction of a 15-inch diameter asbestos cement pumping main from the pumping station to the existing 27-inch diameter gravity sewer which flows to the detention tank, and to parallel this existing 27-inch diameter sewer with a 24-inch diameter sewer as provided for in the Master Plan proposals for Tema. The report concludes that the strengthening of the eastern part of the existing sewerage system of Tema is of utmost importance for the life and expansion of the town.

These recommendations can only be regarded as a short term measure to relieve the immediate situation. As Tema continues to expand the situation will again become critical unless the proposals contained in the Master Plan and Feasibility Reports are implemented at an early date.

c. Future Treatment Plant Site and Submarine Outfall Location

Part of the site for the future treatment plant at west Tema is within the area reserved for future harbour facilities. However the Ghana Railways and Harbours Authority has agreed in principle to the location of the proposed treatment plant at west Tema. In the Feasibility Report the route of the outfall sewer from the proposed treatment plant site to the submarine outfall location crossed land reserved for future harbour development. It has been decided to change the location of the proposed submarine outfall to a position 1,000 feet west of its original position so that the route of the outfall sewer from the treatment plant site will be just outside the western boundary of the harbour.

5. CONSTRUCTION PROGRAMME

a. Construction Programme Considered in the Feasibility Report

Two alternative construction programmes were suggested in the Feasibility Report, the first extended over a period of five years from 1968 to 1972 and provided for immediate implementation of proposals at Accra to alleviate the present pollution of Korle Lagoon. The Tema project was scheduled for construction during the first year of the programme. The second construction programme took into account the recent slowdown of economic development in Ghana and provided for a delay in the construction of the submarine outfalls at Tema and Accra until 1976 and 1977 respectively. In addition construction of sewerage works at Accra scheduled for 1972 was rescheduled over the two year period 1972 to 1973. The sewerage works at Tema scheduled for 1968 were rescheduled over the years 1968 and 1969.

In as much as design work has only commenced in 1968 it is obvious that both these programmes are now unrealistic.

b. Revised Construction Programme

Due to the inclusion of Central Accra Sewerage Scheme as well as the omission of Pumping Station D and Construction Zones 1 and 12 from the proposals for Accra it has become necessary to revise the construction programmes as presented in the Feasibility Report.

The construction of the urgent amelioration works required at Tema by the Tema Development Corporation would allow Tema to continue with the present arrangements for a short period. In addition it would be unwise to divert the present flow at Tema from the existing outfall at Gao Lagoon to west Tema prior to construction of the proposed submarine outfall at west Tema as the

flow would then be discharged over the beach. Little or no flow would be discharged via the existing submarine outfall until Pumping Station T was constructed by the Tema Development Corporation.

A revised five years construction programme has been developed taking into account the above considerations and is given below:

- 1969 - 1970 - Central Accra Scheme
- 1970 - 1971 - Central Accra Scheme
- 1971 - 1972 - Modifications to the Tema system plus the construction of the west Tema submarine outfall
- 1972 - 1973 - Accra Construction Zones 6, 7 and 8 plus construction of the west Accra submarine outfall
- 1973 - 1974 - Accra Construction Zones 9, 10 and 11

It will be seen that the modifications to the Tema system are scheduled for the third year construction period 1971 to 1972. The estimated sewage flow at Tema for this period is about 11.0 mgd. The capacity of the disposal system is about 7.0 mgd and can probably be increased slightly if surcharging of the system is accepted. The situation at Tema will therefore become critical, even with the revised construction programme, if the sewage flows increase according to the revised estimates. It is considered that construction of the modifications to the Tema system and of the submarine outfall at west Tema cannot be delayed beyond this date.

c. Contract Documents

As mentioned previously in this report there is a possibility that construction of the Central Accra Sewerage Scheme will proceed in advance of the main proposals and the present design

programme has been prepared to allow for preparation of the contract documents for the Central Accra Scheme at an early date. The Central Accra Scheme would comprise one contract and would provide for the construction of sewers, pumping mains and pumping stations and the necessary modifications to the existing 12-inch diameter submarine pipeline.

Consideration has been given to the types and number of contracts required to complete the remainder of the Accra Phase I proposals and the work at Tema. One possibility is to subdivide the remainder of the work into three types of contracts based on the type remainder of the pipelines and appurtenances, a contract for the remainder of the pumping stations, and a contract for the submarine outfalls.

Submarine outfall construction is work of a special nature and is usually carried out by contractors especially experienced in this type of work. It is therefore essential that this work be the subject of a separate contract.

However, analysis shows that the total cost of the remaining sewage pumping stations is relatively small, less than \$2.0 million and it is doubtful whether such a relatively small contract could be efficiently carried out by expatriate contractors. It has therefore been decided that it would be more advantageous to include the additional pumping stations within the contracts for additional pipelines and appurtenances.

The remainder of the Accra Phase I and Tema proposals would therefore be planned for implementation as follows:

Contracts for pipelines, appurtenances and pumping stations

Contract for submarine outfalls

Conceivably the optimum programme for construction, considering the availability of funds as well as construction time limitations, would involve breaking the pipeline etc. work into two future contracts. The overall recommended plan, with values of each suggested contract, based on the feasibility report (less items since omitted) would be as follows:

Contract 1 - Central Accra Scheme	\$3,950,000
Contract 2 - Additional Pipelines, Appurtenances and Pumping Stations	\$6,600,000
Contract 3 - Submarine Outfalls	\$4,200,000
Contract 4 - Additional Pipelines, Appur- tenances and Pumping Stations	\$6,653,000

If the Central Accra Scheme is extended to include Korle Bu Hospital the estimated cost for Contract 1 will increase by \$348,000 and the total estimated costs for Contracts 2 and 4 will be reduced by the same amount.

Wherever tenders are called for simultaneously for more than one contract, such as may well be the case in regard to Contracts 2 and 3 and perhaps 4, the documents would contain provisions for a combination tender, as well as for separate tenders.

6. PROGRESS OF WORK

a. Design Procedure and Programme

The design programme is shown in the attached Programme of Work and is spread over the period May 1967 to July 1969. X

It is intended that the majority of the design work will be carried out in Accra but work on pumping station structural, mechanical and electrical designs will be carried out both in Accra and in Arcadia, California. The final contract documents and drawings will be produced in Accra.

It is proposed that the Accra Central Scheme will be accorded first priority in the design programme and it is planned that contract documents for this scheme will be ready by the end of 1968.

A full programme of sub-soil investigations has been planned for the various pumping station sites and along sewer and pumping main routes. Preparatory work is in hand for sea outfall investigations and this work should be completed by mid-April 1968.

The results of these investigations together with those for the soils investigations will be presented at the June 1968 meeting.

b. Topographic Surveys

The topographic survey of Accra commenced early in 1967 with one survey team operating. In May 1967, the number of survey teams was increased to three and remained at this number until January 1968, when a further survey team was added. At the present time a total of six teams are operating in the field. Since August of 1967, one of these teams has been investigating the existing drainage arrangements of properties in Accra and locating the position of septic tanks together with collecting the necessary levels.

This work has been carried out with the assistance of the Accra-Tema City Council who provided two men with a knowledge of the existing septic tanks in Accra. In addition the existing intercepting chambers alongside Korle Lagoon have been emptied with the assistance of the Accra-Tema City Council and details of the chambers recorded.

The survey work has been very slow due to maps not being up to date; delays have occurred in the levelling programme through the survey teams having to bring the maps up to date. It is estimated that about 50%-60% of the total area to be surveyed has been completed and plotted to date. It is anticipated that all the surveying work will be completed by June 1968.

c. Sewer Layout and Design

Sewer layouts for the Central Accra Scheme have commenced but at the time of writing sewer design work has not started. Ground profiles have also been plotted for several of the sewer routes.

d. Soils Investigations

The soils investigations work commenced at the end of February 1968 and is being carried out by Foundation Engineering (Overseas) Ltd. Contract documents for this work had of course previously been prepared. To date boreholes have been put down to depths of 25 feet and 20 feet at the sites of the Area Beach and High Street pumping/ejector stations respectively and work is presently in progress at the proposed site for Pumping Station C. Two holes have been drilled to date at this site to depths of 50 feet and 60 feet respectively which confirm previous results obtained at this site. Arrangements are in hand to proceed with the scheduled pumping test at the site.

e. Site Acquisition and Wayleaves

Site plans for all the proposed pumping station sites and future treatment plant sites have been prepared and submitted to the Project Management. It is hoped that the owner's consent to sell and the reservation of the sites will be concluded shortly. The route of the Korle Lagoon interceptor alongside the Accra Harbour Railway has been agreed with the Railway Authority and permission to lay the sewer along this route has been obtained from the Railway Authority subject to the work conforming with their stipulated requirements.

f. Ocean Investigations

It was originally intended to commence the sea outfall investigations at the end of February 1968. However delays have occurred in the preparatory work and the starting date for these investigations has been rescheduled for the middle of March. To date the preparatory work is almost complete. It is intended to determine the sea bed profile with the assistance of the Ghana Navy using a minesweeper equipped with sonar equipment. This work should take about one week to complete. The remainder of the work comprising investigations of the proposed lines at Accra, Tema and along the Mobil Oil pipelines, as well as carrying out jet probing from low water mark to 25 feet water depth at Accra and Tema is scheduled to be carried out by a private company, Underwater Works Ltd. commencing on the 18th March, 1968.

g. Contract Documents

The non-technical sections of the Contract Documents such as General Conditions of Contract, Parts I and II, Instructions to Tenderers, Form of Tender, Form of Bond etc. have been drafted and will shortly be submitted to the Ghana Water and Sewerage Corporation for their comments and approval.

h. Staffing

The sewerage studies are being directed by Mr. Russell G. Ludwig, Managing Director of Engineering-Science International Ltd. Staff members of Engineering-Science International Ltd. assigned to the Project in Accra are Mr. H. Smith, Project Engineer - Sewerage, Mr. W.R. Gray, Design Engineer - Sewerage, Mr. J.E. Rollason, Senior Surveyor, and Mr. R. Franklin, Structural Design Engineer. Engineers assigned to the Project by the Ghana Government are Mr. G.K. Asafu-Adjaye and Mr. P.G. Omane-Brimpong.

In addition surveyors, draughtsmen, office personnel and other supporting staff, together with facilities for office and field work have been provided by the Ghana Government.

Overall project direction from the head office of Engineering-Science International Ltd. is being controlled by Dr. Harvey F. Ludwig, assisted by Mr. E. Kazmierczak, Chief Engineer. Other head office staff members working on the project include: Joseph L. Feeney, Robert L. White, Walter Babchuk, John C. Olson, and Richard W. Bentwood. Special consultant on ocean outfall design is Dr. E.A. Pearson.