MINISTRY OF LOCAL GOVERNMENT
RURAL AND URBAN DEVELOPMENT
REPUBLIC OF ZIMBABWE

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR IMPROVEMENT OF SEWERAGE FACILITIES
IN THE MUNICIPALITY OF CHITUNGWIZA
IN
THE REPABLIC OF ZIMBABWE

JANUARY, 1998

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON JOGESUIDO SEKKEI CO.,LTD.
NIPPON KOEI CO.,LTD

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PREFACE

In response to a request from the Government of the Republic of Zimbabwe, the Government of Japan decided to conduct a basic study on Project for Improvement of Sewerage Facilities in the Municipality of Chitungwiza and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Zimbabwe a study team from 14 July to 3 August, 1997.

The team held discussions with the officials concerned of the Government of Zimbabwe, and conducted a field study at the study area. After the team returned to Japan, further studies were made, and as this result, the present report was finalized.

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

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

January, 1998

Kimio Fujita
President
Japan International Cooperation Agency

January, 1998

Letter of Transmittal

We are pleased to submit to you the basic design study report on Project for Improvement of Sewerage Facilities in the Municipality of Chitungwiza in the Republic of Zimbabwe.

This Study was conducted by Nippon Jogesuido Sekkei Co., Ltd., and Nippon Koei Co., Ltd., during the period from 8 July 1997 to 31 January 1998. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Zimbabwe and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Masatoshi Momose
Project manager,
Basic design study team on
Project for Improvement of Sewerage Facilities in the Municipality of Chitungwiza

Nippon Jogesuido Sekkei Co., Ltd.

ABBREVIATIONS

ADWF	Average Dry Weather Flow
ARDA	Agricultural and Rural Development Authority
BNR	Biological Nutrient Removal
CH	City of Harare
CMC	Chitungwiza Municipal Council
CSO	Central Statistical Office
DANIDA	Danish Development Agency
DDF	District Development Fund
DDPC	Department of Development Planning and Coordination (MLGRUD)
DEHS	Department of Environmental Health Services
DLAA	Department of Local Authorities Administration (MLGRUD)
DNPWM	Department of National Parks and Wildlife Management (MET)
DNR	Department of Natural Resources (MET)
DPP	Department of Physical Planning (MLGRUD)
DW	Department of Works (City of Harare)
DWR	Department of Water Resources (MLWD)
DWSSC	District Water Supply and Sanitation Sub-committee
EHO	Environmental Health Officer
EHT	Environmental Health Technician
ESA	External Support Agencies
EU	European Union
FC	Forestry Commission (MET)
GI	Galvanized Iron and S
GoZ	Government of Zimbabwe
GP	Growth Point
HCC	Harare City Council
HCMP	Harare Combination Master Plan
HHE	Health and Hygiene Education
IEE	Initial Environmental Examination
IES	Institute of Environmental Studies
IRWWS	Integrated Rural Water Supply and Sanitation
IRWSSP	Integrated Rural Water Supply and Sanitation Programme

IWSD	Institute of Water and Sanitation Development
JICA	Japan International Cooperation Agency
LGA	Local Government Area
LGB	Local Government Board
LPA	Local Planning Authority (Local Authority)
LSCF	Large-Scale Commercial Farming (Area)
MA	Ministry of Agriculture
MET	Ministry of Environment and Tourism
MF	Ministry of Finance
MFA	Ministry of Foreign Affairs
MHA	Ministry of Home Affairs
MHCW	Ministry of Health and Child Welfare
MHE	Ministry of Higher Education
MIC	Ministry of Industry and Commerce
MJLPA	Ministry of Justice, Legal and Parliamentary Affairs
MM	Ministry of Mines
MLGRUD	Ministry of Local Government, Rural and Urban Development
MLWR	Ministry of Lands and Water Resources
MNAECC	Ministry of National Affairs, Employment Creation and Cooperatives
MOHCW	Ministry of Health and Child Welfare
MPCNH	Ministry of Public Construction and National Housing
MPSLSW	Ministry of Public Service, Labour and Social Welfare
MTE	Ministry of Transport and Energy
NCU	National Coordination Unit
NEPC	National Economic Planning Commission
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development
NTC	Norton Town Council
NUST	National University of Science and Technology
O & M	Operation & Maintenance
ODA	Overseas Development Agency
OECF	Overseas Economic Cooperation Fund (Japan)
PDD	Planning & Development Division (Department of Works, City of Harare)
PEIA	Preliminary Environmental Impact Assessment

PSIP	Public Sector Investment Programme
RDC	Rural District Council
RLB	Ruwa Local Board
RTCPA	Regional Town and Country Planning Act
SADCC	Southern African Development Coordination Conference
SAZ	Standards Association of Zimbabwe
SDF	Social Development Fund
SEDCO	Small Enterprise Development Corporation
SIDA	Swedish International Development Agency
SSCF	Small-Scale Commercial Farming (Area)
STW	Sewage Treatment Works
SWLTF	Solid Waste Leachate Treatment Facility
TF	Trickling Filter
UMRBA	Upper Manyame River Basin Authority (proposed in this M/P Study)
VIDCO	Village Development Committee
WARB	Water Act Review Board
WHO	World Health Organization
WPAB	Water Pollution Advisory Board
WPCB	Water Pollution Control Board (proposed in this M/P Study)
WPCCC	Water Pollution Control Coordinating Committee
WPCIC	Water Pollution Control Information Center (proposed in this M/P Study)
WPCS	Water Pollution Control Section (MLWD/DWD)
WPMU	Water Pollution Monitoring Unit (proposed in this M/P Study)
WSP	Wastewater Stabilization Pond
WQCP	Water Quality Checking Point
ZESA	Zimbabwe Electricity Supply Authority
ZIPAM	Zimbabwe Institute of Public Administration and Management

TABLE OF CONTENTS

[Appendix]

Chapter 1 Background of the Project

The Republic of Zimbabwe (hereinafter referred to as Zimbabwe) is located north of the Republic of South Africa and borders the Republic of Zambia, the Republic of Botswana and the Republic of Mozambique. Zimbabwe is a land-locked country and belongs to the tropical semi-day weather climate zone. As of 1992, Zimbabwe had a total population of about 10.41 million in an area of 390,757 sq.km. Zimbabwe, became independent from the United Kingdom in 1980, and entered into the market economy in 1989. It achieved a per capita GNP of US$520 in 1993.

The Upper Manyame River Basin, with an catchment area of about 3,900 sq.km, covers the Chitungwiza Municipality, the Study Area, and five other cities/municipalities including Harare City, the national capital. Lake Chivero and Lake Manyame, built within the subject river basin, are utilised for water supply (with a service population of about 1.5 million), irrigation, navigation, fishing and recreation purposes. However, the water pollution of the rivers and lakes/dams has been considerable in recent years due to rapid urbanisation and industrialisation in the basin. In other words, high concentrations of nitrogen and phosphorus in the dams/lakes had caused eutrophication and led to frequent abnormal growth of water hyacinth and algae. These phenomenon have affected water usage. In addition, Lake Chivero has not been able to spill over from the dam for the last seven years and this has resulted in a serious shortage of water resources. Since the Manyame River flows into the Lake Cabora Bassa in Mozambique, water pollution control measures are required not only for Zimbabwe, but also for Mozambique for the environmental conservation of a multinational river.

Therefore, the preparation of a comprehensive water pollution control plan is essential, prior to the implementation of various countermeasures by different government agencies, to establish a common vision and to provide a mission statement for water quality improvement in the subject river basin based on a realistic assessment of the constraints, opportunities and demands of the area.

In response to a request from the Government of the Republic of Zimbabwe, represented by the Ministry of Local Government, Rural and Urban Development (hereinafter referred to as the MLGRUD), JICA extended Technical Co-operation to prepare a water pollution control master plan for the Upper Manyame River Basin in 1996. (Study period: March 1996 to March 1997) Through this technical co-operation, the Water Pollution Control Master Plan and Feasibility Study on the emergency project was identified through the master plan study were developed.

This Basic Design Study was therefore conducted for the proposed project being determined in the above mentioned Feasibility Study. It's objective was to upgrade the treatment efficiency and to improve quality of treated effluent from the Zengeza Sewage Treatment Works of Chitungwiza Municipality. The subject sewerage facility was discharging its effluent into the Nyatsime River, a major tributary of the Manyame River. Although an implementation of this Project will not contribute to an immediate improvement of aquatic environment in the Upper Manyame River Basin, the Project will play an important role in association with relevant water pollution control measures to be implemented by Zimbabwe. Furthermore, the Project will benefit, as an environmental conservation project in the target area, not only the populace relying on their drinking water from the Manyame River through water pollution control, but also provide improvements to urban environmental sanitation of Chitungwiza Municipality.

Chapter 2 Contents of the Project

2-1 Objectives of the Project

The improvement of water quality and the supplementation of water flow through the reuse of treated wastewater are urgently required for the Upper Manyame River Basin as five cities/municipalities including, the national capital, are drawing water for drinking purposes. Under these circumstances, an effective implementation of comprehensive water pollution control measures by the relevant cities/municipalities is required. As a part of such measures, the objectives of this Project were set forth to augment and upgrade the Zengeza Sewage Treatment Works (hereinafter referred to as the Zengeza STW) of Chitungwiza Municipality, which is located within the catchment area of the Nyatsime River, a major tributary of the Manyame River, and to replace superannuated mechanical and electrical facilities of the existing sewage pumping station.

Upon the completion of this Project, the treatment capacity of the existing Zengeza STW will be doubled and the treatment efficiency will be upgraded to allow for the disposal of treated effluent into the river to supplement the river's water flow.

2-2 Basic Concept of the Project

The Project has as its supreme objective the conservation of the aquatic environment in the Upper Manyame River Basin and its direct objective is the improvement of the water quality in the Nyatsime River.

To achieve the above mentioned objectives, an expansion of the existing Zengeza STW to augment treatment capacity and efficiency is required. In practical terms, it entails the restoration of the treatment performance of the existing facilities, which are being overloaded, and to reuse treated effluent (meeting the quality standards of Zimbabwe) for irrigation. In addition, the project will construct new treatment facilities with the required treatment the efficiency to satisfy effluent quality standards of Zimbabwe to allow discharge of the STW's effluent into the receiving river to supplement water flow in the Upper Manyame River Basin.

Owing to the limited capability of the aquatic environment in the subject area, even a temporary discharge of pollution load leads to anaerobic conditions on the water (fish die due to a lack of dissolved oxygen), due consideration will be given to prevent the discharge of untreated sewage through an interrelated arrangement among the existing and the new treatment facilities. In this respect, the necessary arrangement of the affiliated facilities to the existing treatment facilities will also be considered in connection with the construction of the new treatment facilities.

Regarding to the possibility of excess sludge being generated from the sewage treatment facilities, appropriate measures for reuse in forestation, etc. will be considered from the view point of safety in reuse and ease in operation throughout the year.

In addition to the above mentioned sewage treatment works, the three (3) existing sewage pumping stations (two stations in the St. Mary area and one station in the Tilcor area) will be rehabilitated through the replacement of superannuated mechanical and electrical equipment.

The fundamentals of the Project are described hereunder.

(1) Expansion of Zengeza STW

1) Capacity of new treatment facility

The planned sewage inflow to the Zengeza STW in the target year of 2000 was established in the foregoing Feasibility Study and the capacity of new treatment facility was determined.

The basis for estimating the planned sewage flow was the planned water supply amount for Chitungwiza Municipality under the Harare Metropolitan Water Supply Master Plan in 1995. The actual sewage inflow (36,000 to 40,000 cu.m/day) measured by Chitungwiza Municipality in 1996 and water consumption data obtained by meter reading (daily average 28,900 to 42,000 cu.m/day by month in 1992) were referred to in order to verify the appropriateness of the planned sewage flow.

a. Population projection of Chitungwiza Municipality

Based on the Upper Manyame River Basin Water Pollution Control Master Plan which refers to the population projection of Chitungwiza Municipality under the Harare Metropolitan Water Supply Master Plan, the present population (as of 1992) 354,500 and the future population (2000) 489,000 were adopted (the future population was obtained as average of maximum and minimum estimated population).

b. Per capita sewage flow

The a 90% per capita water consumption which was established for high, medium and low population density areas under the Harare Metropolitan Water Supply Master Plan was held regarded to be the per capita sewage flow for this Project:

Unit: lpcd

Year	High Population Density Area	Medium Population Density Area	Low Population Density Area
1995	60	210	315
2000	63	210	315

The overall per capita sewage flow of the project area in 2000 was calculated to be 68 lpcd taking into consideration the population distribution by population density.

c. Discharge sewage flow by water use category in 2000

- Domestic sewage: 68 lpcd x 489,000 persons = 33,200 cu.m/day
- Commercial wastewater: 1,700 cu.m/day at 5% of domestic sewage based on actual water consumption
- Industrial wastewater: 1,200 cu.m/day as a sum of current wastewater discharge amount and future increase of workers

The total discharged sewage flow in 2000 was estimated at 36,100 cu.m/day (corresponding to the total water supply amount of 40,000 cu.m/day) as a sum of the above sewage flow by water use category.

d. Planned total sewage flow in 2000

The planned total sewage flow in 2000 was estimated at 41,500 cu.m/day including groundwater inflow at 15% of the total discharged sewage flow. This total sewage flow is more or less equivalent to the aforementioned actual measured sewage flow (36,000 to 40,000 cu.m/day) and the actual water consumption

(28,900 to 42,000 cu.m/day) and therefore was considered appropriate for the project.

Based on the above study, the inflowing sewage (41,500 cu.m/day in 2000) was divided at the distribution chamber at the Zengeza STW; 21,500 cu.m/day to the existing treatment facilities and 20,000 cu.m/day (only domestic sewage and the excess of the treatment capacity of the existing facilities) to the new treatment facility. Population, water consumption and sewage flow at present and in 2000 are exhibited in Figure 3.1.

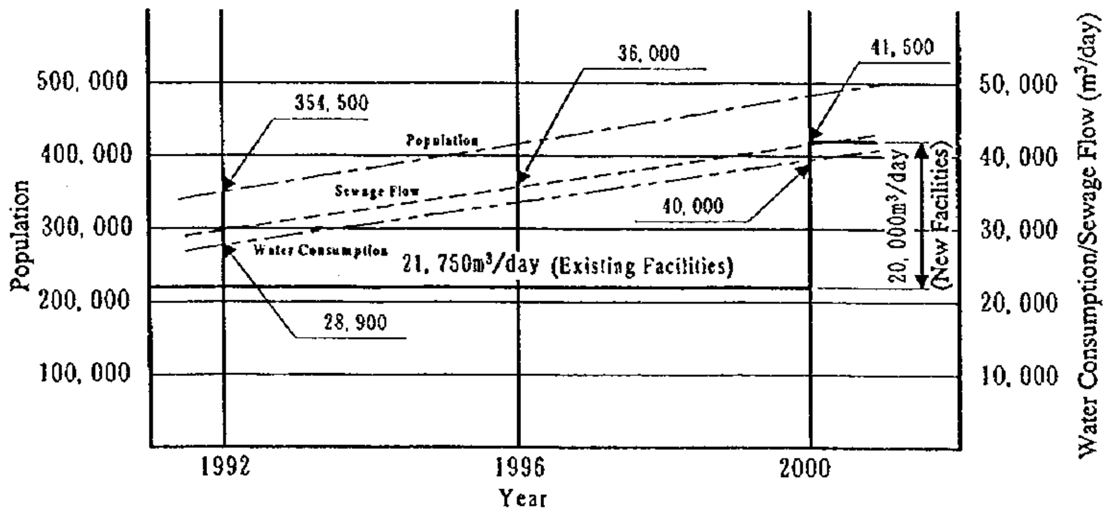


Figure 2.1 Population, Water Consumption and Sewage Flow at Present and in 2000

2) Sewage and Sludge Treatment Method

A week-long, daily measurement was taken of the sewage flow during the field survey of this Study to evaluate several key factors (peak flow during dry season, pollution load fluctuation, planned inflow sewage quality) which are required to the determine characteristics of inflowing sewage and treatment method.

Sewage inflow volume

A continuous 24 hour flow measurement at one hour intervals was carried out at the inlet channel for domestic sewage in the Zengeza STW.

Note: The measurement was carried out at the inlet channel for domestic sewage and took place during the dry season. In this respect, the measured sewage volume did not show the total sewage inflow volume, but was related to the new treatment facility. The total sewage inflow volume (27,000 to 30,000 cu.m/day) at the date of measurement was about 75% of the average daily inflow through the year.

The sewage inflow pattern was shown in Figure 2.2, representing typical pattern of suburban high population density area in Zimbabwe. The peak hours of sewage inflow were observed during 08:00 to 11:00 and small peak at around 16:00. The hourly average sewage inflow was 725 cu.m/hr (equivalent to 17,400 cu.m/day), while the peak flow was 1,085 cu.m/hr (1.5 times of the hourly average flow) and the minimum flow was 350 cu.m/hr (about half of the hourly average flow).

To meet with these sewage inflow fluctuations (i.e., decreased flow at night), the necessary countermeasures were prepared to ensure the stable operation of the biological treatment process.

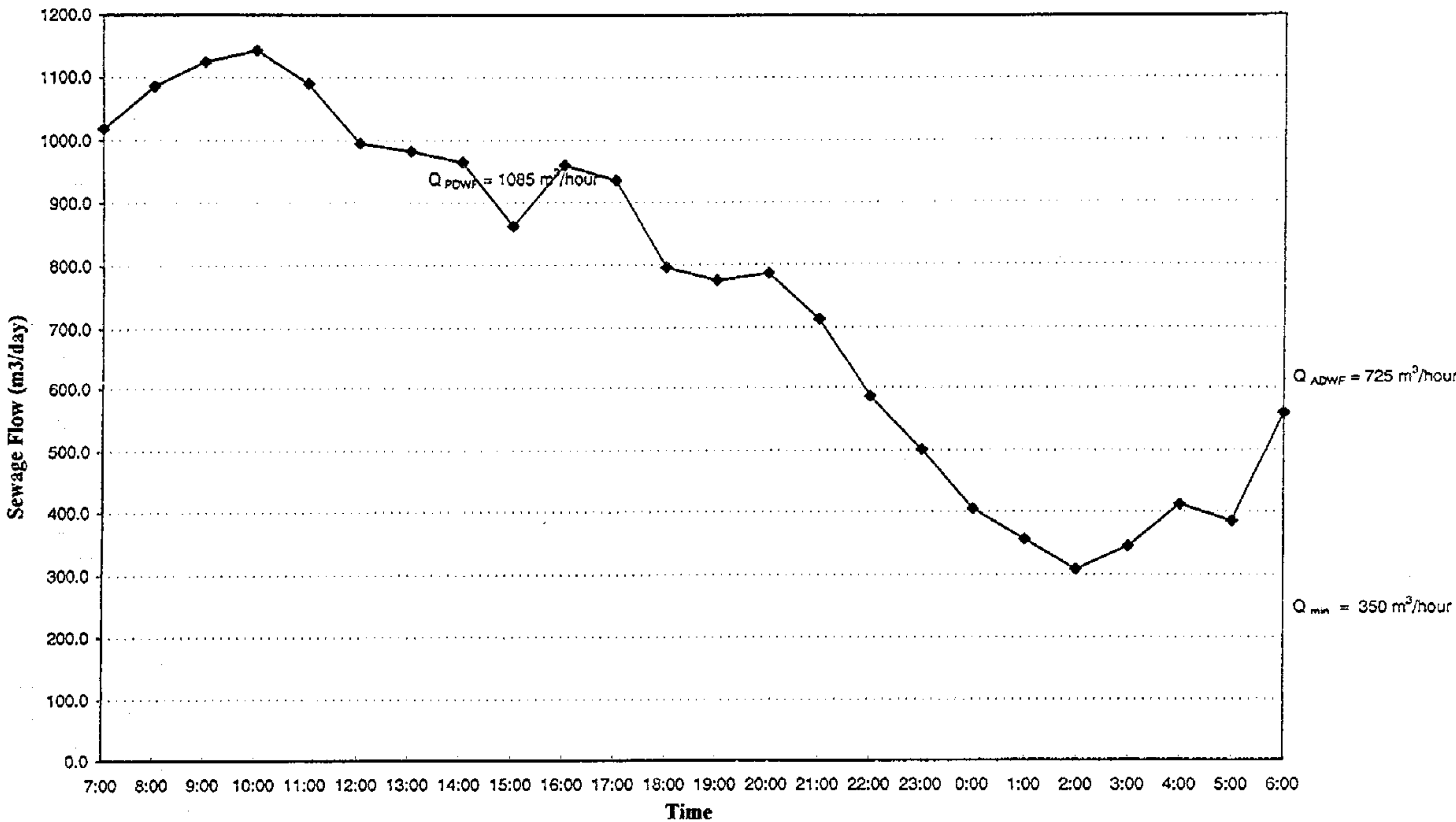


Fig 2.2 Sewage Flow Rate Hydrograph

Inflow sewage quality

Water quality examination was conducted for a composite sample of 24 hours and 24 individual samples collected at one hour intervals.

The average value of each water quality index and the hourly fluctuation pattern in a day were prepared for analysis results on individual samples and are attached in "5.0 Other Data" of this Study Report. From this information, the range of fluctuation on every water quality index can be seen.

Although the water quality fluctuation pattern does not correspond to the sewage inflow fluctuation patter, the pollution load fluctuation pattern obtained from the hourly water quality and sewage inflow data indicates that the peak hours appear from 07:00 to 08:00 for every water quality index and decrease as time passes toward afternoon. During the time frame of midnight to early morning, the lowest figure was continuously observed for about 5 to 6 hours. These survey results were then reflected in the design of the treatment facilities, particularly the sewage flow stabilisation tank and the biological treatment process.

The water quality examination results of a composite sample and the daily average figure of the individual samples are shown below.

Water Quality Index	Unit	Composite Sample	Daily Average of Individual Samples	Design Sewage Quality
COD (Total)	mg/l	1,224	1,349	1,350
COD (Filtered)	mg/l	360	400	400
TKN	mg/l	94	112	115
TKN/COD	-	0.0768	0.0852	0.085
NH_4^+	mg/l	35.1	39.7	40
NH_4^+/TKN	-	0.373	0.348	0.35
T-P	mg/l	11.3	12.4	12.4
TP/COD	-	0.0092	0.0092	0.009
BOD	mg/l	720	680	700
COD/BOD	-	1.70	1.99	1.93
Total Alkalinity	mg/l	180	182	180
Settleable Solids	ml/l	9.8	11.6	12.0

As can be seen in the above table, the analysis results of the composite sample and the individual sample are close to each other, but the daily average of the individual sample are slightly higher. The design sewage quality was then established referring to the latter analysis results.

The average COD, which exceeds 1,200 mg/l, shows the difficulty in attaining a 60 mg/l level in the treated effluent quality by the conventional secondary treatment method. In this respect, the inflowing sewage to the new treatment facility requires the adoption of a stabilisation system of quality and quantity corresponding to hourly fluctuations in terms of both facility design and operation and maintenance. In addition, necessary countermeasures were considered regarding the low alkalinity of the inflowing sewage quality in order to minimise any negative effect on the biological treatment process.

In selecting the optimum sewage treatment method, due attention was paid not only to the quality and quantity of the raw sewage, but also to the need for firm compliance to the effluent quality standards and the removal of nutritious salts required to achieve the current policy of the Ministry of Land and Resources on supplementation of water resources (by means of the reuse of treated sewage) and aquatic environmental conservation. Comparative evaluations of the current domestic sewage treatment methods, including those which being employed in Zimbabwe, were therefore made from the view points of treatment efficiency, construction costs and operation and maintenance, as shown in Table 2.1.

Table 2.1 Comparative Evaluation of Sewage Treatment Methods

Treatment Method	General Feature	Merit/ Demerit	Removal Ratio (%)			Cost		Ease in O&M	Overall Evaluation
			COD	T-N	T-P	Construction	O&M		
Activated Sludge	Biological treatment (mixing with activated sludge and sewage, removal of excess sludge by sedimentation	-Less land requirement -Energy consuming type -Needs many electrical & mechanical equipment	85 to 90	15 to 40	20 to 45	△	△	△	3
Trickling Filter	Biological treatment by aerobic micro-organisms, removal of sludge by sedimentation	-Flexible to meet flow fluctuation -Easier O&M than activated sludge method -Nuisance by odour and growth of fly	75 to 90	15 to 40	20 to 30	○	○	○	3
Stabilisation Pond	Oxidation under natural condition	-Easy O&M by minimum equipment -Needs large plant site	70 to 90	Less than 50	Less than 30	◎	◎	◎	3
BNR (Biological Nutrient Removal)	Biological treatment by combination of anaerobic chamber and aerobic chamber	-Considerably high concentration of phosphorus in excess sludge (reusable as fertiliser)	85 to 95	70 to 95	70 to 90	○	○	○	1
BNR with Coagulant	Enhancement of nutrition removal by addition of coagulant to BNR process	-Higher phosphorous removal ratio than BNR -Increase of sludge volume than BNR	85 to 95	70 to 95	75 to 95	○	△	△	2

Note: Cost comparison was made in comparison to trickling filter method.

Symbol	Construction Cost	O&M Cost	Ease in O&M
◎	Cheap	Cheap	Easy
○	Moderate	Moderate	Moderate
△	High	High	Difficult

When the removal of nutritious salts is not a high priority, trickling filter and stabilisation pond methods are the favourable treatment method for the removal of organic impurities (in some existing STWs, these treatment methods have been employed).

In this evaluation, activated sludge, trickling filter and stabilisation pond were regarded as providing the same level of removal ratio on nutritious salts.

A brief description on the ease of O&M by treatment method is given below:

Activated sludge:	Needs specific O&M skills for oxygen supply, removal of excess sludge and activated sludge control
Trickling filter:	Needs clogging countermeasures for filter media and maintenance of trickling arm
Stabilisation pond:	Needs removal of scum on the pond and grass on embankments
BNR:	Needs oxygen supply by surface aeration and control of sludge concentration
BNR with coagulant:	Needs chemical dosing control in addition to BNR operation

In terms of removal efficiency of T-N and T-P, which is given the highest priority in selecting the optimum treatment method, BNR and BNR with coagulant show better performance than the other treatment methods, while COD is treatment efficiency more or less similar in every treatment method.

As a result of the above evaluation, the BNR process was selected as the optimum treatment method in due consideration of the removal efficiency of T-N and T-P, cost of construction and O&M, as well as the relatively easy O&M. Although the BNR with coagulant method was not selected due to high O&M costs, a such chemical dosing facility can be added in the future when the need arises. The selected BNR treatment process shows a satisfactory performance history for nutrient removal not only in Harare City, but also in other localities in Zimbabwe.

The target sewage to be treated by the new BNR treatment facility is limited to 20,000 cu.m/day of domestic sewage. By this means, the attainment of a steady quality and quantity of the treated effluent is intended. To achieve this goal, necessary measures to stabilise fluctuation of inflowing sewage quality were quantity are considered at the inlet point of the Zengeza STW. In addition, emergency measures to cope with unsteady treatment conditions at the start-up operation or unforeseeable malfunction of the new BNR facility were also considered, such as the provision of a bypass line for supplemental use of the existing STW to avoid the discharge of insufficiently treated effluent into the river.

Aside from removal of organic pollutants and nutrient, disinfection of coliform group bacteria in the treated effluent is necessary, though it is not required by the current regulations in Zimbabwe. At this moment, an introduction of a maturation pond was considered as opposed to chlorination the treatment method so as to avoid costly O&M and the undesirable occurrence of by-products which are believed to have hazardous effects on living organisms and may be regulated within a few years by the government.

For sludge treatment, the thickening-digestion-drying process, which is commonly employed in Zimbabwe, was adopted for the Project. According to the design standards of Zimbabwe for sludge drying beds, the design period for sludge drying is relatively short in comparison to usual period adopted in other countries. In order to attain a steady and effective reuse of dried sludge, pertinent measures were considered to obtain higher dehydration performance.

(2) Affiliated facilities for the existing STW in relation to the new BNR facility

Aside from a minor reconnection of inflow channel relative to the construction of the new BNR facility, a modification of the outlet structure from the anaerobic chamber to the trickling filter, such as the installation of an "orifice", was considered to stabilise the fluctuation of the inflow sewage volume to the exiting STW.

As a countermeasure to the offensive odour being emitted from the anaerobic chamber of the Tilcor Pre-treatment Facility, the treated effluent from new maturation pond was planned to be transmitted to deform the scum floating in the anaerobic chamber.

(3) Rehabilitation of sewage pumping stations

Since the structures of the three existing sewage pumping stations (two stations in the St. Mary area and one station in the Tilcor area) were deemed usable through the future, the superannuated mechanical and electrical equipment were considered to be rehabilitated/replaced.

The two pumping stations in the St. Mary area were determined be able to maintain their present pumping capacity, due to the absence of any urban development plan in the future and the limitation of expansion of the present service area with the use of the existing sewer network. The Tilcor area, on the other hand, has a future development plan for industrial estates with a possible increase of industrial wastewater. However, due to topographic constraints, such as the distance from the existing service area of the sewer network, Chitungwiza Municipality has a plan to build a new pumping station for this particular area. In this respect, the existing pumping station in the Tilcor area was assumed to maintain its present pumping capacity. As a whole, the rehabilitation of these sewage pumping stations were considered to maintain the present pumping capacity with the same equipment specifications, in principle, from the view point of O&M consistency.

(4) O&M considerations

The new BNR facility requires on-the-job training of the present O&M personnel, while the existing STW can be maintained as is. In the implementation of the Project, certain training programs, such as an initial training period for about three months upon completion of the treatment facilities, was considered aside from the appropriate selection criteria of the required equipment (i.e. low cost, ease in O&M, etc.).

(5) Environmental considerations

- Organised and periodical monitoring of water quality is necessary to ensure the conformity of the discharged effluent from the Zengeza STW and the effluent quality standards of Zimbabwe.

- In order for the treated effluent to be discharged from the Zengeza STW, appropriate co-ordination and adjustment is prerequisite for fair and equal arrangements between local farmers and the relevant authorities. To balance the water demand for irrigation and water supply and recreation, careful administration and control is required by the responsible authority.

- Long-term sustainable measures shall be sought for the final disposal of excess sludge. In this connection, the potential needs of farmers and other users shall be evaluated for the reuse of dried excess sludge. Through this, the burden of future storage of excess sludge and its final disposal will be lessened and a future plan for final disposal can be developed.

- A study on possible reuse of excess sewerage sludge for agricultural purposes shall be carried out through a periodical examination of the generated excess sludge. A water quality examination for groundwater and surface water near the excess sludge reusing site of shall also be carried out to monitor possible environmental contamination.

- Careful administration and control in transporting excess sludge from the Zengeza STW to the final disposal point is necessary to avoid negative environmental influences, such as the emission of odour.

- The screening gathered at the Zengeza STW should not be buried at the STW site and should be safely treated at a landfill site of Chitungwiza Municipality. This pertains to the anticipated high risk of groundwater contamination. Other wastes generated at the STW shall also be treated in the same manner.

- The Zengeza STW site shall be fenced to prevent and control access of unauthorised people.

- It is desirable to establish a green belt to act as a buffering area to minimise any undesirable influence on future development, particularly at the south side of the Zengeza STW.

- The detailed design for the expansion of the Zengeza STW shall be carefully carried out in order to secure its environmental acceptability.

- The conceptual environmental administration plan shall be reviewed and updated upon completion of the detailed design of the Project and relevant sections/articles of the plan will be reflected in the tender documents of the Project.

As stated on the above, the basic concept of the Project is to provide the sewage treatment facilities with a treatment capacity of 20,000 cu.m/day mainly focusing on the removal of nutrients in sewage for Chitungwiza Municipality by the target year of 2000, in order to take a part of water pollution control measures for the Nyatsime River and Lake Chivero. It also includes provision of the affiliated facilities of the existing STW relative to the construction of the new BNR facility, and the rehabilitation of the three sewage pumping stations, as a key facility of the sewerage system, in terms of the replacement of the superannuated mechanical and electrical facilities.

2-3 Basic Design

2-3-1 Design Concept

Prior to commence the basic design of sewage treatment facility and equipment planning of the Project, fundamental conditions and design conditions are established as follows taking into consideration of; natural and socio-economic conditions in Zimbabwe, situation and problems involved in construction work and procurement, and nature and characteristics of the Project:

(1) Considerations to natural conditions

The Project area is situated on the plateau at about 1,400 m above the sea level with atmospheric temperature of 20 ℃ ± 6 ℃ through the year and relatively small annual rainfall at about 820 mm of which 80 % is observed during five (5) months (December to April) in the summer season, though it belongs to tropical dry weather climate. Owing to these moderate climatic conditions, no special consideration is required for facility planning, except for some countermeasures during rainy season, i.e. shallow sump drain by pumping. Consideration of seismic force is not required in facility design, since Zimbabwe has not experienced in any earthquake. Since the predominant wind direction has been observed in Northeast to Southeast directions through the year at the Zengeza STW, an attention shall be paid on the layout of treatment facilities.

The project site is owned by Chitungwiza Municipality with sufficient space (about 100 ha) to allow temporary storage of construction equipment and materials and has disposal site of surplus soil within 3 km distance. The proposed site of new BNR has gentle slope (about 2 %) from north in upper slope to south in downward. Utilising this favourable topographic conditions, a gravity flow of treatment process shall be employed from inlet of raw sewage up to discharge point of treated effluent to the river. In addition, the most economic earth work volume for land grading and road plan shall be examined in the maximum utilisation of topographic feature.

Soil conditions at the project site was surveyed and confirmed that surface soil was sandy clay, while deeper layer consisted of weathered granite with presence of large boulders. Since the bearing capacity of ground to support foundation of treatment facilities is determined to be sufficient, the spread foundation method is applied for design of foundation. However, the following considerations are taken up to cope with buoyancy to be caused by groundwater and dewatering from shallow sump and rock excavation based on the results of soil investigations:

- Groundwater level: GL 1,397.5 m in dry season and additional 1.5 m in rainy season
- Hard rock layer: Present between GL 1,397 m and GL 1,400 m.
- Boulders: Assume 10 % of clayey sand layer and weathered granite layer.

(2) Considerations to socio-economic conditions

Zimbabwe is still bearing strong influence of England in customs of daily life and religious behaviour, since it has been under English governance until its independence in 1980s. In this respect, various technical standards and costumes relevant to the Project are principally referred to English ones. Major architectural works are generally designed to be reinforced concrete with brick wall.

Since the project site is owned by Chitungwiza Municipality, the cost of land acquisition is not required, but that of fencing work around the new BNR facility is agreed to be shouldered and implemented by the Municipality.

(3) Considerations to local conditions on construction work

Necessary information prevailing on local conditions for construction pertaining to possibility to procure construction equipment and materials and labour costs, etc. was gathered from the Ministry of Public Works and Housing, the Association of Construction Industries, the Ministry of Transportation and Energy, the National Council on Employment, and the Harare Central Hospital being constructed by the grant aid by the Government of Japan. Major findings and information are summarised hereunder:

- o Construction materials:

  Most of construction materials are available in Zimbabwe. Presently, two companies are producing cement in Harare City and Bulawayo City for a total production capacity of 148,000 tonnes per year. A company in Bulawayo City is expanding its facility to be completed by the end of November 1997 and upon completion of this expansion, the said total production will increase to about 200,000 tonnes per year in Zimbabwe. Many companies are producing ready-mixed concrete and their supply capacity is sufficient enough. However, concrete is poured with the use of crane, due to absence of concrete pump vehicle. Other construction materials, such as sand, gravel, steel bar (deformed steel bar has become popular since 1996), steel pipe, form panel, are available, except building materials for architectural work, such as stainless steel pipe.

- o Mechanical and electrical equipment for sewerage works:

  Mechanical and electrical equipment for sewerage works are partially manufactured in Zimbabwe, but are commonly imported from South Africa due to the poorer quality of domestic products. Engineers/technicians are also dispatched from South Africa for testing pumps, etc. Construction equipment are also available in Zimbabwe, such that the Harare Central Hospital Construction Project is also hiring equipment of local contractors, i.e. crane, loader.

- o Official price of construction materials:

  No official price of construction materials is established and a price list is therefore not published. Owing to limited restrictions on importation, prices of construction materials are simply determined in the competition in market prices. As reference information, the actual bidding results conducted by the Ministry of Transportation and

Energy were obtained (however, prices of construction materials are commonly determined in market competition).

- o Labour cost, etc.:

  Zimbabwe has experienced more than 20 % (at a range from 20 % to 40 %) of inflation, but wages/salaries have not been raised to meet with these inflation. Under these circumstances, salary of government employees was raised for 25 % from July 1997 in comparison to the actual salary in the last year. On the other hand, many strikes have been observed among private sectors and the national government had started intervention with administrative guidance to employers for increase of salary at 28 % from the actual paid amount in the last year. The foreign workers are obliged to secure work permit from the MLGURD.

- o Labour productivity:

  No official figure on labour productivity is established and the English standards are commonly referred to. Actual productivity rates seem, however, to be determined through market competition. It was learnt that the labour productivity in Zimbabwe is generally lower than that of Japan.

- o Import tax for procurement of goods from third country:

  An exemption of the import tax is applicable for the grant aid project by arrangement of the MLGURD.

No comprehensive manufacturer exists in Zimbabwe to supply mechanical and electrical equipment for the use in sewage treatment suitable to the scale of this Project. Only **Baytoman Co., Ltd.**, a South African company, has an office with few staff in Bulawayo City and no factory in Zimbabwe. Therefore, procurement shall rely on the procurement of mechanical and electrical equipment for sewage treatment shall rely on the importation from the abroad. In this respect, relevant information was gathered to look into possibility of procurement from the third country, particularly from South Africa which has the most advanced market development in African region and is a neighbouring country of Zimbabwe. The results of information collection are summarised as follows.

Three large scale manufacturers, having annual sale of more than 250 million Japanese Yen and actual supply and installation experiences on mechanical and electrical equipment for water treatment, were visited and inquired of corporate history, relationship in capital investment between South Africa and mainly Europe, scale of business in total sale, supply records to neighbouring countries, etc.

- o **Baywater Co., Ltd.**

  Baywater is owned by an English company and has 70 personnel with 8 years of history on its factory operation in South Africa (no importation of finished products from England). The total sale in 1996 was 1.3 billion Japanese Yen, of which 70 % were sewerage field and mainly for export to neighbouring countries. **Baywater** retains a sub-contractor in Zimbabwe and has capability to undertake construction work in Zimbabwe.

- o **Beytman Water Treatment Co., Ltd.**

  Beytman Water Treatment Co., Ltd. is one of companies within **Beytman Corporation** under control of **Yiel Beytman Co.**, a South African company. It has 60 employees with an annual sale of about 2 billion Japanese Yen and sufficient experiences to exports their products to neighbouring countries (500 treatment plants since 1941). It also has a branch office in Bulawayo City with 25 personnel including 5 engineers. Electrical control panel and pumps are not manufactured by this company.

- o **Degramont South Africa**

  Degramont South Africa with 25 workers is an affiliated company of **French Degramont Co.** and has an annual sale of about 300 million Japanese Yen (mainly for water supply field, but available to provide sewerage engineering and equipment). It posses an agent in Zimbabwe and capable to undertake construction work in Zimbabwe.

Aside from the above general manufacturers of water treatment machinery, manufacturers of mechanical equipment/pump and electrical equipment were also visited as follows:

- o **S.A. Machinery Co.**

  S.A. Machinery was established as a South African company in 1966 as a manufacturer of screen, conveyor, clarifier, mixer, aerator, spiral pump and sewage sprayer for trickling filter, etc. About 50 workers employed by the company achieve an annual sale of about 500 million Japanese Yen with experiences to export to Zimbabwe. Although it does not have factory in Zimbabwe, the company has an sales agent in Zimbabwe and capable to undertake construction work.

o **KSB Pump Co.**

KSB Pump, established in 1960s as a joint venture of German and South African companies is currently one of the largest manufacturers of pumps for water treatment purpose. With 210 workers, it has an annual sale of about 1.8 billion Japanese Yen (of which about 10 % are achieved by sewage pumps). Submergible pumps are imported from Germany, while other types of pump are manufactured in this company. Although it does not have factory in Zimbabwe, it holds a sales agent in Zimbabwe and has experiences to supply pumps to the Firle STW in Harare City and others in Zimbabwe.

o **ABB Industry Co.**

ABB Industry is one of companies controlled by **ABB Sub-Sahara** under a stock-holding company in Switzerland and manufacturing electrical equipment. A total of 260 employees are working and a total annual sale of 7.5 billion Japanese Yen (of which sewerage-use equipment occupies about 25 %) has been achieved with past performance covering engineering design up to installation of electrical equipment for sewerage works. It also has a factory in Zimbabwe with about 100 employees to manufacture simple electrical parts.

Based on the above mentioned information, it is confirmed that the third country procurement of mechanical and electrical equipment in South Africa is available from European general manufacturers of water treatment equipment (**Baywater, Degramont**, etc.) or from South African manufacturers of water treatment equipment affiliated to European companies in combination with specialised manufacturers of mechanical and electrical equipment.

With regard to legislation on construction work, the following laws and regulations have been collected and shall be reflected in planning and design of the Project. It is also confirmed that no administrative guidance and guidelines has been issued by relevant government authorities for construction work.

o Labour Laws

The previous Labour Relations Act 1985 was updated to be the Labour Relations Act, Revised Edition 1996 (Chapter 28-01)

o Building Code

Model Building (Amendment) By-laws, 1985 (No.5), Statutory Instrument 310 of 1985

- o Sewerage Facility Design Standards

  English standards are principally referred to.

It is confirmed that Chitungwiza Municipality shoulders provision of power supply, telephone and water supply in connection with the implementation of the Project. It is further confirmed with the ZESA (Zimbabwe Electricity Supply Authority) that the ZESA will carry out the primary power supply work in consonance to the construction progress of the Project.

(4) Considerations for utilisation of local contractors and indigenous materials

In Zimbabwe, a total of 56 contractors having the annual contract amount of more than 50 million Japanese Yen are registered at the Ministry of Public Construction and National Housing (MPCNH). Local contractors are deemed to have acceptable level of technical capability, since no particular problem on technical capability of local contractors has been observed and reported in the field of sewerage projects and frequent bidding for civil works are being held by Harare City. Labour forces can also be recruited smoothly. It shall be noted that an overall package contract is prohibited by law in Zimbabwe the and bidding is executed to specialised contractors/manufacturers by category of cost estimates. Under these circumstances, an effective involvement of local contractors/manufacturers is considered for the implementation of the Project.

It is, therefore, considered that indigenous construction materials will be utilised as much as possible and mechanical and electrical equipment will be procured from Japan or South Africa.

(5) Considerations to O&M capability of executing agency

Although Chitungwiza Municipality has just become an independent local authority from Harare City, but has been operating and maintaining the existing Zengeza STW for more than 20 years. The present manager of Zengeza STW has experience on O&M in the STW of Harare City including BNR facility to remove nutrient substances. Other staffs have, at least, similar experiences on the trickling filter process.. Since the repair and rehabilitation of sewer network has also been undertaken by these O&M manpower set-up, it is deemed that these staffs posses experience of common O&M skills. However, a sustainable preventive measures will be required since previous remedial works and replacement have been implemented as an allopathic after occurrence of major breakdown or malfunctions (for details, refer to "the Final Report on the Study of Water Pollution Control in the Upper Manyame River Basin" and presented in the following subsection).

In view of an organisational set-up, a total of 81 personnel are assigned to the Sewerage Reticulation Section and the Zengeza Sewage Treatment Works Section, both under the Water and Sewerage Division of the Municipal Government, as shown below. The present set-up is so far satisfying the organisational requirements. When the current staff recruit plan is achieved, the total number of sewerage staff will increase to 110 personnel.

Zengeza Sewage Treatment Works		Sewerage Reticulation Section	
Works Superintendent	1	Sewerage Foreman	0
Asst. Works Superintendent	0	Plumber Class 1	0
Works Attendant	1	Plumber Class 2	2
Trade Effluent Inspector	0	Asst. Sewerage Foreman	2
Charge Hand	2	Charge Hand	3
Pump/Plant Operator	27	Senior Drain-Layer	3
Pond Operator	24	Drain-Layer Assistant	2
General Hand	0	Sewer Rodman	6
Clerk	1		10
Total	56	Total	25

Under the above mentioned situation, a staffing plan showing required qualification and numbers by position in consideration of future O&M of the new BNR facility and a conduct of manpower training program at the stage of project preparation were prepared and recommended in the course of development study at the request of Chitungwiza Municipality. Needs for the realisation of these aspects were also confirmed with the Chitungwiza Municipality during the field survey of this Basic Design Study. Zimbabwean authorities, i.e. the Zimbabwe Institute of Public Administration and Management, the Institute of Water and Sanitation Development, etc., are conducting staff training program of this sector continuously and the Municipality is dispatching its trainees to the program every year. In addition, it is deemed effective to transfer technology of BNR O&M from staffs of STWs in Harare City to O&M staff of the Municipality with provision of appropriate budgetary arrangement and the Municipality will be urged to take necessary action for this realisation. Upon realisation of the Project, a preliminary O&M guidance and training will be implemented in connection with the facility construction.

An overall financial status of the Municipality at present has been affected by the red balance occurred before 1991 and shows annual debts of about 400 million Japanese Yen for the total of 12 accounting items including water supply and sewerage. The Municipality is currently preparing the framework plan to extinguish these debt services by the year 2001.

In water supply and sewerage sectors, financial balance has been reasonably maintained in the past. In 1995, the sewerage sector resulted a red balance of approximately 10 million Japanese Yen in relation to the total sector expenditure of about 100 million Japanese Yen. This imbalance was caused by commencement of loan repayment at about 30 million Japanese Yen.

In 1996, it turned to leave surplus of about 25 million Japanese Yen from the revenue of about 130 million Japanese Yen. During fiscal year of 1997-1998 (Fiscal year period was changed to follow calendar year and new fiscal year period was temporary set for 1.5 year from July 1997 to December 1998), some 25 million Japanese Yen is expected to be surplus from the total account of about 300 million Japanese Yen. In this assumption, sewerage service charge to be collected from customers occupies majority of expected revenue and is equivalent to about 1.5 % of an average household income (about 1 % in previous year).

The Municipality, which has been making use of surplus from sewerage sector for other public hygiene sub-sectors, has set out target to attain an self-sustainable financial status of each sub-sector by the year 2000 in consonance with the aforementioned financial rebuilding plan. This financial arrangement is therefore deemed prerequisite for the successful achievement of the Project.

(6) Considerations to establish coverage and grade of facilities and equipment

The new sewage treatment facility will employ, in due attention to removal of both organic pollutants and nutrient substances as mentioned before, the BNR process which has widely applied performance records in African nations including Zimbabwe and South Africa. Grade of civil and architectural works is to follow similar level of the existing sewerage facilities in Zimbabwe, except for water tanks for which preventive measures against cracks, etc. will be considered in accordance with the English standards. Mechanical and electrical equipment, such as pumps and aerator, will be similar grade of the existing facilities in Harare City and others. Through these considerations, required sustainability of O&M will be secured to be realised by the local staff of the Municipality.

(7) Considerations to construction period

Since the Project has a nature of comprehensive work for construction of sewage treatment facility, a systematic linkage between the civil and architectural works and subsequent mechanical and electrical works including manufacturing and installation shall be fully considered in determining the construction period. Although the Project does not require any special arrangement among facility construction, installation of mechanical and electrical equipment, and construction period, the presence of rainy season for about 5 month length shall be taken into account to avoid unnecessary delay on project implementation.

In determining the overall construction period, a minimum of 3 month initial operation period of BNR facility shall be considered, in addition to the construction work. This arrangement pertains to secure the minimum time required to cultivate sufficient amount of micro-organisms in the mixed liquor suspended solids (MLSS) until the design treatment efficiency of BNR process is attained.

Since the required construction period is apparently longer than one year period, there may be a plan to split into several fiscal years. However, the Project has a nature of constructing a series of combined treatment process, partial construction of unit facility can not produce the required performance of sewage treatment. In this respect, split of construction period by fiscal year is deemed unrealistic and not applied for this Project.

2.3.2 Basic Design of the Project

(1) Scope of the Project

The Project consists mainly of the following works;

1) Construction of the proposed treatment facilities with a capacity of 20,000 m3/d
   - Sewerage treatment facilities, including grit chamber and screen, primary sedimentation tanks, hydrated lime dosing facility, biological reactor (BNR), final sedimentation tanks and outlet channel
   - Sludge treatment facilities, including sludge thickeners, sludge digestion tanks, sludge drying beds and sludge storage yard
   - Other facilities, such as electrical building and water examination & supervisory building

2) Incidental renovation works related to construction of the proposed treatment facilities

   - Reconnection of the existing inlet sewer to the proposed sewage treatment facilities
   - Reconstruction of the effluent facility of the existing anaerobic pond
   - Installation of the treated water distribution pipe between the existing anaerobic pond of the Tilcor pre-treatment plant and the proposed maturation pond in order to prevent scum accumulation in the anaerobic pond of the Tilcor pre-treatment facilities

3) Rehabilitation of the existing three (3) pump stations, St. Mary No. 1 pump station, St. Mary No. 2 pump station and Tilcor pump station.

   - Replacement of the pumps and incidental pipings.
   - Replacement of incidental electrical equipment including control panels, cable wiring, etc.
   - Replacement of the level detectors
   - Installation of new magnetic flow meters

4) Procurement and supply of equipment

   - Mechanical and electrical facilities for sewerage treatment and sludge treatment, including in-plant pipes, etc.
   - Maintenance vehicles
   - Water analysis equipment

(2) Basic design of the proposed treatment facilities

1) Treatment process

a. Sewage treatment process

The BNR method, which is commonly practiced in Zimbabwe, is proposed for the sewage treatment method, taking into consideration the advantage as a flexible operation to maintain an adequate treated effluent quality against fluctuation of influent sewage amount and quality.

The following processes is proposed to be added in order to secure the treatment in addition to the main processes such as primary sedimentation, BNR reactor and final sedimentation processes.

i. Sewage distribution facility

The facility aims at to distribute 20,000 m^3/day sewage to the new facilities. In addition, the highly concentrated sewage in the morning shall be routed to the existing treatment facilities to reduce the influent sewage quality (daily average COD) of the new facilities to 1,200 mg/l or below.

ii. Equalization tank

The object of the facility is to maintain the microorganisms' stability in the BNR reactor in order to ensure the adequate treated effluent quality. The fluctuation of influent sewage quality and quantity will be mitigated through equalization processes.

iii. Hydrated lime dosing facility

Considering the unexpected low alkalinity of the influent sewage, hydrated lime dosing is proposed to achieve appropriate nitrification and denitrification in the BNR reactor.

iv. Maturation pond

Installing a maturation pond as a disinfection facility instead of utilizing chlorination is recommended in consideration of the economical advantages and the adverse effects that may be caused by the addition of chlorine, including the possible formation of carcinogenic compounds.

The disinfection facility was supposed to be installed in the future in previous JICA Study, because disinfection of the final effluent is not yet required by legislation, but such requirements may be enforced by the time the proposed facilities have been commissioned.

b. Sludge treatment facilities

The establishment of adequate sludge treatment and disposal is an essential item to be studied in order to enable the sustainable maintenance of the system.

Therefore, a gravity thickening process, an anaerobic digestion process and a sludge drying process shall be adopted as such processes are commonly practiced methods in Zimbabwe. In addition, such processes are considered recommended due to the simplicity of each process.

The thickener effluent and supernatant generated from the proposed sludge treatment facilities shall be discharged into the existing pumping facility for agricultural reuse, since their abundant nutrients will exert a bad influence on the proposed sewage treatment facilities.

c. Flow diagram

Fig. 2.3 shows the flow diagram of the proposed facilities.

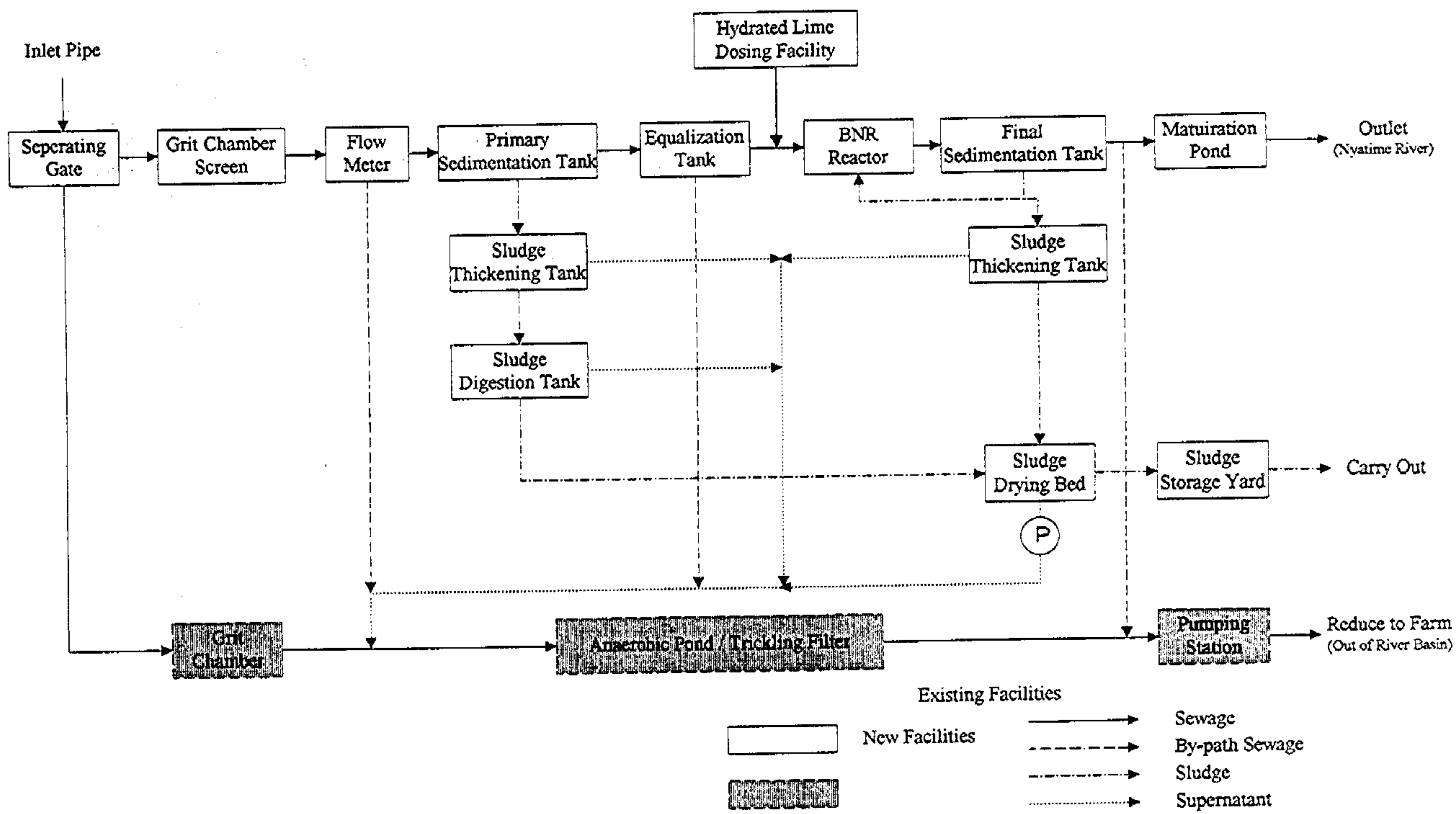


Fig 2.3 Flowsheet of Sewage Tratment Facilities

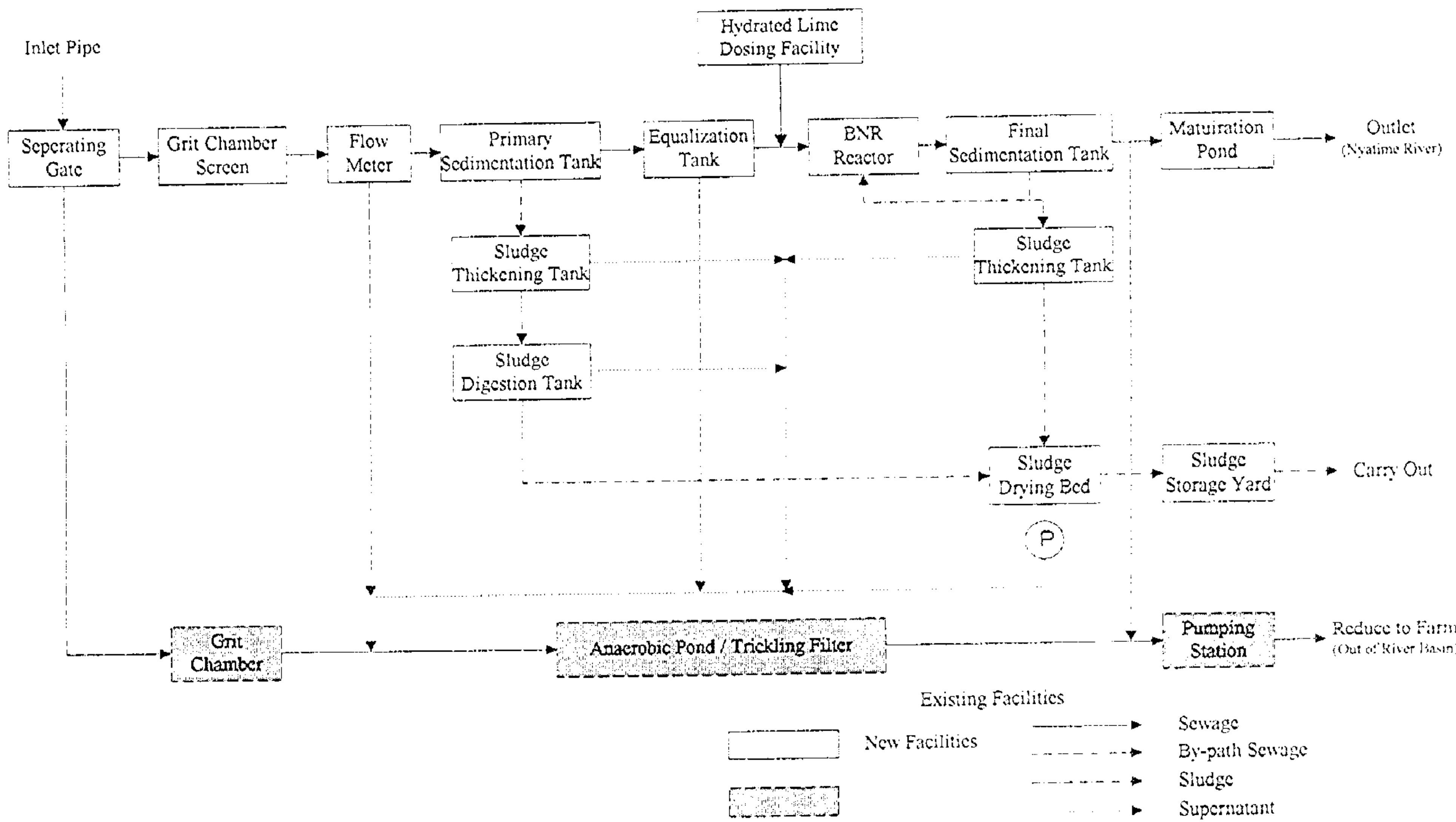


Fig 2.3 Flowsheet of Sewage Tratment Facilities

2) Layout plan

a. Site condition

The proposed site for the Project is adjacent to the existing sewage treatment facilities, located on land owned by the municipality with an area of approximately eighty (80) ha. This is large enough in consideration of the extra site for construction work.

A residence area exists about 700 m from the site in the northeast, and also an industrial area is located at about one (1) kilometer in the northwest.

The ground surface gradient ranges from 1% to 5% declining toward the southern creek. It is indispensable to utilize the slope for hydraulics, facility layout and road planning.

b. Sewage treatment facilities

Gravity flow is the principle for the facility design, due to the distance of the altitude between sewage inlet pipe and bottom of the receiving water is about 10 m.

Taking into account the hydraulic and topological character, it is decided that the inlet part and primary sedimentation tank should be at intervals of 120 meters. Because the required distance of the water level between primary sedimentation tank and BNR reactor is about 3 meters which is determined by the hydraulic profile of the equalization tank.

The flood water level of the discharge point, the planned final effluent water level, was determined to be at two (2) meters above the bottom of the creek based on past records. The top of the embankment for the maturation pond should be higher than the mentioned water level.

c. Sludge treatment facilities

The sludge drying bed and sludge storage yard are placed beside the proposed sewage treatment facilities to ease the tasks of the workers and vehicles, since the frequency of the sludge disposal work and the size of the area is considerable.

The alignments of the supernatant effluent pipes from the proposed sludge treatment facilities are so arranged as to allow for gravity flow. Therefore, the thickening and digestion tanks shall be located on the highest area of the proposed site.

d. The other facilities

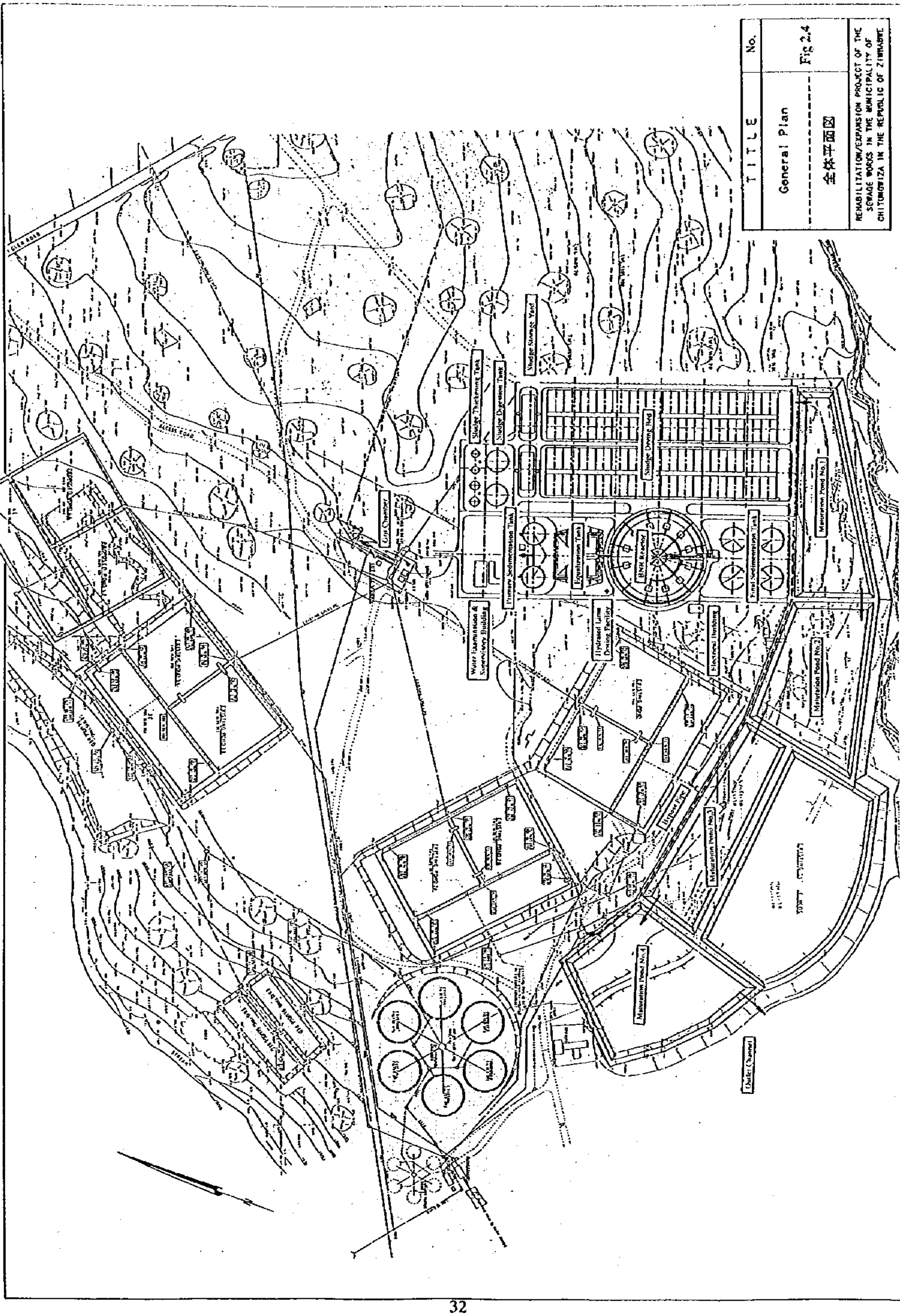
i. Electrical building:

The facility shall be located beside the BNR reactor and final sedimentation tank on account of their high electricity consumption to reduce electric costs.

ii. Water examination and supervisory building:

The location of the building was determined at the west end of the new facilities taking into account the effective access to the existing facilities, proposed sludge treatment and disposal facilities and electrical building as well as to minimize the offensive odor generated from the treatment facilities.

Figure 2.4 shows the General Plan that is determined based on the above principles.



TITLE
No.
General Plan
全体平面図
Fig.2.4
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE
Sludge Thickening Tank
Sludge Digestion Tank
Sludge Storage Yard
Sludge Drying Bed
Grit Chamber
Water Examination & Supervisory Building
Primary Sedimentation Tank
Equalization Tank
BNR Reactor
Hydrated Lime Dosing Facility
Electrical Building
Final Sedimentation Tank
Maturation Pond No.1
Maturation Pond No.2
Maturation Pond No.3
Maturation Pond No.4
Outlet Channel

3) Design standard for the facilities

Design work for the facilities shall be based on Japanese Standards (JIS) and US Standards (ACI, AISC) as well as the British Standards (BS) that is commonly used in Zimbabwe.

The standards of which are used in Zimbabwe related the Study are summarized as below.

CAS A33	Methods of sampling and testing of mineral aggregates, sand and fillers
CAS A34	Aggregates for concrete
CAS A44	Methods of testing soils for civil engineering purposes Part 1 : Preparation, classification and density of soils
CAS A46	Portland cement
CAS 170	The structural use of concrete
BS 1881	Methods of testing concrete
BS 3148	Test for water for making concrete
BS 4449	Hot rolled steel bars for the reinforcement of concrete
BS 4461	Cold worked steel bars for the reinforcement of concrete
BS 4462	Bending dimensions and scheduling of bars for the reinforcement of concrete
BS 4482	Hard drawn mild steel wire for the reinforcement of concrete
BS 4483	Steel fabric for the reinforcement of concrete
SABS CKS 158	Proposed specification for welded fabric

a. Loads

i. Dead loads

Dead loads are defined as self weights of construction materials. The principal dead loads shall bear the following particulars.

Material	Weight (kg/m^3)
Mass concrete	2,300
Reinforced concrete	2,400
Compacted earth	1,800
Water	1,000
Structural steel	7,850
Red-brick wall	1,800
Concrete block wall	1,500
Hard wood timber structure	1,000

ii. Live loads

Live loads are defined as imposition other than dead loads. The prevalent live loads shall conform to the following details.

Location	Weight (kg/m²)
Pitch roof	50
Flat roof	150
Office space floor	300
Office stairways	500
Stairways to roof	400

iii. Lateral pressures

Lateral pressures on basement wall shall enfold the effect generated by a live load surcharge of 1,000 kg/m². The coefficient of active lateral earth pressure shall be between 0.3 and 0.5 depending on soil conditions.

iv. Temperature effects

Influences exerted by change in temperature shall be based on; a temperature range between ±15℃; and a coefficient of linear thermal expansion of 0.000012/℃ for either concrete or steel.

v. Seismic forces

Earthquake effects shall not be considered, in accordance with the common practice in Zimbabwe.

b. Concrete

The proposed facilities shall have the following concrete specifications.

Item	Liquid containing structure	Other structure
Specified compressive strength	250 kg/m²	210 kg/m²
Direct compressive strength	77 kg/m²	-
Compressive strength due to bending	100 kg/m²	85 kg/m²
Diagonal shear strength	9 kg/m²	8 kg/m²
Direct tensile strength in circular tank	15 kg/m²	-

c. Reinforcing steel bar

Bars of size 12mm or larger in diameter shall be deformed bars of Grade SD-295A,B.

The permissible tensile stress shall not exceed the following:

Item	Liquid containing structure	Other structure
Specified tensile strength	2,500 kg/m^2	2,500 kg/m^2
Allowable working strength (at the face in contact with the liquid)	1,250 kg/m^2	—
Allowable working strength (at the face far from the liquid by more than 22.5 cm)	1,500 kg/m^2	1,500 kg/m^2
Allowable working compressive strength	1,200 kg/m^2	1,200 kg/m^2
Minimum steel ratio	0.3 - 0.4%	0.2%

d. Structural steel

Min. ultimate tensile strength	4,100 kg/m^2
Min. yield strength	2,400 kg/m^2

e. Clear cover of reinforcement

Footing in direct contact with ground	5.0 cm
Beam not in direct contact with ground	3.0 cm
Slab not in direct contact with ground	2.0 cm
For column	4.0 cm
For wall (Liquid containing structure)	5.0 cm
For wall (General structure)	3.0 cm

4) Basic concept for selecting the mechanical and electrical equipment

Ease of procurement, easy O & M, efficiency and simple mechanisms are essential in selecting the equipment.

a. Mechanical equipment

i. The basic pump shall be the dry pit type that is commonly used in Zimbabwe.

ii. It is envisaged that the primary settled sludge will be removed from the primary sedimentation tanks using air-operated diaphragm pumps. This method of continuous desludging ensures a constant, relatively concentrated stream of raw sludge for further treatment, either by thickening or digestion process. The suction and delivery pressures generated ensure that blockages rarely occur, even at low pumping rates.

iii. Two screw-type pumps, in a duty/standby configuration, shall be adopted for the return activated sludge pump. The advantage of this type of pump is that pump operation is not complicated by level controls, and also that the range of pumping is infinitely variable. This enables the operator to vary clarifier desludging via telescopic valves to suit the phase separation requirements.

iv. Mixers for the equalization tank, anaerobic tank and anoxic tank shall be of the dual-speed type in order to maintain a constant energy density.

v. Aerators for the aerobic tank shall be of the surface aeration type due to their simple structure, easy maintenance and economic advantages.

vi. A sludge scraper shall be installed for the sedimentation tanks and sludge thickening tanks to improve the treatment efficiency.

vii. The principle type of the gates and valves shall be of the manual type due to their economical advantages and easy maintenance.

b. Electrical equipment

i. Design concept

- In general, every equipment shall be capable of being manually started or stopped from a stop/start station mounted adjacent to the motor, or from the motor control center where the motor starter is located.
- In order to decentralize the electrical installation (away from the main transformer substation), four switchboards are to be located at the major load facilities; i.e. the BNR reactor, the primary sedimentation tank, the sludge treatment facilities and the water examination & supervisory building.
- Each switchboard shall in principle be constructed in accordance with BS IEC 439-1.
- Mounted on the switchboard for each drive shall be an ammeter on one phase only, a run-hour meter, remote stop/start pushbuttons and indicating lamps.
- The area lighting floodlights shall be 250W or 400W high pressure sodium floodlights.

ii. Design standard in Zimbabwe

The general requirements stated below shall be common to all electrical equipment.

- All switch gear must be rated for a power circuit voltage of 390V 50Hz, three phase and neutral. The control circuit voltage in common use throughout Zimbabwe is 220V 50Hz. A low voltage supply, typically 24V 50Hz, is to be used for float switches and other similar apparatuses.

- The medium voltage multi-core cables shall be PVC insulated, standard copper conductors and shall be steel wire armored. All cables not exceeding 16 mm^2 shall be four (4) core, where three cores shall be used for power and the fourth core for grounding.

iii. Bulk power supply by ZESA (Zimbabwe Electricity Supply Authority)

ZEZA have indicated that they expect their scope of work to include:

- extending the existing 11kV overhead line from the present supply point at the existing sewage treatment facilities, to the proposed sewage treatment facilities;
- installing high voltage fuses, lightning arresters and cabling to transformers;
- two indoor mounted 1,000kVA 11/0.4kV transformers.

5) Design of main facilities

Sewage treatment facilities

a. Grit chamber

Function:

The aim of the facility is to settle the settleable solids, such as sand and other relatively heavy substances of the sewage by gravity. The settled matter will be removed with a sand-pump that is to be installed so as to ease the maintenance work. In addition, a manual-type fine screen shall be placed with the object of removing the screenings.

A electrical operation type gate and a manual-type coarse screen is installed in the influent channel of this facility. The gate is aims to distribute the design flow of the existing facilities (21,750 m^3/day) and the proposed facilities (20,000 m^3/day) by automating gate operation, and further, to prevent the inflow of highly concentrated sewage into the proposed facilities.

The highly concentrated sewage will be fed into to the existing treatment facilities with the object of reducing the influent sewage quality (daily average COD) of the new facilities to 1,200 mg/l or below.

Structure:

RC Plug-flow type basin with roof, 1.4 $m^W \times 6.3$ $m^L \times 0.5$ $m^H \times 2$ basin

b. Primary sedimentation tank

Function:

In order to reduce the load on the biological treatment facilities by removing settleable organic matter from the sewage, the facility shall be built. The slettled sludge will be led to the sludge thickening tank by diaphragm type sludge pump. A sludge scraper is proposed to be installed to improve the treatment efficiency.

Structure:

RC Circular Tank, 21.0 $m^D \times 3.2$ $m^H \times 2$ basin

c. Equalization tank

Function:

This facility aims at equalizing the fluctuation of the influent sewage quality and quantity resultant from the inlet gate control. The equalization is necessary to ensure the effectiveness of the microorganisms in the BNR reactor; therefore, through the use of the equalization tank, the desirable treated sewage quality shall be ensured. The flow control, with a orifice-type gate, will enable the facility to maintain an economical and easy operation despite any liquid level fluctuations.

Dual-speed mixers will be added to maintain any remaining particulate material in suspension in the basin.

Structure:

RC Rectangular tank, 40.0 $m^W \times 40.0$ $m^L \times 2.9$ $m^H \times 1$ basin

d. BNR reactor

Function:

Nutrients such as nitrogen and phosphorus, in addition to organic matter will be removed in this facility. The reactor is divided into three zones, namely an anaerobic tank, an anoxic tank and an aerobic tank.

The anaerobic tank and the anoxic tank are equipped with slow speed radial flow type mixers, while the aerobic tank is equipped with mechanical surface aerators. The above equipment are characterized as simple structure, easy operation.

Structure:

RC Circular Tank

i. Anaerobic Tank: Inner dia. 4.7 m to Outer dia. 18.1 m$\times$6.4 $m^H$$\times$1 basin

ii. Anoxic Tank : Inner dia. 18.9 m to Outer dia. 50.1 m$\times$6.4 $m^H$$\times$1 basin

iii. Aerobic Tank : Inner dia. 50.9 m to Outer dia. 84.9 m$\times$4.45 $m^H$$\times$1 basin

e. Final sedimentation tank

Function:

This facility is employed to separate mixed liquid into sludge and supernatant liquor. The sludge will be returned back to the BNR reactor as return sludge using a screw type sludge pump or drawn off to the sludge thickening tank as waste activated sludge. In addition, a sludge scraper is also installed.

Structure:

RC Circular tank, 23.0 $m^D$$\times$3.5 $m^H$$\times$4 basin

f. Maturation pond

Function:

This facility, which is mainly aerobic, is proposed to achieve fecal bacterial removal by utilizing the ultraviolet rays of sunshine.

Structure:

Embanked multi-cell pond, 4 ponds with a capacity 60,000 m^3

g. Outlet channel and bypass pipe

Function:

The treated effluent that is stored in the maturation ponds shall be discharged to the creek through the outlet channel.

In order to provide the necessary oxygen to the effluent, the outfall structure shall be a cascade type owing to the sufficient distance of the water level, four (4) meters, between maturation pond No.4 and the receiving water surface.

The bypass pipe is proposed to be installed so as to lead the treated sewage to the pumping station of the existing treatment facilities, in emergency.

Structure:

i. Outlet channel : RC Cascade type open channel, $1.0\ m^W \times 15\ m^L$

ii. Bypass pipe : RC Pipe, $600\ mm^D \times 450\ m^L$

Sludge treatment facilities

a. Sludge thickening tank

Function:

Due to its remarkable economical advantage, the thickening process is indispensable for the System. Through the thickening process, the moisture content of both the primary sludge and the waste sludge will be reduced; also, the volume of the sludge will be reduced by 70% and 20%, respectively. Therefore, the thickening process contributes to minimize the subsequent process volume requirements and maintenance works for sludge disposal.

The thickened sludge will be sent to the digestion tank (the primary sludge) and the sludge drying bed (the waste sludge) by sludge pump.

A sludge scraper with a picket-fence is proposed to be installed to improve the treatment efficiency.

Structure:

RC Circular tank

i. Tank A (for primary sedimentation tank) : $6.0\ m^D \times 4.0\ m^H \times 2$ unit

ii. Tank B (for final sedimentation tank) : $8.0\ m^D \times 4.0\ m^H \times 2$ unit

b. Sludge digestion tank

Function:

The purpose of the digestion process is the reduction of the volume and the stabilization of the thickened primary sludge itself through the gasification of organic matter. Hence, the process will enable to mitigate the offensive odors from the sludge drying bed.

A sludge circulation pump is proposed to be installed in order to accelerate the methane fermentation.

The digested sludge will be sent to the sludge drying bed by a sludge pump.

Structure:

RC Circular tank, Anaerobic digestion, No-heating with recirculation

20.0 $m^D \times$ 10.0 $m^H \times$ 2 unit

c. Sludge drying bed

Function:

This facility is to dry the digested sludge and the thickened waste sludge and is expected to reduce their water content to about 60 % in two weeks in order to ease the sludge handling for the re-use of the sludge for land application (fertilizer).

Structure:

RC Rectangular type bed, 15.0 $m^W \times$ 20.0 $m^L \times$ 1.0 $m^H \times$ 56 bed

d. Sludge storage yard

Function:

The yard is to be of sufficient size to stock about two month's generation of dried sludge.

Structure:

Brick wall with steel frame, 12.0 $m^W \times$ 36.0 $m^L \times$ 2 buildings

Other facilities

a. Electrical building

Function:

This facility is will carry out the following functions:

- inlet works
- step down transforming
- sub-distribution
- motor control

In general, every drive shall be capable of being manually started or stopped from a start/stop station mounted adjacent to the motor (local), or from the motor control center where the motor starter is located (remote).

Structure:

Brick wall with RC structure, Area 7.6 $m^W \times 17.2$ m^L

b. Water examination and supervisory control building

Function:

This building consists of laboratory, staff office & supervisory control room, labors room and storage room.

The size of the laboratory was decided in regard to the required water quality items to be examined, e.g. water temperature, pH, COD, SS and T-N, because precise water quality analysis (checking for phosphorus, heavy metals and so on for example) will be conducted by contract.

Structure:

Brick wall with RC structure, Area 12.0 $m^W \times 24.0$ m^L

The capacity calculations of above mentioned facilities are attached in APPENDIX 5.2.

Table 2.1 and Table 2.2 shows the outline of the main facilities and equipment.

Table 2.1 Outline of Main Facilities

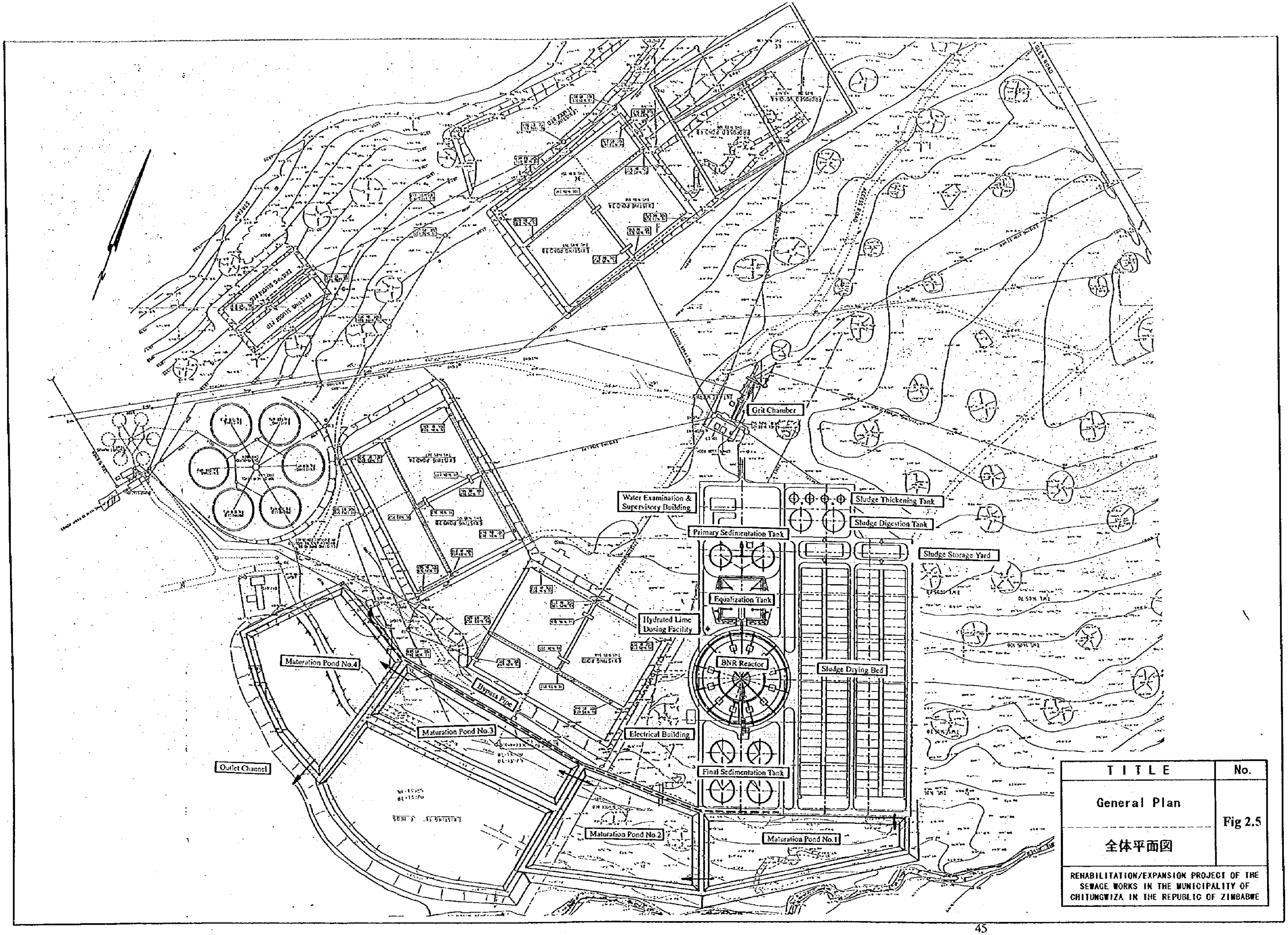
Facilities	Specification	Nos.	Remark
Grit Chamber	Plug flow, gravity type $1.4m^W \times 6.3m^L \times 0.5m^H$	2	
Primary Sedimentation Tank	Circular type with scraper Diameter 21.0m Depth 3.2m	2	
Equalization Tank	Orifice effluent type with mixer Width 40.0m Length 40.0m Depth 2.9m	1	
BNR Reactor	Anaerobic Tank Volume $1,580m^3$ I.D./O.D. 4.7/18.1m Depth 6.4m Anoxic Tank Volume $11,000m^3$ I.D./O.D. 18.9/50.1m Depth 6.4m Aerobic Tank Volume $13,400m^3$ I.D./O.D. 50.9/84.9m Depth 4.45m	1	
Final Sedimentation Tank	Circular type with scraper Diameter 23.0m Depth 3.5m	4	
Maturation Pond	Multi-cell type Total volume $60,000m^3$ Water depth 1.5m	4	
Outlet Channel & Bypass Pipe	Outlet Channel : $1.0m^W \times 15m^L$ (Cascade Type) Bypass Pipe : Dia.$600mm \times 450m^L$ (RC Pipe)	1 1	
Sludge Thickening Tank A (For primary settled sludge)	Circular type with scraper Diameter 6.0m Depth 4.0m	2	
Sludge Thickening Tank B (For final settled sludge)	Circular type with scraper Diameter 8.0m Depth 4.0m	2	
Sludge Digestion Tank (For primary settled sludge)	Type: No-heating with re-circulation Diameter 20.0m Side depth 10.0m	2	
Sludge Drying Bed	Width 15.0m Length 20.0m Sludge height 20cm	56	
Sludge Storage Yard	Yard with roof Width 12.0m Length 36.0m Sludge height 2.0m	2	
Electrical Building	Inlet works & Step down transforming Proposed area $7.6m \times 17.2m = 130.7m^2$	1	
Water Examination and Supervisory Building	Laboratory, Staff office & Supervisory room, Labors room, Storage room Proposed area $12.0m \times 24.0m = 288.0m^2$	1	

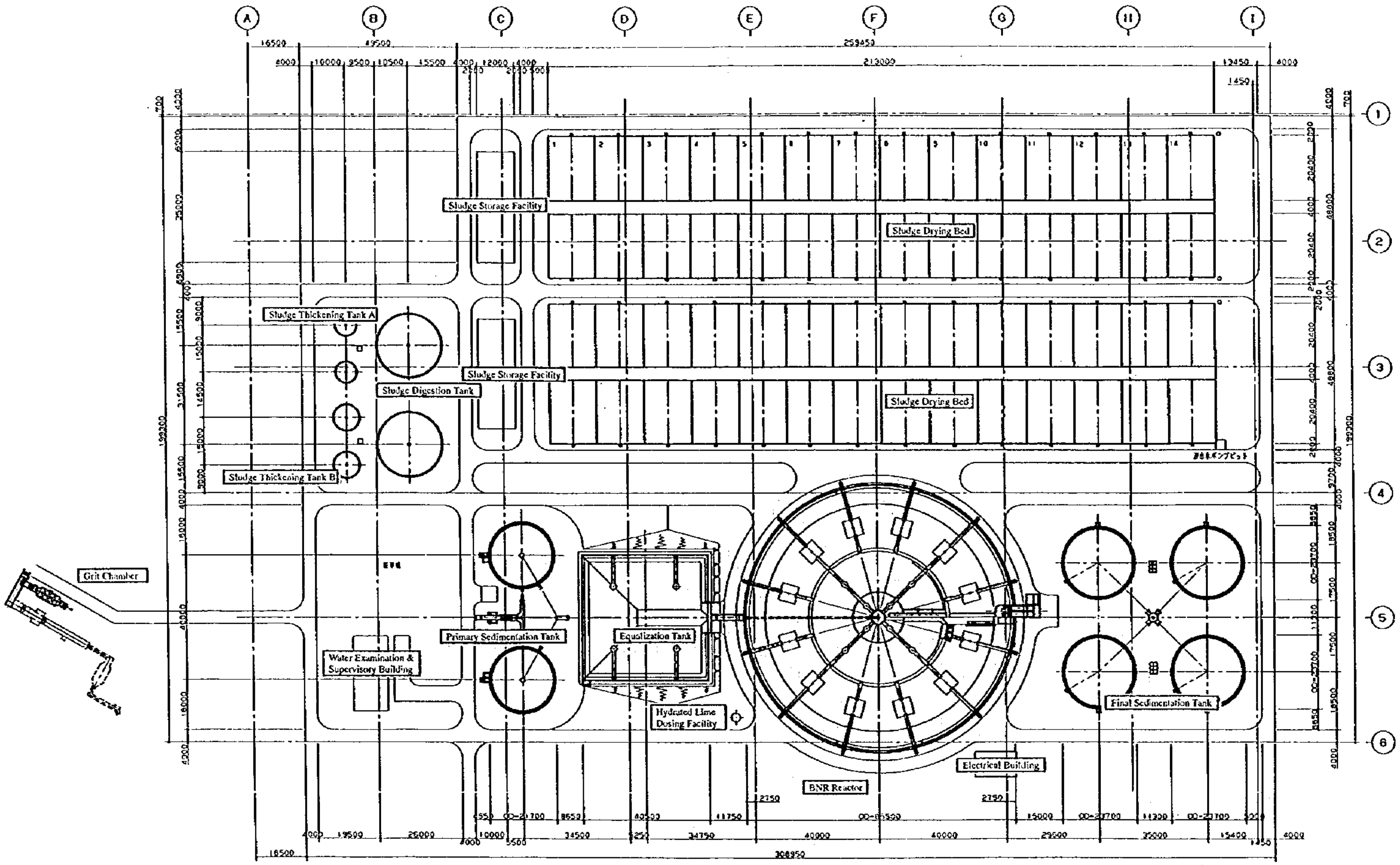
Table 2.3 Outline of Main Equipment

Location	Equipment	Specification	Nos.	Remark
Grit Chamber	Gate	Electrical operation type, $0.6m^W \times 0.8m^H$	1	
	Coarse Screen	Manual type, Screen gap 40mm $1.8m^W \times 1.4m^H$	1	
	Fine Screen	Manual type, Screen gap 14mm $0.6m^W \times 1.4m^H$	2	
Primary Sedimentation Tank	Sludge Scraper	Circumference drive type, $21.0m^D \times 1.5kW$	2	
	Sludge pump	Diaphragm type $\phi 100 \times 0.083m^3/min. \times 6m \times 22kW$	2	
Equalization Tank	Mixer	Speed control type, 11kW	4	
	Gate	Electrical operation type, $0.25m^W \times 0.25m^H$	1	
Hydrated Lime Dosing Facility	Storage Tank	Silo type, $30m^3$ Dissolution tank, $3m^3$	1	
	Dilution Pump	$\phi 80 \times 0.75m^3/min. \times 15m \times 7.5kW$	2	
	Feed Pump	$3.1L/min. \times 8kgf/cm^2$	2	
BNR Reactor	Mixer	Anaerobic Tank : Speed control type, 3kW	4	
		Anoxic Tank : Speed control type, 15kW	4	
	Aerator	Aerobic Tank : 110kW	4	
		90kW	3	
		75kW	3	
		55kW	2	
	Circulation Pump	$\phi 700 \times 27.9m^3/min. \times 0.7m \times 15kW$	3	
Final Sedimentation Tank	Sludge Scraper	Circumference drive type, $23.0m^D \times 1.5kW$	4	
Sludge Pump	Return Activated Sludge Pump	Screw type $\phi 1350 \times 21.0m^3/min. \times 7.5m \times 45kW$	2	
	Waste Activated Sludge Pump	Nonclogging type $\phi 80 \times 0.67m^3/min. \times 15m \times 7.5kW$	2	
Sludge Thickening Tank A	Sludge Scraper	Center drive type, $6.0m^D \times 0.4kW$	2	
	Sludge Pump	$\phi 80 \times 0.097m^3/min. \times 4kgf \times 7.5kW$	3	
Sludge Thickening Tank B	Sludge Scraper	Center drive type, $8.0m^D \times 0.4kW$	2	
	Sludge Pump	$\phi 80 \times 0.11m^3/min. \times 8kgf \times 11kW$	3	
Sludge Digestion Tank	Circulation Pump	$\phi 150 \times 3.0m^3/min. \times 21m \times 22kW$	2	
	Sludge Pump	$\phi 65 \times 0.063m^3/min. \times 8kgf \times 11kW$	3	
Electrical Building	Cubicle	High Voltage, 11KV	1unit	
	Transformer	1000kVA 11/0.4kV	1unit	
	Switchboard		1unit	
Water Examination and Supervisory Building	Monitoring Panel		1unit	
	Meter Panel	Flow, pH, DO, MLSS	1unit	

6) Drawings

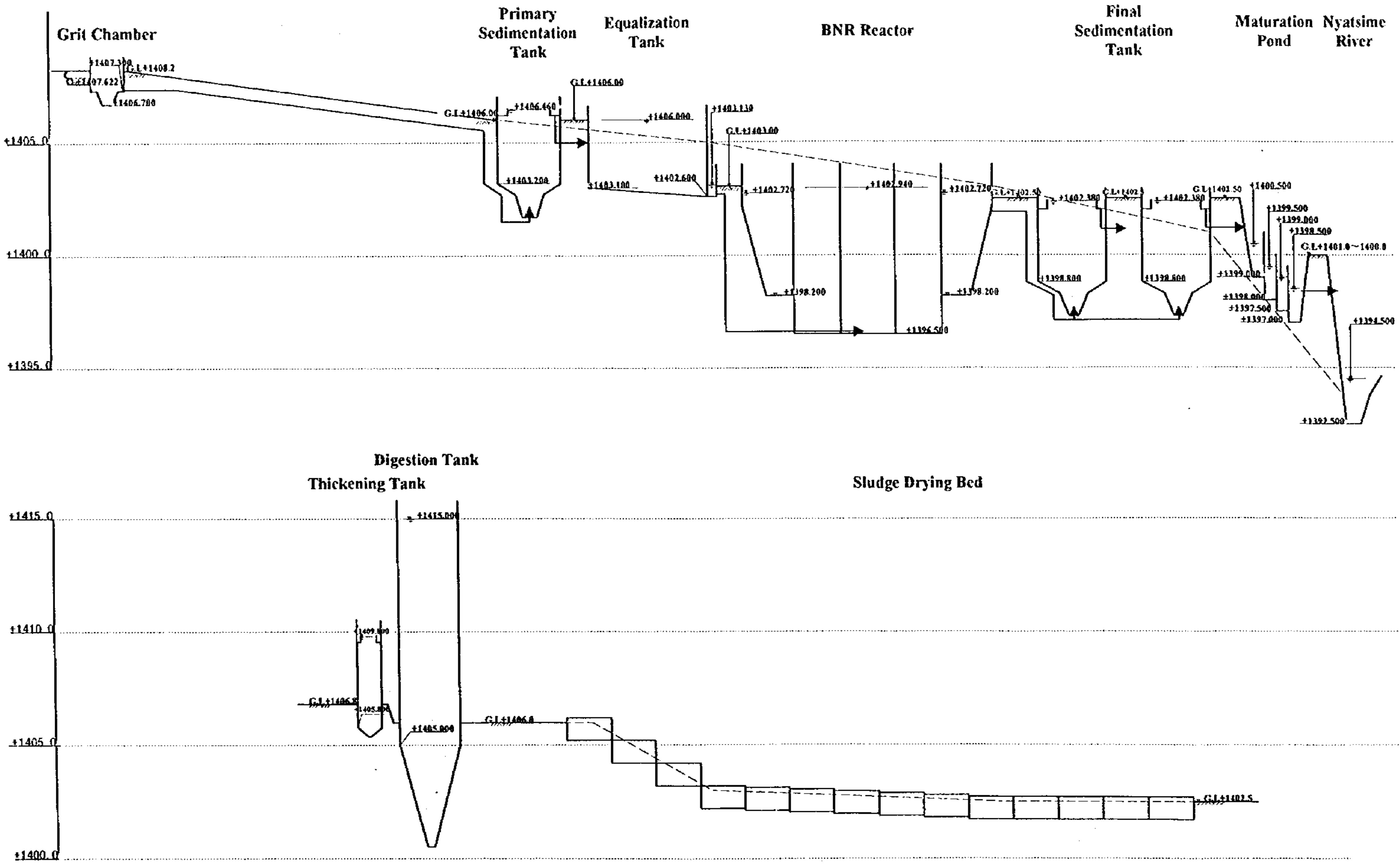
Fig. 2.5 to 2.30 shows basic design drawings of the proposed facilities.


Grit Chamber
Water Examination & Supervisory Building
Sludge Thickening Tank
Sludge Digestion Tank
Primary Sedimentation Tank
Sludge Storage Yard
Equalization Tank
Hydrated Lime Dosing Facility
BNR Reactor
Sludge Drying Bed
Maturation Pond No.4
Bypass Pipe
Maturation Pond No.3
Electrical Building
Final Sedimentation Tank
Outlet Channel
Maturation Pond No.2
Maturation Pond No.1
TITLE
No.
General Plan
全体平面図
Fig 2.5
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE



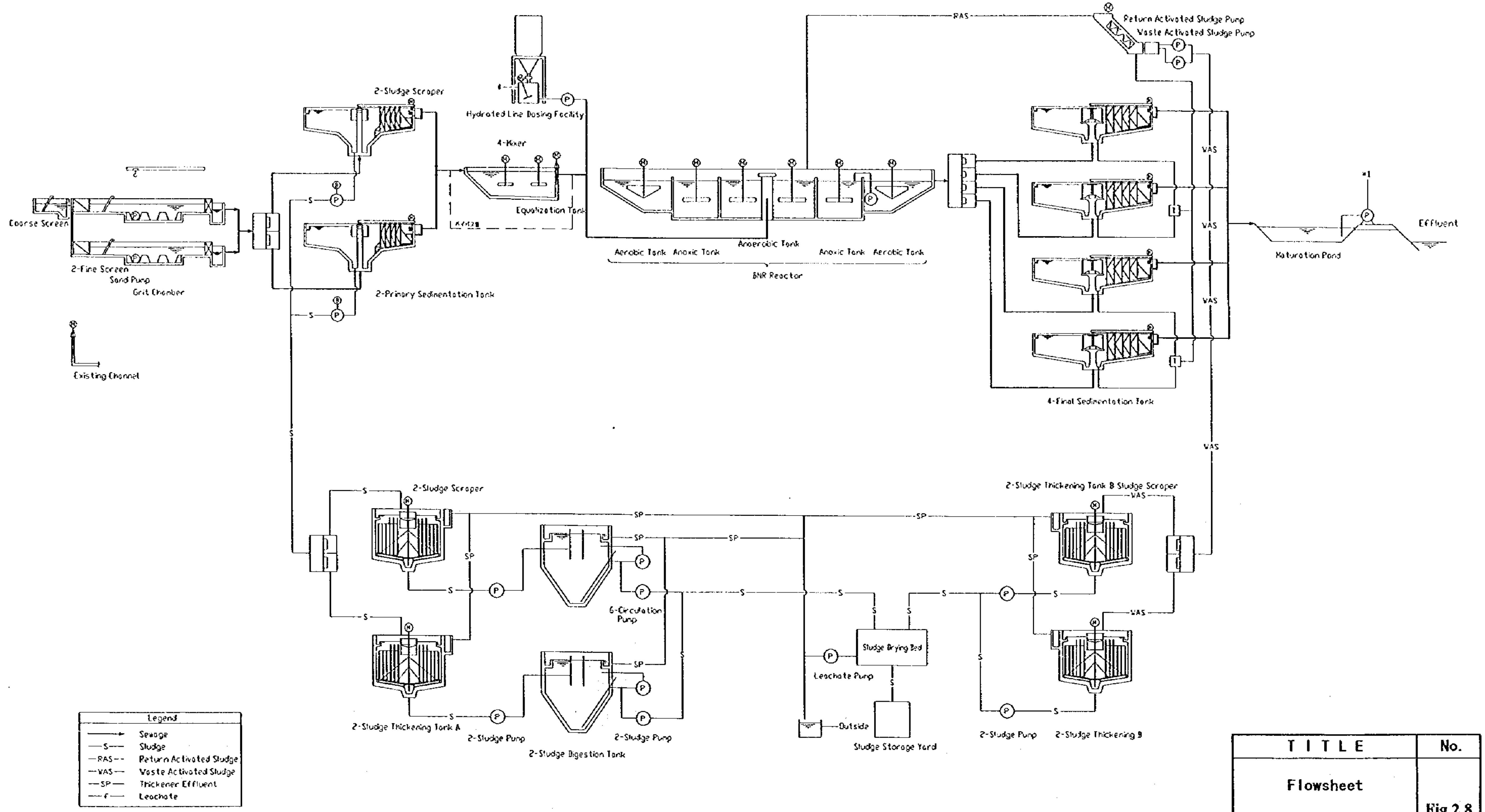
TITLE	No.
General Layout of Facilities 施設配置図	Fig 2.6

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE



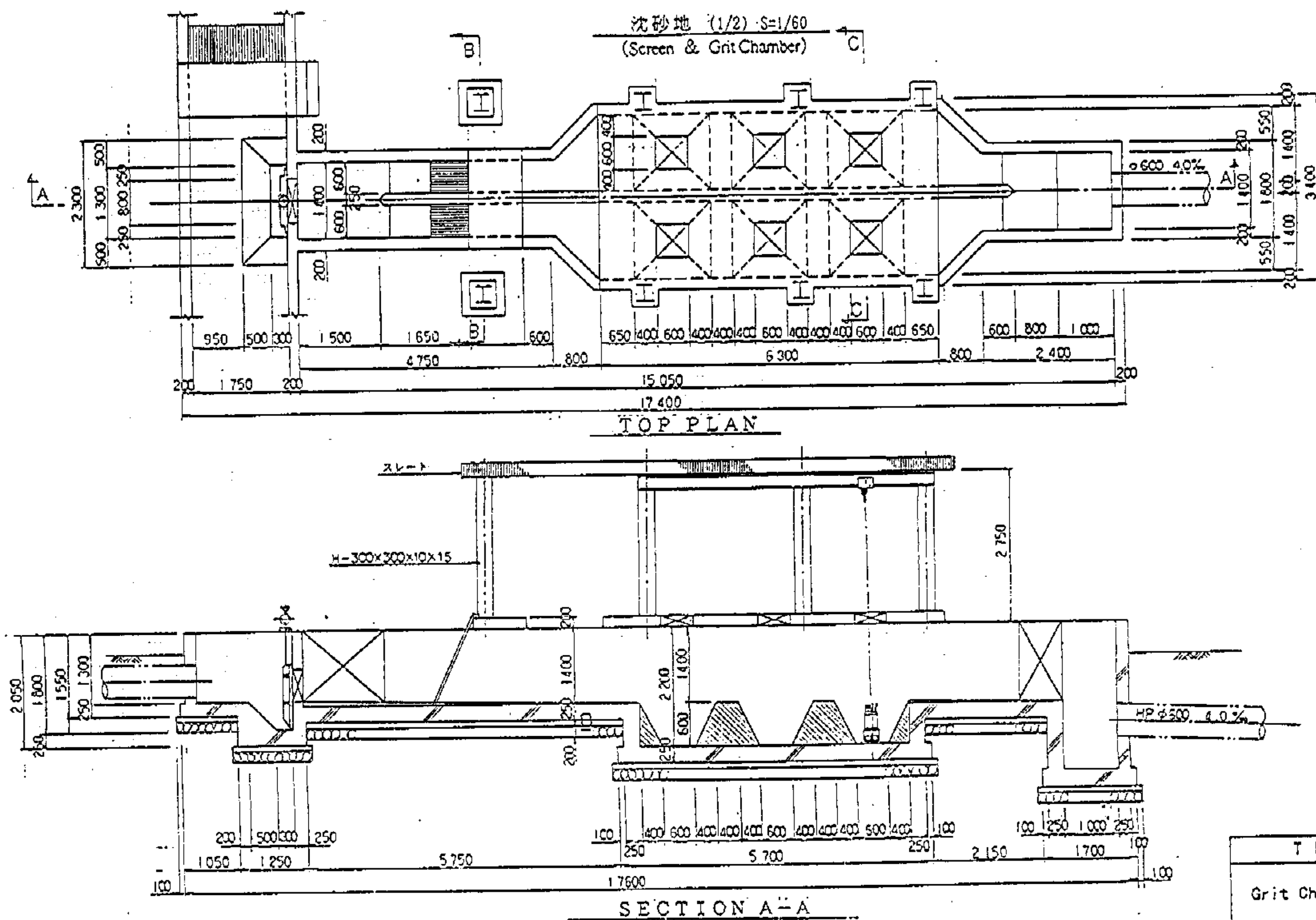
SCALE: V=1/200 H=1/1,500

TITLE	No.
Hydraulic Profile 水位関係図	Fig 2.7
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



TITLE	No.
Flowsheet フローシート	Fig 2.8

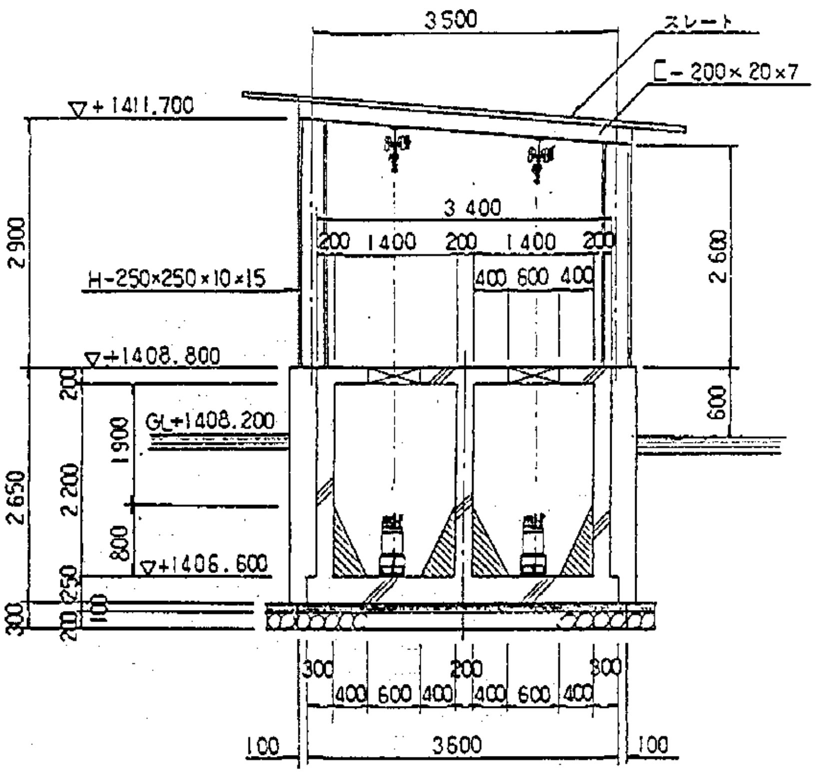
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE



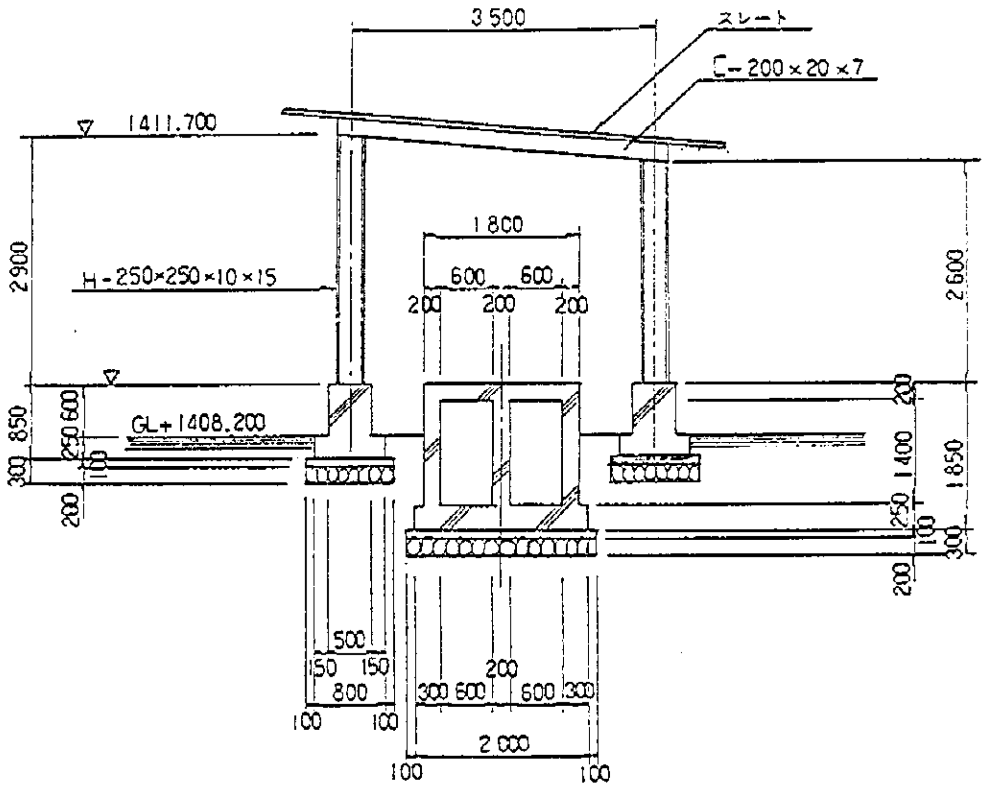
TITLE	No.
Grit Chamber (1/2) 沈砂池(1/2) 平面図・断面図	Fig 2.9

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

沈砂地 (2/2) S=1/60
(Screen & Grit Chamber)



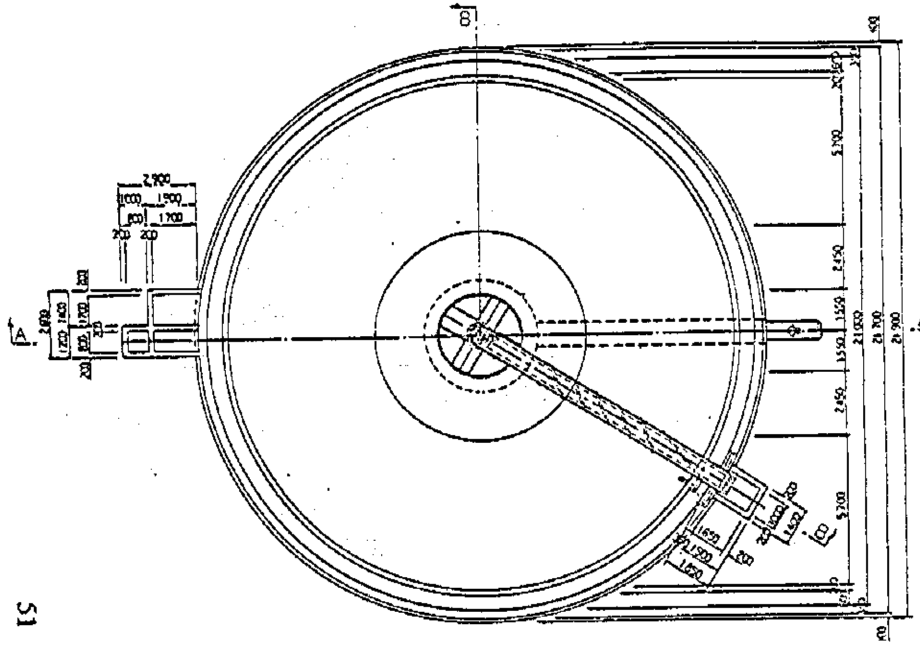
SECTION C−C



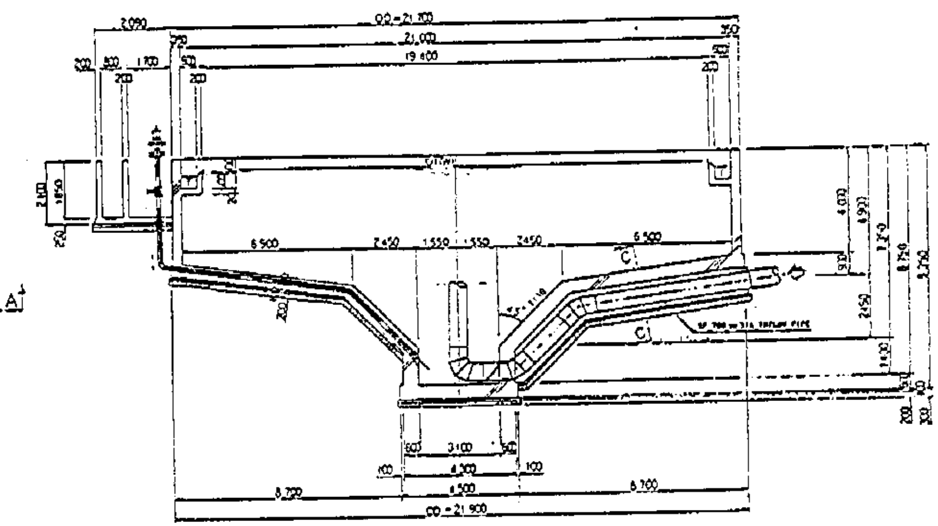
SECTION B−B

TITLE	No.
Grit Chamber (2/2) 沈砂池(2/2) 断面図	Fig 2.10
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

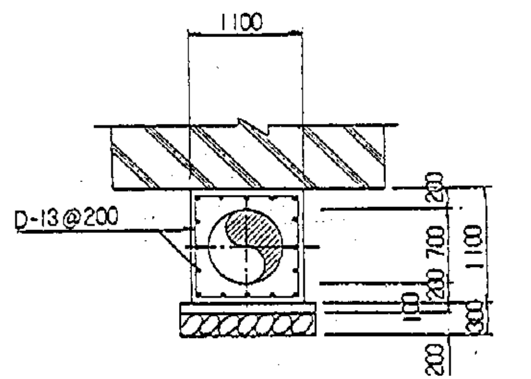
最初沈殿池 (Primary Settling Tank)



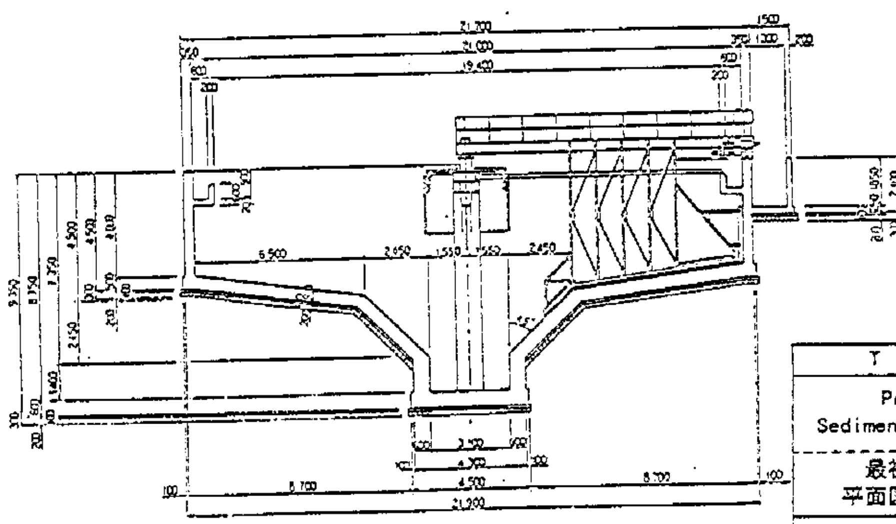
PLAN S=1/200



SECTION A−A S=1/200



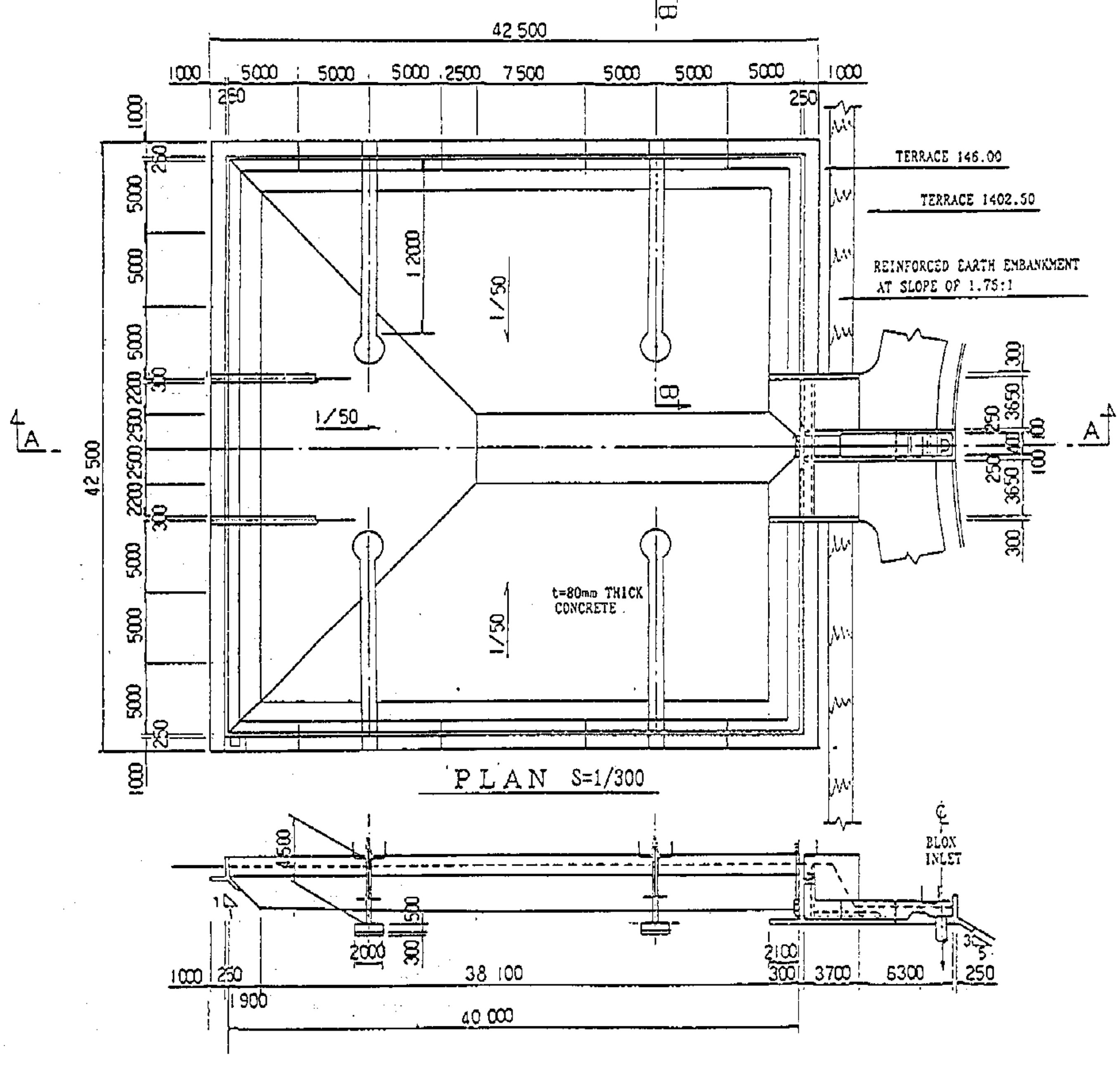
SECTION C−C S=1/50



SECTION B−B S=1/200

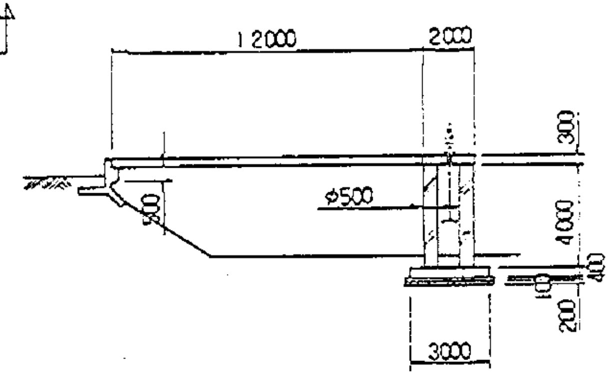
TITLE	No.
Primary Sedimentation Tank 最初沈殿池 平面図・断面図	Fig 2.11
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

調整池 (Equalization basin)



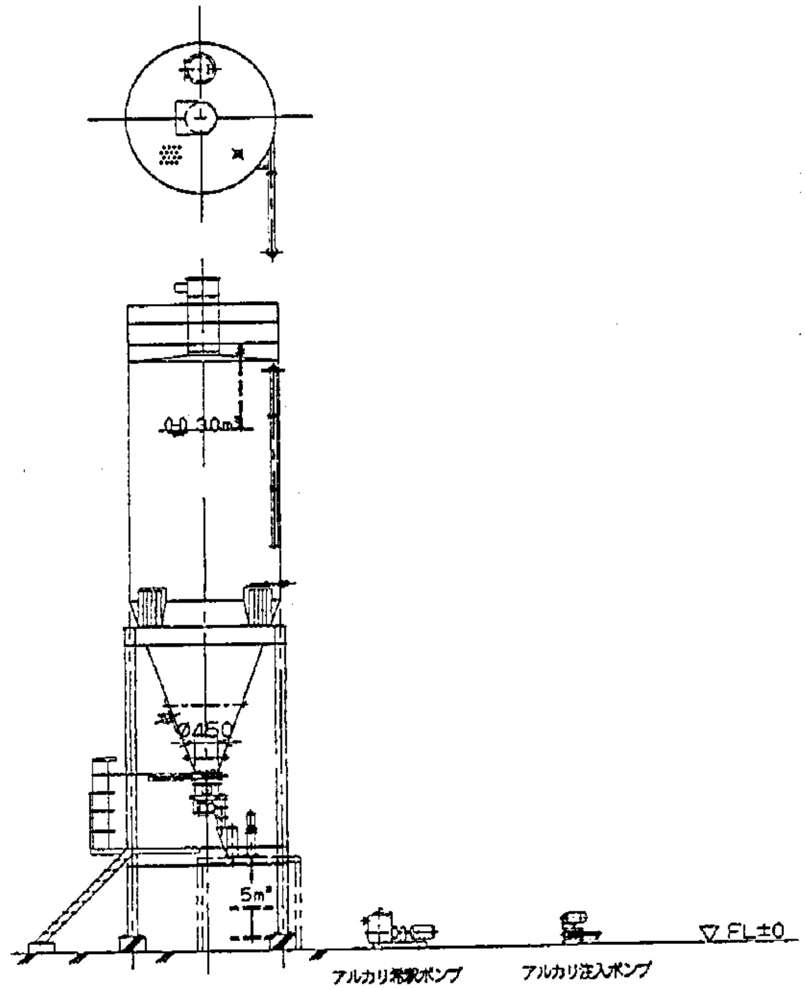
PLAN S=1/300

SECTION A－A S=1/300



SECTION B－B S=1/200

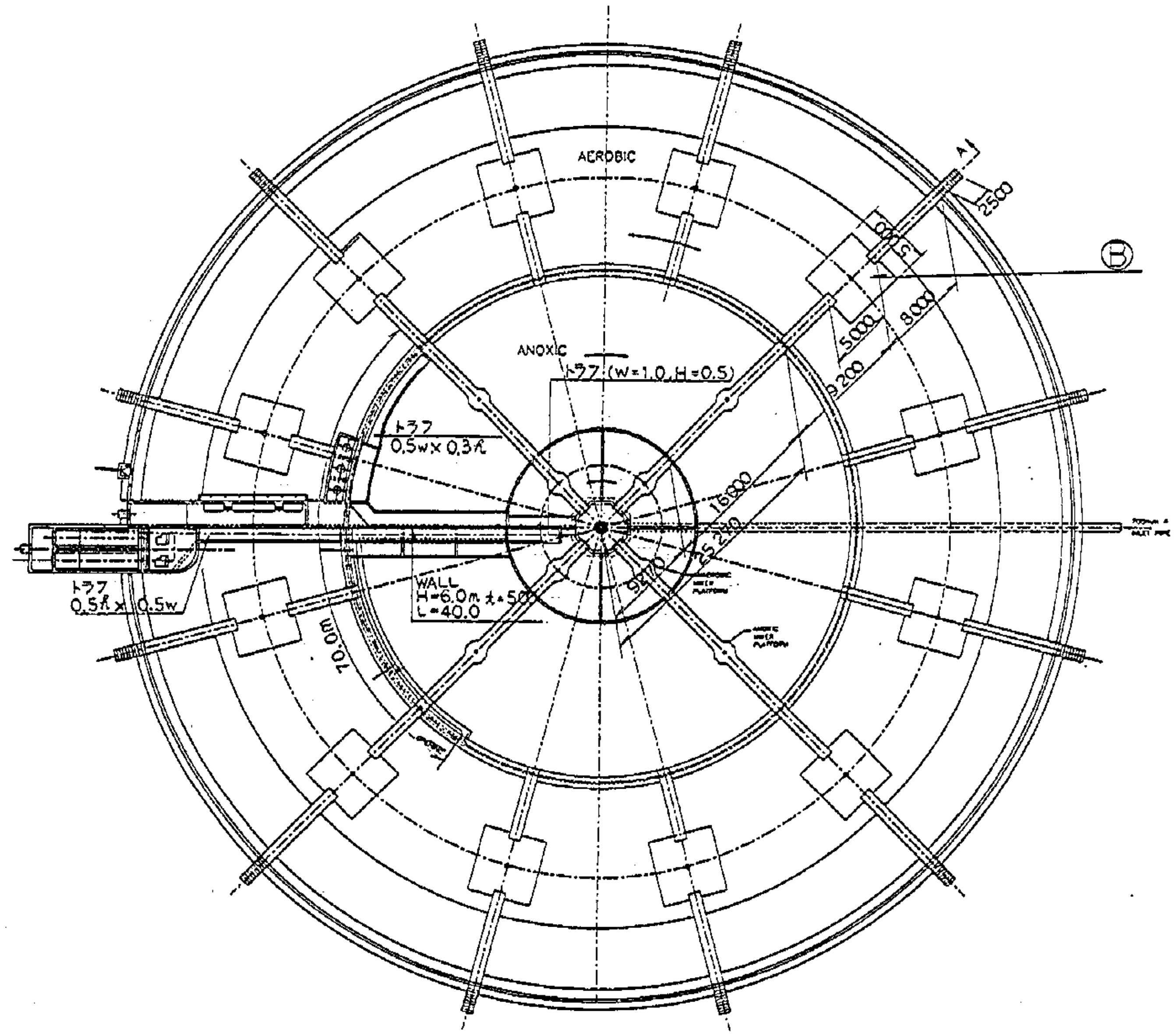
TITLE	No.
Equalization Tank 流量調整池 平面図・断面図	Fig 2.12
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



TITLE	No.
Hydrated Lime Dosing Tank 消石灰投入設備 平面図・断面図	Fig 2.13

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

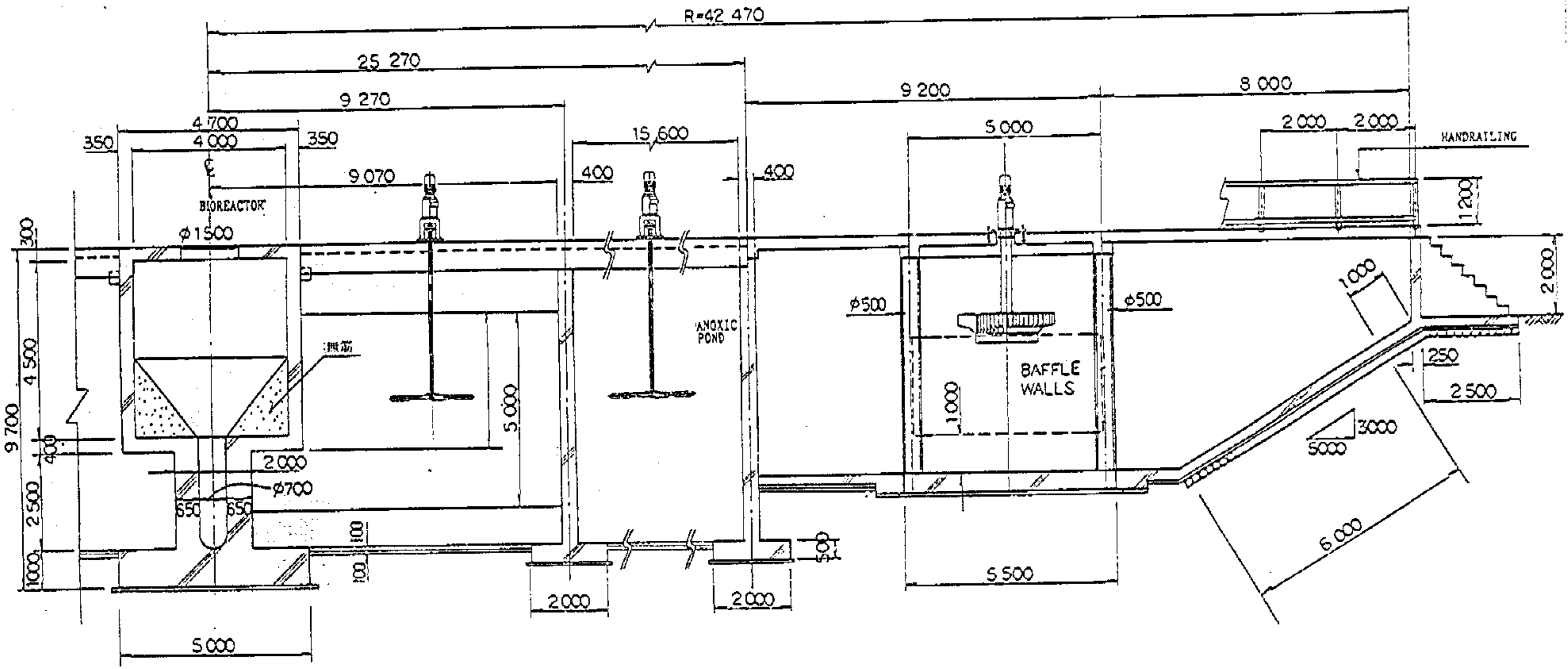
BNR反応槽 (1/2) (Bioreactor)



PLAN

TITLE	No.
BNR Reactor (1/2)	Fig 2.14
BNR反応タンク (1/2) 平面図	
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

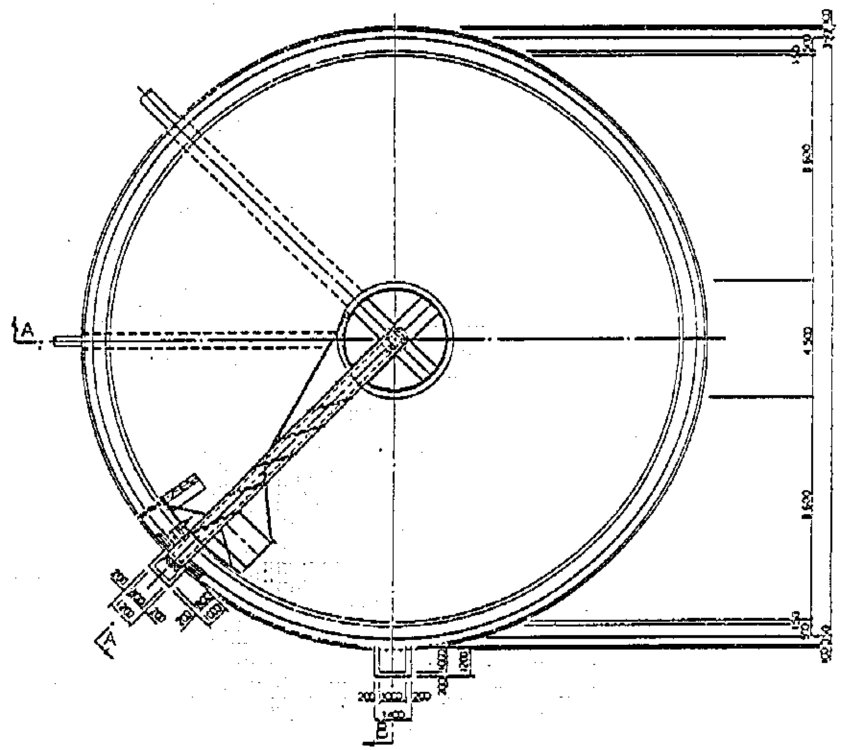
BNR反応槽(2/2) S=1/100 (Bioreactor)



SECTION A-A

TITLE	No.
BNR Reactor (2/2)	Fig 2.15
BNR反応タンク(2/2) 断面図	
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

最終沈殿池（Final clarifier）



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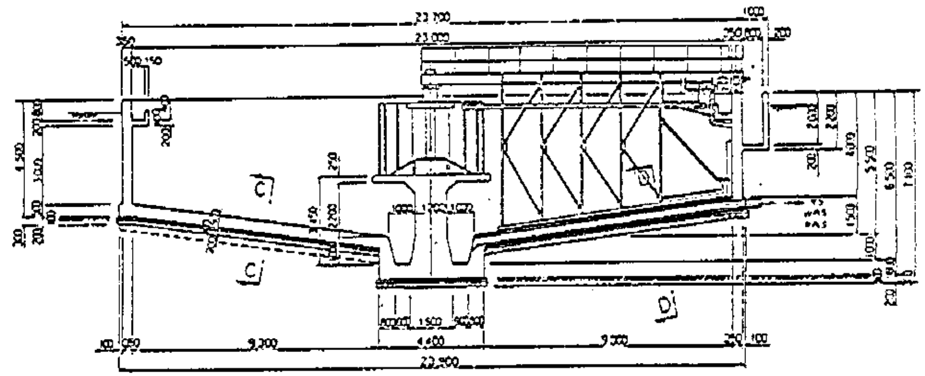
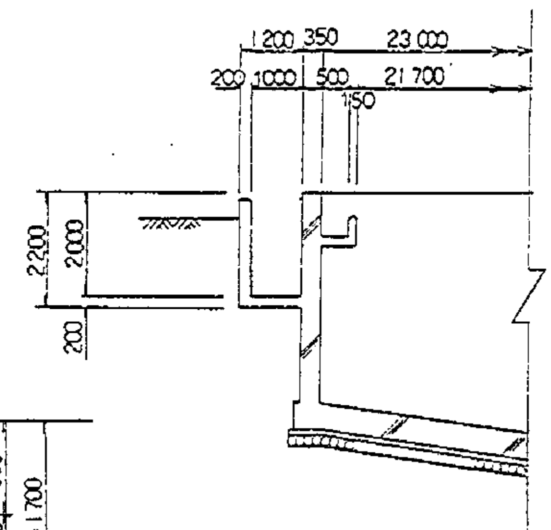
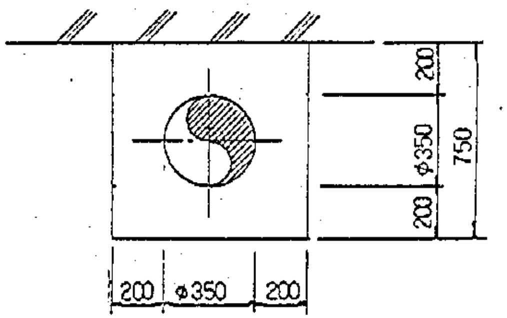


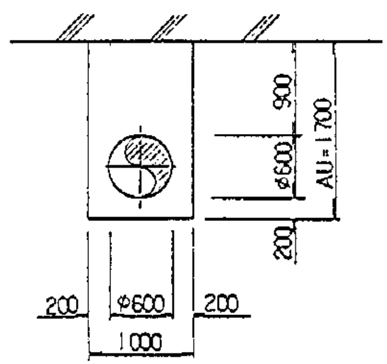
SECTION A－A S=1/200



SECTION B－B S=1/100



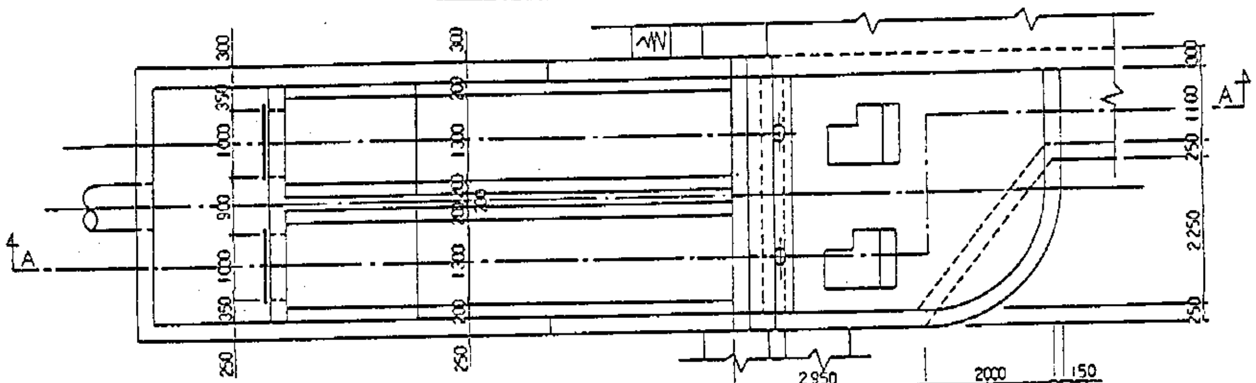
SECTION C－C S=1/20



SECTION D－D S=1/50

TITLE	No.
Final Sedimentation Tank 最終沈殿池 平面図・断面図	Fig 2.16
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

RASポンプ S=1/60 (Return activated sludge pumpstation)



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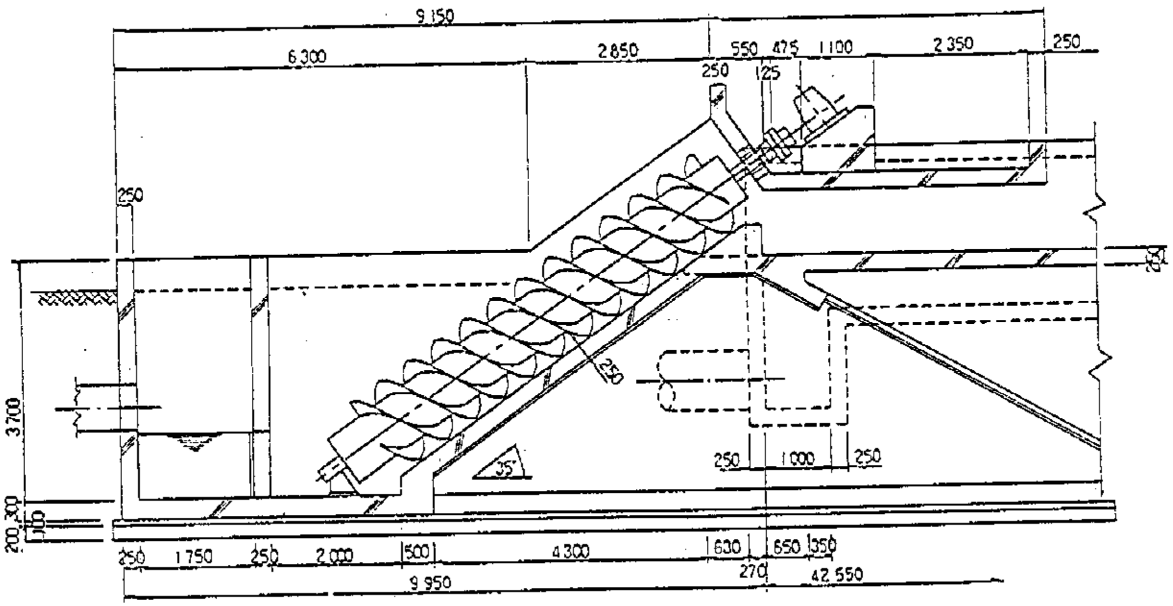
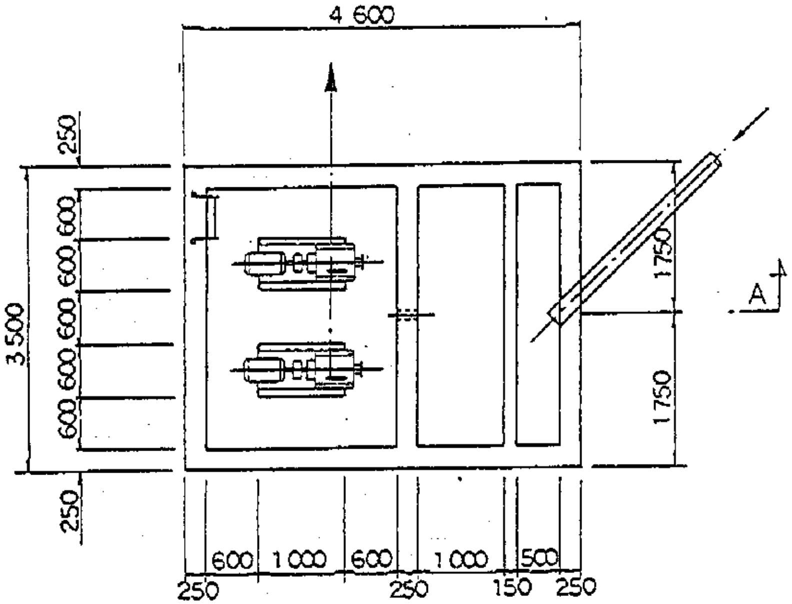


SECTION A-A

TITLE	No.
Return Activated Sludge Pump Facility 返送汚泥ポンプ設備 平面図・断面図	Fig 2.17
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

WASポンプ場 S=1/60 (Waste activated sludge pumpstation)



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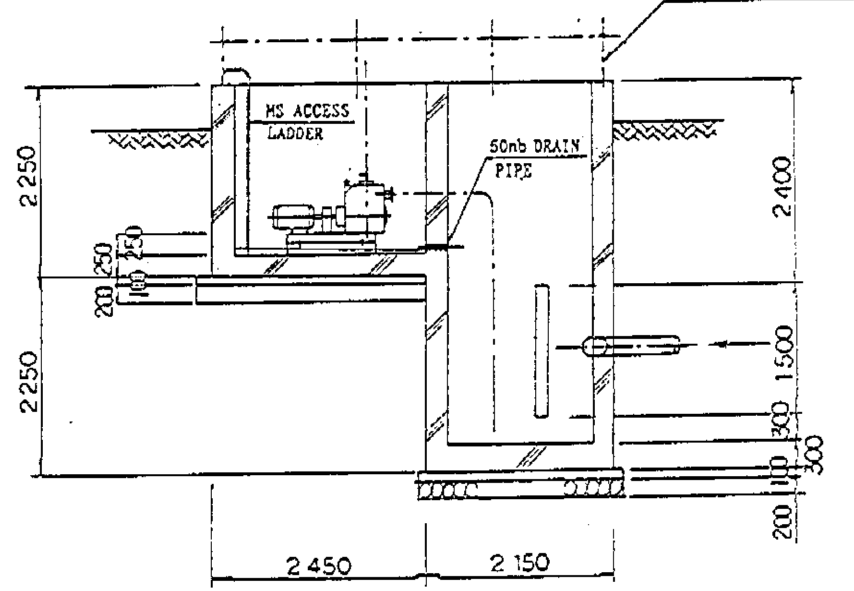
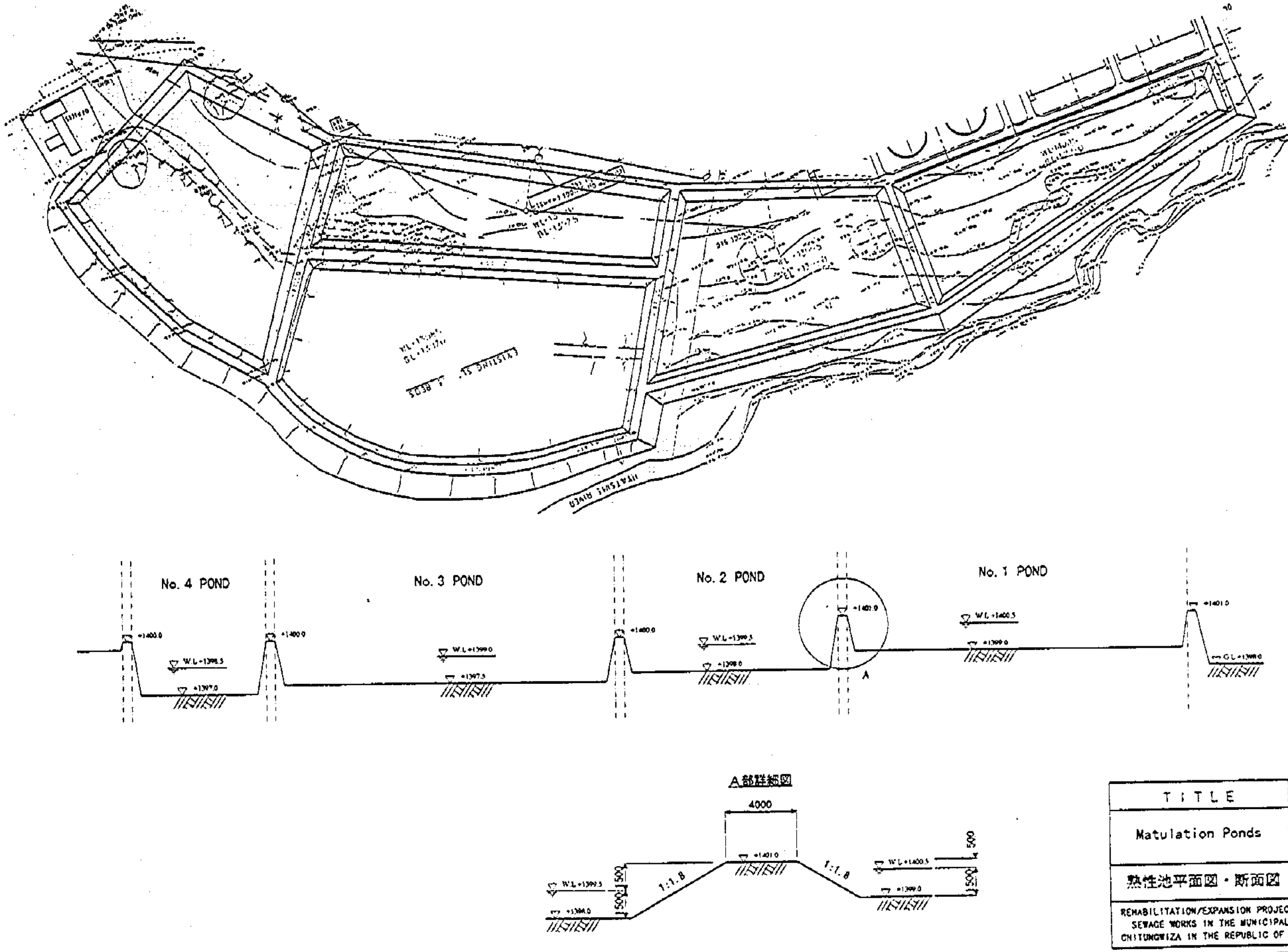


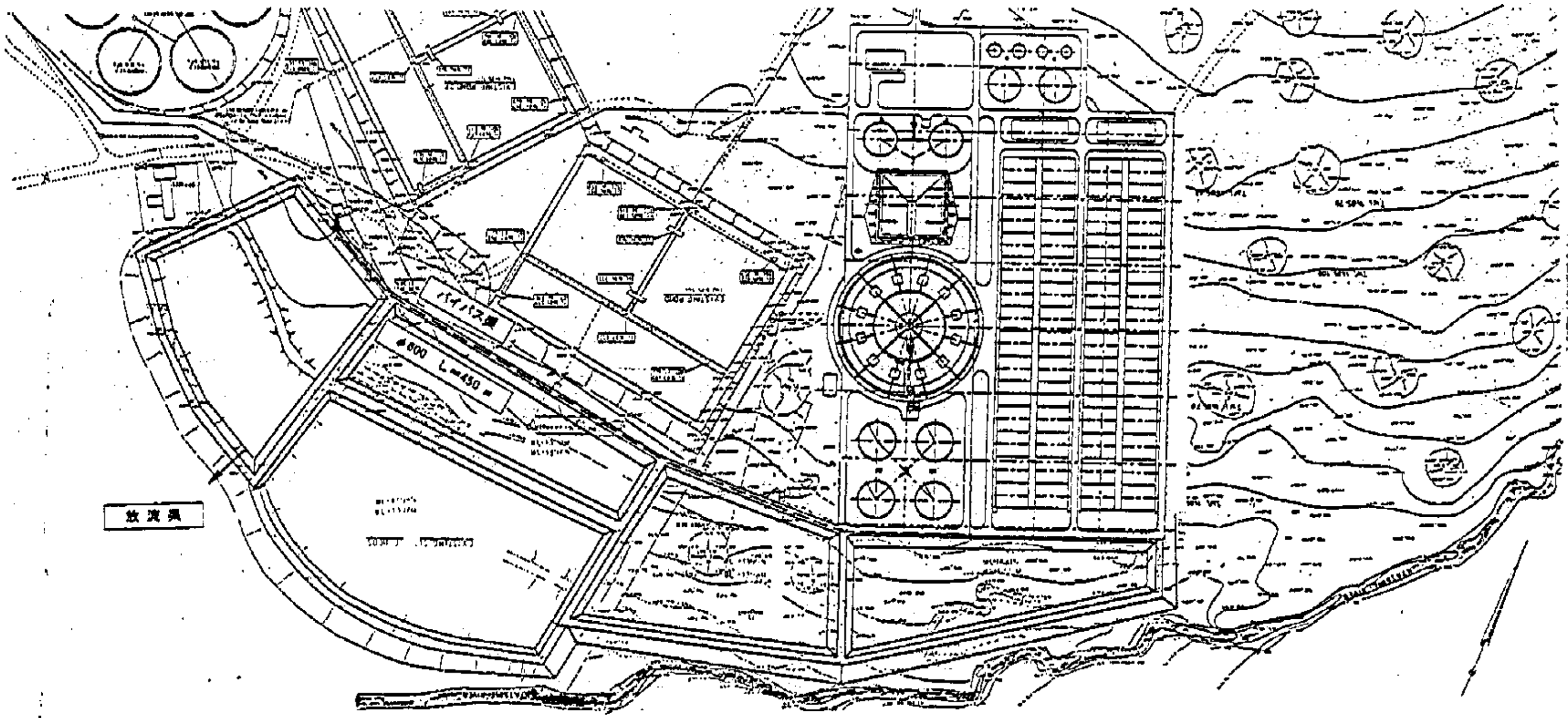
SECTION A−A

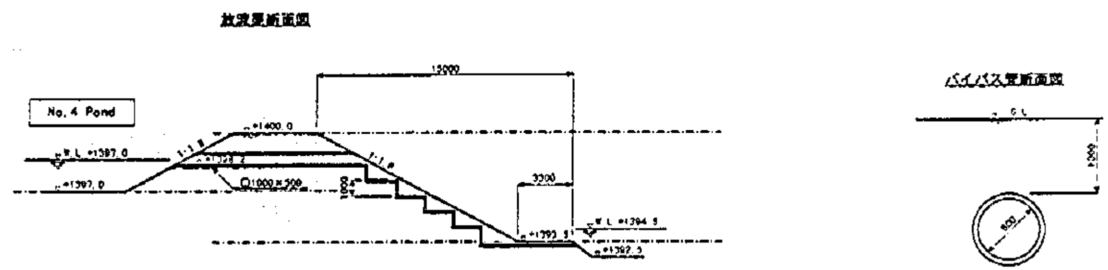
TITLE	No.
Waste Activated Sludge Pump Facility 余剰汚泥ポンプ設備 平面図・断面図	Fig 2.18
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



TITLE	No.
Matulation Ponds	Fig 2.19
熟性池平面図・断面図	

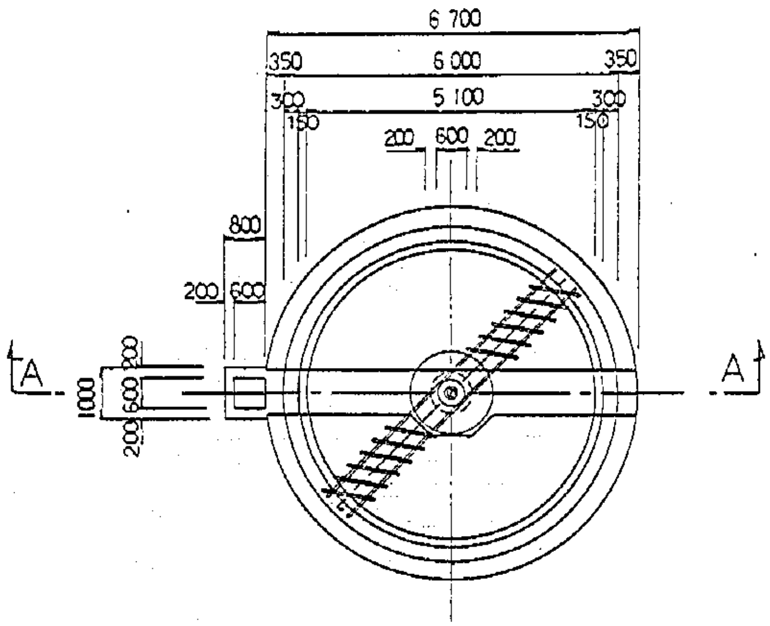
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE



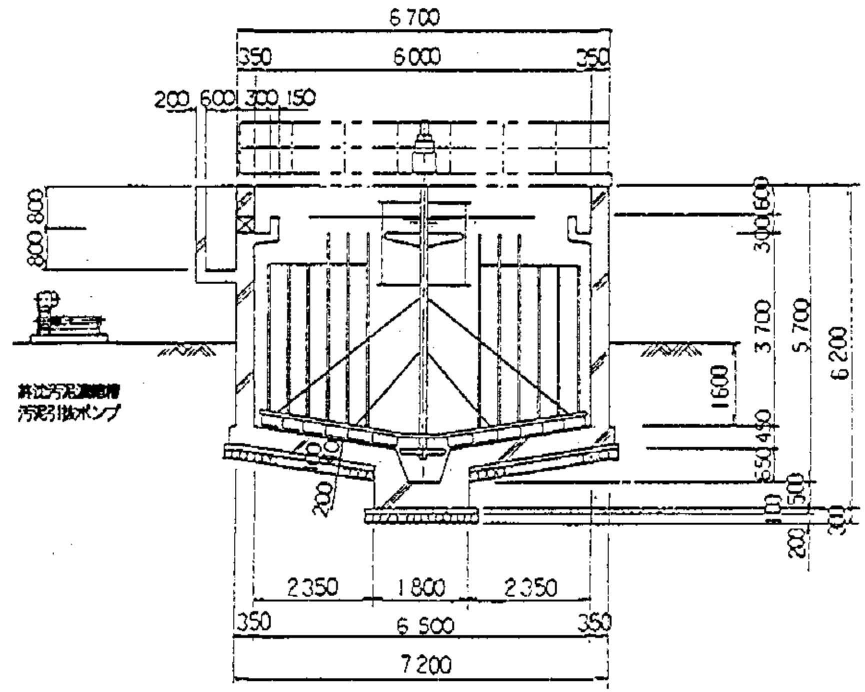


TITLE	No.
Outlet Channel and Bypass Pipe 放流渠・バイパス管計画図	Fig 2.20
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

濃縮タンク（初沈用） S=1/100（Thickener for primary settling tank）



PLAN

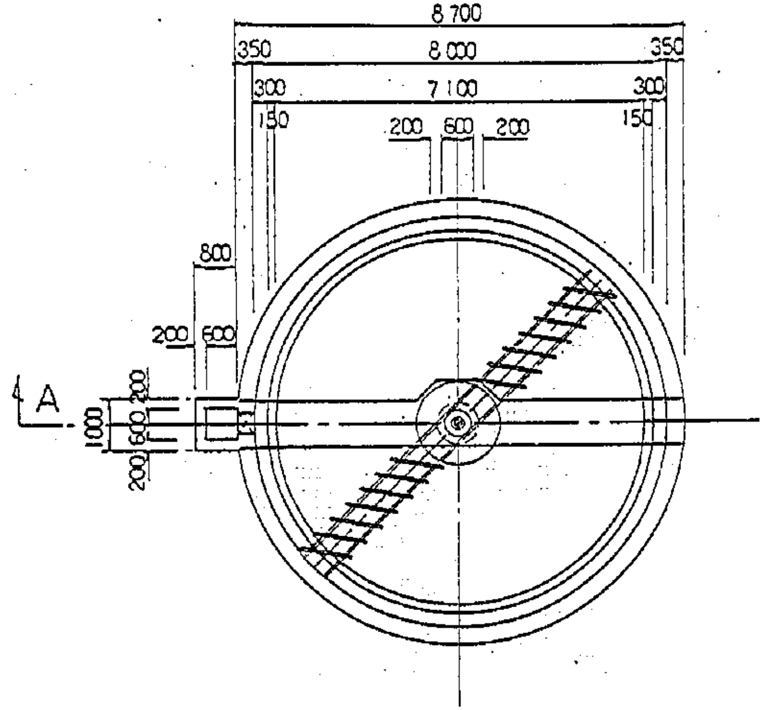


SECTION A－A

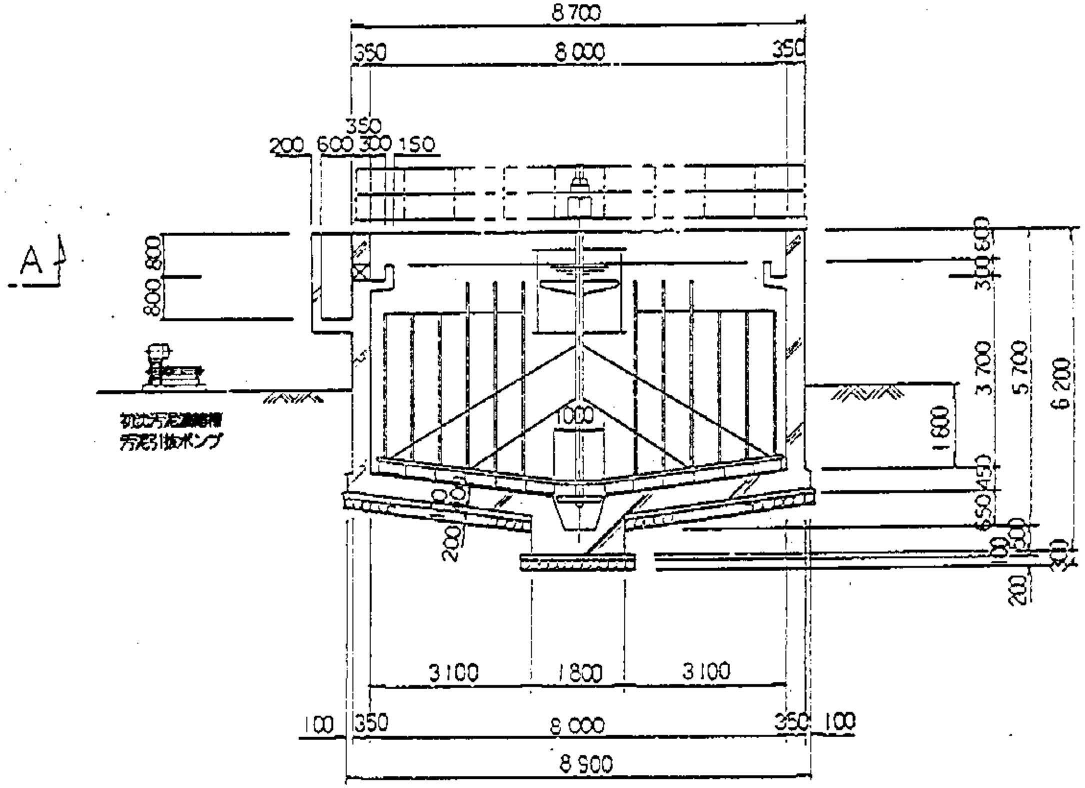
TITLE	No.
Sludge Thickening Tank A 濃縮タンクA 平面図・断面図	Fig 2.21

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

濃縮タンク（終沈用）S=1/100（Thickener for final clarifier）



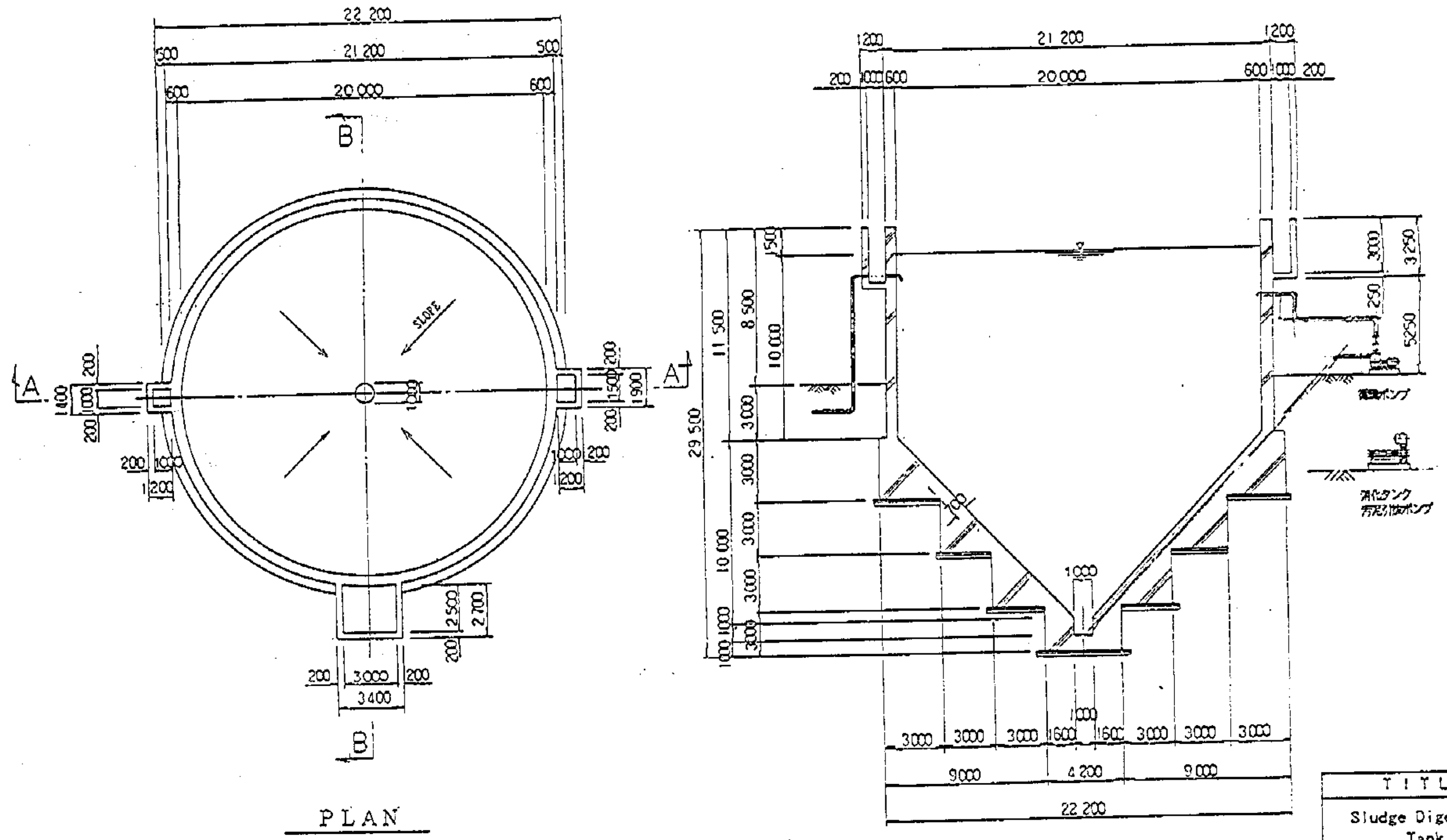
PLAN



SECTION A－A

TITLE	No.
Sludge Thickening Tank B 濃縮タンクB 平面図・断面図	Fig 2.22
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

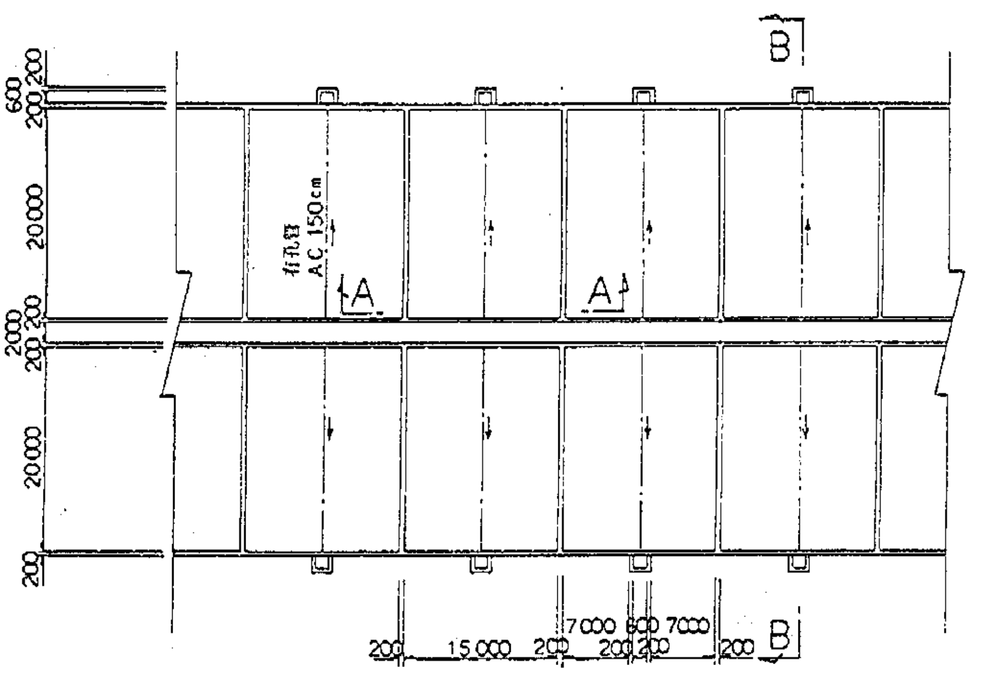
消化タンク S=1/200 (Sludge digestion tank)



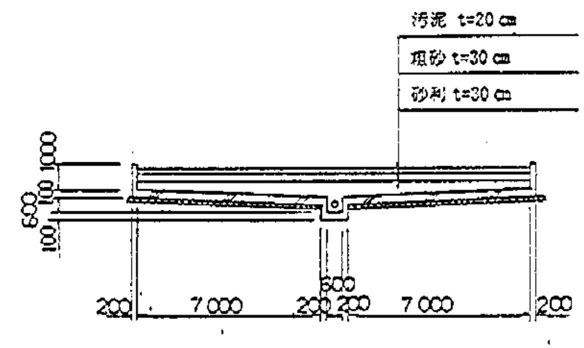
TITLE	No.
Sludge Digestion Tank 消化タンク 平面図・断面図	Fig 2.23

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

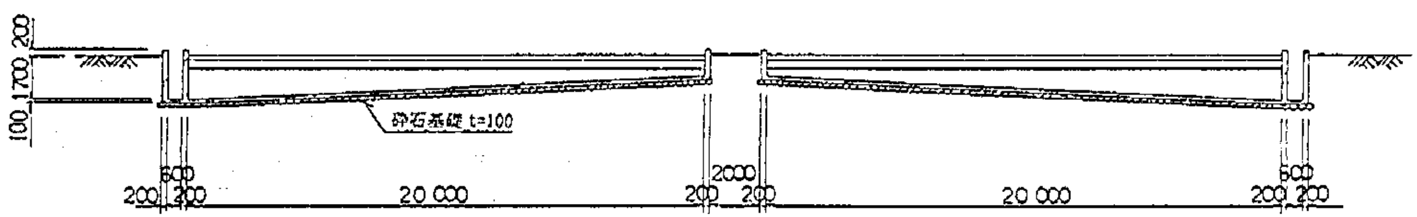
汚泥乾燥床（Sludge drying bed）



PLAN S=1/500



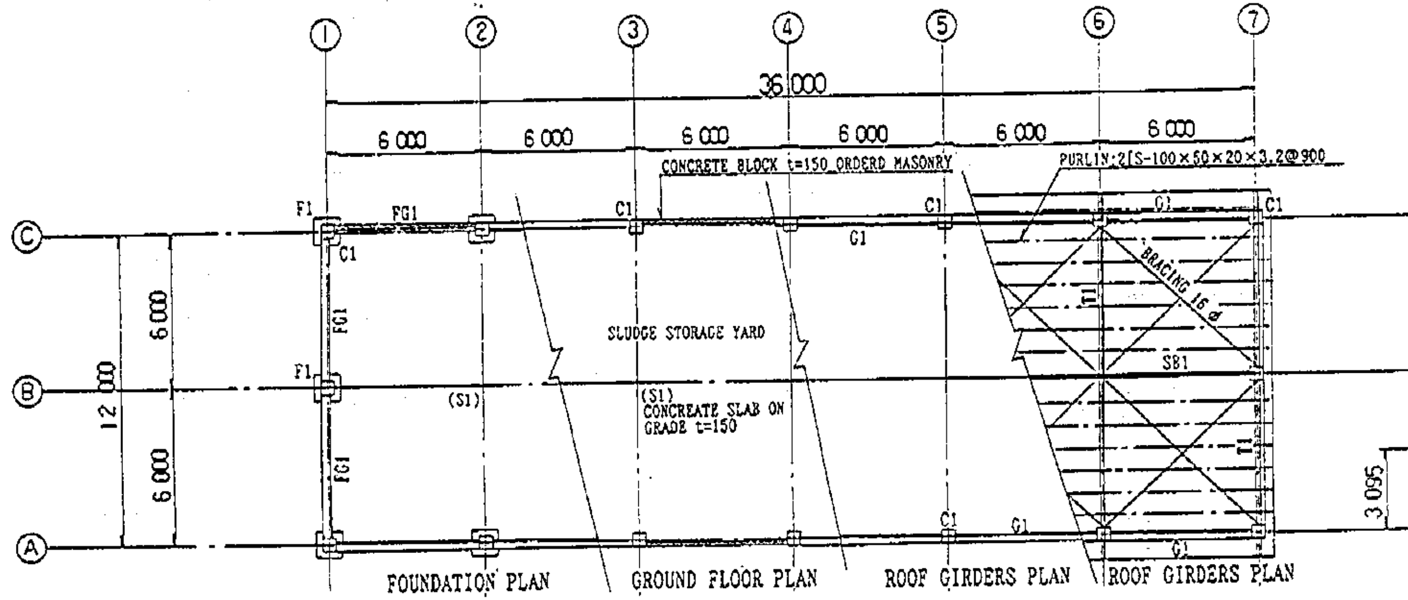
SECTION A－A S=1/200



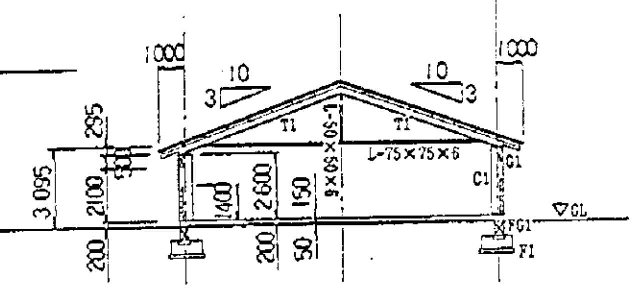
SECTION B－B S=1/200

TITLE	No.
Sludge Beds 汚泥乾燥床 平面図・断面図	Fig 2.24
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

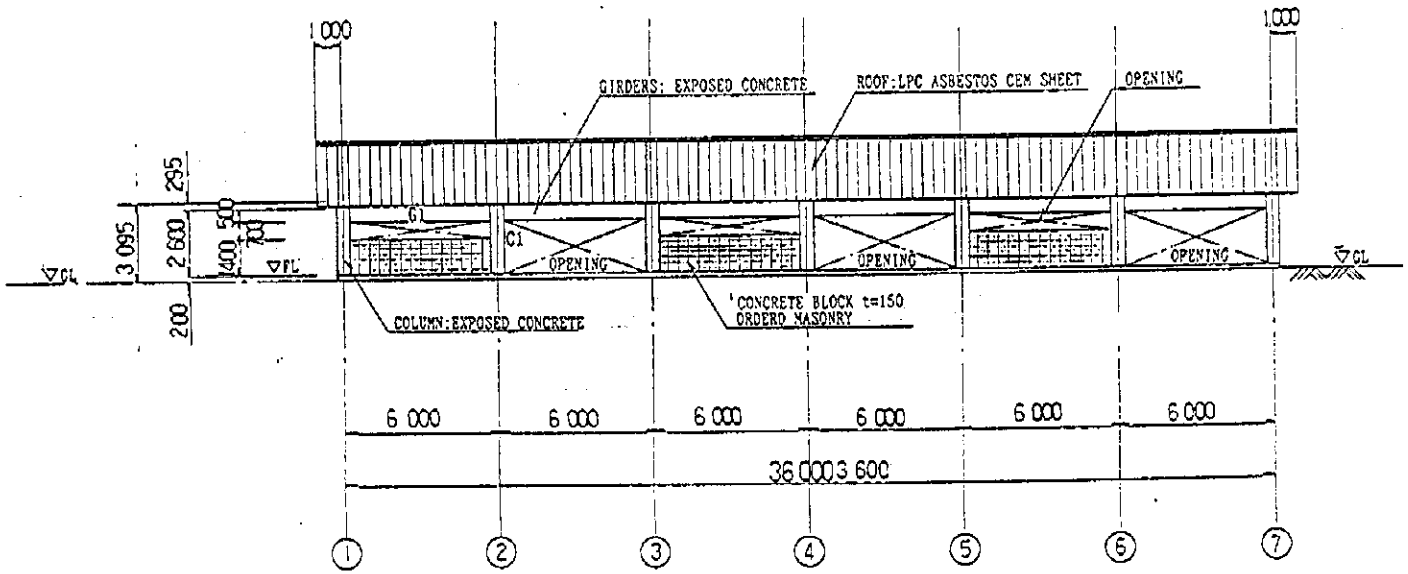
乾燥汚泥貯留庫 S=1/200



GROUND FLOOR PLAN



ELEVATION

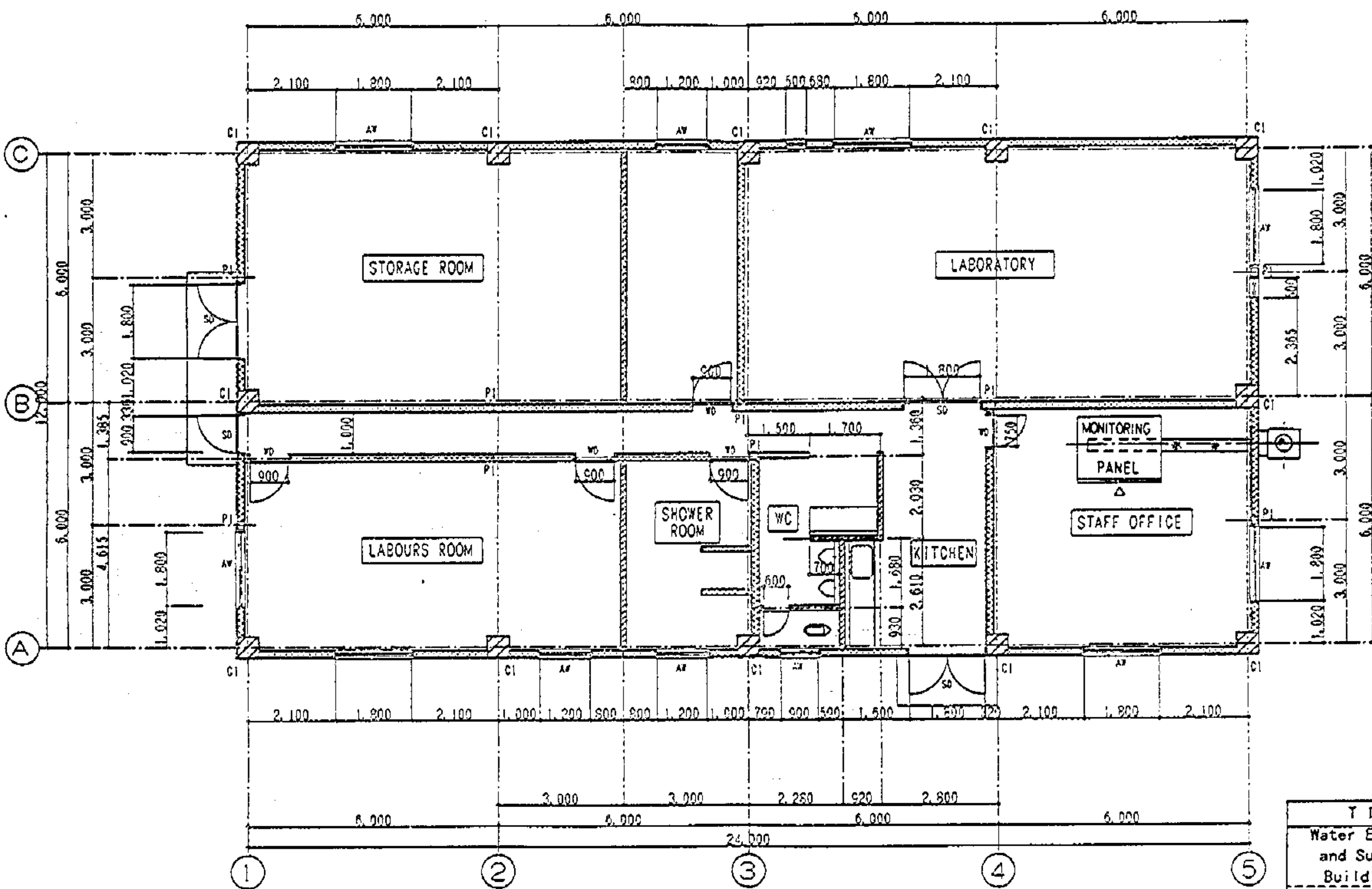


ELEVATION

部 材 表

部材	形状寸法
C1	500×500
F1	1000×1000
FG1	300×600
G1	300×500
SB1	2[S-100×50×20×3.2
T1	H=250×125×4.5×9

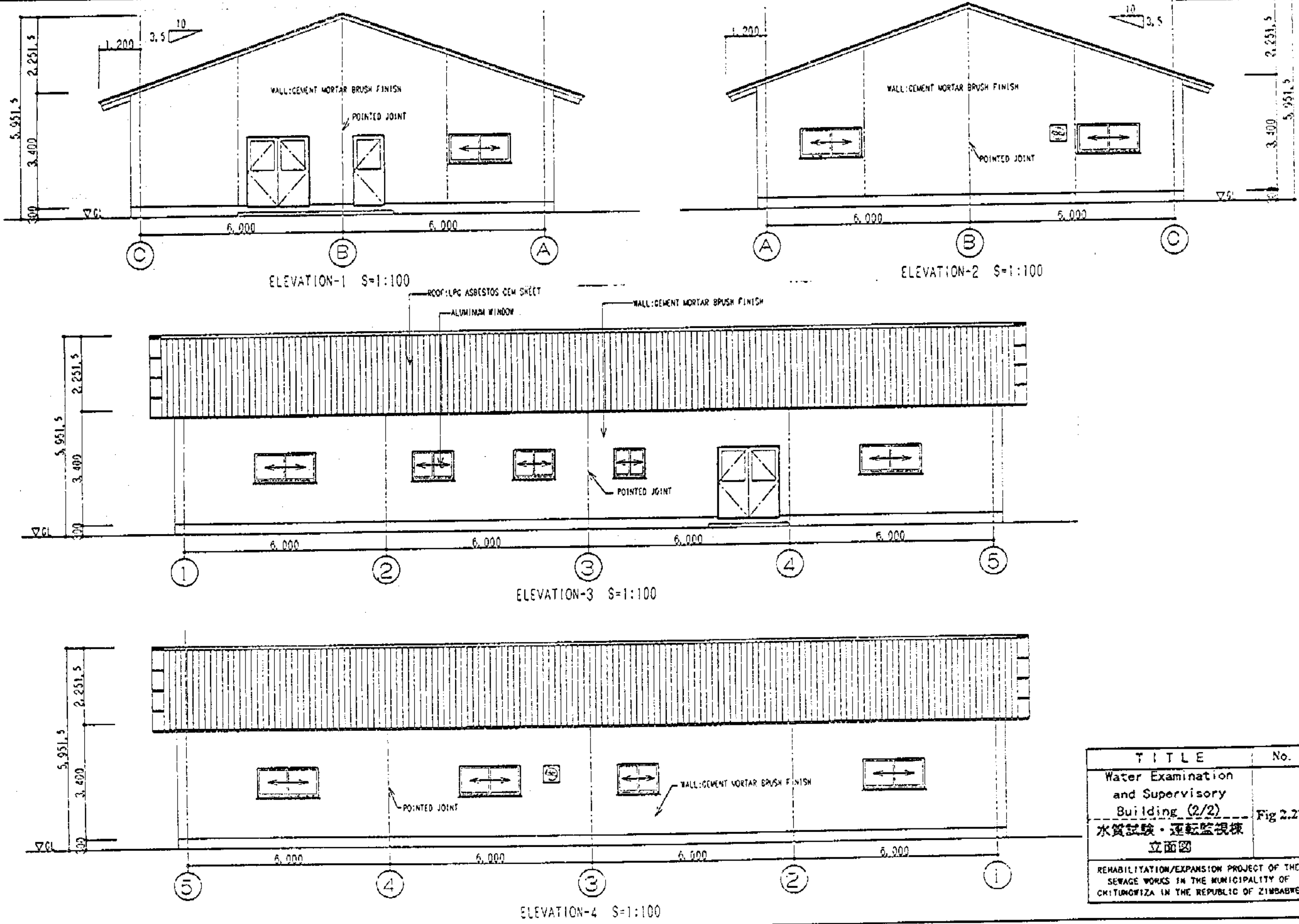
TITLE	No.
Sludge Storage Yard 汚泥貯留施設 平面図・断面図	Fig 2.25
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



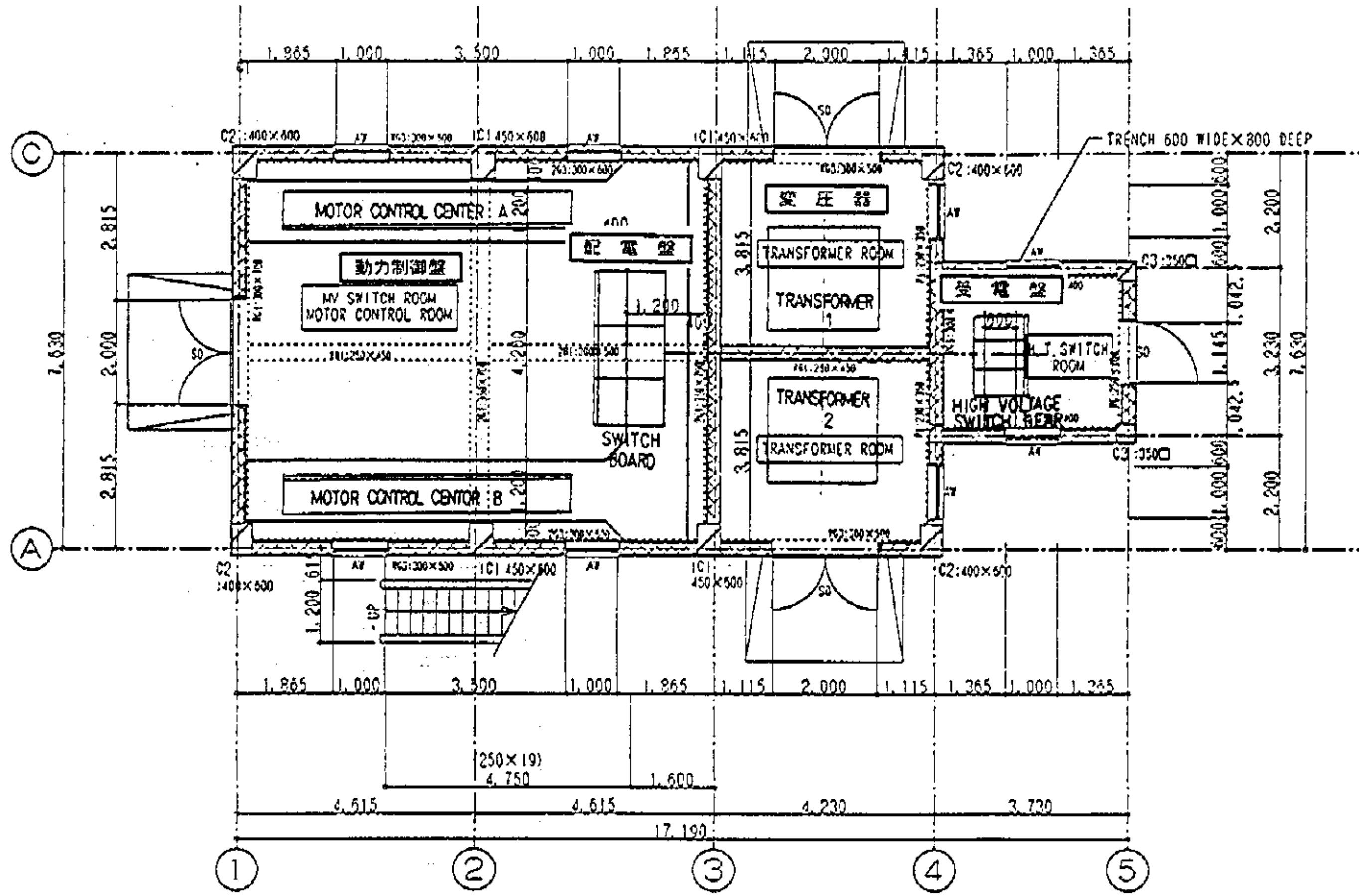
GROUND FLOOR PLAN S=1:100

TITLE	No.
Water Examination and Supervisory Building (1/2) 水質試験・運転監視棟 平面図	Fig 2.26

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

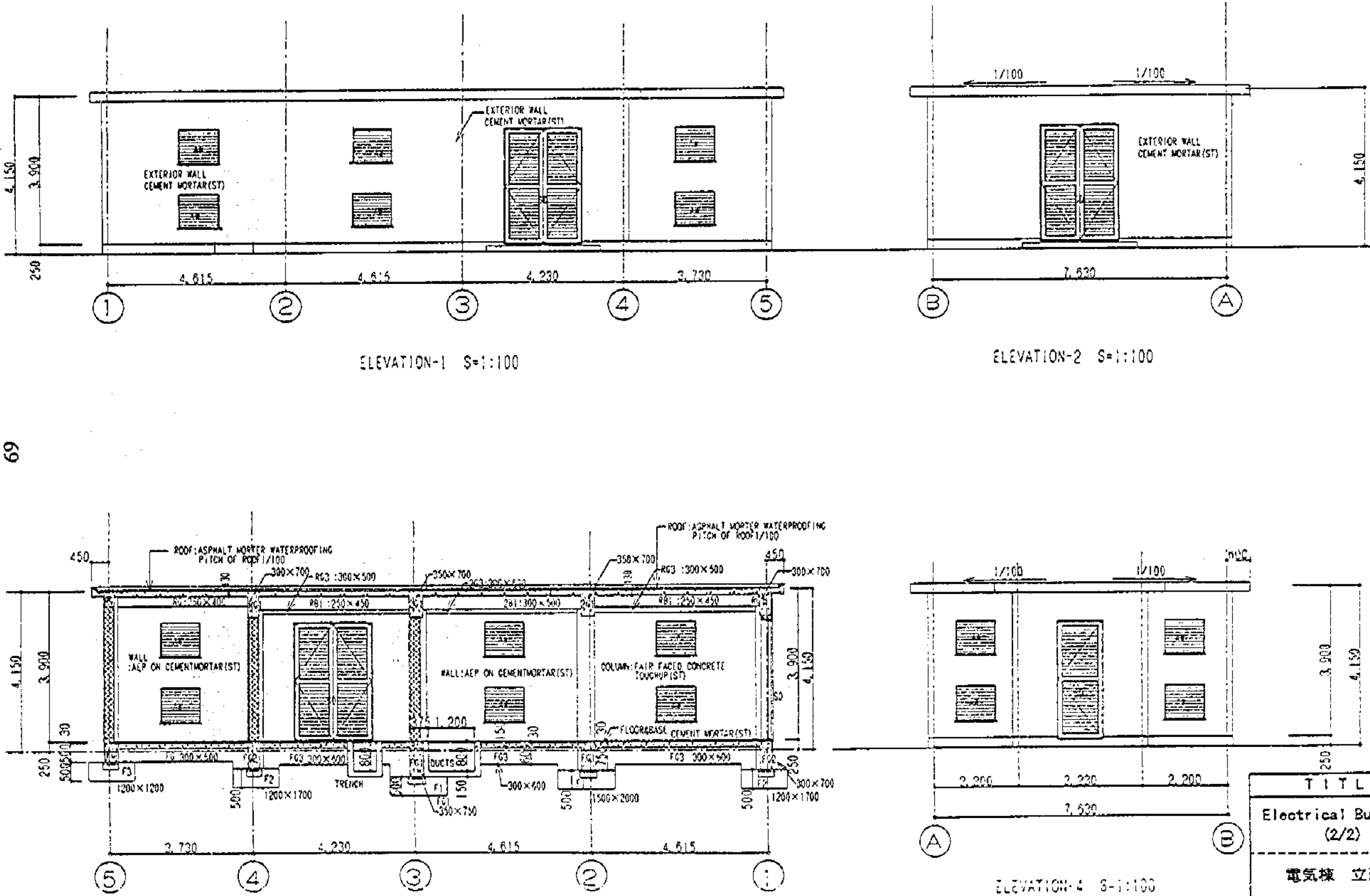


TITLE	No.
Water Examination and Supervisory Building (2/2) 水質試験・運転監視棟 立面図	Fig 2.27
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



GROUND FLOOR PLAN S=1:100

TITLE	No.
Electrical Building (1/2) 電気棟 平面図	Fig 2.28
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



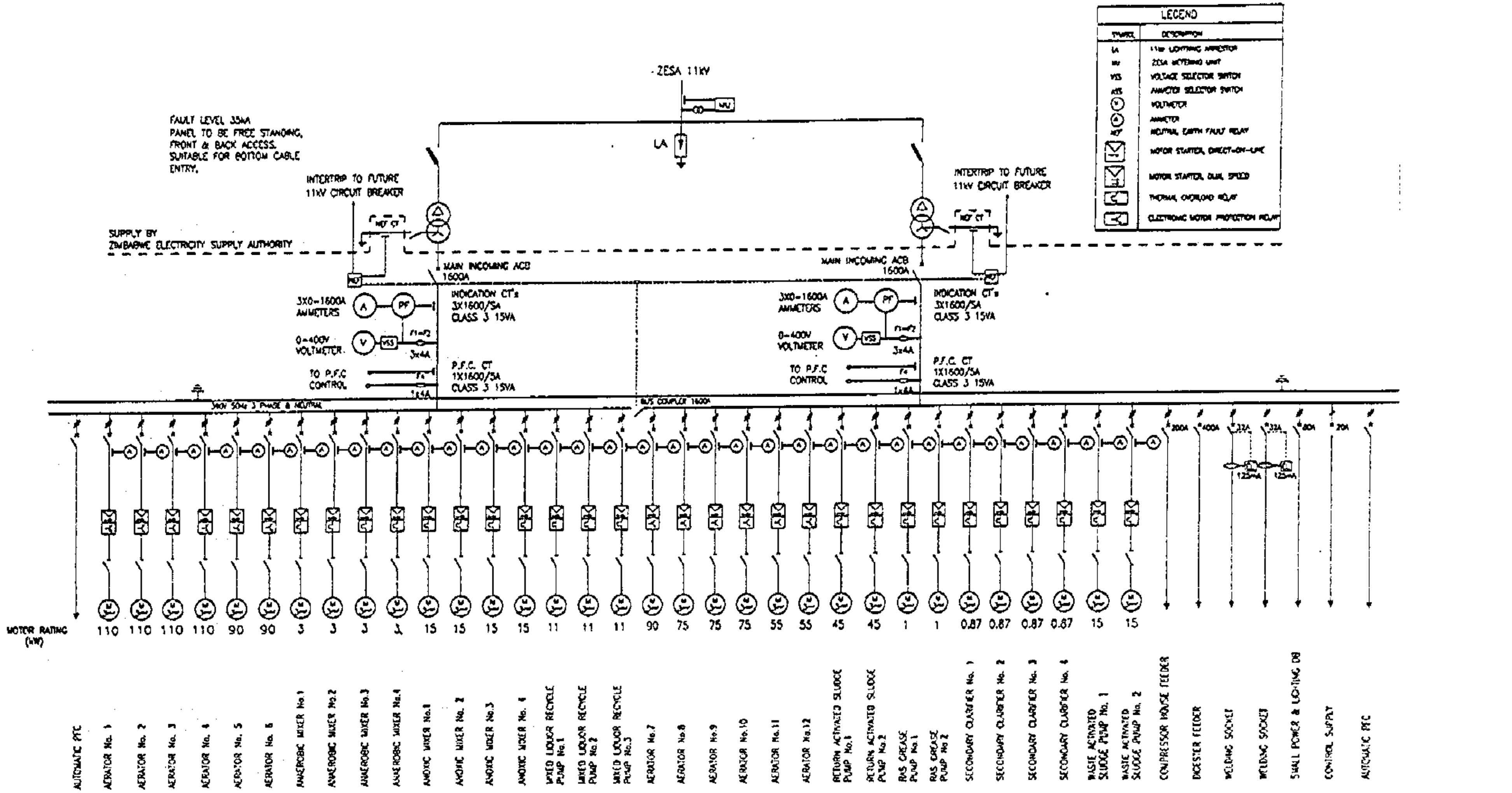
ELEVATION-1 S=1:100

ELEVATION-2 S=1:100

SECTION 1/100

ELEVATION-4 S=1:100

TITLE	No.
Electrical Building (2/2) 電気棟 立面図	Fig 2.29
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	



T I T L E	No.
Singl-line Diagram 単線結線図	Fig 2.30
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

(3) Incidental works of the existing treatment facilities

1) Composition

a. Re-connection work for the existing inlet sewer to the new facilities
The work aims at introducing the sewage to the proposed sewage treatment facilities. Two of the three existing inlet sewers, i.e. the Seke and Zengeza & St. Mary trunk sewers, will be fed into the modified facility.

The sewage influent shall be distributed into existing and proposed facilities making use of proposed exclusive inlet gate, respectively.

Contents: RC Pipe, 1,000 $mm^D \times$ 30 m^L

b. Reconstruction work of the effluent facility for the existing anaerobic pond
The purpose of the work is to ensure the stabilized function of the existing trickling filter facilities by mitigating the daily fluctuation of the influent sewage flow to the anaerobic pond using the proposed facility.

As a result of the Project, the sewage flow to the existing treatment facilities will be reduced drastically from the midnight to early morning time frame. Therefore, flow control function shall be given to the anaerobic pond applying an orifice type effluent facility to the existing four (4) ponds in order to equalize the influent flow for the trickling filter facilities.

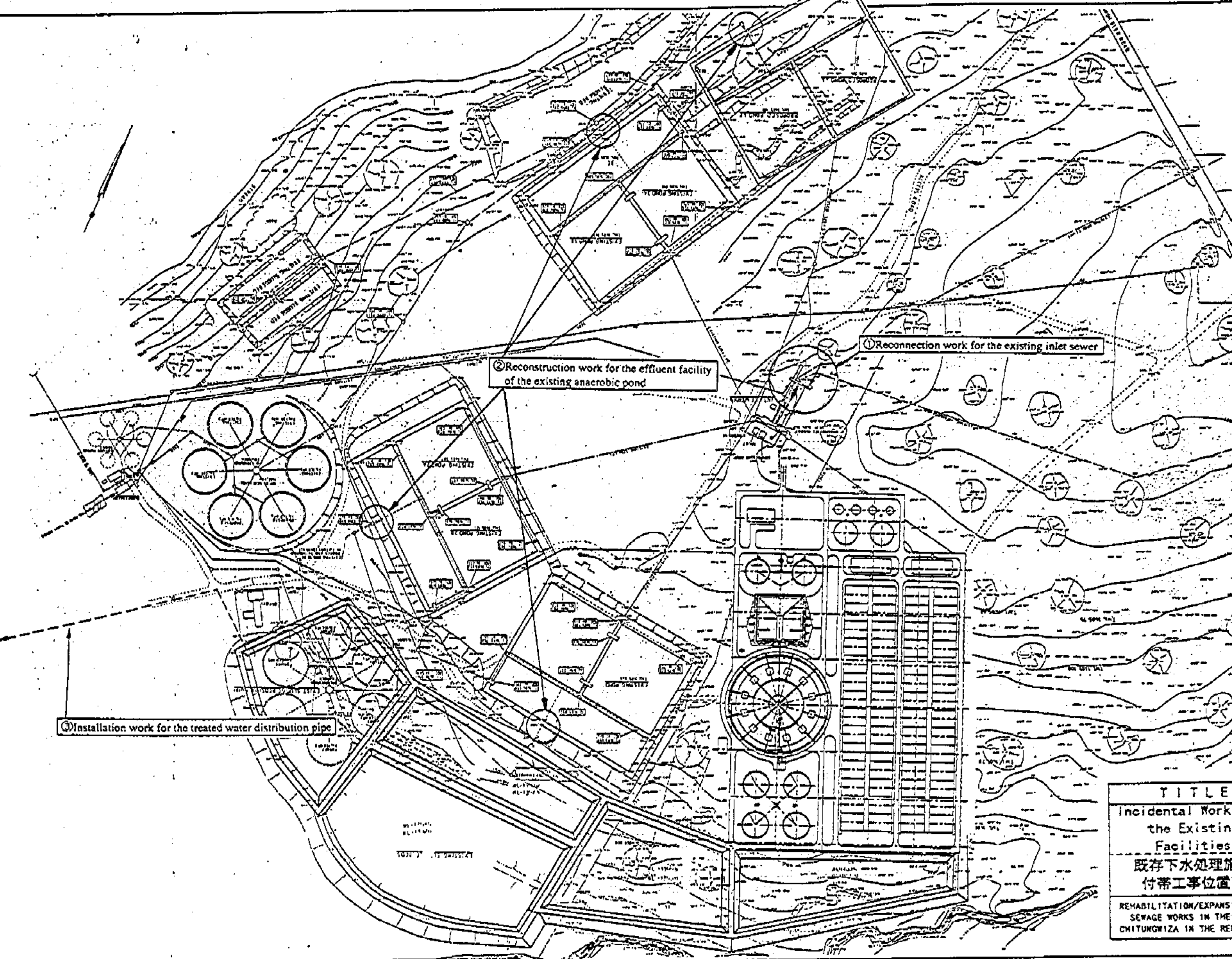
Contents: RC Pit with RC Pipe and PVC pipe× 4 units

c. Installation work for the treated water distribution pipe
The pipe will be arranged to avoid scum accumulation in the anaerobic pond of the Tricor pre-treatment facilities. The source water utilized will be the treated sewage of that is stored in the proposed maturation pond.

Composition: PVC pipe, 150 $mm^D \times$500 m^L

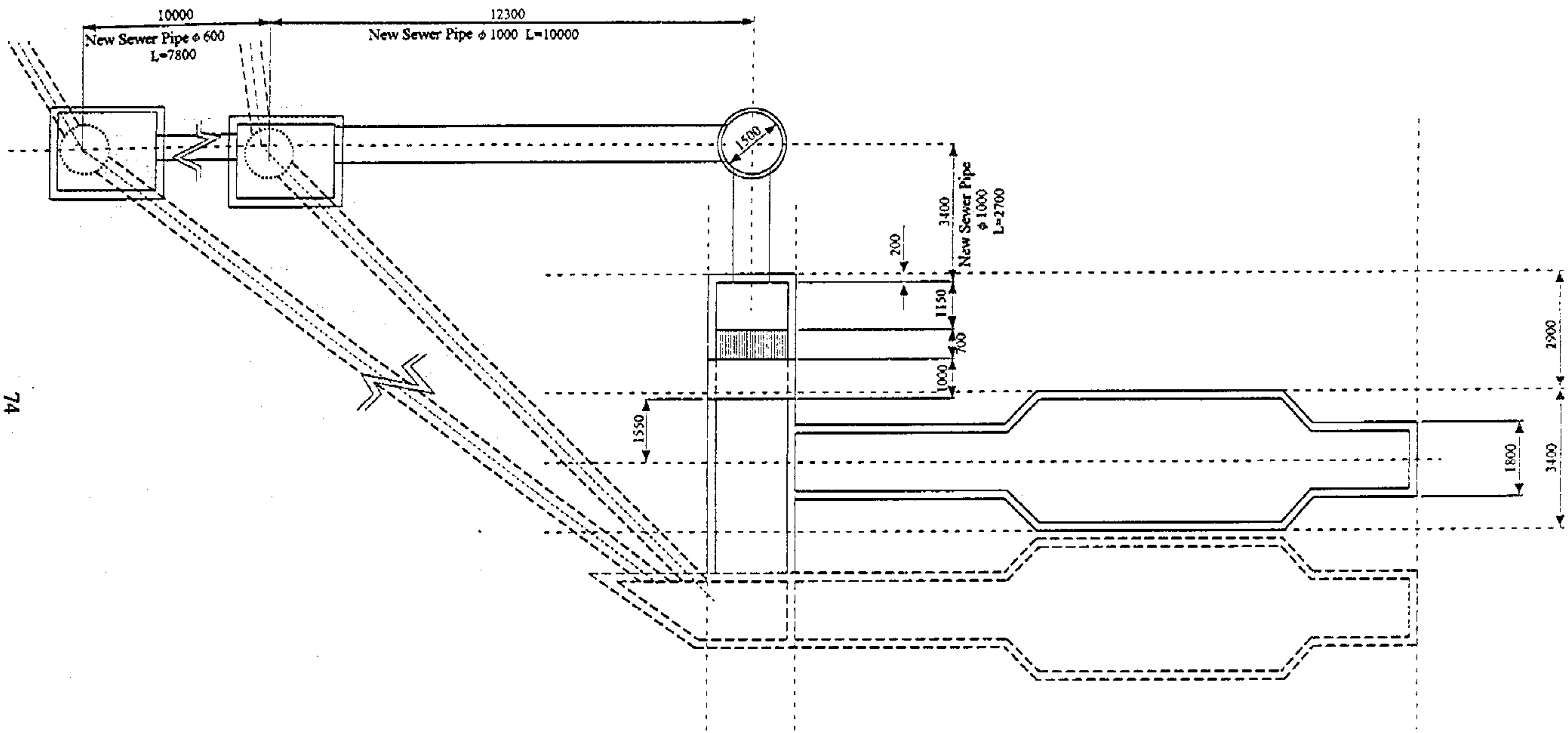
2) Drawings

Fig. 2.31 shows an overview of the incidental works of the existing treatment facilities. Each item of the works is shown in Fig. 2.32 to Fig. 2.34.



TITLE	No.
Incidental Works for the Existing Facilities 既存下水処理施設付帯工事位置図	Fig 2.31
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

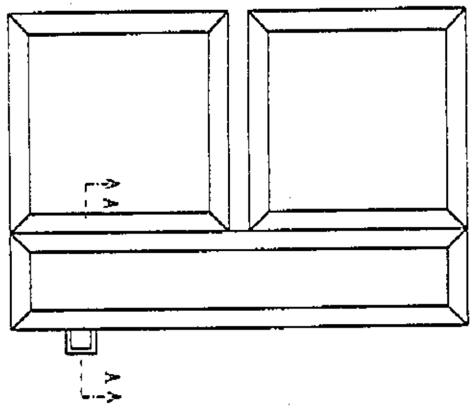
Reconnection of the Existing Inlet Sewer Plan



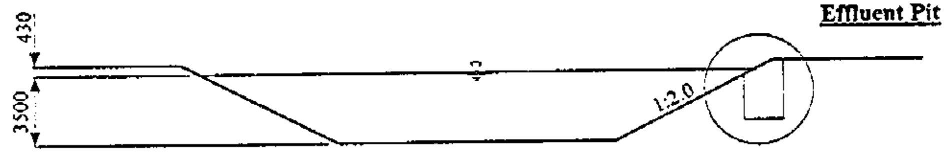
T I T L E	No.
Reconnection of the Existing Inlet Sewer 下水流入管 接続替え計画図	Fig 2.32
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

Anaerobic Pond Effluent Pit

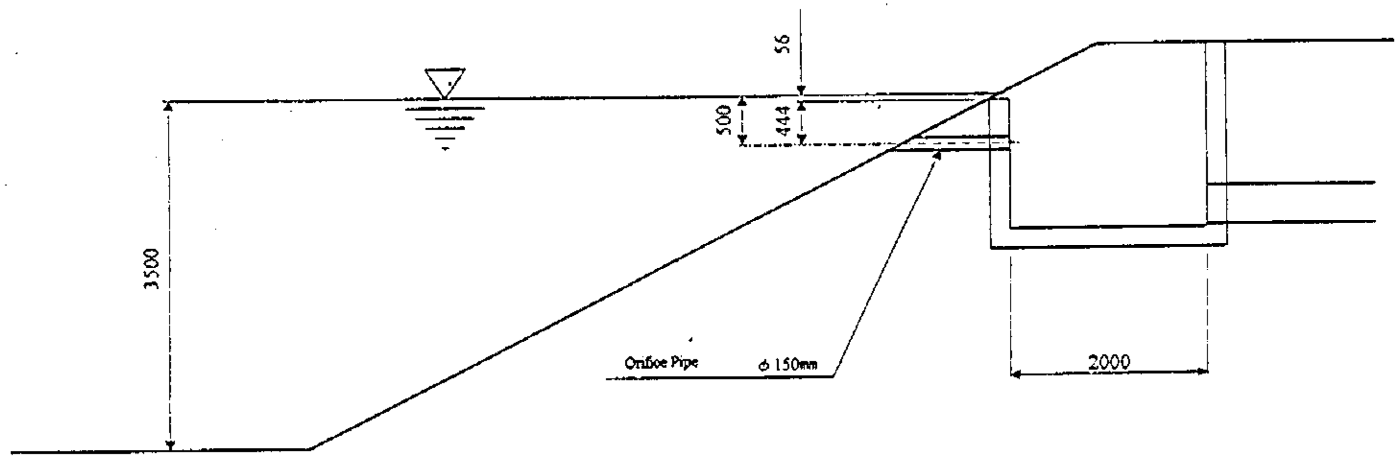
Plan



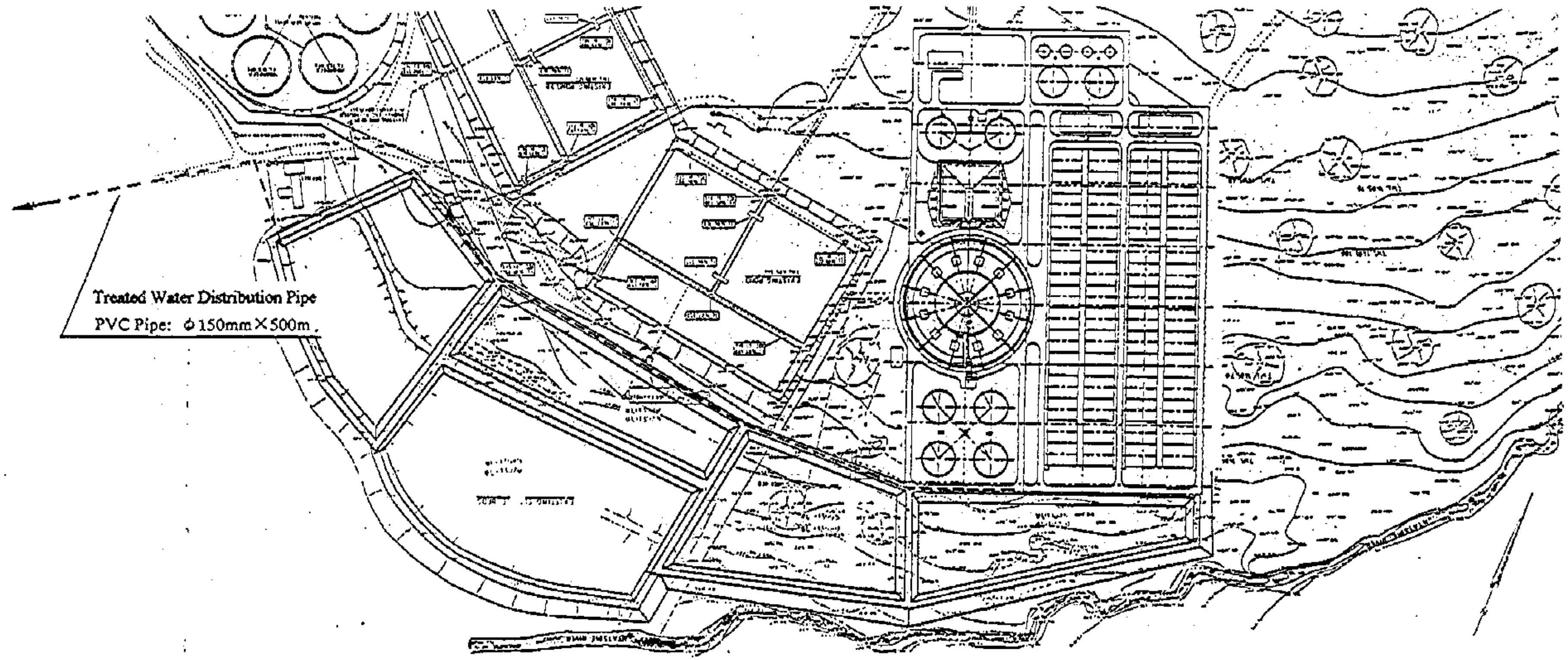
A-A Section

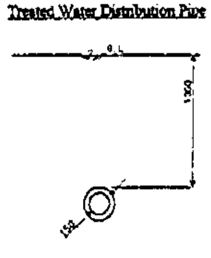


Effluent Pit



T I T L E	No.
Anaerobic Pond Effluent Pit 嫌気性池流出部改造計画図	Fig 2.33
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	





TITLE	No.
Treated Water Distribution Pipe スカム破砕用水送水管敷設計画図	Fig 2.34

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

(4) Rehabilitation works for the existing pumping station

1) Composition

Of the existing three (3) pumping stations, two (2) stations in St. Mary district and one station in the Tircor district, have been playing an important role for the sewerage system in Chitungwiza municipality.

However, the facilities; especially the mechanical and electrical facilities, have become superannuated and are now an obstacle in the system.

Thus, the rehabilitation work for the pumping stations was determined under the conditions of necessity.

The fundamental rules are to select a latest model of the existing pump facilities, also to renovate the incidental electrical equipment, such as control panels, electric cables and float switches at the same time.

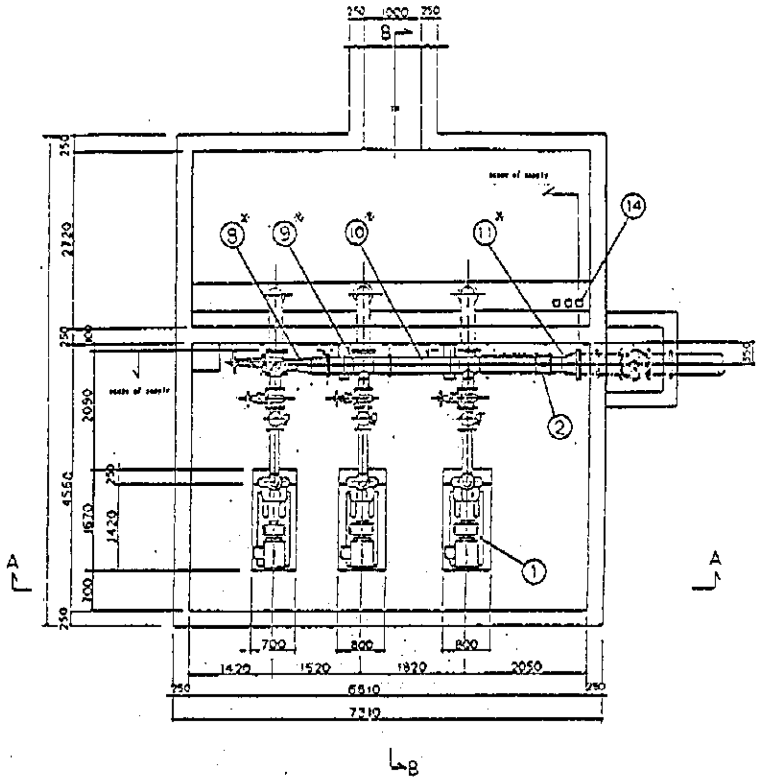
An electro-magnetic flow meter shall be introduced to each pumping station to improve the existing inadequate conditions for operation owing to the fact that the stations do not have such kind of facility.

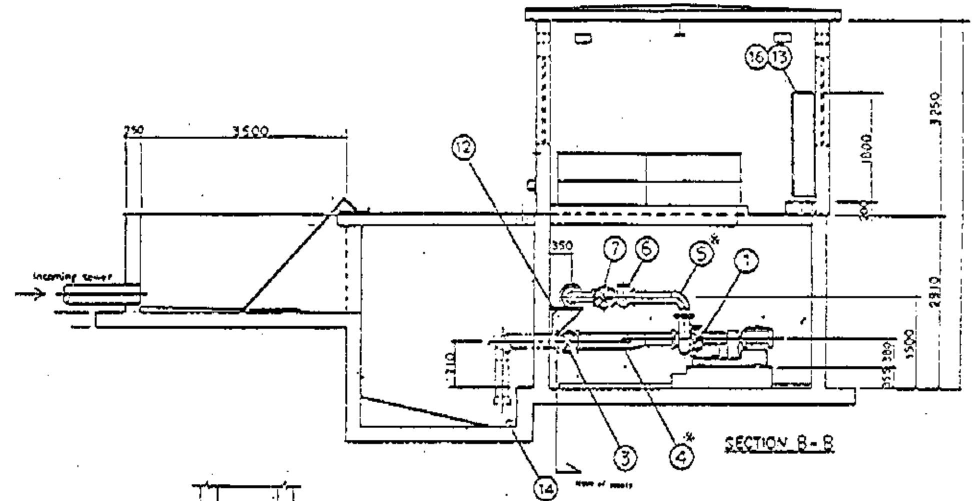
Table 2.5 Main equipment for the rehabilitation of existing pumping station

Location	Name	Specification	Nos.	Remark
St. Mary No. 1 Pumping station	Pump	$\phi 150 \times 2.6m^3/min. \times 34.5m \times 30kW$	3	
	Flow meter	$0 - 7.8m^3/min.$	1	
	Control panel	w/ Level switch	1	
St. Mary No. 2 Pumping station	Pump	$\phi 100 \times 1.2m^3/min. \times 12.5m \times 5.5kW$	2	
	Flow meter	$0 - 2.4m^3/min.$	1	
	Control panel	w/ Level switch	1	
Tircorol Pumping station	Pump	$\phi 150 \times 2.3m^3/min. \times 28.0m \times 22kW$	3	
	Flow meter	$0 - 6.9m^3/min.$	1	
	Control panel	w/ Level switch	1	

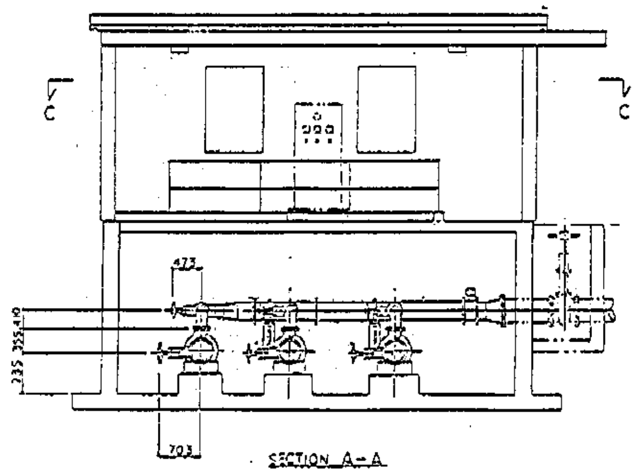
2) Drawings

The basic design drawings related to the rehabilitation work for the pumping stations are shown in Fig. 2.35 to 2.37.

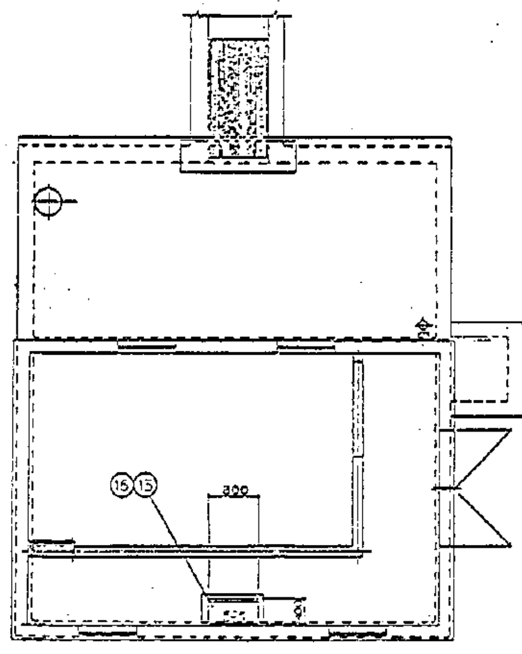




SECTION B-B



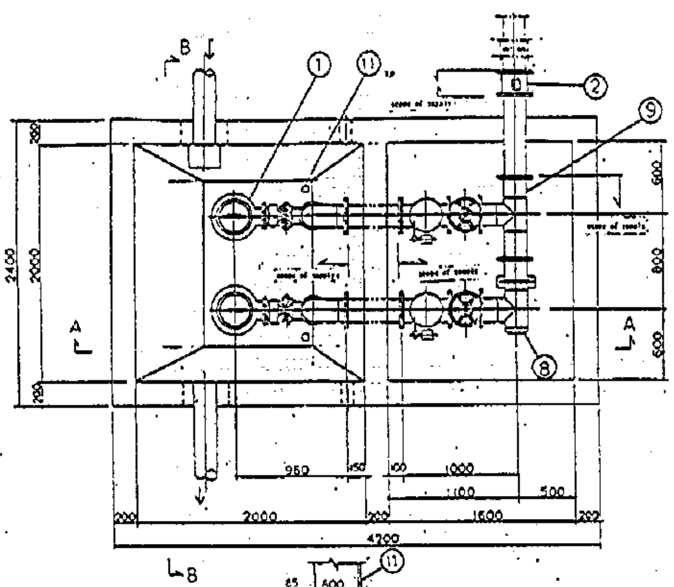
SECTION A-A

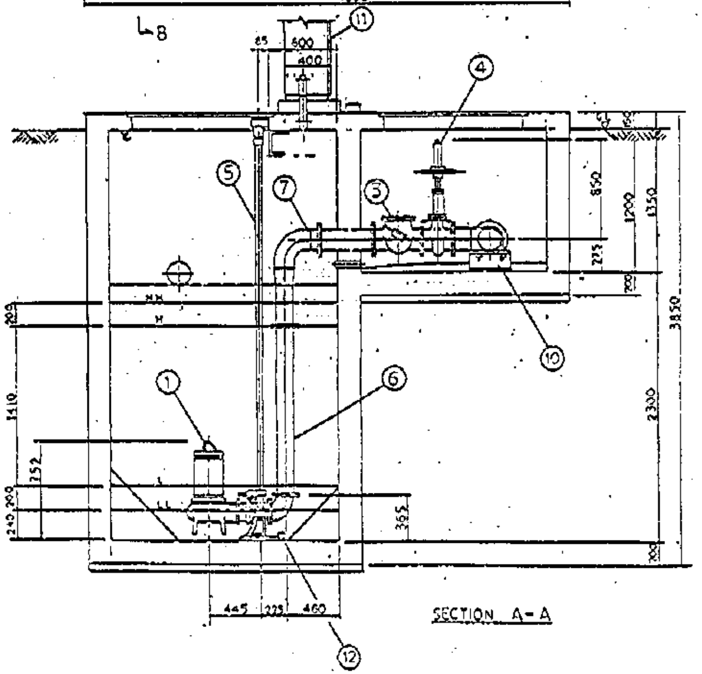


SECTION C-C

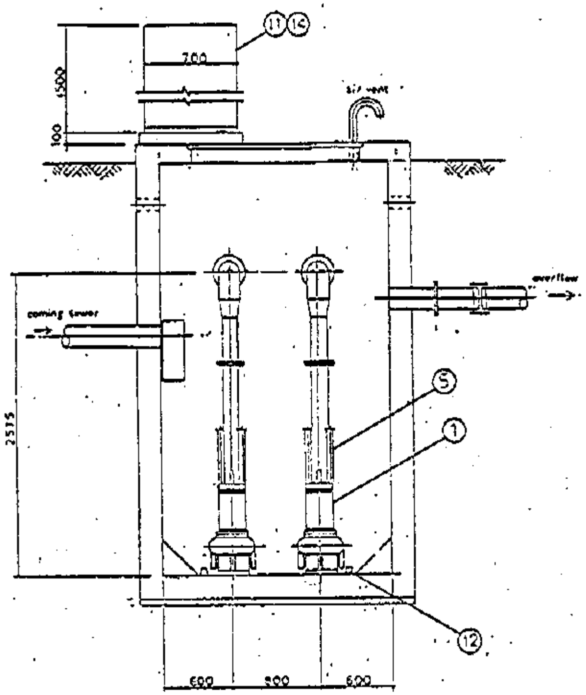
No.	Name	Qty
1	Motor Pump	3
2	Flowmeter	1
3	Gate Valve	3
4	Suction Pipe	3
5	Delivery Pipe	3
6	Check Valve	3
7	Gate Valve	3
8	Delivery Pipe	1
9	Delivery Pipe	1
10	Delivery Pipe	1
11	Delivery Pipe	1
12	Support	2
13	Control Panel	1
14	Water Level Switch	3

TITLE	No.
St. MARY No. 1 Pump Station Rehabilitation Plan St. MARY No. 1ポンプ場改修計画図	Fig 2.35
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	





SECTION A-A

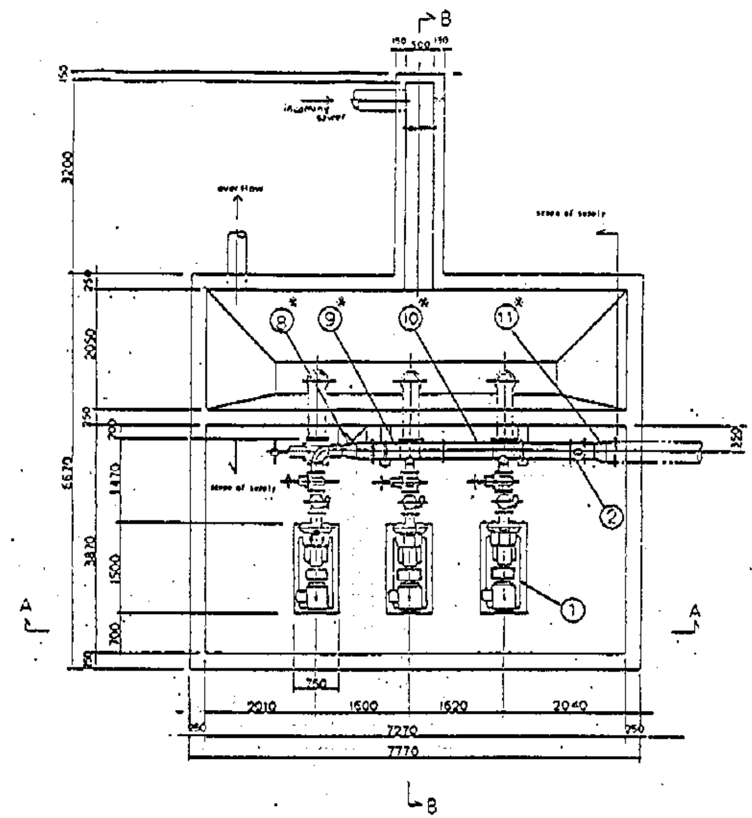


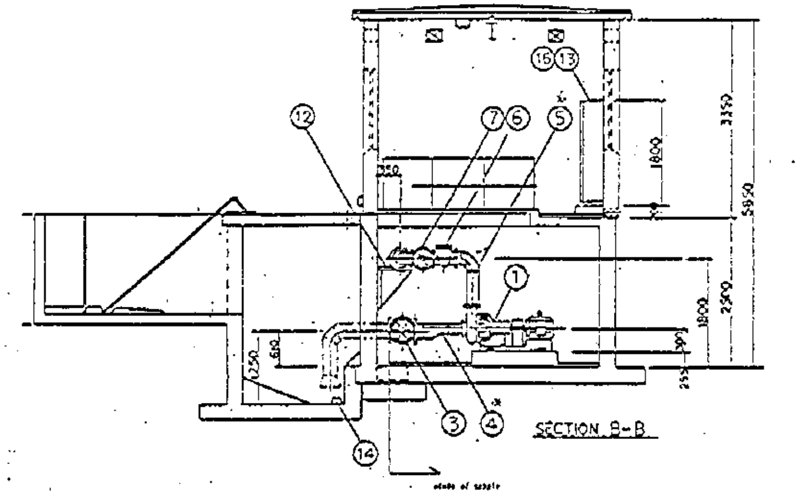
SECTION B-B

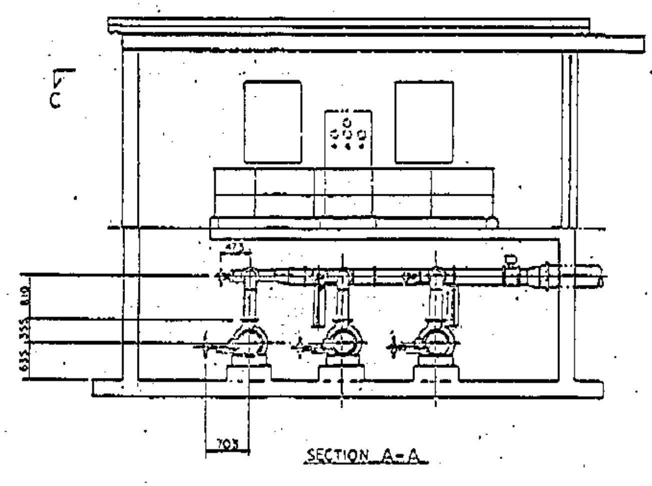
No.	Name	Q'ty
1	Motor Pump	2
2	Flowmeter	1
3	Check Valve	2
4	Gate Valve	2
5	Guide Pipe	4
6	Delivery Pipe	2
7	Delivery Pipe	2
8	Delivery Pipe	1
9	Delivery Pipe	1
10	Support	1
11	Conyrol Panel	1
12	Water Level Switch	2

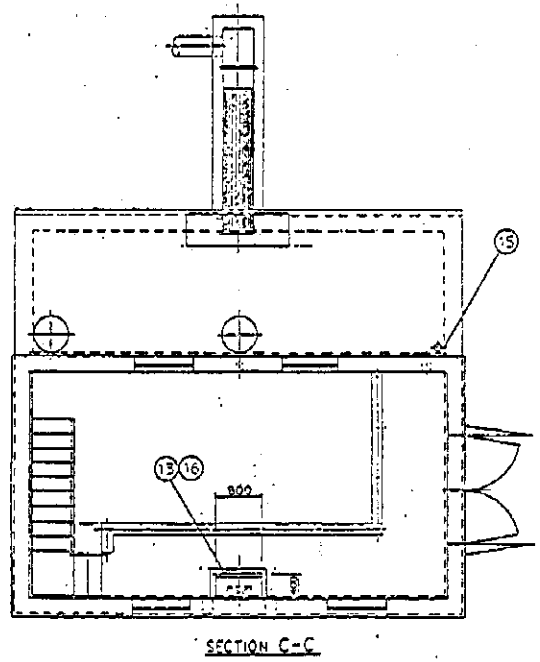
TITLE	No.
St. MARY No. 2 Pump Station Rehabilitation Plan St. MARY No. 2ポンプ場 改修計画図	Fig 2.36

REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE









No.	Name	Q'ty
1	Motor Pump	3
2	Flowmeter	1
3	Gate Valve	3
4	Suction Pipe	3
5	Delivery Pipe	3
6	Check Valve	3
7	Gate Valve	3
8	Delivery Pipe	1
9	Delivery Pipe	1
10	Delivery Pipe	1
11	Delivery Pipe	1
12	Support	2
13	Control Panel	1
14	Water Level Switch	3

TITLE	No.
Tilcor Pump Station Rehabilitation Plan Tilcorポンプ場改修計画図	Fig 2.37
REHABILITATION/EXPANSION PROJECT OF THE SEWAGE WORKS IN THE MUNICIPALITY OF CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE	

(5) Equipment procurement

Vehicles for O&M and water quality analysis equipment shall be procured as well as the mechanical and electrical facilities for the proposed sewage treatment facilities.

1) Vehicles for O & M

A number of backhoe and a dump truck shall be prepared for the maintenance work after the completion of the Project (e.g. screening and scum removal, transporting the dried sludge from the drying bed to the storage yard).

At present, Chitungwiza municipality conducts its maintenance work for sewer reticulation targeting about 42 Km^2 of the municipal area and 450 Km of the total length of the existing sewers.

The vehicles concerning the work are only a truck (3.5t) to transport workers and two pick-up trucks (1t) for supervisory and pipe installation works.

Likewise, one of the two pick-up trucks has been used more than 10 years and is usually inoperative.

Considering the above-mentioned condition, procurement of a pick-up truck is necessary to ensure the sustainable maintenance of sewers with implementing site investigation.

A few comments will be made below on the points pertinent to the maintenance work for the sewers.

a. Site investigation

The investigation work should be prepared covering the entire sewered area in the municipality; also, such work should be performed repeatedly every two years (13 Km^2/year).

The investigation team should consist of an attendant and two workers, and the team should describe the site conditions in a daily record.

b. Pipe cleaning

The yearly pipe cleaning work should be prepared for the entire sewers system in the municipality and should be conducted from the a priority area based on the results of site investigations.

The work shall be conducted by four teams (six persons per team) utilizing manual-type cleaning and should be expected to cover 25 km per year.

c. Pipe rehabilitation

The pipe rehabilitation work is a requisite. Due to the antiquated nature of the existing sewers and their composition, replacement and repair of the damaged sewers will be required. The target sewers are estimated to be about 100 km, and the work should be conducted every ten years for 50% of target sewers.

2) Water quality examination equipment

Water quality examinations are executed with the aim of ensuring proper operation of the treatment facilities based on the examination results. This will involve checking the water quality of the river and industrial wastewater.

The water quality items to be examined in the proposed treatment facility should focus on fundamental items, such as water temperature, pH ,COD ,SS and T-N. Therefore, precise water quality analysis, for example those covering Phosphorus, heavy metals and so on, will be conducted on a contract basis.

The major equipment above-mentioned are shown in Table 2.6.

Table 2.6 Major Equipment

Name	Specification	Piece	Remarks
Vehicle for O&M			
Backhoe	$0.35m^3$	1	
Dump track	6t	1	
Pickup	4WD	1	
Equipment for laboratory			
Portable pH meter		1	
Portable DO meter		1	
Portable ORP meter		1	
MLSS meter		1	
Spectrophotometer		1	
pH meter	for Laboratory use	1	
Electronic balance	readability : 0.1 mg	1	
Electronic drying oven		1	
Water distillation apparatus	heating	1	
Refrigerator	with freezung room	1	
Electronic balance	readability : 0.01 g	1	
Ultrasonic cleaner		1	
Microscope		1	
water bath		1	
Centrifuge		1	
Vacuum pump		1	
Drying shelf		1	
Desiccator	Plastic	1	
Hot water supply apparatus		1	
Draft chamber	120Hx75Dx250W(cm)	2	
UV/VIS Spectrophtmeter		1	
Center work table	180x120x80	2	
Side work table	180x75x80	1	
Corner table	110x110x80	4	
Balance table	90x75x75	1	
Microscope table	150x75x75	1	
Chemical storage equipment	120x50x180	1	
Equipment storage equipment	180x50x180	1	
Sink	180x75x80	2	
Working chair		6	
Glassware		1 set	
Chemicals		1 set	