JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
REPUBLIC OF ZIMBABWE

THE STUDY ON WATER POLLUTION CONTROL IN THE UPPER MANYAME RIVER BASIN IN THE REPUBLIC OF ZIMBABWE

VOLUME 4

DATA REPORT

MARCH 1997

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

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WATER POLLUTION CONTROL MASTER PLAN
FOR
THE UPPER MANYAME RIVER BASIN

VOLUME 4
DATA REPORT

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FOR
THE UPPER MANYAME RIVER BASIN

PART I

WATER POLLUTION MASTER PLAN
FOR
THE UPPER MANYAME RIVER BASIN

CHAPTER 1

Minutes of Meeting
exchanged between JICA and Zimbabwe Side

MINUTES OF MEETING
ON
INCEPTION REPORT
FOR
THE STUDY
ON
WATER POLLUTION CONTROL
IN
THE UPPER MANYAME RIVER BASIN
IN
THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN
THE MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
AND
THE JICA STUDY TEAM

HARARE, APRIL 29, 1996

Mr. A. C. Mpamhanga
Deputy Secretary / Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Masatoshi Momose
Team Leader,
JICA Study Team

Witness:

Mr. J. T. Mutamiri
Under Secretary / Deputy Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Kuniharu Yoshimoto
Chairman
JICA Advisory Committee

吉本國春

The Japan International Cooperation Agency (hereinafter referred to as "JICA), the official agency responsible for the implementation of the technical co-operation programmes of the Government of Japan, dispatched the Study Team to the Republic of Zimbabwe on April 20, 1996 to conduct the Study on Water Pollution Control in the Upper Manyame River Basin" (hereinafter referred to as "the Study") in accordance with the agreement on the Scope of Work for the Study between the Preparatory Study Team of JICA and the Ministry of Local Government, Rural and Urban Development of the Republic of Zimbabwe (hereinafter referred to as "MLGRUD") signed on November 29, 1995.

A series of discussions were made on the Inception Report for the Study (hereinafter referred to as "the IC/R") between the Study Team and officials concerned from MLGRUD, City of Harare, Chitungwiza Municipality, Norton Town Council, and Ruwa Local Board. The attendants for the meetings are listed in Appendix A attached herewith.

The contents of the IC/R were generally agreed between the two parties. The following are major items confirmed through discussions.

1. Objective and Scope of Work for the Study

As stipulated in the Scope of Work agreed between MLGRUD and the JICA Preparatory Study Team, the objectives of the Study are as follows:

(1) Formulation of a Master Plan for water pollution control in the Upper Manyame River basin for the target year 2015 in order to secure potable water supply with acceptable water quality and to establish sustainable pollution control systems.

(2) Conducting a Feasibility Study for the priority project/s identified in the Master Plan.

(3) Provision of technology transfer to the counterpart personnel through the course of the Study.

The Study in Zimbabwe started on April 22, 1996 upon arrival of the Study Team and is scheduled to be completed by the end of March, 1997 through three-stage works including those in Zimbabwe and Japan as presented in the IC/R.

The Study area by planning purpose are as follows:

(1) Water pollution analysis; 3,900 km^2 covering entire upper Manyame River basin

(2) Study of water pollution control countermeasures; 2,900 km^2 excluding those basins of Gwebi river and Muzururu river.

The base year and target years for the planning purpose are agreed as shown below:

Base year: 1995
Urgent (F/S): 2000 (1997-2000)
Medium-term: 2005
Long-term: 2015

2. General Approach to the Project and Study Methodology

General approach to the main components of the Study was generally confirmed as proposed in the IC/R. With regard to water pollution control study, Lake Chivero and Lake Manyame will be considered, although a qualitative analysis may be employed for Lake Manyame.

It was confirmed that the Study will be made in full use of existing data, and simple and practical approach and methodology will be adopted to meet the Study objectives under the time constraint.

It was also confirmed that the priority project/s for the feasibility study shall be determined by the beginning of July, 1996 to conduct Initial Environmental Examination (IEE).

3. Manner of Implementation of the Study

The Steering Committee for the Study will be established to play an important role both for the implementation of the Study and realisation of the project. The committee will be chaired by MLGRUD and will be composed of officials from concerned authorities. A counterpart team will be organised consisting of an overall co-ordinator from MLGRUD and those from the City of Harare, Chitungwiza Municipality, Norton Town Council, and Ruwa Local Board.

4. Undertaking of the Government of Zimbabwe

The MLGRUD will make arrangements for the Study Team to facilitate smooth conduct of the Study as specified in the IC/R.

APPENDIX A

LIST OF ATTENDANTS

Ministry of Local Government, Rural and Urban Development:

Mr. J. T. Mutamiri	Deputy Director, Development, Planning and Co-ordination
Mr. P. F. Duri	Senior Administrative Officer
Mr. A. F. N. Mangena	Acting Assistant Secretary
Mr. J. Mugabe	Administrative Officer

City of Harare:

Mr. E. Mudzuri	Deputy Chief Engineer, Dept. of Works
Mr. Z. Hoko	Engineer, Dept. of Works

Chitungwiza Municipality:

Mr. M. Khosla	Director, Engineering Services

Norton Town Council:

Mr. G. Magombedze	Town Engineer

Ruwa Local Board:

Mrs. F. Mhiti	Acting Secretary
Mr. I. Musaka	Sewerage & Water Engineer

JICA Advisory Committee:

Mr. Kuniharu Yoshimoto	Chairman
Mr. Kazuhiro Fukuda	Co-ordinator, JICA

JICA Study Team:

Mr. Masatoshi Momose	Team Leader
Mr. Hirofumi Sano	Sewerage Planning
Mr. Takafumi Kiguchi	Water Pollution Analysis
Mr. Shusaku Ueno	Water Use Planning
Mr. Hiroshi Terayama	Water Quality Analysis & Monitoring

MINUTES OF MEETING
ON
PROGRESS REPORT (1)
FOR
THE STUDY
ON
WATER POLLUTION CONTROL
IN
THE UPPER MANYAME RIVER BASIN
IN
THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN
THE MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
AND
THE JICA STUDY TEAM

HARARE, JULY 30, 1996

Mr. A. C. Mpamhanga
Deputy Secretary / Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Masatoshi Momose
Team Leader,
JICA Study Team

The Japan International Cooperation Agency (hereinafter referred to as "JICA), the official agency responsible for the implementation of the technical co-operation programmes of the Government of Japan, dispatched the Study Team to the Republic of Zimbabwe on 20 April 1996 to conduct the Study on Water Pollution Control in the Upper Manyame River Basin" (hereinafter referred to as "the Study") in accordance with the agreement on the Scope of Work for the Study between the Preparatory Study Team of JICA and the Ministry of Local Government, Rural and Urban Development of the Republic of Zimbabwe (hereinafter referred to as "MLGRUD") signed on 29 November 1995.

The stage 1 field work of the Study started on 20 April 1996 and was completed on 30 July 1996. The stage 1 field work serves as the basis for the water pollution control master plan, the draft of which will be presented in the Interim Report in the beginning of October 1996. It will also provide preliminary basis for the preparation of the feasibility study for urgent project.

The Progress Report (1) includes all essential data, and information and analyses conducted in the stage 1 field work. The following are the major discussion items in the meeting on the Progress Report (1) between the Study Team and the Steering Committee. The attendants in the joint meeting are listed in Appendix A.

(1) The Study Team presented and discussed on major conditions and assumptions for the master planing. Major items are as follows:

1) Verification and summarisation of present conditions in the Study Area
2) Preparation of fundamentals for water pollution control master planing
3) water pollution analysis
4) Countermeasure plan to control water pollution
5) Priority project; Extension of Zengeza STW and IEE results

(2) Both sides basically agreed upon the contents of the Progress Report (1) to prepare the Interim Report in Japan. In this connection, conditions and assumptions for water pollution control master plan are attached herewith as Appendix B.

With regard to the urgent project for the Zengeza STW, treatment facilities required in application of BNR method will be further studied during F/S stage in consideration of high concentration of BOD and SS caused by the Tilcor industrial complex and to meet the need of effluent quality to be discharged into the river.

(3) Required arrangements for the succeeding field work were confirmed by both parties:

1) Office space for the stage 2 field work from 3 October to the end of December 1996
2) Required arrangements for the seminar to be held in the beginning of October 1996 in the stage 2 field work
3) Counterpart Training in Japan
   Required procedures in the Government of Zimbabwe will be completed immediately to submit the documents for a trainee to the Embassy of Japan.

APPENDIX A

LIST OF ATTENDANTS

Ministry of Local Government, Rural and Urban Development:

Mr. A. C. Mpamhanga	Director, Development, Planning and Co-ordination
Mr. J. T. Mutamiri	Deputy Director, Development, Planning and Co-ordination
Mr. P. F. Duri	Senior Administrative Officer
Mr. S. Munfunguwa	Acting Under Secretary, Dept of Local Authority and Administration, Financial Advisers
Mr. M.R. Ziracha	Senior Planner, Dept. of Physical Planning

President's Office and Cabinet:

Mrs. S. C. Madzinga	Deputy Director, Scientific Liaison Office

National Economic Planning Committee:

Mr. Lovemore Mujuru	Assistant Chief Economist

Ministry of Finance:

Mr. Njodzi Bwerinofa	Senior Administration Officer

Ministry of Transport and Energy:

Mr. L. D. Sigauke	Act. Chief Testing and Research Officer, Dept. of State Roads

Ministry of Environment and Tourism:

Mr. W. Musvibe

Ministry of Agriculture:

Mr. M. Chizanbire	Project Section

City of Harare:

Mrs. Mufaro Jarawaza	Chief Chemist, Engineering Services Div., Dept. of Works

Chitungwiza Municipality:

Mr. M. Khosla	Director, Engineering Services
Mr. Petros Mbira	Engineer, Water & Sewerage

Norton Town Council:

Mr. G. Magombedze	Town Engineer

Ruwa Local Board:

Mrs. J. Makombe	Secretary
Mr. Cornelius Piroro	Technician, Water & Sewerage

Epworth Local Board:

Mrs. R. S. Chakazamba	Administration Officer

JICA Zimbabwe Office:

Mr. Mitsuo Nakamura	Resident Representative

JICA Study Team:

Mr. Masatoshi Momose	Team Leader
Mr. Hirofumi Sano	Sewerage Planning
Mr. Takafumi Kiguchi	Water Pollution Analysis
Mr. Fumihiko Furuichi	Organisation & Institution
Mr. Munenori Tada	Economic & Financial Analysis
Mr. Takuo Kozawa	Construction Planning & Cost Estimate
Mr. Takashi Watanabe	Environmental Study

APPENDIX B

CONDITIONS AND ASSUMPTIONS FOR WATER POLLUTION CONTROL MASTER PLAN

1. Projection of Frame Values

Frame values by local authority in relation to major pollution sources were projected for study based year 1995 and target years of 2005 and 2015.

(1) Population Projection

The 1992 population census data are the base of the projection. Three scenarios were preliminary established for the purpose of water pollution analysis.

(unit: person)

Scenario	Year 2000	Year 2005	Year 2015
Scenario - 1	2,544,734	3,352,469	5,847,019
Scenario - 2	2,318,777	3,210,326	4,221,950
Scenario - 3	2,198,997	2,557,020	3,359,713

Note : Scenario - 1 : Projection by the population growth rate of the "Master plan for Water Distribution, The City of Harare, 1995".
Scenario - 2 : Projection by the factors of residential density of the "Master Plan for Water Distribution, The City of Harare, 1995"
Scenario - 3 : Projection by the population growth rate of the "Harare combination Master Plan, Report of Study, 1992".

The projected population in scenario 1 seems to be exaggerated as canceled in the Harare water supply M/P. The scenarios 2 and 3 are recommended to use for this study.

The present population of Chitungwiza Municipality will be revised to meet the current population reported by the municipality.

(2) Industrial Development

With reference to the projection of industrial wastewater quantity and quality, the number of employees was selected as a parameter. The present number of employees in the industrial sector was obtained; Census of Industrial Projection for Harare and survey results by the Study Team for other 3 local authorities. Future number of employees by local authority was estimated in proportion to the increase of industrial areas (future land use plan) to the present areas.

(3) Livestock

Present number of livestock was quoted from the estimates by the Department of Veterinary Services, Ministry of Agriculture, 1996. Future number of livestock will be assumed to be unchanged.

(4) Farmland and Natural Land

No categorisation of farm land and natural land was made based on the study results of unit pollution load (organic substances) without much difference between the two land area. The total study area is regarded as the potential pollution source in terms of natural pollution.

(5) Solid waste dumping site

Present dumping area of respective local authorities was investigated, while future disposal area was estimated in proportion to the increase of population against present population.

2. Environmental Water Quality Standards

At present environmental water quality standards have not established yet in Zimbabwe. The environmental items for pollution study are assumed; BOD for rivers and COD, T-N and T-P for lakes/dams. In consideration of water use in the study basin, classification in terms of water quality was made by river/lake.

River (BOD): class A (0 - 3mg/l), class B (3 -5mg/l) and class C (5 - 10mg/l)
Lake (COD): class A (0 - 3mg/l), class B (3 - 5mg/l) and class C (5 - 8mg/l)
(T-N) : class A (0 - 0.3mg/l), class B (0.3 - 0.6mg/l) and class C (0.6 - 1.0mg/l)
(T-P) : class A (0 - 0.01mg/l), class B (0.01 - 0.05mg/l) and class C (0.05 - 0.08mg/l)

Water quality checking points and environmental quality standards are proposed with provisional arrangements as follows:

Rivers

No.	Name	Location	Class	Standard BOD	Provisional
CR1	Manyame R..	upstream of Harava Dam	A	< 3mg/l	(5mg/l)
CR2	Manyame R.	upstream of Lake Chivero	B	< 5 mg/l	(5mg/l)

Lakes

No.	Name	Location	Class	Standard			Provisional (2000/2005)		
				COD	T-N	T-P	COD	T-N	T-P
CL1	Seke Dam	Center of Dam	A	< 3	< 0.3	< 0.01	< 5	< 0.4	< 0.05
CL2	L. Chivero	Center of Lake	A	< 3	< 0.3	< 0.01	< 8	< 0.3	< 0.10
CL3	L. Manyame	Center of Lake	A	< 3	< 0.3	< 0.01	< 8	< 1.0	< 0.03

3. Unit Wastewater Quantity and Pollution Load

The unit wastewater pollution load and quantity for the target years by major pollution source will be decided based on the data in previous studies for water supply and sewerage systems in the study area, data obtained through this study, and experiences in Japan. Except for the unit quantity of domestic sewage and commercial/institutional wastewater, adopted figures will be assumed to be constant through the future..

(1) Domestic Sewage

a. Sewage Quantity

Density	Present	2005	2015
High	60 lpcd	65 lpcd	70 lpcd
Medium	210 lpcd	unchanged	unchanged
Low	315 lpcd	unchanged	unchanged
Rural Area	Same to High density area		

Based on the study report of "Master Plan for Water Distribution, Harare" and "Crowborough Sewage Treatment Works", study on actual inflow sewage at Donnybrook STW.

b. Pollution Load

(unit: g/capita/day)

Unit P.L.	High-density	Medium-density	Low-density
BOD	44	47	50
COD	88	94	100
T-N	11	12	13
T-P	1.2	1.3	1.4

Based on the Sanitation manual, study on actual inflow sewage at Donnybrook STW by the JICA Team and reference data in Japan. These load will be assumed to be constant in the future.

Five percent (5%) of above pollution load will be assumed to be concentrated at high density area in unsewered area (septic tanks, etc.) as follows:

(unit: g/capita/day)

Indices	High-density
BOD	2.2
COD	4.4
T-N	0.55
T-P	0.06

Concentration ratio of effluent of sewage treatment works will be assumed as follows:

Direct discharge to rivers: 100%
Irrigation reuse: 8%

(2) Commercial and Institutional Wastewater

a. Sewage Quantity

(Against Domestic Sewage)	Present	2005	2015
Harare City*	75%	78%	80%
Chitungwiza Mun.	5%	unchanged	unchanged
Norton Town, Ruwa and Epworth	Same to Chitungwiza		
Rural Area	nil (negligible)		

Based on actual water supply record. Figures for Harare City includes industrial wastewater.

The commercial/institutional wastewater calculated for Harare City will be allocated to Mukuvisi and Marimba sub-basins with a share of 80% and 20%, respectively.

b. Pollution Load

Assumed to be same as those of average domestic sewage.

(3) Industrial Wastewater

Unit values per employee of factory by type of industry is decided based on the results of survey on 45 factories. These figures will be assumed to be constant through the future.

a. Sewage Quantity

Type of Industry	Unit WW Quantity (m^3/employee/day)
Processed Foodstuffs	0.677
Pulp, Paper & Related Products	4.308
Chemicals	0.288
Plastic Products	0.083
Chemicals, Stone & Clay products	0.833
Metal Products	0.218
Transportation Equipment	0.137
Other Industry Products	0.315

b. Pollution Load

Type of Industry	Unit Pollution Load (g/employee/day)				
	BOD	COD	SS	T-N	T-P
Processed Foodstuffs	966	2,002	301	25.06	9.61
Pulp, Paper & Related Products	9,800	41,871	2,145	163.69	26.71
Chemicals	106	840	306	6.3	1.73
Plastic Products	23	242	1,954	0.27	0.08
Chemicals, Stone & Clay products	91	66	682	13.89	2.26
Metal Products	61	208	93	6.92	0.66
Transportation Equipment	70	392	81	3.54	4.90
Other Industry Products	230	887	397	56.04	6.51

(4) Other Pollution Source

a) Livestock

The standard figures used in Japan will be adopted for generated pollution load. Concentration ratio of pastured livestock will be assumed to be 8%. Pollution load of poultry will be ignored because of minimal emission of wastewater to water bodies.

Concentrated Pollution Load of Livestock (unit: g/head/day)

	Cattle	Sheep/Goats	Pigs	Horses
BOD	51.2	5.12	16.0	17.6
COD	102.4	10.24	32.0	35.2
T-N	30.24	3.04	3.2	13.6
T-P	4.48	0.48	2.0	3.2

b) Natural Land / Farmland

Following values investigated in Japan will be adopted as concentrated pollution load.

	($kg/km^2/d$)
BOD	0.795
COD	11.781
T-N	0.986
T-P	0.082

Pollution load from farmland will be assumed to be same as those of natural land.

c) Solid Waste

Pollution load of leachate caused at solid waste dumping site will be assumed based on size of existing dumping site and investigated results in Japan. Quantity of leachate will be calculated using evaporation amount by Thornthwait's method and average monthly rainfall. Following figures will be adopted.

Quantity (m3/ha/year)	
on-going	3,300
completed	2,000
Quality (mg/l)	
BOD	500
COD	900
T-N	250

Taking account of location of dumping sites, 80% will be adopted as the concentration ratio.

d) Water Treatment Works

Total amount of pollution load of wastewater discharged from water treatment works will be assumed as same as those of intake water. Concentrated load of them will be assumed taking account of present condition of wastewater treatment at WTWs. The expected improvement by the introduction of the backwashed wastewater treatment plant at Morton Jaffray WTW will also be considered in the future analysis.

4. Water Pollution Analysis

Models for projection of water quality of rivers and lakes in the future will be established applying the identified parameters for the model obtained through the present analysis.

Future water pollution analysis of rivers and lakes will be conducted using established models for the year 2005 and 2015.

4.1 Analysis on Rivers

(1) Present Water Pollution Analysis

Flow model of rivers to be applied for present analysis will be established using average flow record during dry season in last 5 years or 10 years and specific discharged rate for respective rivers because of unavailability of present flow record. Present discharged and concentrated BOD loads will be computed for following pollution sources;

Sewered Area -	domestic/commercial/institutional sewage and industrial wastewater
Unsewered Area -	domestic sewage, industrial wastewater, livestock wastewater, solid waste dumping site wastewater, and water treatment works wastewater, and farmland/natural land discharge

BOD concentration of river water investigated by the Study Team at respective water quality checking points set at principal locations along rivers will be adopted for identification of pollution load remaining ratio of respective rivers.

(2) Future Water Pollution Analysis

The rounded figures of pollution load remaining ratio derived through present analysis will be adopted in the future pollution analysis. Flow model established based on the average figures during dry season in last 10 years will be adopted for the future pollution analysis.

In the calculation, following conditions will be assumed in future sewage treatment situation in the study area considering present tendency:

- Existing trickling filters of STWs will be maintained with its present capacity.
- New BNR plants will be constructed to treat increasing raw sewage influent at Crowborough, Firle and Zengeza STWs.
- New STWs with BNR process will be constructed to cope with increasing population in southern and eastern areas of Harare city.
- Wastewater Stabilisation Pond in STWs will be maintained and expanded to cope with increasing influent.
- Augmentation of Norton STW will be carried out adopting Trickling Filter method based on the existing plan.

It will be assumed that treated effluent is sent for irrigation reuse except that treated by BNR. Treatment efficiency of STWs by treatment method will be assumed as follows;

Treatment Efficiency by Treatment Method

Treatment Method	Treatment Efficiency (Pollution Load Reduction Ratio)			
	BOD_5	COD	T-N	T-P
Biological Nutrient Removal	95%	90%	80%	75%
Trickling Filter	90%	85%	30%	30%
Wastewater Stabilisation Pond	90%	85%	40%	40%

4.2 Analysis on Lakes

The pollution analysis of lakes will be conducted under the annual average condition. The water balance of lakes to be adopted in the analysis will be those based on annual average figures in last 5 years or 10 years.

The concentrated pollution loads calculated in the previous section will be summarised for COD, T-N and T-P, respectively. The concentrated pollution loads will be assumed to reach to the subject lakes without reduction (purification) in the main river.

(1) Present Water Pollution Analysis

Self-purification Coefficients in Vollenweider Model of respective lakes will be computed using the following formula for future pollution analysis of lakes under the annual average condition.

$$N = L(N) / ((\rho w+\sigma N) \times V)$$
$$P = L(P) / ((\rho w+\sigma P) \times V)$$
$$COD = L(COD) / ((\rho w+\sigma COD) \times V) + \Delta COD$$
$$\Delta COD = \alpha(N) \times T\text{-}N \times 17.73$$

(2) Future Water Pollution Analysis

Flow model established based on the average figures in last 10 years will be adopted for the future pollution analysis. Applying established pollution load run-off model in the subject lake basin, pollution load concentration at respective water quality checking points will be computed for year 2005 and 2015.

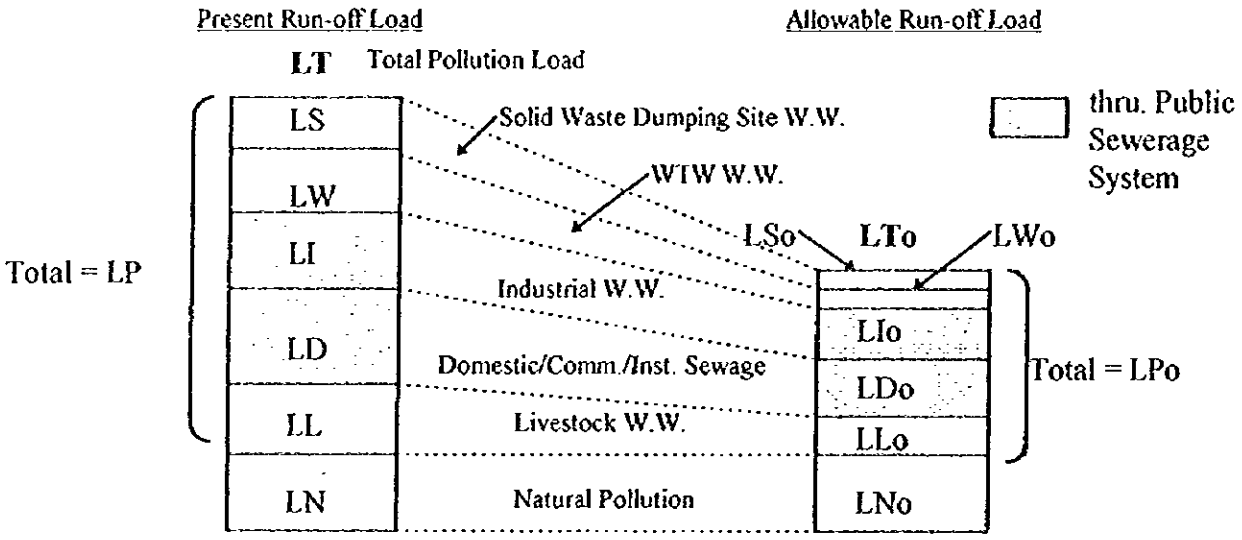
5. Allocation of Pollution Load to be Reduced

Based on the projection results, pollution load to be reduced will be identified and allocated to respective pollution sources at each water quality checking points against recommended environmental water quality standard. The study results will be reported in the Interim Report.

The figure in the next page shows the manner of calculation for allowable pollution load by pollution source.

The allowable pollution load by pollution source is expressed as follows:

$$LSo = LPo \times LS/LP$$
$$LWo = LPo \times LW/LP$$
$$LIo = LPo \times LI/LP$$
$$LDo = LPo \times LD/LP$$
$$LLo = LPo \times LL/LP$$
$$LNo = LN$$



Manner of Calculation for Allowable Pollution Load by Pollution Source

6. Preliminary Study on Water Pollution Control Measures

(1) Technical Aspect

The preliminary study to reduce pollution load to be discharged by pollution source was conducted covering public sewerage systems, industrial wastewater pre-treatment and leachate treatment at solid waste dumping sites.

1) Public Sewerage Systems

Sewerage expansion systems were planned for the four urban areas to meet land use plans for the years 2005 and 2015. The sewage treatment methods of expansion facilities are selected among experienced methods; BNR, TF and WSP. The treatment methods of the respective local authorities for the year 2005 are determined according to present plan/on-going arrangements by the authorities. Those for Harare City (except for the two small STWs) and Chitungwiza are assumed to adopt BNR in the year 2015.

2) Industrial Wastewater Pre-Treatment

The pre-treatment methods for water pollution type industries were studied. The standard facilities were worked out as a reference, referring to the experience at Tilcor industrial complex.

3) Leachate treatment at solid waste dumping sites

The WSP was recommended for the treatment of leachate. The standard facilities are prepared as a reference.

For the City of Harare, two sub-sewerage systems for Harare South and Harare East are recommended in addition to the expansion of existing systems.

(2) Legal and Institutional Arrangements

Policies, procedures, organisation, management and stuffing are key factors for the project's long-term success. It is recommended for the Zimbabwean government to strengthen its institutional capacity by pursuing the following measures.

1) to establish a "Water Pollution Control Board (WPCB)" under the Interministeral River Basin authority (Upper Manyame river Basin authority)" which will assume policy formulation, final decision and approval on the water pollution matters in the upper Manyame river basin;

2) to create a "Water Pollution Control Co-ordinating Committee (WPCCC) to facilitate the co-ordination for project planning and financing at every national, ministry/department and provincial/district levels;

3) to organise a "Water Pollution Control Information Center" responsible for water pollution control with legal enforcement of inspection, instruction and punishment to delinquent polluters and collection of adequate information, particularly on the production facilities which use large volumes of water,

4) to strengthen the "Water Pollution Monitoring Unit", because the monitoring is a base of the water pollution control management; and

5) to provide training and technology dissemination programs on water pollution control for the staff concerned of both the government agencies and local authorities as well as the private sector including manufacturers and the public.

7. Cost Estimates and Financial Study

(1) Cost Estimates

The total cost both for the construction and O & M of the public sewerage facilities for the years 2005 and 2015 will be estimated by urban authority. While the construction cost for other countermeasures will be estimated for only standard facilities as a reference.

The cost functions (formula) on a 1996 price base will be established for the estimation of sewerage construction cost with reference to selected factors (linear meter, service area and sewage treatment capacity). The cost functions of the sewage treatment plant are based on model studies for some standard capacities of treatment facilities considering applicable secondary treatment processes; WSP, TF and BNR. Required cost of such standard facilities will be estimated based on preliminary quantity and unit price in full use of the experiences of the similar projects in Zimbabwe.

The projected cost will comprise direct and indirect cost, administration cost, engineering service requirements and physical contingency. The cost of land acquisition is not included assuming the use of governmental land for the construction of facilities.

(2) Financial Study

Financial arrangements required will be sought to cope with various countermeasures identified in the water pollution control M/P. The study will entail the financial requirements for construction, and operation and maintenance of the facilities in comparison with available funds.

The current sector practices in Zimbabwe for financial arrangements will be analysed with reference to local authority funding formed under the principle of cost recovery. Potential sources of funding will also be studied to manage the financial short fall to meet cost requirements, especially for the implementation of public sewerage projects. The study on the balance between revenue and expenditures of the four local authorities will be made to come up with a simple cash flow statement for analysing net revenue.

8. Priority Project for Feasibility Study

Previous studies and political measures on water pollution control were reviewed. Among water pollution sources identified, the rehabilitation and expansion of existing sewage works are recommended as potential urgent projects for the target year 2000. The potential projects include five existing STWs. The Zengeza STW in Chitungwiza Municipality was selected as an urgent project after comparative study in terms of technical, environmental, and economic and financial aspects. The scope of the project is construction of tertiary treatment facilities (BNR) with a capacity of 20,000m^3/d.

9. Initial Environmental Examination on the Priority Project

An Initial environmental Examination was conducted for the priority project, Zengeza STW, in compliance with the guideline of JICA and Zimbabwe Government. As a result of the study, the recommendation was made to carry out a preliminary Environmental Impact Assessment (PEIA). The Terms of reference for the study shall be consulted with concerned agencies of Zimbabwe.

MINUTES OF MEETING
ON
INTERIM REPORT
FOR
THE STUDY
ON
WATER POLLUTION CONTROL
IN
THE UPPER MANYAME RIVER BASIN
IN
THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN
THE MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
AND
THE JICA STUDY TEAM

HARARE, OCTOBER 9, 1996

Mr. A. C. Mpamhanga
Deputy Secretary / Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Masatoshi Momose
Team Leader,
JICA Study Team

The Japan International Co-operation Agency (hereinafter referred to as "JICA), the official agency responsible for the implementation of the technical co-operation programmes of the Government of Japan, dispatched the Study Team to the Republic of Zimbabwe in 1 October, 1996 to conduct the Stage 2 Field Work of "the Study on Water Pollution Control in the Upper Manyame River Basin" (hereinafter referred to as "the Study") in accordance with the agreement on the Scope of Work for the Study between the Preparatory Study Team of JICA and the Ministry of Local Government, Rural and Urban Development of the Republic of Zimbabwe (hereinafter referred to as "MLGRUD") signed in 29 November, 1995.

The stage 2 field work of the Study started in 1 October, 1996 and is scheduled to be completed in 29 December, 1996. The stage 2 field work serves as the basis for the feasibility study on the priority project, the draft of which will be presented in the Progress Report (2) at the end of the work.

A meeting was held in 8 October, 1996 on the Interim Report for the Study (hereinafter referred to as "the I/R") between the Study Team and the Steering Committee of the Government of Zimbabwe. The attendants for the meeting are listed in Appendix A attached herewith.

The I/R presents the Water Pollution Control Master Plan and also provides preliminary basis of the feasibility study for an urgent project. The contents of the I/R were generally agreed between the two parties. The following are major items confirmed through discussions.

(1) Present arrangements and conditions in the environmental sector
(2) Fundamentals for water pollution study
(3) Present water pollution analysis
(4) Projection of future pollution and pollution load to be reduced
(5) Countermeasures to be reduced by different pollution source
(6) Cost requirements and implementation plan
(7) Priority project for the conduct of feasibility study

The summary of the contents of respective items is attached in Appendix B. Expansion/rehabilitation of the Zengeza STWs was selected as the priority project for the feasibility study.

The MLGRUD requested the JICA to donate the equipment used by the Study Team upon completion of the Study. The request will be transferred to JICA head office in Japan. The request letter from the MLGRUD including the list of the equipment is attached in Appendix C.

The MLGRUD will complete the procedures in the Government of Zimbabwe for dispatch of a trainee with reference to this Study. The documents will be submitted to Japan Embassy immediately.

APPENDIX A

LIST OF ATTENDANTS

Ministry of Local Government, Rural and Urban Development:

Mr. J. T. Mutamiri	Deputy Director, Dept. of Development Planning and Co-ordination
Mrs. S. N. Musungwai	Assistant Secretary, Dept. of Development Planning and Co-ordination
Mr. M.R. Ziracha	Principal Planner, Dept. of Physical Planning
Mr. J. Mugabe	Admin. Officer, Dept. of Development Planning and Co-ordination

Ministry of Agriculture:

Mrs. A. T. Mhlanga	Environmental Chemist, Dept. of Research & Specialist Services
Mr. S. M. Mushiri	Soil Chemist, Dept. of Research & Specialist Services

Ministry of Health and Child Welfare:

Mr. G. Mangwiro	Assist. Director, Environmental Health Services Dept.
Mr. M. Kadzatsa	Port Health Co-ordinator, Env'l Health Services Dept.
Mr. G. Chaumba	Pollution Officer, Env'l Health Services Dept.

Ministry of Transport and Energy:

Mr. J. Hwindingwi	Chief Testing and Research Officer, Dept. of State Roads

City of Harare:

Mr. Zvikomborero Hoko	Engineer, Engineering Services Div., Dept. of Works
Mr. Mafuko	Chemist, Engineering Services Div., Dept. of Works

Chitungwiza Municipality:

Mr. M. Khosla	Director, Engineering Services

Ruwa Local Board:

Mrs. J. Makombe	Secretary

Epworth Local Board:

Mrs. R. S. Chakazamba	Administration Officer

JICA Zimbabwe Office:

Mr. Tomohiro Seki	Assistant Resident Representative

JICA Advisory Committee:

Mr. Kuniharu Yoshimoto	Chairman
Miss. Junko Abe	Co-ordinator, JICA

JICA Study Team:

Mr. Masatoshi Momose	Team Leader
Mr. Hirofumi Sano	Sewerage Planning
Mr. Takafumi Kiguchi	Water Pollution Analysis
Mr. Toshiki Naka	Sewerage Facilities Planning

APPENDIX B

OUTLINE OF WATER POLLUTION CONTROL MASTER PLAN

1. Master Plan for Water Pollution Control in the Upper Manyame River Basin

1.1 Present Water Pollution Status of the Water Body

The water quality of the lakes/dams is characterised by its high concentration of T-N and T-P, which exceeds the critical eutrophication level/oligotrophic lake (T-N > 0.2 mg/l and T-P > 0.02 mg/l). In addition, the COD concentration is three to six times higher than the allowable level for drinking water purpose. Heavy metals (Zn, Ni, Fe and Cd) were detected in the water body; however, the concentrations were within the allowable levels for drinking water sources (WHO standard). Agricultural chemicals were not detected through the examination of this study.

1.2 Projection of Frame Values

A projection of the various frame values from the present (1995) to the final target year (2015) was made for the identified water pollution sources.

The national census results in 1992 were, in principle, employed for the 1992 urban population as the projection base for planning years. However, the present population of Chitungwiza used in the Harare Combination M/P was employed to meet the current situation.

Two scenarios on future population were constructed for the purpose of water pollution control planning among the four studied cases. The projected population of the Study Area in the year 2015 for scenarios 1 and 2 are 4,035,097 and 3,575,878, respectively.

The number of employees was adopted as a frame value for industrial development. Industry was classified into 19 types and then the number of employees and their ratio by type of industry was calculated. The future number of employees was estimated for each sub-basin on the assumption that this number will increase in accordance with the increase rate of the industrial area in the future land use plan. The total number of employees at present and in the year 2015 was estimated at 93,800 and 296,700 persons, respectively.

The present number of major livestock in the Study Area was provided by the Department of Veterinary Services of Ministry of Agriculture. The future figures for water pollution analysis are assumed to be unchanged under the current status of development.

Farmland and natural land were not separated for the water pollution study. With regard to solid waste dumping sites as potential pollution sources, the quantity of leachate at the landfill site was assumed to increase in proportion to the population growth.

1.3 Water Use and Hydrological Conditions of the Water Body through the Future

The direct use of river water is minimal due to the limited flow available during the dry season, while the reuse of treated effluent is dominant in the entire Study Area. On the other land, lakes/dams are utilised for water supply (presently 477,000 m^3/d is availed), recreation and commercial fisheries purposes. At the present time, there is no plan on future water use in the study basin.

The Harare Water Supply System covers Harare City and its adjoining urban areas for the reported demand of 360,000 m^3/d. The raw water sources depend on four impoundments. Two existing WTWs, Prince Edward and Morton Jaffray, adopt conventional water treatment systems. The future water consumption for the year 2012 was projected in the Harare Water Supply M/P with three options ranging from 1,230,000 m^3/d to 1,868,000 m^3/d. Even under the assumption of full use of the treated effluent discharged from the STWs (600,000 m^3/d), a shortfall of 800,000 m^3/d is projected regarding the medium water demand (1,390,000 m^3/d). At present, a water source development program has been studied to utilise the water from the Nyagui River.

Water quality standards are proposed for the main river and lakes/dams, in terms of environmental items taking account of water use. While for health related items, it is deemed appropriate to adopt, at least, the same items applying the respective values based on the WHO standards. Provisional standards are recommended for BOD, COD, T-N and T-P under the present situation. For the monitoring of the water quality, water quality checking points and reference points are proposed.

The flow pattern of the rivers, the water level and the discharge rate of the lakes were analysed to come up with the flow balance. The average run-off ratio in the study basin was 8.7 % in the last 10 years, which is almost same as that in the whole of Zimbabwe (8 %). The balances between inflow and outflow in the annual average at the respective lakes/dams were studied considering the control factors: river flow, rainfall to the surface of the lake/dam and the flow from direct lake/dam catchment area for inflow and evaporation from the surface of lake/dam, water intake and discharge to the main river for outflow. In addition, the fluctuation of the water level of the lake/dams and miscellaneous flow were taken into account for the flow balance estimation. Future flow balance was studied using the relevant data for the last 10 years. The STWs discharge to the rivers was assumed to be equivalent to the projected sewage flow of adopted BNR treatment process. The present discharge flow from Lake Manyame is assumed to be maintained through the future, assuming that the intake amount at the WTW will be controlled with reference to the treated effluent discharge levels from the STWs.

1.4 Unit Wastewater Quantity and Quality

The unit wastewater quantity and quality for the target years by major pollution source were studied. References were made to the previous studies conducted in Zimbabwe for water supply and sewerage expansion/development. The factors used for this purpose are population, the number of employees by industrial type, the number of livestock and the land area, for domestic sewage, industrial wastewater, livestock and farm land/undevelopped land, respectively. For the unit domestic sewage quantity, the figures used in the Harare Water Supply M/P were employed. The unit industrial wastewater quantity and quality were derived from the results of the field survey.

1.5 Present Water Pollution Analysis

The present water pollution analysis was undertaken to establish the simulation model to be adopted for future water pollution analyses. The pollution load covers human-related and natural pollution both for point and non-point sources. The flow model of the entire study basin was based on the average flow rates of the last 10 years.

The water quality indices to be used in the analysis for rivers is BOD; representing the water pollution by organic substances mainly caused by human activities. The run-off model for the dry season was applied for the pollution analysis of rivers.

The calculated pollution load remaining ratios imply not only the self-purification capacity of the rivers, but also the adjustment factor of the assumptions of the concentration ratios. The ratios of the respective rivers are calculated as shown in the following table and these were modified for application in future pollution analyses:

Pollution Load Remaining Ratio of Rivers

River	Calculated PLRR	Applied in Future Analysis
Manyame R. (upstream)	18.6%	20%
Ruwa R.	17.4%	20%
Nyatsime R.	29.3%	30%
Mukuvisi R.	18.6%	20%
Manyame R. (downstream)	35.9%	35%
Marimba R.	31.5%	30%
Muzururu R.	6.0%	10%
Gwebi R.	21.7%	20%

The Vollenweider Model was adopted as the water pollution simulation model of the lakes/dams in terms of T-N, T-P and inflow-COD. The pollution analysis, in terms of COD, was conducted for the inflow-COD and the secondary produced COD caused mainly by phytoplankton in the lake. The secondary produced COD was analysed by the ΔCOD method.

Based on the estimated water balance models, self-purification coefficients of the lakes for each pollutant were computed as summarised in the following table:

Self-purification Coefficients of Lakes

Coefficients*	Seke & Harava Dams	Lake Chivero	Lake Manyame
σN	0.18797	0.04270	0.01151
σP	0.20574	0.00868	0.02769
σCOD	0.07551	0.00908	0.00440
$\alpha(N)$	82.5%	100.2%	42.9%

*: Self-purification coefficients in following formula

$N = L(N) / ((\rho w+\sigma N) \times V)$

$P = L(P) / ((\rho w+\sigma P) \times V)$

$COD = L(COD) / ((\rho w+\sigma COD) \times V) + \Delta COD$

$\Delta COD = \alpha(N) \times T\text{-}N \times 17.73$

1.6 Future Water Pollution Analysis

The development of two new STWs and the augmentation of the existing STWs were assumed as a pre-condition for the future pollution analysis by considering the present prevailing conditions.

Based on the established BOD load run-off model of each river, applying the computed pollution load remaining ratios, a projection of BOD concentration at water quality checking points of rivers was made for each scenario as shown in the following table:

Projected Future BOD Concentration at WQCPs

River	WQ CP	Stan-dard	Present	Scenario 1		Scenario 2	
				2005	2015	2005	2015
Manyame (u/s)	C_{R1}	<3	1.1	1.32	1.48	1.03	1.13
Ruwa	R_{R1}	-	3.8	2.40	3.55	1.96	3.13
Nyatsime	R_{R2}	-	2.1	3.58	4.42	3.84	3.96
Manyame (d/s)	R_{R3}	-	1.0	1.52	2.62	2.34	2.51
Mukuvisi	R_{R4}	-	2.0	3.61	3.39	3.87	3.99
Manyame (d/s)	C_{R2}	<5	1.4	3.00	3.16	3.30	3.42
Marimba	R_{R5}	-	8.7	5.96	5.61	7.67	7.28
Muzururu	R_{R6}	-	0.5	0.89	0.95	0.78	0.82
Gwebi	R_{R7}	-	1.6	1.56	1.68	1.35	1.43

(unit: mg/l)

The projected BOD concentrations at the C_{R1} and C_{R2} WQCPs are less than the environmental water quality standards through the future under the assumed conditions.

A projection of the water quality of the lakes/dams in the future was conducted applying the simulation model with the computed self-purification coefficients. The results were

summarised in the following table:

Projected Future Pollution Load Concentration at WQCPs of Lakes

Lake/Dam	WQ CP	Quality Standard 2005	Quality Standard 2015	Present	Scenario 1 2005	Scenario 1 2015	Scenario 2 2005	Scenario 2 2015
T-N (mg/l)								
Seke & Harava	C_{L1}	<0.4	<0.2	0.65	0.66	0.68	0.64	0.66
L. Chivero	C_{L2}	<0.4	<0.2	0.51	0.70	0.81	0.62	0.81
L. Manyame	C_{L3}	<0.4	<0.2	0.75	0.74	0.76	0.73	0.74
T-P (mg/l)								
Seke & Harava	C_{L1}	<0.05	<0.01	0.07	0.07	0.08	0.07	0.07
L. Chivero	C_{L2}	<0.10	<0.01	0.27	0.40	0.45	0.36	0.46
L. Manyame	C_{L3}	<0.03	<0.01	0.04	0.04	0.04	0.04	0.04
COD_{Cr} (mg/l)								
Seke & Harava	C_{L1}	<10	<6	20.63	20.68	21.74	20.23	21.13
L. Chivero	C_{L2}	<16	<6	25.30	32.58	36.42	30.26	39.64
L. Manyame	C_{L3}	<16	<6	22.70	20.11	21.15	19.77	20.83

The Seke/Harava Dams and Lake Manyame show almost constant water quality. However, the water quality of Lake Chivero will be worse to some extent in the future.

1.7 Study on Pollution Load Reduction

The allowable pollution load (PL) at each WQCP of the river was calculated using the environmental water quality standards and the projected flow rates. The calculation results indicate that the reduction of the PL is not necessary for both C_{R1} and C_{R2} because of the projected low BOD concentration during the dry season.

The allowable PL at each WQCP of the lakes/dams was calculated using the environmental water quality standards and the projected water balances. The calculation results indicate that the required pollution road reduction is quite large at all WQCPs for all pollution indices - especially for the year 2015.

The calculation results for Scenario-1 and Scenario-2 show almost the same pollution level, though the individual figures are different.

In the year 2015, most of the allowable PL becomes less than the natural PL because of the assumed strict water quality standards. Therefore, the accomplishment of the environmental water quality standards in the year 2015 is impossible at all WQCPs.

At the point C_{L1} (Seke and Harava Dams), the PL reduction shall be conducted mainly for the domestic and livestock PLs. Since the possible countermeasures have been assumed for the projection of the domestic PL already, and the livestock PL accounts for a large share (about 80%) of the required PL reduction, the effort for PL reduction shall be concentrated on the

livestock PL.

At the point C_{L2} (Lake Chivero), the PL reduction shall be conducted mainly for the domestic PL (about 90% of the PL reduction requirement). Since practical countermeasures were already counted, drastic countermeasures shall be introduced even in the year 2005.

At the point C_{L3} (Lake Manyame), more than 90% of the required PL reduction is accounted for by the livestock PL. Therefore, the PL reduction shall be attained mainly by the livestock PL. The PL reduction requirement for the solid waste PL is negligible compared with the total PL. The PL reduction in the WTWs will be accomplished in the year 2005 in assumption of the introduction of the wastewater treatment facilities to the Morton Jaffray WTW.

It may be possible to maintain the future water quality at the present level with the countermeasures assumed in the water quality projection. In other words, those countermeasures, i.e. the augmentation of the sewerage systems and the provision of WTWs wastewater treatment facilities, are requisite to maintain the present water quality through the future. These countermeasures are adopted in the water quality projection as practical and possible ones to be implemented, and the calculation result is acceptable both in terms of water quality and in securing the river flow, this is in line with the policy of the Ministry of Lands and Water Resources.

Though the improvement of the water quality of the lakes/dams is desirable for the operation of water treatment works and other water use purposes, it is difficult in practice to introduce advanced and expensive technical countermeasures. The operation cost of the WTWs and the STWs have a trade-off relationship, and it is economical to treat the necessary amount of water only at the WTWs if the raw water quality is acceptable.

It is strongly recommended that continuous water quality and flow monitoring at selective sampling points and water quality indices be conducted. In addition, periodical reviews and analyses of the water pollution status be implemented to obtain reliable data and to establish a reliable pollution analysis model. The introduction of the advanced and costly countermeasures shall be discussed through such periodical reviews.

1.8 Study on Countermeasures for Water Pollution Control in the Study Area

The required countermeasures for water pollution control for the years 2005 and 2015 were studied focusing on the public sewerage systems. In this regard, sewage treatment level is assumed to meet the requirements of the water pollution control to preserve present water quality of the water body through the future. Other countermeasures for the remaining pollution sources are also studied to come up with reference information. Furthermore, the relevant laws and regulations to be enforced were studied, including the requirements to accept industrial wastewater into the public sewerage systems, as well as water quality monitoring

systems.

(1) Public Sewerage Systems

The design sewage flow of respective STWs in 2015 was estimated by scenario, average dry weather flow of which are shown below.

Sewage Works	Scenario-1 (m^3/day)	Scenario-2 (m^3/day)
Crowborough	178,900	124,200
Firle	309,700	277,900
Marlborough	4,800	2,600
Donnybrook	12,300	11,700
Harare South	92,100	47,400
Harare East	37,600	37,600
Zengeza	70,200	107,700
Norton	41,300	26,500
Ruwa	18,400	5,700
Total	765,300	641,300

The trunk and lateral sewers for the expansion area by scenario were planned by treatment area, as shown below, provided with some pump stations, as required.

Sewage Works	Scenario	Diameter (mm)	Length (km)	No. of Pump Station
Crowborough	1	500-1,350	35.6	1
	2	400-1,200	35.6	1
Firle	1	800-1,200	34.7	1
	2	800-1,200	34.7	1
Marlborough	1	None	None	None
	2	None	None	None
Donnybrook	1	None	None	None
	2	None	None	None
Harare South	1	700-1,800	20.5	1
	2	600-1,350	20.5	1
Harare East	1	900-1,350	12.0	0
	2	900-1,350	12.0	0
Zengeza	1	450-1,000	35.2	3
	2	500-1,200	35.2	3
Norton	1	300-1,100	26.3	2
	2	250-900	26.3	2
Ruwa	1	200-1,000	22.8	4
	2	150-600	22.8	4

The three types of sewage treatment method currently used by local authorities are adopted as alternatives; WSP, TF and BNR. The treatment capacities for the expansion of respective sewerage systems with treatment methods are summarized below.

Sewage Works	Required Expansion Capacity (m^3/day)	Treatment Method
Crowborough	124,900 (Scenario-1, 2015)	BNR
	70,200 (Scenario-2, 2015)	BNR
Firle	237,700 (Scenario-1, 2015)	BNR
	205,900 (Scenario-2, 2015)	BNR
Marlborough	2,800 (Scenario-1, 2015)	WSP
	600 (Scenario-2, 2015)	WSP
Donnybrook	6,800 (Scenario-1, 2015)	WSP
	6,200 (Scenario-2, 2015)	WSP
Harare South	92,100 (Scenario-1, 2015)	BNR
	47,400 (Scenario-2, 2015)	BNR
Harare East	37,600 (Scenario-1, 2015)	BNR
	37,600 (Scenario-2, 2015)	BNR
Zengeza	49,800 (Scenario-1, 2015)	BNR
	87,300 (Scenario-2, 2015)	BNR
Norton	37,900 (Scenario-1, 2015)	TF
	23,100 (Scenario-2, 2015)	TF
Ruwa	13,100 (Scenario-1, 2015)	WSP
	400 (Scenario-2, 2015)	WSP

(2) Industrial/Slaughterhouse Wastewater Treatment

The pre-treatment facilities for industrial/slaughterhouse wastewater is necessary for the combined treatment with domestic sewage. Processed Foodstuffs, Slaughterhouse and Pulp & Paper related Products are major types to adopt the measures because of the discharge of highly concentrated organic substances. The pre-treatment process entails Anaerobic Pond and Facultative Pond (target treated effluent quality: BOD less than 600-1,000 mg/l).

(3) Solid Waste Collection and Disposal

The WSP was recommended as a standard treatment method to treat leachate at the solid waste dumping site.

(4) Livestock and Other Pollution Sources

The countermeasures to reduce pollution loads caused by livestock and other non-point sources are recommended as follows:

- Secondary treatment (Wastewater Stabilisation Pond) of discharged drainage before flowing into nearby streams
- Re-location of the livestock breeding area to the outside of the study basin

(5) Other Technical Countermeasures

Aside from technical countermeasures, the following are possible methods.

- Removal of the nutrients by fishery
- Removal of the nutrients by plants and disposal outside of the basin

In addition, dredging of the sediments accumulated at the bottom of lakes/dams is recommended to remove nutrients in the closed water body.

(6) Basic Strategy for Legal and Institutional Arrangements

To ensure the coherent water pollution control in the Study Area, it is proposed to establish the well-coordinated inter-agency bodies; Upper Manyame River Basin Authority (UMRBA) and Water Pollution Control Board (WPCB).

In addition, it is a prerequisite to strengthen the institutional capabilities of the implementing agencies consisting of the MLGRUD and local authorities concerned. In order to ensure the long-term success of the water pollution control project, it is "must" to consolidate their institutions in terms of information system, manpower and financial resources.

To solve the legislative and administrative problems on water pollution, the Water Act and relevant water regulations are to be reviewed and updated to define the responsibilities of the national government, local authorities and business enterprises, and to clearly formulate the basic principles for the implementation of water pollution measures. The proposed legal arrangements comprise the following countermeasures:

- Establishment of environmental water quality standards
- Strengthening of effluent regulations
- Enactment of trade effluent control by-laws
- Review and updating of other legislation relating to water pollution control

(7) Monitoring and Feedback System for Water Pollution Control

The review of Water Act is necessary for a more inter-sectoral and participatory approach so as to achieve co-ordination.

The sampling points shall be determined considering current and future water uses, the location and number of existing monitoring stations for water quality and flow rate. Water quality indices for water quality examination shall be determined in the light of water quality standards.

(8) Community Involvement

To ensure the sustainable development of the country, there is a need for the government to establish enabling legal and policy frameworks to facilitate community involvement in natural resources management.

The proposed "Water Pollution Control Information Centre" shall undertake, together with the local authorities, the dissemination of water pollution related information to the private sector and the public. It is also vital to accelerate the "community development" to organise people's participation in the environmental management.

1.9 Cost Estimate by Public and Private Investment and Financial Study

The total cost, both for construction and O & M, for the year 2005 and 2015 was estimated for the public sewerage projects using different scenarios, while the standard cost for other countermeasures was prepared as a reference. The sewage works comprise treatment facilities in application of either BNR, TF or WSP and sewage collection systems.

The cost functions using a 1996 price base were established for the estimation of the construction costs required by the applicable treatment method, pump station and sewer. The total construction costs required by scenario for the public sewerage projects from 2000 to 2015 are:

Scenario 1	6,802.76 Million Z$
Scenario 2	5,706.27 Million Z$

The O & M cost required by scenario for the public sewerage systems at the target year of 2000, 2005 and 2015 are shown below.

Scenario	Target Year	O & M Cost (Mill Z$/year)
Scenario-1	2000	5.700
	2005	78.670
	2015	114.865
Scenario-2	2000	7.553
	2005	62.007
	2015	97.043

1.10 Implementation Plan for the Countermeasures

Implementation plan for water pollution control in the upper Manyame River Basin refers to physical development of public sewage works, and leagal, institutional and financial arrangements. Two alternatives of the implementation schedule are worked out mainly because of the financial capabilities of the local authorities concerned. The mid-term

development plan is recommended to implement in the third phase in the case of Alternative 2.

The management system for water pollution control was proposed based on the existing administrative structure and the envisioned reform under the Public Sector Investment Programme. The well-coordinated inter-agency bodies called "Upper Manyame River Basin Authority" shall be established. In addition, the institutional capability of the implementing agencies/authorities shall be strengthened. In this connection, the institutional/legal measures proposed in this Master Plan are recommended to put into practice within the Action Plan period up to the year 2000.

(1) Alternative 1, Scenarios 1 & 2

First Phase -2000	Second Phase 2001-2005	Third Phase 2006-2015
Short-term Development	Middle-term Development	Long-term Development
Sewer - Harare (4 Works) - Chitungwiza - Norton - Ruwa	Sewer - Harare (4 Works) - Chitungwiza - Norton - Ruwa	Sewer - Harare (6 Works) - Chitungwiza - Norton - Ruwa
BNR - Chitungwiza	BNR - Harare (4 Works) - Chitungwiza	BNR - Harare (4 Works) - Chitungwiza
	WSP - Harare - Ruwa	WSP - Harare (2 Works) - Ruwa
	TF - Norton	TF - Norton

(2) Alternative 2, Scenarios 1 & 2

First Phase -2000	Second Phase 2001-2015
Short-term Development	Middle-term Development
Sewer - Harare (4 Works) - Chitungwiza - Norton - Ruwa	Sewer - Harare (4 Works) - Chitungwiza - Norton - Ruwa
BNR - Chitungwiza	BNR - Harare (4 Works) - Chitungwiza
	WSP - Harare - Ruwa
	TF - Norton

2. Study on Priority Project and Initial Environmental Examination

The previous studies and political measures on water pollution control were reviewed. Among the water pollution sources, the rehabilitation and expansion of existing sewage works are recommended as potential projects including the institutional strengthening, as required. Of the potential projects (the Crowborough, Firle, Zengeza, Norton and Ruwa STWs), the Zengeza STW was selected as an urgent project after a comparative study in terms of the technical, environmental improvement, economic and financial aspects. The implementing capacity of the concerned authorities and the sustainability of the project were also considered. The scope of the project was recommended to construct sewage treatment facilities using the BNR method with a capacity of 20,000 m^3/d.

An IEE report was prepared in compliance with the guidelines of JICA and the Zimbabwe Government. The report comprises a project description, a site description, the IEE methodology and an analysis of the potential environmental impacts entailing the tabulation of the IEE findings. After clarification of the positive and negative environmental impacts, it was recommended that a Preliminary Environmental Impact Assessment (PEIA), as defined in the Zimbabwe Environmental Impact Assessment Policy of 1994, be carried out.

APPENDIX C Letter from the MLGRUD on the Donation of Equipment used by JICA Study Team

Ref : ADM/59/7

Date : 15/11/96

Resident Representative
Zimbabwe Office
Japan International Cooperation Agency

Attention : Mr. Mitsuo Nakamura

RE : **REQUEST FOR DONATION OF EQUIPMENT : WATER POLLUTION CONTROL PROJECT IN THE UPPER MANYAME RIVER BASIN : JAPANESE ASSISTANCE :**

Reference is made to the abovementioned project which is on-going and was agreed upon between the Government of Japan and that of Zimbabwe. As you know this Ministry is hosting the project on behalf of the local authorties (Harare, Chitungwiza, Norton and Ruwa) with Japan International Cooperation Agency giving the technical assistance. It would be appreciated if you could donate the equipment that the JICA Study Team is using to the Ministry for future use.

We understand that some of the items which maybe available for the donation are on the attached list.

A. C. Mpamhanga
for: **SENIOR SECRETARY FOR LOCAL GOVERNMENT, RURAL AND URBAN DEVELOPMENT**

LIST OF EQUIPMENT REQUESTED TO BE DONATED

1. Portable Type COD Meter with accessories:
   Model: COD-50S, TOA Electronics Co., Ltd. 1 set

2. Portable Type Water Quality Meter with accessories:
   Model: WQC-20A, TOA Electronics Co., Ltd. 1 set

3. Portable Type Current Meter with accessories:
   Model: J-051, Yokogawa Weathac Corp. 1 set

4. Sampling Tools:
   Vacuum Pump;
   Model: ULVAC G-5, Shinku Kiko Co., Ltd. 1 set
   Vacuum Filteration Bottle;
   Model: VIDREX 500cc, Kokura Glass Industries Co., Ltd. 2 bottles
   Measuring Cylinder;
   Plastic Cylinder 1000cc 1 set

5. Copy Machine with accessories:
   Model: U-Bix 112Z, Konica Corp. 1 set

MINUTES OF MEETING
ON
PROGRESS REPORT (2)
FOR
THE FEASIBILITY STUDY
ON
THE URGENT PRIJECT
IN
THE UPPER MANYAME RIVER BASIN
IN
THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN
THE MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
AND
THE JICA STUDY TEAM

HARARE, DECEMBER 20, 1996

Mr. A. C. Mpamhanga
Deputy Secretary / Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Masatoshi Momose
Team Leader,
JICA Study Team

The Japan International Co-operation Agency (hereinafter referred to as "JICA), the official agency responsible for the implementation of the technical co-operation programmes of the Government of Japan, dispatched the Study Team to the Republic of Zimbabwe in 3 October, 1996 to conduct the Stage 2 Field Work of "the Study on Water Pollution Control in the Upper Manyame River Basin" (hereinafter referred to as "the Study") in accordance with the agreement on the Scope of Work for the Study between the Preparatory Study Team of JICA and the Ministry of Local Government, Rural and Urban Development of the Republic of Zimbabwe (hereinafter referred to as "MLGRUD") signed in 29 November, 1995.

The stage 2 field work of the Study started in 1 October, 1996 and was completed in 26 December, 1996. The stage 2 field work serves as the basis for the feasibility study on the priority project, the draft of which will be presented in the Draft Final Report at the end of February 1997.

A meeting was held in 20 December, 1996 on the Progress Report (2) for the Study (hereinafter referred to as "the P/R (2)") between the Study Team and the Steering Committee of the Government of Zimbabwe. The attendants for the meeting are listed in Appendix A attached herewith.

The P/R (2) presents the Feasibility Study on a preliminary base for an urgent project covering tha followings:

(1) Preliminary design of facilities and construction plan
(2) Plan of institutional arrangements
(3) Rough cost estimates and investment plan
(4) Financial plan with cost recovery
(5) Preliminary Environmental Impact Assessment (PEIP)

The summary of the contents of respective items is attached in Appendix B. The contents of the P/R (2) were generally agreed between the two parties. However, further descriptions/ arrangements will be made for the feasibility study with reference to the study results in the M/P in terms of population projection, trade effluent collection and treatment and present financial practies of the Municipality.

Draft Final Report (Summary and Main Report in combination of the M/P and F/S) will be hand carried by Mr. J. Mugabe, MLGRUD before 15 February 1997 to hold final steering committee on 27 February,1997. The second seminor will be conducted on 25 February, 1997.

The MLGRUD requested the JICA to donate the equipment used by the Study Team upon completion of the Study. The request will be transferred to JICA head office in Japan. The request letter from the MLGRUD including the list of the equipment is attached in Appendix C.

APPENDIX A

LIST OF ATTENDANTS

Ministry of Local Government, Rural and Urban Development:

Mr. A. C. Mpanhanga	Director, Dept. of Development Planning and Co-ordination
Mr. J. T. Mutamiri	Deputy Director, Dept. of Development Planning and Co-ordination
Mr. M.R. Ziracha	Principal Planner, Dept. of Physical Planning
Mr. J. Madzivanyika	Acting Assistant Sceecretary
Mr. J. Mugabe	Admin. Officer, Dept. of Development Planning and Co-ordination

Ministry of Agriculture:

Mr. S. M. Mushiri	Soil Chemist, Dept. of Research & Specialist Services

Ministry of Environment and Tourism:

Mr. R. Muzawazi	Environmental Health Services Dept.

Ministry of Transport and Energy:

Mr. J. Hwindingwi	Chief Testing and Research Officer, Dept. of State Roads

City of Harare:

Mr. E. Mudzuri	Deputy Chief Engineer, Water & Sewerage., Dept. of Works
Mrs. Mufaro Jarawaza	Chief Chemist, Engineering Services Div., Dept. of Works

Chitungwiza Municipality:

Mr. T. N. Chiroodza	Town Clerk
Mr. M. Khosla	Director, Engineering Services
Mr. Petros Mbira	Engineer, Water & Sewerage

Norton Town Council:

Mr. G. Magombedze	Town Engineer

Ruwa Local Board:

Mr. Cornelius Piroro	Technician, Water & Sewerage

JICA Zimbabwe Office:

Mr. Mitsuo Nakamura	Resident Representative

JICA Study Team:

Mr. Masatoshi Momose	Team Leader
Mr. Hirofumi Sano	Sewerage Planning
Mr. Toshiki Naka	Sewerage Facilities Planning
Mr. Fumihiko Furuichi	Organization & Institution
Mr. Munenori Tada	Economic & Financial Analysis
Mr. Takuo Kozawa	Construction Planning & Cost Estimate
Mr. Takashi Watanabe	Environmental Study

APPENDIX B

OUTLINE OF FEASIBILITY STUDY FOR REHABILITATION /EXPANSION OF THE URGENT PROJECT

1. Introduction

The field work of Stage 2 Study of the study on "Water Pollution Control in the Upper Manyame River Basin in the Republic of Zimbabwe" (hereinafter referred to as "the Study") began with the arrival of the JICA study team (hereinafter referred to as "the Study Team") on 3 October 1996 ad finished on 26 of December 1996

During the JICA study team's stay in Zimbabwe several important events took place. These events are as follows:

- Essentials of the draft Master Plan for Water Pollution Control for the Upper Manyame River Basin on 8 October 1996.

- Seminar on the above Master Plan was conducted at the Meikles Hotel on 11 October 1996 for officials from local and national government agencies in Zimbabwe.

The particulars of the field works for Stage 2 of the Study are as follows:

Objective: Conduct a feasibility study o the priority project identified in the Master Plan with a provision for technology transfer to the counterpart personnel.

Scope of Work:
1. Supplementary data collection and field survey
2. Preliminary design of facilities and construction plan
3. Plan and institutional arrangement
4. Rough cost estimates and investment plan
5. Financial plan with cost recovery
6. Conduct Preliminary Environmental Impact Assessment (PEIA)
7. Preparation of Progress Report (2) and discussions on the report

2. Rehabilitation/Expansion for the Zengeza Sewage Works

2.1 Background

A key component of the Water Pollution Control Master Plan is that the sewerage systems in the study basin be augmented to ensure that the present water quality level be maintained through the future. As part of this plan, priority projects for the year 2000 were studied, incorporating the objectives of conservation of water quality and providing fresh water inflow into the impoundments while maintaining the policy of the apartment of Water Development's to maximize water reuse and to ensure water supply during time of drought

The Zengeza Sewage Treatment Works in Chitungwiza Municipality was selected from among the potential projects as being the candidate for urgent rehabilitation and expansion based on technical, environmental improvement, economic and financial aspects.

2.2 Study Area

The study area covers 42 km^2 area hat is under the jurisdiction of the Chitungwiza Municipality, 60% of which is presently served by the existing sewerage system. Chitungwiza has a population of over 400,000 and is one of the fastest growing area in Zimbabwe, with an annual grows rate of around 9%.

The proposed site for the extension of the Zengeza STW is owned by the Chitungwiza Municipality and the site to the cost of the existing STW facilities.

2.3 Existing Conditions of Water Supply and Sanitation/Sewage Works

2.3.1 General

The climate of the study area has three pronounced seasons. "Spring" is from September to November and is hot and dry (avg. daily temperature 22°C ± 6°C). "Summer" is the rainy season, wherein hot and wet conditions (avg. daily temperature 20° C ± 6°C with 80% of the annual mean 820 mm rainfall). The remainder of the year is fairly cold and dry (avg. dairy temperature 16°C ± 6°C).

The topography of the area lies at altitudes ranging from 1,390 to 1,460 m above sea level with a gentle slope both from the northwest and the northeast towards the southern center of the municipality where the STW is located. The ground elevation where the STW is located is 1,400m ± 4 m with a comparatively rich topography.

Geologically, the municipality is underlain by granite. At the STW site, decomposed granite/sand silt is found from the surface to about 0.5 m down followed by residual decomposed granite to one meter or more.

2.3.3 Water supply

The monthly water demand of Chitungwiza fluctuates between 22,000 m^3/day to 42,000 m^3/day, depending on the season; the annual average (1992) was estimated at 28,900 m^3/day. Servicing this demand is the Morton Jaffray Water Treatment Works through the bulk water supply system of Harare. The Seke service reservoir covers the entire services area of the municipality.

The future water demand of the area (year 2012) has been estimated at being the following figures in the Harare Water Supply Master Plan (assuming a population of 663,000):

- residential-46,300 m^3/day
- commercial/industrial/institutional - 22,400 m^3/day
- non-revenue water - 7,600 m^3/day

2.3.3 Sewerage

The sole STW for Chitungwiza is the Zengeza plant. The Zengeza STW was built over 20 years ago to have a designed treatment capacity of 21,750 m^3/day using the following facilities: screen and grit removal, anaerobic ponds, trickling filters, and a pumping station. The effluent is transmitted to a maturation pond to be partially used for irrigation of the Imbgwa farm. The BOD removal rate is approximately 80%, with an average effluent BOD of 180 mg/l (the raw sewerage is 970 mg/l). The service coverage is nearly 100%.

The sewerage system in Chitungwiza is afflicted with the following problems:

- Numerous leakages of raw sewerage from old/ill-maintained facilities
- Highly overloaded - estimated inflow is between 36,000 to 40,000 m^3/day versus the design capacity of 21,750 m^3/day.
- Aging facilities - there are numerous problems with the pumps and other facilities
- Nearby Tilcor anaerobic ponds are ill-maintained and pose health/odor hazards
- Current use of ill-treated effluent for irrigation poses a water pollution hazard

The future sewage volume in Chitungwiza is projected at being 415,000 m^3/day in the year 2000 based on an estimated population of 489,000.

2.4 Frame Values and Land Use

The frame values used in the Study area important as they provide the base upon which many of the design considerations, etc. are based. The frame value concerning the population for the target year was modified to reflect two scenarios as shown below. Using these two scenarios, the design population for the year 2000 was established at 489,000 as an intermediate figure. The land use plan was based on the Master Plan.

2.4.1 Frame Values

The frame values for the estimates of population, industrial/commercial are summarized below.

Population	Present (1992)	1995	2000	2015
Case 1:	354,500	405,000	537,800	962,500
Case 2:	as above	as above	439,500	573,100

Comm/Industrial	Present (1992)	2000	2015
Industrial Area (km^2)	1.35	1.35	9.41
Factory Land Area (ha)	108.0	108.0	752.8
No. of Employees/ha	43.48	43.48	43.48
No. of Employees	2,500	3,100	32,800

2.4.2 Land Use

The land in Chitungwiza was based on the Master Plan. At present 55% or 22.82 km^2 of the municipal area is used for residential purposes and this area is comprised solely of high and medium density areas; the majority being high density (85% or 19.47 km^2). Of the open spaces at present, there are some developments planned including a 1.75 km^2 area of St. Mary's which will include high density, school, commercial establishments and a church. By the year 2015, the left bank of the Nyatsime is projected to be the area where most of the industrial growth will be concentrated while the residential areas are projected to expand in other locations.

2.5 Quantity and Quality of Sewage

The quantity and quality of sewage was based on the figures in the Master Plan. The average quantity in the overall service area in 2000 was calculated at 68 lpcd and the wastewater discharged by the commercial/institutional locations was estimated at being 5% of the domestic sewerage. The summarized numbers are as follows:

Domestic sewage quality/quantity (ADWF)

Category	Quantity (lpcd)			Quality (gpcd)			
	Present	2000	2015	BOD	SS	TN	TP
High density	60	63	70	44	51	11	1.2
Medium density	210	315	315	47	54	12	1.3
Low density	315	315	315	50	58	13	1.4

Based on the above, the unit quantity and projected population, total inflow of sewage into the STW in the year 2000 was calculated to be about 41,5000 m^3/day. The design sewage volume of the existing STW, which will treat combined domestic/industrial sewage, was established at 21, 750 m^3/day while the additional facilities, which will treat domestic sewage only, was established at 20,000 m^3/day. The pollution load concentration (mg/l) for the existing and the expansion facilities are as follows:

STW	BOD	SS	TN	TP
Rehabilitated Existing	592	644	134	15
New Expansion	564	653	141	15

2.6 Planning and Design Approach for the Urgent Project

2.6.1 Technical Considerations

The planning and design approach for the expansion/rehabilitation of the Zengeza STW was done in consideration of the particulars of the STW, the study area, and the financial/technical parameters, whilst keeping in line with the long-term sewerage development plan, as outlined in the Master Plan. The planning and design approach is summarized below.

The existing sewage works will be fully utilized for the expansion of the treatment facilities to meet the future sewage volume. The existing trickling filter will be used within its capacity to treat the combined residential and industrial sewage through the future and a staged construction of additional treatment facilities, using the BNR process, will be undertaken as needed.

The existing sewage treatment works, pump stations and sewers is planned. A parallel sewer line to the existing trunk sewer from the St. Mary's is planned to handle the sewage generated by new housing development in that area. These steps will mitigate the severely overloaded condition of the STW. Moreover, all of the facilities will be designed in a manner that will provide safeguards against the possibility of overflows that would contaminate the surrounding water sources.

The sludge generated by the STW will be treated through the use of thickening, anaerobic digestion and drying for reuse as fertilizer. The treated sludge will be promoted for use as a fertilizer to reduce the amounts of sludge to be handled otherwise; a sanitary landfill will be necessary. The sludge storage area will be designed to not flow out during heavy rains in order to prevent water pollution problems.

The construction plan for the new treatment facilities and the existing facilities will be developed for both sewage and sludge treatment. The soil conditions and the groundwater table are major concerns for the design of the facilities. The grade of the facilities and equipment used in the project will be determined based on the experience of Harare as well as the simplicity and ease of the operation of the facilities. The use of local materials and labor intensive arrangements both for the construction and operation and maintenance of the facilities will be considered.

2.6.2 Institutional Reinforcement

The national government agencies should concern itself with major policy and planning issues and with establishing the criteria to be applied by the lower governmental levels in resolving major issues. At each political and administrative level, it is "must" to delineate the authority and responsibility of the organizational structure.

In the Chitungwiza Municipality, the planning and project implementation for rehabilitation/ expansion of the Zengeza Sewage Treatment Works and its operations and management are vested in the Engineering Services Department (ESD). In order to strengthen its organizational structure and improve the system's efficiency as a whole, the increase in personnel and frequent retraining and upgrading of skills are needed.

To ensure the smooth implementation of the priority project, the training programme should be duly carried out for the both administrative and technical personnel, particularly for the staff undertaking the operations & maintenance of the sewage treatment works and water quality monitoring. The training programmes should be designed to strengthen the planning and management capacity of middle and senior level professionals working in the sanitation/ sewerage sector and also provide adequately trained personnel for the operation of the relevant treatment works. In addition, it is important to provide training seminars and workshops to disseminate all water pollution related information to the interested people.

2.6.3 Legal Arrangement

To tackle the legislative and administrative problems on water pollution control, the Water Act and relevant water regulations should be reviewed and updated to define the responsibilities of the national government, local authorities and business enterprises, and to clearly formulate the basic principles that should govern the promotion of environmental measures, so as to be able to implement water pollution measures in a comprehensive and unified manner.

In order to deal with imminent and potential problems before they occur or become serious, and also to prepare the water pollution control plan, it is essential to formulate, as quickly as possible, the "Environmental Water Quality Standards".

The trade effluents in the municipal area should be properly controlled in accordance with the "Trade Effluent Control" regulations. In view of their contents and actual applications, it is necessary to review and upgrade them to the status of "by-laws", in order to achieve a given percent reduction and enable charge all pollutants a uniform price, based on the quantity and quality of their discharge.

To expedite the legal and procedural arrangements for the effective water pollution control in the Municipality area, it is advisable to set up a "Task Force" which takes charge of reviewing/ updating the existing regulations & standards, and/or formulating new statutes.

2.6.4 Financial Management

The urban Council of Chitungwiza acts as the executing body in respect of implementation of the Project. The Council is in a position to borrow capital funds from the national government and finance expenditures on operation and maintenance as well. The ultimate objective of financial management is sustainability of the Council's self-finance towards implementation of the Project. Two approaches can be taken into account. One is the role of the government to ease financial burden on the Council. The other is the effective management of sewerage revenue and expenditures to be handled by the Council.

Financial assistance of the government comprises i) identification of donor fund with preferential loan conditions, ii) exemption of foreign exchange premium to lower on-leading rate and iii) mobilization of the government grant to finance administration charge and engineering service in the form of technical assistance. While as the borrower's position the Council will be responsible for increase of sewerage revenue and control on sewerage expenditures. Revenue increase can be achieved by two methods. One is introduction of a new tariff called effluent charge, and the other is the efficient management of revenue bases on which sewerage flat tariffs are imposed. Perhaps management of debt service would be the crucial factor to keep expenditures at the level planned at the time of budgeting. In this regard, loan disbursed from the government is the best source of fund which guarantees regular repayment of debt service.

2.7 Sewage Collection System

2.7.1 Rehabilitation/Modification Plan of Existing Sewer Reticulation

The rehabilitation/modification plan for the existing pump stations (St. Mary's No.1, 2 and Tilcor) are prepared for mechanical and electrical facilities. The rehabilitation/modification plan is presented in Sub-section 2.9.

The following are required equipment for each pump stations.

(1) St.Mary's No.1 pump station
- Pump facility : 150mm^{dia} x 2.60m^3/min x 34.5m x 25.0kw x 3(1) units
- Inplant pipe : 1 set (including valve box and flow meter)
- Electrical panel : 1 set (including house wiring)

(2) St.Mary's No.2 pump station
- Pump facility : 100mm^{dia} x 1.20m^3/min x 12.5m x 5.0kw x 2(1) units
- Inplant pipe : 1 set (including valve box and flow meter)

Electrical panel : 1 set (including house wiring)

(3) Tilcor pump station

Pump facility : 150mm^{dia} x 2.30m^3/min x 28.0m x 18.0kw x 3(1) units

Inplant pipe : 1 set (including valve box and flow meter)

Electrical panel : 1 set (including house wiring)

2.7.2 Expansion Plan for Residential Development Area in St.Mary's

New pump station, force main and gravity trunk sewer are also designed for the residential development area in western end of St. Mary's. Collected sewage by gravity sewer inflows in new pump station and pumped through force main to the starting point of gravity trunk sewer, in parallel with the existing trunk sewer, then conveyed to the Zengeza STW. The required equipment and materials are as follows.

(1) New St.Mary's pump station

Screen and grit chamber : 1 set

Pump facility : 150mm^{dia} x 3.00m^3/min x 58.0m x 50.0kw x 3(1) units

Inplant pipe : 1 set (including valve box and flow meter)

Electrical panel : 1 set (including house wiring)

(2) Force main pipe

Pipe material : AC pipe

Diameter : 300 mm

Total length : 2,600 m

(3) Gravity Trunk Sewer

Pipe material : AC pipe

Diameter : 525 mm

Total length : 4,280 m

No. of manhole : 51 sets

2.8 Sewage and Sludge Treatment and Disposal

2.8.1 Rehabilitation of Existing Facilities

The Rehabilitation of existing facilities is carried out not only to maximize their functions, but also for the proper O&M through the future.

The scope of rehabilitation is 1) Existing Zengeza STW, 2) Irrigation Facility and 3) Tilcor Pre-treatment Facility. The proposed rehabilitation work for these facilities are as follows.

Facilities	Rehabilitation Work
Existing STW	Installation of Connection Pipe 650mm dia, AC, 1 unit, L = 30 m (Connect exiting and proposed effluent channel at Grit Chamber)
	Removal of sludge in Anaerobic Ponds, V = 13,600 m^3
	Removal of sludge in Trickling Filter, V = 1,220 m^3
	Construction of sludge disposal pit
	Replacement of flow meters for the Parshall Flumes, 2 units
	Construction of fence, L = 700 m
Irrigation Facility	Replacement of pump facilities Pump : 400 m^3/hr x 1 unit Motor : 185 kW x 1 unit Valve : 1 unit Control Panel : 1 unit
Tilcor Pre-treatment Facility	Removal of sludge, V = 2,200 m^3
	Construction of sludge disposal pit
	Replacement of scum jet nozzle and piping (water will be supplied from proposed infiltration pump station)
	Rehabilitation of No.3 storage pond as equalization pond in wet season

2.8.2 Expansion of the Zengeza STW

The treated effluent of proposed expansion of STW will be discharged to Nyatsime River as a valuable water source during the time of drought. Thus, the effluent quality shall be stable and be within the discharge standards (GN 687/77).

BNR method is employed and the system only treats domestic sewage. Connection pipe from proposed effluent channel to the existing is also installed to allow all sewage flow into the existing STW in case of accident. The followings are the proposed facilities.

Facilities	Dimensions
Distribution Chamber	Trunk sewer 675 mm, 2 units 0.7 - 1.2 m^W x 15.5 m^L x 1.16 m^H
Screen & Grit Chamber	Coarse screen (screen gap 40 mm) 1.2 m^W x 1.2 m^H x 2 nos.
	Fine screen (screen gap 14 mm) 0.9 m^W x 1.24 m^H x 2 nos.
	Parshall flume Capacity = 30,000 m^3/day x 2 nos.
	Grit Chamber 1.8 m^W x 6.0 m^L x 7.6 m^D x 2 nos.
Primary Sedimentation Tank	Type : Dortmund tank 12.2 m^{dia} x 11.5 m^D x 6 nos.
BNR Reactor	13.6 m^W x 95.5 m^L x 4.5 m^D x 2 nos.

(Cont'd)

Facilities	Dimensions
Final Sedimentation Tank	Type : Clarifier 26.0 m^{dia} x 3.5 m^{D} x 4 nos.
Outlet Work	1.0 - 3.0 m^{W} x 5.0 m^{L} x 1 nos.
Sludge Thickener	Type : Dortmund Tank 11.6 m^{dia} x 11.3 m^{D} x 2 nos.
Anaerobic Digestion Tank	Type : No-heating, recirculation 20.0 m^{dia} x 19.5 m^{D} x 2 nos.
Sludge Drying Bed	30 m^{W} x 60 m^{L} x 6 nos.
Sludge Storage Yard	Yard with Roof 12 m^{W} x 60 m^{L} x 1 nos.
Sludge Disposal Pit	100 m^{W} x 100 m^{L} x 4 m^{D}
Laboratory and other rooms	Total area = 12 m^{W} x 24 m^{L} = 288 m^{2}
Inplant Pipe	Total length = 3.2 km

2.9 Construction Plan, and Operation and Maintenance

2.9.1 Construction Plan

All the construction site is situated on a flat land or a gentle slope. The access to the site is easy from the municipality road and the existing residential road. It is about 30 minutes from Harare City to each site by asphalt pavement road.

The workable days are assumed to be 21 days per month in average, as a result of analysis of suspended day due to rainfall, Saturday, Sunday and holiday. The daily rainfall data was obtained from Belvedere gauging Station at Harare City.

Availability of local contractors is quite enough for the sewage construction works including mechanical and electrical works, from surveying existing sewage project, interview with civil contractor, subcontractor and special contractor and CIFOZ registered contractor.

Labor will be supplied from the subcontractor and special contractor. The operator, driver and assistance will be included in the hiring equipment charges.

Almost construction materials are produced in Zimbabwe. The imported materials are also available from the local market. There are many manufacturer, supplier and sales agent in Harare.

The construction period is planned to be 18 months (1.5 years) considering with meteorological conditions of rainy season, availability of Zimbabwe contractor and equipment supply conditions. The construction sites are dotted and each work will be carried out in parallel work employing the many subcontractors and special contractors.

The construction of sewer pipeline and pump station will be constructed during dry season in principle. The expansion sewage works will be made for 1.5 years according to bulk excavation, structure construction , mechanical installation and so on.

The construction works will be made by a conventional method. The detailed construction schedule will be established in the Feasibility Study Report based on the preliminary quantity.

2.9.2 Operation and Maintenance of Sewerage Facilities

Proper O&M is indispensable to extend their durable years and to display their full capacity.

(1) Sewer Reticulation

Sewer

There are 3 types of O&M work for sewer, namely :

Site Investigation	: 3 person/team x 1 team
Pipe Cleaning	: 6 person/team x 4 teams
Rehabilitation	: 2 persons for construction supervision and 4 contractors

Each work is carried out by O&M team and their activity shall be recorded in daily report.

Pump Station

There are 2 types of O&M work for pump station, they are :

Daily O&M	: 24 hours, 3 shifts (4 person including stand-by)/pump station
Periodical O&M	: Removal of scum from pump pit (every 6 months), Overhaul of pump (every 5 - 10 years)

Each work is carried out by resident workers and their activity shall be recorded in daily report.

(2) Sewage Treatment Works

Existing STW

One of the four units of Anaerobic Pondsill be kept open for emergency and maintenance.
Desludge is neded at least once a year for every pind.
For other facilities, usual O&M work will be continued.

New STW

- Primary Sedimentataion Tank
  Twice in a day, the sludge shall be withdrawn and pumped to anaerobic digestion tank.
- BNR Reactor
  The required nutrient concentration shall be maintained for effective treatment. In a wet season, supplemental nutrient will be supplied by suparnatant.
- Sludge Drying Bed and Sludge Storage Yard
  The dried sludge will be gathered by manual and loaded by transportation machenary then carried to storage yard.

2.10 Cost Estimates

2.10.1 Construction Cost

The construction cost is estimated based on the preliminary quantity of the Progress Report (2). The unit price is applied considering with the Master Plan in the Preliminary Report, the information of material supplier, hiring company and contractor, and the cost is divided into foreign currency and local currency portion.

The construction cost is tentatively estimated on the Progress Report (2) stage. The cost will be re-estimated in the Feasibility Study based on the work item, preliminary quantity and unit price.

The price level is to be December 1996 and the exchange rate is US$1.00 = Z$ 10.5 = J.Yen 115.0.

The construction cost comprises direct cost, land acquisition and compensation cost, administration expenses, engineering services, physical contingency and price escalation. The cost of land acquisition and compensation is not included, since the acquired land for construction use is owned by the Municipality of Chitungwiza. Breakdown is shown below.

	Description	Foreign (Z$)	Local (Z$)	Total (Z$)	Total (US$)
I.	Direct Construction Cost	93,133,897	73,779,486	166,913,383	15,896,513
II.	Land Acquisition and Compensation	0	0	0	0
III.	Administration Expenses	0	4,000,000	4,000,000	380,952
IV.	Engineering Services	8,382,051	6,640,154	15,022,205	1,430,686
	Total (I,II,III and IV)	101,515,948	84,419,640	185,935,588	17,708,151
V.	Physical Contingency	10,151,595	8,441,964	18,593,559	1,770,815
	Total (I,II,III,IV and V)	111,667,543	92,861,604	204,529,147	19,478,966
VI.	Price Escalation	6,579,000	52,143,000	58,722,000	5,592,571
	Grand Total	118,246,543	145,004,604	263,251,147	25,071,538

Note:Foreign - imported materials and equipment
Local - indigenous materials and labour
Direct Construction Cost - including direct, indirect (overhead and profit) construction cost

2.10.2 Operation and Maintenance Cost

(1) Sewer Reticulation

The annual O&M cost for sewer reticulation is Z$ 3,646,000/year.

(2) Sewage Treatment Works

The annual O&M cost for the Zengeza STW is Z$ 8,236,000/year.

2.11 Institutional, Legislative and Financial Study

2.11.1 Institutional Development

Under the supervision of the MLGRUD (strictly speaking its DDPC), Chitungwiza Municipality is empowered to implement development projects including the priority project.

To support substantially the decision-making functions of the municipal administrative system, there is a need to strengthen the managerial capabilities of the existing "Management Committee". Then, it is proposed to create newly a "Project Coordination Committee (PCC)" which is to exclusively deal with the matters/issues of the priority project.

For smooth implementation of the project, it is recommended to establish a "Project Management Office (PMO)" under the Director of the Engineering Services Department (ESD). Consequently, the Director of ESD will be appointed as a Project Director of the project. The PMO will be headed by a Project Manager and composed of technical and administrative specialists with enough experiences in each field.

To assure the efficient O&M of the project facilities, it is important to consolidate the Sewerage Section, especially in terms of manpower and monitoring. With a view to strengthen its monitoring capacity, it is strongly recommended to construct a "Chemical Laboratory" for water quality analyses. Besides, it is proposed to establish an operational unit to be called as the "Waste Water Inspectorate (WWI)" under the Laboratory for efficient enforcement of the Trade Effluent Control By-laws.

With regard to the human resources development, the properly organized and designed training programmes should be carried out for both the administrative and technical and the existing and new staffs.

2.11.2 Legal Arrangement

In order to ensure effective and efficient environmental management and water pollution control, the legal arrangements proposed in the Master Plan are expected to be carried out as soon as possible, within the (Short-Term) Action Plan period up to the Year 2000.

The primary arrangements necessary for legislative framework consolidation related to water pollution control include the following : 1) review of "Water Act", 2) enactment of "Environmental Management Act", 3) establishment of "environmental Water quality Standards" 4) amendment of the existing "Effluent Regulations", and 5) review of updating of other legislation relating to water pollution control.

In order to control the water pollution in the Municipality area, specially the trade effluents form the industrial area, it is recommended to enact the "Trade Effluent Control By-laws" as quickly as possible. Since the enactment of laws & regulations are really complex tasks, it is proposed to set up a "Task Force for Legal Arrangements". The primary assignments of this Task force will include the drafting works of the following laws and regulations : Trade Effluent Control By-laws, Model Building By-laws, Waste Management By-laws and others.

2.11.3 Financial Study and Implemantation Plan

The financial study aims to evaluate the Council's self-financing condition under implementation of the Project. The condition of self-finance could be checked by the balance between projected revenue and expenditures consisting of operating expenses and debt service, as expressed by the following equation.

Balance = Revenue - O & M cost - debt service

Sewerage revenue comprising both sewerage charges based on flat tariffs and effluent charges to be introduced is projected taking into account two factors; expansion of revenue base and the real growth of income. O & M costs estimated are classified into those for the existing and proposed facilities. Debt services the Council would have to repay are composed of the scheduled repayment committed by the existing liabilities and new repayment to be borne by implementation of the Project.

The four alternative financial schemes are assumed in order to estimate debt services relating to the Project.

Alternative Case	Type of Fund		Premium
	GOZ	Donor	
Base	Loan	Loan	Charge
Alt. 1	Grant	Loan	Charge
Alt. 2	Loan	Loan	Subsidy
Alt. 3	Grant	Loan	Subsidy

Donor is assumed to be most concessionary bilateral fund with the lending rate of 3% per annum. Premium, the difference between lending and on-lending rates is assumed to be 8%.

Base : The loan scheme with premium
Alt 1 : A combination of GOZ's grant and donor's loan with premium
Alt 2 : The loan scheme without premium
Alt 3 : A combination of GOZ's grant and donor's loan without premium

Balance is estimated by alternative case with the following results.

unit: Z$ million

Balance	2000	2010	2020
Base case			
Annual in the target year	-29	14	119
Accumulated	-65	-167	614
Alt 1			
Annual in the target year	-27	17	122
Accumulated	-59	-131	680
Alt 2			
Annual in the target year	-10	28	134
Accumulated	-17	24	947
Alt 3			
Annual in the target year	- 8	31	137
Accumulated	-11	60	1,013

Revenue would be sufficient to cover operating expenditures and the scheduled repayment of the existing liabilities, but not large enough to cover new debt service even for Alt 3 which is the most preferential financial scheme. The results of balance estimated is still subject to final costing of the Project.

Implementation plan of the Project encompasses physical development plans, institutional development, legal arrangements and financial arrangements. Action Programs entail all preparatory works for various measures proposed for implementation of the Project.

(1) Institutional

1) Preparation for a "Water Pollution Control Coordinating Committee",
2) Preparation for a "Project Coordination Committee",
3) Preparation for a "Project Management Office", and
4) Preparation for operation and maintenance works to be strengthened.

(2) Legal

1) Legal measures relating to the existing Acts, Regulations and Standards.
2) Preparation for a " Task Force for Legal Arrangements " which is principally designed to enact the "Trade Effluent Control By-law" at the Council's level.

(3) Financial arrangement

1) Preparation for the government financial assistance to alleviate financial burden on the Council.

(4) Detailed design

Immediately after the completion of the Feasibility Study in March 1997, implementation period is broadly divided into three stages.

- First stage : Most of Action Programs covering institutional, legal
(April to June, 1997) : and financial arrangements should be carried out.
- Second stage : Implementation of detailed design
(July 1997 to March 1998)
- Third stage : Construction of the Project
(April 1998 to Sep. 1999)

2.12 Project Evaluation

The Project will be evaluated from the aspects: i) benefits of the Project, ii) environmental aspect, iii) institutional and financial aspects, iv) economic aspect, and v) overall evaluation of the Project. The approach and methodology of evaluation employed for each aspect are summarized as follows.

(1) Benefits of the Project

The Project is expected to generate a wide range of benefits in respect of their nature and recipients, which can be classified into tangible and intangible benefits. Tangible benefits are to be quantified as much as possible, while intangible benefits will be qualitatively assessed.

(2) Environmental Aspect

The version of "Environmental Aspect" focuses on the potential positive impacts of the Project with the following components.

1) Improvement of effluent quality due to BNR treatment process and the existing secondary treatment facilities to be improved.
2) Mitigation of the current sanitation problem, odour at the STW site.
3) Reuse of treated effluent for potable water supply.
4) Employment opportunities during construction and for operation of plants.

(3) Institutional and Financial Aspects

Implementation capability of the Council will be assessed from both institutional and financial aspects. In particular financial aspect would demonstrate quantitative analysis of to what extent the government financial assistance would be required for implementation of the Project.

(4) Economic Aspect

Economic viability of the Project shall be evaluated by EIRR or net present value based on economic benefits and cost estimated.

(5) Overall Evaluation of the Project

The Project will be comprehensively assessed balancing evaluation of each aspect. Overall evaluation is intended to be rather qualitative than quantitative.

APPENDIX C

REQUEST LETTER FOR DONATION OF EQUIPMENT

LIST OF EQUIPMENT REQUESTED TO BE DONATED

1. Portable Type COD Meter with accessories:
   Model: COD-50S, TOA Electronics Co., Ltd. 1 set

2. Portable Type Water Quality Meter with accessories:
   Model: WQC-20A, TOA Electronics Co., Ltd. 1 set

3. Portable Type Current Meter with accessories:
   Model: J-051, Yokogawa Weathac Corp. 1 set

4. Sampling Tools:
   Vacuum Pump;
   Model: ULVAC G-5, Shinku Kiko Co., Ltd. 1 set
   Vacuum Filteration Bottle;
   Model: VIDREX 500cc, Kokura Glass Industries Co., Ltd. 2 bottles
   Measuring Cylinder;
   Plastic Cylinder 1000cc 1 set

5. Copy Machine with accessories:
   Model: U-Bix 112Z, Konica Corp. 1 set

Correspondence should not be addressed to individuals

Telegrams: "LOCALGOV", Harare
Telephone: 790691/9, 728201/9
Facsimile: 792307

Private Bag 7706, Causeway
Zimbabwe

ZIMBABWE

Reference

MINISTRY OF LOCAL GOVERNMENT, RURAL AND URBAN DEVELOPMENT
Mukwati Building
Fourth Avenue
Harare
Zimbabwe

Ref : ADM/59/7

Date : 19/11/96

Director of Social Development Study Department
Japan International Cooperation Agency

Attention : Mr. Kuroda

RE : **REQUEST FOR DONATION OF EQUIPMENT : WATER POLLUTION CONTROL PROJECT IN THE UPPER MANYAME RIVER BASIN : JAPANESE ASSISTANCE :**

Reference is made to the abovementioned project which is on-going and was agreed upon between the Government of Japan and that of Zimbabwe. As you know this Ministry is hosting the project on behalf of the local authorities (Harare, Chitungwiza, Norton and Ruwa) with Japan International Cooperation Agency giving the technical assistance. It would be appreciated if you could donate the equipment that the JICA Study Team is using to the Ministry for future use.

We understand that some of the items which maybe available for the donation are on the attached list.

A. C. Mpamhanga
for: **SENIOR SECRETARY FOR LOCAL GOVERNMENT, RURAL AND URBAN DEVELOPMENT**

MINUTES OF MEETING
ON
DRAFT FINAL REPORT
FOR
THE STUDY ON WATER POLLUTION CONTROL
IN
THE UPPER MANYAME RIVER BASIN
IN
THE REPUBLIC OF ZIMBABWE

AGREED UPON BETWEEN
THE MINISTRY OF LOCAL GOVERNMENT,
RURAL AND URBAN DEVELOPMENT
AND
THE JICA STUDY TEAM

HARARE, FEBRUARY 27, 1997

Mr. A. C. Mpambanga
Deputy Secretary / Director,
Development, Planning and Co-ordination,
Ministry of Local Government, Rural and
Urban Development

Mr. Masatoshi Momose
Team Leader,
JICA Study Team

The Japan International Cooperation Agency (hereinafter referred to as "JICA), the official agency responsible for the implementation of the technical cooperation programmes of the Government of Japan, dispatched the Study Team to the Republic of Zimbabwe on 20 February, 1997 to conduct the final discussion on the Draft Final Report for "the Study on Water Pollution Control in the Upper Manyame River Basin" (hereinafter referred to as "the Study") in accordance with the agreement on the Scope of Work for the Study between the Preparatory Study Team of JICA and the Ministry of Local Government, Rural and Urban Development of the Republic of Zimbabwe (hereinafter referred to as "MLGRUD") signed in 29 November, 1995.

The stage 3 field work of the Study started on 20 February, 1997 and was completed on 2 March, 1997. A meeting was held on 27 February, 1997 on the Draft Final Report for the Study (hereinafter referred to as "the D/F)") between the Study Team and the Steering Committee of the Government of Zimbabwe. The attendants for the meeting are listed in Appendix A attached herewith.

Major subjects presented in the D/F Report were explained by the Study Team and generally agreed by the both parties.

Through the discussions, it was confirmed by the both parties that the M/P for the water pollution control was prepared from macrocosmic view point and a priority project was identified for the near future (2000) as well as staged expansion/rehabilitation through the year 2015 for all existing STWs.

The Study Team will complete the report making revisions as required based on the discussions with the representatives of the Local Authorities.

APPENDIX A

LIST OF ATTENDANTS

Ministry of Local Government, Rural and Urban Development:

Mr. J. T. Mutamiri	Under Secretary, Dept. of Development Planning and Co-ordination
Mrs. T. A. Chivore	Under Secretary
Mrs. S. N. Musungwa	Assistant Secretary, Dept. of Development Planning and Co-ordination
Mr. J. Mugabe	Administrative Officer, -ditto-

Ministry of Health and Child Welfare:

Mr. G. Mangwiro	Assist. Director, Environmental Health Services Dept.

Ministry of Land and Water Resources:

Mr. M. D. Chipfunde	Senior Water Pollution Control Officer

City of Harare:

Mr. Z. Hoko	Engineer, Engineering Service Div. of Works

Chitungwiza Municipality

Mr. M. Khosla	Director, Engineering Service

Ruwa Local Board

Mr. C. Piroro	Technician, Water & Sewerage

Epworth Local Board

Mr. J. Chifanba	Accountant

JICA Study Team

Mr. M. Momose	Team Leader
Mr. H. Sano	Sewerage Planning
Mr. T. Naka	Sewerage Facilities
Mr. M. Tada	Economic and Financial Analysis

Correspondence should not be addressed to individuals

Telegrams: "LOCALGOV", Harare
Telephone: 790601/9, 728201/9
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Private Bag 7706, Causeway
Zimbabwe

ZIMBABWE

Reference:

MINISTRY OF LOCAL GOVERNMENT, RURAL AND URBAN DEVELOPMENT
Mukwati Building
Fourth Avenue
Harare
Zimbabwe

Ref : ADM/59/7

27 February 1997

The Managing Director
Japan International Cooperation Agency
Shinjuku Maynds Tower
1-1, Yoyogi, Shibuya - ku,
Tokyo
Japan

MIN. OF LOCAL GOVT
AND URBAN DEV.
28 FEB 1997
REGISTRY (c)
PRIVATE BAG 7706, CAUSEWAY

Dear Sir,

RE : **LIST OF EQUIPMENT REQUESTED TO BE DONATED : UPPER MANYAME WATER POLLUTION CONTROL STUDY: MLGRUD: JAPANESE ASSISTANCE :**

Receipt of your letter on the above matter dated November 19, 1996 is hereby acknowledged. We would like to express our sincere appreciation and to thank you for donating the equipment listed in the attachment to our Ministry.

The donated equipment shall be used for the purpose of further progress on Water Pollution Control in the Upper Manyame River Basin. The equipment has already been used during the study and proved to be fruitful.

Once again, may I say that your cooperation has been mostly welcome and highly appreciated.

Yours faithfully

P.P A. C. Mpamhanga
Development Planning and Coordination
for : **SENIOR SECRETARY FOR LOCAL GOVERNMENT, RURAL AND URBAN DEVELOPMENT**

cc. Senior Secretary for Local government, Rural and Urban Development

APPENDIX C

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