

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 2 - I

MAIN REPORT

MARCH 1997

JICA LIBRARY



J1136675(4)

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

SSS

JR

97-041

EXCHANGE RATE (AS of 1 December 1961)

US\$ 1.0 = 73.10 Yen (115.0)

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 2 - I

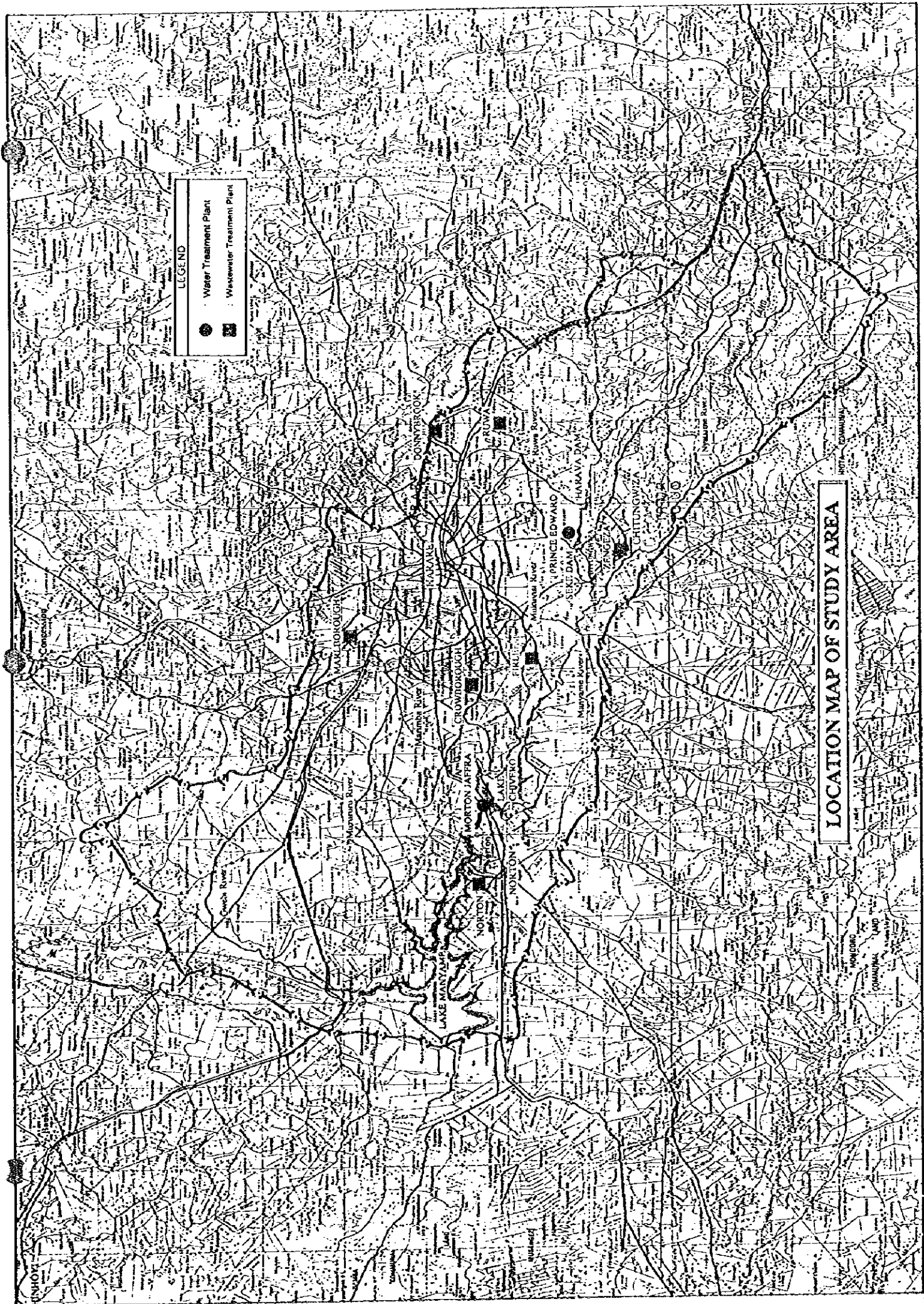
MAIN REPORT

MARCH 1997

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



1136675 [4]



LEGEND

- Water Treatment Plant
- Wastewater Treatment Plant

LOCATION MAP OF STUDY AREA

MANICOR
COMANAMA



**WATER POLLUTION CONTROL MASTER PLAN
FOR
THE UPPER MANYAME RIVER BASIN**

**VOLUME 2
MAIN REPORT**

TABLE OF CONTENTS

	PAGE
Location Map	
Table of Contents	i
List of Tables	xiii
List of Figures	xix
Abbreviations	xxix

PART I

**WATER POLLUTION CONTROL MASTER PLAN
FOR
THE UPPER MANYAME RIVER BASIN**

CHAPTER 1 INTRODUCTION.....	1-1
CHAPTER 2 ADMINISTRATIVE COMPOSITION AND PHYSICAL CHARACTERISTICS IN THE STUDY AREA	
2.1 Outline of the Study Area	2-1
2.1.1 Local Administrative Overview.....	2-1
2.1.2 Administrative Composition of the Study Area.....	2-2
2.2 Physical Characteristics in the Study Area	2-6
2.2.1 Meteorology.....	2-6
2.2.2 Topography and Geology.....	2-7
2.2.3 Hydrology and Hydrogeology.....	2-8
2.2.4 Natural Environment and Ecology in the Study Area.....	2-9
CHAPTER 3 ENVIRONMENTAL MANAGEMENT AND WATER POLLUTION STATUS	
3.1 Present Institutions for Water Pollution Control and Environmental Management.....	3-1
3.1.1 Institutional Framework for Water Pollution Control	3-1
3.1.2 Primary Ministries and Institutions for Water Pollution Control	3-2
3.1.3 Training and Manpower Development	3-14
3.1.4 System for Implementing the Water Pollution Control Project.....	3-19

3.2	Present Policies and Countermeasures for Water Pollution Control.....	3-21
3.2.1	National Development Plans.....	3-21
3.2.2	Local Development Plans	3-25
3.3	Laws and Regulations Relevant to Water Pollution Control and Environmental Management	3-29
3.3.1	Water Pollution Control.....	3-29
3.3.2	Environmental Conservation and Management.....	3-38
3.4	Financial Arrangements for Environmental Management.....	3-41
3.4.1	National Government.....	3-43
3.4.2	Local Government.....	3-46
3.4.3	Sewage and Water Works.....	3-54
3.4.4	Tariff System and Structure.....	3-62
3.5	Water Pollution Status in the Study Area	3-63
3.5.1	Concerned Agencies Undertaking Water Quality Examination and Monitoring	3-65
3.5.2	Water Pollution Status in the Study Water Body	3-66
3.5.3	Effluent Water Quality at Major Pollution Sources	3-83

CHAPTER 4 SANITATION CONDITIONS AND WATER POLLUTION CONTROL MEASURES AT PRESENT AND IN THE FUTURE

4.1	Sanitation Conditions.....	4-1
4.1.1	General.....	4-1
4.1.2	Harare City.....	4-1
4.1.3	Chitungwiza Municipality	4-2
4.1.4	Norton Town Council	4-5
4.1.5	Ruwa Local Board	4-5
4.1.6	Epworth Local Board.....	4-5
4.2	Existing Public Sewage Works, Industrial Wastewater Treatment Works and Urban Drainage	4-8
4.2.1	Existing Public Sewage Works.....	4-8
4.2.2	Industrial Wastewater Treatment Works	4-23
4.2.3	Urban Drainage.....	4-24
4.3	Present Solid Waste Collection and Disposal.....	4-26
4.3.1	General.....	4-26
4.3.2	Harare City.....	4-26
4.3.3	Chitungwiza Municipality	4-29
4.3.4	Norton Town Council	4-30
4.3.5	Ruwa Local Board	4-33
4.4	Present Status of Wastewater Treatment at Water Treatment Works	4-35
4.5	Planned/On-going Water Pollution Control Plans.....	4-40
4.5.1	Harare City.....	4-40
4.5.2	Chitungwiza Municipality	4-41
4.5.3	Norton Town Council	4-42

4.5.4	Ruwa Local Board.....	4-44
-------	-----------------------	------

CHAPTER 5 SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE

5.1	Socio-Economic Perspective.....	5-1
5.1.1	National Perspective	5-1
5.1.2	Study Area	5-3
5.2	Present and Future Land Use.....	5-6

CHAPTER 6 PROJECTION OF FRAME VALUES

6.1	General.....	6-1
6.2	Population Projection.....	6-1
6.2.1	Urban Population of Calculation Base Year 1992.....	6-1
6.2.2	Rural District Population of Calculation Base Year 1992.....	6-2
6.2.3	Alternative Population Projection of the Study Area	6-8
6.2.4	Future Population Scenarios.....	6-18
6.3	Industrial Development.....	6-18
6.3.1	General.....	6-18
6.3.2	Situation of Industries.....	6-18
6.3.3	Methodology of Projection.....	6-25
6.3.4	Estimation of Number of Employees.....	6-27
6.4	Livestock.....	6-30
6.5	Farmland/Natural Land.....	6-33
6.6	Solid Waste Dumping Sites	6-33

CHAPTER 7 WATER USE AND HYDROLOGICAL CONDITIONS OF THE WATER BODY THROUGH THE FUTURE

7.1	Water Use in the Study Area	7-1
7.1.1	Water Use in the Entire Study Basin	7-1
7.1.2	Domestic and Industrial Water Supply.....	7-2
7.1.3	Environmental Water Quality Standards.....	7-9
7.2	Hydrological Condition of the Rivers and Lakes	7-20
7.2.1	Rainfall.....	7-20
7.2.2	Flow Rate of the Rivers and Discharge of the Lakes and Dams	7-22
7.2.3	Flow Rate Estimation and Flow Balance.....	7-30

CHAPTER 8 UNIT WASTEWATER QUANTITY AND QUALITY

8.1	General.....	8-1
8.2	Domestic/Commercial/Institutional Sewage.....	8-1
8.2.1	Unit Sewage Quantity.....	8-1

8.2.2	Unit Pollution Load	8-11
8.3	Industrial Wastewater	8-15
8.3.1	Unit Wastewater Quantity	8-15
8.3.2	Unit Pollution Load	8-17
8.4	Unit Pollution Load of Other Pollution Sources.....	8-17
8.4.1	Livestock.....	8-17
8.4.2	Slaughterhouse.....	8-19
8.4.3	Natural Land/Farmland.....	8-19
8.4.4	Other Pollution Sources.....	8-23

CHAPTER 9 PRESENT WATER POLLUTION ANALYSIS

9.1	General.....	9-1
9.2	Concept of Water Pollution Analysis	9-1
9.2.1	Rivers.....	9-1
9.2.2	Lakes/Dams.....	9-6
9.3	Frame Values and Pollution Load by Sub-basin.....	9-8
9.3.1	Domestic/Commercial/Institutional Sewage.....	9-8
9.3.2	Industrial Wastewater	9-12
9.3.3	Other Wastewater	9-23
9.4	Establishment of Pollution Load Run-off Model with Water Quality Checking Points	9-28
9.4.1	Rivers.....	9-28
9.4.2	Lakes/Dams.....	9-31
9.5	Present Water Pollution Analysis.....	9-39
9.5.1	General.....	9-39
9.5.2	Rivers.....	9-39
9.5.3	Lakes/Dams.....	9-40

CHAPTER 10 FUTURE WATER POLLUTION ANALYSIS

10.1	General.....	10-1
10.2	Frame Values and Pollution Load by Sub-basin.....	10-1
10.2.1	Domestic/Commercial/Institutional Sewage.....	10-1
10.2.2	Industrial Wastewater	10-14
10.2.3	Other Pollution Load	10-14
10.3	Pollution Load Run-off Model.....	10-15
10.3.1	Rivers	10-15
10.3.2	Lakes/Dams.....	10-19
10.4	Future Water Pollution Analysis.....	10-19
10.4.1	General.....	10-19
10.4.2	Rivers	10-19
10.4.3	Lakes/Dams.....	10-26

CHAPTER 11 STUDY ON POLLUTION LOAD REDUCTION

11.1	General.....	11-1
11.2	Composition of Present Pollution Load by Pollution Source at Respective WQCPs	11-2
	11.2.1 Rivers (BOD).....	11-2
	11.2.2 Lakes/Dams (T-N, T-P and COD).....	11-3
11.3	Allowable Pollution Load and Required Pollution Load Reduction.....	11-5
	11.3.1 Rivers (BOD).....	11-5
	11.3.2 Lakes/Dams (T-N, T-P and COD).....	11-7
11.4	Allowable Pollution Load and Required Pollution Load Reduction by Pollution Source	11-7
11.5	Countermeasures for Reduction of Pollution Load	11-16

CHAPTER 12 STUDY ON COUNTERMEASURES FOR WATER POLLUTION CONTROL IN THE STUDY AREA

12.1	General.....	12-1
12.2	Public Sewerage Systems.....	12-1
	12.2.1 General.....	12-1
	12.2.2 Service Coverage by Administrative Area.....	12-2
	12.2.3 Fundamentals for Design of Sewerage Facilities	12-7
	12.2.4 Design Criteria and Planning for Sewage Collection System	12-14
	12.2.5 Sewage Treatment Facility	12-24
12.3	Industrial/Slaughterhouse Wastewater Treatment.....	12-48
12.4	Solid Waste Collection and Disposal.....	12-49
12.5	Livestock and Other Pollution Sources.....	12-50
12.6	Other Technical Countermeasures.....	12-50
12.7	Basic Strategy for Institutional and Legal Arrangements.....	12-50
	12.7.1 Institutional Arrangements.....	12-51
	12.7.2 Legal Considerations	12-54
	12.7.3 Policy Directions for Water Pollution Control.....	12-64
	12.7.4 Proposed Management for Water Pollution Control	12-65
12.8	Monitoring and Feedback System for Water Pollution Control	12-78
	12.8.1 General Improvement Needs.....	12-78
	12.8.2 National Agencies.....	12-80
	12.8.3 Local Authorities	12-82
12.9	Community Involvement.....	12-83

CHAPTER 13 COST ESTIMATE BY PUBLIC AND PRIVATE INVESTMENT AND FINANCIAL STUDY

13.1	General.....	13-1
13.2	Standard Sewage and Sludge Treatment Facilities.....	13-1
	13.2.1 Public Sewage Works	13-1

13.2.2	Industrial Wastewater Pre-treatment Facilities.....	13-3
13.2.3	Solid Waste Leachate Treatment Facilities	13-4
13.2.4	Procurement of Materials and Equipment	13-4
13.3	Unit Cost and Cost Functions for Construction/Rehabilitation of Facilities.....	13-5
13.3.1	Unit Cost.....	13-5
13.3.2	Cost Functions for Construction of Facilities.....	13-9
13.4	Cost Requirements for Expansion of Sewerage Facilities.....	13-15
13.5	Operation and Maintenance Cost.....	13-31
13.5.1	Standard Sewage and Sludge Treatment Facilities.....	13-32
13.5.2	Unit Cost and Cost Functions for Operation and Maintenance.....	13-33
13.5.3	Cost Requirement.....	13-37

CHAPTER 14 IMPLEMENTATION PLAN FOR THE COUNTERMEASURES

14.1	Basic Conditions	14-1
14.2	Financial Arrangements by Local Authorities.....	14-3
14.3	Legal and Institutional Arrangements.....	14-8
14.4	Implementation Plan	14-9

PART II
FEASIBILITY STUDY
FOR
REHABILITATION/EXPANSION
OF
THE ZENGEZA SEWAGE WORKS

	PAGE
CHAPTER 1 GENERAL.....	1-1
 CHAPTER 2 STUDY AREA	
2.1 Location of the Study Area.....	2-1
2.2 Climate, Topography and Geological Conditions	2-1
2.2.1 Climate.....	2-1
2.2.2 Topography.....	2-4
2.2.3 Geological Conditions	2-4
2.3 Socio-Economic Conditions	2-4
 CHAPTER 3 EXISTING CONDITIONS OF WATER SUPPLY AND SANITATION/SEWAGE WORKS	
3.1 Water Supply at Present and in the Future	3-1
3.1.1 Service Coverage and Water Supply System.....	3-1
(1) Present Water Supply in Chitungwiza Municipality.....	3-1
(2) Future Water Supply	3-2
3.1.2 Institutional, Legislative and Financial Arrangements.....	3-2
(1) Institutions and System Management for Water Supply.....	3-2
(2) Legal Issues in Water Supply.....	3-5
(3) Financial Arrangement.....	3-8
3.2 Sanitation/Sewerage.....	3-17
3.2.1 Service Coverage and Sewerage System	3-17
(1) Service Coverage.....	3-17
(2) Sewer Reticulation	3-18
(3) Sewage Treatment Works	3-26
3.2.2 Institutional, Legislative and Financial Arrangements.....	3-43
(1) Institutional Set-up.....	3-43
(2) Laws and Regulations	3-53
(3) Financial Arrangements	3-55
 CHAPTER 4 FRAME VALUES AND LAND USE	
4.1 General.....	4-1

4.2	Population	4-1
4.3	Industry	4-2
4.4	Land Use at Present and in the Future	4-3

CHAPTER 5 QUANTITY AND QUALITY OF SEWAGE

5.1	General.....	5-1
5.2	Domestic and Commercial/Institutional Sewage.....	5-1
	(1) Unit quantity and quality of domestic sewage and those of commercial/institutional wastewater	5-1
	(2) Sewage volume and quality (pollution loads).....	5-2
5.3	Industrial Wastewater	5-3
	(1) Unit quantity and quality of industrial wastewater	5-3
	(2) Industrial wastewater quantity and quality.....	5-3
5.4	Design Sewage Volume and Concentrations of Pollution Loads.....	5-4
	(1) Design sewage inflow volume into the STW	5-4
	(2) Concentrations of pollution loads (BOD, SS, TN and TP).....	5-5
	(3) Concentration of pollution loads both for expansion and rehabilitation of existing sewage treatment facilities.....	5-6

CHAPTER 6 PLANNING AND DESIGN APPROACH FOR THE URGENT PROJECT

6.1	Technical Considerations.....	6-1
6.1.1	Conformity of the Urgent Project with the Long-term Sewerage Development Plan	6-1
6.1.2	Interrelationship between the Urgent Project and the Planned/Designed/On-going Projects.....	6-2
6.1.3	Combined/Separate Treatment of Industrial Wastewater and Domestic Sewage.....	6-2
6.1.4	Rehabilitation/Modification of the Existing Facilities for the Full Use	6-3
6.1.5	Reuse of Treated Effluent and Sludge	6-3
6.1.6	Sewage Collection Method and Reticulation.....	6-4
6.1.7	Sewage and Sludge Treatment Methods.....	6-4
6.1.8	Construction Plan.....	6-4
6.1.9	Countermeasures against Emergency Cases	6-5
6.2	Institutional Reinforcement	6-5
6.2.1	Overall Institutional Framework.....	6-5
6.2.2	Strategies for Municipal Institutional Consolidation.....	6-6
	(1) Organisational Structure for Project Implementation	6-6
	(2) Operations and Management of the Municipal Sewerage System.....	6-8
6.2.3	Staffing and Training.....	6-9

6.3	Legal Arrangement	6-12
6.3.1	Legislative Framework and Issues.....	6-12
6.3.2	Formulation of Effective Water Pollution Control Legislation.....	6-13
6.4	Financial Management.....	6-15
6.4.1	Role of National Government	6-16
	(1) Donor Funds.....	6-17
	(2) Responsibility of National Government.....	6-18
6.4.2	Role of Chitungwiza	6-19
	(1) Introduction of Effluent Charge	6-19
	(2) Management of Expenditures.....	6-21

CHAPTER 7 SEWAGE COLLECTION SYSTEM

7.1	General.....	7-1
7.2	Fundamentals and Criteria for Sewer Reticulation Design	7-1
7.2.1	Design Population and Sewage Collection Area	7-1
7.2.2	Design Sewage Quantity.....	7-1
	(1) Peak Factor.....	7-1
	(2) Design Sewage Quantity	7-1
	(3) Design Sewage Quantity for Sewer Reticulation.....	7-4
7.2.3	Design Criteria.....	7-6
	(1) Design Criteria for Sewer.....	7-6
	(2) Design Criteria for Pump Station.....	7-6
	(3) Design Criteria for Force Main	7-6
	(4) Formula for Sewer Reticulation Design.....	7-6
7.3	Rehabilitation/Modification Plan of Existing Sewer Reticulation	7-7
7.3.1	Rehabilitation/Modification Plan of Existing Pump Station	7-7
	(1) St. Mary's No.1 Pump Station	7-8
	(2) St. Mary's No.2 Pump Station	7-8
	(3) Tilcor Pump Station	7-11
7.3.2	Rehabilitation/Modification Plan of Existing Sewer.....	7-11
7.4	Expansion Plan for Residential Development Area in St. Mary's	7-13
7.4.1	Expansion Plan of New Trunk Sewer.....	7-13
7.4.2	Expansion Plan of New Pump Station.....	7-16

CHAPTER 8 SEWAGE AND SLUDGE TREATMENT AND DISPOSAL

8.1	Rehabilitation of Existing Facilities	8-1
8.1.1	Concept of Facility Plan	8-1
	(1) Existing Sewage Treatment Works.....	8-1
	(2) Facilities for the Effluent Pumping and Final Disposal.....	8-2
	(3) Pre-treatment Facilities for the Tilcor Industrial Area.....	8-2
8.1.2	Design Conditions and Design Criteria	8-3

	(1) Existing Sewage Treatment Works.....	8-3
	(2) Facilities for the Effluent Pumping and Final Disposal.....	8-3
	(3) Pre-treatment Facilities for the Tilcor Industrial Area.....	8-3
8.1.3	Treatment Flow and Facility Design.....	8-3
	(1) Existing Sewage Treatment Works.....	8-3
	(2) Facilities for the Effluent Pumping and Final Disposal.....	8-5
	(3) Pre-treatment Facilities for the Tilcor Industrial Area.....	8-8
8.2	Expansion of the Zengeza STW.....	8-9
8.2.1	Concept of Facility Plan	8-9
	(1) Sewage Treatment to Comply with Effluent Regulations for Discharge to Rivers.....	8-9
	(2) Independent Treatment of Domestic Sewage.....	8-13
	(3) Sludge Treatment for Re-use.....	8-13
	(4) Emergency Measures	8-13
	(5) Layout of Facilities	8-13
	(6) Discharging Treated Sewage into River.....	8-14
8.2.2	Design Condition and Design Criteria.....	8-14
	(1) Design Conditions.....	8-14
	(2) Design Criteria	8-15
8.2.3	Treatment Flow and Facility Design.....	8-17
	(1) Treatment Process.....	8-17
	(2) Facilities Plan.....	8-17

CHAPTER 9 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE

9.1	Construction Plan.....	9-1
9.1.1	Conditions for Construction of Sewerage Facilities.....	9-1
	(1) Project Site	9-1
	(2) Access to the Site	9-2
	(3) Workable Day	9-2
	(4) Availability of Local Contractors.....	9-2
	(5) Hiring Construction Equipment	9-4
	(6) Labor Source	9-4
9.1.2	Construction Materials and Equipment	9-5
	(1) Local Material	9-5
	(2) Imported Material.....	9-5
9.1.3	Construction Method of Sewerage Facilities.....	9-5
	(1) Construction Schedule	9-5
	(2) Sewer Reticulation	9-6
	(3) Expansion of Sewage Treatment Works.....	9-8
9.2	Operation and Maintenance of Sewerage Facilities	9-13
9.2.1	Sewer Reticulation.....	9-13
	(1) Sewer.....	9-13

	(2) Pump Station	9-16
9.2.2	Sewage Treatment Works	9-18
	(1) Existing Sewage Treatment Works	9-18
	(2) New Sewage Treatment Works	9-19
	(3) Tiltcor	9-24

CHAPTER 10 COST ESTIMATES

10.1	Construction Cost	10-1
10.1.1	Basic Conditions	10-1
10.1.2	Direct Construction Cost	10-1
	(1) Preliminary and Generals	10-1
	(2) Civil Works	10-1
	(3) Mechanical Works	10-2
	(4) Constitution of Construction Cost	10-2
10.1.3	Indirect Cost	10-3
	(1) Land Acquisition and Compensation	10-3
	(2) Administration Expenses	10-3
	(3) Engineering Services	10-3
	(4) Contingencies	10-3
10.1.4	Construction Cost	10-3
10.2	Operation and Maintenance Cost	10-5
10.2.1	Sewer Reticulation	10-5
	(1) Sewer	10-5
	(2) Pump Station	10-8
	(3) Total O & M Cost	10-9
10.2.2	Sewage Treatment Works	10-10

CHAPTER 11 INSTITUTIONAL, LEGISLATIVE AND FINANCIAL STUDY

11.1	Institutional Development	11-1
11.1.1	Organisation for Project Implementation	11-1
	(1) Supervising and Coordinating Agency at Central Government Level	11-1
	(2) Coordinating and Implementing Organisation at Municipal Level	11-3
	(3) Executing Body at Municipal Level	11-3
11.1.2	Organisation for Operation and Maintenance of the Facilities	11-5
	(1) Strengthening the Sewerage Sector	11-5
	(2) Establishment of the Chemical Laboratory and Wastewater Inspector	11-6
	(3) Human Resources Development	11-13
11.2	Legal Arrangements	11-15
11.2.1	Proposed Short-term Action on Water-related Legislation	11-15
11.2.2	Enactment of the Trade Effluent By-laws and Other Municipal Ordinances relating to Water Pollution Control	11-15

11.3	Financial Study and Implementation Plan	11-16
11.3.1	Financial Study	11-16
	(1) Basic Conditions and Assumptions.....	11-16
	(2) Projection of Revenue.....	11-21
	(3) Operation and Maintenance Cost	11-25
	(4) Debt Service of the Project	11-26
11.3.2	Implementation Plan	11-28
	(1) Action Programs.....	11-29
	(2) Implementation Plan.....	11-32

CHAPTER 12 PROJECT EVALUATION

12.1	General.....	12-1
12.2	The Urgency of the Project	12-1
12.3	Benefit and Justification of the Project.....	12-2
12.4	Viability of the Project.....	12-8
	12.4.1 Technical Aspects	12-8
	12.4.2 Environmental Aspects	12-9
	12.4.3 Financial Aspects.....	12-11
	12.4.4 Economic Aspects.....	12-12
	12.4.5 Institutional Aspects	12-13
12.5	Comprehensive Evaluation	12-14

LIST OF TABLES

PART I **WATER POLLUTION CONTROL MASTER PLAN** **FOR** **THE UPPER MANYAME RIVER BASIN**

<u>Table No.</u>	<u>Title</u>	<u>Page No.</u>
CHAPTER 1 INTRODUCTION		
CHAPTER 2 ADMINISTRATIVE COMPOSITION AND PHYSICAL CHARACTERISTICS IN THE STUDY AREA		
2.1.1	Present Population and Area in the Study Area.....	2-5
2.2.1	Monthly Meteorological Data of Harare City	2-6
2.2.2	Outline of Rivers in the Study Area	2-8
2.2.3	Outline of Lakes and Dams.....	2-8
CHAPTER 3 ENVIRONMENTAL MANAGEMENT AND WATER POLLUTION STATUS		
3.1.1	Authorities and Their Jurisdiction/Functions for Water Pollution Control in the Study Area	3-15
3.1.2	Manpower Development Programmes for the Staff of the Sewage Treatment Works Concerned.....	3-20
3.3.1	List of the Pieces of Legislation Related to Environmental Management	3-42
3.4.1	Government Expenditures	3-43
3.4.2	Loans Disbursement from MLGRUD in Urban Sector	3-44
3.4.3	Summary Financing Plan by Project Component	3-45
3.4.4	Water and Sewerage Tariffs in the Urban Councils related to the Master Plan Study	3-64
3.5.1	Water Quality Monitoring by Concerned Agencies	3-67
3.5.2	Present Water Quality at Major Points on the Manyame River	3-71
3.5.3	Present Water Quality on Tributaries	3-75
3.5.4	Present Water Quality at Lakes and Dams	3-79
3.5.5	Average Wastewater Quality Discharged from Factories by Industrial Type.....	3-86
3.5.6	Average Effluent Quality and Number of Factories Exceeding Effluent Standard	3-87
3.5.7	Water Quality at STWs.....	3-89
3.5.8	Outline of Examined Wells.....	3-91
CHAPTER 4 SANITATION CONDITIONS AND WATER POLLUTION CONTROL MEASURES AT PRESENT AND IN THE FUTURE		
4.1.1	Septic Tank Served Population.....	4-1
4.2.1	Sewered Area and Population.....	4-9
4.2.2	The List of Existing Sewage Treatment Works.....	4-10

4.2.3	Sewage Treatment Methods/Processes and Effluent Reuse	4-11
4.2.4	Present Sewerage Services and Problem Areas.....	4-12
4.2.5	General Comparison of Sewage Treatment Process.....	4-22
4.2.6	Current Status of Pre-treatment Facilities.....	4-25
4.3.1	General Composition of Solid Waste in Harare	4-27
4.3.2	General Composition of Solid Waste in Chitungwiza.....	4-29
4.4.1	Relationship between Intake and Wastewater	4-35

CHAPTER 5 SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE

5.1.1	Percent Distribution of the National Population by Age and Sex ,1992	5-2
5.1.2	Average Annual Household Net Income, 1990 (Z\$)	5-5
5.1.3	Socio-Economic Indicators of Harare Province and Zimbabwe.....	5-5
5.2.1	Land Use of the Lake Chivero Catchment Area	5-6
5.2.2	Present and Future Land Use	5-7
5.2.3	Land Use of Harare City by Sub-Basin	5-10
5.2.4	Land Use of Chitungwiza Municipality by Sub-Basin	5-15
5.2.5	Land Use of Norton Town Council by Sub-Basin.....	5-17
5.2.6	Land Use of Ruwa Local Board by Sub-Basin.....	5-20

CHAPTER 6 PROJECTION OF FRAME VALUES

6.2.1	1992 Urban Population by Different Source	6-1
6.2.2	Suburban Area Composition by Sub-Basin of River/Lake.....	6-4
6.2.3	Population Distribution by River/Lake Sub-Basin in Harare City(1993).....	6-6
6.2.4	Rural District Population in 1992.....	6-8
6.2.5	River/Lake Area Composition by Urban Area/Rural District	6-9
6.2.6	Population Distribution to River/Lake Sub-basins by Urban Area/Rural District(1992/1993).....	6-10
6.2.7 (1)	Population Projection of the Study Area (Case-1).....	6-12
6.2.7 (2)	Population Projection of the Study Area (Case-2).....	6-13
6.2.7 (3)	Population Projection of the Study Area (Case-3).....	6-14
6.2.7 (4)	Population Projection of the Study Area (Case-4).....	6-15
6.2.8	Comparison of Population Projection of the Study Area	6-16
6.2.9	Comparison of Population Projection between Urban Authorities	6-17
6.2.10 (1)	Population Projection by Urban Area by River/Lake Sub-Basin (Scenario-1)	6-19
6.2.10 (2)	Population Projection by Urban Area by River/Lake Sub-Basin (Scenario-2)	6-22
6.2.11	Summary of Population Projection by River/Lake Sub-Basin for Two Scenarios.....	6-24
6.3.1	Features in Each Industrial Area (1995).....	6-25
6.3.2	Present Number of Employees and Composition Ratio by Industrial Type.....	6-26
6.3.3	Classification of Industrial Type.....	6-28
6.3.4	Present and Future Number of Employees	6-29
6.4.1	Number of Major Livestock in the Study Area	6-31
6.4.2	Breakdown of Veterinary Areas by Sub-basin	6-31

6.4.3	Number of Major Livestock in Zimbabwe	6-32
-------	---	------

CHAPTER 7 WATER USE AND HYDROLOGICAL CONDITIONS OF THE WATER BODY THROUGH THE FUTURE

7.1.1	Water Use in the Entire Study Basin	7-1
7.1.2	Outline of Water Treatment Works	7-2
7.1.3	Water Consumption by Category (1986 - 1991).....	7-4
7.1.4	Water Consumption (1992 - 1994)	7-4
7.1.5	Alternative Future Demand Projection	7-6
7.1.6	Water Demand and Water Source.....	7-7
7.1.7	Effluent Standard of Wastewater, Zimbabwe.....	7-10
7.1.8	Proposed Classification.....	7-11
7.1.9	Classification of Total Nitrogen and Total Phosphorus	7-12
7.1.10	Proposed Environmental Standard.....	7-13
7.1.11	Environmental Standard for Health Related Items	7-15
7.1.12	Recommended Water Quality Checking/Reference Points	7-17
7.1.13	Provisional Water Quality Standard	7-18
7.1.14	Water Quality Standard/Provisional Value	7-18
7.2.1	Monthly Rainfall (1985/94).....	7-21
7.2.2	Data Availability on Flow Rate and Discharge	7-22
7.2.3	Annual Average Flow Rate.....	7-24
7.2.4	Monthly Average Flow Rate.....	7-24
7.2.5	Annual Average Run-off Ratio (Rivers).....	7-24
7.2.6	Annual Average Discharge	7-25
7.2.7	Monthly Average of Discharge.....	7-25
7.2.8	Annual Average Run-off Ratio (Lakes and Dam)	7-25
7.2.9	Annual Average Water Level of Lakes/Dams	7-25
7.2.10	Monthly Average Water Level of Lakes and Dams	7-27
7.2.11	II-V Curve of Lakes and Dams.....	7-28
7.2.12	Factors for the Study of Flow Balance	7-30
7.2.13	Specific Discharge Rate.....	7-31
7.2.14	Present Daily Flow of the Rivers.....	7-32
7.2.15	Inflow and Outflow Water Balance at Lakes/Dams	7-35
7.2.16	Flow Rate to be Adopted in Analysis	7-39
7.2.17 (1)	Estimated Water Balance (Scenario-1).....	7-40
7.2.17 (2)	Estimated Water Balance (Scenario-2).....	7-41

CHAPTER 8 UNIT WASTEWATER QUANTITY AND QUALITY

8.2.1	Water Supply and Consumption Records (1986 - 1991).....	8-2
8.2.2	Water Consumption by Category (1986 - 1991).....	8-3
8.2.3	Water Sales Volume	8-9
8.2.4	Water Consumption in Chitungwiza	8-10
8.2.5	Raw Sewage Quantity and Quality at Donnybrook STW.....	8-12
8.2.6	Estimated Unit Pollution Load and Comparison with Experience in Japan.....	8-13

8.2.7	Unit Generated Pollution Load of Domestic Sewage	8-13
8.2.8	Unit Concentrated Pollution Load of Domestic Sewage in Unsewered Area.....	8-14
8.3.1	Composition Ratio of Employees by Industrial Type.....	8-16
8.3.2	Unit Quantity of Industrial Wastewater by Industrial Type	8-16
8.3.3	Unit Pollution Load of Industrial Wastewater by Industrial Type	8-18
8.4.1	Unit Pollution Load of Livestock	8-17
8.4.2	Unit Concentrated Pollution Load of Livestock (Dry Season).....	8-19
8.4.3	Unit Pollution Load of Slaughterhouse (Pigs).....	8-19
8.4.4	Land Use in the Manyame River Basin (Upstream of Chivero Lake).....	8-20
8.4.5	Unit Pollution Load of Woodlands in Japan	8-20
8.4.6	Unit Natural Pollution Load	8-21
8.4.7	Unit Pollution Load of Farmland in Japan.....	8-21
8.4.8	Investigation on Fertiliser Quantity	8-22
8.4.9	Unit Pollution Load of Farmland.....	8-22
8.4.10	Water Quality of Leachate from Solid Waste Landfill Site in Japan	8-23
8.4.11	Water Quality of Leachate from Solid Waste Damping Site.....	8-24

CHAPTER 9 PRESENT WATER POLLUTION ANALYSIS

9.3.1	Population by Sewered/Unsewered by Sub-basin (Present).....	9-10
9.3.2	Discharged Pollution Load at Sewage Treatment Works (Present)	9-13
9.3.3	Estimated Domestic/Commercial/Institutional Pollution Load by Sewered/Unsewered Area by Sub-basin - BOD (Present).....	9-14
9.3.4	Estimated Domestic Pollution Load by Sewered/Unsewered Area by Sub-basin - COD (Present)	9-16
9.3.5	Estimated Domestic Pollution Load by Sewered/Unsewered Area by Sub-basin - T-N (Present).....	9-18
9.3.6	Estimated Domestic Pollution Load by Sewered/Unsewered Area by Sub-basin - T-P (Present).....	9-20
9.3.7	Present and Future Industrial Wastewater Quantity	9-22
9.3.8	Present and Future Industrial Wastewater Pollution Load	9-24
9.3.9	Industrial Wastewater Quantity and Pollution Load	9-25
9.3.10	Number of Major Livestock by Sub-basin.....	9-26
9.3.11	Pollution Load of Livestock (Present).....	9-27
9.3.12	Pollution Load of Farmland/Natural Land.....	9-29
9.3.13	Pollution Load of Solid Waste Dumping Site	9-30
9.4.1	Concentrated Pollution Load by Sub-basin by Pollution Source (Present, BOD, Dry Season).....	9-33
9.4.2	Concentrated Pollution Load by Sub-basin (Present, BOD, Dry Season).....	9-35
9.4.3	Concentrated Pollution Load by Sub-basin by Pollution Source (Present, COD).....	9-36
9.4.4	Concentrated Pollution Load by Sub-basin by Pollution Source (Present, T-N)	9-37

9.4.5	Concentrated Pollution Load by Sub-basin by Pollution Source (Present, T-P).....	9-38
9.5.1	Pollution Load Remaining Ratio of Rivers (Present, BOD, Dry Season).....	9-44
9.5.2	Pollution Load Remaining Ratio of Rivers.....	9-40
9.5.3	Water Pollution Analysis of Lakes (Present, Sake & Harava Dams).....	9-45
9.5.4	Water Pollution Analysis of Lakes (Present, Lake Chivero).....	9-46
9.5.5	Water Pollution Analysis of Lakes (Present, Lake Manyame).....	9-47
9.5.6	Self-purification Coefficients of Lakes.....	9-40

CHAPTER 10 FUTURE WATER POLLUTION ANALYSIS

10.2.1	Population by Sewered/Unsewered by Sub-basin (Scenario-1).....	10-6
10.2.2	Population by Sewered/Unsewered by Sub-basin (Scenario-2).....	10-7
10.2.3	Projected Wastewater Quantity by Sewered/Unsewered Area by Sub-basin (Scenario-1).....	10-8
10.2.4	Projected Wastewater Quantity by Sewered/Unsewered Area by Sub-basin (Scenario-2).....	10-9
10.2.5	Pollution Load from Sewage Treatment Works (scenario-1).....	10-11
10.2.6	Pollution Load from Sewage Treatment Works (scenario-2).....	10-12
10.2.7	Treatment Efficiency by Treatment Method	10-10
10.2.8	Concentrated Pollution Load by Sub-basin by Pollution Source	10-13
10.2.9	Concentrated Pollution Load from Solid Waste Dumping Site (Future).....	10-16
10.4.1	Projected Future BOD Concentration at WQCPs.....	10-26
10.4.2	Projected Future Pollution Load Concentration at WQCPs of Lakes	10-27

CHAPTER 11 STUDY ON POLLUTION LOAD REDUCTION

11.2.1	Composition of Present Run-off BOD Load by Pollution Source.....	11-2
11.2.2	Composition of Present Inflow Pollution Load by Pollution Source at WQCPs (T-N, T-P and COD).....	11-4
11.3.1	Allowable Pollution Load and Required Pollution Load Reduction (BOD)	11-6
11.3.2	Required Pollution Load Reduction (T-N).....	11-8
11.3.3	Required Pollution Load Reduction (T-P).....	11-9
11.3.4	Required Pollution Load Reduction (COD)	11-10
11.4.1	Allowable Pollution Load by Pollution Source at WQCPs (Scenario-1).....	11-11
11.4.2	Allowable Pollution Load by Pollution Source at WQCPs (Scenario-2).....	11-12
11.4.3	Required Pollution Load Reduction by Pollution Source at WQCPs (T-N)	11-13
11.4.4	Required Pollution Load Reduction by Pollution Source at WQCPs (T-P).....	11-14
11.4.5	Required Pollution Load Reduction by Pollution Source at WQCPs (COD).....	11-15

CHAPTER 12 STUDY ON COUNTERMEASURES FOR WATER POLLUTION CONTROL IN THE STUDY AREA

12.2.1	Service Coverage by Urban Authority.....	12-2
12.2.2	Design Served Population by Sewage Works.....	12-9
12.2.3	Unit Sewage Quantity	12-8

12.2.4	Unit Sewage Quality	12-8
12.2.5	Industrial Wastewater Quantity	12-8
12.2.6	Peak Factor for Design of Sewerage Facilities.....	12-10
12.2.7	Design Sewage Quantity.....	12-12
12.2.8	Design Sewage Quality	12-13
12.2.9	Expansion Area for the Lateral Sewers	12-15
12.2.10 (1)	Required Trunk Sewers by Treatment Area (Scenario-1)	12-16
12.2.10 (2)	Required Trunk Sewers by Treatment Area (Scenario-2)	12-17
12.2.11 (1)	Required Pump Stations by Treatment Area (Scenario-1)	12-18
12.2.11 (2)	Required Pump Stations by Treatment Area (Scenario-2)	12-19
12.2.12	Effluent Regulation for Discharge into River (Zone II)	12-27
12.2.13	Effluent Regulation for Irrigation Reuse	12-27
12.2.14	Removal Ratio by Sewage Treatment Method	12-34
12.2.15	Design Sewage Quantity and Quality	12-34
12.2.16 (1)	Required Sewage Treatment Facilities by Sewage Treatment Work (Scenario-1).....	12-36
12.2.16 (2)	Required Sewage Treatment Facilities for Zengeza Sewage Treatment Work (Scenario-1).....	12-36
12.2.17 (1)	Required Sewage Treatment Facilities by Sewage Treatment Work (Scenario-2).....	12-37
12.2.17 (2)	Required Sewage Treatment Facilities for Zengeza Sewage Treatment Work (Scenario-2).....	12-37
12.2.18	Expansion Plan by STWs in 2005, 2015 (Scenario-1)	12-38
12.4.1	Leachate Quantity at Solid Waste Dumping Site	12-49
12.4.2	Leachate Quality at Solid Waste Dumping Site	12-49
12.8.1	Recommended Water Quality Indices for Water Bodies.....	12-80

CHAPTER 13 COST ESTIMATE BY PUBLIC AND PRIVATE INVESTMENT AND FINANCIAL STUDY

13.3.1	Labor Cost.....	13-6
13.3.2	Material Cost.....	13-7
13.3.3	Equipment Cost.....	13-8
13.4.1	Summary of Construction Cost for Sewage Treatment Works.....	13-24
13.4.2 (1)	Construction Cost for Sewage Treatment Works (Scenario-1)	13-25
13.4.2 (2)	Construction Cost for Sewage Treatment Works (Scenario-2)	13-27
13.4.3 (1)	Construction Cost for Sewage Treatment Works (Scenario-1) 2000, 2005 and 2015.....	13-29
13.4.3 (2)	Construction Cost for Sewage Treatment Works (Scenario-2) 2000, 2005 and 2015.....	13-30
13.5.1	O & M Cost.....	13-37

CHAPTER 14 IMPLEMENTATION PLAN FOR THE COUNTERMEASURES

PART II
FEASIBILITY STUDY
FOR
REHABILITATION/EXPANSION
OF
THE ZENGEZA SEWAGE WORKS

Table No.	Title	Page No.
CHAPTER 1 GENERAL		
CHAPTER 2 STUDY AREA		
2.3.1	Basic Infrastructure in Chitungwiza Municipality.....	2-5
CHAPTER 3 EXISTING CONDITIONS OF WATER SUPPLY AND SANITATION/SEWAGE WORKS		
3.1.1	WHO Drinking Water Standards (WHO Geneva 1986).....	3-7
3.1.2	Revenue and Expenditure of Water Account	3-17
3.2.1	List of Major Trunk Sewer	3-18
3.2.2	List of Sewage Pump Station in Chitungwiza	3-20
3.2.3	Domestic and Institutional/Commercial Sewage volume by Line.....	3-21
3.2.4	Sewage Volume by Line and Type of Sewage	3-22
3.2.5	Present Conditions of Existing Trunk Sewers	3-24
3.2.6	Existing/On-going Sewage Treatment Works	3-29
3.2.7	List of Existing Sewage Treatment Works' Facilities	3-30
3.2.8	List of Facilities for Irrigation Use and Final Disposal of the Sewage	3-33
3.2.9	List of Pre-treatment Facilities for Tilcor Industrial Area.....	3-35
3.2.10	Staff Complements for the Zengeza Sewage Treatment Works and Sewerage Reticulation.....	3-51
3.2.11	Major Issues for Implementation of the Sewerage Improvement Project in Chitungwiza Municipality	3-56
3.2.12	Loan Disbursement for Sewerage Projects.....	3-58
3.2.13	Sewerage Component of PSIP for 1996/97	3-58
3.2.14	Relative Strength of Chitungwiza.....	3-60
3.2.15	Sewerage/Revenue and Expenditures Budgeted.....	3-62
3.2.16	Capital Investment and Finance.....	3-64
3.2.17	Loan Conditions of Existing Liabilities.....	3-65
3.2.18	Sewerage Revenue and Expenditures	3-66
CHAPTER 4 FRAME VALUES AND LAND USE		
4.3.1	Present and Future Number of Employees	4-2
4.3.2	Present and Future Number of Employees by Industrial Type.....	4-3
4.4.1	Present and Future Land Use.....	4-5

CHAPTER 5	QUANTITY AND QUALITY OF SEWAGE	
5.2.1	Unit Domestic Sewage Quality.....	5-1
5.2.2	Relationship Between BOD and SS in Harare.....	5-2
5.2.3	Unit Generated Pollution Loads	5-2
5.3.1	Unit Quantity and Quality of Industrial Wastewater	5-3
5.3.2	Industrial Wastewater Quantity and Quality (the year 2000).....	5-4
5.4.1	Design Sewage Inflow Volume	5-4
5.4.2	Concentrations of Domestic Sewage	5-5
5.4.3	Pollution Load of Institutional/Commercial Wastewater	5-5
5.4.4	Concentrations of Industrial Wastewater.....	5-6
5.4.5	Concentrations of Combined Sewage.....	5-6
5.4.6	Concentrations of Pollution Loads for Rehabilitation of Existing Sewage Treatment Facilities.....	5-7
CHAPTER 6	PLANNING AND DESIGN APPROACH FOR THE URGENT PROJECT	
6.4.1	Loan Conditions of Donors.....	6-18
CHAPTER 7	SEWAGE COLLECTION SYSTEM	
7.2.1	Residential Area and Population by Ward.....	7-2
7.2.2	Design Sewage Quantity	7-4
7.3.1	List of Mechanical and Electrical Equipment Required for St. Mary's No.1 P.S.....	7-8
7.3.2	List of Mechanical and Electrical Equipment Required for St. Mary's No.2 P.S.....	7-8
7.3.3	List of Mechanical and Electrical Equipment Required for Tilcor P.S.....	7-11
7.4.1	List of Length of New Sewer and Manhole by Excavation Depth	7-16
7.4.2	List of Required Pump Facilities	7-19
CHAPTER 8	SEWAGE AND SLUDGE TREATMENT AND DISPOSAL	
8.1.1	Accumulated Sludge Disposal	8-6
8.2.1	General Comparison of Nutrient Removal Treatment Methods	8-11
8.2.2	List of Zengeza Sewage Treatment Works' Facilities.....	8-19
CHAPTER 9	CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE	
9.1.1	Rainfall Data and Workable Day.....	9-3
9.2.1	Working Items by O & M Types on Sewer	9-14
9.2.2	Working Items of Pump Station by O & M Types	9-17
9.2.3	Required Total Staff Number for O & M of Sewer Reticulation	9-18
9.2.4	Sludge Treatment and Disposal	9-20
CHAPTER 10	COST ESTIMATES	
10.1.1	Summary of Construction Cost for Rehabilitation/Expansion Works of the Zengeza Sewage Works.....	10-4
10.2.1	Labor Cost by Classification.....	10-5
10.1.2	Detailed Disbursement Schedule.....	10-6

10.2.2	Rehabilitation Cost for Damaged Sewers.....	10-8
10.2.3	Total O & M Cost for Sewer Reticulation.....	10-10
10.2.4	Annual O & M Cost for Zengeza STW.....	10-10

CHAPTER 11 INSTITUTIONAL, LEGISLATIVE AND FINANCIAL STUDY

11.1.1	Proposed Staffs Placement for O & M of the Rehabilitated /Expanded New Facilities an the Municipal Sewerage System.....	11-8
11.1.2	Qualifications Required to Employ the New Staffs for O & M of the Rehabilitated/Expanded Facilities	11-9
11.1.3	Trade Effluent Standards for Discharge into Municipal Sewers.....	11-12

CHAPTER 12 PROJECT EVALUATION

12.4.1	Comparison of Alternative Sewage Treatment Processes.....	12-8
--------	---	------

LIST OF FIGURES

PART I **WATER POLLUTION CONTROL MASTER PLAN** **FOR** **THE UPPER MANYAME RIVER BASIN**

Figure No.	Title	Page No.
CHAPTER 1 INTRODUCTION		
1.1	Upper Manyame River Basin.....	1-2
CHAPTER 2 ADMINISTRATIVE COMPOSITION AND PHYSICAL CHARACTERISTICS IN THE STUDY AREA		
2.1.1	Administrative Structure in Zimbabwe.....	2-1
2.1.2	Local Administrative Composition in the Study Area.....	2-3
CHAPTER 3 ENVIRONMENTAL MANAGEMENT AND WATER POLLUTION STATUS		
3.1.1	Organisation Structure for Water Pollution Control in Zimbabwe	3-3
3.1.2	Organisational Chart of the Ministry of Local Governmen Rural and Urban Development(MLGRUD)	3-5
3.1.3	Procedure Flow for Implementation of the Water Pollution Control Projects	3-22
3.5.1	The Location of Self-recording Water Level Surveillance Station and Water Sampling Points in the Upper Manyame River Basin	3-68
3.5.2	Water Quality of Manyame River (Skyline Bridge).....	3-69
3.5.3	The Location of Sampling Points in the Water Bodies	3-73
3.5.4	Water Quality (NH ₄ -N) of Nyatsime River	3-77
3.5.5	Water Quality (NH ₄ -N) of Mukuvisi River	3-77
3.5.6	Water Quality (NH ₄ -N) of Marimba River	3-77
3.5.7	Water Quality of the Lake Chivero (Top Layer).....	3-82
CHAPTER 4 SANITATION CONDITIONS AND WATER POLLUTION CONTROL MEASURES AT PRESENT AND IN THE FUTURE		
4.1.1	Typical Standard Design of Septic Tank in Zimbabwe.....	4-2
4.1.2	Septic Tank Service Area in Harare	4-3
4.1.3	Septic Tank Service Area in Chitungwiza.....	4-4
4.1.4	Septic Tank Service Area in Norton	4-6
4.1.5	Septic Tank Service Area in Ruwa	4-7
4.2.1	Existing Sewerage System in Harare.....	4-14
4.2.2	Existing Sewerage System in Chitungwiza	4-17
4.2.3	Existing Sewerage System in Norton.....	4-19
4.2.4	Existing Sewerage System in Ruwa.....	4-20
4.3.1	Location of Two Dumping Sites in Harare.....	4-28

4.3.2	Location of Dumping Site in Chitungwiza	4-31
4.3.3	Location of Dumping Site in Norton	4-32
4.3.4	Location of Dumping Site in Ruwa	4-34
4.4.1	Morton Jaffray WTW Flow Sheet for Treatment of Backwash Sludge	4-37
4.4.2	Morton Jaffray WTW Section Plan of Backwash Sludge	4-38

CHAPTER 5 SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE

5.1.1	Population Pyramid, 1992.....	5-2
5.1.2	Population Pyramid, Harare Province, 1992	5-4
5.2.1	Land Use Plan in Harare City (Year 2015).....	5-9
5.2.2	Land Use Plan in Chitungwiza Municipality (Year 2015).....	5-14
5.2.3	Land Use Plan in Norton Town Council (Year 2015).....	5-16
5.2.4	Land Use Plan in Ruwa Local Board (Year 2015).....	5-19

CHAPTER 6 PROJECTION OF FRAME VALUES

6.2.1	Suburban Area in Harare City.....	6-3
6.2.2	Population Projection by Case.....	6-16

CHAPTER 7 WATER USE AND HYDROLOGICAL CONDITIONS OF THE WATER BODY THROUGH THE FUTURE

7.1.1	Harare Water Supply Impounding Dams.....	7-3
7.1.2	Schematic Water Supply System	7-5
7.1.3	Water Demand, Source, and Plant Capacity.....	7-8
7.1.4	Environmental Water Quality Classification Check Points and Reference Points.....	7-19
7.2.1	Annual Rainfall Observation Results	7-20
7.2.2	Annual Rainfall (1985/94).....	7-21
7.2.3	Monthly Rainfall (1985/94).....	7-21
7.2.4	Flow Pattern (Yearly)	7-23
7.2.5	Flow Pattern (Monthly)	7-23
7.2.6	Rainfall and Run-off Ratio (Rivers)	7-23
7.2.7	Discharge Pattern (Yearly)	7-26
7.2.8	Discharge Pattern (Monthly)	7-26
7.2.9	Rainfall and Run-off Ratio (Lakes and Dam).....	7-26
7.2.10	Annual Average Water Level of Lakes/Dams	7-27
7.2.11	Monthly Average Water Level of Lakes/Dams	7-27
7.2.12	H-V Curve for Dam and Lake.....	7-28
7.2.13	Water Reserve of Seke and Harava Dam.....	7-29
7.2.14	Water Reserve of Lake Chivero and Manyame.....	7-29
7.2.15 (1)	Flow Model of Rivers in Dry Season (Present).....	7-33
7.2.15 (2)	Annual Flow Model of Lakes (Present).....	7-36
7.2.16	Annual Flow Balance (Present).....	7-37
7.2.17 (1)	Flow Model to be Adopted in Analysis of Rivers (Scenario-1)	7-42

7.2.17 (2)	Flow Model to be Adopted in Analysis of Lakes (Scenario-1).....	7-43
7.2.18 (1)	Flow Model to be Adopted in Analysis of Rivers (Scenario-2).....	7-44
7.2.18 (2)	Flow Model to be Adopted in Analysis of Lakes (Scenario-2).....	7-45

CHAPTER 8 UNIT WASTEWATER QUANTITY AND QUALITY

CHAPTER 9 PRESENT WATER POLLUTION ANALYSIS

9.1.1	Flow Diagram of Water Pollution Study (Rivers).....	9-2
9.1.2	Flow Diagram of Water Pollution Study (Lakes).....	9-3
9.1.3	Location of Rivers, Lakes and STWs.....	9-4
9.1.4	Flow Diagram of Analysis for Rivers and Lakes.....	9-5
9.2.1	Concept of Pollution Load Flow System of Rivers.....	9-7
9.2.2	Concept of Pollution Load Run-off.....	9-9
9.4.1	Flow Model for Present Water Pollution Analysis.....	9-32
9.4.2	Pollution Load Run-off Model for Present Water Pollution Analysis (BOD, Dry Season).....	9-34
9.4.3	Pollution Load Run-off Model for Present Water Pollution Analysis (COD).....	9-41
9.4.4	Pollution Load Run-off Model for Present Water Pollution Analysis (T-N).....	9-42
9.4.5	Pollution Load Run-off Model for Present Water Pollution Analysis (T-P).....	9-43

CHAPTER 10 FUTURE WATER POLLUTION ANALYSIS

10.1.1	Flow Model for Future Water Pollution Analysis (for Rivers, Scenario 1, Dry Season).....	10-2
10.1.2	Flow Model for Future Water Pollution Analysis (for Rivers, Scenario 2, Dry Season).....	10-3
10.1.3	Flow Model for Future Water Pollution Analysis (for Lakes/Dams, Scenario 1).....	10-4
10.1.4	Flow Model for Future Water Pollution Analysis (for Lakes/Dams, Scenario 2).....	10-5
10.3.1	Pollution Load Run-off Model for Future Water Pollution Analysis (BOD, Scenario 1, 2005, Dry Season).....	10-17
10.3.2	Pollution Load Run-off Model for Future Water Pollution Analysis (BOD, Scenario 1, 2015, Dry Season).....	10-18
10.3.3	Pollution Load Run-off Model for Future Water Pollution Analysis (COD, Scenario 1, 2005).....	10-20
10.3.4	Pollution Load Run-off Model for Future Water Pollution Analysis (COD, Scenario 1, 2015).....	10-21
10.3.5	Pollution Load Run-off Model for Future Water Pollution Analysis (T-N, Scenario 1, 2005).....	10-22

10.3.6	Pollution Load Run-off Model for Future Water Pollution Analysis (T-N, Scenario 1, 2015).....	10-23
10.3.7	Pollution Load Run-off Model for Future Water Pollution Analysis (T-P, Scenario 1, 2005).....	10-24
10.3.8	Pollution Load Run-off Model for Future Water Pollution Analysis (T-P, Scenario 1, 2015).....	10-25

CHAPTER 11 STUDY ON POLLUTION LOAD REDUCTION

11.1.1	Manner of Calculation for Allowable Pollution Load by Pollution Source	11-1
--------	--	------

CHAPTER 12 STUDY ON COUNTERMEASURES FOR WATER POLLUTION CONTROL IN THE STUDY AREA

12.2.1	Sewerage Service Area in Harare	12-3
12.2.2	Sewerage Service Area in Chitungwiza.....	12-4
12.2.3	Sewerage Service Area in Norton.....	12-5
12.2.4	Sewerage Service Area in Ruwa.....	12-6
12.2.5	Sewerage Collection System in Harare.....	12-21
12.2.6	Sewerage Collection System in Chitungwiza	12-23
12.2.7	Sewerage Collection System in Norton.....	12-25
12.2.8	Sewerage Collection System in Ruwa	12-26
12.2.9	Sewage Treatment Flow Sheet.....	12-31
12.2.10	Layout of the Crowborough STW in Harare	12-39
12.2.11	Layout of the Firlie STW in Harare.....	12-40
12.2.12	Layout of the Marlborough STW in Harare	12-41
12.2.13	Layout of the Donnybrook (Block 2) STW in Harare	12-42
12.2.14	Layout of Harare South STW in Harare	12-43
12.2.15	Layout of Harare East STW in Harare.....	12-44
12.2.16	Layout of the Zengeza STW in Chitungwiza.....	12-45
12.2.17	Layout of the Norton STW in Norton.....	12-46
12.2.18	Layout of the Ruwa STW in Ruwa.....	12-47
12.7.1	Proposed Institutional Set-up for Water Pollution Control in Zimbabwe	12-66
12.7.2	Proposed Structure for Implementation of the Priority Sewage Project.....	12-70
12.8.1	The proposed Sampling Points in the Water Bodies	12-81

CHAPTER 13 COST ESTIMATE BY PUBLIC AND PRIVATE INVESTMENT AND FINANCIAL STUDY

13.3.1	Relationship between Treatment Capacity and Unit Construction Cost (Trickling Filter Process).....	13-17
13.3.2	Relationship between Treatment Capacity and Unit Construction Cost (Biological Nutrient Removal Process, BNR).....	13-17
13.3.3	Relationship between Treatment Capacity and Unit Construction Cost (Wastewater Stabilization Pond)	13-18
13.3.4 (1)	Relationship between Treatment Capacity and Unit Construction Cost (Concrete Pipe, Hume Pipe)	13-18

13.3.4 (2)	Relationship between Treatment Capacity and Unit Construction Cost (Asbestos Fibre Cement Pipe, Sewer)	13-19
13.3.4 (3)	Relationship between Treatment Capacity and Unit Construction Cost (Asbestos Fibre Cement Pipe, Pressure).....	13-19
13.3.4 (4)	Relationship between Treatment Capacity and Unit Construction Cost (Polyvinyl Chloride Pipe, Pressure).....	13-20
13.3.4 (5)	Relationship between Treatment Capacity and Unit Construction Cost (Steel Pipe).....	13-20
13.3.5	Relationship between Treatment Capacity and Unit Construction Cost (Storage Pond, Irrigation Area).....	13-21
13.3.6 (1)	Relationship between Treatment Capacity and Unit Construction Cost (Pump Equipment)	13-21
13.3.6 (2)	Relationship between Treatment Capacity and Unit Construction Cost (Pump Station, Irrigation, TF)	13-22
13.3.6 (3)	Relationship between Treatment Capacity and Unit Construction Cost (Pump Station, Irrigation, WSP).....	13-22
13.3.7	Relationship between Treatment Capacity and Unit Construction Cost (Industrial Wastewater Pre-treatment Facilities, Anaerobic Pond and Facultative Pond)	13-23
13.3.8	Relationship between Treatment Capacity and Unit Construction Cost (Solid Waste Leachate Treatment Facilities, WSP)	13-23
13.5.1	Sewage Pump Station Annual O & M Cost	13-38
13.5.2	WSP Annual O & M Cost.....	13-38
13.5.3	TF Annual O & M Cost	13-39
13.5.4	BNR Annual O & M Cost.....	13-39
13.5.5	Industrial Wastewater Annual O & M Cost.....	13-40
13.5.6	Solid Waste Leachate Annual O & M Cost.....	13-40

CHAPTER 14 IMPLEMENTATION PLAN FOR THE COUNTERMEASURES

14.4.1	Implementation Plans.....	14-14
--------	---------------------------	-------

PART II
FEASIBILITY STUDY
FOR
REHABILITATION/EXPANSION
OF
THE ZENGEZA SEWAGE WORKS

Figure No.	Title	Page No.
CHAPTER 1 GENERAL		
CHAPTER 2 STUDY AREA		
2.1.1	Location of the Study Area.....	2-2
2.2.1	Annual Wind Direction at Zengeza STW.....	2-3
CHAPTER 3 EXISTING CONDITIONS OF WATER SUPPLY AND SANITATION/SEWAGE WORKS		
3.1.1	Organization Structure for Water Resources Development and Environmental Management in Zimbabwe.....	3-3
3.1.2	Organization Chart of the Chitungwiza Municipal Council.....	3-4
3.1.3	Organization Chart of Town Treasurer.....	3-14
3.2.1	Existing Sewerage System.....	3-19
3.2.2	Flow Diagram of Sewage Volume by Trunk Sewer	3-23
3.2.3	Layout of Existing/On-going Sewage Treatment Facilities.....	3-27
3.2.4	Location of Maturation Pond and Imbgwa Farm in relation to the STW.....	3-31
3.2.5	Layout of the Pre-treatment Facilities for Tilcor Industrial Area.....	3-34
3.2.6	Organization Chart of the Ministry of Local Government, Rural and Urban Development (MLGRUD)	3-44
3.2.7	Precedure Flow for Implementation of the Water Pollution Control Projects	3-46
3.2.8	Structure for Implementation of Sanitation/Sewerage Projects and Major Functions of Each Organization Concerned.....	3-48
CHAPTER 4 FRAME VALUES AND LAND USE		
4.4.1	Present Land Use in Chitungwiza Municipality	4-4
4.4.2	Land Use Plan in Chitungwiza Municipality (Year 2000)	4-6
4.4.3	Land Development Plan for St. Mary's (Year 2000).....	4-7
4.4.4	Land Use Plan in Chitungwiza Municipality (Year 2000)	4-8
4.4.5	Proposed Area for the Development of Housing and Irrigation Purpose	4-9
CHAPTER 5 QUANTITY AND QUALITY OF SEWAGE		
CHAPTER 6 PLANNING AND DESIGN APPROACH FOR THE URGENT PROJECT		

CHAPTER 7 SEWAGE COLLECTION SYSTEM

7.2.1	Ward Boundary and Development Area in St. Mary's.....	7-3
7.2.2	Sewage Collection Area of Two Existing and New Pump Stations in St. Mary's....	7-5
7.3.1	Rehabilitation Plan of St. Mary's No.1 Pump Station.....	7-9
7.3.2	Rehabilitation Plan of St. Mary's No.2 Pump Station.....	7-10
7.3.3	Rehabilitation Plan of Tilcor Pump Station.....	7-12
7.4.1	Sewer Reticulation Plan for Development Area in St. Mary's.....	7-14
7.4.2	Profile of New Trunk Sewer.....	7-15
7.4.3	Plan of New Pump Station.....	7-17
7.4.4	Section of New Pump Station (A-A).....	7-18

CHAPTER 8 SEWAGE AND SLUDGE TREATMENT AND DISPOSAL

8.1.1	Flow Diagram of Zengeza Sewage Treatment Works.....	8-4
8.1.2	Location of Existing Facilities' Rehabilitation.....	8-7
8.2.1	Flow Diagram of Zengeza Sewage Treatment Works.....	8-18
8.2.2	Layout of Zengeza Sewage Treatment Works.....	8-20
8.2.3	Layout of Zengeza Sewage Treatment Works (BNR).....	8-21
8.2.4	Section A - A of Zengeza Sewage Treatment Works.....	8-22
8.2.5	Distribution Chamber, Screen and Parshall Flume Plan and Section.....	8-23
8.2.6	Grit Chamber Plan and Section.....	8-24
8.2.7	Primary Sedimentation Tank Plan and Section.....	8-25
8.2.8	BNR Reactor Plan and Section.....	8-26
8.2.9	Final Sedimentation Tank Plan and Section.....	8-27
8.2.10	Sludge Thickener Plan and Section.....	8-28
8.2.11	Anaerobic Digestion Tank Plan and Section.....	8-29
8.2.12	Sludge Drying Bed Plan and Section.....	8-30
8.2.13	Layout of Inplant Pipe and Outlet Works Plan and Section.....	8-31
8.2.14	Laboratory Plan and Section.....	8-32
8.2.15	Sludge Storage Yard Plan and Section.....	8-32

CHAPTER 9 CONSTRUCTION PLAN, AND OPERATION AND MAINTENANCE

9.1.1	Construction Schedule for Rehabilitation/Expansion of Zengeza Sewage Works....	9-7
-------	--	-----

CHAPTER 10 COST ESTIMATES

CHAPTER 11 INSTITUTIONAL, LEGISLATIVE AND FINANCIAL STUDY

11.1.1	Proposed Organization Framework for Implementation of the Priority Project : Rehabilitation and Expansion of the Municipal Sewerage System.....	11-2
11.1.2	Proposed Organization Strengthening for Project Implementation and O & M of the Municipal Sewerage System.....	11-7
11.3.1	Implementation Plan.....	11-33

CHAPTER 12 PROJECT EVALUATION

ABBREVIATIONS

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

LSCF	Large-Scale Commercial Farming (Area)
MA	Ministry of Agriculture
MET	Ministry of Environment and Tourism
MF	Ministry of Finance
MFA	Ministry of Foreign Affairs
MHA	Ministry of Home Affairs
MHCW	Ministry of Health and Child Welfare
MHE	Ministry of Higher Education
MIC	Ministry of Industry and Commerce
MJLPA	Ministry of Justice, Legal and Parliamentary Affairs
MM	Ministry of Mines
MLGRUD	Ministry of Local Government, Rural and Urban Development
MLWR	Ministry of Lands and Water Resources
MNAECC	Ministry of National Affairs, Employment Creation and Cooperatives
MOHCW	Ministry of Health and Child Welfare
MPCNH	Ministry of Public Construction and National Housing
MPSLSW	Ministry of Public Service, Labour and Social Welfare
MTE	Ministry of Transport and Energy
NCU	National Coordination Unit
NEPC	National Economic Planning Commission
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development
NTC	Norton Town Council
NUST	National University of Science and Technology
O & M	Operation & Maintenance
ODA	Overseas Development Agency
OECE	Overseas Economic Cooperation Fund (Japan)
PDD	Planning & Development Division (Department of Works, City of Harare)
PEIA	Preliminary Environmental Impact Assessment
PSIP	Public Sector Investment Programme
RDC	Rural District Council
RLB	Ruwa Local Board
RTCPA	Regional Town and Country Planning Act
SADCC	Southern African Development Coordination Conference
SAZ	Standards Association of Zimbabwe
SDF	Social Development Fund
SEDCO	Small Enterprise Development Corporation
SIDA	Swedish International Development Agency

SSCF	Small-Scale Commercial Farming (Area)
STW	Sewage Treatment Works
SWLTF	Solid Waste Leachate Treatment Facility
TF	Trickling Filter
UMRBA	Upper Manyame River Basin Authority (proposed in this M/P Study)
VIDCO	Village Development Committee
WARB	Water Act Review Board
WHO	World Health Organization
WPAB	Water Pollution Advisory Board
WPCB	Water Pollution Control Board (proposed in this M/P Study)
WPCCC	Water Pollution Control Coordinating Committee
WPCIC	Water Pollution Control Information Center (proposed in this M/P Study)
WPCS	Water Pollution Control Section (MLWD/DWD)
WPMU	Water Pollution Monitoring Unit (proposed in this M/P Study)
WSP	Wastewater Stabilization Pond
WQCP	Water Quality Checking Point
ZESA	Zimbabwe Electricity Supply Authority
ZIPAM	Zimbabwe Institute of Public Administration and Management

Government of Zimbabwe Fiscal Year

July 1 - June 30

Currency Equivalent (as of December, 1996)

US\$ 1.00 = Z\$ 10.500

Z\$ 1.00 = US\$ 0.095

PART I

WATER POLLUTION MASTER PLAN
FOR
THE UPPER MANYAME RIVER BASIN

CHAPTER 1

INTRODUCTION



CHAPTER 1 INTRODUCTION

The Upper Manyame River, one of the tributaries of the Zambezi River, is defined as the upstream reach from the Manyame Dam wall, and its basin covers about 3,900 km². The Upper Manyame River Basin has been playing an important role for water supply, irrigation, navigation, fishing and recreation purposes. However, the water pollution of the rivers and lakes/dams has been considerable in recent years due to rapid urbanisation and industrialisation in the basin. The Upper Manyame River Basin is shown in Figure 1.1.

The water supply for the five urban areas in the subject basin, with a total population of about 1.5 million as of 1992, is mainly dependent on Lake Chivero and Lake Manyame. Therefore, the preparation of a comprehensive water pollution control plan is essential, prior to the implementation of various countermeasures by different governmental agencies, to establish a common vision and to provide a mission statement for water quality improvement in the subject river basin based on a realistic assessment of the constraints, opportunities and demands of the area.

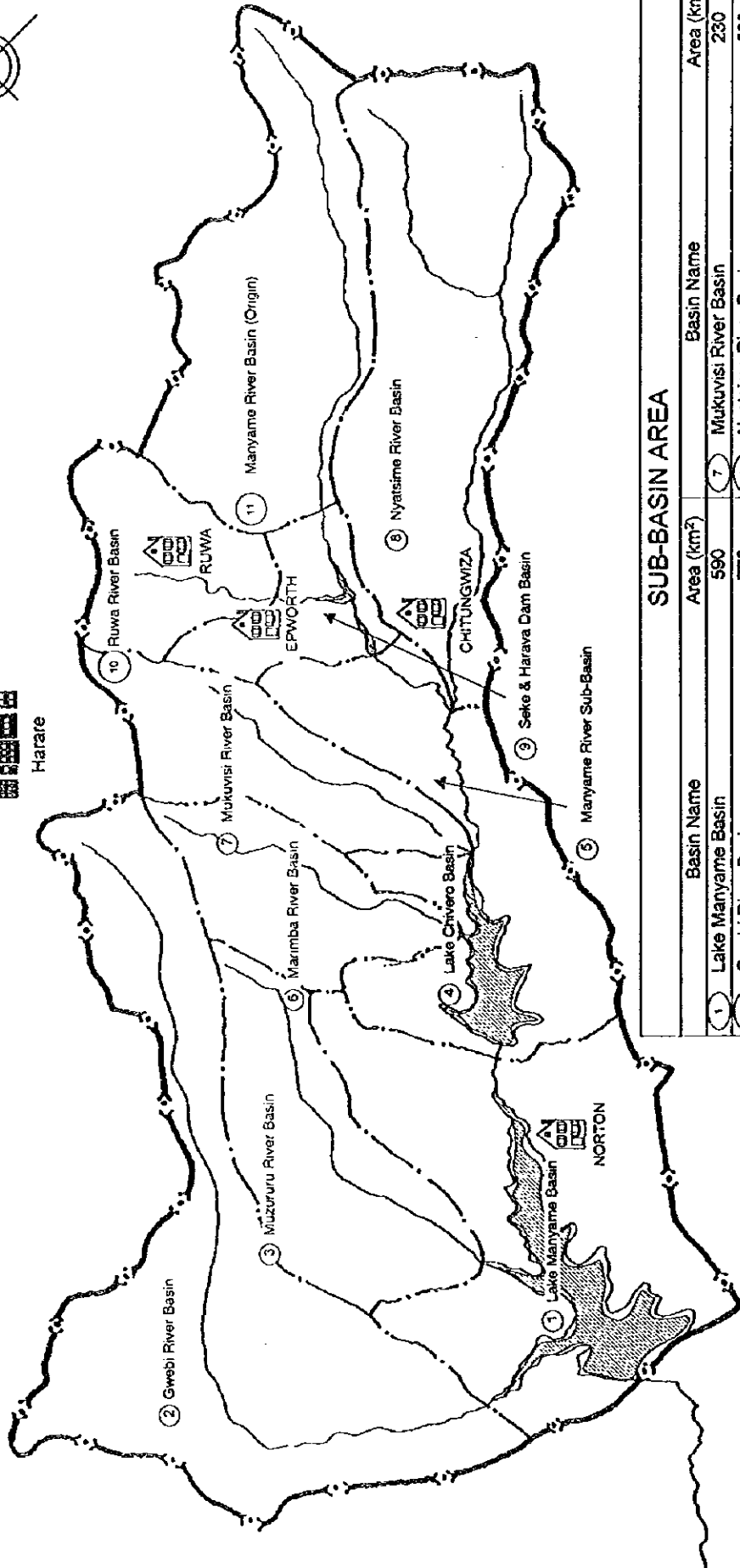
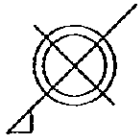
In response to a request from the Government of the Republic of Zimbabwe, represented by the Ministry of Local Government, Rural and Urban Development, JICA extended Technical Co-operation Assistance to prepare a water pollution control master plan for the Upper Manyame River Basin.

This master plan presents a water pollution analysis and recommendations on the required countermeasures for water pollution control with the target years of 2005 and 2015, in the subject river basin. The findings and field measurement results obtained during the conduct of the Stage 1 field work in Zimbabwe formed the primary study base of the plan.

In developing the water pollution control master plan, the following conditions and/or approaches to the major study items were employed:

(1) Major Water Pollution Sources

The water pollution sources are categorised into those of natural origin and human activities, comprising point and distributed sources in terms of the manner of the effluent



SUB-BASIN AREA

Basin Name	Area (km ²)	Basin Name	Area (km ²)
1 Lake Manyame Basin	590	7 Mukuvisi River Basin	230
2 Gwebi River Basin	770	8 Nyatsime River Basin	580
3 Muzururu River Basin	310	9 Seke & Harava Dam Basin	115
4 Lake Chivero Basin	255	10 Ruwa River Basin	195
5 Manyame River Sub-Basin	166	11 Manyame River Basin (Origin)	474
6 Marimba River Basin	215	Total	3,900

FIGURE 1.1 UPPER MANYAME RIVER BASIN

discharge into public water bodies. Major water pollution sources are identified including sewage discharged from urban areas, treated/untreated industrial wastewater, effluent from sewage treatment plants, agricultural chemicals, fertiliser and livestock from commercial/communal farmland.

(2) Future Development Scenarios in the Study Area

Future frame values are projected as the bases for the water pollution control study and sewage treatment plans including land use, population, industrial development and agricultural promotion. Local development plans, prepared in compliance with the "Second Five-Year National Development Plan", are fully referred to.

(3) Present and Future Water Supply in the Study Area

The effective use of limited water resources, entailing the reuse of treated effluent, is a major concern of a country in the semi-arid tropics where the overall water resources are limited. While, the present joint water supply capacity of the Morton Jaffray Waterworks and the Prince Edward Waterworks (used to supplement the peak demand) is 705,000 m³/day. The annual intake amount from the lakes/dams (about 400,000 m³/day) is almost equivalent to the storage capacity of Lake Chivero. In this regard, the water supply capacity comparing to the increasing demand in the study basin, seems to becoming increasingly critical year by year. The limitation of the water supply capacity is a control factor regarding future development. Future frame values are to be projected in consideration of the current conditions as well as any new water source development plans introducing water from outside of the study basin.

(4) Projection of Water Pollution and Allocation of Pollution Load to be Reduced by Different Pollution Source

The Upper Manyame River Basin is composed of two small dams (the Seke and the Harava) and two large lakes (Chivero and Manyame). The water pollution analysis in terms of T-N and T-P (preserved substances) is done for Lake Chivero, Lake Manyame and the Haraba and Seke dams to come up with countermeasures to combat the eutrophication problem. The water pollution mechanism of the rivers is roughly analysed (COD/BOD index), in consideration of the flow rate of the Manyame River during the dry season (only 1-2 m³/sec) constituted by sewage and effluent discharged from STWs.

The required pollution load to be reduced by the different pollution sources are estimated according to the principle of polluters pay in proportion to their respective contributions to the water pollution problem.

(5) Countermeasure Plan for Water Pollution Control

Countermeasures for the conservation of water quality in the public water body are to be recommended by target year, referring to the pollution load to be reduced by the different type of pollution sources. Among the study factors, sewage treatment methods are discussed with the following considerations:

- Appropriate technologies, especially for the low-cost operation and maintenance of the facilities, shall be employed, taking into consideration the financial status of the government.
- Reuse of treated effluent shall be considered for irrigation and for replenishing water sources, as is already being practised in the study area.

The removal of nutritious substances out of the water bodies is another alternative including fishery and planting arrangements. Furthermore, the laws and regulations to be enforced are discussed, including the requirements to receive industrial wastewater into public sewerage systems and monitoring systems.

(6) Institutional, Financial and Managerial Aspects

The current conditions of the institutional, financial and managerial arrangements are analysed both for the national and local government levels. The financial arrangements required for the implementation of sector projects/programs are recommended based on sector investment experiences both in locally funded and foreign assisted projects. It is also essential to establish a water quality monitoring program for the particular water bodies. Recommendations are to be made reflecting the updated Water Act, which is under consideration by the appropriate review committee in Zimbabwe.

(7) Urgent Project(s) and Environmental Investigation

An evaluation of the potential projects for selection of urgent project(s) is made with an emphasis on the possible contribution to the improvement of the water environment. Other important factors for the comparative study include the urgency, cost requirements, and the effectiveness of financial/economic aspects. In connection to the selected

project, an initial environmental examination is conducted to analyse the negative impact of the project to the present environmental conditions and to identify the need of an environmental impact assessment.

CHAPTER 2

**ADMINISTRATIVE COMPOSITION
AND PHYSICAL CHARACTERISTICS
IN THE STUDY AREA**

CHAPTER 2 ADMINISTRATIVE COMPOSITION AND PHYSICAL CHARACTERISTICS IN THE STUDY AREA

2.1 Outline of the Study Area

2.1.1 Local Administrative Overview

Local administration in Zimbabwe consists of a series of political subdivisions, which are as follows in descending order: province, district, ward and village. Figure 2.1.1 shows the administrative structure in Zimbabwe. There are eight (8) provinces, five (5) cities, seven (7) municipalities, eight (8) towns, four (4) local boards, 57 rural districts and a thousand villages.

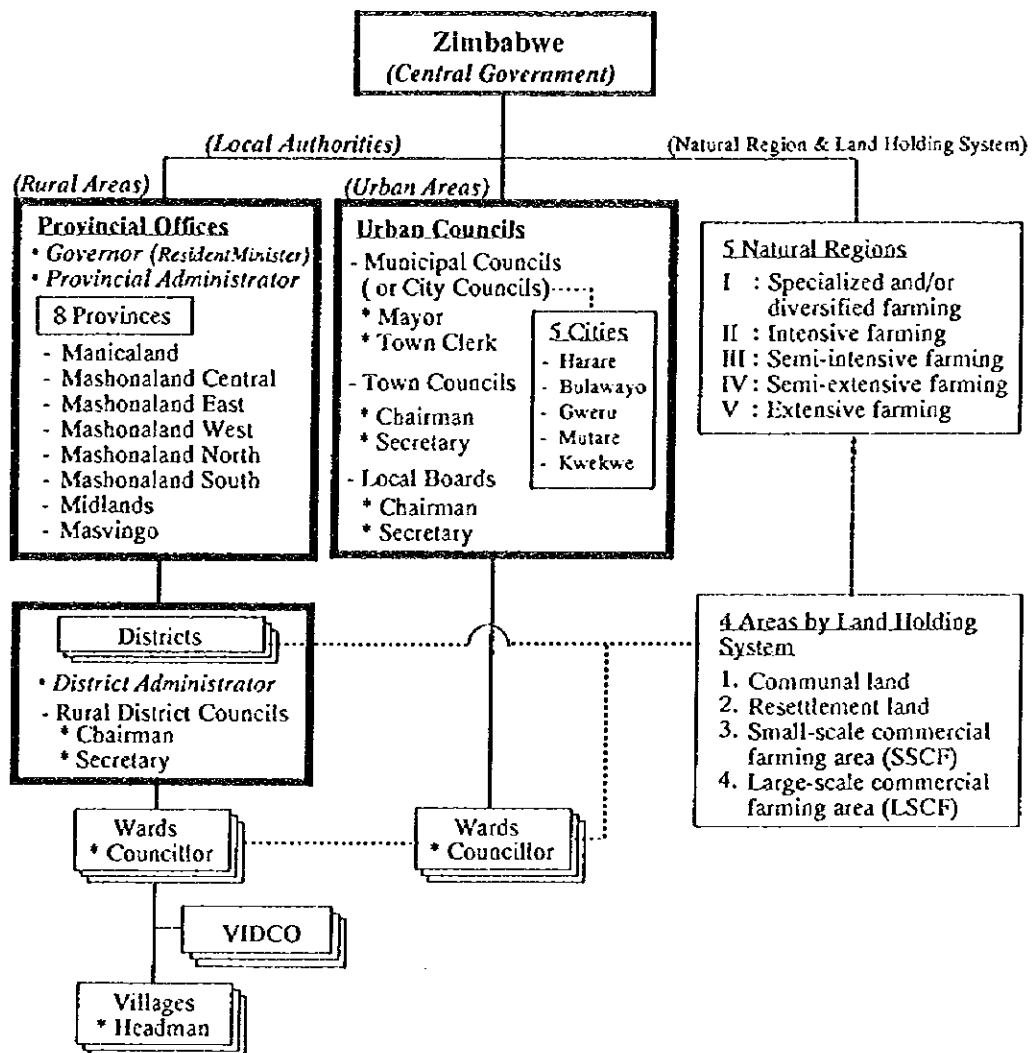


Figure 2.1.1 Administrative Structure in Zimbabwe

Each province has a provincial office of each department under the governor (exclusively in charge of political matters) who is appointed by the central government. The actual provincial administration is undertaken by the Provincial Administrator also appointed by the government and he conducts administration with a certain extent of autonomy. District-level administration is entrusted to district administrators and the district office of each department. The two cities of Harare and Bulawayo are endowed with the same political level of authority as the provinces in their respective jurisdictions.

Subordinate to the provinces are the Urban Councils and Rural District Councils with enactment of the Urban Councils act in 1995, which administer urban and rural areas, respectively. An Urban Council is comprised of City Council, Municipal Council, Town Council or Local Board, according to its developmental status. In the rural areas, the previous District Councils for Communal Lands and the Rural Councils for Commercial Land, which were designated by land use category, were merged to form Rural District Councils (RDCs) in 1988.

The RDCs can be considered as a major step forward in terms of "developing local government" or in a direction of "decentralization". Their current capacity, however, varies considerably from one part of the country to the other, as the human and physical resources they inherited from their predecessor councils is quite different.

A 10-Member Ministerial Committee has been established to oversee the government's decentralization programme, which will see the transfer of a wide range of powers, roles and functions from central government to rural districts. Decentralization aims to minimize bureaucracy, promote and strengthen democracy and civic responsibility as citizens participate in their governance and development.

2.1.2 Administrative Composition of the Study Area

The Study Area, the Upper Manyame River Basin, covers Harare City and three (3) provinces: Mashonaland East, Mashonaland Central and Mashonaland West. Figure 2.1.2 shows the local administrative composition of the Study Area.

Ministry of Local Government, Rural and Urban Development
(MLGRUD: Central Government)

Province and Chartered City

Mashonaland East		Mashonaland Central		Mashonaland West		Harare City	
Urban Council	Rural District Council (R.D.C.)	Urban Council	Rural District Council (R.D.C.)	Urban Council	Rural District Council (R.D.C.)	Urban Council	Urban Council
<ul style="list-style-type: none"> ● Chitungwiza Municipality Council ● Ruwa Local Soard ● Epworth Local Board 	<ul style="list-style-type: none"> ● Goromonzi ● Manyame ● Harare ● Marondera 	Not Applicable	<ul style="list-style-type: none"> ● Mazowe 	<ul style="list-style-type: none"> ● Norton Town Council 	<ul style="list-style-type: none"> ● Chegutu ● Zvimba 	<ul style="list-style-type: none"> ● Harare City Council 	

Figure 2.1.2 Local Administrative Composition in the Study Area

The local autonomous administrative units within the Study Area consist of five (5) urban councils and seven (7) rural district councils as of July 1996. The urban councils include City of Harare, the Municipality of Chitungwiza, the Town of Norton, and the Ruwa and Epworth Local Boards. Table 2.1.1 shows the local administration units by province/chartered city and their respective corresponding areas and present population. Following are the outline of the urban councils concerned:

(1) Harare City

The City of Harare is the capital city of Zimbabwe. It is situated in the upland region of the country at latitude 17.5° (S) and longitude 31° (E), and encompasses an area of some 560 km², with a 1992 population of 1,126,500. The first municipal authority was formed as a Board of Management in 1891. It was granted city status in 1935.

(2) Chitungwiza Municipality

The Municipality of Chitungwiza, currently the third largest in the country in terms of population, lies approximately 9 km south of the Harare City boundary. It was formed in 1978 by the amalgamation of three of Harare's former dormitory townships: Seke, Zengeza and St. Mary's. A town council was proclaimed in 1981 and since then a strong emphasis has been placed on attracting various industries and commercial developers to the town; this is in sharp contrast to the original purpose of the locality as a dormitory town for low-income workers employed in the capital city. Chitungwiza was proclaimed a municipality in February 1996 and is responsible for the civic affairs of about 400,000 people.

(3) Norton Town

The Town of Norton, some 40 km west of Harare City, was originally developed in the 1970s as a dormitory town for workers in Harare City. The urban area of Norton was administered until 1993 as part of the Norton-Selous District Council. A town board was instituted in 1993 to administer the some 19.5 km² granted town status. Norton, with a 1992 population of 20,000, is expected to rapidly develop as a result of its new status as a service centre for the Chegutu district.

Table 2.1.1.1 Present population and Areas in the Study Area

Province/Chartered City			Urban Council (within Study Area)			Rural District Council (within Study Area)		
Name	Area (km ²)	Population (1992)	Name	Area (km ²)	Population (1992)	Name	Area (km ²)	Population (1992)
Harare City	557.45	1,126,473	Harare City	447.1	* 1,214,119	N.A		
Mashonaland East	32,230.00	1,034,342	Chitungwiza Municipality	42.0	274,912	Goromonji	495.6	29,325
			Ruwa Local Board	31.4	1,447	Manyame	534.1	15,521
			Epworth Local Board	11.1	62,630	Harare	258.9	21,600
						Marondera	226.6	6,828
Mashonaland Central	28,347.00	856,736	N.A			Mazowe	254.0	11,360
Mashonaland West	57,441.00	1,112,955	Norton Town	19.5	20,405	Chegutu	261.1	6,776
Total	118,575.45	4,130,506		551.1	1,573,513	Zvimba	1,318.6	48,950
							3,348.9	140,360

Note: *; Present population in 1993 (refer to Table 6.2.3 (1) to 6.2.3 (2) in Water Pollution Master Plan)

(4) Ruwa Local Board

Some 8 km² of the Ruwa farming area was designated as a growth point in 1986. The centre is located in a large-scale commercial farming area along the Harare-Mutare Road and is about 23 km from Harare City. The area has been formally excised from the rural district council's authority subsequent to the formation of the Ruwa Local Board. The population in 1992 was about 1,500 and the majority of development has been undertaken by the private sector.

(5) Epworth Local Board

Some 34 km² of mission land in Epworth, located in the south-east of Harare City, was occupied by refugees in the 1970s. After independence, the area was taken over by the Ministry of Local Government, Rural and Urban Development. The infrastructure in the area was upgraded with financial assistance from USAID with the aim of attaining the standard of utilities in Harare City. Epworth was proclaimed as a Local Board in 1996. The 1992 population was enumerated at 62,600.

2.2 Physical Characteristics in the Study Area

2.2.1 Meteorology

The Department of Meteorological Services has been carrying out an intensive monitoring of meteorological and hydrological parameters throughout the country (details are referred to in Appendix 2.2).

Meteorological data of Harare City monitored at Belvedere Station during the past 30 years is summarised in Table 2.2.1.

Table 2.2.1 Monthly Meteorological Data of Harare City

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total (Ave.)
Ave. Rainfall (mm)	186	173	96	38	7	2	2	3	6	40	89	181	823
Ave. Temp. (C)	20.0	19.8	19.4	18.7	15.9	13.6	13.6	15.6	19.0	21.3	20.8	20.4	18.2
Ave. Humidity (%)	77	79	72	67	61	59	51	47	45	46	61	72	61

As shown on the table, climate in the Study Area is very seasonal with three distinct, wet or dry, seasons. "Spring" is a hot and dry season from September to November and rainfall is

unlikely to occur. The average daily temperature is approximately $22^{\circ}\text{C} \pm 6^{\circ}\text{C}$. "Summer" is classified as the rainy season with hot and wet conditions from December to April. The average daily temperature is about $20^{\circ}\text{C} \pm 6^{\circ}\text{C}$. The remaining period of the year is a cold and dry season, so called as "Winter" in other parts of the world. The average temperature is approximately $16^{\circ}\text{C} \pm 6^{\circ}\text{C}$.

Mean total annual rainfall is approximately 820 mm in the Study Area with annual fluctuations ranging from 440 mm to 1,220 mm. During the summer season, approximately 80% of the total annual rainfall is observed.

Winds in Zimbabwe are generally from an easterly direction throughout the year, carrying moist air from the sea. Wind directions in Harare for the months of January, July and October show light winds over 4 knots which are commonly observed 50% to 80% of the time in any month of the year.

2.2.2 Topography and Geology

The Study Area is generally a gently undulating plateau. Most of the Study Area lies on an altitude ranging from 1,400 to 1,500 meters above sea level and the lowest altitude is approximately 1,300 meters.

The Study Area is generally underlain by Archaean age rocks forming a part of the Zimbabwe Basement Complex. The upper part of the Study Area is underlain by rocks of the Older Gneiss Complex containing relatively small inclusion of schistose rocks being comprised of meta-sediments and meta-volcanics of the Bulawayan Age, while a relatively small part of the upper extremity of the Study Area is underlain by granite.

The lower part of the Study Area including, Lake Manyame, is on the other hand, almost entirely underlain by granite which excludes a relatively large portion of the northern flank and a part of the north-western boundary. Rocks in the northern flank are mostly meta-sediments and meta-volcanics of the Bulawayan Age. Harare City, including its industrial area, lies on the outcrop and sub-outcrop of these rocks. A narrow belt of schistose is seen on the ridge of hills which form the abutment of Lake Manyame.

2.2.3 Hydrology and Hydrogeology

An extensive monitoring of hydrological parameters is carried out by the Department of Meteorological Services with a network of stations around the country. The hydrological Bureau of the Division of Water Development also maintains a network of river and groundwater flow monitoring stations.

There are six (6) tributaries in the Upper Manyame River Basin Area and four (4) lakes/dams. Raw water is being drawn from lakes/dams of Seke, Chivero and Manyame for water supply to Harare and Chegutu. In this river basin, there are also seven (7) sewage treatment plants. An outline of the rivers in the Study Area is shown in Table 2.2.2, while that of lakes/dams is shown in Table 2.2.3. The configuration of sub-river basins in the Study Area is shown in Figure 1.1.

Table 2.2.2 Outline of Rivers in the Study Area

River	Length (km)	Catchment Area (km ²)	Remarks
Manyame	131.0	3,930	Harava Dam, Seke Dam, Lake Chivero,
Gwebi	83.0	680	Marlborough WWTP
Muzururu	35.0	320	
Marimba	16.5	230	Crowborough WWTP
Mukuvisi	23.5	230	Firle WWTP
Nyatsime	56.0	590	Zengeza WWTP
Ruwa	24.0	180	Donnybrook WWTP, Ruwa WWTP

Table 2.2.3 Outline of Lakes and Dams

Name	Year of Construction	Storage Capacity (10 ³ m ³)	Max. Surface Area (ha)
Lake Manyame	1976	480,236	8,100
Lake Chivero	1952	247,181	2,630
Seke Dam	1929	3,380	110
Harava Dam	1972	9,026	215

The flow rate of the rivers fluctuates very seasonally. A large volume of river flow is normally observed during summer season (December to April), while the minimum flow occurs in winter, (May to August) wherein compensation water from the upstream dams is released.

The mean annual flow of Manyame River is approximately $304.7 \times 10^6 \text{ m}^3$, while the total annual flow varies from $20.7 \times 10^6 \text{ m}^3$ to $796.5 \times 10^6 \text{ m}^3$. The Manyame River occupies as much as

80% of the total gauged flow, while the Mukuvisi and Marimba Rivers contribute to the rest of flow rate.

Abstraction and discharge from Lake Manyame account for about 60% of the total outflow, while 30% of the total outflow is estimated to be lost by evaporation. Upon completion of the downstream Darwendale Dam (Lake Manyame), the amount of water released from Lake Manyame has been somewhat reduced. Groundwater inflows and outflows are considered to be minimal in comparison with the surface flows.

2.2.4 Natural Environment and Ecology in the Study Area

The Study Area falls under Natural Region II definition as per agro-ecological classification of Zimbabwe, and is considered an intensive farming region. As a result of intensive agriculture and urban development, the natural environment has been modified throughout most of the Study Area.

The underlying granitic geology of most of the Study Area has given rise to light textured sandy soils except where basic rocks extending up the Mazowe valley to the northern edge of Harare have resulted in heavier textured, more clayey soils.

(1) Terrestrial flora

In broad vegetation terms, the Study Area falls into the miombo belt that occurs all over the Central African plateau between 800 m and 1,800 m above sea level and where annual rainfall is in the range 500 mm - 1,800 mm (Wild and Barbosa, 1967). A particular feature of the miombo woodlands is the bright coloured red, purple and green foliage of early spring. Most of the woody species flower before the rains.

With the relatively high rainfall in the Study Area, the dominant upland vegetation is similar in all soil types, *Brachystegia spiciformis* - *Julbernardia globiflora* woodlands and savannah woodlands. The largest trees in these deciduous woodlands are *B. spiciformis* and *J. globiflora* while grow up to about 13 m tall. Commonly associated species include *Combretum molle*, *Faurea saligna*, *Monotes glaber*, *Uapaca Kirkiana*, *Phytostigma thonningii* and *Pterocarpus rotundifolius*. *Julbernardia globiflora* regenerates faster than *B. spiciformis* and areas where this species is dominant often represent areas of secondary growth following cultivation. Common shrubs include the three species

Bauhinia petersiana, *Lansea discolour* and various *Grewia* species. The grass layer is usually sparse where the woodlands are well developed but denser where the canopy is more open. Typical species are *Hypparrhenia filipendula*, *Hyperthelia dissolute*, *Pogonarthria squarrosa* and *Brachiaria brizantha*. The flame lily *Gloriosa superba* may be conspicuous during the wet season. On the rocky hills (kopjes) a variety of other species not found on the deeper soils, such as *Brachystegia glaucescens* and *Commiphora* sp. are common. Colourful aloes are also a feature of rocky outcrops and kopjes.

Scattered throughout the woodlands are large termitaria (anthills) usually covered with a dense thicket of woody vegetation which often contains, in addition to the typical woodland species, other species such as *Albizia amara*, *Cassia abbreviata* and *Ziziphus mucronata*.

In the northern part of the Study Area and near Melfort and Bromley there are areas where the water table is too high for the typical woodlands and a more open tree savannah occurs. The grassland is generally dominated by *Hypparrhenia* sp. with scattered *Parinari curatellifolia* trees up to 15 m tall.

The woodlands and savannah are dissected by seasonally wet grasslands (vleis), that develop into small stream as they pass down the catena and join together. The vleis are dominated by tall grasses such as *Hypparrhenia filipendula* and *Hyperthelia dissoluta* and although the streams themselves do not have a well developed riverine vegetation, as would be found at lower altitudes, trees such as *Syzygium guineense*, *Combretum erythrophyllum* and *Acacia karroo* are often found along the banks and reedbeds (*Phragmites* sp.) are common.

Relatively small areas of *Acacia* savannah also occur, usually in the vicinity of smaller streams, typical trees being *A. sieberana* and *polyacantha*.

(2) Terrestrial fauna

Before development took place, most of the large mammals found in Zimbabwe also occurred within the Manyame catchment, but agricultural and urban development have made the area unsuitable for the larger wild mammals except where fenced game parks have been established. Outside these game parks kudu, reedbuck, duiker, steenbuck,

antbears, naboons and monkeys still occur and also a range of smaller carnivores and omnivores such as civet, genets, mongooses, jackals, bushpigs hares and rodents. Many of these smaller animals are primarily nocturnal and seldom seen.

Although deforestation and agriculture have altered the natural environment, many of the 640 species of birds recorded in Zimbabwe can be found within the Study Area, both as resident species and migrants. Many species have adapted to development and Peregrine and Lanner falcons have been recorded nesting in central Harare on the high rise buildings. Little swifts and Palm swifts are also common in the city as well as house sparrows, which are not indigenous to Zimbabwe but are now found in all urban areas. One group of birds that has been particularly favoured by the development of dams are the water and wading birds. The larger impoundments and smaller farm dams and the overflow from the sewage works are all suitable habitats and the number and variety of birds at these sites can be striking.

Reptiles and amphibians are well represented in the Study Area and Broadley and Blake (1979) give 37 species of reptile recorded and another 25 of probable occurrence in Lakes Mellwaine (Chivero) and Robertson (Manyame) Recreational Parks, on the Manyame River. These include snakes, lizards and tortoises as well as monitor lizards. There is habitat for a number of fossorial amphibians and reptiles, such as burrowing frogs and amphisbaenids.

(3) Aquatic ecology

The eutrophication of the river system and Lake Chivero in particular has led to large amounts of algae and floating aquatic plants, particularly water hyacinth (*Eichornia crassipes*), water lettuce (*Salvinia molesta*), and water fern (*Azolla filiculoides*). The floating aquatic plants interfere with commercial fishing and recreational uses of Lake Chivero in particular. Methods of combating the water hyacinth have included spraying with chemicals and manual removal and more recently, biological control using a weevil, *Neochetina eichhorniae*, is showing promising results. Rooted macrophytes such as *Lagarosiphon major* are also very common in the lakes and these aquatic systems also have a diverse populations of aquatic fauna.

About 28 species of fish are known from the Upper Manyame, (Marshall, 1982) and Lakes Chivero and Manyame both support commercial fisheries as the eutrophic nature of the impoundments leads to high fish productivity.

A feature of the larger reservoirs is the very marked thermal stratification that occurs as the surface water warms during the summer causing two discrete layers to form. The lower layer remains colder but accumulates nutrients from the decay of sinking organic matter and becomes anaerobic. At the beginning of the cool season, stratification breaks down as the surface layer cools, the layers mix and trapped nutrients from the lower layer are released resulting in algal blooms. De-oxygenated water from the lower coming to the surface may also cause fish deaths as happened at Lake Chivero in March-April 1996.

References:

- Broadley, D.G. and Blake, D.K. 1979. A Checklist of the reptiles of the natural Parks and other conservation areas of Zimbabwe-Rhodesia. *Arnoldia Rhod.* 8 (35):1-15
- Marshall, B.E. 1982. The fish of Lake Mellaine. In *Lake Mellaine: The eutrophication and recovery of a tropical African lake* J. Thornton (Ed) pp. 156-188. The Hague; Dr. W. Junk
- Wild, H. and Barbosa, L.A. 1967. *Flora zambesiaca supplement; vegetation map of the Flora Zambesiaca area.* M.O. Collins, Harare, Zimbabwe