CHAPTER 3

ENVIRONMENTAL MANAGEMENT AND WATER POLLUTION STAUS

CHAPTER 3 ENVIRONMENTAL MANAGEMENT AND WATER POLLUTION STATUS

3.1 Present Institutions for Water Pollution Control and Environmental Management

3.1.1 Institutional Framework for Water Pollution Control

In Zimbabwe, the government control is exercised at three separate political levels:

- National : Central government agencies
- Provincial : Provincial offices
- Local : Local authorities: urban councils including cities and municipalities, towns, local boards and rural district councils

(1) National Organisation

The national agency concerns itself with major policy and planning issues and with establishing the laws, regulations and criteria to be applied by the lower governmental levels in resolving major issues. The national or provincial agencies provide varying degrees of regulation, supervision and assistance, while sewage disposal is essentially a local function.

(2) Provincial Organisation

Provincial interests in water pollution control are also important. The provincial government's responsibility is central, especially designated to undertake the pollution control in rural areas. The provincial government has varying degrees of authority delegated to them by the national government. However, all authorities generally repose in the national government.

(3) Local Organisation

The local organisation is political or administrative entity established by law for the purpose of acquiring, constructing, improving, maintaining and operating projects for the public use, including sewage collection and treatment facilities.

In the urban areas, the water pollution control functions are vested in the independent local authorities (urban councils) or assigned to their departments (such as engineering or public works). The organisation for managing the sewage collection and disposal systems takes many forms and depends upon local circumstances in each local government area.

3.1.2 Primary Ministries and Institutions for Water Pollution Control

In Zimbabwe, no one agency has sole responsibility for water pollution control. At the national level, there are four (4) major government agencies which are directly involving in the water pollution control and two (2) particularly concerning with its planning and financial management aspects.

The various central government, local government, statutory and non-governmental bodies responsible for or professionally interested in water pollution control in Zimbabwe in general and the Study Area in particular are shown in Figure 3.1.1.

The primary central and local government agencies/institutions which are involving in the water pollution control planning and management are the following:

Central Government Agencies

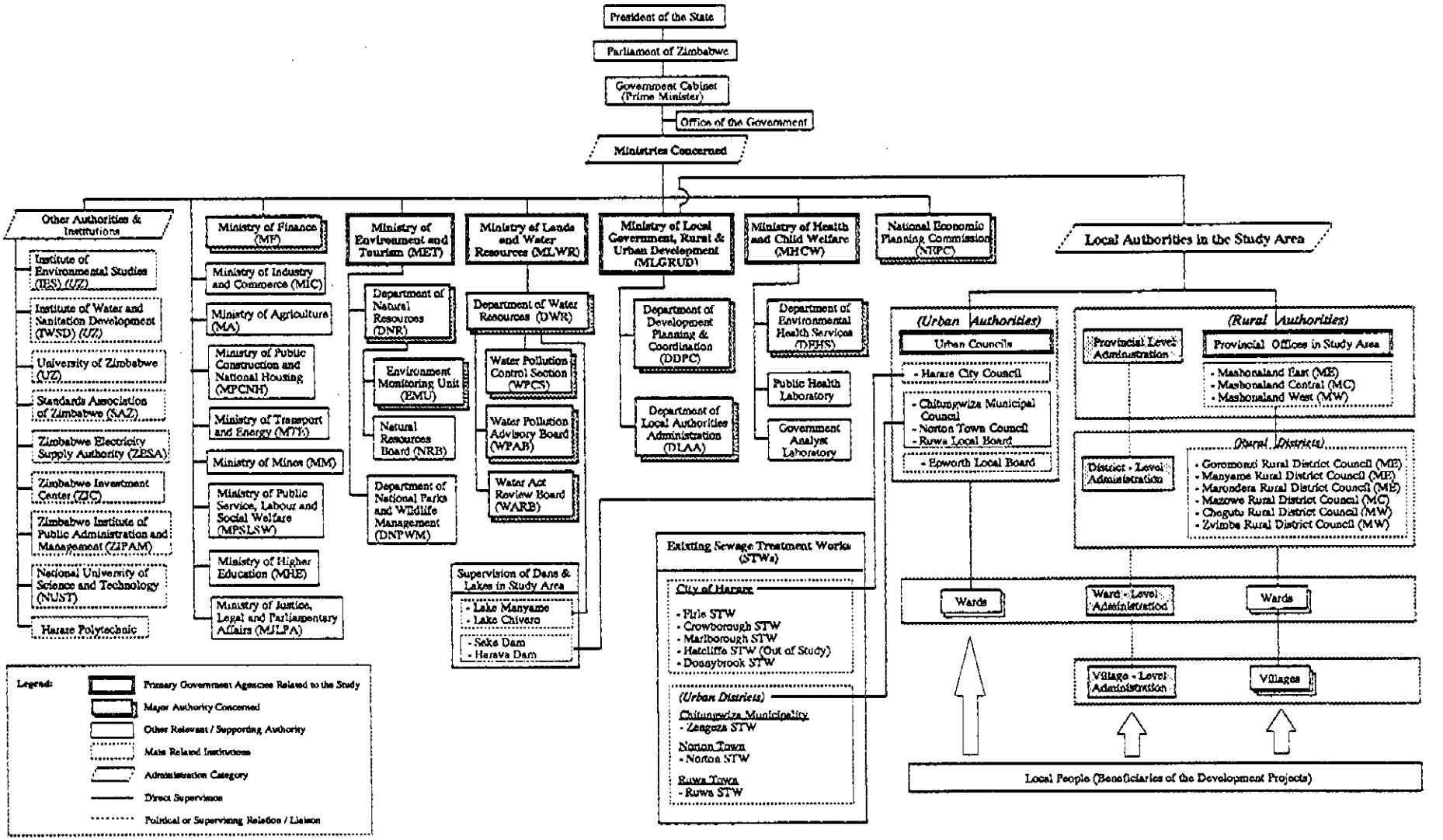
1) Ministry of Local Government, rural and Urban Development (MLGRUD)
2) Ministry of Lands and Water Resources (MLWR)
3) Ministry of Environment and Tourism (MET)
4) Ministry of Health and Child Welfare (MHCW)

(Supporting Government Agencies in Planning and Financing)

5) National Economic Planning Commission (NEPC)
6) Ministry of Finance (MF)

Local Authorities

1) Provincial and District Offices
2) Urban Councils (including Cities, Municipalities, Towns and Local Boards)
3) Rural District Councils



Source : JICA Study Team

Figure 3.1.1 Organization Structure for Water Pollution Control in Zimbabwe
(Main Agencies & Institutions Related to the Implementatin of Water Pollution Control Projects)

The following are the major agencies/ institutions involving in the water pollution control in the Study Area and their respective responsibilities and functions:

(Central Government Agencies)

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

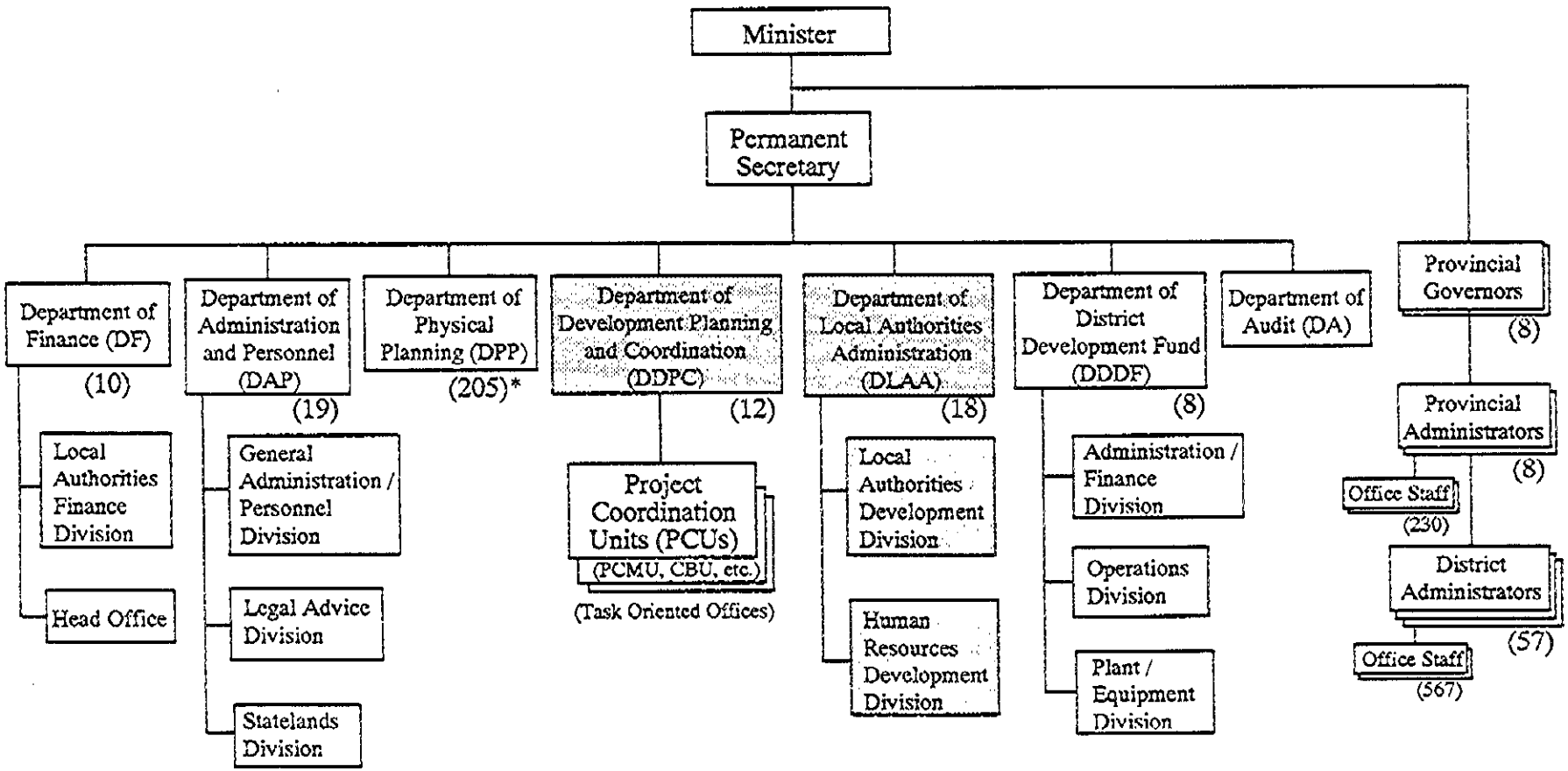
The MLGRUD is responsible for supervising local authorities and regional development including both the rural and urban areas with the following main functions:

- to develop grassroots local administrative and consultative structure to enable the devolution of self-governing powers;
- to foster infrastructural, superstructural and human resources development at local level to enhance the capacity of local organs, specially local authorities in order for them to assume the full responsibility of planning for their own development as well as developing administrative and management skills;
- to evolve the policies aiming at:
  - correcting developmental and administrative imbalances amongst local authorities,
  - providing infrastractural development assistance to local authorities,
  - planning for spatial development of the country,
  - administering urban and rural statelands, and
  - providing for and administering proper land settlement in rural areas; and
- to approve the development plans and their amendments.

The organisational chart of the MLGRUD is shown in Figure 3.1.2.

The MLGRUD consists of seven (7) departments: Department of Development Planning and Co-ordination, Local Authorities Administration, Physical Planning, District Development Fund, Administration and Personnel, Finance and Audit. Among the above seven departments, the first two are deeply involved in this Master Plan Study.

The Department of Development Planning and Co-ordination (DDPC) is the principal acting counterpart institution which liaises and co-ordinates with the other government agencies and institutions for smooth implementation of the Study. DDPC is designated



Notes: Total No. of Head Office Staff (Permanent) : 231, as of July 1996, excluding DPP Personnel.
Figures in parentheses ( ) indicate the total number of permanent staff of the Departments and Divisions involving in implementation of the water pollution control project.
PCMU = Programme Coordination and Monitoring Unit CBU = Capacity Building Unit
* This figure is not included in the Head Office Total Number, because it comprises its own provincial/ district staff.

Source : MLGRUD

Figure 3.1.2 Organizational Chart of the Ministry of Local Government, Rural and Urban Development (MLGRUD)

responsibility for overall co-ordination of regional (rural and urban) development assistance activities.

The Department of Local Authorities Administration (DLAA) assumes the following functions:

- enforcement of Acts and By-laws;
- promotion of human resources development and discipline enhancement of staff in local authorities;
- preparation and supervision of elections;
- appropriate research in various aspects of local government with a view to instituting reform in policies, concepts, structures and practices.

The MLGRUD is one of the most important government agency, since its sole mission is to supervise all the local authorities decentralised, which take direct charge of environmental protection and management including the water pollution control.

In conjunction with the Ministry of Finance (MF), the MLGRUD also determines the nature of local finance. Officials from the MLGRUD are found in every part of the country. Provincial Administrators, being MLGRUD's officials influence the nature of local development programme.

The MLGRUD refers pollution matters to the Department of Water Resources (DWR) of MLWR, according to:

- Regional, Town and Country Planning Act, 1976 (Section 27)
- Regional Town and Country Planning (Development) Regulations, 1976 (GN 927 of 1976) subparagraph (ii) of Section 6 (i)(b)

Through these instruments, MLGRUD controls the kind of development occurring so as not to jeopardise the quality of the water. A memorandum on the control of development was also produced by the Water Pollution Control Section and also a handbook to assist Local Planning Authorities with pollution control.

(2) Ministry of Lands and Water Resources (MLWR)

The Ministry of Lands and Water Resources (MLWR) with its departments is the most important central agency which affects the development of national lands and water resources. Effectively, the Department of Water Resources (DWR) oversees water management of the country.

The organizational chart of the MLWR is shown in Figure 3.1.1, Section 3.1, Chapter 2, Supporting Report.

The Water Pollution Control Section (WPCS) of the department of Water Resources (DWR) has the mandate to control "water pollution" countrywide, in terms of the Water Act, 1976, Part IX, Section 101 and 102, and to enforce the effluent discharge standards set in the Water (Effluent and Wastewater Standards) regulations, GN 687/1977.

In order to achieve the above objectives, parts of its functions are delegated to provincial water engineers and local authorities. The WPCS is responsible for the co-ordination of activities by these bodies and for ensuring that a uniform and consistent approach to water pollution is applied throughout the country. The roles of WPCS can be summarised as follows:

- routine inspections of all sewage works, industries, mines and farms for waste disposal methods and methods of works operation;
- liaison with Local Planning Authorities on control and abatement of pollution;
- monitoring of effluent discharges from all industries and mines and run-off from roads and farms;
- water quality monitoring to assess effects of pollution on the flora and fauna of rivers, dams and/or reservoirs (limnology);
- design and monitoring of water quality (ambient) and drinking water surveillance programmes for all water treatment plants, reservoirs and distribution networks owned by the Department of Water Resources;
- liaison with all provincial water engineers on various sampling programmes and water pollution issues;
- data collection, processing, analysis and storage;
- attendance to all pollution reports throughout the country;
- preparation of water quality reports and investigations; and

- liaison with water related boards/institutions, e.g. Water Pollution Advisory Board (WPAB), Air Pollution Advisory Board (APAB), Natural Resources Board (NRB), Confederation of Zimbabwe Industries (CZI), government ministries, etc.

The WPCS also takes charge of conducting review studies on the Water Act and elaborating its revised draft together with the Water Act Review Board (WARD).

A "Water Pollution Advisory Board" was set up in terms of the Water Act. The Department of Water Resources (DWR) chairs this Board (Meetings), consisting of experts from various organisations concerned with water pollution.

The functions of the Board are to advise the Minister of Lands and Water Resources on:

1) all maters regarding water pollution control; and
2) issues of exemption permits which local authorities may apply for in terms of the Water Act to allow them to discharge sewage effluent which does not comply with the relevant standards.

The latter may be in order to enable them to upgrade or relocate sewage treatment plants or in cases where the effluent standards are unnecessarily strict. The Minister of Lands and Water Resources can only issue such a permit after consultation with the Minister of Health and Child Welfare, according to the Water Act, Part IX, Section 101(3).

The Water Pollution control Section is in the process of building a National Water Quality Laboratory with a view to stepping up the water analysis programme to boost the current monitoring programme.

(3) Ministry of Environment and Tourism (MET)

The Ministry of Environment (MET) has general responsibilities for environmental management through the Natural Resources Act and several other acts. The Natural Resources Act, section 46 (3) (a) and (4) (b) and (e) seeks to control pollution by requiring a person to take steps to prevent activities which pollute water. The organisational chart of the Ministry of Environment and Tourism (MET) is included in Figure 3.1.2, Section 3.1, Chapter 2, Supporting Report.

In 1992, the Government of Zimbabwe initiated a bilateral assistance programme in environmental and natural resource management with the Government of Canada. The programme, called "Zimbabwe Natural Resources Management Programme" with Z$120 million for five years, is divided into two primary projects.

- a field support component has been developed within DNR to build capacity in integrated resource management, environmental impact assessment, resources documentation and extension services; and
- an Environmental Planning and Co-ordination Unit (EPCU) Project which has been established within MET. The EPCU has direct responsibilities relating to the co-ordination and implementation of the National Conservation Strategy and results of the UNCED process.

Now in its fourth year, the EPCU project is focusing attention and resources on supporting the government's efforts to review and reform environmental legislation. There were several preliminary steps that have been taken to support the current examination of environmental laws during the early 1990's. Since then, an interim Environmental Impact Assessment (EIA) policy has been introduced with the intention that it will be entrenched within law after a sound testing in the field.

More recently, a legal consultant was hired to begin the legislative review process. The results of review works summarised in the several papers (As to the reports, refer to Section 3.3).

(4) Ministry of Health and Child Welfare (MHCW)

The Department of Environmental Health Services (DEHS) of the Ministry of Health and Child Welfare (MHCW) is responsible for:

- conception, design, operation and surveillance of specialised programmes and facilities necessary for the control of the quality of air, land, water and man's personal and working environment;
- assessment and monitoring of areas of potential environmental hazards; and
- assistance in setting standards for the protection of man's health and well being.

The organisational chart of the Ministry of Health and Child Welfare (MHCW) is given in Figure 3.1.3, Section 3.1, Chapter 2, Supporting Report. The major roles / functions of the DEHS include:

- control of communicable diseases;
- health education, especially on food and water quality;
- implementation of sanitation programs and inspection;
- wastes and waste management;
- water quality monitoring;
- control of air pollution and hazardous substances;
- inspection of premises; and
- port health activities

Water quality monitoring activities are done at provincial and district level. Regular checks are done on domestic water as well as effluent discharges. Samples collected are analysed by the Public Health Laboratories and the Government Analyst Laboratory.

The Department of Environmental Health Services (DEHS) of the MHCW administers the Public Health Act and Public Health (Effluent) Regulations, 1972. As regards the water pollution control, DEHS informs the Department of Water Resources, Water Pollution Control Section of the MLWR of any contaminated discharges into rivers, streams, dams & reservoirs or seepage into the groundwater.

Whereas the Water Pollution Control Section (WPCS) is mainly concerned with illegal discharge of contaminants into rivers and into the underground water, the Department of Environmental Health Services (DEHS) is concerned with good housekeeping, e.g. of sewage works, and with the quality of sewage effluent used for irrigation, which is laid down under the Public Health (Effluent) Regulations, 1972.

As to the irrigation for farms, farmers may enter into agreements with local authorities using guidelines provided by the WPCS to use sewage effluent for this purpose. The local authority has to ensure that its effluent will satisfy the Public Health (Effluent) Regulations, 1972.

The Minister of Health and Child Welfare must be consulted on the issue of effluent discharge exemption permits, in terms of the Water Act, Part IX, Section 101(3).

(5) National Economic Planning Commission (NEPC)

The National Economic Planning Commission (NEPC) is the leading agency, responsible for the planning and monitoring of the national economy. National development plans and economic programs are prepared by this Commission.

The NEPC is also responsible for planning external assistance and co-ordinating preparation of development project proposals. The Commission is chaired by the State President.

Public Sector Investment Program (PSIP) is a medium and long-term capital investment budget, in which NEPC indicates the most efficient allocation of resources to achieve development objectives.

(6) Ministry of Finance (MF)

The Ministry of Finance (MF) is a financing agency which both directly and indirectly affects the activities in the central government agencies/institutions as well as local government areas. It appropriates central funds for the provincial administration and local authorities of all forms. The budget approved for central line agencies under various ministries are spent in local government areas.

The MF is responsible for determining external assistance requirements together with the National Economic Planning Commission (NEPC).

(Local Authorities)

(7) Department of Works (DOW) of the Harare City Council

Local authorities are empowered by the Minister of Lands and Water Resources (MLWR) to report pollution matters in their areas of jurisdiction to Water Pollution Section of MLWR, if the Minister deems them capable (Water Act, 1976, Part IX, section 103 and 104). The organisational chart of Harare City Council is given in Figure 3.1.4, Section 3.1, Chapter 2, Supporting Report.

The main local authority in the Study Area, the Harare City Council, has in turn set up a Trade Waste Inspectorate, who controls industrial effluent discharges in terms of by-laws under the Urban Councils Act (1995), Section 180, in order to protect sewer systems, the treatment plants and water courses. They also provide advisory services to industry and sample for tariff purposes. Water and wastewater sampling points and frequency in the city of Harare are included in Table 3.1.1, Section 3.1, Chapter 2, Supporting Report. The staff complements of the four (4) Sewage Treatment Works concerned in the city of Harare are given in Table 3.1.2 to 3.1.5, Section 3.1, Chapter 2, Supporting Report.

(8) Town Engineer's Departments; Chitungwiza Municipal Council, Norton Town Council, and Ruwa and Epworth Local Boards

These local authorities are responsible for the collection, treatment and disposal of sewage and industrial effluents within their boundaries in a similar manner to the city of Harare.

Chitungwiza, Norton and Ruwa have sewage works, while Epworth does not; as it has developed from an informal settlement, it relies on pit latrines at present.

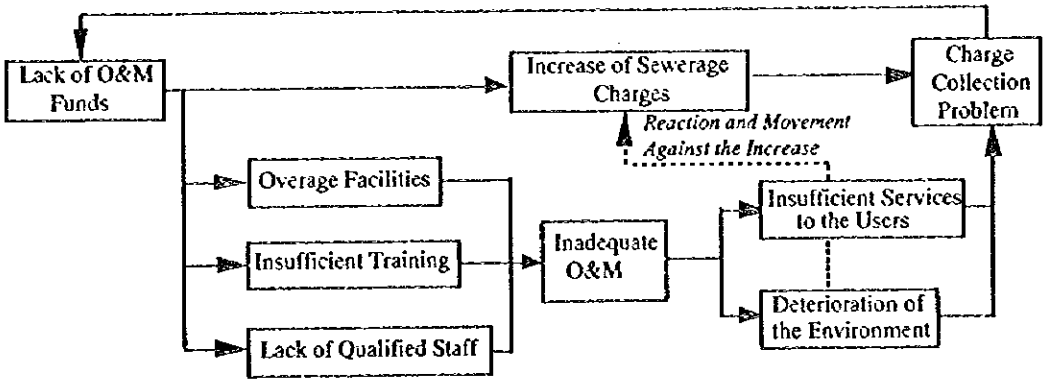
The organisational charts of Chitungwiza Municipal Council, Norton Town council, and Ruwa and Epworth Local Boards are shown in Figures 3.1.5, 3.1.6, 3.1.7 and 3.1.8, Section 3.1, Chapter 2, Supporting Report.

(9) Sewage Treatment Works

The existing sewage treatment works in the Study Area became generally too small for the anticipated workloads and are inappropriately operated and maintained. Major institutional & organisational issues in each sewage treatment works concerned reside in the following two points: 1) lack of qualified and experienced personnel and 2) poor training (refer to Table 3.1.2, Section 3.1, Chapter 2, Supporting Report).

With regard to the operation and maintenance of the existing sewage treatment works, their costs are barely covered by the revenues within the "sewerage accounts" of each

Council. Operation and management are apt to fall into a kind of vicious circles as shown below.



The staff components of the respective sewage treatment works concerned are given in Tables 3.1.3 to 3.1.9, Section 3.1, Chapter 2, Supporting Report.

To sum up, the institutional framework for water pollution control with the ministries/institutions concerned and their functions and responsibilities can be broadly defined as follows:

Agencies / Institutions	Functions & Responsibilities
1) Ministry of Local Government and Rural and Urban Development (MLGRUD)	- Construction and /or rehabilitation of wells, rural roads and community centres under DDF scheme - Supervision of local development plans - Co-ordination of regional (rural & urban) development programs and projects
2) Ministry of Lands and Water Resources (MLWR)	- Management of lands - Security of water sources for agriculture, hydropower generation , water supply, etc. - Irrigation development - Water resources planning for basins and zones - Formulation of water resources development investigation projects - Water resources management
3) Ministry of Environment and Tourism(MET)	- Environmental control and management (Water quality)
4) Ministry of Health and Child Welfare (MHCW)	- Monitoring of water quality and hygiene
5) National Economic Planning Commission (NEPC)	- Planning and monitoring of the national economy - Planning of external assistance - Co-ordination of development project proposals
6) Ministry of Finance (MF)	- Appropriation of central funds - Determination of external assistance requirements
7) Local Authorities	- Planning and management are decentralised to local authorities, which increase autonomy and

As described above, several authorities are involved in the water pollution control in the Upper Manyame River Basin. Their involvement in water pollution control are summarised in terms of jurisdiction/ functions in Table 3.1.1.

3.1.3 Training and Manpower Development

In Zimbabwe, there exist various institutions which train/educate people in the courses directly and indirectly related to water pollution control. The following are the major institutions which contribute to the human resources development in this sector:

(1) University of Zimbabwe (UZ)

- Department of Civil engineering: This offers degree courses which are related and are applicable to water pollution control. Direct liaison with the Water Pollution Control Unit is helping establish relevant courses in this degree.
- The Geography Department also has water pollution control courses on offer to its students.
- The B.Sc. General Degree has various courses which are directly applicable to water pollution control like chemistry, biology, microbiology, which are basic requirements for water pollution control officers in the civil service.

(2) Institute of Water and Sanitation Development (IWSD/UZ)

The IWSD was developed from the Training Centre for Water and Sanitation (TCWS), a project of the UNDP-World Bank Programme hosted by the Department of Civil Engineering, University of Zimbabwe.

The institute located in the University of Zimbabwe (UZ) offers training through short and medium duration courses, some of which are commissioned courses held at the request of sector agencies and organisations. The courses vary from management of water supplies and sanitation to waste management. The participants are drawn from local and regional institutions and companies.

Table 3.1.1 Authorities and Their Jurisdiction/Functions for Water Pollution Control in the Study Area

Authorities / Jurisdiction/Functions	Agencies In Charge	
	Government Agency	Local Authority
1. Water Pollution Control		
1) Water Act and Regulation	- Department of Water Resources (DWR) / Ministry of Lands and Water Resources (MLWR)	-
2) Environmental Water Quality Standard	- Department of Water Resources (DWR) / Ministry of Lands and Water Resources (MLWR)	-
3) Water Pollution Control	- Department of Water Resources (DWR) / Ministry of Lands and Water Resources (MLWR) - Water Pollution Board (WPB) & Water Pollution Control Section (WPCS)/DWR/MLWR	- Department of Health Services (DHS) / City of Harare
4) Environmental Water Aspects	- Department of Natural Resources (DNR) / Ministry of Environment and Tourism (MET)	-
2. Environmental Assessment	- Ministry of Environment and Tourism (MET)	-
3. Water Quality Monitoring and Countermeasure Order	- Department of Environmental Health Services (DEHS)/ Ministry of Health and Child Welfare (MHCW) - Department of Natural Resources / MET	- Department of Works (DW) / City of Harare
4. Water Sampling and Quality Examination	- Water Pollution Control Section (WPCS) / DWR / MLWR - Department of Environmental Health Services (DEHS) / MHCW	- Department of Works (Water Quality Laboratory) / City of Harare (CH)
5. Hydrological Data Collection and Keeping	- Department of Water Resources (DWR) / MLWR - Department of Natural Resources / MET	-
6. Control of Wastewater Treatment/Sewerage System	- Ministry of Local Government, Rural and Urban Development (MLGRUD)	- City Council, Municipal Council, Town Council, Local Board
7. Operations and Management of Water Treatment Plant	- Ministry of Local Government, Rural and Urban Development (MLGRUD)	- Department of Works (Engineering services Division/ Waste & Sewerage Branch), City of Harare - Engineering Services Department (Water and Sewage Division), Chitungwiza Municipal Council - Town Engineering Department (Water & Sewer Reticulation Division), Norton Town Council - Works / Engineering Department (Sewerage Works Division), Ruwa Local Board
8. Refuse Collection and Disposal	- Ministry of Local Government, Rural and Urban Development (MLGRUD)	- Department of Works (Amenity Division / Waste Management Branch), City of Harare - Engineering Services Department (Roads & Services Division/Refuse & Cleaning Section), Chitungwiza Municipal Council - Town Engineering Department (Refuse Collection / Amenities Division), Norton Town Council - Works / Engineering Department (Health / Amenities Division), Ruwa Local Board

Source : JICA Team

The Institute collaborates with international training institutes to host specific to the needs of the Southern African region. Not only the training for technical, managerial and planning issues form the major part of the training but also training of trainers and the use of participatory approaches are being emphasised.

The Institute also offers research opportunities in the waste management sector within and beyond the borders of Zimbabwe.

(3) Institute of Environmental Studies (IES/UZ)

The Institute functions mainly to facilitate inter-disciplinary collaboration in research and education on environmental issues, and stimulates new initiatives in these fields.

The Institute also provides a forum for the exchange of information and ideas (e.g. organising seminars, funding publications); assists in obtaining funds for research and studentships, disseminates information about environmental issues, provides consultancy services, including policy analysis and advice on environmental issues, and helps maintain a national environmental database.

(4) National University of Science and Technology (NUST)

The National University of Science and Technology offers degrees in applied chemistry and water engineering which are relevant to pollution control.

(5) Harare Polytechnic

The Polytechnic fosters civil engineering technicians and various subjects are applicable to water pollution control. It also brings up technicians in chemistry, biology and microbiology, who can work directly as pollution control technicians.

In liaison with the Water Pollution Control Section of the Department of Water Resources, the Polytechnic is in the process of establishing a water and wastewater management technician course with the help of Canadian funding. These technicians will be employed as water pollution control technicians by the Department of Water

Resources, local authorities and other industries who have environmental sections in their establishments.

(6) International Union for the Conservation of Nature (IUCN)

The Union holds courses, workshops and seminars on environmental issues such as Human and social Perspectives in Natural Resources Management. Their groups are normally middle level managers in the water management and natural resources sectors.

(7) Scientific and Industrial Research and Development Centre (SIRDC)

The Scientific and Industrial Research and Development Centre (SIRDC) has an Environment and Remote Sensing Institute, which is involved in training people in environmental courses. It has sponsored some to masters level, and they are now involved in environmental research.

The Environmental Unit is still new and planning its way forward. It intends to provide structures courses, workshops, in-house training and external courses. In conjunction with the Cleaner Production Centre, the Unit carries out environmental impact audits and process analysis in order to identify processes that have minimum negative environmental impacts. They are also involved in public awareness, organisation of seminars and symposia, giving advice on aspects of controlling air, water and soil pollution and assessing environmental impairment.

(8) Department of Water Resources (DWR)

The Department of Water Resources (DWR) has an on-going training program for its staff. Water Pollution Control Section (WPCS) and National Water Quality Laboratory staff have been trained to masters level in both analytical chemistry and microbiology, with the help of ODA funding as part of the technical co-operation programme to establish the laboratory.

There are two week in-house courses in monitoring, sampling, etc., which are offered to province-based water supplies technicians involved in water pollution control. Further

in-house training is planned for the laboratory staff ranging from lab management to database management.

Some courses will also be established to attract a regional market, and these will be run in conjunction with the Institute of Water and Sanitation.

(9) Harare City Council

Training is offered in-house to sewage treatment plant operators, trade waste inspectors and water scientists. Laboratory staff sponsored to the Harare Polytechnic College for a technicians courses and the operators and inspectors take the water and environmental management operators courses which is in three parts:

- Part 1 and 2 are City of Harare certificates
- Part 3 is a Chartered Institute of Water and Environment Management certificate

The course is also offered to the Department of Water Resources staff and those of other local authorities.

(10) Zimbabwe Institute of Public Administration and Management (ZIPAM)

The Zimbabwe Institute of Public Administration and Management (ZIPAM) was established within the Ministry of Public Service, Labour and Social Welfare (MPSLSW) in 1984 to contribute to the development of the new nation by helping to build a dynamic, performance-oriented public service.

In 1993, ZIPAM became a fully fledged parastatal enterprise and its functions were broadened to cater for private sector requirements. Specially, ZIPAM seeks to enhance management performance through:

- training for top, senior and middle level managers in the civil service, local authorities, parastatal enterprises and the private sector;
- consultancy services in organisational development, management of development, training needs analysis, market research, project appraisals, etc.; and
- Research and publication.

It is reported that since its establishment, over 4,500 managers and dignitaries have had the opportunity to attend its training programmes including the following areas:

- human resources management and development;
- training development and management;
- government policy design and management;
- project design and management;
- financial management and budget reforms;
- local government and urban development; and
- others.

With regard to the manpower development programmes to the staff working in the Sewage Treatment Works of the urban local authorities concerned, they are shown in Table 3.1.2 (1).

According to the interview and questionnaire surveys to the respective officers in charge, the training programmes were organised and provided to their staff only in the City of Harare and Chitungwiza, but it is reported "none" in Norton Town and Ruwa Local Board due to the limited budget.

To the question on the training programmes expected to be provided in the future, several expectations are presented as summarised in Table 3.1.2 (2). The results of the surveys reveal the fact that every authorities recognise the importance of training programmes to improve operational skills of their staff in parallel with the expansion and/or rehabilitation of the plants.

3.1.4 System for Implementing the Water Pollution Control Project

The project financial sources for planning, construction and operation of a sewage treatment system usually come from the Public Sector Investment Programme (PSIP) funds (central government loan fund), own resources of local authorities, open market funds and/or international institutions.

In case of the construction of a new plant or big rehabilitation or expansion works, funds are mostly raised by means of PSIP and/or financial assistance from foreign country or international institution. The procedure flow for implementation of the water pollution control projects is indicated in Figure 3.1.3.

Table 3.1.2 Manpower Development Programmess for the Staff of the Sewage Treatment Works Concerned

(1) Manpower Development Programme in Last Five Years for the Staff of the Sewage Treatment Works in the Study Area

Manpower Development Programs Provided in Last Five (5) Years for Your Staff						
Title of the Training Program (incl. Seminors, Workshops, etc.)	Organizer	Fund Source	Year	Duration (Month & Days)	No. of Participants (Your Institution Only)	Program Themes (Specialities)
(City of Harare)						
1. Management for Water Pollution Control	City of Harare	City of Harare	Every Year	1 Year	6 - 10	Improvement of skills for treatment plant management
(Chitungwiza Municipality)						
2. Water and Wastewater Works Operators Course	IWSD	Chitungwiza Municipality	1996-97	2 Years	10	Improvement of operational skills
3. Management Training and Development Programmes	ZIPAM	"	1996	3 to 10 Days	30	Seminar for Urban Councillors & Project Management and Auditing
(Norton Town)						
4. None	-	-	-	-	-	-
(Ruwa Local Board)						
5. None	-	-	-	-	-	-

(2) Training Programmes Expected to be Provided in the Future

Title of the Training Program (incl. Seminors, Workshops, etc.)	Expected Organizer	Fund Source	Year	Duration (Month & Days)	No. of Participants (Your Institution Only)	Program Themes (Specialities)
(City of Harare)						
1. Technical Skills Upgrading Programme	Zimbabwe Institute of Engineers (ZIE) or IWSD	City of Harare or MLGRUD	1996	-	All technical staff	- Project planning and management - Sanitation engineering - Computer technology - Modern technology on water and sanitation
(Chitungwiza Municipality)						
2. Occupational Health and Safety	Zimbabwe Occupational Health and Safety	Chitungwiza Municipal Council	1997	6 months	Technical Staff	Making the people aware of dangers in the working environment and reduce accidents
3. Operations of Works Plant and Equipment	"	"				
(Norton Town)						
4. Pump Maintenance Course (after rehabilitation)	Norton Town Council	-	1996		11	Upgrading of maintenance technology
5. Sewage Works Operations Course	IWSD	-	1996	3 Years	1	Improvement of operational skills
(Ruwa Loca Board)						
6. Water and Sewage Treatment Works Course	IWSD	Ruwa Loca Board	1996-97	12 months	2	Water quality monitoring at Sewage treatment works

Source : Data derive from the interview and questionnaire surveys conducted in July 1996 to the officers of each urban local authority concerned.

At central government level, the planning and financing the water pollution control projects are administered by the three government agencies: National Economic Planning Commission (NEPC) for planning, Ministry of Finance (MF) for financing and MLGRUD for supervising the local authorities and co-ordinating their development activities.

As shown in Figure 3.1.3, in the event that the local authority has recourse to the funds from international agencies, most of activities for project implementation will necessarily be carried out through inter-agency co-ordination.

To promote a water pollution control project, the local authority should submit its development plan MLGRUD for approval.

3.2 Present Policies and Countermeasures for Water Pollution Control

The Government of Zimbabwe promotes the policy to decentralise the present administration system to local authorities to establish a bottom-up managing system. Decentralisation of the administration system aims to allow greater participation of provincial administration and local governments in the annual planning and budgeting process and link regional development needs to national decision-making processes. However, judging from the analyses described in the previous Section, this policy does not seem to be thoroughly put into practice.

3.2.1 National Development Plans

Since independence in 1980, the Government of Zimbabwe implemented the following national development plans as an instrument for achieving socio-economic development.

(1) Transitional National Development Plan, 1982/83 - 1984/85
(2) First Five-Year National Development Plan, 1986-1990
(3) Second Five-Year National Development Plan (SFYNDP), 1991-1995

The Second Five-Year National Development Plan (SFYNDP) ended up in December 1995 and the Government of Zimbabwe is in the process of formulating a national vision and long-term development strategies, which will be based on the aspirations of the people.

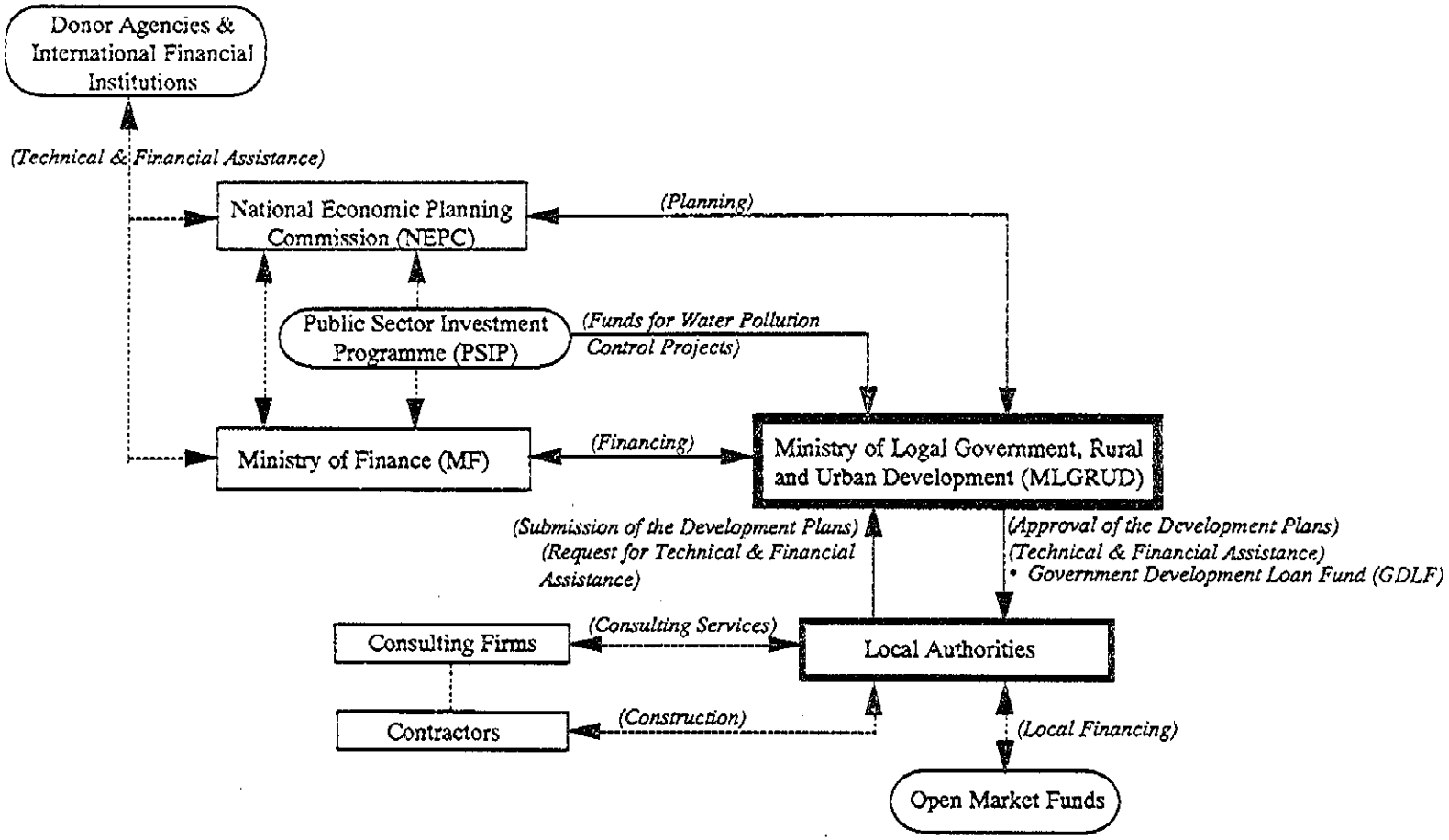


Figure 3.1.3 Procedure Flow for Implementation of the Water Pollution Control Projects

The national long-term or 25-year development plan called "Zimbabwe Vision 2020" is to provide the country with direction in its socio-economic development efforts. Through this, long-term development strategies will be formulated to serve as a guiding framework for short and medium-term policies and plans by government, private sector and the civic groups.

Some of the major components of the National Vision 2020 are reported to be the policies on: 1) "indigenization" of the economy and 2) drought management. Indigenization of the economy is intended to ensure the participation of people in the development process and their benefits.

The "Medium Term Action Plan Framework" is also under preparation based on the perspectives given by the vision and long-term development strategies identified in the vision, while the drought policy is to make the country less vulnerable to the scourges of drought and famine.

Since the previous development plan has not been achieved to the desired extent, the priority areas are to remain in rural development, land reform, economic expansion and employment creation, etc. in the next "Medium Term Action Plan (MTAP) framework" which is scheduled to be brought into effect in December 1996. This MTAP will be implemented together with the "Three-Year Rolling Budget" which is to be introduced from the fiscal year 1997.

Waiting for publication of the accomplishment report on the SFYNDP and implementation of the next Medium Term Action Plan, major components of the SFYNDP are indicated for the time being as follows.

Out of 12 objectives of the SFYNDP described below, the most critical objectives were: 1) improvement in living conditions, 2) reduction of poverty, 3) economic growth with the increase in investment and employment opportunities.

The main objectives of the Second Five-Year National Development Plan (SFYNDP) and its targets were the following:

1) Improvement in living conditions and reduction of poverty,
   - The target is to increase per capita GDP from Z$1,508 in 1990 to Z$1,673 by 1995 (at 1990 prices)

- People's participation in the development process is the foundation for self-reliant and self-sustained development

2) Economic growth
   - at least an average GDP growth rate of 4.6% per annum
3) Increasing and restructuring of investment
   - Z$17,000 million (1990 prices) over the Plan period
4) Expansion and liberalisation of trade
5) Stabilisation of public finances
   - Reduction of the government expenditure from 45.9% of GDP in 1990/91 to 38.5% in 1995/96
6) Reduction of the rate of inflation
   - Decline from the high average annual rate of 25% in 1990/91 to about 9% by 1995/96
7) Creation of employment opportunities
8) Population planning
   - reduction of the population growth rate
9) Regional development
   - Achievement of balanced regional development
10) Rural and urban development
   - Expansion of the economic base and income-generating capacity in rural areas
11) Conservation of environment
12) Development of science and technology

The GDP was planned to grow at an average annual rate of 4.6% during the SFYNDP period compared with 3.2% average annual rate attained during the 1986-90 period (see Table 3.2.1, Section 3.2, Chapter 2, Supporting Report).

Zimbabwe's macro-economic performance and management since its independence can be summarised as follows:

- sluggish output and export growth,
- recovery of investment since the mid-1980s, but little increase in formal sector employment; and
- substantial structural reform since 1991, but continued unsustainable fiscal deficits.

During the 1997 fiscal year, the Public Sector Investment Programme (PSIP) is designated to be the main instrument for implementing the provision of economic and social infrastructure for the growth of the productive sector (refer to Table 3.2.2, Section 3.2, Chapter 2, Supporting Report).

To create a favourable environment for the productive sector, a number of social and economic infrastructural programmes are planned to get high priority during the PSIP period. Of high priority in the 1997 financial year is the provision of adequate social infrastructure including facilities for health and education. This PSIP has a critical role in supporting the social and economic infrastructure development including water pollution control and sewage projects by providing the necessary funds.

The proposed total capital programme for the fiscal year 1997 amounts to Z$4,523 billion, of which Z$2,431 billion will be from external sources in the form of grants and loans. The loans of World Bank called "Urban II" are incorporated in this PSIP. The "Urban II" loan programme which amounts to about US$80 million (for 5 years) covers 21 urban areas in Zimbabwe and is contributing to improvement of basic socio-economic infrastructure including water and sewerage, roads, residential stands, etc.

In the fiscal year 1997, the MLGRUD has been allocated about Z$1billion mainly for the provision of general infrastructure development in urban and communal areas.

Of the above twelve targets, the basic policies for environmental conservation including necessarily water pollution control are clearly formulated in terms of "improvement in living conditions" and "conservation of environment". More specific policies and countermeasures are stipulated in the respective relevant laws and regulations (refer to Section 3.3).

3.2.2 Local Development Plans

The "Regional, Town and Country Planning Act, 1976" provides for the preparation of local development plan by Local (Planning) Authority. The main objective of this Act is to provide for orderly planning of regions, districts and local areas with the objective of conserving and improving the physical environment in order to promote health, safety, order, amenity, convenience and efficiency as well as economy in the development of land and related purposes.

In terms of part III of the Act, local authorities are empowered to:

- prepare development plans;
- amend development plans;
- determine planning applications submitted to the Authority; and
- take enforcement action, where there has been a breach of planning regulations.

Specially in the urban areas, the spatial extent and population have increased tremendously resulting in significant challenges for local authorities to ensure their sustainable development and provide a comprehensive and reliable services throughout the areas. To tackle such issues, every local authority starts to prepare their own urban planning and/or project study reports with a view to improve their basic infrastructure.

The major critical issues pointed out in most of plans and reports concern the water supply, sewerage and solid waste/refuse disposal and their management. The most critical trend in the development over the years is that the urban local authorities failed to provide efficient and reliable services because of inadequate financial resources to make investments in the basic urban infrastructure.

Numerous studies were carried out by the planning & development division of each local authority in order to establish the type and extent of future developments and the likely population growth within the area. These reports provide a framework for the layout and development of the designated planning areas.

The (urban) local authorities in the Study area have respectively the following development plans and/or project & study reports especially on the water pollution control:

City of Harare

1) Harare Combination Master Plan (Report of Study & Written Statement), August 1992;
2) Harare Water Supply Study (Raw Sources Pre-Feasibility Report), September 1993 (Revision July 1994), Department of Water Development, Ministry of Lands, Agriculture and Water Development;

3) Master Plan for Water Distribution, Volume 5: Pre-Feasibility Study on Water Treatment Processes (Report A - Desk Studies), March 1994, Department of Works, City of Harare;
4) Crowborough Sewage Treatment Works, Discussion Document on the Proposed Growth within Crowborough Catchment and the Sizing of Future Extensions to Crowborough Sewage Treatment Works, August 1994, Department of Works, City of Harare;
5) Harare Sewerage Firle V Project, Report on Subsidiary Sewers in the Firle Catchment Area, November 1994, Department of Works, City of Harare;
6) Master Plan for Water Distribution, Appendix A: Development Planning & Population Growth, June 1995, Department of Works, City of Harare;
7) Master Plan for Water distribution, Volume 3: Existing Supply Area, October 1995, Department of Works, City of Harare;
8) Crowborough Sewage Treatment Works, Volume 1 - Catchment Study (Final Report), October 1995, Department of Works, City of Harare.

Chitungwiza Municipality

1) Chitungwiza Town Council 5-Year Financial Performance Programme, 1993/94 to 1997/98;
2) Urban Development Projects
   - Zengeza Sewage Treatment Woks and Sewer Reticulation Development Project (Phase I)
   - Second Urban Development Project (Sewerage Augmentation Scheme: Phase II), February 1996

Norton Town

1) Norton Master Plan (The Study Report and Written Statement), October 1995, Norton Town Council;

2) Report on the Feasibility Study for New Sewage Treatment Works, May 1996, Norton Town Council;

3) Report on the Rehabilitation of Norton Sewage Treatment Works and Sewage Pump Station, May 1996, engineering Department, Norton Town Council.

Ruwa Local Board

1) Ruwa Local Development Plan, March 1996, Ruwa Local Board

Epworth Local Board

1) Socio-Economic Study, Epworth Local Government Area, 1989, (actually Epworth Local Board)

Urban Local Authorities

1) Zimbabwe Urban Solid Waste Management Study (Final Report), August 1995, MLGRUD

Among the development plans enumerated above, the Harare Combination Master Plan is a comprehensive study report which provides a strategic land use policy framework at regional and sub-regional level for the development and control of the physical environment in the Greater Harare. As a finding of the study, the report points out that the potential for development in both Harare and Chitungwiza depends on the availability of public utility infrastructure such as water, sewage, electricity, traffic and transportation systems. The report also indicates the urgent need to introduce the environmental impact assessment for major development projects and to conserve the river courses and water supply sources.

The rapid urban growth in Zimbabwe has imposed huge stresses on the environment in relation to water resources. The stresses exist both in terms of quantity and quality of the resources. Material flux from many urban wastes (liquid, solid, industrial, etc.) are, in particular, so large that they are not easily attenuated in the immediate vicinity leading to the pollution of rivers and aquifers.

In such urban areas densely populated, the impact of pollution is seriously recognized. The existing sewerage systems in the areas are inappropriately operated and maintained, and need

to be expanded or replaced completely, as they became too small for the anticipated workloads.

3.3 Laws and Regulations Relevant to Water Pollution Control and Environmental Management

The effectiveness of measures for control of water pollution depends on the enactment of comprehensive and realistic laws and statutes, coupled with their prudent administration and management and the commitment of adequate financial and other resources.

In Zimbabwe, a new revised edition of the "Statute Law of Zimbabwe" is published in five (5) volumes. This contains the Constitution and all current Acts of Parliament in a revised, amended and updated form, including all Acts passed by Parliament up to March, 1996.

Both the central government and local authorities are required to comply with the requirements of national policies, law and regulations when executing their legal powers and responsibilities.

3.3.1 Water Pollution Control

Control of water pollution is necessary for the protection of the aquatic environment and the maintenance of acceptable quality in lakes, reservoirs, streams, groundwater and so on. The first step to be taken in determining the degree of treatment and other measures required for control purposes is the establishment of environmental water quality standards.

In 1970s under the regime of Rhodesia, Zimbabwe had turned to establishing and/or strengthening its legal structures as a means of more effectively controlling water quality. A principal provision of these statutes was the promulgation of the following water regulations:

1) Water Act , 1976 (amended in 1984 , 1989 and 1993)
2) Water Pollution Control (Waste and Effluent Water Standards) Regulations, 1971;
   - Repealed and replaced by 4) Water Regulations, 1977
3) Public Health (Effluent) Regulations, 1972;
4) Water (Effluent and Wastewater Standards) Regulations, 1977

- Dealing with the standards of effluents that may be discharged into natural water courses.

5) Public Health Act, relating to sanitation, housing and water supplies;

Notes: Regulations currently in effect are underlined.

(1) Water Act

The preamble of the Water Act states that the legislation is "to provide, inter alia, for the planning of the optimum development and utilisation of the water resources of Zimbabwe and for the prevention and control of water pollution". The Act is assigned to the Minister of Energy and Water Resources Development (actually Minister of Lands and Water Resources).

This Act consists of twelve (12) areas covering such administrative matters as the powers of the Minister and the Secretary for Water Development, the establishment of water boards, the water court and its powers and procedures, the making of regulations and offences and penalties and water matters specially. Part IX of the Act is titled "Water Pollution Control" and includes sections 101 through 105; three of these sections deals directly with water pollution control.

According to the Water Act, 1976, "Pollution " is defined to mean:

- such contamination or other alteration of the biological, chemical or physical properties of the public stream or water, including changes in colour, odour, taste, temperature or turgidity; or

  such discharge of any gaseous, liquid, solid or other substance into the public stream or water;
- as will or is likely to create a nuisance or render the public stream or private water, public water or underground water,

  as the case may be, detrimental, harmful or injurious to the health, safety or welfare of the public or any section thereof or to any consumer or user of the water or to any birds, fish or other aquatic life, livestock or wild animals.

(2) Effluent Standards

The effluent disposal is governed by two (2) sets of regulations:

- Discharge to land is controlled by much less strict regulations, viz. the Public Health (Effluent) Regulations (GN 638/72), issued under the Public Health Act, and
- Discharge to rivers is controlled by the Water (Effluent and Wastewater Standards) Regulations (GN 687/77), issued under the Water Act (1976).

The important provisions of the above regulations are summarised as shown below.

The "Public Health (Effluent) Regulations, 1972" stipulates the standards required for the reuse of effluents by irrigation. On the other hand, the "Water Pollution Control (Waste and Effluent Water Standards) Regulations, 1971", subsequently replaced by the "Water (Effluent and Wastewater Standards) Regulations, 1977", dealt with the standards of effluents that may discharged into natural water courses.

Public Health (Effluent) Regulations	
Conventional Works	Pond System Effluent
a) Surface irrigation of non-edible crops, pastures & Plantations	
BOD ≤ 70 mg/l	DO ≥ 1 mg/l at all times
b) Spray irrigation of ditto	
BOD ≤ 30 mg/l	BOD ≤ 30 mg/l
c) Surface or spray irrigation of the above, plus pastures for dairy cattle, and cut flowers	
BOD ≤ 10 mg/l E. Coli. ≤ 10/100 ml	BOD ≤ 1 mg/l at all times E. Coli. ≤ 10/100 ml
d) Public amenities, playing fields, etc.	
Same as c) above, plus chlorination	

Water (Effluent & Wastewater Standards) Regulations	
Parameter	Limit
pH	6 ~ 9
Temperature	≤ 35 deg.C
Dissolved Oxygen	≥ 60% sat.
Chemical Oxygen Demand	≤ 60 mg/l
Total Undissolved Solids	≤ 25 mg/l
Total Dissolved Solids	≤ 500 mg/l
Anmonia	≤ 0.2 mg/l
Chlorine	≤ 100 mg/l
Total N	≤ 10 mg/l
Also limits for heavy metals, oils, pesticides and other toxic	

Note: Original Regulations are attached in 3.3.1 Relevant Regulations, Section 3.3, Chapter 2, Supporting Report..

The standards for discharge to rivers were introduced to control eutrophication of important dams, and require nutrient removal. The current "Water (Effluent and Wastewater Standards) Regulations, 1977" were made in terms of section 135 of the Water Act, 1976. The Regulations are composed of the three major clauses: Interpretation, Prescribed standards of quality for effluent and wastewater and Sampling procedure.

Although these regulations provide a basis for legal control of the discharge of effluent or wastewater, complete prevention of any discharge of effluent or wastewater is practically impossible, and in extreme conditions, even from well designed systems, occasional discharges of raw or partially treated sewage have to be expected.

Water quality standards have generally taken on of two forms - (ambient stream) water standards and (wastewater) effluent standards. The approach to environmental protection, including water pollution control, taken by Zimbabwe, has been to apply the "best practicable means" method used in the United Kingdom, by setting standards according to needs of local environments and economic circumstances. Effluent

standards are considered to be more useful in order to identify the polluter and enforce the regulations.

(3) Trade Effluent Control

The Urban Councils Act (Chapter 214) prescribed the "Trade Effluent Control" and all stipulations is now incorporated in the Urban Councils Act (No.24), 1995, even though their Section numbers are changed. In the Urban Councils Act, 1995, the Section 180 stipulates the "projection of public sewers and public drains".

In terms of Section 180 (1) (c), (d) and (e) of the Urban Councils Act (1995), no person shall, except with the consent of the Council and subject to such conditions it may impose:

1) discharge or put into or permit to enter a public sewer or public drain any solid, liquid or gaseous substance which the council, by notice in writing to the person concerned, has prohibited from being discharged into that sewer or drain on the grounds that it is likely to injure or damage that sewer or drain, interfere with the free flow of sewage or storm-water or cause a nuisance or involve danger to the health of persons entering that sewer or drain or employed at the sewage works or to endanger, destroy or be injurious to the structure of any public sewer, public drain, sewage works or land or to the processes used therein or thereon; or

2) discharge or put into or permit to enter a public sewer any storm-water; or

3) discharge or put into or permit to enter a public drain any sewage.

In terms of 1) above, every Urban Councils have set the following limits on effluents which are discharged into each sewerage system. The Urban Councils may also impose limits on any other substances which are not listed below as it deems necessary for the protection of public sewers or drains.

pH.....6.8 - 9.0

Settlable solids (cm^3 / litre) .....less than 10.0

Fats (mg / l).....less than 400.0

Mineral Oils .....Nil

Organic Oils .....Nil

Individual Heavy Metals (mg / l)....less than 50.0

Calcium Carbide .....Nil

Bitumen.....Nil

Cyanides.....Nil

Temperature (°C) .....less than 60

With respect to 2), storm-water is prohibited from entering their sewerage system from any source within the premises including:

a) unroofed structures including washbays, etc.,
b) broken or low sewer inlet gullies,
c) broken sewer manhole covers, and
d) broken sewer pipes, etc.

With respect to 3), any wastewater that arise from any process or activity carried out in the factory or premises is considered as sewage and must not be allowed to enter the public storm-water drains. All such water should enter the sewerage system.

The contents of the regulations on "trade effluent control" are the same in every urban councils and being applied in controlling trade effluent from industries. As sample, the regulations of trade effluent control in the City of Harare is attached in 3.3.2 Trade effluent control standards, Section 3.3, Chapter 2, Supporting Report.

(4) Effluent Irrigation

The effluent from sewage treatment ponds and conventional and modified conventional works cannot be discharged directly to a water course. However, it is common practice to use the effluent to irrigate land specifically set aside for this purpose. In any cases, final effluent from this land should be to an acceptable standard.

Main problem with irrigation is the acceptable effluent quality which varies from wet season to dry season. A major problem is the eutrophication in effluent storage dams. The "Guidelines for the Disposal of Sewage and Sewage Effluent in Wet Weather", issued by the former Ministry of Water Development (MWD, 1978) take account of this

problem by allowing direct discharge of treated effluent in excess of 1 average dry weather flow (ADWF) to rivers in periods of prolonged wet weather.

The factors to be used to determine the design of effluent irrigation schemes are the following:

- quantity of effluent,
- rainfall amount and pattern,
- soil type and permeability,
- subsoil drainage (if any),
- method of irrigation, and
- crop type.

The crop is often pasture grass or gum trees, both of which can withstand extreme variations in irrigation rate, and a rule of thumb for sizing schemes is:

- to provide 35 ha/1,000m^3/day ADWF.

Source: Sanitation Manual Design Procedures, Technical Manuals and Guidelines for Infrastructure Projects (Manual 5), December 1990.

(5) Construction of Building and Sewerage Work

In terms of Section 183 of the Urban Councils Act (Chapter 214), as read with Section 83A of the Rural Councils Act (Chapter 211), the then Minister of Local Government and Housing made the following by-laws: The "Model Building By-laws", 1977 (amended in 1980 and 1981).

These By-laws include twelve (12) chapters, and Chapter 3 & the subsequent chapters are primarily concerned with providing technical information on the standards to which building and sewerage work shall be undertaken. The provision of these by-laws do not cover all administrative matters associated with building and sewerage work, and each local authority is likely to have further by-laws which it has made or adopted concerning: a) applications for and the supply of water, b) applications for connections to public sewers and the making of such connections; and others.

Chapter 9 is titled "Drainage and Sewerage" and consists of the following 7 parts:

- Part I : General requirements in respect of sewerage and plumbing work
- Part II : Quality and design or sanitary fittings, piping and accessories
- Part III : Construction and fixing of soil-pipes and waste-pipes and fittings
- Part IV : Construction and laying of private and combined private sewers
- Part V : Septic tanks and private disposal plants
- Part VI : Storm-water drainage and use of sewers
- Part VII: Cleaning, inspection and testing

In terms of Part V, Section 78 (1), "no person shall, on any premises, construct or use any septic tank and appurtenant disposal works for the treatment and disposal of sewage without the written consent of the local authority". Section 79 (1) stipulates that "every septic tank shall be sited, designed and constructed to the approval of the local authority, and in accordance with C.A.S. No. CAI, small domestic septic tank installations".

(6) Solid Waste Management

Solid wastes contain various pollutants and contaminants and become sources of water pollution. Solid waste/ refuse removal and its management concern, to a great extent, the water pollution and urban sanitation and environment.

In terms of Section 180 of the Urban Councils Act (Chapter 214) and the Public Health Act, the local authorities are required to enact appropriate by-laws pertaining to issues such as sanitation, refuse collection, its transportation and disposal. For example, the Harare City Council applies the Harare Waste Management By-laws of 1979 as the major legal instrument for its solid waste management.

These By-laws are adopted in most of urban councils for solid waste management and main provisions are almost the same. However, the provisions of these by-laws do not cover the current waste management practices, and the urban local authorities are increasingly failing to provide efficient and reliable refuse removal and its management, because of spatial extent and rapid population growth in the urban areas.

These By-laws consist of the following fourteen (14) Sections:

- Section 1 : Title and date of operation
- Section 2 : Application
- Section 3 : Interpretation of terms
- Section 4 : Regular removal of domestic waste
- Section 5 : Provision of waste-receptacles
- Section 6 : Use of waste-receptacles
- Section 7 : Removal of excess domestic waste and garden waste
- Section 8 : Control of deposit of waste
- Section 9 : Sanitary services
- Section 10 : Disposal of industrial waste
- Section 11 : Waste-disposal sites
- Section 12 : Charges for services
- Section 13 : General
- Section 14 : Repeals

As pointed out in the final report on "Zimbabwe Urban Solid Waste Management Study" in August 1995, there is need for a "National Waste Act" which provides the necessary legal framework for a co-ordinated solid waste management. Ordinances and regulations regarding littering and improper disposal of solid waste and penalties for violation should be formulated and responsibilities of enforcement agencies must be clearly delineated.

Major constraints in the solid waste management of the urban local authorities can be summarised as follows:

1) lack of finance,
2) aged equipment,
3) lack of knowledge to run the disposal sites,
4) insufficient manpower development, and
5) lack of awareness to the public.

(7) Livestock Pollution

With regard to the livestock (farm) pollution, there are no specific regulations. This problem may be regulated in terms of water pollution and/or solid waste, as mentioned above.

According to the interview survey, droppings (dung or excrement) of domestic animals become part of the soil organic matters. Some may enter the stream directly but these are very small quantities.

There are no slaughterhouses (cows & pigs) on the farms. Most of livestock are sent directly to established abattoirs in towns - namely Marondera and Chinhoyi.

As to the settings and enforcement of the standards & regulations mentioned above, they are summarised in Table 3.3.1, Section 3.3, Chapter 2, Supporting Report. Except the largest urban local authority (City of Harare), it is actually difficult for the other medium and small urban authorities to apply/ enforce them properly. This is mostly due to their limited funds and lack of manpower.

3.3.2 Environmental Conservation and Management

The environmental legislation, policies, standards and guidelines in Zimbabwe are too much fragmented. There are seven major pieces of government legislation and some documents relevant to environmental protection and management that the Ministry of Environment and Tourism (MET) has recently prepared for environmental legislation reform.

(1) Legislation

1) Natural Resources Act (amended by several Acts in 1975, 1976, 1979 and 1981)
2) Forest Act
3) Communal Land Forest Produce Act, 1987
4) Parks and Wild Life Act, 1975 (amended at the 1st August 1990)
5) Trapping of Animals Act, 1975
6) Hazardous Substances Act, 1974
7) Atmospheric Pollution Act, 1977

(2) Related Documents

1) A Review on Zimbabwe's Natural Resource and Land Use Legislation, and Some Options for Implementing an Integrated Management Approach to Natural Resources to Achieve Environmentally Sound sustainable Development, December 1990

2) Policy for Wildlife Zimbabwe, January 1992
3) Environmental Impact Assessment Policy, July 1994
4) Report on Zimbabwe's Environmental Legislation, Assessment of Report: Alternative Approach Towards Reform, May 1995
5) Environmental Legislation Reform for Zimbabwe (Staff Report), December 1995
6) Review of the Report: "Towards an Environmental Management Act - Review and Revision of Zimbabwe's Environmental Legislation", January 1996

The impact of pollution has long been recognised. Many Environmental Impact Assessment (EIA) studies have been carried out, some as early as the mid-1970s but most since the mid-1980s. However, the role of laws in controlling environmental quality has only recently been established.

Government is responding to such priority problems as deforestation, soil erosion, loss of biodiversity, and air and water pollution through a number of statutory instruments, policies, programmes and projects.

Though the Second Five-Year Development Plan (1991-1995) specified that EIA be undertaken before projects are implemented, there was no formal Government procedure. In December 1993, according to a clear directive from the Cabinet, the Ministry of Environment and Tourism (MET) commenced to develop the necessary legislation and policy to implement effective environmental management and sustainable development in the country.

Consequently, an "Environmental Impact Assessment Policy (EIA Policy)" was developed in 1994 and being implemented by the Ministry of Environment and Tourism for application to development projects likely to have significant environmental consequences. However, this EIA Policy is being established on a trial basis. Its design and further application is to be reviewed annually until it is superseded by formal legislation requiring EIA.

It is pointed out that one of the major impediments to more effective environmental management for Zimbabwe is the lack of clear and co-ordinated institutional, policy and legislative framework for delivery on a national level. Zimbabwe currently lacks a coherent and comprehensive environmental law framework.

Staff Report on environmental Legislation Reform for Zimbabwe (December 1995) recommends the development of a new piece of legislation under the auspices of the Ministry of Environment and Tourism and enactment of a new "Environmental Management Act". The current Environmental Legislation Reform aims to improve the country's environmental framework to make it more efficient, effective and fair.

On the other hand, the Review Report on Zimbabwe's Environmental Legislation identifies the following as the major problems of the environmental law framework:

- fragmentation;
- lack of integration of social and economic factor into environmental planning;
- discriminative legislation on the basis of land tenure categories;
- inadequate legislation to determine appropriate standards;
- failure to centralise the role of the Ministry of Environment and Tourism; and
- Lack of inter-sectoral co-operation and participatory mechanisms in planning framework.

Zimbabwe's environmental legislation is contained in over 18 different statutes and administered by at least 8 different Ministries.

The above reports also suggest modifications of the following pieces of legislation in conformity with the EIA process in the new Environmental Management Act:

- Mines & Minerals Act, 1961 (for new mines and exploration)
- Water Act, 1976 (amended in 1984 , 1989 and 1993)
- Natural Resources Act, 1981 (for dams)
- Regional, Town and Country Planning Act, 1976 (empowering the local [planning] authority to prepare, amend, approve and implement the development plans)
- Rural District Councils Act , 1988 (for plans)
- Agricultural & Rural Development Act

In addition to the above, there are a number of government legislations that are relevant to environmental protection and management including water pollution control. These are:

1) Natural Resources Act, as amended in November 1981
2) Statutory Instrument 204 of 1990 (providing for the establishment of local boards
2) Land Acquisition Act, 1986 (amended in 1992)
3) Communal Land Act, 1982

4) Rural Land Act (regulating the disposal and subdivision of State land)
5) Public Health Act (relative to sanitation, housing and water supplies)
6) Rural District Council (RDC) Act, 1988
7) Urban Councils Act, 1995 (with reference to the powers of urban councils to control pollution and regulate land use)

A list of different pieces of environmental legislation which is administered by different government agencies is shown in Table 3.3.1.

As for the tariffs (water, sewerage, refuse collection, etc.), they are fixed by the local authorities after the written approval of the Minister of Local Government, Rural and Urban Development (MLGRUD) and levied in terms of Section 220 and 221 of the Urban Councils Act of 1995.

On the other hand, some major local authorities have already formulated the local regulations on the environment against pollution by industrial ad urban activities as principal targets. Harare City, Ruwa Local Board, etc. have their own regulations under the control of each Urban Councils.

3.4 Financial Arrangements for Environmental Management

The term "environmental management" is usually defined as the broad objectives encompassing conservation of natural resources and wildlife. The environmental issues discussed in this section is more specifically narrowed down to the field of sanitation and water pollution control rather than environmental conservation.

The environmental management takes the form of project components (public sewerage systems, and solid waste collection and disposal), and supporting activities (monitoring of water quality, and institutional and training programs) in the field of sanitation and water pollution control. Financial arrangements for project components consist of capital, and

Table 3.3.1 List of the Pieces of Legislation Related to Environmental Management

Legislation	Responsible Organization
1. Natural Resources Act	Department of Natural Resources, Ministry of Environment and Tourism (MET)
2. Forest act	Forestry Commission, MET
3. Parks and Wildlife Act	Department of National Parks and Wildlife Management, MET
4. Bees Act	Ministry of Agriculture MA)
5. Trapping of Animals Control Act	Ministry of Environment and Tourism (MET)
6. Hazardous Substances and Articles Act	Ministry of Health and Child Welfare (MHCW)
7. Atomospheric Pollution Prevention Act	Department of Meteorological Services, Ministry of Transport and Energy
8. Noxious Weeds Act	Ministry of agricdultue (MA)
9. Plant, Pests and Diseases Act	Ministry of Agriculture (MA)
10. Mines and Minerals Act	Ministry of Mines (MM)
11. Regional Town and Country Planning Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
12. Urban Councils Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
13. Rural Councils Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
14. District Councils Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
15. Communal Lands Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
16. National Museums and Monuments Act	Ministry of Home Affairs (MHA)
17. Communal Land Forest Produce Act	Ministry of Local Government, Rural and Urban Development (MLGRUD)
18. Water Act	Department of Water Resources, Ministry of Lands and Water Resources (MLWR)

Source : Resources Development Division, Ministry of Environment and Tourism (MET)

operation and maintenance costs. Projects for water pollution control are principally under the jurisdiction of local governments. The National Government on-lends capital funds to local governments on a loan basis only. Operation and maintenance cost is financed by local governments. Accordingly, financial status of local authority is the key issue for analysis of financial arrangements for capital, and operation and maintenance cost. Water quality monitoring and training programs are financed through the budget of the relevant institutions such as central government agencies and local governments.

In view of the growing population between 5 and 7 percent per annum in urban areas such as Harare and Chitungwiza, an emphasis should be given to the role of urban section to accommodate the increasing demands for urban services in terms of public services and infrastructure. The investment policy in the urban sector is currently geared to housing development, which was clearly spelled out in the Second Five Year National Development Plan. But there was no explicit statement of investment policy to tackle the environmental deterioration caused by the population pressure on the water courses and lands in urban areas.

3.4.1 National Government

The pubic investment in urban sector takes the form of lending from the central government to local authorities. Capitals are credited to local authorities in the form of long-term loans, whose sources are from domestic financial market, multilateral and bilateral aids. Long-term loans correspond to the mark noted by (*) in Table 3.4.1.

Table 3.4.1 Government Expenditures

Unit: Million Z$

	1990/91	1991/92	1992/93	1993/94	1994/95
Current expenditure	6,830	8,732	11,614	12,995	14,783
Goods and Services	4,193	5,048	6,641	7,866	8,959
Interest payments	1,137	1,577	2,309	2,991	3,200
Subsidies	534	961	1,104	360	548
Transfer payments	967	1,146	1,560	1,777	2,077
Capital expenditures	858	1,200	1,423	1,724	1,777
Net lending	657	1,246	621	1,260	
Long-term(*)	543	824	703	1,125	
Investment	58	152	65	104	
Short-term	55	271	(147)	31	

Source: Zimbabwe Achieving Shared growth, World Bank

Of the many line agencies, the Ministry of Local Government, Rural & Urban Development (MLGRUD) and the Ministry of Public Construction & National Housing (MPCNH) are the major lending agencies to the local authorities.

The MLGRUD has been responsible for various projects handled by local governments in the field of finance. Most of national government's loan is lent to local governments as District Development Fund to upgrade rural infrastructure, mainly roads. Historical performance of loan disbursement from the MLGRUD to local governments in urban sector with the break down by source of fund is presented in Table 3.4.2.

Table 3.4.2 Loans Disbursement from MLGRUD in Urban Sector

Unit: Million Z$

Source of funds	1990/91	1991/92	1992/93	1993/94	1994/95
Government fund	13.8	74.1	176.4	138.2	168.7
Foreign					
World Bank (Urban II)		0.5	6.0	53.6	116.8
Other external			21.6	21.9	62.7
Sub-total		0.5	27.6	75.5	179.5
Total	13.8	74.6	204.0	213.7	348.2

Source: Local Authorities Administration, MLGRUD

The World Bank is the major source of foreign capital, recently involved in implementation of the nation-wide Project called Urban II. The other external sources consist of European Investment Bank and African Development Bank, which finances the Harare Water Supply Project and Firle V (augmentation of the existing Firle sewage treatment works) in Harare City. The government fund is also mobilized as a part of capital finance to projects of local government in urban areas. The share of the government capital out of total funds decreased from almost 100% in 1991/92 to 48% in 1994/95, presumably because of high interest rates in domestic financial market.

The World Bank currently commits itself to various urban development projects called "Urban Sector and Regional Development Programme (Urban II Project)". The City of Harare and the Norton Town Council are the target areas to include in Urban II. The project background is as follows:

Borrower	: Central government
Agencies concerned	: MLGRUD, MPCNH
	: Zimbabwe Electricity Supply Authority
	: Local Authorities
	: Building societies
Loan amount	: US$ 580 million
Project components	: Primary infrastructure
	- water augmentation
	- sewer augmentation
	- roads and drainage
	Housing infrastructure
	- site development of low/middle income housing schemes
	- mortgage finance
	Urban services
	- plants
	- equipment
	-vehicles
	Electricity services

The project cost of the Urban II by component is shown in Table 3.4.3:

Table 3.4.3 Summary Financing Plan by Project component

Unit: Million US$

	Total	IBRD/Bilateral Doners Passed on as			Building
Component	Cost	Loans	Grants	Gov't	Societies
Low/Middle Income Housing:					
On-site Infrastructure	108.63	23.61		85.02	
Housing Finance	241.96				241.96
Computer Equipment	7.15	7.15			
Community Facilities	21.36	4.27		17.09	
Electricity Supply	27.80	7.63		20.17	
Primary Infrastructure	94.55	24.13		70.42	
Urban Services & Maintenance	54.81	31.31		23.50	
Regional Development	13.53	2.40		11.13	
Institutional Development	10.21	0.50	3.00	6.71	
Total Financing Required	580.00	101.00	3.00	234.04	241.96

Source: Staff Appraisal Report Urban Sector and Regional Development Project IBRD, May 1989

An IBRD loan of US$80 million, together with other donors would, amount to US$101 million, which would finance 17.5% of the total project costs (US$580 million). Bilateral donors would provide US$3 million as a grant. Government funds would provide US$234 million or 40% of the total project cost. Private funds from the building societies would provide US$242 million or 42% of the total project cost. The total project cost (US$580

million) includes physical contingency (US$24.1 million), price contingency (US$59.72 million), and tax and duties (US$33.1 million).

The project cost (base cost) of the primary infrastructure by component is as follows:

Unit: US$ Million

	Local	Foreign	Total
Road & Storm Water	8.28	3.55	11.83
Water supply	24.85	10.65	35.50
Sewerage	12.89	5.52	18.41
Design & Supervision	3.49	1.68	5.17
Total	49.51	21.40	70.91

A list of the projects included in the primary infrastructure components is a well-balanced project formation consisting mainly of water and sewer augmentation. The advantage of the Urban II is attributed to the formation of multiple project components to be implemented by the respective urban councils. Thus, a plan for water augmentation is counter-balanced by sewer augmentation, taking account of water pollution control. Out of the loan amount (US$ 70.91 million) allocated to primary infrastructure, about 50 will be disbursed to water and 25 percent will be distributed to sewerage development. Accordingly, the sewer component (water pollution control) would account for US$ 18.41 million in Urban II.

The proceeds of the IBRD loans, together with the government loan are lent to local the authorities through the General Development Loan Fund (GDLF) provided by the MLGRUD and the National Housing Fund (NHF) by the MPCNH. Loans to primary infrastructure are released from the GDLF through the MLGRUD. The terms and conditions of the leading of funds to the local authorities are as follows:

1) Repayment period : 25 years
2) Grace period : 3 years
3) Prevailing interest rate : 12.05%

3.4.2 Local Government

(1) Local Authority Finance

The accounting systems of the local authorities are based on a separate system, with expenditures and income of each type charge to a particular account. The aggregate

accounting (one-city) is, in general, the common system in most countries, but each account is expected to be self-financing here. The typical accounts adopted by the local authorities are as follows:

- Rate account
- Water and sewer account
- Health/clinic account
- Education account
- Housing account

Except for the rate account, revenue is financed by tariffs, flat monthly charges and rent levied by the city council and is intended to cover the full cost (operating expenditure and debt service requirement) of each service. The rate account, which might otherwise be called the general administration account, does not have any specific tariffs or rents. The revenue of the rate account receives the proceeds of the general local taxes collected the areas, including fees paid by business companies for operation licenses and fees paid by vehicle owners.

Development funds are mostly owed to external loans consisting of the internal revenue of the central government, foreign currencies lent by both multilateral and bilateral aid, and the domestic financial market. The central government is responsible for both internal revenue and foreign loans as the General Development Loan Fund (GDLF), which is released to the local authorities. The GDLF is earmarked during the budget cycle based on a project-by-project evaluation by the government. Thereafter, the GDLF is released during the fiscal year for those projects that have been approved. The central government exercises a number of fiscal controls over the local authorities through the MLGRUD, including the approval of both budgets and the use of its borrowing powers. In the course of project appraisal, the MLGRUD assesses the capacity of the local authorities to borrow the funds required for a particular project.

The Financial Performance Plan (FPP) is prepared by the local government to show the financial performance of the local authorities. The FPP is designed to provide the details of each account, including the extent that the account is in annual deficit (surplus), the status of the debt service, the requirements for increasing sources of revenue to move from an annual deficit to a surplus for each account. The principal objective of the FPP is to instigate a programme of revenue increase while expenditures are kept at planned levels; it is hoped that

this would result in a revenue balance or surplus within a three to five year period. The minimum obligation on annual basis required for the FPP is that the total revenues to be expected should be sufficient to cover operating expenses and debt service requirements. At any event, the FPP is a valuable tool to assess the borrowing power of the local authorities, enabling the MLGRUD to check if the proposed projects under the PSIP are in line with the targets agreed on by the MLGRUD and the local authorities.

In general, the principle of cost recovery is applied to each account that can be run separately. Under current practice, two financial statements (a statement of revenue and expenditure, and a balance sheet) are prepared for each account. The principal of revenue to recover operating expenditures and debt services (interest and principals) for each account is given below.

Account	Revenue Source
1) Water	Tariff and Connection fees
2) Sewerage	-do-
3) Housing	
On-site development	Plot sales
Housing construction	Mortgage repayment
4) Waste management	Refuse fees
5) Education	School fees
6) Hospital	Medical fees

Cost recovery would be logical in that the users are obliged to pay for all costs for the operation of a respective utility service in return for the benefits received. In this sense, the use of cost recovery would be clearly understood to make the users pay for costs on service-to-service basis. But this approach is sometimes unfair to some users who do not receive their expected benefits in return for the supply of utility services. One example is that a large scale housing development would definitely push up the tariff for water and sewerage, because the augmentation of both utilities ought to be necessary as associated costs of housing development. Under such circumstances, such associated costs would be considered external costs as a result of housing development. The costs would be recovered not on a service-to-service basis (single separate account), but on a multiple accounts basis. The project components of the World Bank-assisted Urban II had the following cost recovery plan:

Project components	Recovery Sources		
	Plot sales	Tariffs	Rates
Site and services	o	o	
Electricity services		o	
Primary infrastructure	o	o	o

The recovery sources for primary infrastructure are well-balanced, consisting of plot sales, tariffs and rates (property tax). The recovery source for electricity service is, on the other hand, confined to the electricity tariff. In this sense, a comprehensive plan of revenue generation including housing development, has to be taken into account in order to the recover project costs related to primary infrastructure.

(2) Harare City

Revenue and expenditure

The latest performance (1991/92-1993/4) of revenue and expenditure is summarised as follows:

Unit: Million Z$

	1991/92	1992/93	1993/94	1994/95
Revenue	326	394	626	715
Expenditure	333	435	630	661
Balance	(7)	(41)	(4)	54
Accumulated deficit	(29)	(70)	(74)	(20)

Harare city has recently suffered from a revenue deficit, which ought to be financed by its own revenues or short-term credits. Due to the large population (more than one million) in the city, it seems to be difficult to control general administration expenses. Accordingly, the rate account became deficit in 1992/93 and in 1993/94 successively. The balance of other account was almost negative. It might be inferred that of increase of tariffs and rents would not have been sufficient to cover the growing operating expenditures. Therefore, strict cost controls to avoid unnecessary expenses are strongly required. The consolidated income statement of Harare City is shown in Table 3.4.1, Section 3.4, Chapter 2, Supporting Report.

Balance Sheet

The balance sheet of Harare City is summarised as follows:

Unit Million Z$

	1991/92	1992/93	1993/94	1994/95
Assets				
Fixed	670	816	976	1,292
Current	237	292	385	511
Total	907	1,108	1,361	1,803
Liabilities and Capital				
Long-term	408	496	624	794
Short-term	253	276	285	406
Capital	246	336	452	603
Total	907	1,108	1,361	1,803

Long-term outstanding liabilities consists of government loans, bonds issued, commercial loans and private annuity funds. The City Council established a Consolidated Loans Fund which was approved by the Ministry of Local Government Rural and Housing in 1977. All loans received are pooled. Advances and interest are repaid to borrowing accounts on a half-yearly basis. Capital outlay shares a substantial portion (about 90%) of fixed assets, which is mostly financed by the Consolidated Loans Funds. The average annual capital investment (capital outlay) was about Z$150 million during 1991/92-1993/94 and jumped into Z$ 322 million in 1994/95.

The repayment of loans (debt service) is supposed to be financed by net revenue (revenue balance) according to cost recovery. Owing to an increase in the accumulated revenue deficit, such recurrent costs have been funded by drawdowns of cash deposits, various contribution funds and money reserved from the sale of property assets.

The consolidated balance sheet is shown in Table 3.4.2, Section 3.4, Chapter 2, Supporting Report.

2) Chitungwiza Municipality

Revenue and Expenditures

A statement of revenue and expenditures is summarised as follows:

Unit million Z$

Fiscal Year	1991/92	1992/93	1993/94	1994/95
Revenue	72	73	99	141
Expenditures	68	86	97	130
Balance	5	(12)	1	11
Accumulated deficit	(35)	(47)	(46)	(35)

Financial performance in terms of revenue balance gradually improved towards the fiscal year of 1994/95. This owned much to a revenue surplus in the rate, and water, sewerage, and refuse accounts. The improvement of the revenue balance resulted in the reduction of the accumulated revenue deficit, though the accumulated deficit was still substantial in 1994/95. The continuos revenue deficit appears to be in the housing, health and welfare accounts. The consolidated income statement is shown in Table 3.4.3, Section 3.4, Chapter 2, Supporting Report..

Balance Sheet

The long-term outstanding liabilities consists of government loans for housing development and capital development fund. Government loans were about 75% of the total loans in 1994/95. The capital development fund consist of unexpended government loans and commercial loans. Capital outlay shares about 77% of total fixed assets.

The balance sheet of Chitungwiza Municipality is summarised as follows:

Unit: MillionZ$

	1992/92	1992/93	1993/94	1994/95
Assets				
Fixed	61	63	61	68
Current	26	21	33	48
Total	87	84	94	136
Liabilities and Capital				
Long-term	51	53	51	71
Short-term	55	60	67	65
Capital	(19)	(29)	(24)	0
Total	87	84	94	136

Assets have been balanced by funds from long-term loans and short-time credits during 1991/92-1994/95. Because of a continuous negative revenue balance, capital has not been positive in the balance sheet. Nevertheless, the capital account substantially recovered due to a reduction of the deficit. The consolidated balance sheet is shown in Table 3.4.4.,

Section 3.4, Chapter 2, Supporting Report.

(3) Norton Town Council

Revenue and Expenditures

The historical performance of revenue and expenditures of Norton Town Council is summarised as follows:

Unit: Million Z$

	1991/92	1992/93	1993/94	1994/95
Revenue	5.1	7.9	7.8	10.5
Expenditure	4.8	7.7	8.1	10.2
Balance	0.3	0.2	(0.3)	0.3
Accumulated deficit	(2.7)	(2.5)	(2.8)	(2.5)

Although the revenue balance on annual basis has shown a minimal surplus, the revenue balance accumulated continued to be negative. Primary infrastructure, comprising water, sewerage and roads is included in the Town Board Account. This account was not financially well-managed, contributing to the revenue deficit. As a whole, the revenue surplus accrued from the housing and beerhall account is counter-balanced by the deficit derived from other accounts. The consolidated income statement is shown in Table 3.4.5., Section 3.4, Chapter 2, Supporting Report.

Balance Sheet

About two-thirds of the current assets consist of revenue surplus, special funds and temporary advances to capital development funds. In other words, those current assets (liquidity fund) could be effectively utilised for the capital formation of fixed assets. The fixed assets consist largely of land and buildings, and plants and equipment to be utilised for daily operations.

From the viewpoint of capital finance, the increase of long-term loans was remarkable, but some loans were advanced to the capital development fund or remained unexpended. Despite the accumulated revenue deficit, the capital account produced a minimal surplus.

Implementation of development projects requiring a substantial amount of loans would squeeze the liquid assets and put a heavy burden on the users owing to an increase in tariffs

or changes; these increase would be more than their affordable capacity-to-pay. The consolidated balance sheet is shown in Table 3.4.6., Section 3.4, Chapter 2, Supporting Report.

(4) Ruwa Local Board

The Ruwa Local Board separated from Harare City in 1990 is still in the development stage. The financial resources of the Local Board are quite small, accounting for only Z$2 million in the revenue account in 1993/94. The revenue and expenditures are summarised as follows:

Unit: Million Z$

	1991/92	1992/93	1993/94
Revenue	0.58	1.22	2.42
Expenditures	0.35	0.47	1.07
Balance	0.23	0.75	1.35
Accumulated surplus	0.30	0.21	0.97

The Local Board seemed to have made efforts to sustain a revenue surplus. The four accounts appear to be in the Auditor's Report. All accounts were financially well-maintained, resulting in a revenue surplus. The increase of revenue was substantial in the water and housing accounts. This was mainly attributed to the dramatic increase of the water tariff and of rents on houses. The consolidated income statement is shown in Table 3.4.7., Section 3.4, Chapter 2, Supporting Report.

Balance Sheet

Most of the fixed assets accounted for by the plant, equipment and tools to be used for daily operations. Revenue assets, constituting a substantial portion of the current assets, are made up of stocks and bank deposits.

Revenue contributions are a the part of the funds used to finance the capital formation of fixed assets. The Board still has enough capacity for borrowing loans since its revenue surplus surpasses its debt services. The debt services repaid between 1992/93 and 1993/94 were merely Z$7 thousands. The consolidated balance sheet is shown in Table 3.4.8., Section 3.4, Chapter 2, Supporting Report.

3.4.3 Sewage and Water Works

(1) Harare City

Revenue and Expenditure

The revenues and expenditures of the water account consist of water sales and connection fees, and those of the sewerage account are sewerage tariff, reticulation fees and the sales of treated sewage to farms. Sewage is currently sold to farms at the price of 7 Zcent per m^3.

Due to the increase of the water and sewerage tariffs, both the water and sewerage revenues substantially increased in 1994/95, resulting in a revenue surplus of Z$96.7 million in the water account and Z$17.2 million in the sewerage account. The revenues and expenditures are summarised as follows:

Unit: Million Z$

	1991/92	1992/93	1993/94	1994/95
Water				
Revenue	58.0	69.2	149.5	240.7
Expenditures	67.9	88.2	126.5	144.0
Balance	(9.9)	(19.2)	23.0	96.7
Sewerage				
Revenue	24.5	29.2	46.2	60.4
Expenditures	24.2	32.0	39.4	43.2
Balance	0.3	(2.8)	6.8	17.2

Morton Jaffray constituted by far the largest share of water expenditures. The share was kept constant at around 52 percent from 1991/92 to 1994/95. Sewerage expenditures consist largely of reticulation, treatment works and farming operations. The expenditures for farming operations are the operation and maintenance cost of canals and equipment utilised to sell the sewage to farms. Reticulation constituted the largest share of the sewerage expenditures, between 33 and 40 percent from 1991/92 to 1994/95.

There were the seven sewage treatment works under operation, out of which one treatment work (southern) was already disposed of in 1993/94. The historical records of the operation and maintenance costs expended by the two sewage treatment works (Crowborough and Firle) are shown as follows:

		1994/95
Firle		
Annual expenditures	(million Z$)	10.6
Annual influent flow	(million m^3)	48.3
Unit cost	(Z/m^3$)	0.22
Crowborough		
Annual expenditures	(million Z$)	7.4
Annual influent flow	(million m^3)	20.2
Unit cost	(Z/m^3$)	0.37

Remarks: Annual influent flow is estimated based on present influent flow (Crowborough 55,311m^3 per day, Firle 132,291m^3 per day).

The unit cost per m3 is estimated to be Z$0.22 at the Firle STW and Z$0.37 at the Crowborough STW. The consolidated income statement of the water and sewerage account is shown in Table 3.4.9., Section 3.4, Chapter 2, Supporting Report.

Investment and Finance

Capital assets of the water are account comprised of thee Morton Jaffray WTW, and the distribution networks of Harare Water Supply. Those of the sewerage account consist of reticulation, several sewerage treatment works and irrigation canals used for farming operations. The capital assets of the both accounts and the total of Harare City are contrasted below:

Unit: Million Z$

	1991/92	1994/95
Capital Assets		
Water	211	391
Sewerage	72	186
Harare total	593	1,200

Capital assets of both the water and sewerage accounts constitute 48 percent of the total assets in 1991/92 in 1994/95.

The sources of the funds used to finance capital assets consist of long-term loans, special funds and capital. Loans constituted the largest share of capital finance. This share was 83 percent for the water account and 80 percent for the sewerage account in 1994/95. The loans outstanding of both accounts and the total of Harare City is contrasted as follows:

Unit: Million Z$

	1991/92	1994/95
Loan outstanding		
Water	162	326
Sewerage	44	149
Harare total	408	794

Loan outstanding of both accounts constituted about 50 percent of Harare total loans outstanding in 1991/92 and 60 percent in 1994/95. The major sources of the loans used to finance the major projects are given below:

Projects	Source of Funds
Harare Water Supply	European Investment Bank
	African Development Bank
Water Distribution/Reservoir	World Bank (Urban II)
-Highfield SPCA Pipeline	
-Hatcliffe trunk Main	
Reservoirs	
Firle V	European Investment Bank
Hatcliffe Sewerage Treatment	World Bank (Urban II)

Based on the balance sheet, both investment and capital finance by source on the flow basis can be calculated, which is summarised as follows:

Unit: MillionZ$

Water

	1991/92 - 1994/95			
	Investment	Disposal	Net investment	Average Annual Investment
Total	185.4	5.5	179.9	61.8

	1991/92 - 1993/94			
	Finance	Repayment/ Transfer	Net finance	Average Annual Repayment Flow
Loan	180.2	16.5	163.7	5.5
Fund	1.0	1.0	0	
Capital	20.9	4.7	16.2	
Total	202.1	22.2	179.9	

Sewerage

	1991/92 - 1994/95			Average Annual Investment
	Investment	Disposal	Net investment	
Total	118.9	5.4	113.5	39.6

	1991/92 - 1994/95			Average Annual Repayment Flow
	Finance	Repayment/ Transfer	Net finance	
Loan	116.5	11.7	104.8	3.9
Fund	0	0.2	(0.2)	
Capital	14.7	5.8	8.9	
Total	131.2	17.7	113.5	

During the period from 1991/92 to 1994/95, the average annual investment flow was calculated to be Z$61.8 million for the water account, and Z$39.6 million for the sewerage account. The average annual loan repayment was Z$5.5 million for the water account and Z$3.9 million for the sewerage account. The amount of loan repayment was calculated to be within the revenue surplus of both accounts in 1994/95. The statement of investment and finance is shown in Table 3.4.10., Section 3.4, Chapter 2, Supporting Report.

(2) Chitungwiza Municipality

Revenue and Expenditures

Water and sewerage are combined into one account. The water and sewerage account produced successive revenue surpluses from 1991/92 to 1994/95. The revenue consists of water and sewerage charges. The revenue and expenditures are summarised as follows:

Unit: Million Z$

	1991/92	1992/93	1993/94	1994/95
Revenue				
Water charges	8.54	9.34	24.00	31.31
Sewerage charges	2.58	2.72	3.77	4.84
Maintenance charges	0.05	0.10	0.07	0.02
Others	-	0.04	0.06	1.82
Sub-total	11.17	12.20	27.90	37.99
Expenditures	7.65	10.52	12.13	28.09
Estimated O&M cost of Zengeza Treatment	1.21	1.72	2.20	2.68
Balance	3.52	1.68	15.77	9.90

The sewerage charge is based on a flat tariff, while the water charge consists of a flat tariff and a per m^3 consumption tariff. Accordingly, the rate of increase in water revenues was much larger than that in sewerage revenue. Water constituted the substantial share (82 percent) of the total revenue in 1994/95. The increase of both the water and sewerage tariffs pushed up the revenue amount in 1993/94 and 1994/95, resulting in a Z$15.8 million surplus in 1993/94 and Z$9.9 million in 1994/95.

The Auditor's Report of Chitungwiza does not include the historical operating expenditures of the Zengeza STW. The Zengeza STW used to be owned by Harare City and was transferred to Chitungwiza in 1991/92. The operating expenses of the Zengeza were recorded in the City Treasure's Report (1990/91) of Harare and were accounted at Z$0.98 million as of 1990/91. The expenses of 1990/91 are inflated in proportion to escalation rate of the consumer price index given below in order to estimate the current operating expenditure of the Zengeza STW for the years 1992-1995.

	1990	1991	1992	1993	1994	1995
CPI	100	123	175	224	273	335

The operating expenses of the Zengeza STW are estimated to be Z$2.68 million in 1994/95. The current influent flow to the Zengeza is estimated to be 36,405 m^3/day. The operating expenses per m^3 are estimated as follows:

Operating expenditures	Annual influent flow	Unit cost per m^3
Z$2.68 million	13.3 million m^3	Z$0.20

The unit cost per m^3 is estimated at Z$0.20, which is almost equal to that of the Firle STW.

Investment and Finance

The capital assets of the water and sewerage account and those of Chitungwiza as a whole are contrasted as follows:

Unit: million Z$

	1992/93	1994/95
Capital assets		
Water and Sewerage	18.89	36.19
Chitungwiza Total	45.04	68.91

The capital assets of the water and sewerage account constituted about 42 percent of the total assets in 1992/93 and 52 percent in 1994/95. The increased share was attributed to water and sewerage augmentation works. The upgrading of the Zengeza STW consists of an irrigation canal and an anaerobic pond in which about Z$7 million was invested.

The sources of the fund to finance capital assets consist of loans, special funds and capital. The loans outstanding constituted the dominant share of the capital finance in the balance sheet. This share was 91 percent in 1992/93 and 1994/95. The loan outstandings for water and sewerage are compared to that of Chitungwiza's total and are summarised below.

Unit: Million Z$

	1992/93	1993/94
Loan outstanding		
Water and Sewerage	17.2	32.8
Chitungwiza Total	53.0	70.9

The loans outstanding for water and sewerage constituted about 32 percent of total loan in 1992/93 and 46 percent in 1993/94. The increased share can be explained by the substantial amount of loans disbursed for the water and sewerage augmentation works.

The investment flow and capital finance by source is calculated based on the balance sheet and is summarised as follows:

Unit: Million Z$

Water/ Sewerage	1992/93 - 1994/95			
			Net investment	Avg. Annual investment
	Investment	Disposal		
Total	17.50	0.19	17.31	8.8
	Finance	Repayment	Net finance	Avg. Annual repayment
Loan	17.93	2.34	15.59	1.2
Fund	1.72	-	1.72	
Capital	-	-		
Total			17.31	

During the period from 1992/93 to 1994/95, the average annual investment was calculated at Z$8.8 million. The average annual repayment was Z$1.2 million. The repayment of Z$1.2 million was within the revenue surplus of Z$18.8 million in 1993/94 and Z$9.9 million in

1994/95. The financial statement of the water and sewerage account is shown in Table 3.4.11., Section 3.4, Chapter 2, Supporting Report.

(3) Norton Town Council

The Auditor's report of Norton Town Council does not report the financial performance of a water and sewerage account separately. All financial data relating to water and sewerage are included in the Town Board Account stated in the Report. Accordingly, data had to be traced back to the bookkeeping kept by the treasury section of the Council. There was no breakdown of water and sewerage charges on the revenue account. The account items are identical on both revenue and expenditure accounts. This style of financial format is also identified in the sewerage account of the City Treasure's Report of Harare.

Revenue and Expenditures

The revenue balance has been minimally surplus during the period from 1991/92 to 1994/95, except for the fiscal year of 1993/94. The revenue and expenditures are summarised as follows:

Unit: Z$

	1991/92	1992/93	1993/94	1994/5
Revenue	660,588	969,171	1,304,100	2,496,998
Expenditure	389,935	744,523	1,326,208	2,104,775
Balance	270,653	224,648	(22,108)	392,223

The operating expenses of the Norton STW were Z$450,670 in 1994/95. The current flow to the Norton STW is estimated at 2,700 m^3 per day. The operating expenses per m^3 are estimated as follows:

Operating expenses	Annual influent flow	Unit cost per m^3
Z$450,670	0.98 million m^3	Z$0.46

Unit cost per m^3 is estimated at Z$0.46, which is higher than those of the Firle and Crowborough STWs.

Investment and Finance

The ongoing sewer upgrading aims to rehabilitate the existing biological filter. The rehabilitation cost is reported at Z$1.4 million, out of which about Z$0.9 million was already

disbursed. Although the scope of work is not clear at the moment, a new STW will be launched under the World Bank assisted Urban II project. Project appraisal and design commenced as of December 1995. The financial statement of water and sewage works of Norton Town Council is shown in Table 3.4.12., Section 3.4, Chapter 2, Supporting Report.

(4) Ruwa Local Board

The Auditor's Report began to report the financial performance of the Board on the basis of separate accounts in the fiscal year of 1992/93. The accounts stated in the Auditor's Report are 1) Rate, 2) Water, 3) Works, and 4) Housing. The sewage works are included in the third account (Works). Financial data relating to the sewage works are taken out in order to combine them with the water works, which is summarised as follows:

Revenue and Expenditures

Unit: Z$

	1992/93	1993/94
Water		
Revenue	83,835	243,259
Expenditures	45,295	143,972
Balance	38,540	99,287
Sewerage		
Revenue	17,248	128,045
Expenditures	1,586	105,565
Balance	15,662	22,480

The Board seemed to maintain a self financing criteria for both its water and sewage works. The increase of revenue was outstanding in 1993/94. In particular , the sewerage revenue increased nearly seven-fold in 1993/94. This is attributed to increase of the tariff and expansion of the reticulation fees. The existing STWs (waste stabilization pond) started construction in 1993. The operating expenses were Z$105,965 in 1993/94. The present flow to the existing ponds is estimated at 2,865m^3 per day. The unit cost per m^3 is estimated as follows:

Operating expenses	Annual inflow	Unit cost per m^3
Z$105,965	1.05 million m^3	Z$0.10

The unit cost per m^3 is estimated at Z$0.10. The estimated operating expenses per m^3 are lower than those of the Firle or Crowborough STWs, since the Ruwa STW is not equipped with TF or BNR.

Investment and Finance

The fixed assets of the Ruwa Local Board consist of machines and tools for water work, and waste stabilization ponds for sewage treatment as of 1993/94. Investment from 1992/93 to 1993/94 amounted to Z$206,469 consisting of water works (Z$52,546) and sewage treatment works (Z$153,923). The source of finance for investment comes from the Ruwa Board's own capital. The financial statement of water and sewage works conducted by the Ruwa Local Board is shown in Table 3.4.13., Section 3.4, Chapter 2, Supporting Report.

3.4.4 Tariff System and Structure

In Zimbabwe, taxes and levies are collected by the central government and the local authorities. The local authorities are also allowed to collect such taxes, levies, fees and user charges for those services they should provide in terms of any appropriate law and regulation.

Charges including water, sewerage, refuse collection, etc. are fixed by the local authorities after the written approval of the Minister of Local government, Rural and Urban Development (MLGRUD).

In view of the recent high inflation rates (currently pegged at around 25%), most of the local authorities decide to review annually their tariff structure (consisting of charges for water, sewerage, refuse collection and others). In case of the City of Harare, the sewerage charges are scheduled to be increased from October 1996, while the water charges are scheduled to go up from February 1997. In the other three urban local authorities (Chitungwiza, Norton and Ruwa), revised charges are applied in July (at the beginning of fiscal year). The general data on charges collection system of the Urban Councils in the Study area are summarized in Table 3.4.14, Section 3.4, Chapter 2, Supporting Report.

As an example, the water and sewerage tariff structure in the City of Harare is shown below:

Water Tariff

1) Single family dwelling under which are served by a separate meter
2) Commercial and industrial
3) Flat

Sewerage Tariff

1) Capable but not connected to sewer
2) Residential
3) Commercial
4) Public institution (exempted rate)

Note : The tariff structure in the small local authority area, which is more simple than that in the City of Harare.

In most of cases, the water and sewerage charges are collected monthly at the same time from the beneficiary-users. Table 3.4.4 shows the water and sewerage tariffs in the urban councils in the Study Area.

3.5 Water Pollution Status in the Study Area

The Upper Manyame River Basin covers the national capital Harare, which has a population of 1.5 million. Due to the recent excessive population growth and economic development, water pollution caused by domestic and industrial wastewater, as well as solid waste dumping, has become remarkable in the area's water sources (i. e. lakes, rivers and dams). In the area's lakes and dams, eutrophication triggered by high concentrations of nitrogen and phosphorus has been observed.

At Lake Chivero, excessive water hyacinth growth was reported as well as the blooms of algae in Harava Dam and Seke Dam. Further, in addition to the water quality problem, Lake Chivero has suffered from a chronic water shortage as demonstrated by the minimal overflow from it's spill way since 1990.

The on-going water quality monitoring systems, the water pollution status of the public water bodies and the effluent water quality at the major pollution sources are presented in this section. The available data were obtained from the relevant authorities (mainly from the City of Harare) and the field investigation conducted through this Study.

Table 3.4.4 Water and Sewerage Tariffs in the Urban Councils Related to the Master Plan Study

(Unit : 2$ = Zimbabwean Dollar)

Water Tariff	Rate per month per cubic metre	Monthly Charge	Sewerage Tariff	Monthly Charge
City of Harare		*(Fixed)*		*(Fixed)*
1) Single Family Dwelling under which are served by a separate meter	1st 13 m3 at 95.0c per m3	$10.00	1) Capable - capable but not connected to sewer	$13.00
	14 m3 - 39 m3 at 150.0c per m3		2) Residential	$16.00 per fixture each toilet
	40m3 - 69 m3 at 255.0c per m3		3) Commercial	$48.00 per fixture
	70m3 - 3000m3 at 375.0c per m3		4) Industrial (Effluent Charges) - Basic	$1.5 per m3
	In excess of 300m3 450.0c per m3		- for each effluent exceeding 80 milligrammes	$4.00 per litre
2) Commercial and Industrial	1st 300m3 at 375.0c per m3	$200.00	5) Public Institutions (Exempted rate)	$14.00 per fixture
	In excess of 300m3 at 450.0c per m3			
3) Flats	180.0c	$10.00		
Chitungwiza Municipality				
1) Residential	1st 9 m3 or lesser	$11.37	1) Residential (per household/ month)	$23.70
	Thereafter, per per m3	$1.71	2) Commercial (per month)	$70.55 (per water closet)
2) No-Residential	per m3	$5.82	3) Industrial (per month)	$117.60 (per water closet)
3) Government Institutions	per m3	$5.82		
Norton Town		*(Fixed)*		*(Fixed)*
1) Water Charges for Medium & Hight Density Area Only *)	$3.00 per 1-10 m3 $3.50 per 11-50 m3 $4.50 per 51-100 m3 $5.00 above 100 m3	$5.00	1) Residential (Low Density Area)	$37.50
			2) Single Quarters	$37.50
2) Water Connection		$900.00	3) Commercial / Service Industrial (High Density Area)	$22.00
*) Water Charges for Low Density Area are collected by MLWR			4) Schools (per point)	$32.00
			5) Hopital (per point)	$26.25
Ruwa Local board				
1) Residential	1 - 5 m3	$23.00	1) High Density	$17.00 per month
	6 - 20 m3	$3.56		
	21 - 40 m3	$3.73		
	Above 41 m3	$4.10	2) Low Density	$200.45 per annum
2) Commercial	1 - 10 m3	$53.00		
	11 - 40 m3	$3.73	3) Commercial	$1.20 per m3 based on metred water consumption
	41 - 60 m3	$4.10		
	Above 61 m3	$4.51		
3) Industrial	1 - 10 m3	$120.00	4) Industrial	$1.20 per m3 based on metred water consumption
	11 - 40 m3	$3.73		
	41 - 60 m3	$4.10		
	Above 61 m3	$4.51		

Note : Tariffs as of July 1995
Sources : Local Authorities Concerned

3.5.1 Concerned Agencies Undertaking Water Quality Examination and Monitoring

The pertinent authorities for water quality examination and monitoring are the Ministry of Land and Water Resources (MLWR) at the central government level and the City of Harare at the local government level.

The examination/monitoring of public water bodies is conducted by the Water Pollution Control Section (WPCS), Department of Water Resources (DWR) of the MLWR through the collection of data from 12 self-recording water level surveillance stations, 20 river water sampling points and 15 groundwater sampling wells within the Study area. However, the water quality monitoring of the lakes/dams are not carried out by WPCS at present. The water sampling is performed once every month and water quality examinations are carried out by the Government Analyst Laboratory of the Ministry of Health and Child Welfare (MHCW). The capacity and efficiency of the Government Analyst Laboratory is the current limiting factor in the development of the program. This has resulted in the need for the DWR to have its own laboratory, and it is in the process of acquiring one at the moment. However, about 19 indices regarding the water quality are examined, the representative indices (BOD, SS, T-N and T-P etc.) that measure water pollution are not examined.

Regarding the method of water sampling, the summary of the guidelines now distributed to all relevant field staff in Zimbabwe is shown in Table 3.5.1, Section 3.5, Data Report.

Since the City of Harare is stipulated by the Water Act to be responsible for the pollution control/regulation of the public water bodies under its jurisdiction, the city has been conducting water quality examinations at 48 river water sampling points and also in Seke Dam, Lake Chivero and Lake Manyame. Many sampling points in the rivers are the same points with the MLWR. The river flow rate is not measured. Still, about 14 indices regarding the water quality of public water bodies are examined, but the representative indices (BOD, COD, SS, T-N and T-P etc.) that measure water pollution are not examined in the same as the MLWR.

Further, the inflow and effluent water quality examinations of the STWs in terms of major pollutants within Harare, and the canal water quality examination of farm irrigation systems reusing the effluents from the STWs are carried out. Industrial wastewater quality examination is also conducted based on the standards for wastewater discharged into the sewerage system, as stipulated in the Urban Council Act. The relevant detailed information

on water quality monitoring in Harare are shown in Table 3.5.1, Section 3.5, Chapter 2, Supporting Report.

The summary of the water quality monitoring by the MLWR and the City of Harare are shown in Table 3.5.1 and the location of the self-recording water level surveillance stations of the MLWR and water sampling points of both agencies are shown in Figure 3.5.1.

The major problems of the present water quality monitoring system in the study area are enumerated as follows:

(1) The concerned agencies are conducting water quality monitoring programs individually. There is no comprehensive management of the water quality monitoring programs by the MLWR.

(2) Although water quality is periodically monitored by the concerned agencies, their frequency/interval, sampling points and water quality indices of monitoring are not consistent amongst the concerned agencies.

(3) No adequate legislation exists to control non-point-source pollution from agricultural and urban runoff.

(4) There is a large quantity of data from the water quality monitoring program which has not been analyzed and there is no database system for the monitoring program.

(5) The Acts controlling water pollution have been in operation for a long time and are now out dated.

3.5.2 Water Pollution Status in the Study Water Body

Based on the investigation results and data gathered from the agencies concerned, the present water pollution status in the public water bodies: the Manyame River and its tributaries and the lakes/dams was analyzed. All data on water quality of the rivers/lakes gathered from the concerned agencies are included in Table 3.5.2 to 3.5.21 and Figure 3.5.1, Section 3.5, Data Report, while the results of water quality examination done through this Study is shown in Table 3.5.45 to 3.5.48, Section 3.5, Chapter 2, Data Report. The water quality examination of

Table 3.5.1 Water Quality Monitoring by Concerned Agencies

Agencies	MLWR	City of Harare
Department	Water Pollution Control Section (WPCS), Department of Water Resources (DWR)	Engineering Services Division, Department of Works
Objective	1) Monitoring of water pollution in the rivers 2) Policy making for pollution control 3) Assess in the efficiency of water pollution control methods 4) Development of the natural water data base	1) Monitoring of water pollution in the public water bodies (rivers, lakes/dams) 2) Monitoring of effluent discharged from the STWs 3) Monitoring of effluent discharged from factories 4) Monitoring of groundwater in irrigation area re-using the effluent from the STWs
Number of Surveillance Stations and Sampling Points	1) 12 self-recording water level surveillance stations 2) 20 river water sampling points 3) 15 boreholes operated by WPCS	1) 48 river water sampling points 2) 3 lake/dam water sampling points 3) 5 STWs 4) Factories
Frequency/Interval	1 time a month	Depending on sampling points
Water Quality Indices	pH, Oxygen Absorbed, COD_{Cr}, EC, Total Alkalinity, Cl^-, SO_4^{2-}, Mg^{2+}, Ca^{2+}, NH_4-N, NO_3-N, PO_4-P, Fe, Mn, Pb, Cr, K, Na	pH, Hardness, DO, Oxygen Absorbed, EC, Total Alkalinity, Cl^-, Ca^{2+}, NH_4-N, NO_3-N, PO_4-P, Fe, Mn, Albuminoid

Notes: MLWR: Ministry of Land and Water Resources

public water bodies and major pollution sources conducted through this study are shown at length in 3.5.1, Section 3.5, Chapter 2, Supporting Report.

At present, because of the absence of appropriate environmental water quality standards in Zimbabwe, the present water quality of the water bodies was evaluated referring to the general requirements to meet different purposes of water use.

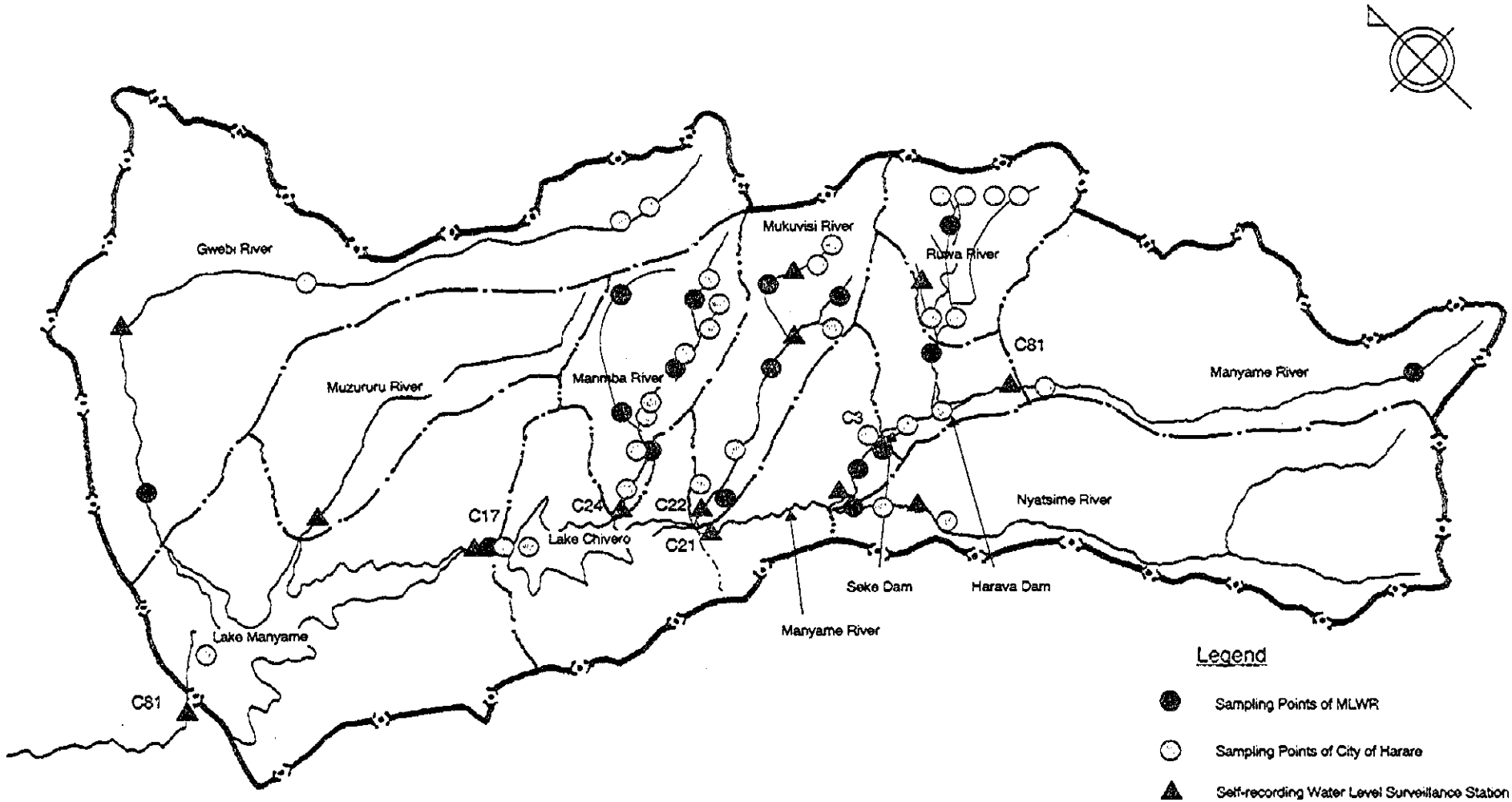


Figure 3.5.1 The Locations of Self-recording Water Level Surveillance Station and Water Sampling Points in the Upper Manyame River Basin

(1) Rivers

1) Manyame River

The yearly fluctuation of ammonia nitrogen (NH_4-N) which shows the effluent discharge from the STW at the Skyline Bridge, upstream of the Lake Chivero, is shown in Figure 3.5.2. This figure shows that such concentrations have been rapidly dropped since 1995. This recovery of the water quality of the Manyame River may be a result of the arrangement at the Zengeza STW to send treated effluent to the farm land starting from August 1995.

In connection with the analysis of the present water quality in the study water body, the data of September 1995 - May 1996 were fully utilized, due to the change in the water pollution resulting from the decision to cease the effluent discharge into the Nyatsime River from the Zengeza STW.

The present water quality at the major sampling points in the Manyame River currently observed by the authorities is shown in Table 3.5.2. and the locations of these water sampling points are shown in Figure 3.5.3.

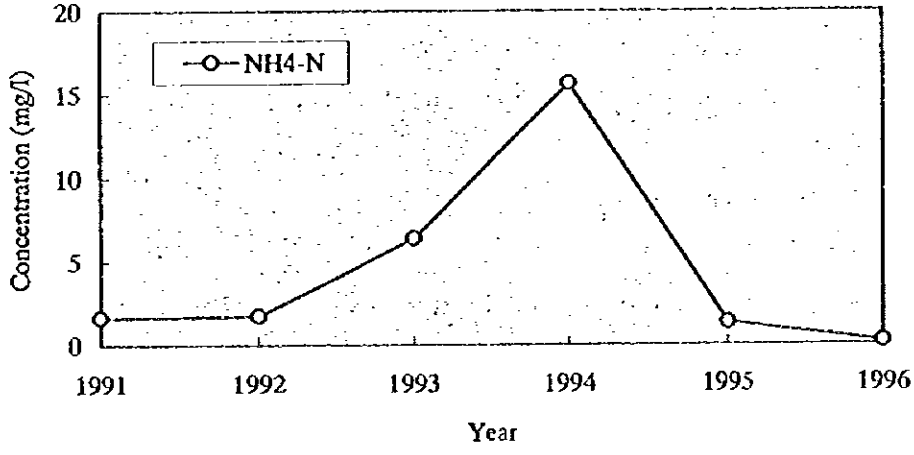


Figure 3.5.2 Water Quality of Manyame River (Skyline Bridge)

The concentrations of biochemical oxygen demand (BOD), suspended solid (SS) and dissolved oxygen (DO) at the major sampling points in the Manyame River are observed with ranges; BOD: 0.6-1.1 mg/l, SS: 7.8-31.2 mg/l and DO: 3.13-6.59 mg/l. In the comparison with the allowable level for drinking water at rivers (BOD: less

than 3 mg/l, SS: less than 25 mg/l, DO: more than 5 mg/1), these items are almost within the allowable range at all sampling points. Moreover the concentrations of total nitrogen (T-N) and total phosphorus (T-P) are observed with ranges of T-N: 0.50-0.80 mg/1, T-P: 0.052-0.080 mg/l.

As to heavy metals, zinc (Zn), nickel (Ni), iron (Fe) and cadmium (Cd) were detected, of which Ni, Fe and Cd slightly exceeded the allowable limit of the health requirements of the WHO guideline for drinking water (Zn: less than 3 mg/l, Ni: less than 0.02 mg/l, Fe: less than 0.3 mg/l, Cd: less than 0.003 mg/1). This means that heavy metals do not adversely effect Lake Chivero; however, Cd which has a significant impact on the human health, must be observed periodically. Although the effluent of the STWs is considered as a major pollution source, a high concentration of heavy metals was not detected through this Study. However, high concentrations of Fe, Ni and Zn were detected in industrial wastewater through this Study. This means that there is the possibility of a lingering influence from the past effluent discharge from the STWs. On the other hand, the cause of the detected Cd were not clarified by this Study.

Concerning agricultural chemicals, atrazine, captan and chlorpyrifos were examined as the representative agricultural chemicals in the study area. But these chemicals were not detected through this Study, which was carried out in the dry season. Agricultural chemicals must be checked periodically through the year.

2) Tributaries

The water quality of the respective tributaries before their confluence with the Manyame River is shown in Table 3.5.3. The concentrations of BOD, SS and DO of each river are observed with ranges; BOD: 1.6-3.8 mg/l, SS: 10.3-12.4 mg/l and DO: 5.0-6.70 mg/l. Through the comparison with the allowable level for fishery in rivers (BOD: less than 5 mg/l, SS: less than 50 mg/l, DO: more than 5 mg/1), it is observed that these items are within the allowable levels except for the Marimba River. Regarding the water quality of the Marimba River, as the past water quality data are the same level as the Mukuvisi River, the results seen this study are deemed temporary.

Table 3.5.2 Present Water Quality at Major Points on the Manyame River

Source	Sampling Point		Season	Item	BOD	COD	SS	DO	pH	Cl^-	EC	Hardness	T-N	NH_4-N	NO_2-N	NO_3-N	T-P	PO_4-P	Oil
	No.	Location			mg/l	mg/l	mg/l	mg/l	-	mg/l	uS/cm	-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	R1	Upstream	Rain	Ave.	-	-	-	4.48	7.17	14.4	130	50.0	-	0.140	-	0.007	-	0.090	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	4.48	7.17	14.4	130	50.0	-	0.140	-	0.007	-	0.090	-
	R2	Newroad Bridge	Rain	Ave.	-	-	-	7.53	6.71	30.0	300	70.0	-	0.250	-	0.021	-	0.350	-
			Dry	Ave.	-	-	-	6.00	7.09	11.0	150	80.0	-	-	-	-	-	0.180	-
			Total	Ave.	-	-	-	7.02	6.84	23.7	250	73.3	-	0.250	-	0.021	-	0.300	-
	R4	Skyline Bridge	Rain	Ave.	-	-	-	1.75	8.07	19.0	200	50.0	-	0.200	0.015	0.021	-	0.340	-
			Dry	Ave.	-	-	-	4.50	7.10	9.0	140	65.0	-	-	0.009	0.003	-	0.180	-
			Total	Ave.	-	-	-	3.13	7.59	14.0	170	57.5	-	0.200	0.012	0.012	-	0.260	-
	R8	Downstream of Lake Chivero	Rain	Ave.	-	-	-	3.85	7.49	87.0	840	156.0	-	-	-	0.005	-	-	-
			Dry	Ave.	-	-	-	5.55	6.73	51.0	390	120.0	-	0.120	-	-	-	0.100	-
			Total	Ave.	-	-	-	4.70	7.11	69.0	615	138.0	-	0.120	-	0.005	-	0.100	-
JICA Study	R1	Upstream	Dry	-	1.1	28.4	31.2	7.00	6.65	7.0	60	40.0	0.80	0.130	STR	0.014	0.052	0.004	20
	R2	Newroad Bridge	Dry	-	0.6	11.4	7.8	5.30	6.67	10.0	115	40.0	0.75	0.150	0.003	0.025	0.060	0.030	17
	R4	Skyline Bridge	Dry	-	1.0	11.4	20.0	4.50	6.66	12.0	130	50.0	0.50	0.200	0.011	0.004	0.080	0.030	23
Total	R1	Upstream	Rain	Ave.	-	-	-	4.48	7.17	14.4	130	50.0	-	0.140	-	0.007	-	0.090	-
			Dry	Ave.	1.1	28.4	31.2	7.00	6.65	7.0	60	40.0	0.80	0.130	STR	0.014	0.052	0.004	20
			Total	Ave.	1.1	28.4	31.2	5.74	6.91	10.7	95	45.0	0.80	0.135	-	0.011	0.052	0.047	20
	R2	Newroad Bridge	Rain	Ave.	-	-	-	7.53	6.71	30.0	300	70.0	-	0.250	-	0.021	-	0.350	-
			Dry	Ave.	0.6	11.4	7.8	5.65	6.88	10.5	133	60.0	0.75	0.150	0.003	0.025	0.060	0.105	17
			Total	Ave.	0.6	11.4	7.8	6.59	6.80	20.3	216	65.0	0.75	0.200	0.003	0.023	0.060	0.228	17
	R4	Skyline Bridge	Rain	Ave.	-	-	-	1.75	8.07	19.0	200	50.0	-	0.200	0.015	0.021	-	0.340	-
			Dry	Ave.	1.0	11.4	20.0	4.50	6.88	10.5	135	57.5	0.50	0.200	0.010	0.004	0.080	0.105	23
			Total	Ave.	1.0	11.4	20.0	3.13	7.48	14.8	168	53.8	0.50	0.200	0.013	0.012	0.080	0.223	23
	R8	Downstream of Lake Chivero	Rain	Ave.	-	-	-	3.85	7.49	87.0	840	156.0	-	-	-	0.005	-	-	-
			Dry	Ave.	-	-	-	5.55	6.73	51.0	390	120.0	-	0.120	-	-	-	0.100	-
			Total	Ave.	-	-	-	4.70	7.11	69.0	615	138.0	-	0.120	-	0.005	-	0.100	-

Table 3.5.2 Present Water Quality at Major Points on the Manyame River (cont'd)

Source	Sampling Point		Season	Item	Heavy Metals										Pesticide		
	No.	Location			Al	Cu	Hg	Zn	Pb	Ni	Fe	As	Cr^{+6}	Cd	Atrazine	Captan	Chlorpyrifos
					mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	R1	Upstream	Rain	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
	R2	Newroad Bridge	Rain	Ave.	-	-	-	-	-	-	0.90	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	0.90	-	-	-	-	-	-
	R4	Skyline Bridge	Rain	Ave.	-	-	-	-	-	-	0.04	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	0.04	-	-	-	-	-	-
	R8	Downstream of Lake Chivero	Rain	Ave.	-	-	-	-	-	-	0.72	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	0.12	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	0.42	-	-	-	-	-	-
JICA Study	R1	Upstream	Dry	-	NIL	NIL	ND	0.19	NIL	0.07	0.16	NIL	NIL	0.02	NIL	NIL	NIL
	R2	Newroad Bridge	Dry	-	NIL	NIL	ND	0.02	NIL	0.03	NIL	NIL	NIL	0.04	NIL	NIL	NIL
	R4	Skyline Bridge	Dry	-	NIL	NIL	ND	0.02	NIL	NIL	0.21	NIL	NIL	0.04	NIL	NIL	NIL
Total	R1	Upstream	Rain	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.19	NIL	0.07	0.16	NIL	NIL	0.02	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.19	NIL	0.07	0.16	NIL	NIL	0.02	NIL	NIL	NIL
	R2	Newroad Bridge	Rain	Ave.	-	-	-	-	-	-	0.90	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.02	NIL	0.03	NIL	NIL	NIL	0.04	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.02	NIL	0.03	0.90	NIL	NIL	0.04	NIL	NIL	NIL
	R4	Skyline Bridge	Rain	Ave.	-	-	-	-	-	-	0.04	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.02	NIL	NIL	0.21	NIL	NIL	0.04	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.02	NIL	NIL	0.13	NIL	NIL	0.04	NIL	NIL	NIL
	R8	Downstream of Lake Chivero	Rain	Ave.	-	-	-	-	-	-	0.72	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	0.12	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	0.42	-	-	-	-	-	-

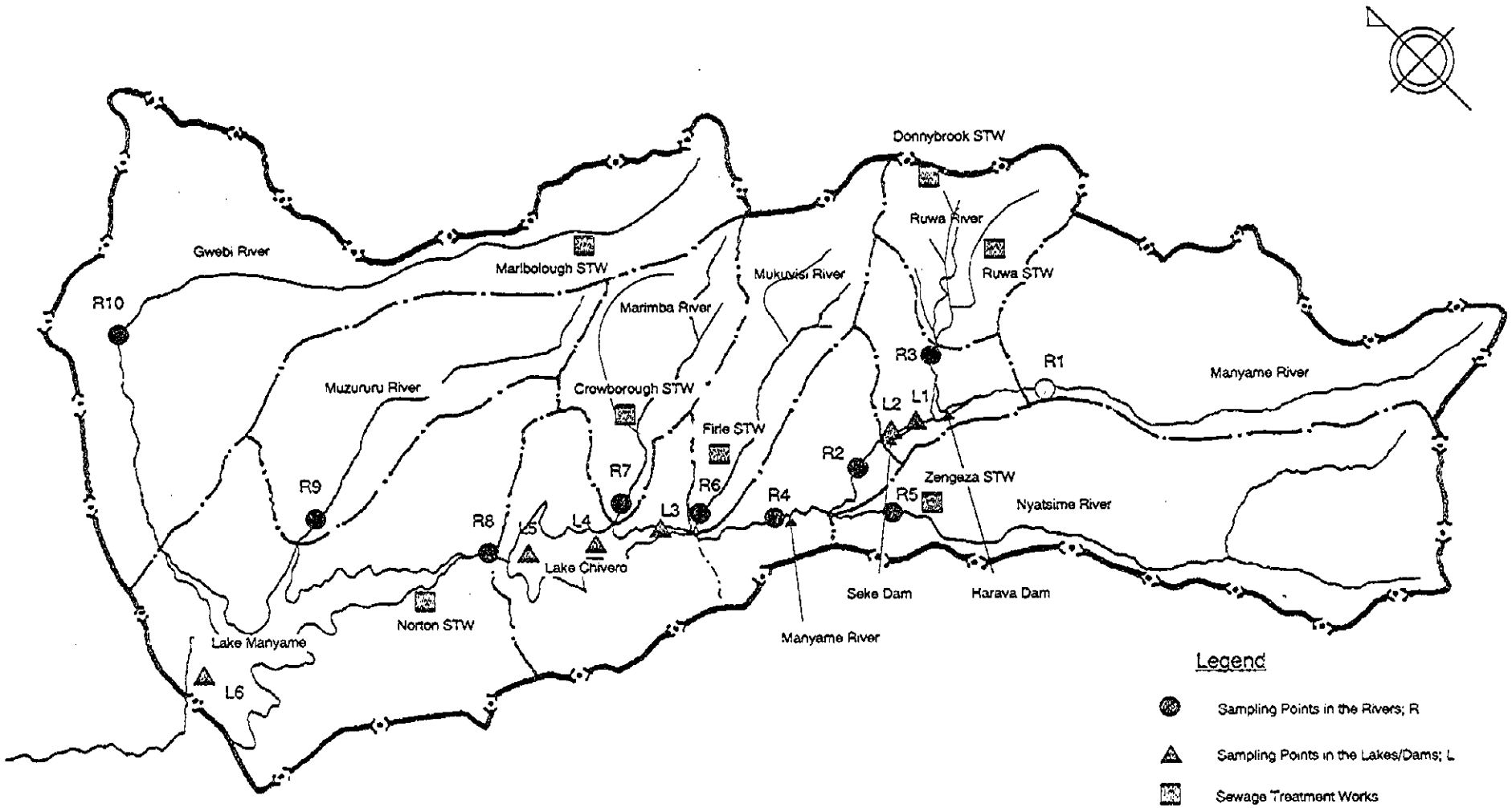


Figure 3.5.3 The Locations of Sampling Points in the Water Bodies

The concentrations of T-N and T-P are observed with ranges of T-N: 0.50-0.80 mg/l, T-P: 0.052-0.274 mg/l. The concentration of T-P in the Ruwa and Nyatsime River are higher than the other rivers.

Among the four major tributaries, namely the Ruwa, Nyatsime, Mukuvisi and Marimba River, there are STWs (the Donnybrook, Ruwa, Zengeza, Firle and Crowborough STWs) in their respective river basins.

Figures 3.5.4 to 3.5.6 show the NH_4-N concentration upstream and downstream of the existing STWs in the Nyatsime River, the Mukuvisi River and the Marimba River. Figure 3.5.4 shows the influence by the effluent of the Zengeza STW under over loaded conditions in 1991. To cope with this situation, in August 1995, the whole effluent was diverted to the Imbgwa Farm for irrigation rather than being discharge into the Nyatsime River. This countermeasure contributed to the rapid recovery of the river's water quality.

Likewise, the effluent discharged from the Firle STW seems to have affected the water quality of the Mukuvisi River as shown in Figure 3.5.5. On the other hand, the Crowborough STW is notable in that it appears to have no impact on the water quality of the river. However, the discharged phosphorus may be a one of the causes of water pollution in Lake Chivero.

As to heavy metals, and agricultural chemicals (atrazine, captan and chlorpyrifos), though the discussed conditions on the main river are common to its tributaries, Cd was detected in the Nyatsime and Ruwa River shall be monitored in the future. Agricultural chemicals also need to be observed in the future.

Regarding the Muzururu and Gwebi River, the evaluation of the water quality was carried out based on the results through this Study, since there was no existing data available. The impact of the treated effluent discharged from the Marlbolough STW to Lake Manyame seems to be minor in terms of BOD, T-N and T-P, due to the longer water courses and comparatively small pollution loads discharged in the sub-basins.

Table 3.5.3 Present Water Quality on Tributaries

Source	Sampling Point		Season	Item	BOD	COD	SS	DO	pH	Cl⁻	EC	Hardness	T-N	NH_4-N	NO_2-N	NO_3-N	T-P	PO_4-P	Oil
	No.	Location			mg/l	mg/l	mg/l	mg/l	-	mg/l	uS/cm	-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	R3	Ruwa River	Rainy	Ave.	-	-	-	6.18	7.39	79.4	545	85.0	-	4.325	0.552	0.047	-	1.630	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	6.18	7.39	79.4	545	85.0	-	4.325	0.552	0.047	-	1.630	-
	R5	Nyatsime River	Rainy	Ave.	-	-	-	-	6.97	90.0	930	145.0	-	32.350	0.390	0.069	-	5.100	-
			Dry	Ave.	-	-	-	-	7.43	55.0	610	90.0	-	30.000	0.052	0.003	-	3.200	-
			Total	Ave.	-	-	-	-	7.12	78.3	823	126.7	-	31.570	0.277	0.047	-	4.470	-
	R6	Mukuvisi River	Rainy	Ave.	-	-	-	3.80	7.48	149.0	1,250	430.0	-	6.400	0.250	0.015	-	1.650	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	3.80	7.48	149.0	1,250	430.0	-	6.400	0.250	0.015	-	1.650	-
	R7	Marimba River	Rainy	Ave.	-	-	-	5.75	7.61	161.0	1,253	215.0	-	0.290	0.030	0.015	-	0.820	-
			Dry	Ave.	-	-	-	6.50	7.31	89.0	470	210.0	-	0.910	0.090	0.010	-	1.160	-
			Total	Ave.	-	-	-	6.00	7.51	137.0	992	213.3	-	0.600	0.050	0.013	-	0.930	-
MLWR	R7	Marimba River	Rainy	-	-	32.0	-	-	8.80	161.1	136	-	-	0.050	-	3.100	-	1.200	-
			Dry	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	-	-	32.0	-	-	8.80	161.1	136	-	-	0.050	-	3.100	-	1.200	-
JICA Study	R3	Ruwa River	Dry	-	3.8	34.1	10.3	6.60	6.87	16.0	170	80.0	0.80	0.480	0.112	NIL	0.274	0.140	20
	R5	Nyatsime River	Dry	-	2.1	22.7	26.6	5.60	6.91	13.0	150	50.0	0.70	0.370	0.018	0.026	0.122	0.052	20
	R6	Mukuvisi River	Dry	-	2.0	17.0	11.2	6.20	6.87	42.0	460	150.0	0.80	0.350	0.100	0.260	0.370	0.134	16
	R7	Marimba River	Dry	-	8.7	54.0	8.0	5.10	7.17	99.0	800	130.0	19.00	8.500	0.230	NIL	3.800	1.000	12
	R9	Muzururu River	Dry	-	0.5	34.1	12.0	5.80	7.05	9.0	290	100.0	0.50	0.260	NIL	0.003	0.058	0.024	NIL
	R10	Gwebi River	Dry	-	1.6	22.7	12.4	6.70	7.22	7.0	175	50.0	0.65	0.240	NIL	0.008	0.052	0.024	3
Total	R3	Ruwa River	Rainy	Ave.	-	-	-	6.18	7.39	79.4	545	85.0	-	4.325	0.552	0.047	-	1.630	-
			Dry	Ave.	3.8	34.1	10.3	6.60	6.87	16.0	170	80.0	0.80	0.480	0.112	NIL	0.274	0.140	20
			Total	Ave.	3.8	34.1	10.3	6.39	7.13	47.7	358	82.5	0.80	2.403	0.332	0.024	0.274	0.885	20
	R5	Nyatsime River	Rainy	Ave.	-	-	-	-	6.97	90.0	930	145.0	-	32.350	0.390	0.069	-	5.100	-
			Dry	Ave.	2.1	22.7	26.6	5.60	7.17	34.0	380	70.0	0.70	15.190	0.035	0.015	0.122	1.626	-
			Total	Ave.	2.1	22.7	26.6	5.60	7.07	62.0	655	107.5	0.70	23.770	0.213	0.042	0.122	3.363	-
	R6	Mukuvisi River	Rainy	Ave.	-	-	-	3.80	7.48	149.0	1,250	430.0	-	6.400	0.250	0.015	-	1.650	-
			Dry	Ave.	2.0	17.0	11.2	6.20	6.87	42.0	460	150.0	0.80	0.350	0.100	0.260	0.370	0.134	-
			Total	Ave.	2.0	17.0	11.2	5.00	7.18	95.5	855	290.0	0.80	3.375	0.175	0.138	0.370	0.892	-
	R7	Marimba River	Rainy	Ave.	-	32.0	-	5.75	8.21	161.1	695	215.0	-	0.170	0.030	1.558	-	1.010	-
			Dry	Ave.	8.7	54.0	8.0	5.80	7.24	94.0	635	170.0	19.00	4.705	0.160	0.010	3.800	1.080	-
			Total	Ave.	8.7	43.0	8.0	5.78	7.73	127.6	665	192.5	19.00	2.438	0.095	0.784	3.800	1.045	-
	R9	Muzururu River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	0.5	34.1	12.0	5.80	7.05	9.0	290	100.0	0.50	0.260	NIL	0.003	0.058	0.024	NIL
			Total	Ave.	0.5	34.1	12.0	5.80	7.05	9.0	290	100.0	0.50	0.260	NIL	0.003	0.058	0.024	NIL
	R10	Gwebi River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	1.6	22.7	12.4	6.70	7.22	7.0	175	50.0	0.65	0.240	NIL	0.008	0.052	0.024	3
			Total	Ave.	1.6	22.7	12.4	6.70	7.22	7.0	175	50.0	0.65	0.240	NIL	0.008	0.052	0.024	3

Table 3.5.3 Present Water Quality on Tributaries (cont'd)

Source	Sampling Point		Season	Item	Heavy Metals										Pesticide		
	No.	Location			Al	Cu	Hg	Zn	Pb	Ni	Fe	As	Cr^{+6}	Cd	Atrazine	Captan	Chlorpyrifos
					mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	R3	Ruwa River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
	R5	Nyatsime River	Rainy	Ave.	-	-	-	-	-	-	0.95	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	1.06	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	0.98	-	-	-	-	-	-
	R6	Mukuvisi River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
	R7	Marimba River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
MLWR	R7	Marimba River	Rainy	-	-	-	-	-	0.10	-	0.10	-	-	-	-	-	-
			Dry	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Total	-	-	-	-	-	0.10	-	0.10	-	-	-	-	-	-
JICA Study	R3	Ruwa River	Dry	-	NIL	NIL	ND	0.07	NIL	0.02	0.24	NIL	NIL	0.03	NIL	NIL	NIL
	R5	Nyatsime River	Dry	-	NIL	NIL	ND	0.10	NIL	NIL	0.08	NIL	NIL	0.03	NIL	NIL	NIL
	R6	Mukuvisi River	Dry	-	1.86	NIL	ND	0.06	NIL	0.04	2.64	NIL	NIL	NIL	NIL	NIL	NIL
	R7	Marimba River	Dry	-	NIL	NIL	ND	0.04	NIL	0.04	0.22	NIL	NIL	NIL	NIL	NIL	NIL
	R9	Muzururu River	Dry	-	NIL	NIL	ND	0.06	NIL	NIL	0.08	NIL	NIL	NIL	NIL	NIL	NIL
	R10	Gwebi River	Dry	-	NIL	NIL	ND	0.02	NIL	NIL	0.03	NIL	NIL	NIL	NIL	NIL	NIL
Total	R3	Ruwa River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.07	NIL	0.02	0.24	NIL	NIL	0.03	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.07	NIL	0.02	0.24	NIL	NIL	0.03	NIL	NIL	NIL
	R5	Nyatsime River	Rainy	Ave.	-	-	-	-	-	-	0.95	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.10	NIL	NIL	0.57	NIL	NIL	0.03	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.10	NIL	NIL	0.76	NIL	NIL	0.03	NIL	NIL	NIL
	R6	Mukuvisi River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	1.86	NIL	ND	0.06	NIL	0.04	2.64	NIL	NIL	NIL	NIL	NIL	NIL
			Total	Ave.	1.86	NIL	ND	0.06	NIL	0.04	2.64	NIL	NIL	NIL	NIL	NIL	NIL
	R7	Marimba River	Rainy	Ave.	-	-	-	-	0.10	-	0.10	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.04	NIL	0.04	0.22	NIL	NIL	NIL	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.04	0.05	0.04	0.16	NIL	NIL	NIL	NIL	NIL	NIL
	R9	Muzururu River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.06	NIL	NIL	0.08	NIL	NIL	NIL	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.06	NIL	NIL	0.08	NIL	NIL	NIL	NIL	NIL	NIL
	R10	Gwebi River	Rainy	Ave.	-	-	-	-	-	-	-	-	-	-	-	-	-
			Dry	Ave.	NIL	NIL	ND	0.02	NIL	NIL	0.03	NIL	NIL	NIL	NIL	NIL	NIL
			Total	Ave.	NIL	NIL	ND	0.02	NIL	NIL	0.03	NIL	NIL	NIL	NIL	NIL	NIL

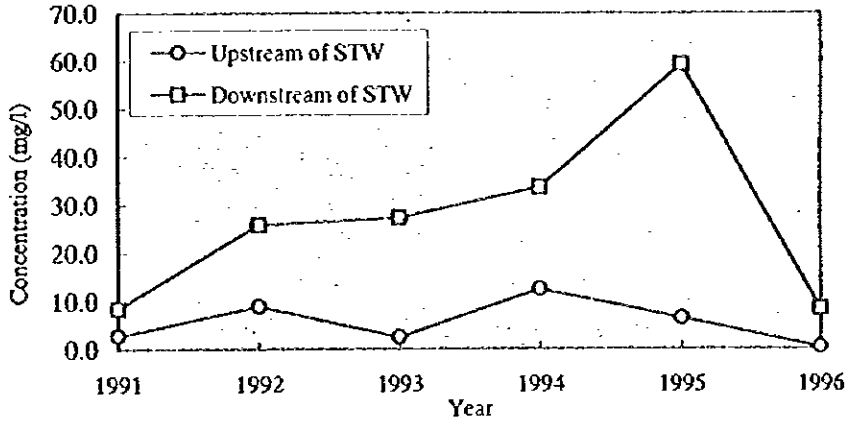


Figure 3.5.4 Water Quality (NH_4-N) of the Nyatsime River

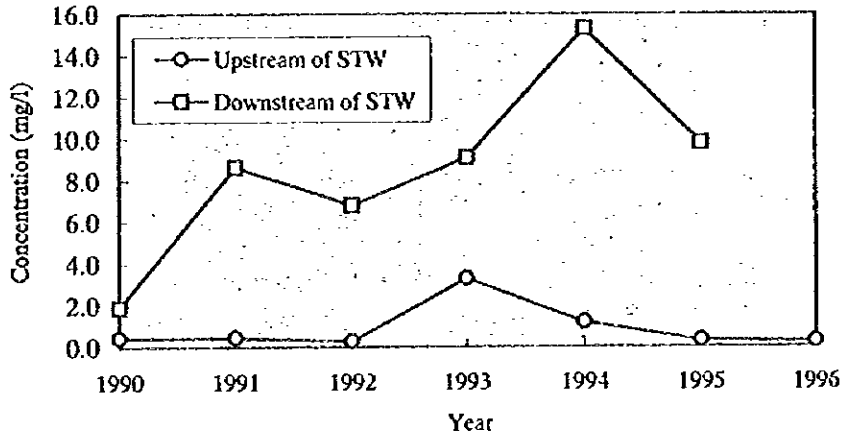


Figure 3.5.5 Water Quality (NH_4-N) of the Mukuvisi River

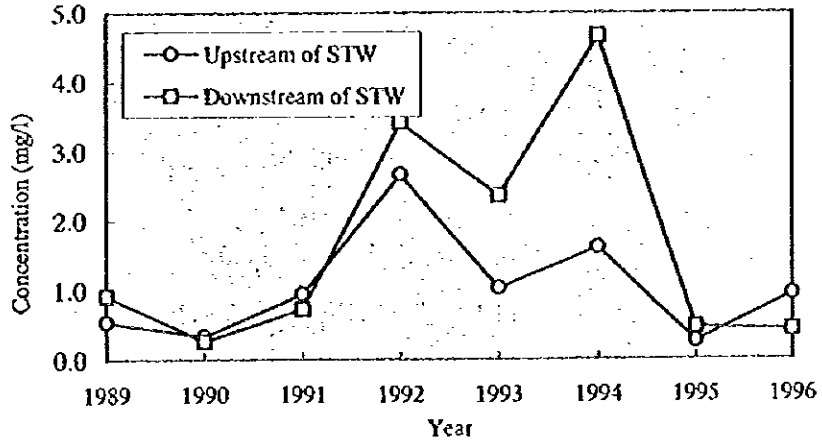


Figure 3.5.6 Water Quality (NH_4-N) of the Marimba River

(2) Lakes/Dams

The present water quality data of the Seke Dam, Lake Chivero and Lake Manyame are shown in Table 3.5.4.

1) Seke Dam

The water quality of the Seke Dam is characterized by its high concentration of nitrogen (T-N: 0.65 mg/l) and phosphorous (T-P: 0.070 mg/l), which exceed the allowable level for drinking water in lakes (T-N: less than 0.3 mg/l, T-P: less than 0.01 mg/l). Such high levels of nitrogen and phosphorous show that the dam is prone to euthrophication. However, the low concentration of inorganic nitrogen (NH_4-N, NO_2-N, NO_3-N) means that the influence of livestock excreta, fertilizer, dried grass is greater than the effluents from the Donnybrook STW, the Ruwa STW which are located upstream of the dam.

Through the comparison with the allowable level of water quality indices for drinking water source in lakes (COD_{Mn}: less than 3 mg/l, SS: less than 25 mg/l, DO: more than 5 mg/l), it is observed that COD_{Mn} (9.5 mg/l) is three times higher than the allowable standards and also DO (5.8 mg/l) slightly exceeds the standards. Thus, it is obvious that the deterioration of the water in the Seke Dam is in progress.

As to heavy metals, Zn, Ni, Fe and Cd were detected, of which Ni, Fe and Cd exceed the WHO guidelines for drinking water (Zn: less than 3 mg/l, Ni: less than 0.02 mg/l, Fe: less than 0.3 mg/l, Cd: less than 0.003 mg/l). Although the effluent of STWs is major source of organic pollution, the concentration of heavy metals are not significant, provided however that Cd, among others, should be observed periodically. As to the origin of these heavy metals, industrial wastewater contains high concentrations of Fe, Ni and Zn. The possible influence of heavy metals which may be dissolved from detritus is assessed.

Table 3.5.4 Present Water Quality at Lakes and Dams

Source	Lakes/Dam	Point	Layer	Item	pH	T-COD_{Cr}	S-COD_{Cr}	T-COD_{Mn}	S-COD_{Mn}	DO	SS	Cl^-	EC	Hardness	T-N	NH_4-N	NO_2-N	NO_3-N	T-P	PO_4-P	Oil
					-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	uS/cm	-	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	Seke Dam	L2	Top	-	7.67	-	-	-	-	-	-	13.0	-	36	-	0.050	0.002	0.003	-	0.060	-
			Bottom	-	6.85	-	-	-	-	-	-	13.0	-	40	-	0.440	0.003	0.001	-	0.176	-
	Lake Chivero	L5	Top	-	8.71	-	-	-	-	-	-	87.0	-	140	-	0.100	0.004	0.002	-	0.400	-
			Middle	-	8.47	-	-	-	-	-	-	89.0	-	140	-	0.105	0.007	0.002	-	0.640	-
			Bottom	-	8.58	-	-	-	-	-	-	91.0	-	132	-	0.110	0.007	0.001	-	0.380	-
	Lake Manyame	L6	Top	-	7.19	-	-	-	-	-	-	23.0	-	-	-	0.145	0.0025	0.0055	-	0.080	-
JICA Study	Seke Dam	L1	Top	-	6.83	13.8	13.1	11.3	11.3	5.7	10.1	7.0	117	30	0.70	0.170	0.039	0.036	0.072	0.017	11.5
			Middle	-	6.77	20.8	18.5	7.8	7.8	5.7	6.4	8.0	117	50	0.85	0.180	0.004	0.007	0.065	0.020	10.5
		L2	Top	-	6.83	22.3	19.5	10.7	10.6	6.1	2.7	8.0	113	40	0.45	0.170	0.004	0.044	0.080	0.014	9.5
			Middle	-	6.82	25.6	21.6	7.9	6.8	5.7	1.6	8.0	102	35	0.58	0.150	0.005	0.003	0.063	0.018	9.5
		Ave.	Top	-	6.83	18.1	16.3	11.0	11.0	5.9	6.4	7.5	115	35	0.58	0.170	0.022	0.040	0.076	0.016	10.5
			Middle	-	6.80	23.2	20.1	7.9	7.3	5.7	4.0	8.0	110	43	0.72	0.165	0.005	0.005	0.064	0.019	10.0
	Lake Chivero	L3	Top	-	7.04	22.0	22.0	20.5	15.2	4.6	5.4	39.0	405	145	0.41	0.280	0.057	0.000	0.280	0.180	25.5
			Middle	-	7.16	22.0	22.0	18.4	13.3	4.4	4.4	40.0	415	110	0.37	0.220	0.048	0.009	0.231	0.176	9.0
		L4	Top	-	7.23	30.2	19.5	15.0	14.6	4.4	4.2	42.5	428	110	0.45	0.140	0.042	0.003	0.235	0.204	13.0
			Middle	-	7.18	24.9	24.9	12.0	11.8	4.6	4.5	42.0	425	125	0.33	0.130	0.027	0.000	0.290	0.206	5.5
		L5	Top	-	7.35	22.2	19.5	15.3	14.3	4.9	3.7	41.0	415	135	0.68	0.120	0.023	0.043	0.253	0.218	30.5
			Middle	-	7.41	30.5	18.1	8.4	8.4	5.2	3.6	41.5	415	110	0.83	0.110	0.026	0.027	0.331	0.208	13.0
		Ave.	Top	-	7.21	24.8	20.3	16.9	14.7	4.6	4.4	40.8	416	130	0.51	0.180	0.041	0.015	0.256	0.201	23.0
			Middle	-	7.25	25.8	21.7	12.9	11.2	4.7	4.2	41.2	418	115	0.51	0.153	0.034	0.012	0.284	0.197	9.2
	Lake Manyame	L6	Top	-	7.50	17.0	17.0	15.2	15.2	6.3	2.4	23.0	270	130	0.80	0.130	0.007	0.042	0.030	0.010	2.0
			Middle	-	7.51	28.4	24.0	22.6	22.6	7.1	3.0	23.0	250	100	0.70	0.130	0.008	0.000	0.058	0.008	11.0
Total	Seke Dam		Top	-	7.25	18.1	16.3	11.0	11.0	5.9	6.4	10.3	115	36	0.58	0.100	0.000	0.000	0.076	0.000	10.5
			Middle	-	6.80	23.2	20.1	7.9	7.3	5.7	4.0	8.0	110	43	0.72	0.165	0.005	0.005	0.064	0.019	10.0
			Bottom	-	6.85	-	-	-	-	-	-	13.0	-	40	-	0.440	0.003	0.001	-	0.176	-
			Ave.	-	6.97	20.7	18.2	9.5	9.2	5.8	5.2	10.4	113	40	0.65	0.235	0.003	0.002	0.070	0.065	10.3
	Lake Chivero		Top	-	7.96	24.8	20.3	16.9	14.7	4.6	4.4	63.9	416	135	0.51	0.140	0.023	0.009	0.256	0.301	23.0
			Middle	-	7.86	25.8	21.7	12.9	11.2	4.7	4.2	65.1	418	128	0.51	0.129	0.021	0.007	0.284	0.419	9.2
			Bottom	-	8.58	-	-	-	-	-	-	91.0	-	132	-	0.110	0.007	0.001	-	0.380	-
			Ave.	-	8.13	25.3	21.0	14.9	13.0	4.7	4.3	73.3	417	132	0.51	0.126	0.017	0.006	0.270	0.367	16.1
	Lake Manyame		Top	-	7.35	17.0	17.0	15.2	15.2	6.3	2.4	23.0	270	130	0.80	0.138	0.005	0.024	0.030	0.045	2.0
			Middle	-	7.51	28.4	24.0	22.6	22.6	7.1	3.0	23.0	250	100	0.70	0.130	0.008	0.000	0.058	0.008	11.0
			Bottom	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Ave.	-	7.43	22.7	20.5	18.9	18.9	6.7	2.7	23.0	260	115	0.75	0.134	0.007	0.012	0.044	0.027	6.5

Table 3.5.4 Present Water Quality at Lakes and Dams (cont'd)

Source	Lakes/Dam	Point	Layer	Heavy Metals										Pesticide		
				Al	Cu	Hg	Zn	Pb	Ni	Fe	As	Cr^{6+}	Cd	Atrazine	Captan	Chlorpyrifos
				mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
City of Harare	Seke Dam	L2	Top	-	-	-	-	-	-	1.02	-	-	-	-	-	-
			Bottom	-	-	-	-	-	-	2.33	-	-	-	-	-	-
	Lake Chivero	L5	Top	-	-	-	-	-	-	0.16	-	-	-	-	-	-
			Middle	-	-	-	-	-	-	0.16	-	-	-	-	-	-
			Bottom	-	-	-	-	-	-	0.50	-	-	-	-	-	-
	Lake Manyame	L6	Top	-	-	-	-	-	-	0.25	-	-	-	-	-	-
JICA Study	Seke Dam	L1	Top	0.00	0.00	0.00	0.09	0.00	0.03	0.27	0.00	0.00	0.02	0.00	0.00	0.00
			Middle	0.30	0.00	0.00	0.11	0.00	0.05	0.44	0.00	0.00	0.02	-	-	-
		L2	Top	0.00	0.00	0.00	0.11	0.00	0.02	0.24	0.00	0.00	0.03	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.14	0.00	0.02	0.21	0.00	0.00	0.01	-	-	-
		Ave.	Top	0.00	0.00	0.00	0.10	0.00	0.03	0.26	0.00	0.00	0.03	0.00	0.00	0.00
			Middle	0.15	0.00	0.00	0.13	0.00	0.04	0.33	0.00	0.00	0.02	0.00	0.00	0.00
	Lake Chivero	L3	Top	0.00	0.00	0.00	0.13	0.00	0.03	0.13	0.00	0.00	0.01	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.12	0.00	0.03	0.13	0.00	0.00	0.01	-	-	-
		L4	Top	0.00	0.00	0.00	0.09	0.00	0.02	0.14	0.00	0.00	0.03	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.10	0.00	0.02	0.11	0.00	0.00	0.01	-	-	-
		L5	Top	0.00	0.00	0.00	0.10	0.00	0.03	0.48	0.00	0.00	0.00	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.09	0.00	0.04	0.40	0.00	0.00	0.01	-	-	-
		Ave.	Top	0.00	0.00	0.00	0.11	0.00	0.03	0.25	0.00	0.00	0.01	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.10	0.00	0.03	0.21	0.00	0.00	0.01	0.00	0.00	0.00
	Lake Manyame	L6	Top	0.00	0.02	0.00	0.19	0.00	0.04	0.28	0.00	0.00	0.00	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.16	0.00	0.04	0.20	0.00	0.00	0.00	-	-	-
Total	Seke Dam		Top	0.00	0.00	0.00	0.09	0.00	0.03	0.64	0.00	0.00	0.02	0.00	0.00	0.00
			Middle	0.15	0.00	0.00	0.13	0.00	0.04	0.33	0.00	0.00	0.02	0.00	0.00	0.00
			Bottom	-	-	-	-	-	-	2.33	-	-	-	-	-	-
			Ave.	0.08	0.00	0.00	0.11	0.00	0.04	1.10	0.00	0.00	0.02	0.00	0.00	0.00
	Lake Chivero		Top	0.00	0.00	0.00	0.11	0.00	0.03	0.21	0.00	0.00	0.01	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.10	0.00	0.03	0.20	0.00	0.00	0.01	0.00	0.00	0.00
			Bottom	-	-	-	-	-	-	0.50	-	-	-	-	-	-
			Ave.	0.00	0.00	0.00	0.11	0.00	0.03	0.30	0.00	0.00	0.01	0.00	0.00	0.00
	Lake Manyame		Top	0.00	0.02	0.00	0.19	0.00	0.04	0.27	0.00	0.00	0.00	0.00	0.00	0.00
			Middle	0.00	0.00	0.00	0.16	0.00	0.04	0.20	0.00	0.00	0.00	-	-	-
			Bottom	-	-	-	-	-	-	-	-	-	-	-	-	-
			Ave.	0.00	0.01	0.00	0.18	0.00	0.04	0.24	0.00	0.00	0.00	0.00	0.00	0.00

Concerning the agricultural chemicals, the atrazine, captan and chlorpyrifos were examined as the representative agricultural chemicals in the study area. But these chemicals were not detected in the lakes/dams through this Study which was carried out in the dry season. Agricultural chemicals must be monitored periodically through the year.

There is no significant difference in the water quality at the sampling points upstream and downstream of the dam. Also, the difference in water quality between the upper layer and the lower layer of the stored water is not obvious, except that the extremely high concentration of NO_3-N was observed in the upper layer.

2) Lake Chivero

As in the Seke Dam, water quality in Lake Chivero is characterized by its high concentration of nitrogen (T-N: 0.51 mg/l) and especially phosphorous (T-P: 0.27 mg/l), which exceed the allowable level for drinking water in lakes (T-N: less than 0.3 mg/l, T-P: less than 0.01 mg/l). The concentration of T-P is about four-times higher than that of the Seke Dam. Inorganic nitrogen concentrations are also high. This means that the lake was significantly affected by the inflow from the area upstream of the lake.

The annual fluctuation of NH_4-N and PO_4-P in Lake Chivero is shown in Figure 3.5.7. The figure shows that the water pollution resumed in 1990 and then rapidly progressed. Also shown in the figure is that the decrease of NH_4-N in 1995 reflects the suspension of effluent discharge from the Zengeza STW to the river. Likewise, the effluent from the STW affected remarkably the lake's water quality.

The COD_{Mn} concentration (14.9 mg/l) in the lake is very high, at about five-times the allowable level for drinking water in lakes (COD_{Mn}: less than 3.0 mg/l, SS: less than 25 mg/l, DO: more than 5 mg/l), while SS (4.3 mg/l) is below than the standards and DO (4.7 mg/l) exceeds the standards. Although water sampling was carried out at three points downstream of the confluence point of the Marimba River, the influence of the Marimba River is not clearly identified. However, the tendency of increasing T-N and T-P concentration downstream indicates the possibility of solution of nutrient substances from the detritus in the lake.

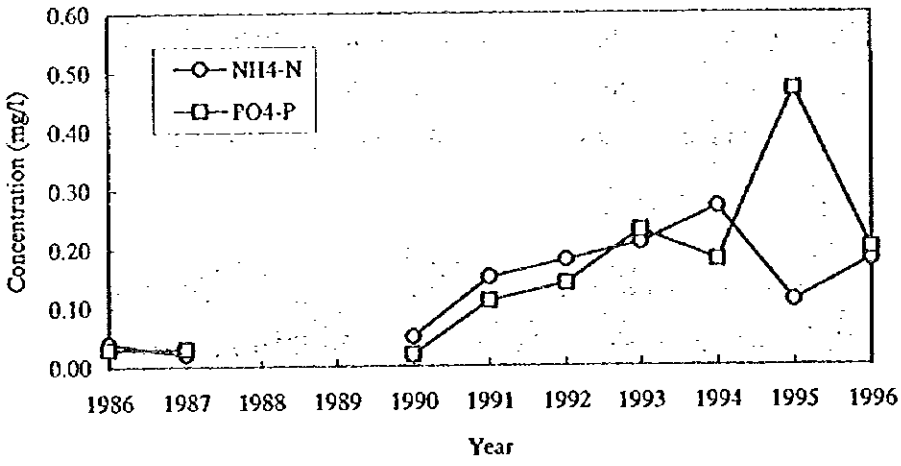


Figure 3.5.7 Water Quality of the Lake Chivero (Top Layer)

With regard to heavy metals, the conditions are the same as at the Seke Dam and the lake water is still deemed to be allowable as a drinking water source.

Concerning the agricultural chemicals, the atrazine, captan and chlorpyrifos were examined as the representative agricultural chemicals in the study area. But these chemicals were not detected in the lakes/dams through this Study which was carried out in the dry season. Agricultural chemicals must be monitored periodically through the year.

3) Lake Manyame

As in the other lakes, water quality in Lake Manyame is characterized by its high concentration of nitrogen (T-N: 0.75 mg/l) and phosphorous (T-P: 0.044 mg/l), which exceed the allowable level for drinking water in lakes (T-N: less than 0.3 mg/l, T-P: less than 0.01 mg/l). The concentration of T-N is the same level to that of the Seke Dam. On the other hand, the lower concentration of inorganic nitrogen indicates that the lake is mainly affected by livestock excreta, fertilizer and dried grass.

The COD_{Mn} concentration (18.9 mg/l) in the lake is very high, at about six-times the allowable level for drinking water in lakes (COD_{Mn}: less than 3 mg/l, SS: less than 25 mg/l, DO: more than 5 mg/l), while SS and DO are less than the allowable level.

Regarding heavy metals, Zn, Ni, Fe were detected of which Ni (0.04 mg/l) was slightly exceeding the WHO guidelines for drinking water (Zn: less than 3 mg/l, Ni: less than 0.02 mg/l, Fe: less than 0.3 mg/l). Considering its low concentration, the lake water is deemed to be still allowable as a drinking water source.

Concerning the agricultural chemicals, the atrazine, captan and chlorpyrifos were examined as the representative agricultural chemicals in the study area. But these chemicals were not detected in the lakes/dams through this Study which was carried out in the dry season. Agricultural chemicals must be monitored periodically through the year.

3.5.3 Effluent Water Quality at Major Pollution Sources

Based on the investigation results and data gathered from the local authorities concerned, the effluent water quality at the major pollution sources (factories and sewage treatment works) were analyzed. The data of effluent water quality from the sewage treatment works gathered from the local authorities are included in Table 3.5.22 to 3.5.44, Section 3.5, Data Report.

(1) Factories

Harare, Chitungwiza, Norton and Ruwa have the industrial areas featuring daily life related industries, such as processed foodstuffs and textile products. Recently, these factories have become major pollution sources in the Study Area. Most of the industrial wastewater is discharged into the sewer system and its effluent standards are stipulated in "Controlling Trade Effluent from Industries" (Chapter 214, Urban Council Act). However these standards are deemed to be looser than that prescribed in the Water Regulations, in terms of the number of the water quality indices and their values.

Considering the types of industry in the study area, especially the organic pollutant types, i.e. processed foodstuffs, pulp/paper, chemicals, etc., eight major types were selected for sampling and analysis through this study. The water sampling was conducted at 45 large-scale factories belonging to the above mentioned types as follows:

Harare	
Crowborough Service Area	10 factories
Firle Service Area	15 factories
Chitungwiza	10 factories
Norton	5 factories
Ruwa	5 factories
Total	45 factories

A water sampling point was designated at the effluent channel for every factory. The sampling was carried out three-times a day to make composite sample for the examination. The examination results refer to the calculation of the unit quantity and quality of industrial wastewater which are to be utilized in the projection of present/future wastewater volume and pollution load. The examination results are shown in Table 3.5.49, Data Report.

Based on the results of the industrial wastewater quality examination, the average wastewater quality by industrial type was calculated as shown in Table 3.5.5. The following are industrial types with higher concentration in terms of environmental water quality items.

Wastewater Temperature	:	Chemical and Processed Foodstuffs
pH	:	Ceramics and Stone & Clay Products
BOD, COD and SS	:	Processed Foodstuffs, Pulp/Paper & Related Products and Chemicals (extremely high, about 30 times of common effluent standards)
Nitrogen and Phosphorus	:	Processed Foodstuffs, Pulp/Paper & Related Products and Chemicals
Oil	:	Chemicals and Processed Foodstuffs

High concentrations of heavy metals were detected in some wastewater discharged from factories as follows :

Processed Foodstuffs	:	Hg and Fe
Pulp, Paper and Related Products	:	Al, Ni and Fe
Chemicals	:	Hg and Ni
Plastic Products	:	Al and Pb
Ceramics, Stone & Clay Products	:	Hg
Metal Products	:	Al, Ni and Fe
Transportation Equipment	:	Zn and Ni

In general, the Fe and Ni concentrations are high. Thus, industrial wastewater may be regarded as a major origin of Fe, Ni detected in rivers/lakes. Factories such as processed foodstuffs, pulp/papers and related products, and chemicals are discharging highly concentrated effluent into the sewer system.

Although the effluent standards in the Water Regulations are not applied to the industrial wastewater, referring to the relevant regulations and standards set forth in Water Act, the Urban Council Act and the common effluent standards. Almost all factories are exceeding the major pollution indices, i.e. BOD, COD, SS, nitrogen, phosphorous, Fe, Ni, Pb and Zn, as shown in Table 3.5.6. Especially, three industrial types, processed foodstuffs, pulp/paper and related products, and chemicals, are discharging wastewater exceeding the effluent standards by more than ten times. Generally, the pre-treatment facilities at factories inadequate. In this connection, it is obvious that the industrial wastewater is the major cause of over-loading at STWs and adversely affecting their treatment efficiency.

(2) Sewage Treatment Works

The STW's effluent is one of the major pollution sources of rivers and lakes/dams, and contribute to eutrophication in the lakes/dams.

Table 3.5.5 Average Wastewater Quality Discharged from Factories by Industrial Type

Water Quality Indices	Unit	Processed Foodstuffs	Pulp, Paper & Related Products	Chemicals	Plastic Products	Ceramics, Stone & Clay Products	Metal Products	Transportation Equipment	Other Industry Products
Water Temp.	C	26.4	17.5	34.5	14.2	19.0	17.6	21.2	20.2
pH	-	5.14	6.13	6.16	7.00	8.80	7.59	7.61	7.37
BOD	mg/l	1,405	2,275	744	259	27	158	247	324
T-COD_{Cr}	mg/l	3,438	9,720	7,816	2,665	61	521	856	1,612
T-COD_{Mn}	mg/l	624	1,672	1,106	195	24	84	174	265
DO	mg/l	3.8	3.7	3.0	5.8	5.9	5.6	2.9	4.2
SS	mg/l	600	498	2,840	2,155	147	124	350	655
Cl^-	mg/l	1541.1	247.0	634.7	25.8	441.6	50.7	64.9	32.9
EC	uS/cm	5,429	3,000	4,305	464	2,037	841	1,066	7,884
Hardness	*	1,568	400	174	159	539	126	148	908
T-N	mg/l	43.94	38.00	25.72	3.32	3.29	15.93	12.55	108.49
NH_4-N	mg/l	34.27	31.00	5.66	1.62	0.04	6.47	0.63	87.90
NO_2-N	mg/l	0.254	0.000	0.011	0.000	0.006	0.014	0.003	0.002
NO_3-N	mg/l	1.20	0.00	0.15	0.00	11.18	0.68	1.12	0.00
T-P	mg/l	17.298	6.200	9.727	0.861	0.474	1.599	21.249	6.027
PO_4-P	mg/l	4.18	4.80	1.52	0.13	0.21	0.34	3.76	0.47
Oil	mg/l	135.7	49.0	1608.9	22.4	26.1	11.9	59.8	40.3
Al	mg/l	1.22	37.00	2.27	16.34	1.79	32.84	0.69	1.58
Cu	mg/l	0.13	0.21	0.81	0.13	0.08	0.26	0.11	0.12
Hg	mg/l	2.88	0.00	5.41	0.00	9.77	0.00	0.00	1.86
Zn	mg/l	1.30	0.45	0.93	1.44	0.10	5.21	4.30	0.99
Pb	mg/l	0.32	0.36	0.20	11.94	0.26	0.54	2.61	0.58
Ni	mg/l	0.10	6.61	4.65	3.34	0.81	12.24	4.89	28.30
Fe	mg/l	2.94	6.47	3.80	3.21	0.67	11.33	2.55	1.62
As	mg/l	0.75	0.00	0.69	0.00	0.00	0.64	0.38	0.00
Cr^{6+}	mg/l	0.00	0.00	0.66	0.11	0.03	0.19	0.00	26.54
Cd	mg/l	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note) * : mg/l as $CaCO_3$

Table 3.5.6 Average Effluent Quality and Number of Factories Exceeding Effluent Standard

		Total No. of Factories	Temp. C	pH -	BOD mg/l	T-COD_{Mn} mg/l	SS mg/l	Cl mg/l	T-N mg/l	T-P mg/l	Al mg/l	Cu mg/l	Hg mg/l	Zn mg/l	Pb mg/l	Ni mg/l	Fe mg/l	As mg/l	Cr^{6+} mg/l	Cd mg/l
Effluent Standards	Water Regulation							100	10.0	1.0		0.50	0.50	1.00	0.05	0.30	0.30	0.05	0.05	0.01
	Urban Council Act		60	6.8-9.0							50	50	50	50	50	50	50	50	50	50
	Japanese			5.8-8.6	160	160	200		120	16		3.00	0.01	5.00	0.10		10	0.10	0.50	0.10
Processed Foodstuffs	Ave.Quality		26.4	5.14	1,405	624	600	1541.1	43.94	17.298	1.22	0.13	2.88	1.30	0.32	0.10	2.94	0.75	0.00	0.01
	No. of Factory	18	0	1	17	15	12	10	14	16	0	1	4	5	17	0	18	7	0	1
Pulp, Paper & Related Products	Ave.Quality		17.5	6.13	2,275	1,672	498	247.0	38.00	6.200	37.00	0.21	0.00	0.45	0.36	6.61	6.47	0.00	0.00	0.00
	No. of Factory	1	0	0	1	1	1	1	1	1	0	0	0	0	1	0	1	0	0	0
Chemicals	Ave.Quality		34.5	6.16	744	1,106	2,840	634.7	25.72	9.727	2.27	0.81	5.41	0.93	0.20	4.65	3.80	0.69	0.66	0.00
	No. of Factory	6	0	0	5	2	2	3	6	5	0	2	2	1	3	0	4	2	2	1
Plastic Products	Ave.Quality		14.2	7.00	259	195	2,155	25.8	3.32	0.861	16.34	0.13	0.00	1.44	11.94	3.34	3.21	0.00	0.11	0.00
	No. of Factory	2	0	0	2	2	2	1	1	1	0	0	0	2	2	0	2	0	1	0
Ceramics, Stone & Clay Products	Ave.Quality		19.0	8.80	27	24	147	441.6	3.29	0.474	1.79	0.08	9.77	0.10	0.26	0.81	0.67	0.00	0.03	0.00
	No. of Factory	2	0	0	0	1	1	2	1	1	0	0	1	0	2	0	2	0	1	0
Metal Products	Ave.Quality		17.6	7.59	158	84	124	50.7	15.93	1.599	32.84	0.26	0.00	5.21	0.54	12.24	11.33	0.64	0.19	0.00
	No. of Factory	4	0	0	1	0	0	0	3	3	1	1	0	1	4	1	4	3	2	0
Transportation Equipment	Ave.Quality		21.2	7.61	247	174	350	64.9	12.55	21.249	0.69	0.11	0.00	4.30	2.61	4.89	2.55	0.38	0.00	0.00
	No. of Factory	6	0	0	4	3	4	0	4	5	0	0	0	1	5	1	6	2	0	0
Other Industry Products	Ave.Quality		20.2	7.37	324	265	655	32.9	108.49	6.027	1.58	0.12	1.86	0.99	0.58	28.30	1.62	0.00	26.54	0.00
	No. of Factory	6	0	0	3	3	3	0	5	4	0	0	1	2	6	6	6	0	2	0

There are six STWs in Manayame River Basin, namely the Crowborough, Firle and Donnybrook STWs (supervised by Harare City), the Zengeza STW (Chitungwiza Municipality), the Norton STW (under the jurisdiction of the Norton Town Council), and the Ruwa STW (managed by Ruwa Local Board). Since all industrial wastewater is received by the sewer system, only STWs are regulated by the effluent standards based on the Water Act.

However, such effluent standards, especially nitrogen and phosphorus concentrations, can not be achieved by means of secondary treatment processes except for the BNR method. Thus, treated effluent is discharged into pastures or forestry lands for irrigation instead of rivers in order to avoid violating the standards.

Water quality examinations were conducted at six STWs through this study; Crowborough, Firle, Donnybrook (No.2), Zengeza, Norton and Ruwa. Water samples were collected at inflow and outflow points of each STW. In the case of the Crowborough and Firle STWs, which are provided with trickling filter and BNR facilities, treated effluent was sampled from both facilities. Water sampling was conducted three times a day to a make composite sample.

The existing water quality data collected from the respective STWs and the results of the examination through this study are summarized in Table 3.5.7, while the detailed existing data of the STWs and the results of this study are included in Table 3.5.50, Section 3.5, Data Report. The BOD of the inflow sewage ranges from 480 to 970mg/l, with an average of 695mg/l. The BOD at the Zengeza STW is the highest among the STWs; it is heavily affected by the industrial wastewater discharged from the Tilcor industrial complex.

Regarding heavy metals, since no metals exceeding the discharge standards were detected through the examination, the impact from industrial wastewater seems to be negligible.

Table 3.5.7 Water Quality at STWs

STW	Sampling Point	Treatment Method	Inflow Rate	BOD	Removal Efficiency	T-COD_{Cr}	Removal Efficiency	T-COD_{Mn}	SS	Removal Efficiency	T-N	Removal Efficiency	T-P	Removal Efficiency	PO_4-P	Removal Efficiency
			(m3/day)	mg/l	%	mg/l	%	mg/l	mg/l	%	mg/l	%	mg/l	%	mg/l	%
Firle	Inflow		132,312	483.28		1025.77		-	509.00		64.06		-		7.91	
				1300.00		1136.00		181.0	660.00		50.00		4.800		1.10	
	Effluent	TF	104,636	152.62	68.4	267.95	73.9	-	98.02	80.7	38.67	39.6	-		4.49	43.2
				210.00	83.8	653.00	42.5	103.6	210.00	68.2	57.00	-14.0	5.300	-10.4	3.90	-254.5
		BNR	27,676	20.46	95.8	101.14	90.1	-	26.93	94.7	13.38	79.1	-		2.54	67.9
				8.00	99.4	56.80	95.0	13.0	5.00	99.2	1.40	97.2	1.480	69.2	0.80	27.3
Crowborough	Inflow		55,368	619.35		1355.02		-	649.94		54.97		-		6.74	
				610.00		1490.00		168.4	180.00		53.00		5.000		4.30	
	Effluent	TF	39,381	125.01	79.8	281.98	79.2	-	101.82	84.3	37.86	31.1	-		5.23	22.4
				115.00	81.1	454.00	69.5	77.8	40.00	77.8	30.00	43.4	5.700	-14.0	2.40	44.2
		BNR	15,986	21.48	96.5	91.32	93.3	-	29.95	95.4	9.30	83.1	-		1.54	77.2
				9.00	98.5	107.00	92.8	14.0	1.00	99.4	1.00	98.1	0.008	99.8	NIL	
Donnybrook (No.2)	Inflow		1,350	776.96		-		-	-		218.75		-		13.34	
				1120.00		1562.00		242.0	204.00		50.00		1.880		1.80	
	Effluent	WSP		104.56	86.5	-		-	-		99.63	54.5	-		10.97	17.8
				105.00	90.6	284.00	81.8	99.4	90.00	55.9	62.00	-24.0	9.400	-400.0	7.50	-316.7
Zengeza	Inflow		-	973.95		-		-	-		52.19		-		-	
				320.00		1080.00		418.0	300.00		115.00		17.400		10.00	
	Effluent	TF	-	141.00	85.5	-		-	-		58.31	-11.7	-		-	
				130.00	59.4	540.00	50.0	266.0	134.00	55.3	119.00	-3.5	16.600	4.6	10.00	0.0
Norton	Inflow		-	660.00		1496.20		-	-		83.30		-		7.60	
				540.00		767.00		142.0	290.00		47.00		4.600		2.70	
	Effluent	TF		520.00	21.2	1191.90	20.3	-	-		65.80	21.0	7.600		-	
				30.00	94.4	233.00	69.6	84.0	76.00	73.8	29.00	38.3	7.600	-65.2	4.50	-66.7
Ruwa	Inflow		-	657.27		-		-	-		44.68		-		10.15	
				260.00		284.00		86.4	70.00		32.00		2.520		1.92	
	Effluent	WSP	-	133.64	79.7	-		-	-		3.88	91.3	-		2.38	76.6
				55.00	78.8	142.00	50.0	73.4	31.00	55.7	21.00	34.4	2.160	14.3	1.20	37.5

Note) Above: Average of Data from City of Harare, Department of Works
Below: Examination results by JICA Study Team

As to the treatment efficiency of the STWs, in terms of BOD, the Crowborough and Firle STWs show favorable performance; 68 to 80% using the trickling filter, 96 to 97% using the BNR, while the T-N removal rate is 80 to 83% using the BNR. The BOD removal rates at other STWs are 87% using the stabilization pond in Donnybrook, 86% using the trickling filter in Zengeza and 80% using the stabilization pond in Ruwa. The efficiency of the trickling filter at Norton STW was only 21%. Therefore, the rehabilitation of the facilities are underway. The effluent quality from the BNR at the Crowborough and the Firle STWs is quite good, 10 mg/l in BOD and 10 mg/l in T-N. Except for trickling filter at the Norton STW, the effluent BOD ranges from 8 to 210 mg/l.

Only the effluent from the BNR of the Crowborough and Firle STWs, which conforms to the requirements of the Water Act, is discharged to the river, while the rest is discharged to pasture or forestry land for irrigation purpose. This fact owes to the strictness of the standards requiring less than 10.0 mg/l of nitrogen and less than 1.0 mg/l of phosphous in the effluent.

As to heavy metals, since the influent load is small, it will not affect the STW's effluent quality.

(3) Wells

The treated effluent at the STWs within the study area is used for irrigation. In this connection, water quality examination was carried out through this study at the wells near the re-use site to assess its influence to the groundwater.

Three (3) STWs in Harare City, Crowborough, Firle and Donnybrook, are located in the fringe of the City and their re-use sites of treated effluent are situated nearby their respective STWs. Their surrounding environment is a high density area, developed long before the provision of water supply systems. Thus, there are no wells in this area. A limited number of wells were used for daily life before the completion of the water supply system, they still exist in low density areas in the vicinity of the irrigation re-use site of the Marlborough STW. A water quality analysis was conducted at two wells (W4 & W5) within this area (location of the sampling points are shown in Figure 3.5.3, Section 3.5, Data Report.

The effluent of the Zengeza STW in Chitungwiza Municipality is pumped to Imbgwa Farm for irrigation, which is located outside of the Study Area and is about 7km away

from the STW. A water quality analysis was conducted at a well used for drinking purpose in a small village near the farm (W1), and two wells (W2 and W3) at another farm and a golf course which are about 3 km away from the former well. (location of the sampling points are shown in Figure 3.5.2, Section 3.5, Data Report)

Table 3.5.8 Outline of Examined Wells

Sampling No.	Location of Irrigation Land	Concerned STW	Purpose	Distance from Irrigation Land	Depth of Well
W1	Imbgwa	Zengeza	Drinking	0.5 km	10 m
W2	Imbgwa	Zengeza	Drinking	4.5 km	10 m
W3	Imbgwa	Zengeza	Drinking	3.5 km	8 m
W4	Marlborough	Marlborough	Sprinkling	3.0 km	6 m
W5	Marlborough	Marlborough	Sprinkling	3.0 km	7 m

The results of the water quality analysis are shown in Table 3.5.51, Section 3.5, Data Report. The results of the three wells in Imbgwa (W1, W2 and W3) indicate the presence of high nitrogen and phosphorus concentrations. Although the value of T-N is high, due to the concentration of inorganic nitrogen, such as NH_4-N, NO_2-N and NO_3-N, are low. Thus, these wells are assumed to be influenced by livestock excreta, nitrogen fertilizer and dried grass rather than the effluent from the STW. On the other hand, the nitrogen and phosphorus concentration in W1, which is nearer to the re-use site, is higher than that of W2 and W3. There is a possibility of groundwater contamination by the effluent from the STW.

The same phenomenon was observed at the wells near the Marlborough STW (W4 and W5). The concentration of nitrogen and phosphorus is high, but inorganic nitrogen is low. This means water may be affected by fertilizer and grass rather the effluent from the STW.

With regard to heavy metals, the analysis results are evaluated in comparison with the WHO's drinking water guideline; as a result, the water quality in some wells slightly exceeds the standards as shown below:

Index with standard		Wells Exceeding the standards
Fe (less than 0.3 mg/l)	:	All wells
Ni (less than 0.02 mg/l)	:	W2 and W5
Cd (less than 0.003 mg/l)	:	W4 and W5

However, considering that the WHO's guideline describes the "desirable" level as drinking water and does not imply that drinking of water exceeding the guideline's quality standards will cause immediate health hazards, the possibility of a direct health hazard from these wells is deemed to be minimal. The influence of the effluent reuse for irrigation is deemed to be scarce, as Cd was not detected and the Ni level was within the relevant standards at the Zengeza STW.

Concerning the agricultural chemicals, atrazine, captan and chlorpyrifos were examined as the representative agricultural chemicals in the study area. But these chemicals were not detected in the wells in this Study.

Although the influence of the treated effluent in relation to the groundwater quality was not clearly demonstrated, it is recommended that periodical observation and monitoring of wells at strategic location be carried out to wit the safety for drinking use.