CHITNGWIZA MUNICIPALITY
REPUBLIC OF ZIMBABWE

THE PROJECT FOR THE IMPROVEMENT OF WATER SUPPLY, SEWAGE AND SOLID WASTE MANAGEMENT IN CHITUNGWIZA IN THE REPUBLIC OF ZIMBABWE

FINAL REPORT

Summary

SEPTEMBER, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NJS CONSULTANTS CO., LTD

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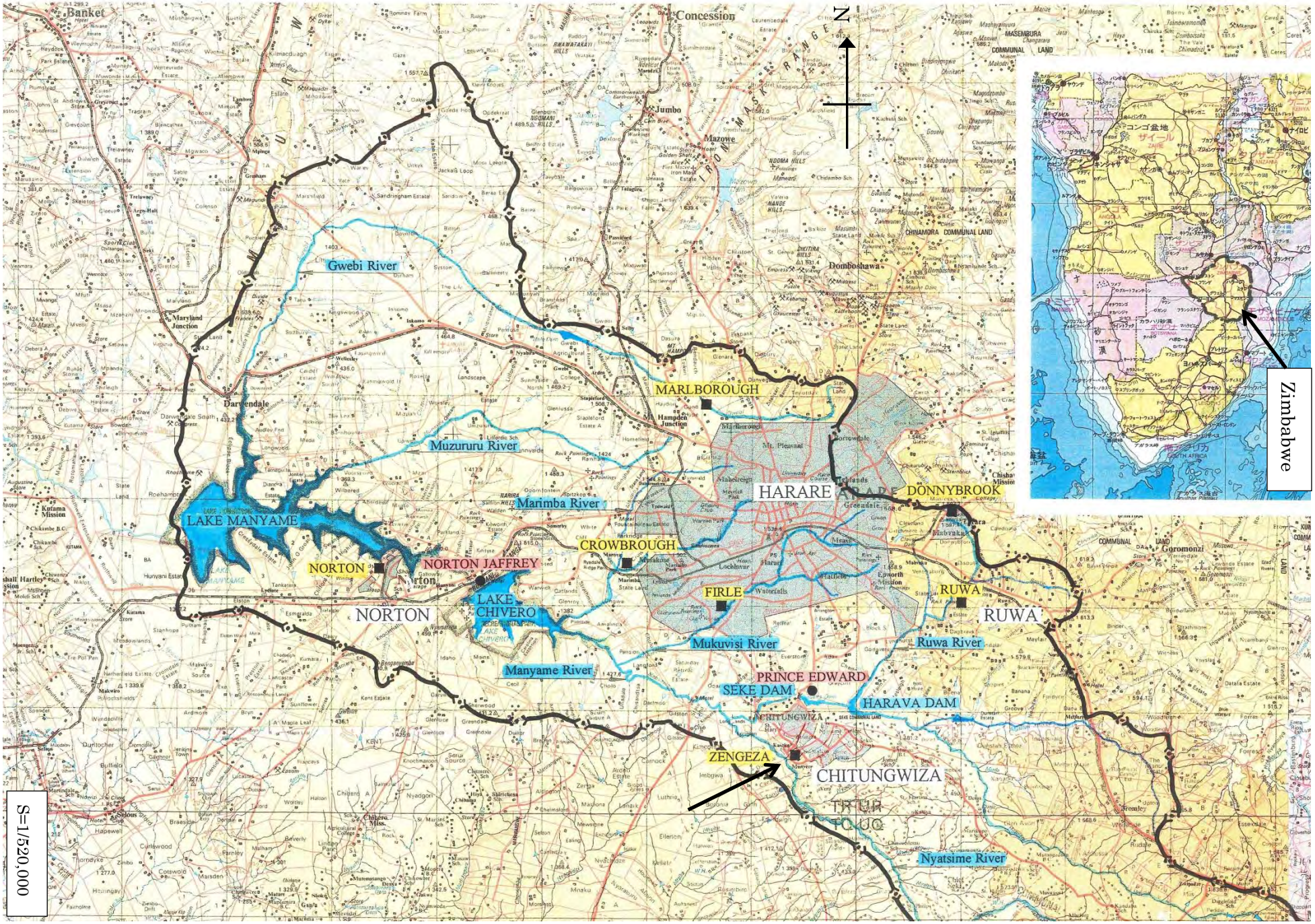
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Gwebi River
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MARLBOROUGH
HARARE
DONNYBROOK
CROWBROUGH
NORTON
NORTON JAFFREY
FIRLE
RUWA
PRINCE EDWARD
SEKE DAM
HARAVA DAM
ZENGEZA
CHITUNGWIZA
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Concession
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Mazowe
Domboshawa
Darwendale
Maryland Junction
Mt. Hampden Junction
Goromonzi
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List of Acronyms

ADA	Annual Daily Average
AfDB	African Development Bank
ATP	Ability to Pay
AusAID	Australian Agency for International Development
AWF	African Water Facility
BNR	Biological Nutrient Removal
CIDA	Canadian International Development Agency
CPI	Consumer Price Index
DANIDA	Danish International Development Agency
DFID	Department for International Development of the UK
DGIS	Directorate-General for International Cooperation of the Netherlands
EIRR	Economic Internal Rate of Return
EMA	Environmental Management Agency
ENPV	Economic Net Present Value
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FINNIDA	Finnish International Development Agency
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
FPL	Food Poverty Line
F/S	Feasibility Study
GDP	Gross Domestic Product
GNI	Gross National Income
GIZ	German Agency for International Cooperation
GOZ	Government of Zimbabwe
IBNET	International Benchmarking Network for Water and Sanitation Utilities
IDBZ	Infrastructure Development Bank of Zimbabwe
IFAD	International Fund for Agricultural Development
IFRS	International Financial Reporting Standards
ILO	International Labour Organization of the United Nations
IMF	International Monetary Fund
IPSAS	International Public Sector Accounting Standards
JICA	Japan International Cooperation Agency
JPY	Japanese yen
LA	Local Authority
MDG	Millennium Development Goal
MDTF	Multi-Donor Trust Fund
MEPIP	Minister of Economic Planning and Investment Promotion
MF	Ministry of Finance
MIS	Management Information System
MLGURD	Ministry of Local Government, Urban and Rural Development

M/P	Master Plan
MTP	Zimbabwe Medium Term Plan: 2011-2015
MWRDM	Ministry of Water Resources, Development and Management
NGO	Non-Governmental Organization
NORAD	Norwegian Agency for Development Cooperation
NRW	Non Revenue Water
NSP	New Stabilization Pond
NSSA	National Social Security Authority
ODA	Official Development Assistance
O&M	Operation and Maintenance
PAYE	Pay-as-you-earn tax
PDL	Poverty Datum Line
PFM	Public Financial Management
PPP	Public Private Partnership
PSIP	Public Sector Investment Program
SDC	Swiss Agency for Development and Cooperation
SIDA	Swedish International Development Cooperation Agency
STP	Sewage Treatment Plant
STW	Sewage Treatment Works
TA	Technical Assistance
TCPL	Total Consumption Poverty Line
UN Women	United Nations Entity for Gender Equality and the Empowerment of Women
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United Nations Fund for Population Activities
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
USD, US$	United States dollar
VAT	Value Added Tax
WASH	Water, Sanitation and Hygiene
WB	World Bank
WHO	World Health Organization
WSSW	Water Supply, Sewerage and Solid Waste Management
WTP	Willingness to Pay
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
ZIMRA	Zimbabwe Revenue Authority
ZIMSTAT	Zimbabwe National Statistic Agency
ZIM$	Zimbabwe dollar
ZINARA	Zimbabwe National Road Authority
ZINWA	Zimbabwe National Water Authority
ZSTP	Zengeza Sewage Treatment Plant

＜PART 1　BASIC STUDY ＞

CHAPTER 1　INTRODUCTION

1.1　The Background of the Study

In the late 1990s, rapid population growth in the Harare area contributed to a surge in residential and industrial developments. This brought about an increase in wastewater flow generated from the area, which was more than the treatment capacity of the existing wastewater treatment plant. As a result, runoff from the excess wastewater began to pollute the environment and water resources, such as Lake Chivero and Lake Manyame, with water quality worsening as the population grew and the area further developed.

To improve the situation, the government of Japan implemented a grant project for Chitungwiza Municipality and constructed a wastewater treatment plant in "The Project for Improvement of Sewerage Facilities in the Municipality of Chitungwiza", which was then handed over to the government of Zimbabwe in 2000. However, the economic conditions of Zimbabwe did not get any better in 2000, and the budget for proper infrastructure maintenance and improvements in water supply, sewerage and solid waste management was insufficient, thus making the environmental status worse in spite of the implementation of the project.

As a result of the above-mentioned conditions, the sewerage system has not been functioning properly resulting to a deterioration of the water quality of the water source and the attendant increase in the cost of operation and maintenance of the system. This situation caused the society negative impacts such as the cholera outbreak in the area in 2008.

The political situation in Zimbabwe has improved since 2008 eight years after some European countries and United States of America had imposed economic sanctions due to political reasons. The political stability in Zimbabwe prompted the government of Japan to resume bilateral and humanitarian aid activities. One of these is "The Project for the Improvement of Water Supply, Sewage and Solid Waste Management in Chitungwiza in the Republic of Zimbabwe" (hereinafter referred to as the Project).

With the economic and political stability in Zimbabwe, JICA conducted in January and February 2011 an investigation and data collection and analysis of the environment conditions in Chitungwiza Municipality in the "Data Collection Study on Improvement of Sanitary Environment of Chitungwiza Municipality". The report identified the dysfunctional situation not only for the solid waste management and sewerage, but also for the water supply system in Chitungwiza Municipality, upon

which, the government of Zimbabwe recognized that improvements were needed to upgrade the living conditions and the environment for the people of Chitungwiza. Consequently, the government of Zimbabwe decided to develop "The Project for the Improvement of Water Supply, Sewage and Solid Waste Management in Chitungwiza in the Republic of Zimbabwe", which addresses the essential improvements to the municipality's water supply, sewerage and solid waste management, and requested the government of Japan for a technical cooperation to develop the plan.

The government of Japan appointed JICA to start study on the specific plan for the project in June 2011, according to the agreement between the two governments. The Scope of Work of the technical cooperation (S/W) was discussed between JICA, Chitungwiza Municipality and the relevant authorities in Zimbabwe and was finalized on the 25th August 2011.

1.2 Objective of the Study

The objective of the study is to prepare the Master Plan (hereinafter referred to as M/P) and the Feasibility Studies (hereinafter referred to as F/S) for water supply, sewerage and solid waste management in Chitungwiza Municipality. In the F/S, the high priority projects will be selected and studied from the projects in the M/P. At the same time, the study will benefit the local counterparts (C/P) in Zimbabwe by building their capacity for future development planning.

1.3 Study Area and Scope of the Study

The Scope of Works identifies the stipulated study area as whole city area of Chitungwiza Municipality. However, in terms of the necessity of obtaining the detailed information of non-point pollution sources, Lake Chivero, Lake Manyame and its catchment area (including area of City of Harare), although out of the study area in the SW, are included in the area.

The main study area is Chitungwiza Municipality with the entire Upper Manyame Catchment Area and the city of Harare, the largest town in the catchment. In establishing the M/P, the following items were examined – effectiveness of the measure, operation and maintenance of the facility, problems and issues, necessary assistance by residents and Capital Expenditure and Operation Expenditure. Possible countermeasures for said items were also proposed.

An integrated approach was undertaken in this study, where pollution load in dry/wet weather condition, non-point pollution sources, and solid waste management were studied in parallel, considering the fact that all the surface run-off flow into the lakes.

1.4 Issues and Considerations Attended in the Study

Issues and considerations needed for the study are summarised in Table 1.1.

Table 1.1 Issues and Considerations

Items	Issues and Considerations
1. Organization of the study	・Chitungwiza Municipality is the C/P of the study and responsible for preparing M/P and F/S. ・A steering committee shall be established to examine the implementation of the study progress. Representatives from the Ministry of Local Government, Rural and Urban Development (MoLGURD） and the Ministry of Water Resources Development and Management (MoWRDM) shall be actively involved in the steering committee as core members by giving advice/guidance and leading the committee.
2. Phases of the Study	In the first year, the basic data shall be collected and analysed as Phase 1: Basic Investigation, and M/P to be prepared as Phase 2: Determination of M/P. In the second year, F/S shall be implemented as Phase 3: Implementation of Feasibility Study (F/S).
3. Capacity Development of C/P	A detailed work plan shall be prepared to improve C/P capabilities through M/P and F/S preparation and enhance their knowledge in maintenance and operation of the water supply, sewerage and solid waste management.
4. Pilot Project	During the M/P preparation, pilot project will be implemented to improve the capacity of the personnel and organization's strength in the management of water supply, sewerage and solid waste management. The outcomes of the pilot project shall be verified and evaluated be reflected in the final M/P report.
5. Study on Potential Donors to Implement Prioritized Projects	・Implementation of the priority projects by potential donors other than JICA will also be studied. Potential donors shall be researched and identified to cooperate with JICA for the priority projects. ・Meetings shall be held to inform each donor most updated information and progress of the study.
6. Existing Wastewater Treatment Plant	The repair work of the existing wastewater treatment plant constructed by JICA grant shall be studied in terms of methodology of repairs and funding through discussion with C/P and JICA based on the outcome of the Phase 1. The wastewater treatment plant was designed /implemented by NJS Consultants CO., LTD under JICA grant aid.
7. Current regulation/water quality standard for sewage /wastewater /treated effluent in Zimbabwe	Based on the current economic situation and poorly maintained infrastructure in Zimbabwe, the current regulations/standard set forth by the government of Zimbabwe are considered to be difficult to meet and apply on the sewerage system proposed in the study. In the study, these issues will be examined from various aspects and addressed.
8. Activities of AfDB and coordination with AfDB	The detailed information on the water and sewer facility maintenance projects in Chitungwiza Municipality proposed by African Development Bank (AfDB) shall be obtained from AfDB. The way of collaboration will be studied for better outcome through coordination and proposals will be made and included in the study.
9. Proposal of Effective Operation and Performance Indicator	・Necessary information and data shall be collected to establish a quantitative and qualitative performance indicator, which measures effectiveness and performance of the implemented projects. The target performance level will be set for 2 years after the completion of the projects proposed in the M/P. ・The target level shall be established according to future monitoring capability and verification of recipients used in M/P. In addition, indirect effects and impacts by development will be confirmed.
10. Economic and Financial Analysis	Through the discussion with the government of Zimbabwe, Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR) shall be studied for the projects proposed in the M/P.
11. Socio-Environment Consideration Study	・Following JICA socio-environment guidelines, progress of the Environmental Impact Statement, other related documents, and the status of land acquisition /resettlement in the study shall be researched and verified to provide appropriate support and advice. ・In the process of determining the project site, social impacts, such as land acquisition and resettlement shall be carefully considered to provide appropriate advice/recommendation.

1.5 Feasibility Study in Phase III

In order to guarantee the sustainability of the facilities to be developed in the future, it was decided through the discussion of both sides of Zimbabwe and Japan to put a certain period before the F/S to observe and confirm the financial status of Chitungwiza Municipality. Implementation of F/S will be considered when the restructuring of the municipality shows a certain progress.

CHAPTER 2 SOCIAL AND PHISICAL CHARACTERISTICS IN THE STUDY AREA

2.1 Outline of the Target Area

A topographical map of Zimbabwe is shown in Figure 2.1 and target area of this study is Chitungwiza Municipality as shown in the figure.

Source: Howstuffworks.com

Figure 2.1 Topography Map of Zimbabwe

The area of Zimbabwe is 290,757 km^2, it is slightly larger than Japan, but the longest distance between the western edge and eastern edge is less by 900 km due to its circular configuration. Zimbabwe sits astride the high plateaus between the Zambezi and Limpopo rivers, its main drainage systems. The majority of the country is elevated and relatively flat, 21% being more than 1,200 m above sea level. The target area of Chitungwiza Municipality including Harare Province is located in above area.

The target area has a tropical climate with a rainy season usually from late October to March but the climate is moderated by the high altitude. The average temperatures in major parts of target area (Manyame catchment) are relatively medium, from 12.0C to 20.0 C on average and the rainfall in this region is around 750-900 mm/annum.

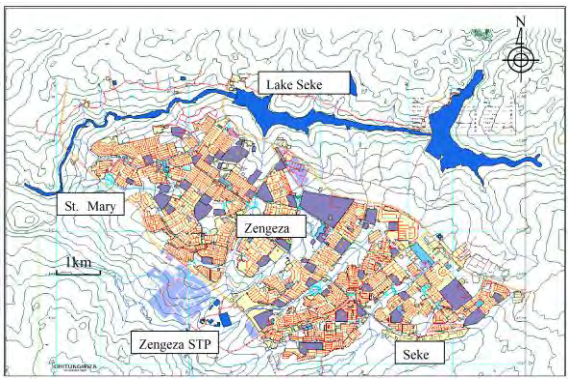


Figure 2.2 Layout of Chitungwiza Municipality

Zimbabwe gained independence as the “Republic of Zimbabwe”, is ruled by aboriginal people since 1980 after 57 years of the independence era ruled

by while people. After the independence, the country suffered the famous "hyper-inflation" and spreading of various epidemics, such as HIV and cholera. The hyper-inflation was finally solved by giving up of own currency and introduction of US dollar, and epidemics were almost solved by the effort of the National Health Service and various donor organizations. The country is divided into 10 provinces and Harare province is composed of City of Harare as the capital city and some districts including Chitungwiza Municipality. The total population of the country was 11,632,000 according to the 2002 census, and while the average population density is 30 people/ km^2, that of Harare province is 2,174 people/ km^2, very large.

Chitungwiza gained full municipal status in 1981 and most of the municipality area is classified as high density (around 250 people/ha) residential area with a population of 323,000 according to the 2002 census. In the municipality, most of the housing units were connected to water supply network and sewer pipes and in addition there is a garbage collection system with an open dumping site. However, there is a poor condition of water supply, breaking down of STP (Sewage treatment Plant) and PSs (Pump Stations) for sewerage system, and many places of illegal dumping of garbage.

2.2 Relevant Organizations of the Study

In Zimbabwe, the government has 32 ministries. Within these ministries, "Ministry of Local Government Rural and Urban Development" and "Ministry of Water Resources and Development" are the counterpart units. Target area of Chitungwiza Municipality is included in Harare Province as a district. Chitungwiza Municipality has six (6) departments under the mayor and town clerk as shown in Figure 2.3. Water supply and sewerage section are managed by the Engineering Department, and solid waste matters are managed by the Health Service Department.

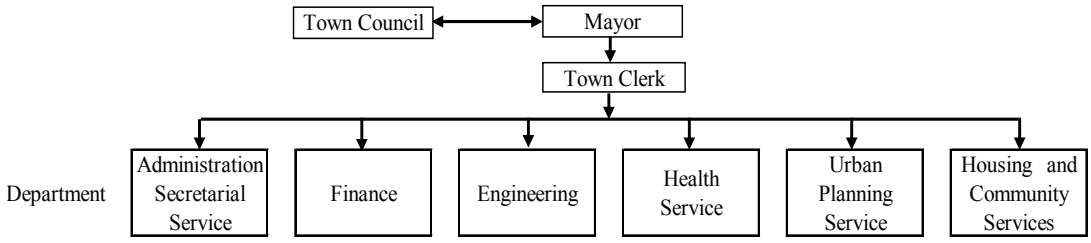


Figure 2.3 Organization Chart of Chitungwiza Town Council

2.3 Relevant Matters for Target Field of the Study

Harare province is located in Sub-zone CH4 [1] included in Upper Manyame Sub-Catchment Area, which provides water source to the province, and almost all waste water derived from the province is

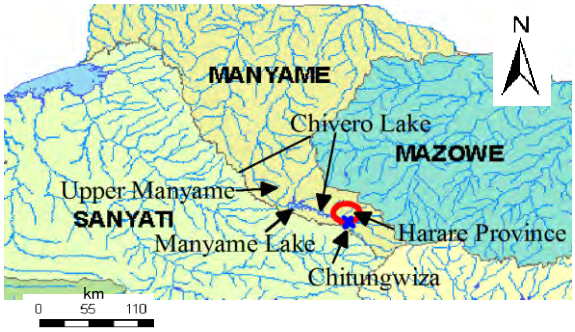


Figure 2.4 Map of Upper Manyame Sub-catchment Area

[1] One of five sub-zones in Upper Manyame Catchment

discharged to the catchment area. The location of major lakes and Chitungwiza in the catchment area is shown in Figure 2.4, and the hydro-geological features of it are shown in Table 2.1.

Table 2.1 Hydro-geological Features of Manyame Sub-Catchment Area

Sub-zoon	Catchment Area(km^2)	Unit yield(mm)	Storage ($mil.m^3$)	10% Yield ($mil.m^3$)	Yield in Use (%)	Rainfall (mm/y)	Evaporation (mm/y)
CH4	1,959	83	753	149	91	799	1,631
CH5	1,817	91	90	71	43	821	1,696
Total	3,776		842	220			
Average		87			68	809	1,662

Remarks: CH4 and CH5 are the two of the five subzones in the catchment
Source: JICA Project Team

There are two large lakes, Chivero and Manyame in the sub-zone, which are major water resources of the area. For these lakes, since all waste water with little or no treatment is discharged into these lakes, they have been heavily contaminated.

Historically, Zimbabwe's urban water supply and sanitary services development has been driven by principles of high service levels and standards and universal access for all, making them unique in Africa. However, due to the economical hardship, the conditions have drastically dropped. For instance, access to urban water supply decreased from 97% in 1990 to 60% in 2008 and access to urban sanitation decreased from 99% in 1990 to 40% in 2008. Then the central government, urban authorities and ZINWA stipulated a recovery period which will develop improved institutional options for water services provision including regulation of service delivery, tariffs and dealing with effluent. In order to realize it, the financing of the sector needs to be established through mechanisms such as the ring fencing of water services revenue, incentivizing improved operational efficiency and addressing capital investment financing needs.

2.4 Environmental Status in the Project Area

The state of pollution of the water bodies that are water supply sources is deteriorating since these also serve as final disposal points of some partially treated wastewater from the STPs. Due to intermittent water supply; some residents rely heavily on unprotected shallow wells even for drinking water. These wells among others are causes of the cyclical outbreaks of cholera and typhoid. These are aggravated by the inappropriate drainage and toilet systems and high groundwater level that are most likely to affect groundwater quality. Another issue is garbage that is dump indiscriminately in the designated open dumpsite or in illegal dumpsite with some garbage finding its way to the nearest river that is part of the network that supplies drinking water. At most times, these are malodorous and high fly breeding areas; sometimes human wastes are dumped together with domestic wastes. Significant negative effects associated with this unsanitary method are surface and groundwater pollution, foul odour and air pollution, exposure to hazardous substances and breeding grounds for disease vectors.

Two monitoring programmes are conducted: 1) by EMA for surface water and effluent; and 2) by DOH [2](Chitungwiza) for groundwater. The major challenges that face the present water quality monitoring system are: 1) Both EMA and the DOH have no comprehensive management of the water quality monitoring programmes; 2) No database system for the monitoring programme in both agencies; 3) Enforcement of some provisions in the Acts and SIs (Statutory Instruments) on compliance monitoring has not been fully implemented; 4) Some standards are not yet established; and 5) Absence of microbiological monitoring of effluent from STPs for water reuse such as agriculture/irrigation and livestock farming.

Five water quality monitoring points for years 2007-2012 were established in the Upper Manyame Basin by EMA. Due to the absence of ambient water quality standards, the results were evaluated referring to the effluent standard (SI 6, 2007) using the BLUE classification (Blue criteria - environmentally safe), showed that in areas that failed, river water quality already exhibited the characteristics of an effluent. Indices consistently failing the effluent standards for discharge are: BOD (all points), DO (2 points), TSS (2 points), TDS (I point), PO_4 (2 points), Fe (2 points), and Mn (3 points). In all instances, the points of Seke Bridge and Nyatsime River (after the discharge point of Zengeza STP) consistently failed to meet minimum standards set for these parameters.

Eight wells of the total 35 shallow and borehole wells tested in 2012 were found positive for coliform bacteria. E. coli was present in 3 of these wells. The physical and chemical characteristics of well water tested were all within allowable limits except for the high levels of nitrate in 3 wells.

CHAPTER 3 INSTITUTIONAL, LEGAL AND FINANCIAL FRAMEWORK OF WATER QUALITY MANAGEMENT

3.1 Institutional and Legal Framework for Water Quality Management

There are various agencies involved in water quality management: the national government: provincial offices: local authorities: and statutory (parastatal) and non-governmental bodies. At the national level, there are 4 major agencies which are directly involved in water quality management, and another 2 that are particularly concerned with planning and financial management. Several institutions also train/educate people in the courses directly and indirectly related to water pollution control.

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. For the

[2] Department of Health of Chitungwiza Municipality

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 Government promotes the policy to decentralise the present administration system to local authorities to establish a bottom-up managing system. To achieve socio-economic development, the Government prepared national development plans to outline the economic policies, priorities, projects and programmes for a particular period, the latest is the Medium Term Plan, 2011 -2015. The local development plans prepared by the local authorities provide for orderly planning of regions, districts and local areas. The local authorities are also required to establish an Environmental Action Plan (local) based on the concept of sustainable development and community empowerment.

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. A number of laws, statutory instruments, regulations and guidelines have been promulgated necessary for the protection of the aquatic environment, maintenance of acceptable quality in lakes, reservoirs, streams, groundwater and public health.

The Environmental Impact Assessment process is applied to projects that are identified by EMA before these are implemented. Public participation is also a requirement of the EIA process and the policy states that the public should participate in the preparation and review of EIA reports. These consultations typically focus on determining the probable impacts and the mitigation measures that will be acceptable to the community involved.

3.2 Financial Framework for Water Quality Management

The central government's expenditure in 2011 was USD 2.7 billion, or about 30% of GDP, indicating that the government is relatively small-sized. A 52% of the expenditure was appropriated for employment cost, followed by other recurrent expenditure (24%) and capital expenditure (22%). On the revenue side, VAT accounted for 33%, followed by personal income tax (21%), corporate income tax (14%) and custom duty (11%). The Government of Zimbabwe (GOZ) adopts the cash budgeting principle whereby its expenditures are contained within its own capacity to finance them by cash. Thus the expenditures and the revenues nearly balance. Borrowing funds from domestic and international lenders is quite difficult for the GOZ due to the lack of creditworthiness. Old foreign debts of the GOZ have been unpaid and Western countries' economic sanction has not been lifted.

The amount of ODA that the GOZ receives is also limited. During the first nine months of 2012, the ODA receipt was about USD 0.4 billion from bilateral sources and USD 0.2 billion from multilateral sources. The bilateral and multilateral assistances to the GOZ are disbursed through trust funds such as Zim Fund (managed by African Development Bank) and Global Fund (by UN). The Water Sanitation

and Hygiene (WASH) Cluster in Zimbabwe is coordinated by UNICEF, covering mainly urban water and sanitation rehabilitation.

The fiscal sizes of the GOZ, the City of Harare Council, the Chitungwiza Municipality Council, the water supply accounts, the sewerage accounts and the waste management accounts are comparatively shown in Table 3.1.

Table 3.1 Comparison of Recurrent Budgets 2011

(US$ million, projection or estimation base)

Government		Recurrent revenue	Recurrent expenditure	Surplus / Deficit
Zimbabwe		3,020.4	2,744.9 *	275.5
Harare total		250.4	246.4	4.0
	Water	81.8	103.6	-3.3
	Sewerage	18.5		
	Waste management	20.1	20.1	0.0
Chitungwiza total		20.1	24.5	-4.4
	Water	5.9	4.4	1.5
	Sewerage	2.2	1.6	0.6
	Waste management	2.9	3.1	-0.2

Source: Compiled by JICA Project Team

* Including capital expenditure

Local Authorities (LAs) such as the City of Harare and the Chitungwiza Municipality too operate the cash budget and live within their means. Raising sufficient funding to ensure satisfactory service delivery is big challenges for them. Bank loans are generally difficult to obtain due to the unstable fiscal situation. The Public Sector Investment Programme (PSIP) fund is a loan facility from the central government to LAs which can be used for infrastructure development including water supply and sanitation. The PSIP allocation, however, is very limited reflecting the tight credit situation of GOZ itself. Harare is owed by many of the residents due to the council's service delivery slippage and the residents' impoverishment. Also the state and the business community are their big debtors. Likewise Chitungwiza faces a similar problem of indebtedness by many ratepayers unsatisfied with the council's service delivery. At both councils the employment costs constantly constitute the greatest portion (above 40%) of the recurrent expenditures. This high level of the employment costs crowds out non-wage expenditures in areas such as social service delivery and infrastructure development.

Domestic tariffs and monthly water bills of water, sewerage and refuse collection in Chitungwiza and Harare were computed and compared. Harare has the low density area tariff and the high density area tariff, while Chitungwiza has no such distinction. In terms of water bill, residents of Chitungwiza are

charged USD 15.89 per month which is slightly higher than those who live in high density areas of Harare, who are charged USD 15.75. But residents in low density areas of Harare are billed nearly a double (USD 28.65). For both sewerage and refuse collection, Chitungwiza residents are charged much lower bills. The monthly sewerage bill in Chitungwiza is USD 4.51 per connection, while in Harare the bills are USD 5.75 at high density areas and USD 12.65 at low density areas. The refuse collection bill in Chitungwiza is USD 3.36 per residence, while in Harare they are USD 7.48 at high density areas and USD 10.93 at low density areas. Other utility and service bills were also compared with the water, sewerage and refuse collection bills in Chitungwiza. The water bill (USD 15.89) is less than a half of the monthly electricity bill (USD 37.30), LP gas cost (USD 30) and firewood (USD 30). The sewerage bill (USD 4.51) and the solid waste management bill (USD 3.36) are even lesser. The mobile telephone cost (USD 30) is nearly twice the water bill.

The performance comparison of water supply, sewerage and solid waste management between Chitungwiza and Harare was attempted using limited amount of financial data. Although further technical data are needed to complete the analysis, provisional results are summarized in Table 3.2. The following can be said from the results.

- In Chitungwiza both the water supply and the sewerage have achieved nearly the full coverage. The coverage in Harare is relatively high being over 80%. However, it should be noted that even when the water is supplied during limited hours or with limited amounts, the population is regarded to be served.
- The operating cost coverage ratio of water and sewerage is 1.36 at Chitungwiza, being considered favourable as the operating revenues exceed the operating expenses. The same ratio is 0.97 at Harare, meaning that the operating expenses exceed the operating revenues therefore unfavourable. Chitungwiza is a water “deliverer”, as they purchase treated water from Harare and distribute it. While Harare is a water “manufacturer”- cum – “deliverer”, meaning that they treat raw water and distribute the treated water. This difference in business model and the price of treated water are mostly causing the difference of operating cost coverage ratio.
- The operating cost coverage ratio of solid waste management is 1.18 at Chitungwiza and 1.00 at Harare, meaning that Chitungwiza is sound and that Harare is not. In terms of the annual operational cost per served population, Chitungwiza shows USD8.13, which is lower therefore favourable when compared with USD12.49, the same indicator of Harare. This cost difference, however, does not indicate the difference of service level as this information is not clarified.

Table 3.2 Performance Comparison of Harare and Chitungwiza

Indicator	Chitungwiza	Harare
Population in served area	354,500	1,581,900
Water coverage (%)	99	85
Water production (m^3/day)	30,000	640,000
Sewerage coverage (%)	99	80
Total water consumption * (liter/person/day)	64	205
Non revenue water (%)	25	57
Operational cost W&WW (USD/m^3 water sold)	0.73	1.03
Average revenue W&WW (USD/m^3 water sold)	1.00	1.00
Operational cost SWM (USD/served population)	7.57	12.71
Staff per 1000 population served - Water	0.15	0.83
Staff per 1000 population - SWM	0.49	0.65
Collection period W (Days)	766	N/A
Collection ratio W (%)	65	N/A
Operating cost coverage W&WW (ratio)	1.36	0.97
Operating cost coverage SWM (ratio)	1.18	1.00

Source: Compiled by JICA Project Team
* computed as "total water use devided by served population", therefore includes industrial use.
W = water supply, WW = wastewater, SWM = solid waste menagement, N/A = not available

CHAPTER 4 CURRENT STATUS OF WATER SUPPLY, SEWAGE AND SOLID WASTE MANAGEMENT

4.1 Water Supply

4.1.1 Water Supply System of Great Harare Area

Chitungwiza Municipality is distributed bulk water from Harare Water Works, of which supply areas are Harare Urban, Harare Rural, Chitungwiza, Epworth and other surrounding areas. The total population of the service area of Harare Water Works is 1,947,000 in 2002, while that of Chitungwiza is 323,260 according to 2002 census.

Water supply in Harare Province and the surrounding areas relies on surface water withdrawn from Lake Chivero, Harava, Seke and Manyame Dams. All these impoundments are located on the Manyame River System. According to SAPROF study “Harare Water Supply Project” (1993-1996), the total 537,050 m^3/day, 15% of yield from Chivero-Manyame catchment and in addition 163,200 m^3/d of recycled water derived from advanced sewage treatment plants (STPs) can be available by 2005. However, after the infamous hyper-inflation, all advanced treatment processes in STPs in Manyame River System, including Zengeza STP located in Chitungwiza, broke down and stopped operations. It means over 150,000 m^3/d of waste water has directly flowed in the river system. In 2012 march, only around 10% of advanced processes were operational.

There are two water treatment plants (WTPs), Prince Edward (PE) WTP and Morton Jaffray (MJ) WTP, for Harare Water Works in the catchment area. The design production capacity of PE-WTP is 90,000 m^3/d. However, the actual capacity is 55,000 m^3/d in ordinal seasons and 40,000 m^3/d in the dry season, respectively. The WTP is located only several km north of Chitungwiza Municipality and distributes bulk water to the municipality. Raw water for the WTP is taken from Seke and Harava Dams, and the yield capacity of the lakes is not enough to meet the production amount due to the small storage volume of the dams with a total of 12.5 million m^3.

Since the WTP was constructed in 1950 and renovated in 1973, the facilities have deteriorated due to lack of proper rehabilitation. However, replacement of major facilities was done in 2009-2012 by EU and Red Cross even though the replacement was not thorough. The WTP employs sludge blanket type sedimentation basin and rapid sand filter, and inject not only aluminium sulphate, soda ash, chlorine and coagulation aid but also activated carbon powder to improve on the heavily contaminated water condition. When this WTP is stopped due to power failure or lack of water source, water is distributed to Chitungwiza Municipality by gravity from the eastern area of City of Harare, which elevation is much higher than that of the municipality. MJ-WTP is a major water production source of Harare Water Works and the recent actual production amount is said to be 585,000 m^3/d, even though the design capacity is 520,000 m^3/d (less 80,000 m^3/d due to broken down facilities). The raw water is taken from Lake Chivero (60%) and Manyame (40%) Dam, and Chivero Lake is heavily contaminated because almost all waste water discharged from the catchment area is flowing in without treatment.

The Majority of purified water from MJ-WTP is pumped through four transmission mains to the Warren Control P/S (pump station) and distributed to the distribution areas of Harare Water Works. This water distributes to Chitungwiza Municipality only when PE-WTP is stopped through the pipe network of the city.

4.1.2 Water Supply System in Chitungwiza Municipality

As mentioned in the previous section, Chitungwiza Municipality is basically supplied bulk water from PE-WTP, and the average flow rate is 30,000m^3/d based on flow measurement by the Team. Figure 4.1 shows the model of the current water distribution system in the municipality. The system is very peculiar because the majority of water is distributed to the municipality by transmission pump at PE-WTP directly although all water distributed from Harare Water Works should once be transmitted to the ground reservoirs in Seke Reservoir Site, and the water should be distributed to the municipality from ground reservoirs directly or from the elevated tank for high elevation areas.

The ground reservoirs are only used for a pump pit for the lift pump of the elevated tank. It means that the reservoir volume of around 41,000 m^3 is not used for flow regulation and the distribution flow is constant even though the demand changes from time to time.

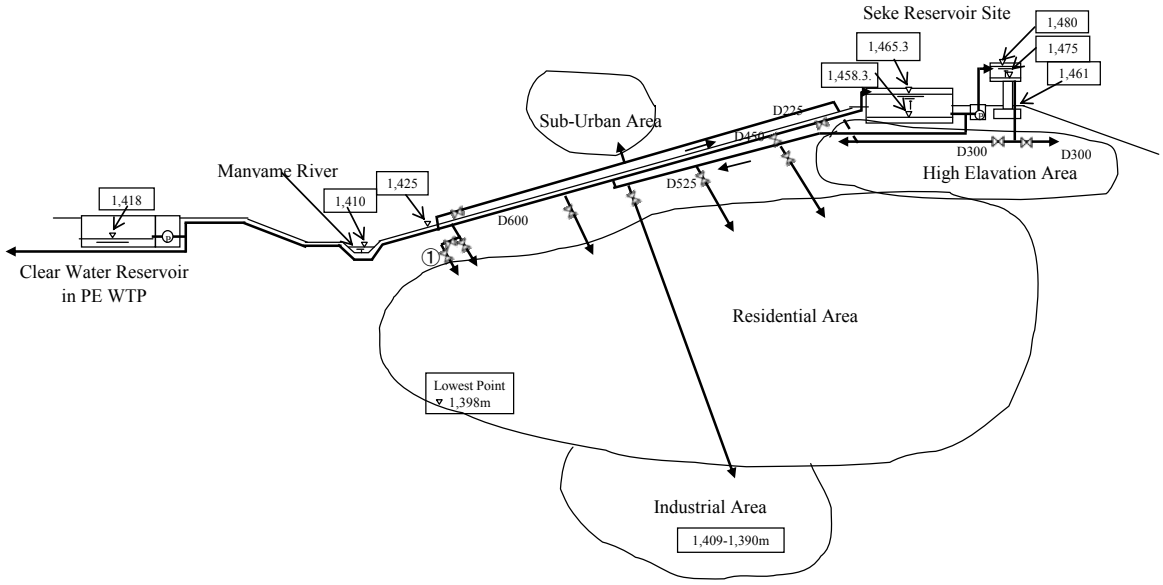


Figure 4.1 Current Water Supply System in Chitungwiza

Because of such kind of uncompleted distribution system and insufficient bulk water supply, water supply condition of the municipality is very poor. Water distribution for the majority of people is limited to less than two days a week.

4.1.3 Population of Distribution Area

The estimated current population of Harare Metropolitan Area is estimated to be 2,213,000 including that of Chitungwiza Municipality of 354,500, although Harare Water Works estimates the total population of the area to be 4.5 million. For the estimation of Chitungwiza population, the number of housing units was counted by Google Map and average number of people per household was actually surveyed.

4.1.4 Water Consumption of Target Area

In Harare Water Works distribution area, current actual production amount of MJ- WTP and PE-WTP is 640,000 m^3/d in normal season, while the water consumption in 2012 was estimated to be 383,000 m^3/d (domestic: 261,000, industrial: 90,000 and commercial/institutional: 32,000). Since the NRW (Non Revenue Water) rate is estimated to be 57% (by Harare Water Works), the distribution amount is required to be 890,000 m^3/d, and therefore the water supply is currently not enough to meet the demand.

Chitungwiza Municipality is supplied bulk water from Harare Water Works, and the average water supply amount of 30,000 m^3/d is simply regulated by Harare Water Works so that it does not meet the demand. The water consumption records of the municipality for domestic use are not reliable because of very little meter readings. However, those for commercial/institutional and industrial use are relatively reliable because the tariff collection is based on the meter reading records. Water

consumption of such entities is 2,200 m^3/d (industrial use; 1,100 and other various entities use; 1,100) and it means that the domestic consumption is 20,300 m^3/d (30,000 × (1-0.25(assumed NRW rate)) – 2,200 = 20,300). Per capita consumption of the municipality was determined to be 61.5 lpcd.

However, since the majority of people living in the municipality are never supplied with sufficient water, over 3,000 wells are used for supplemental water supply.

4.2 Sanitation/Sewerage: Service Coverage and Sewerage System

(1) Service coverage

Within the Chitungwiza municipal area of 1,519.5 ha, three townships (St. Mary's, Zengeza and Seke) and the Tilcor industrial area are almost fully served by the public sewerage system. However, there are areas which are not connected to Zengeza STP due to blockage or malfunction of the sewerage system. In St. Mary's, population of some 54,000 are not connected due to breakdown of three pump stations in the area. Also, around 21,300 in Seke north are not connected because of blockages in the trunk sewers; while about 35,900 in Seke-south are not connected due to the breakdown of a pipe bridge discharging the sewage into a channel. Finally, about 7,100 in a part of the Zengeza near the industrial area are not connected, again due to sewer breakdown. From the result of the investigation, about 410 ha and about 120,000 of the areas' population are not connected to the ZSTP. Since the ZSTP is not working, full flow of sewage has been flowing out to both of Nyatsime River and Manyame River. After the completion of the AWF project for sewers and three pump stations, most of the sewage from the municipality will flow into the ZSTP. In this connection, earlier rehabilitation of ZSTP with the commencement of treatment is required. Rehabilitation of ZSTP will be conducted for pre-treatment (screening and grit chamber), three anaerobic ponds, five units of trickling filters and pump stations for irrigation under the AWF project.

(2) Sewer Reticulation

The sewer reticulation in the study area consists of major trunk sewer, secondary sewer, lateral sewer, house connections and pump stations. The sewage collection system employed is the separate system and makes full use of gravity, except for some areas in St. Mary's and the Tilcor industrial area. Clogging of the sewers has been a serious problem in the system. The removal of deposited sand and silt in the sewers is done by using a jet-cleaning vehicle. However, this has not been done since the equipment broke down in 2001. Sand in the sewers and screenings accumulated at the pump stations has to be manually removed. The major trunk sewers are branched to three lines and an independent alignment to the Zengeza STP without joining any other lines on its route. There are four pump stations in St. Mary's (No. 1, 2 and No. 3) and in the Tilcor industrial area due to topographical configuration.

The industrial wastewater from the Tilcor area is discharged to the river instead of draining it into

major trunk sewer of Tilcor due to break down of the trunk sewers and manholes. Trunk sewers are considered to have adequate capacity for the flow. However, sewer clogging and sewage spilling out from the manholes have been frequently occurring. They are considered to be the result of the inflow of sand from the outside. The three major trunk sewers are thought to have sufficient capacities against current sewage flow. However, the sewer reticulation (including the trunk sewers) system is not properly maintained as shown from the frequently reported spilling-out from manholes.

As a result of the evaluation of existing sewers, the sewer reticulations have some leeway for the expected flow and rated pump discharge capacities. A major problem has been the sand deposit in the sewer lines due to high sand concentration in the sewage. This unit generation of the sand in the sewers and their origins have been studied in the Pilot Project in this Project and the situation is understood to be serious necessitating drastic countermeasures.

Vandalism against the sewerage system is another issue. Theft of the manhole covers, disposal of the solid waste to the sewer lines have been recorded a lot in Chitungwiza Municipality.

(3) Sewage treatment works

The Zengeza Sewage Works is situated north of Nyatsime River between two tributaries draining the Seke section of the Residential Area. The existing and proposed new Industrial Area lies to the southwest and is unable to gravitate to the Zengeza Works. The present capacity of the Works was designed for about 40,000 m^3/day within the present fenced area. However, all the works are not functioning due to breakdown of the facilities. The Zengeza Sewage Treatment Plant was designed by the City of Harare for an ultimate flow of 27,270 m^3/day. This Works was commissioned late in 1978 and consisted of two sets of anaerobic ponds and two biological filters. In December 1980, biological filter number 3 was commissioned and in June 1981, the third set of anaerobic ponds were in operation with the fourth biological filter being commissioned in September 1986, and the fifth biological filter commissioned in 1987.

The treatment capacity of the old system with trickling filters is 21,750 m^3/day. The present sewage inflow rate is 27,000 to 35,000 m^3/day as assumed in the former section, and the BOD concentration 600 mg/l (estimated figure: 577 mg/l), the SS concentration 650 mg/l (estimated figure: 648 mg/l). The treatment processes employed at the STP include anaerobic ponds for the primary treatment and trickling filters for the secondary treatment, and Biological Nutrient Removal (BNR) facility for advanced treatment as shown below. There is no final sedimentation tank and the treated effluent is sent to farmland for the old system. The regulation to discharge effluent into the river is strict, not allowing for the secondary treated effluent. The effluent is therefore sent to the farmland for further treatment and re-use/disposal under the old system. For the BNR system, effluent from the system was good enough for discharge directly to the river till 2004.

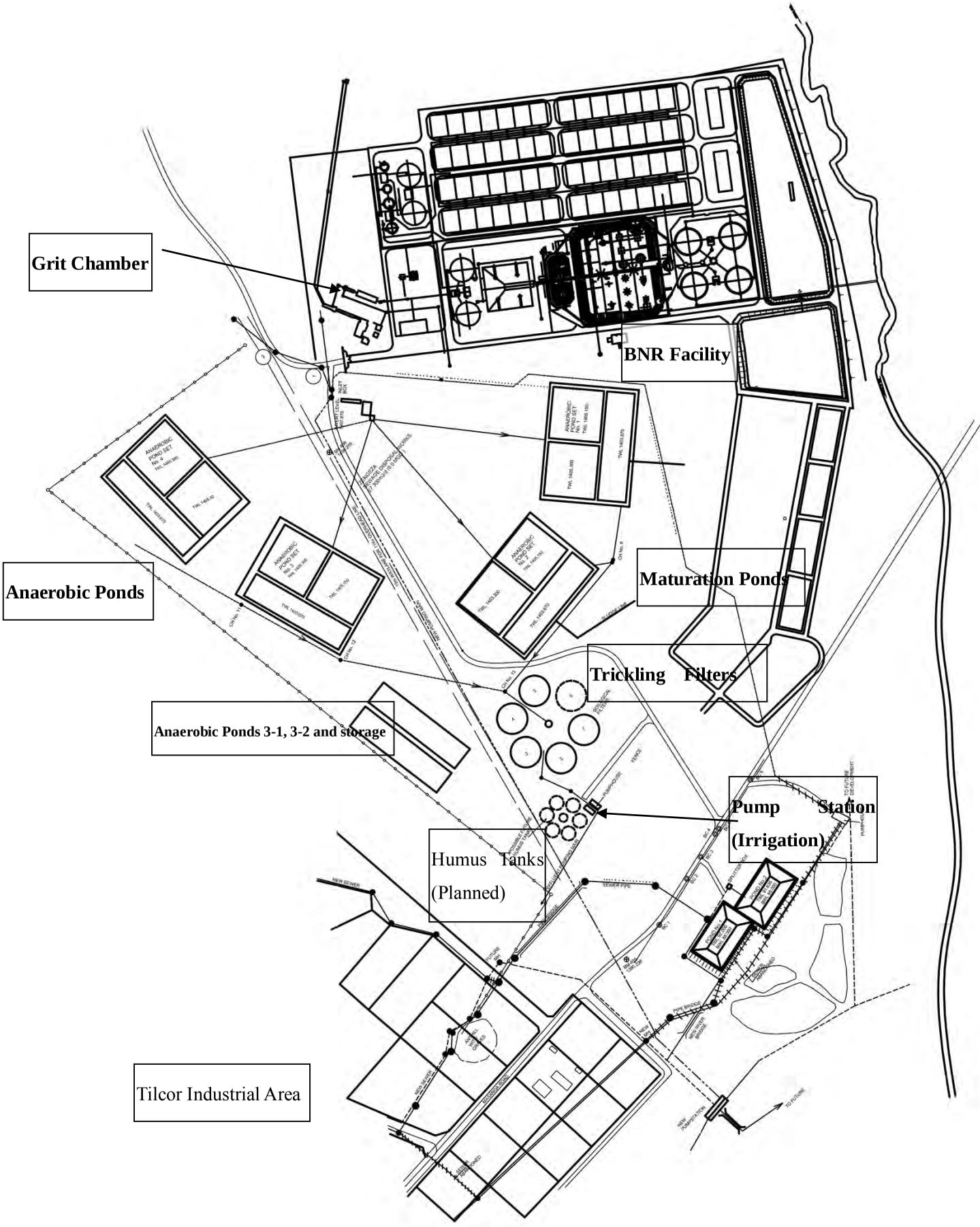


Figure 4.2 Plant Layout of the Zengeza STP Source: JICA Project Team

4.3 Solid Waste Management

4.3.1 Current State on Solid Waste Management in Chitungwiza Municipality

(1) Organization of solid waste management service

Solid waste management in Chitungwiza is currently carried out by the solid waste management section under the Health Department headed by a deputy director.

(2) Collection and transport system

The collection system in Chitungwiza municipality is classified into two systems, 1) house-to house collection method which the municipality's tipper trucks collect the household waste packed with a bag on a road side, and 2) skip-bin method which the municipality's skip loader collect skip bins at shopping areas or markets. The collected wastes are transported to a final disposal site (open dumping), which is located at about 5km from the city center. The municipality's collection service area cover all city areas. However, there are some non-collection service areas in each district of Saint Mary's, Zengeza and Seke. The main cause of non-collection is estimated to be inaccessibility of collection vehicles due to bad road conditions or existence of discharge of sewage on the road leading to the areas.

(3) Final disposal

1) Existing open dumpsite

The existing final disposal site in Chitungwiza Municipality is located at 3 to 5 km from the city centre. The landfill is an open dumping without truck scale, administration office, fence, rainwater drain ditch, leachate treatment facility and impermeable liner for leachate.

2) Future plan on final disposal facility

The Chitungwiza Municipality has a future land use plan which covers a new final disposal site with an area size of 38.1 ha, 4.5 km from the city center and the its ownership of the central government.

The site is adjacent to a future housing lot and is not recommend as final landfill site because of its close distance to the housing lot and schools.

(4) Recycling / Intermediate treatment

Recycling business is currently done by one private group in Chitungwiza. They recycle plastics and glass, and do not recycle paper or carton. The group sells these recyclable materials to manufacturers in Harare.

4.3.2 Current State on Solid Waste Management in City of Harare

The solid waste management in City of Harare is operated by waste management and final disposal sections which belong to the Amenity Department. A total of 1,030 staff members are involved in the operation of solid waste management. For the residential area, a house-to-house collection system is provided while the container collection system is used for the commercial and industrial areas.

However, compactor trucks are used to be provided collection service at residential areas.

The final disposal site is located at around 10 to 15 km north from the city centre. The facility is just an open dumping area which has no fence, lining, truck scale, and rainwater drain and leachate treatment facilities. There are waste pickers at the landfill site.

4.3.3 Waste Amount and Composition Survey

(1) Waste generation amount

1) Daily Per Capita Waste Generation or Waste generation Amount per Establishment

The amount of per capita waste generation for residential area is about 0.43 kg/person/day in average; while establishments generate a total average of 2,283.4 kg/establishment of waste daily.

2) Daily generation Amount of waste

The current amount of waste generated on a daily basis in Chitungwiza Municipality is estimated at 176.6 t/day and the most of the waste is generated from residential areas.

(2) Waste composition

Food waste and yard waste make up most of the waste produced by the residential communities. The results show that high and middle income areas produced higher food waste compared to low income areas. On the other hand, the low income areas generated more yard waste compared to other income areas.

4.3.4 Illegal Dumping Survey

The completed survey resulted in the identification of 390 illegal dumpsites throughout the municipality. The majority of the sites are in Zengeza district, followed by Seke South. The sites were visible to the public. A great majority of the sites documented in this report were located in close proximity to streams. The illegal dumping sites cover an estimated area of 100,000 m^2 and have an approximate volume of 60,000 m^3.

CHAPTER 5 EVALUATION OF CURRENT ISSUES

5.1 Water Supply

5.1.1 Harare Metropolitan Area

The major issues for water supply in Harare Metropolitan Area are described below:

(1) Water Resource Shortage and Contamination

Water resources for WTPs, which Harare Water Works is operating are Lake Chivero and Manyame

Dam for Morton Jeffray (MJ) WTP and Seke and Harave Dams for Prince Edward(PE) WTP. The comparisons between the intake amount of WTPs and yield capacities are shown Table 5.1.

Table 5.1 Comparisons between WTP Intake Amount and Yield Capacities

WTP/Item	Intake Amount ($1000m^3$/d)		Yield Capacity ($1000m^3$/d)			Capacity ($mil.m^3$)	Storage Year (year)	
	Design	Actual	4%	10%	20%		Design	Actual
Morton Jaffray	630	643.5*1	422.7	559.6	743.1	727.4	3.16	3.62
Prince Edward	95	60-45*2	13.9	26.4	31.5	12.6	0.36	0.63

*1: Production amount of 585,000 m^3/d in 2011 × 1.1 = 643.500 m^3/d

* 2: Intake during ordinary season is 60,000m^3/d while during dry season is 45,000 m^3/d

The JICA Project Team recommended that the total yield capacity with 10% risk including recycled water from sewerage for MJ-TWP is 759,600 m^3/d and that for PE-WTP with 20% risk is 31,800 m^3/d. It means that Water source for MJ-WTP is enough and that for PE-WTP falls short.

However, the assumed actual demands of the distribution area are 383,000 m^3/d daily average and 440,000 m^3/d daily maximum, and if 57% of NRW ratio is adapted necessary distribution amounts are 891,000 m^3/d and 1,070,000 m^3/d to the actual production amount of 640,000 m^3/d. Therefore since the water distribution amount to the service area is strictly short, a Kunzwi Dam development plan (Developed yield capacity of around 200,000 m^3/d) is the highest priority plan for Harare Water Works.

The water source of MJ-WTP is Chivero Lake (60%) and Manyame Lake (40%). Chivero Lake receives all discharge water from Harare Metropolitan area, which has been discharged directly through Manyame River without any treatment, while Manyame Lake receives water overflowed from Chivero Lake only during the rainy season and river water from some rivers with less developed catchment areas. These are the reasons why Chivero Lake contamination has been quite extreme but Manyame Lake has not been as much contaminated. Because the urbanization of catchment area of Seke and Harave Lake has not been so heavy, contamination of these lakes is less than that of Chivero and Manyame Lakes. Table 5.2 shows the raw water qualities of MJ-WTP and PE-WTP.

Table 5.2 Raw Water Quality of WTPs (2010)

Items/WTP	MJ Average	PE Average
pH	8	7.3
Total Solids (mg/l)	266	152
Dissolved Solids (mg/l)	258.9	100.1
Suspended Solids (mg/l)	56.4	78.9
Turbidity (NTU)	19.5	3.6
Colour (Hazen Units)	>70	30
Total Hardness (mg/l $CaCO_3$)	152	61
Dissolved Oxygen	1.9	5.9
BOD_5	1.1	1.2
Free NH_3 (N)	0.61	TR
Iron (mg/l Fe)	Nil	Nil
Manganese (mg/l Mn)	0.17	0.135
Conductivity (ms/m)	303	143
Temperature ^OC	26.8	24.7

(2) Deteriorated facilities, insufficient repair and replacement

In PE-WTP, from 2009 to 2012, the major facilities have been replaced or repaired, therefore this

WTP can be operated normally with the actual production capacity of 55,000 m^3/d even though the recovery of the automatic and monitoring function of facilities were not implemented.

The facilities of No.1 Plant of MJ-WTP are very old and deteriorated, and the half of facilities has been inoperable, causing severe water shortage. In addition, the deterioration of the rest of facilities has been progressing, and the management of Harare Water Works has formulated a rehabilitation plan and has been trying to acquire necessary funds for the plan even though they have not succeeded. The transmission and distribution pipes and facilities have also heavily deteriorated as shown by the extreme NRW (Non Revenue Water) ratio of 57%, and the management also formulated a plan for the rehabilitations. These severe deteriorations were caused by insufficient maintenance and repair due to lack of adequate budget.

5.1.2 Chitungwiza Municipality

(1) Insufficient supply amount of bulk water

The frequent interruption of the water supply in many areas is caused either on purpose by Harare Water Works, or simply because of the lack of water. If the municipality can acquire 36,000 m^3/d it can distribute water to almost all areas even though it is not at once. The biggest problem is the intentional stoppage or reduction of bulk water by Harare Water Works due to unpaid charge for the bulk water or severe shortage of water for Harare itself.

(2) Uncompleted water transmission and distribution facilities

In the municipality, bulk water is basically distributed to the supply areas from distribution pipes branched from transmission pipes to transmit from PE-WTP to Seke reservoirs, and if it is transmitted to the ground reservoirs a shutting down of branch pipes is required. Because reservoirs should be used for flow regulation to meet fluctuating water demands, this system is incomplete. In addition, some hydraulic evaluation results for the existing pipe network by normal flow of 45,000 m^3/d shows that many pipes have negative pressure, and thus water cannot flow to many areas in the municipality by gravity.

(3) Insufficient maintenance of facilities and low collection rate of water charges

The facilities which the municipality manages are the water transmission and distribution facilities; water transmission lines with various valves, four ground reservoir structures, one small scale P/S, one elevated reservoir and water distribution lines from the diameter of 50 to 525 mm. Within these facilities, the condition of P/S is very poor, some valves have broken down and some old pipe lines are clogged.

In municipality water service section, the account of water charge to consumer is normally USD 5.5-5.7 mil. But, actual collected charges were USD 3.7-3.9 mil. from 2010 to 2011, while the bulk

water charge from Harare Water Works was around USD 3.4 mil. Because the other expenses of the water section was around USD 0.6 mil., the actual incomes were not enough to the expenditure of USD 4.0-4.3 mil. The municipality has paid the total of only USD 1.2 mil despite the total of USD 10.3 mil charged from 2010 to 2012. The total amount of overdue to Harare Water Works reached USD 12.7 mil. by February 2013.

5.2 Sanitation and Sewerage

5.2.1 Functional Recovery of the Sewerage System in the Chivero Catchment Area

Harare is the capital city of Zimbabwe and is located in the Lake Manyame catchment area. It discharges STP effluent into the main tributaries of Lake Chivero and also abstracts its raw water from the lake. Wastewater is treated at the two main STPs of Crowborough (capacity 54,000 m^3/d) and Firle (144,000 m^3/d).

These two plants treat about 60% of the raw wastewater using modified activated sludge systems, popularly referred to as biological nutrient removal (BNR) systems, whilst the rest (40%) is treated by means of trickling filters (TF). Effluent from Crowborough STP is discharged to Marimba River and that of Firle STP flows into the Mukuvisi River except for effluent for irrigation. The trickling filter effluent and primary and secondary sludge (after digestion for primary sludge only) are mixed and used for pasture irrigation.

However, the two major STPs are partly broken and overloaded and often discharge partially treated effluent into the main tributaries of Lake Chivero. As a result, water quality of Marimba River and Mukuvisi River has been badly deteriorated in recent years, resulting in serious water quality problems in Lake Chivero. Since both STPs almost discontinued the use of the BNR facility because of budget problems, the direct discharge has polluted Lake Chivero more.

Zengeza STP in Chitungwiza Municipality was treating about 36,000 m^3/day by TF and BNR processes. However, after 2004, both treatments were discontinued because of serious budget problem affecting proper maintenance. At the same time, effluent transmission pump broke down resulting in the direct discharge of the raw sewage into Nyatsime River polluting its tributaries.

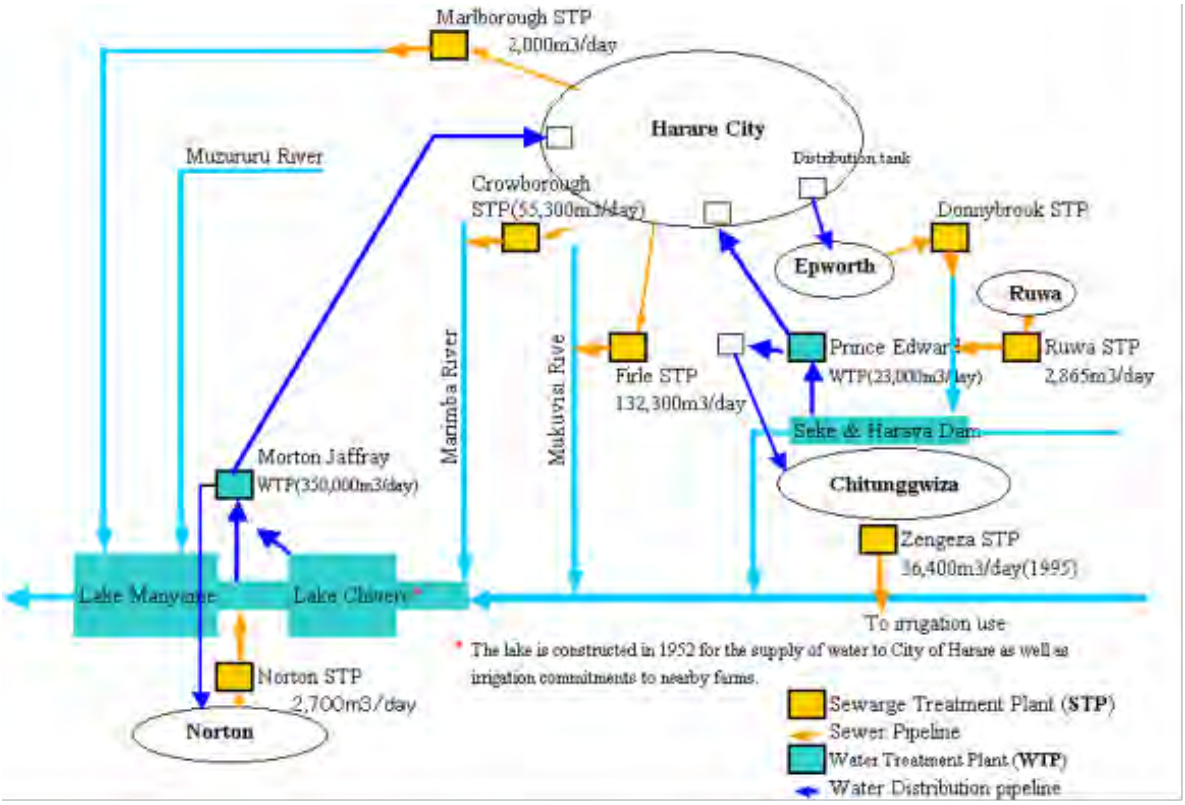


Figure 5.1 Manyame Catchment and WTP/STP Facilities

For Norton, TF process was working till the year of 2000. However, treatment was discontinued also because of budget problems. After the breakdown of the transmission pump to the irrigation farm caused by vandalism, raw sewage has been discharged to the Lake Manyame. In August 2012, the Morton Jaffray WTP partially discontinued water intake from the Lake Manyame due to the water pollution, affecting water supply for the City of Harare. The accident was caused by direct discharge of the raw sewage from Norton STP.

Ruwa STP has a stabilization pond process. However, satisfactory maintenance work such as sludge removal from the anaerobic ponds has not been done by the township. Half treated sewage has been discharged to the Nyatsime River polluting the Lake Chivero. The discharge of partially treated wastewater into rivers is obviously not sustainable in the long-run as it could result in the further deterioration of water quality in Lake Chivero. Polluting the water sources by discharge of unsatisfactory sewage treatment and discharge is obvious from the study.

As shown in the pollution analysis, most of the generated pollution loads are considered as coming from Harare and Chitungwiza. Thus, functional recovery of the sewerage system including irrigation of the farms is urgently needed for the improvement of the environment in the catchment. As presented in the Chapter 6 Pollution Analysis, sewage is the biggest pollution load for the water sources in the catchment area. And improvement of the water quality is projected in the simulation after the rehabilitation of the STPs. Thus, rehabilitation of the sewerage system will be the urgent

measure to be taken. AfDB project for the six cities for the rehabilitation of water, sewage and hygiene and AWF project for the Chitungwiza Municipality will be taken as urgent measures for this project, and complementation between this project and AfDB/AWF projects will be required.

All the STPs have the problems for the sewage treatment process. Multi-donor fund under AfDB has been financing the rehabilitation of facilities for City of Harare. AWF project will fund the Zengeza STP aimed at the rehabilitation of five existing units of trickling filters, pump station for irrigation and others for urgent measures. The project will be economically desirable, but not sufficient to improve effluent water quality. It will be required to take supplementary measures to get satisfactory water quality as required by regulations. Norton STP is also broken down. However, there is no specific rehabilitation plan for the STP.

5.2.2 Water Quality Conservation

The main water management problem in the catchment is that wastewater discharges contribute significantly to eutrophication in Lake Chivero and Manyame, although the current extent is not well known. The problem is compounded by the fact that water released from the lake does not take place frequently in years of low rainfall as the dam floodgates are permanently closed. A big problem is that the population in the catchment depends on the water from Lakes Harava, Seke, Chivero and Manyame, until another water source will be developed. The Zimbabwe Government should reconstruct the water quality monitoring system as well as the functional recovery of sewerage system in order to conserve these water sources. The establishment of the water conservation measures is the major point in terms of protecting/ safely securing the water sources and improving the environment by water pollution control. Even if the irrigation is used to alleviate the washout of the pollutant and nutrient for the water body, this might pollute the groundwater and soil in the long run.

5.2.3 Sewer Reticulation

Sewer reticulation in Chitungwiza was roughly confirmed to have capacity required for the future flow till 2030. However, it will need a lot of repair work and rehabilitation. The work includes continuous sand removal. Breakdown of the sewers as well as all the sewage pump stations is found in the Municipality. Sewage spills have been seen around the Municipality. From the standpoint of environment conservation, urgent countermeasures must be taken. To deal this situation, AWF project is underway for rehabilitation of sewer reticulation and three pump stations. Since the budget of AWF project is limited, not all the problematic parts will be covered. For example, Tilcor industrial area is not included in the AWF project. All the sewage from the Tilcor flows into the existing channel in the area thereby polluting Nyatsime River. Then, supplemental measures will be needed in this field as well. The situation of the sewer reticulation is the same in other Municipalities.

5.2.4 Sand Issues

Another issue is the presence of sand in the pipelines and reticulation. Although rehabilitation work has been on-going under the AfDB scheme (Multi donor fund) for city of Harare and Chitungwiza municipalities, clogging problems caused by sand deposit in the pipelines or pump stations are prevalent: Clogging of sewers, sewage spilling out from manholes polluting streets, buried grit chamber in the STP by sand deposit and flooding in the pump station due to inappropriate sand disposal method around the sewage facility. The origin of the sand is thought to be sand used by residents when washing their pots. However, the real reason has not yet been identified. The sand deposit in the sewers is seen to also negatively affect lake capacity. In order to plan the right counter measure for the sand issue, field tests were conducted.

5.3 Solid Waste Management

5.3.1 Evaluation of Current Issues on Solid Waste Management

(1) Illegal dumping

Illegal dumping was identified in and around the Chitungwiza Municipality by the illegal dumping survey. Lack of public awareness, problems of accessibility of the municipality's collection service, lack of the municipality's collection capacity and no comprehensive plan for controlling illegal dumping are estimated as causes of illegal dumping.

(2) Collection & transport

1) Insufficient collection capacity

The municipality's collection vehicles have been used for over 10 years old and most are either malfunctioning or non-functioning. The current collection level to the current waste generation amount is only 38%, which clearly shows the low capacity of the municipality's collection service.

2) Frequency of collection service

The frequency of the municipality's collection service is currently on a weekly basis which presents a problem from the point of view of hygiene, as kitchen waste will have to be stored for the same period in the in household.

3) Lack of capacity of operation and maintenance

In the solid waste management section, fuel or tires are not often supplied. These are necessary for proper operation and maintenance of the vehicles to ensure service vehicles for scheduled solid waste collection. The appropriate budget is not allocated to the normal operation of the solid waste management.

(3) Final disposal

The current final disposal facility is an open dumping which has no fence, truck scale nor function of leachate control system, such as impermeable liner. Soil covering, which is effective for hygiene control such as pest management, is not carried out. In addition, the municipality's facility is not

managed appropriately as waste pickers currently operate in the dumping site. The municipality has not done much to improve the existing open dumping site even with the order/ recommendation of EMA.

CHAPTER 6 ANALYSIS OF WATER QUANTITY AND QUALITY IN MANYAME CATCHMENT AREA

6.1 Water Quantity and Quality in Manyame Catchment Area

(1) Water use in the entire study basin

In the upper Manyame river basin, the major impoundments are Lake Manyame, Lake Chivero, Seke Dam and Harava Dam. Several rivers flow into these water bodies. The direct use of river water is minimal due to limited availability during dry season. As for irrigation, about 200 private dams are scattered in the Gwebi and Muzururu catchment area, while the reuse of treated effluent is dominant in the entire Study Area. On the other hand, lakes and dams are utilized for water supply, recreation and commercial fishery purposes. Four impoundments are the most valuable water sources for water supply of metropolitan Harare where presently 467,000 m^3/day are availed of. As for recreational usage, Lake Manyame and Lake Chivero are designated as national recreational parks with a variety of interests including fishing, boating, swimming and game viewing. Commercial fishery is also allowed in both lakes. Since these impoundments are situated at a lower elevation than the urban area and farm land, generated wastewater reach the lakes.

(2) Ambient water quality standards

In Zimbabwe, the regulation of effluent for wastewater has been enacted. However, the ambient water quality standards have yet not been established. To prepare the water pollution control plan for the Upper Manyame Basin, the establishment of the Ambient Water Quality Standard would be primarily required. A proposal for the Ambient Water Quality Standard was made in "the Study on Water Pollution Control in the Upper Manyame River Basin in the Republic of Zimbabwe" (hereinafter the Study 1997), in 1997 conducted by JICA. Since the Study 1997 is considered to be sound for the catchment area, proposed standard will be followed in this study.

The ambient items for rivers as adopted in Japan comprise pH, BOD, SS, DO and a coliform group; and for the lakes Total Nitrogen (T-N) and Total Phosphorus (T-P) were added and COD was replaced by BOD. In view of practicability to the present situation in Zimbabwe, it is deemed appropriate to adopt at least the same items and apply respective values based on WHO standards, while such items, other than the Japanese Standards, shall be subject to be added when they are detected in the subject water body through monitoring and/or being introduced in economic activities.

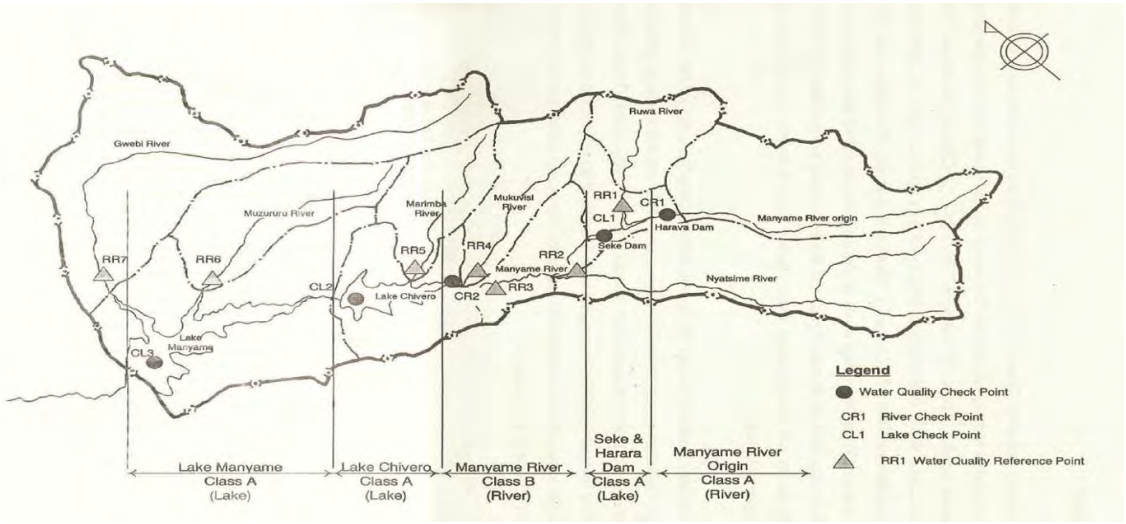


Figure 6.1 Subject of Sub-water Bodies. Source: JICA Project Team

(3) Flow balance in the future

Approximately 1,000,000 m^3/day has been inflowing to the Lake Chivero from the catchment including the effluent from the Firle STP, Crowborough STP, Zengeza STP, Ruwa STP and Norton STP. Around 640,000 m^3/day has been drawn for the water supply from the PW-WTP and MJ-WTP. Water loss by evaporation and others is assumed to be 450,000 m^3/day which is 60% of the total outflow from the Lake Chivero. Lake Manyame has been supplying about 60% of raw water for the MJ-WTP (about 360,000 m^3/day). Inflow from the Lake Chivero averages about 80,000 m^3/day. Water loss by evaporation and others is assumed to be about 250,000 m^3/day. Approximately 930,000 m^3/day has been flowing into Lake Manyame from the catchment with less inflow from the STP.

6.2 Current Water Pollution Analysis

6.2.1 Methodology

(1) Rivers

In the study, the residual ratio of the pollution load of each river was derived through the analysis of self-purification. Reached pollution load was estimated using frame values, unit pollution load and assumed reaching ratio. Run-off load was estimated based on the existing data on flow rate and water quality of rives.

(2) Lakes/Dams

Water quality indices used in the study were T-N, T-P and COD. COD was uti1ised to eliminate the influence of algae in the examination of BOD. The Vollenweider Model was adopted for the water pollution simulation model in terms of T-N, T-P and COD, and the increase of COD caused by elution from sediment in the lake is considered in this concept.

6.2.2 Fundamentals for the Analysis

(1) Domestic/Commercial/Institutional/ Sewage

The pollution load collected from the sewered area will flow into the sewage treatment plant. The pollution load was calculated using existing data at the STPs. BOD load was adopted for the water pollution analysis of rivers; while COD, T-N and T-P load were selected for the pollution analysis of lakes.

(2) Industrial wastewater

1) Industrial wastewater flow

Industrial wastewater flow was examined using the data of industrial wastewater flow per employee and the number of employees.

2) Pollution load

Pollution load was calculated by multiplying the unit pollution load of industrial wastewater per employee and the number of employee at present.

3) Sewered/ Unsewered wastewater

Wastewater flow and pollution load were calculated for sewered/ unsewered by public sewerage system based on the present conditions described below.

6.2.3 Result of the Current Water Quality Analysis

Result of the pollution analysis for the current status is summarised below:

(1) Generated pollution load

The biggest pollution loads in the catchment area are from City of Harare, which is about 110,000 kg-BOD/day. The reached pollution load to the Chivero Lake is assumed to be about 33,000 kg-BOD/day, reducing about 70% of the load in the river. Chitungwiza Municipality comes in second, discharging a pollution load about 13,000 kg-BOD/day. The reached pollution load to the Manyame river is assumed to be 3,900 kg BOD/day reducing about 70% of the load in the river. While the reduction of the pollution load in the river is quite significant, the influence of these loads is still serious as evidenced by the continuing deterioration of water quality in the rivers and lakes as shown in (2). Influence of non-point sources such as natural pollution and pollution from livestock is not significant compared with the load from the urban area.

(2) Status of river pollution

Other than the Upper-Manyame river, the entire aquatic environment is seriously polluted.

Upper-Manyame river:	Clean (1.3 mg BOD/l) with low pollution load
Ruwa river:	Polluted (97 mg BOD/l) with high pollution load from Ruwa
Downstream of Seke:	Clean (1.5 mg BOD/l) with high pollution load from Ruwa
Nyatsime river:	Heavily polluted (118 mg BOD/l) by Chitungwiza pollution load

Manyame River before Chivero: Polluted (40 mg BOD/l) with high pollution load
Lake Chivero: Polluted (5.0 mg BOD/l, 10.8 mg N/l, 0.7mg P/l)
Lake Manyame: Polluted (2.0 g BOD/l, 19.1 mg N/l, 1.5 mg P/l)
Remarks: BOD was used for the Lakes for the simplicity, instead of COD

The rivers receive sewage from Harare and Chitungwiza and are seriously polluted with pollution loads coming from both urban and rural areas. Eutrophication of the lakes is also serious as indicated by concentrations of N and P. One of the problems is the flow rate of the rivers especially in the dry season when flow rate is one-third that of rainy season, and dilution of nutrients does not work effectively.

(3) Purification capability of the lakes

The purification of the rivers and lakes of pollution loads is evaluated to be very effective in the improvement of water quality according to the model. Water quality of the intake for the water treatment plant is actually much better than the computed result. It shows the high performance of the lakes in the water treatment capability.

6.3 Future Water Pollution Analysis

6.3.1 General

Scenario 0 : Same condition with current condition as of 2012 (No improvement)
Scenario 1 : All the STPs operation under condition after the urgent improvement
Scenario 2 : All the STPs operation with 3 STPs upgrading BNR (from TF or WSP to BNR)
Scenario 3 : All the STPs operation with 100% irrigation
Scenario 4 : No improvement for only ZSTP to confirm the influence of pollutant discharge from Chitungwiza Municipality

Analytic models cover both human and natural pollution loads generated for point and non-point sources. The flow model employs the same flow shown in the current analysis of the entire basin for future water pollution analysis. Population projection was conducted for 2020 and 2030 with 1.6% of population increase ratio in Chitungwiza and 1.4% of ratio in other areas after considering the current status and trends.

(1) In the scenario 0, no improvement was considered to predict the worst pollution status.
(2) Scenario 1 took urgent measures for Crowborough STP and Firle STP for Harare (Rehabilitation of BNR and Trickling Filters by Zim Fund), Zengeza STP for Chitungwiza (Rehabilitation of Trickling Filters by AWF project), and rehabilitation of Norton STP by some donor. The Ruwa STP was planned as existing in this case, which is waste stabilization pond.
(3) Scenario 2 is planned to predict the effect of the employment of the BNR process for Firle STP, Crowborough STP and Zengeza STP.
(4) Scenario 3 was planned to evaluate the effect of the irrigation by which the pollution loads can be completely transferred outside of the catchment.

(5) Scenario 4 is excluding the improvement of only Chitungwiza Municipality to evaluate the scale of the effect of the pollutant discharge from the municipality

6.3.2 Discussion and Conclusion

(1) General

Based on the load run-off model established, the concentration of the parameters at water quality checking points of rivers was conducted and projected for each scenario for the years 2020 and 2030.

(2) Rivers

The result of the pollution analysis for the current status in the dry season is summarised below:

Based on the load run-off model established, the concentration of the parameters at water quality checking points of rivers was conducted and projected for each scenario for the years 2020 and 2030.

< Scenario 0, - no improvement >

Reached pollution loads from City of Harare will be 1.5 times, or from the current 110,000 kg-BOD/day to about 160,000 kg-BOD/day in 2030. Load from Chitungwiza will also increase from the current 13,000 kg-BOD/day to 24,000 kg-BOD/day in 2030. Water quality in the Ruwa River, Mukuvisi River, Marimba River will be serious. T-N and T-P show the same tendency.

Ruwa river: Polluted (97 mg BOD/l ⇒530 mg BOD/l)
Nyatsime river: Polluted (118 mg BOD/l⇒218 mg BOD/l)
Manyame river before Chivero:
Polluted (40 mg BOD/l⇒72 mg BOD/l)

Thus, no improvement will bring the disastrous influence to the Lake Chivero and Lake Manyame. The situation must be avoided because Water source for the WTPs will be polluted. Ground water source will be polluted as well by infiltration of sewage into the ground.

< Scenario 1, 2 >

From Harare, generated pollution loads to the rivers will decrease to about 3,400 kg-BOD/day from the current 110,000 kg-BOD/day in scenario 1, 2 in 2030. Chitungwiza Municipality will discharge no pollution loads due to irrigation use. T-N and T-P show the same tendency with the BOD.

Ruwa river: Improved (97 mg BOD/l ⇒6.7 mg BOD/l)
Nyatsime river: Improved (118 mg BOD/l⇒3.9 mg BOD/l) from Chitungwiza
Manyame river before Chivero:
Improved (40 mg BOD/l⇒2.3 mg BOD/l)

Improvement of Sewerage of City of Harare by Zim Fund project and Chitungwiza by AWF project will improve the current status drastically. Followed augmentation/continued effort of maintenance will keep the ambient environment as improved.

< Scenario 3 >

From Harare, generated pollution loads to the rivers will decrease to zero in scenario 3 in 2030. Chitungwiza Municipality will discharge no pollution load due to irrigation use. T-N and T-P show the same tendency with the BOD.

Ruwa river: Improved (97 mg BOD/l ⇒7.6 mg BOD/l)
Nyatsime river: Improved (118 mg BOD/l⇒4.3 mg BOD/l)
Manyame river before Chivero:
Improved (40 mg BOD/l⇒2.4 mg BOD/l)

Generally speaking, the measures of wastewater treatment will be effective for water quality improvement.

< Scenario 4 >

From Harare, generated pollution loads to the rivers will decrease to zero in scenario 4 in 2030. Chitungwiza Municipality will discharge biggest pollution load to Nyatsime River, about 16,000 kg-BOD/day because of no improvement of sewerage. T-N and T-P show the same tendency with the BOD.

Ruwa river: Improved (97 mg BOD/l ⇒7.6 mg BOD/l)
Nyatsime river: Polluted (118 mg BOD/l⇒147 mg BOD/l)
Manyame river before Chivero: Improved (40 mg BOD/l⇒28.5 mg BOD/l)

Nyatsime River will be polluted very badly because of pollutant discharge from Chitungwiza Municipality. Inflowing pollution load to Lake Chivero will be 5,565 kg-BOD/day increased from 3,636 kg-BOD/day which is 1.53 times bigger than Scenario 1. Influence of no-treatment at ZSTP will drastically aggravate the water quality in the Nyatsime River.

(3) Lakes / Dams

The improvement of water quality of lakes/dams from the present status is shown below:

Although the change in water quality will be very slow compared with the case of the river, water quality will become worse in scenario 0 but will see improvement in scenario 1, 2, 3 and 4. Concentration of T-N and T-P is relatively high in every case. In the scenario 2, employing BNR for all facilities will be significant in terms of water cycle. However, water quality in Lake Chivero will be a bit worse than scenario 1 in which irrigation is employed for the facilities other than BNR.

Table 6.1 Water Quality Projection in Seke and Harava Dam

Items	Scenario Number	Water Quality (mg/L)		
		2012	2020	2030
COD	Scenario 0	3.6	3.6	3.7
	Scenario 1		3.5	3.5
	Scenario 2		3.5	3.5
	Scenario 3		3.5	3.5
	Scenario 4		3.5	3.5

Items	Scenario Number	Water Quality (mg/L)		
		2012	2020	2030
T-N	Scenario 0	4.0	4.2	4.5
	Scenario 1		3.7	3.7
	Scenario 2		3.7	3.7
	Scenario 3		3.7	3.7
	Scenario 4		3.7	3.7
T-P	Scenario 0	0.3	0.3	0.4
	Scenario 1		0.3	0.3
	Scenario 2		0.3	0.3
	Scenario 3		0.3	0.3
	Scenario 4		0.3	0.3

Source: JICA Project Team

Table 6.2 Water Quality Projection in Lake Chivero

Items	Scenario Number	Water Quality (mg/L)		
		2012	2020	2030
COD	Scenario 0	9.2	9.5	10.2
	Scenario 1		8.3	8.3
	Scenario 2		8.5	8.5
	Scenario 3		8.1	8.1
	Scenario 4		8.4	8.4
T-N	Scenario 0	9.0	9.1	9.6
	Scenario 1		8.6	8.7
	Scenario 2		8.9	9.0
	Scenario 3		8.4	8.4
	Scenario 4		8.7	8.7
T-P	Scenario 0	0.7	0.7	0.7
	Scenario 1		0.7	0.7
	Scenario 2		0.7	0.7
	Scenario 3		0.7	0.7
	Scenario 4		0.7	0.7

Source: JICA Project Team

Table 6.3 Water Quality Projection in Lake Manyame

Items	Scenario Number	Water Quality (mg/L)		
		2012	2020	2030
COD	Scenario 0	17.5	17.8	18.5
	Scenario 1		16.7	16.7
	Scenario 2		16.9	16.9
	Scenario 3		16.5	16.5
	Scenario 4		16.8	16.8
T-N	Scenario 0	17.8	17.9	18.4
	Scenario 1		17.4	17.4
	Scenario 2		17.6	17.7

Items	Scenario Number	Water Quality (mg/L)		
		2012	2020	2030
	Scenario 3		17.2	17.2
	Scenario 4		17.4	17.5
T-P	Scenario 0	1.5	1.5	1.5
	Scenario 1		1.4	1.4
	Scenario 2		1.4	1.5
	Scenario 3		1.4	1.4
	Scenario 4		1.4	1.4

Source: JICA Project Team

CHAPTER 7 PILOT PROJECT

7.1 Water Supply

7.1.1 Hand Pump Installation

There are over 3,000 wells installed in Chitungwiza Municipality. Almost all these wells utilize a bucket and rope to hoist water; this is quite inefficient and insanitary. The Team thereby planned to improve this inefficient and insanitary condition through installation of hand pumps. The selected area is Unit L as shown in Figure 7.1, where water is distributed for several hours in a week, and in addition, there are many wells with a high yield capacity.

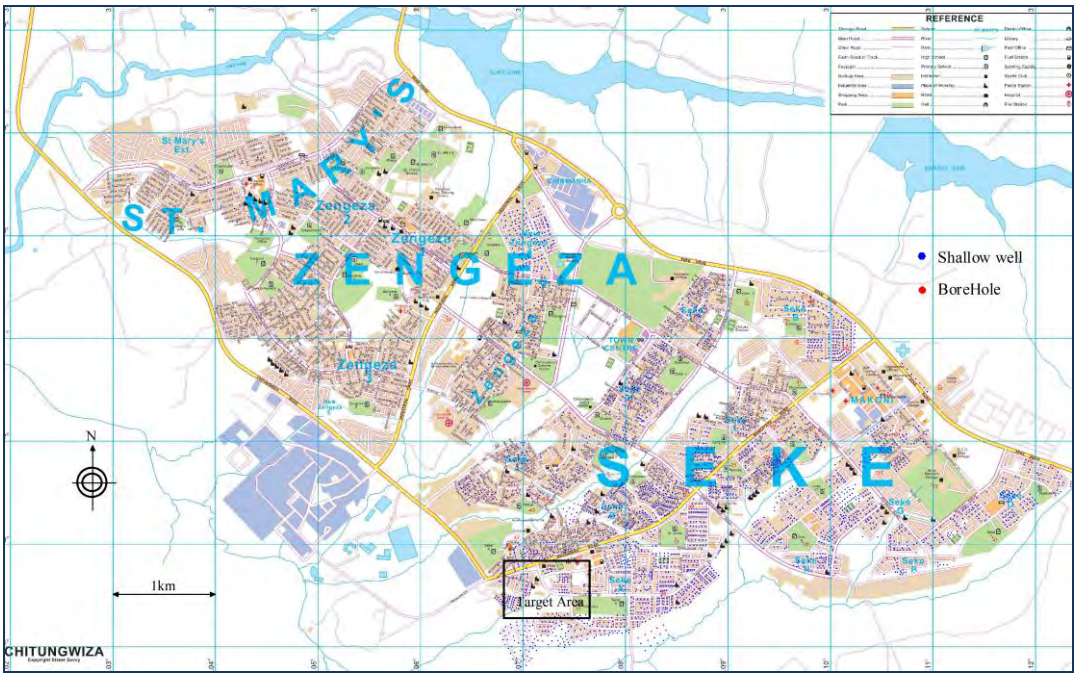


Figure 7.1 Location of Selected Area

In the target area, 10 wells were selected for installation based on these conditions; the yield capacity is relatively large and people in

Photo 7.1 Elephant Pump

the housing units surrounding the area are using the well. An "Elephant Pump" is selected as the hand pump because it is prevailing in the municipality and is locally fabricated using common materials. Before and after installation, some questionnaires and public awareness on water quality problems and basic manner of utilizing pump were carried out. Survey results were analyzed numerically and are summarized below including features of families utilizing target wells:

1) The number of families utilizing each well range from 7-30 (average 16.4)
2) The number of sample families selected was 68 out of 164, 41.4%
3) Average number of people in surveyed families was 8.7
4) Average consumption (intake) of well water was 284 litters/day
5) Average spending time of water taken from wells is 55.4 minutes
6) For the hygiene and safety of drinking water, 57% of people use tablets, which can be purchased from the local market and/or distributed for free by donor organizations.

After installation of the hand pumps, changes listed below were observed:

1) Water consumption was slightly increased by 1.17 times (333/284)
2) Spending time was drastically decreased by 0.36 times (19.6/55.4)
3) The rate of using tablets was not marginally changed due to the instructions on distributed leaflets
4) Some families complained about the poor quality of hand pumps, but after modification of these by the manufacturer under the requirement of the Team, these complaints ceased

7.1.2 Water Leakage Survey and Flow Measurement

(1) Methods

For water leakage measurement, night time measurements of two areas were carried out in this pilot project. During the night time, since water consumption by people is little, water flow in a particular area is assumed to be the water leakage. For flow measurement of branch pipes, the flow of branch pipes was measured according to the request of the municipality water supply section. In the water supply system of Chitungwiza Municipality, only one flow meter is measuring the bulk water from PE-WTP to the municipality and this data was of great importance in the analysis of measured results. Originally, two ultra-sonic flow meters were planned to be used, but unfortunately one of them which was brought from Japan could not be used to measure pipe flow, only one flow meter was then used by a local specialist. The location of measurement points is shown in Figure 7.2, and areas "e" and "f" were selected for water leakage measurement. Distribution pipes are not connected to other areas in these selected areas.

Point ①-⑩ were the originally selected measurement points but actually only ①-⑤ and ⑧ were measured due to the availability of one meter and low flow rate in the measuring week.

(2) Survey results

1) Water leakage survey

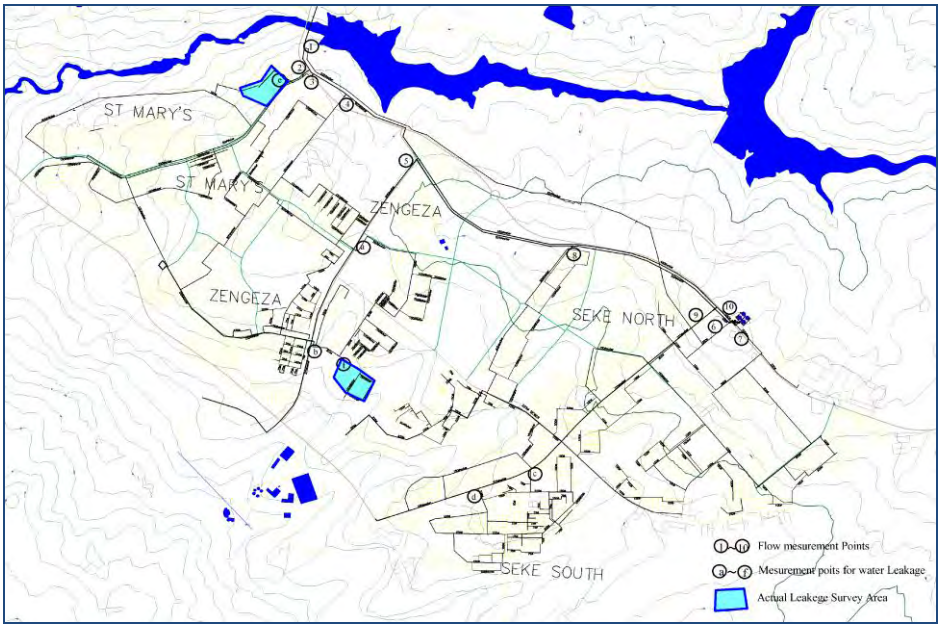


Figure 7.2 Location of Flow Measurement Points

Area "e" is composed of a housing complex, which was constructed in late 1980 and the area has always been distributed compared to the intermittent distribution in other areas. This is due to the fact that the branch valve to regulate the distribution flow broke down under the open condition. However since it was repaired in August 2012, it has only been closed by the municipality if necessary.

Area "f" is composed of the largest hospital in the municipality constructed in 1976 and a housing complex.

Because this area was the first priority area for the municipality to provide a sustainable water supply, Valve ⑤ never fully closes. Measurement results for water leakage survey of area "e" were shown in Figure 7.3. As shown in the figures, in the midnight the water flow apparently decreases, and the average flow was decided by two hour intervals of measurement.

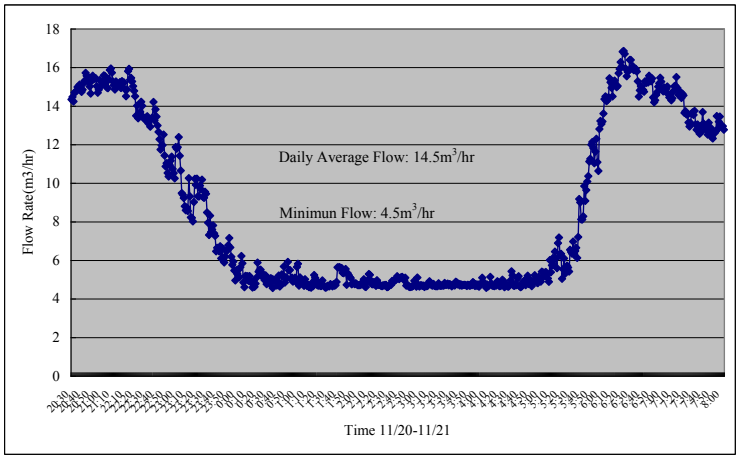


Figure 7.3 Measurement Results of Area "e"

Based on the figures, if water consumption in midnight is assumed to be the water leakage, water leakage ratio of each area is calculated as shown below:

Area "e": 4.5/14.5=31.0%

Area "f": 6.5/20.5=31.7%

2) Flow measurement results

During this week, water could not reach reservoirs and places located on high elevation areas due to low water flow. A limited water flow measurement for branch pipes was carried out because Valve ⑤ is never completely closed and in addition, various water flow conditions cannot be made from the operating conditions of valves due to the low water flow. Water flow from City of Harare was around 15,000 m^3/d from Monday to Thursday, and 18,000 m^3/d from Friday. Water flow was maximum 400 m^3/d of pipe ⑤ and 100-300 m^3/d of others.

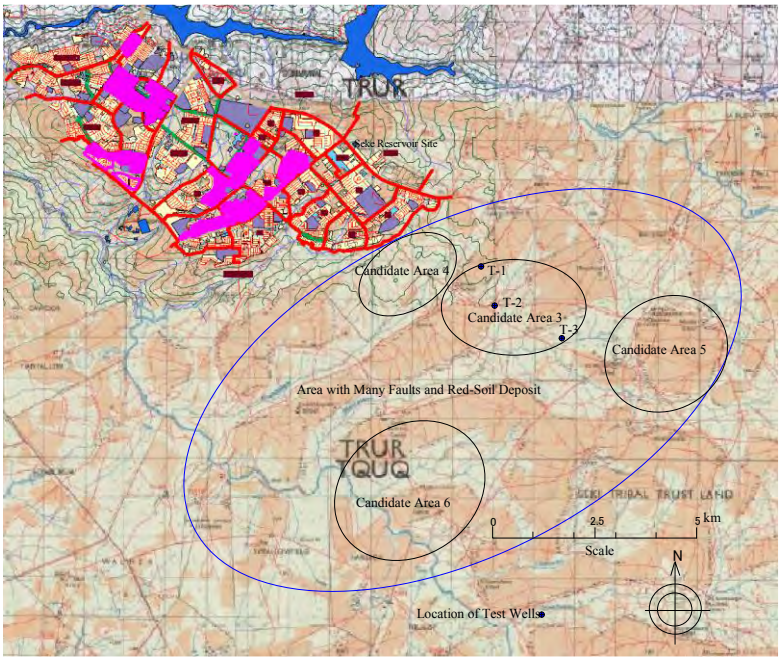


Figure 7.4 Location of Candidate Areas

7.1.3 Groundwater Resource Survey

In Chitungwiza Municipality, there are over 3,000 shallow wells and around 50 boreholes, and these are used by people living mainly in Seke North, Seke South and the eastern part of Zengeza, where piped water is distributed only for several hours in a week. These wells have not dried up by daily consumption even in dry seasons.

Thus, JICA Project Team started to find groundwater resources surrounding the municipality. After the failure of the first stage survey the Team hired another definitive hydro-geologist and restarted the second survey. The hydro- geologist showed some candidate areas as shown Figure 7.4. Within four (4) candidate areas, Area 3 is surveyed by electrical resistance tests, three (3) test wells was installed at the most hopeful points. As shown in Table 7.1, one well was negative but other two well's yield capacities were positive.

Table 7.1 Results of Yield Capacity Tests of Test Wells

No.	Geology	Elevation (m)	Well Depth (m)	Water Level(GL-m)		Yield capacity		
				Initial	Dynamic	L/sec	m^3/hr	m^3/day
T-1	Red-soil	1,458	60	7	33	0.3	1.1	26
T-2	Fault of granite	1,442	60	1.8	24	3.5	12.6	302
T-3	Fault of dolerite	1,440	60	1.4	15	3.9	14.0	337

The water quality analysis results of two positive wells are shown in Table 7.2. The water quality is not so well because of too low pH and high concentration of bacteria/coliform, but these can be easily

removed by chlorine and lime injection. However, the hydro-geologist asserted that there is no large scale groundwater resource with yields of over 10,000 m^3/day because of the low recharge capacity of the areas.

Table 7.2 Water Quality Analysis Results of Wells

Item	unit	WHO Standard	T2	T3
pH	---	6.5-8.9	**5.7**	**5.7**
Conductivity	μs/cm	1,600	14	70
TDS	mg/L	1,000	10	49
Alkalinity	mg/L	---	10	20
Hardness	mg/L	250	15	13
Calcium	mg/L	250	3.1	3.2
Turbidity	NTS	5	0.2	0.1
Iron	mg/L	0.3	0.10	0.08
Manganese	mg/L	0.1	0.03	0.05
Copper	mg/L	0.30	0.03	0.02
Zinc	mg/L	0.10	0.02	0.02
Nitrate	mg/L	50	0.93	0.93
Potassium	mg/L	---	1.7	4.6
Magnesium	mg/L	150	1.7	1.2
Sodium	mg/L	200	4.5	6.7
Sulphate	mg/L	250	6	18
Chloride	mg/L	250	6	18
Bacteria	no./ml	100	**2,900**	**110**
Coliform	no./100ml	Nil	**209**	**109**
E-coli	---	Negative	Negative	Negative

His assumption was maximum 5,000 m^3/d of the resource from all four (4) candidate areas and the average yield capacity of wells will be 3-5 m^3/hr (72-120 m^3/day).

7.2 Sewerage

7.2.1 Survey for the Sand Generation

In the pilot project for the sewerage, the survey was conducted with the cooperation of the residents, counter-part and local consultants (under contracts) as follows:

1) Confirmation of Current Status of Manholes and Sewers
2) Unit generation rate of sand in the sewage in Chitungwiza Municipality,
3) Reached unit sand volume to Zengeza STP,

(1) Study on generation of sand in the sewerage

Clogging problems of reticulation by sand deposit or malfunction of pump stations recurrences frequently: Clogging of sewers, sewage spilling out from manholes polluting streets, buried grit chamber･trickling filters in the STP by sand deposit and flooding in the pump station due to inappropriate sand disposal method around the sewerage facility. The origin of the sand has been considered to be a sole reason of pot washing by residents. However, no identification was made for the real reason. In order to plan right counter measures for the sand issue, series of field tests was

conducted. A Pilot Project for the sand issue was conducted to identify the unit generation rate of sand in the sewerage to prove the origin of the sand and also to get the detailed information of the sewered area.

(2) Study area

150 residences were selected from the 5 areas in Chitungwiza Municipality for the study.

(3) Sand trap

Prototype sand trap was developed. The structure is similar to the grease trap but it has bottom of sieve to catch the sand. In the survey, effectiveness of the trap and unit sand generation rate per capita were studied. The trap was designed to release fine particles of the sand and silt under 425 micro m going through the sieve to avoid clogging of the devices by the fine particle.

(4) Monitoring

Monitoring was planned to be conducted in the dry season in order to avoid the influence of the rain. The devices were monitored for more than two weeks. Monitoring was not on a daily basis. This is because Chitungwiza Municipality is currently facing serious water supply challenges. Consequently it was noted that behavioural habits of the targeted house- holds have been affected by this intermittent water supply situation. People are more conscious of conserving every drop of water; hence the amount of anticipated sand entering the sewerage network might be small compared with that which would enter the same network during normal water supply periods.

(5) Water Supply Situation

Number of times that the various areas were supplied with water during the monitoring period is checked and found water supply was made only three or four times. As a result of the above, sampling in Areas 4 and 5 were limited to only 3 times due to this problem of water supply. The residents do not drain used water to sewerage without water supply, and then the devices were not used when the tap water was not supplied. In areas 4 and 5 residents rely more on boreholes and wells. Residents normally hoard water when the water is available and use them sparingly thereby distorting the real impact of the amount of sand entering the sewerage network.

7.2.2 Result of the Field Work and Analysis

(1) The amount of sand in the field study

In total about 14,000 ml of sand excluding garbage was monitored through the field work. Since fine particle like silt goes through the pores of the sieve, correction was made.

(2) Unit generation rate of sand from Study Area

Unit sand generation rate was obtained as follows: Per house sand generation 43,863 g/489 houses =

89.7 g/house/day, Per capita sand generation 89.7 g/9.1 residents = 9.86 g/capita/day

The amount is considered to be reasonable from the experience of the field survey of the pot washing.

Unit generation rate of sand was determined as follows:

Per capita sand generation rate: 10 g/capita/day

Per house sand generation rate : 90 g/house/day

Besides, rate of water supplied days during the days of operation was 489/2392.5 = 0.204, which means that days of water supplied is averagely only 1.4 days (7days × 0.204 = 1.43days) through the entire municipality. It can be said that the residents are withstanding severe living condition in the Municipality. Boreholes and shallow wells are considered to be the core water source for the residents.

(3) Findings

Findings were summarised as follows:

1) All the 137 houses selected were using the sand for every washing work regardless of availability of water, which proves the manner as a common manner.
2) Water supply during the period of the study, water was supplied only 3 or 4 times from the taps. Availability of water supply was computed as averagely 20% and it was almost common in all the area.
4) Thus, water from well or stored water was assumed to be used for about 80% of the days from the computation.
5) The sewage after the washing was discharged to the sewerage in the kitchen when water is available, but when unavailable, sewage was disposed in the garden or outside, since the water is not derived from the tap in the kitchen but from outside.
6) About 90 g of sand was averagely used in a house a day by computation from the derived data.
7) Unit sand generation rate per capita was about 10g/capita/day. (Refer to above (4))
8) Soot of the pots was deemed to come from firewood, gas or paraffin, when the electricity is out due to power failure which is confirmed by interviews, observation at the field. However, since using firewood is a traditional way, it might be a regular way even when the residents have power in their houses. Anyhow, power failure is considered to be affecting the pot washing.

From these facts, since the residents have been using the sand for pot washing whether they have water or not, inflow of the sand into the sewers will increase when the water supply is improved. Thus, sand use is independent matter with the water supply. Although sand removal would be done by the municipality as required after the refurbishment and improvement, most desirable way is the stoppage of the use of the sand in the residents to cope with the sand issue.

7.2.3 Zengeza Sewage Works – Inlet Works Grit Survey

(1) Confirmation of sand inflow to ZSTP

In order to validate the results obtained from the household grit survey as extrapolated above, it was

proposed to measure the amount of grit reaching the works by gravity. All the sewage pumping stations were not working due to rehabilitation works currently going on at these facilities during the survey. The survey was conducted at the inlet works chamber just before the screens. The survey commenced on 21st of November at 14:30pm, immediately after the cleaning work. The survey ran for two weeks to match the number of days the household grit survey was conducted. The existing gates were throttled as small as possible to make the water level high in the chamber to slow down the velocity. Inflow of sand was assumed to be 3.837 m^3 from the unit generation rate derived in the study, and the volume of the sand deposit during 2 weeks was 4.875 m^3. Since the deposited sand for more than 10 years in the sewers could be washed out reaching the Inlet Chamber in the ZSTP for some reason, it is considered that the both result is showing fairly good consistency.

(2) Findings

1) Assumption of the deposit was 3.8 m^3, while the actual measurement was 4.9 m^3.
2) Although there is a margin of error, computation of sand deposit in the ZSTP was close to the actual deposit in the chamber at the entrance of the inflow.

7.2.4 Projection of Sand Generation in the Future

From the study, it was found that availability of water supply was very much limited to low level of about 20%, although the situation of water supply will be improved in the future. From our survey, volume of the sand inflowing to the ZSTP is directly connected to the availability of water supply as shown above. Then, sand inflow to the ZSTP was assumed as 2.115 m^3/day for 100% water supply. It will be more than 700 m^3 in a year. This seems what is seen in the old facility in the ZSTP, namely buried anaerobic ponds and sand-clogged trickling filters. This indicates usual sand removal work for STP, PS and sewers is very important to maintain the facility, if the sand inflow keeps on.

7.2.5 Educational Activity

On the other hand, educational activity/enlightenment/introduction of penal regulations for the residents is very essential as well. Seminar for the residents, presentation to the schoolboys/girls regarding the sanitary, environment and sewage facility will be very useful to reduce the sand. In the latter part of the project, these activities will be planned and conducted. Introduction of penal regulation must be done in parallel with the providing the alternative to the residents.

7.3 Solid Waste Management

7.3.1 Approach to Implementation of Pilot Project

(1) Selection of project sites

The project sites of the pilot project were selected through identifying the non-collection service area in a map, discussions with the municipality and site inspection of candidate sites. Two communities of Zengeza 4 and Unit J extension of Seke South were selected.

(2) Explanation of Pilot Project to community residents

The local consultants and the municipality's solid waste department visited each household of the project sites on the explanation of the implementation of the pilot project.

(3) Public education

In the proposed pilot project, the public education was carried out.

(4) Proposed combination system of primary and secondary collection

In the non-collection service areas, a primary collection using of manual carts by CBOs (Community based Organizations), their transport to a collection point and another combined collection system of the municipality's secondary collection by using their collection vehicles was proposed.

(5) Monitoring before and after Pilot Project / Stakeholder Meetings

Before and after the implementation of the pilot project, a monitoring through a questionnaire survey was carried out with the municipality (C/P) to verify the process of the activities, validity or efficiency of activities and input, outcome of the pilot project and their evaluation.

Stakeholder meetings were held to share the outcome of the pilot project.

7.3.2 Results of the Pilot Project

(1) Monitoring results

1) Monitoring before Pilot Project

The following results were obtained through the questionnaire survey;

- The majority of the residents (86%) showed concern about issues of solid waste management and the diseases related to improper waste disposal.
- 90% of the respondents were willing to participate in the activities of waste reduction, recycling and composting waste at household level
- Most of the residents replied that the infrastructure development such as roads can be a permanent solution compared to the attempt of the development of collection points since such collection points will become a dumping site if the municipality fails to collect the waste

2) Monitoring results after Pilot Project

The following results were obtained;

- The residents (97% of the respondents) replied that the pilot project was a good attempt
- The majority of the residents replied that they secured a cleaner environment after the pilot project compared to the previous state before the pilot project
- Most of the residents (82% of the respondents) were aware of the fact that a USD20 fine has to be paid for an illegal dumping, but because there is no refuse collection in their communities they are forced to dump their waste illegally.

- Most of the residents (83% of the respondents) were willing to produce craft works from the recyclable materials for earning their income and also for the purpose of waste reduction

(2) Stakeholder Meetings

The followings following opinions were obtained;

- The educational awareness on appropriate discharge of waste should be carried out until there is an attitude change in the people towards waste reduction
- One of NGO groups can play an important role as a partner in public education including source separation
- The municipality's collection service of once a week is not sufficient. The service should be provided twice a week.
- Unit J Extension residents who are close to access roads could take out their waste for Municipal collection on Wednesday when the collection in Unit J is done.

(3) Outcome and challenges identified

The following outcome was obtained through implementation of the pilot project.

- Most of the community residents had concern on the pilot project and they thought that the pilot project was a good attempt.
- Most of the community residents recognized that they secured a cleaner environment after the pilot project compared to the previous state before the pilot project
- Most of the community residents were willing to participate in the activities of waste reduction, recycling and composting waste at household level.
- Most of the residents (83% of the respondents) were willing to produce craft works from the recyclable materials for earning their income generation and waste reduction, at the same time.
- The operators were willing to continue their work of primary collection after the implementation of the pilot project.
- Other communities in the municipality's non-collection areas who were not part of the pilot project expressed concern for the project to be implemented in their communities as well.

The following challenges were identified;

- Some residents discharged human excreta to the operators because many houses have no ablution facilities in the pilot project communities.
- On several days there was no collection service for the secondary collection from collection points by the Municipality due to council strikes, breakdown of collection vehicles and fuel challenges.
- Some residents thought that the pilot project only benefited a minute population of Chitungwiza.

< PART 2 MASTER PLAN >

CHAPTER 8 IMPROVEMENT PLAN FOR WATER SUPPLY

8.1 Demand Projection

The results of population projection, daily average demand projection, and daily maximum demand projection (including NRW [Non Revenue Water]) are shown in Table 8.1.

Table 8.1 Results of Demand Projection

Name	Item	2012	2020	2030
Harare	Population(×1000)	2,195	2,715	3,949
	Daily ave. demand(×1000 m^3/d)	382.9	501.2	756.3
	Daily maximum consumption(×1000 m^3/d)	960.0	858.7	1,135.9
Chitungwiza	Population(×1000)	330	389.1	440.8
	Daily ave. demand(×1000 m^3/d)	28.6	34.1	39.3
	Daily maximum consumption(×1000 m^3/d)	43.8	46.1	52.4

(1) The condition of population projection

Target year of Mater Plan (M/P) is stipulated to year 2030, based on agreement between the Japanese and Zimbabwean Governments. In addition, middle target year of 2020 is stipulated as the target year of Feasibility Study (F/S). Population growth rates are referred to the rate of SAPROF Study, which is 5.5% of City of Harare and 6% of majority of surrounding towns between 2005 and 2020. Chitungwiza Municipality has planned for a new expansion area on the opposite side of Nyatsime River. There are many vacant spaces in municipality developed areas and these spaces will be filled in the population projection by 2020. For the projection of 2030, one ward in above new developing area will be 70% filled.

(2) The condition of daily average water demand projection

The conditions of demand projection of Harare Area from 2012 to 2020 and 2020 to 2030 are; the domestic unit demand (Lpcd) of Harare urban and rural, Epworth, Ruwa and Norton will increase by 10%, the industrial demand will increase by 50%, and the commercial and institutional demand will increase by 20%. Currently, there is a shortage in water distribution flow to Chitungwiza Municipality, and actual water supply cannot meet demand. In the assumption, the current actual unit demand for domestic use is assumed to be 80 Lpcd, and since the whole municipality can be categorized as very high-density area and there are many wells for the supplemental supply, the unit demand is assumed not to increase. The increased demand rates from 2012 to 2020 and from 2020 to 203 are assumed to be 20% for the commercial/institution, and 50% for industry, the same rates as with Harare Area.

(3) The condition of daily maximum water demand projection

The calculation of daily maximum flow for distribution network, daily factor f1 (=daily

maximum/daily average) and NRW (Non Revenue Water) must be determined. The NRW rate in Harare Urban and Rural is assumed to be 57%* in 2012, 35%* in 2020 and 20% in 2030, while the NRW rate of bulk water supply is assumed to be 30% in 2012, 20% in 2020 and 15% in 2030. Daily factor of f1 is assumed to be 1.15. *: From Urgent Infrastructure Rehabilitation-India Eximbank

The staffs of the water supply section of Chitungwiza Municipality consider the leakage rate (NRW rate) being very low. The leakage ratio of 0.25 in municipality is estimated to be the difference between the water supply and sewage inflow of Zengeza STP (Sewage Treatment Plant). The daily factor of f1 is assumed to be 1.15 same as Harare Area.

8.2 Evaluation of the balance between Water Resource/Production and Demand

In Harare Area, the available dams for water supply are Chivero, Manyame, Seke and Harava Dams, and their yield capacity is not enough to meet the demand including NRW and then the Kunzwi and Musami projects are planned for the water resources of Great Harare Area. The balance between water demand (including NRW) and water source considering these planned dams is shown in Figure 8.1.

As shown in the figure, currently the water source is outstandingly short, and although after the development of Kunzwi and Musami Dam the source capacity is set to meet the demand, the production capacity cannot meet the demand soon due to rapid increase of demand.

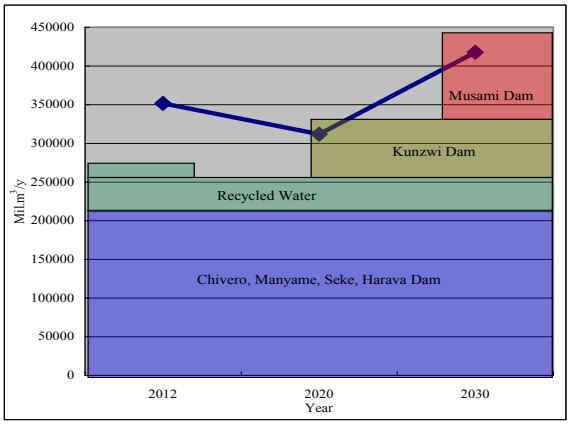


Figure 8.1 Comparisons between Water Demand and Source

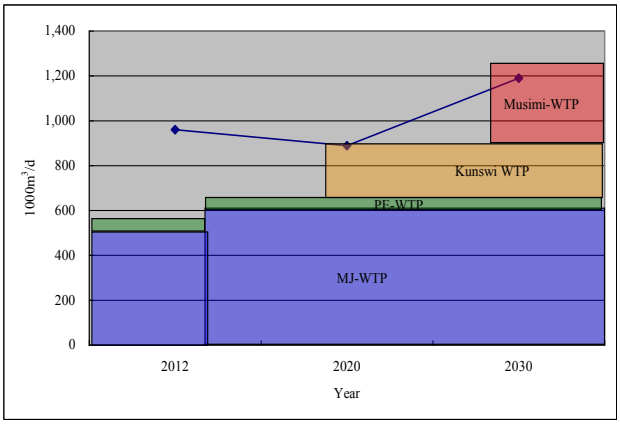


Figure 8.2 Comparisons between Water Demand and Production Capacity

The balance between water production capacity and demand is shown in Figure 8.2 and the tendency is almost similar to that of the water source. Because of insufficient water supply from Harare Water Works, groundwater resources were surveyed. However it was found that a total yield capacity of 5,000 m^3/d is the limit surrounding the municipality. From the results of a test well survey, two (2) hopeful wells with capacity of over 300 m^3/d can be installed, but since these wells cannot be installed nearby each other, the number of wells will be limited.

8.3 Improvement Plan for Harare Water Works

The refurbishment plan formulated by Harare Water Works is urgently required, and a pipe rehabilitation works named “non revenue water reduction project” which targets to reduce NRW from

57% to 35%, is tried to be realized with a budget of 75.3mil.USD. In addition, a comprehensive improvement plan including Kunzwi Dam and WTP, the transmission pipe, expansion of distribution system and rehabilitation of distribution pipes, which are formulated SAPROF Team are also tied to realized with the assumed costs of around USD 350 mil. However, two donors have been found for previous rehabilitation work, but no donor has been found for the current project. As mentioned previously, since Kunzwi Dam will meet the demand only until 2020, Musami Dam and WTP are required by 2030 with the cost of USD 422 mil.

8.4 Improvement Plan for Chitungwiza Municipality

8.4.1 Water Resource Acquisition

As mentioned previously, the groundwater resource surrounding the municipality is not enough for a major water source. However, a development plan for Muda Dam, which lies 30km south of the municipality, can be applied only for the municipality. However, the development plan is quite costly; from the total cost is USD 93 mil. by using the existing Prince Edward(PE) WTP, or USD 109 mil. with the construction of a new WTP, to USD 19 mil. of share of expenses for Kunzwi Dam development. Then the municipality will continuously rely on the bulk water from Harare Water Works.

Accordingly, the municipality must pay the charge of bulk water without delay (currently the total income of water supply section equals the total expense of the section including bulk water) to secure receiving of bulk water. However, since the future water supply to the municipality is predicted unstable due to shortage of water amount to the consumers and frequent breaking down of facilities, the municipality will secure supplemental water from wells.

8.4.2 Improvement of Water Supply System of Municipality

For efficient utilization of limited water source, all bulk water fed from Harare Water Works should be transmitted first to Seke reservoirs, and then distributed to the municipality by gravity from ground reservoirs and the elevated tank. For realization of above, items to be improved for municipality existing facilities are listed below;

1) Transmission pipe of diameter 600 mm should be reinforced from PE-WTP to reservoir
2) The distribution pipe network should be reinforced because of the low flow capacity
3) The lift PS in Seke reservoir site should be replaced because it has already deteriorated
4) The pipes in Seke reservoir site should be remodelled
5) Some old distribution pipes have been clogged and these should be replaced

For supplemental water supply, items stated below should be implemented

1) To develop groundwater resource of 3,000m^3/d, which was found nearby municipality, and to transmit to Seke Reservoirs
2) To utilize existing shallow wells (3,000) and borehole (52) more efficiently with installation of

hand pump (420) and electrical pump(10)

3) To install shallow wells (280) in the area where the number of shallow wells is small, and borehole (51) for some public grounds such as schools and offices.

8.4.3 Improvement Plan for 2030

Water distribution facilities for ward 1 will be required in 2030. In this plan, distribution pipes in the ward will be predicted to be constructed by developers of Wards, but a distribution main from the reservoir to the ward needs to be constructed from the project funds. For this area, water can be distributed from Seke ground reservoir by gravity. Additional water resource for Chitungwiza Municipality will be increased from bulk water of Harare Water Works utilizing developed water from Kunzwi and/or Musami Dam.

8.4.4 Operation and Maintenance

For electricity consumption, target facilities are lift pumps in Seke reservoir site and well pumps with transmission pumps for supplemental well pumps. For chemical consumption for disinfection is caused by supplemental well water in Seke reservoir site. However, these consumption and cost is very small compares with the cost of bulk water (the cost will be raised from 0.25 to 0.3 USD/m^3due to burden of water resource development). The staff of water supply section strongly desire proper meter readings, and then meter reading group should be included within water supply section.

After the completion of the project, staff number of water supply section (59) will be predicted to be increased to be 91 because of increased staff for meter reading.

CHAPTER 9 IMPROVEMENT PLAN FOR THE SEWAGE

9.1 Sewerage Rehabilitation in the Catchment Area

The Master Plan should adopt the rehabilitation of the sewerage system in the catchment area. The on-going Zim-Fund project will rehabilitate the Crowborough and Firle STPs in Harare while the AWF project will be applied for Chitungwiza. These are deemed to be appropriate from the result of pollution analysis. Augmentation of the facility will be needed for the Zengeza STP in 2020. Donors for the Norton Council must be looked for to rehabilitate the treatment plant. Countermeasure for the sand issue will be taken as well. The procurement of heavy equipment to haul away sand removed from the site is indispensable in the sand removal program.

9.2 Sewerage Planning in the Catchment

Sewerage planning was selected as the priority in the catchment. These activities were evaluated essential for water source conservation of the catchment.

Urgent rehabilitation programs in the catchment for Harare and Chitungwiza have been implemented by Zim Fund and AWF project. Since the evaluation of both projects was basically effective, urgent measures for the sewerage in both municipalities are sufficient except for the areas excluded from the project. However, in the above-mentioned project, the Municipality/Council of Ruwa, Epworth and Norton are not included from the Zim Fund or the AWF. The result of the pollution analysis shows that the employment of the advanced BNR system does not have much advantage compared to conventional system in terms of water quality conservation.

< Norton >

After 2000, the sewerage system malfunctioned, and vandals broke the pump station handling effluent water for irrigation purposes. Thus, raw sewage is being directly discharged to Lake Manyame, polluting the lake. Urgent measures must be taken to rehabilitate the facility in order to save the water source. A study on the sewerage plan will be required, and donors must be found to fund this project.

< Ruwa >

It is necessary to rehabilitate/upgrade the existing wastewater stabilization pond. Effluent should be transferred to the farms for irrigation to conserve water quality in Ruwa River. A study on the improvement of the sewerage facilities will be required, and donors must be found to fund this project.

< Epworth >

The municipality does not have sewerage system, but this will be needed in the near future in order to secure the groundwater source. A study on the sewerage plan / system will be required, and donors must be found to fund this project.

9.3 Planning of Chitungwiza Sewerage

(1) Zengeza Sewage Treatment Plant (ZSTP)

For the Zengeza STP, urgent rehabilitation and augmentation in the mid-term are necessary. Urgent rehabilitation has been conducted under AWF project (AfDB, Grant-Aide) for pipelines and pump stations. The Scope of Works is rehabilitation of the old trickling filters for the capacity of about 20,000 m^3/day including pump stations to send the effluent to the Imbwa Farm. It does not include the rehabilitation of existing BNR facility. Even sludge treatment plant will not be needed. Sludge (Humus from Trickling Filters) can be sent to the Imbwa Farm after the stabilization in the maturation ponds. For the urgent measure within five years, rehabilitation of the trickling filters will be adequate for the inflow of about 20,000 m^3/day. However, augmentation of the facility will be needed after five years due to population growth. The existing BNR facility can be used for the augmentation planning.

Alternatives for the Zengeza STP Rehabilitation as follows:

Plan 1 Stabilization Pond: New Construction of Stabilization Ponds

Plan 2 Trickling Filters + Oxidation Ditch:
Rehabilitation of existing TF by Zim Fund Project, Remodelling of the existing BNR
with reuse of existing sludge treatment facility

Plan 3 Trickling Filters + BNR:
Rehabilitation of existing TF by Zim Fund Project,
Full-Rehabilitation of existing BNR

For Plan 1, new construction of stabilization pond, a lot / area of 100 ha must be secured to execute the plan. This facility can be constructed in the existing waste disposal site without any cost for the land. Capital expenditure (CAPEX) for the Stabilization pond will be USD 128 million, although the operation expenditure (OPEX) will be lower, at USD 1,077 thousand per yr.
For Plan 2, CAPEX will be USD 20.1 mil with the OPEX of USD 2,045 thousand per yr.
For Plan 3, CAPEX will be USD 15.4 mil with the OPEX of USD 4,687 thousand per yr.

Plan 2 is recommended, from the standpoint of utilizing the existing BNR facility, having fairly good effluent water quality, economical, and having an aspect of easy operation and maintenance.

(2) New Pump Station and sewers for the development area

New Pump Station with pipelines: Capex: USD 2,592 thousand, and Opex USD 133 thousand per yr

(3)Tilcor Pump Station

Tilcor pump station is a pump station by which industrial wastewater in the industrial area was sent to ZSTP. The pump station and pipelines (2 pipe bridges) before the pump station has been broken down these ten years and all the sewage from the industrial area has been discharged to the Nyatsime River directly.
Rehabilitation of Tilcor Pump Station with pipelines: Capex: USD 384 thousand, Opex USD 77 thousand per yr.

CHAPTER 10 IMPROVEMENT PLAN ON SOLID WASTE MANAGEMENT

10.1 Approach to Formulation of the Improvement Plan

Based on the review of current issues / problems, the results of the pilot project on solid waste management and as well as the requirement of the laws, regulations and national strategies which were collected and identified in the field survey, improvement options are proposed. These options are then evaluated, selected, and prioritized for implementation. The planning framework, such as future waste generation amount, target collection, waste diversion level and the waste stream for the target years, are then set up to put each improvement plan into proper and tangible perspective.

10.2 Potential Improvement Measures on Solid Waste Management

The potential improvement measures are summarized in Table 10.1.

Table 10.1 Summary of Potential Improvement Measures

Solid Waste Management	Problem	Potential Measures for Improvement
Discharge	• Illegal dumping was identified throughout the city which may cause environmental or public health risks • Reduction of waste generation	• Implementation of cleanup activities • Enhancement of enforcement of laws and regulation • Source separation • Home composting
Collection and transport	• Illegal dumping due to the local conditions beyond the municipality's collection service • Insufficient capacity of collection and transport due to breakage and traffic accidents	• Implementation of cleanup activities • Development or procurement plan of equipment for collection and transport operation • Community based collection activity (Primary collection by CBOs)
Intermediate treatment	No concrete action plan for waste diversion / 3Rs or development of intermediate treatment facilities	Development of intermediate treatment facilities for waste diversion (e.g. Home composting, community composting, central composting, material recovery facility, incineration and bio-gasification, etc.)
Final disposal	Open dumping site without appropriate management may cause environmental and public health problems	• Safe closure of existing open dumping • Development of sanitary landfill

10.3 Evaluation and Selection of Technical Options and Proposed Improvement Plan on Solid Waste Management

Taking the time frame of the master plan up to 2030 into consideration, the cleanup of illegal dumping and the procurement of collection / transport equipment should be implemented as high priority. The safe closure of existing open dumpsite and the development of sanitary landfill which is currently recommended by EMA, should follow these components. The intermediate treatment of recyclable waste such as development of MRF (Material Recycle Facility) and central compost facility should be implemented at the phase where a level of SWM maturity has been achieved. Home composting and community composting should be implemented as early as possible in terms of waste reduction at generation source.

10.4 Setup of Planning Framework

10.4.1 Projection of Future Waste Generation Amount

The future waste generation amount at each target year is shown in Table 10.2.

Table 10.2 Future Waste Generation Amount Unit: ton/day

	Year				
	2012	2015	2020	2025	2030
Total Generation Amount	176.3	193.3	225.2	271.6	346.1

10.4.2 Setup of Target Collection and Waste Diversion Level

The target waste collection, waste diversion level and their improvement plan are proposed in Table 10.3.

Table 10.3 Planned Target Waste Collection, Diversion Level and Improvement Plan

Target Improvement Level and Improvement Plan		Target Years			
		2012 (Current)	2020	2025	2030
Improvement of Waste Collection	Target Waste Collection Level (%)	38	100	100	100
	Proposed Improvement Plan	-	• Procurement of Collection Equipment • Procurement of Skip Bins • Implementation of Primary and Secondary Collection	• Procurement of Skip Bins • Implementation of Primary and Secondary Collection	• Procurement of Skip Bins • Implementation of Primary and Secondary Collection
Improvement of Waste Diversion	Target Waste Diversion Level (%)	-	10	15	28
	Proposed Improvement Plan	-	• MRF (2) • Home Composting (3) • Community Composting (5)	• MRF (3) • Home Composting (5) • Community Composting (7)	• MRF (3) • Home Composting (7) • Community Composting (8) • Central Compost Facility (10)

Notes: The figures including those in parenthesis show the target ratio to total generation amount.

10.5 Materials / Equipment Development Plan

Table 10.4 shows the proposed collection system.

Table 10.4 Proposed Collection System by Generation Source

Generation Source		Type of Equipment for Collection	Frequency of Collection
Residential Area	Areas of accessible of municipality's collection service	• Tipper truck (for 50% of target collection volume) • Compactor truck (for 50% of target collection volume)	Twice a week
	Areas of not accessible of municipality's collection service	Primary collection by CBOs (manual carts) + Secondary collection by municipality (multi loader) + Skip Bin	Twice a week
Establishments		Multi loader + Skip Bin	Daily

Notes: CBOs: Community Based Organizations

The estimated quantity of the collection equipment is shown in Table 10.5.

Table 10.5 Estimated Quantity of Collection Equipment

Type of Equipment	Year of Procurement		
	2020	2025	2030
Tipper Truck (10 m^3)	11	-	-
Compactor Truck (8 m^3)	9	-	-
Multi Loader	23	-	-
Container (5 m^3)	432	432	432

10.6 Facility Development Plan

10.6.1 Intermediate Treatment Facility

(1) Home Composting

Home composting will be implemented through promotion activities by facilitators by providing containers and composting seeds. The home composting will commence on launching a pilot activity targeting at 100 households for expanding it.

(2) Community Composting

Community composting will be implemented by developing a small-scale facility with a capacity of 250 kg/day, and equipped with shredder, scale and water jet machine. Its operation will be implemented by CBOs (Community based Organizations) through the construction of 10 pilot facilities in 10 communities.

(3) Central Composting Facility

The major component of the facility is shown in Table 10.6.

Table 10.6 Facility Outline of Central Compost Facility

Item No.	Description	Unit	Quantity
1.	Capacity: 35.0 ton /day	-	-
2.	Location: Existing Open Dump Site	-	-
3.	Land area	m^2	8,200
4.	Process: Windrow method	-	-
5.	Building Area • Compost Building • Administration Building • Receiving Area • Primary Sorting Area • Others	m^2	Approx. 6,300
6.	Equipment for operation • Truck scale • Belt conveyor • Drum Cutter, Screen and Segregation, etc. • Wheel Loader • Open Dump Truck (2 ton , 4 ton)	LS	1

(4) MRF (Material Recovery Facility)

The outline of the MRF is shown in Table 10.7.

Table 10.7 Outline of MRF

Item No.	Description	Unit	Quantity
1.	Capacity: 11.0 ton /day	-	-
2.	Location: Existing Open Dump Site	-	-
3.	Land area	m^2	1,500
4.	Building Area • Operation building (sorting, washing) • Administration Building	m^2	Approx. 420

Item No.	Description	Unit	Quantity
	Other areas: • Temporary storage area for incoming recyclable materials • Truck scale • Storage areas (sorted materials) • Parking areas	m^2	
5.	Equipment for operation • Truck scale • Belt conveyor • Shredder • Wheel Loader • Open Dump Truck (2 ton)	LS	1

10.6.2 Final Disposal Facility

(1) Cleanup of Illegal Dumping Sites

Illegal dumping identified throughout the city should be cleaned up immediately to preserve the urban sanitation landscape. The clean-up of about 840,000 m^3 of the illegally dumped waste (estimated by the subcontracted survey) will be carried out by using the heavy machines of a front-end loader and a dump truck.

(2) Safe Closure of Existing Open Dump Site

The proposed safe closure of the existing open dumping site is composed of a removal / refilling of existing dumped waste in the designated area of the existing land, carrying out of soil covering, and installation of gas vent pipes and drain ditch.

The outline of the safety closure of the existing open dumpsite is shown in Table 10.8.

Table 10.8 Outline of Safety Closure of Existing Open Dumpsite

Item	Description
Land area for safety closure	About 6.0 ha
Removal of existing dumped waste	About 565,000 m^3
Landfilling of waste	About 825,000 m^3
Soil covering	50 cm of soil cover
Rain water drain system	Drain ditch (About 1,300 m)
Fence (H = 2.5 m)	About 1,300 m
Gas vent pipe	40 units

(3) Development Plan of New Sanitary Landfill

1) Evaluation of Candidate Sites of New Landfill

Two candidate sites, one candidate site proposed by the urban planning services of the municipality and another site of the existing open dumping site, were evaluated for the suitability for development of a sanitary landfill. The candidate site proposed by the urban planning services is adjacent to the future lands for schools, housing lots and also to the existing river course, accordingly, the candidate site by the urban planning services is not suitable. Therefore, the existing dumping site should be utilized as a new landfill site

2) Facility Plan of Proposed Sanitary Landfill

The outline of the new landfill is shown in Table 10.9.

Table 10.9 Outline of New Sanitary Landfill

Item	Component
1. Structure	• Excavation of existing open dump site and a construction of an enclosure dike • Estimated land landfill area: 220m × 400m
2. Planned Landfilled Volume	• 1.6 million m^3
3. Landfilling method	• Semi-aerobic landfilling
4. Leachate collection facilities	• Impermeable liner sheet • Leachate collection pipes (main, branch) • Leachate reservoir pit
5. Leachate treatment	Recirculating method using pump
6. Rain water drain system	Rainwater drain ditch
7. Connection Road	Access road / onsite road
8. Groundwater monitoring	Groundwater monitoring wells
9. Weighing system of incoming waste	Truck scale
10. Landfill gas	Landfill gas vent pipes

10.7 Cost Estimate

The total estimated cost for proposed solid waste management system is USD 76,478 K. The total operation and maintenance cost, on one hand, is estimated USD 4,674 K at the target year of 2030.

10.8 Implementation Schedule

The implementation schedule is shown in Figure 10.1.

Figure 10. 1 Implementation Schedule of the master Plan on Solid Waste Management

Project Component	Year																	
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Cleanup of Illegal Dumping Site	1)	1)	1)	1)	1)	1)	2)	2)	2)	2)	2)							
Procurement of Collection Equipment	1)	1)	1)	1)	1)	1)	2)	2)					2)					2)
Safety Closure of Existing Open Dumpsite	1)	1)	1)	1)	1)	1)	2)	2)	2)									
Construction of New Final Disposal Facility	1)	1)	1)	1)	1)	1)												
Home Composting	1)	1)	1)	1)	1)	1)	2)	2)										
Community Composting Facility	1)	1)	1)	1)	1)	1)		2)	2)									
MRF (Material Recovery Facility)	1)	1)	1)	1)	1)	1)	2)											
Central Composting Facility	1)	1)	1)	1)	1)	1)					2)	2)						

Notes:
1) Preparation (Feasibility Study, Action Programs, Detail Design, Tender Process, etc.)
2) Implementation (Construction, Procurement, etc.)

CHAPTER 11 COST ESTIMATE AND FINANCIAL STUDY

11.1 General

The following conditions are assumed to prepare the cost estimation for this project

Exchange Rate USD 1 = 77.98 yen

Taxes

1) VAT : 15% of the expenditure

2) Import Tax Average 10% of the expenditure for civil -elated works according to Zimbabwe Revenue Authority

Others

1) Consulting Services 7 % of the direct cost
2) Physical Contingency 5 % of the direct cost and consulting services
3) Price Contingency 5% of the direct cost and consulting services

11.2 Estimated Costs for Proposed/ Recommended Improvements

11.2.1 Construction Cost

(1) Water Supply Facilities

In Chapter 9, Plan 1 was selected as the recommended option for the water supply improvements for this project. The following table is a summary of the estimated construction cost for Plan 1 Water Supply Facility improvements for the existing water supply system in Chitungwiza.

Table 11.1 Estimated Construction Cost for Water Supply Facilities (Target year of 2020)

Sub-No	Facility	Brief Work Description	Total Cost (K USD)
1.1.1	Distribution Pipes	To increase the current water supply distributed by the existing water distribution system, install and supply the following new facilities to the existing: • New DI pipes with a diameter of 350 to 700 mm • New uPVC pipes with a diameter of 160 to 355 mm • New gate valves with a size of 100 to 700 mm	12,551
1.1.2.	Seke Reservoir Site	To utilize the capacity of the existing Seke Reservoir ground reservoir more efficiently for the water demand, install and supply: • Reinforced transmission pipe with diameter of 600 mm • Refurbishing of P/S • Construction of disinfection and neutralization facilities • Refurbishing of pipes works in the site with flow meter	13,494
1.1.3	Well Group	To take well water from surrounding areas • Three group of boreholes and transmission facilities • Transmission pipes	3,726
		Grand Total	29,771

Table 11.2 Estimated Construction Cost for Water Supply Facilities (Target year of 2030)

Sub-No	Facility	Brief Work Description	Total Cost (K USD)
1.2.1	Distribution Pipes for Future Development	To increase the current water supply distributed by the existing water distribution system, install and supply the following new facilities to the existing: • New DI pipes with a diameter of 400 mm • New gate valves with a size of 400 mm • Mechanical works	13,116

Table 11.3 Estimated Construction Cost for Supplemental Water Supply Facilities (Urgent)

Sub-No	Facility	Brief Work Description	Total Cost (K USD)
1.3.1	Supplemental Water Supply	To take supplemental water and rehabilitate distribution network • To install shallow wells with hand pumps and borehole • To rehabilitate clogged pipes	2,747

(2)Sanitation/Sewerage Facilities

Prior to the target year of 2020, the existing trickling filters in the old Zengeza STP will be rehabilitated by AfDB and planned construction will commence in early 2013 and be completed by the end of 2014. This plan has been approved based on the obtained information. In this M/P, the construction cost of each of the five alternative options for the sewage facilities is compared for review. Therefore, each option has a different implementation plan. In addition, the construction of a new sewage pump station and installation of sewer pipes are proposed to facilitate the anticipated sewage from the future development area as one improvement for the target year of 2030.

Table 11.4 Cost Estimations for Recommended Improvement Plans

Facility		Brief Work Description	Estimated Capacity m^3/day	Implementation Plan			Total Cost (K USD)
				Facility	Comen.	Comp	
ZENGEZA STP (2020)	OPTION 1 New Stabilization Pond	Construction of new ponds	36,000	NSP	2018	2019	128,619
	OPTION 2 Ex TF + Oxidation Ditch	Modification to the existing BNR with the replacement of the existing Anaerobic Anoxic Basins with oxidation ditch, and usage of the existing TF	20,000 + 21.750 (Ex. TF) = 41,750	Ex TF	2013	2014	20,121
				BNR	2020	2022	
	OPTION 3 Ex TF+ BNR	Rehabilitation to the existing BNR and usage of the existing TF	20,000 + 21.750 (Ex. TF) = 41,750	Ex TF	2013	2014	15,377
				BNR	2020	2022	

Facility	Brief Work Description	Total Cost (K USD)
Pump Station (2030)	Installation of 3.3m^3/min ×30kW ×3 pumps in the building	2,592
Tilcor Industrial Area (Urgent)	Installation of 27 kW × 3 pumps in the building Steel Pipe dia 200 mm with RC Pipe support ×2, L=100 m ACP dia 300 mm ×2, L=100 m	384

(3)Solid Waste Management Facilities

The following table is a summary of the estimated construction cost for the recommended solid waste management improvements in Chitungwiza.

Table 11.5 Cost Estimations for Solid Waste Management System

Sub-No.	Facility	Brief Work Description	Total Cost (K USD)
3.1.1	Cleanup of Illegal Dumping Site	Cleanup of the existing illegal dump sites by equipment	5,602
3.1.2	Procurement of Collection Equipment	Purchasing new heavy duty equipment and bins: 16 tripper trucks, 12 compactor trucks, 32 multi-loaders, and 1,515 skip bins	20,878
3.1.3.	Safety Closure of Existing Open Sump Site	Modification to the existing disposal sites with construction of gas exhausts, operation roads, drainage ditches, and fences	20,261
3.1.4.	Construction of New Final Disposal Facility	Construction of the new final disposal facility including administration and warehouse buildings, disposal sites with leachate collection facilities, reservoir pit, leachate treatment ponds, drainage, ground monitoring wells, and fences and purchasing new equipment	18,588
3.1.5.	Home Compost	Pilot Project: demonstrating and educating local people about home composting by instructors and providing plastic containers.	88
3.1.6.	Community Compost Plant	Pilot Project: construction of a new community compost plant including compost proceeding building, guard house, and providing equipment.	199
3.1.7.	MRF (Material Recovery Facility)	Construction of a new material recovery facility including MRF and administration buildings, and providing equipment	1,485
3.1.8.	Central Composting Facility	Construction of a new central compost centre including compost and administration buildings, receiving, sorting, treatment, process and storage areas and providing equipment.	9,377
		Ground Total	76,478

(4) Total

The summary table of the estimate construction costs for the urgent provision and proposed improvements for the target year of 2020 and 2030 is provided below.

Table 11.6 Construction Costs for Urgent Provision

Item	Cost (K USD)
Water Supply	2,747
Sewage	384
Total	3,131

Table 11.7 Construction Costs for a Target Year of 2020 and 2030 (K USD)

Improvements	Option1			Option2			Option3		
Target Year	2020	2030	Total	2020	2030	Total	2020	2030	Total
Water Supply	29,771	13,116	42,887	29,771	13,116	42,887	29,771	13,116	42,887
Sewage	128,619	2,582	131,211	20,121	2,592	22,713	15,377	2,592	17,969
Solid Waste	55,006	21,472	76,478	55,006	21,472	76,478	55,006	21,472	76,478
Total	**213,396**	**37,180**	**250,576**	**104,898**	**37,180**	**142,078**	**100,154**	**37,180**	**137,334**

11.2.2 Operation and Maintenance Cost

(1)Water Supply Facilities

Annual operation and maintenance cost for water supply facilities is estimated USD 6,983 thousand per year for 2020 and USD 7,803 thousand per year for 2030.

(2)Sanitation/ Sewerage Facilities

The O&M cost for each alternative option of the sanitation/ sewer facilities as below:

Zengeza STP Option1: USD 1,077 thousand per year, Option 2: USD 2,405 thousand per year, Option 3: USD 4,687 thousand per year

Pump station and sewer network: USD 133 thousand per year

Tilcor industrial area: USD 77 thousand per year

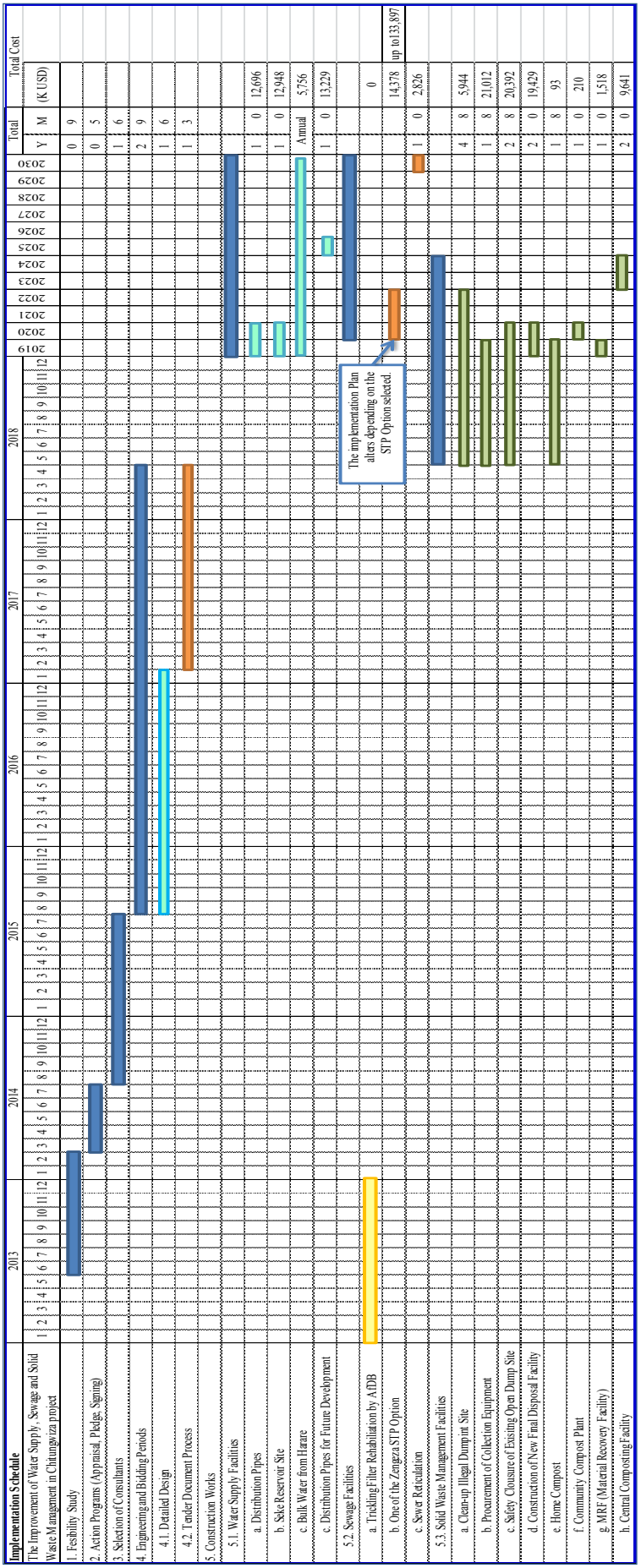
(3)Solid Waste Management

Annual operation and maintenance cost for solid waste management is estimated USD 3,910 thousand per year for 2030.

11.3Implementation Plan

The Implementation plan for the Improvement of Water Supply, Sewage and Solid Waste Management in Chitungwiza project is prepared in this M/P for discussion purpose. More detailed implementation plan will be discussed in the future Feasibility Study.

Figure 11.1 Implementation Schedule



CHAPTER 12 FINANCIAL AND ECONOMIC ANALYSIS

Financial analyses of the M/P projects were conducted using the cost data estimated by JICA Project Team. The revenue data used for the analyses were constructed mostly based on the current tariff and billing situations. The population forecast prepared by JICA Project Team was also used. The financial net present value (FNPV) and the financial internal rate of return (FIRR) were computed and the results were analyzed in comparison with the weighted average cost of capital of 2.8%.

Main economic benefits taken up in the economic analysis were disability adjusted life years (DALYs) and willingness to pay (WTP). Economic costs identified in the economic analysis were computed through conversion from the financial costs. The economic net present value (ENPV) and the economic internal rate of return (EIRR) were computed and the results were analyzed in comparison with the economic opportunity cost of capital of 12%.

Resultant IRRs and NPVs of each M/P project are summarized in Table 12.1. None of the M/P projects is financially viable. The financial viabilities of the M/P projects could be obtained by external assistance such as grant from foreign development partners or subsidy of the GOZ.

Table 12.1 IRRs and NPVs of M/P Projects

	FIRR	FNPV (USD million)	EIRR	ENPV (USD million)
Water supply	-5.2%	-33.5	28.9%	31.7
Sewerage (Option 2)	-17.1%	-41.4	23.8%	15.5
Solid waste management	-13.3%	-92.2	4.8%	-15.4
Hurdle rate	2.8%		12.0%	

However, from the viewpoints of economical viability, the M/P projects are worth implementing. The water supply project and the sewerage project show an EIRR higher than the hurdle rate of 12%. The solid waste management project has a lower but still positive EIRR. The low EIRR of the solid waste management project can be reinforced by combining it with water supply and sewerage projects. The combined water supply, sewerage and solid waste management project shows 18.5% EIRR and USD 31.7 million ENPV, which satisfy the economic viability requirement.

CHAPTER 13 CONCLUSION AND RECOMMENDATION

13.1 Background

- Zengeza STP was constructed by Japanese ODA project and transferred in 2000. Operation of the facility was suspended in 2004 due to O&M problem and its budget.

- Data Collection Study on Improvement of Sanitary Environment of Chitungwiza City was conducted during January and February in 2011. As a result of the investigation, it was recognized that a comprehensive approach is needed for water supply and solid waste management as well as sewage for the improvement of sanitary condition in Chitungwiza.
- The government of Japan appointed JICA to start the study on technical corporation for development for two years from April 2012: Phase I Basic Study, Phase II Establishment of Master Plan, Phase III Feasibility Study. (Conducted by NJS Consultants Co. Ltd.)
- City of Harare has been developing the "Greater Harare Water and Sanitation Strategic Plan" with the assist by WB to improve water supply and sanitation services for City of Harare and 4 municipalities (Chitungwiza, Ruwa, Epworth and Norton) by September 2013.
- Since investors meeting will be held in the project above, it is expected that various investors will be involved for the project for concerned municipalities.

13.2 Analysis of current condition for Water Supply

- The actual production capacity of Harare Water Works in 2012 is around 640,000m^3/day, while the water demand was estimated to be 383,000m^3/day. The production capacity is considered not to enough because the necessary capacity is estimated 890,000m^3/day due to 57% of the NRW (Non-Revenue Water) of Harare distribution area.
- Chitungwiza Municipality (354,000 of population by 2012 census) almost completely depends on the bulk water distributed by Harare Water Works. The normal distributed flow is 30,000m^3/day, but it is frequently reduced to 12,000-15,000m^3/day.
- There are reservoirs with 41,000m^3 of volume in Chitungwiza, however these are not used for water supply regulation. Water distribution to Chitungwiza is pumped up constantly from Prince Edward WTP even though the water demand is fluctuated.
- Chitungwiza Municipality only paid 10% to the balk water bill to Harare Water Works; 1.2mil.USD out of total balk water bill of 12.7mil.USD for past three (3) years were paid on February 2013
- Water supply of balk water to Chitungwiza Municipality is restricted due to unpaid bill, and shortage of water amount and frequent breakdown of facilities of Harare Water Works. Thus total over 3,000 of wells are used for supplemental water supply in the municipality

13.3 Current Status of Sewerage

- Raw sewage has been discharged to Manyame catchment area from City of Harare and the Municipalities.
- There are two sewage treatment facilities in Chitungwiza : Old facility of trickling filters constructed in 1978 with the capacity of 20,000m^3/d and latest facility of BNR with the capacity of 20,000m^3/d constructed by Japanese ODA.
- A part of St.Mary area, Seke North area and Seke South area in Chitungwiza were not covered due to break down of pump stations, clogging of sewers. One of the cause of the break down is the deposit of sand in the sewers. Residents have been using the sand for the pot washing. The sand in the sewer was cleaned by Jet Cleaning Machine before. After the breakdown of the cleaning machine it was made by manually after 2001.
- In the AWF project under AfDB, sewers and pump stations were rehabilitated, which will enable the whole sewage reach to the STP. Existing old Trickling filters in Zengeza STP will be rehabilitated by Zim Fund as well.

13.4 Analysis of current condition for Solid Waste Management

- Method is House–to-house collection of waste bags and collection of skip bin. Collected wastes are transported to the dumping site about 5km away from the municipality by truck once a week.
- Currently, the system cannot cover whole the area due to bad road condition.
- Wastes have been disposed in the open dumping site without any control.
- 390 Illegal dumping sites were found in the study with the total wastes amount of 60,000m^3.

13.5 Current Status of Water Cycle and Aquatic Environment

- Daily inflow to Lake Chivero is approx. 1,000,000m^3/d. Approx. 640,000m^3/d is taken as raw water for the water supply.
- Population of City of Harare is around 1,600,000 with two major STP of Crowborough （54,000m^3/d) and Firle（144,000m^3/d）. About 60 % of the sewage was treated by BNR process while rest of sewage was treated by trickling filter process. However, BNR process is not working because of breakdown.
- Total sewage generated in the Manyame catchment area is about 230,000 m^3/d, with the 90 % share of Harare (approx. 200,000m^3/d) and 10% share of Chitungwiza (22,000 m^3/d).
- BOD loading for the catchment from Harare is 110,000kg-BOD/d, and that of Chitungwiza is 13,000kg-BOD/d （12% of Harare)

13.6 Current Status of Flow and Water Quality and Future Projection

- Worsening of every parameter of water quality was confirmed in the analysis.
- Since the catchment area has characteristics with low specific run-off and large variation of annual rainfall, it will not be easy to secure ample surface water. Then construction of sewerage and its appropriate operation & maintenance is essential to the environmental management on the premises of water cycle in the closed system.
- AWF project and ZIM Fund project in the catchment area were evaluated effective to the environmental improvement in the pollution analysis. Appropriate operation & maintenance and augmentation for the increase of wastewater flow.
- For the improvement of the water environment of the catchment, priority is the treatment of the sewage from City of Harare regardless of process employed.

13.7 Alternatives for Water Supply

- By increasing the capacity of distribution, coping with the demand can be executed. Even if the total distribution flow to the municipality is not enough, distribution will be made equally to all consumers. The plan will be affected by Harare Water Works. The municipality must pay the water bill constantly.
- By construction of well group, even though the intake capacity of 3,000m^3/day is small, it will enable to supplement the water supply when the reduction of water supply takes place.
- When alternatives above are implemented, all municipality will have equal water supply even though the water supply from Harare Water Works is unstable due to the water shortage . Then shallow wells for the areas where allocation of wells was few will be installed and some clogged old pipes will be replaced by the items of 1.3.1.

13.8 Alternatives for Sewerage

- Refurbishing the existing BNR facility to Oxidation Ditch system with lower O&M cost and easier maintenance is most appropriate plan in terms of engineering and economic aspects. However, it is not urgent issue since rehabilitation project of old system (Existing trickling filters) is under way by Zim Fund (As of July, 2013).
- After the rehabilitation of Zengeza STP, expenditure for the operation & maintenance will be minimum since the process is trickling filters which require less power than other processes.
- Chitungwiza municipality must take care of the facilities for the sanitation of the residents in the municipality. Revision of tariff for the sewage or securing another income will be needed for the operation & maintenance. One of the promising income sources is selling the treated water for the irrigation. Appropriate unit rate will be important.

- For the augmentation of the facility in the mid-term, redesign of the existing BNR to Oxidation Ditch system will be the best plan in terms of cost and operation & maintenance.

13.9 Alternatives for Solid Waste Management

- Closing of the existing disposal site, new construction of the sanitary land fill and procurement of collection equipment were planned.

13.10 Financial Analysis

- FIRR and EIRR were examined for the analysis on Project Cost, O&M Cost for project life of 40 yrs
- Negative FIRRs were shown although the EIRRs were positive.
- Selling of treated water to irrigation has some possibility to improve the FIRR of sewage part.

13.11 Feasibility Study in Phase III

- Through the study of Phase I (Basic Study) and Phase II (Master Plan), JICA Project Team found that the main issue in Chitungwiza was not present in the sewage part but rather in the water supply. The improvement work of the sewerage in Chitungwiza (Urgent rehabilitation) was already on-going and from the result of the pollution analysis, the improvement work is deemed to benefit the improvement of the environment. Further, it was clarified that the main pollutants for the water source have been coming from City of Harare rather than Chitungwiza Municipality

- During the course of the project, JICA Project Team also encountered another problem of Chitungwiza Municipality as well as Zimbabwe Government, namely financial problem. The financial issue has been affecting every part of the domestic life and public administration.

- In order to guarantee the sustainability of the facilities to be developed in the future, it was decided through the discussion of both sides of Zimbabwe and Japan to put a certain period before the F/S to observe and confirm the financial status of Chitungwiza Municipality. Implementation of F/S will be considered when the restructuring of the municipality shows a certain progress.