CHAPTER 3

Preliminary Enviornmental Impact Assessment

EXECUTIVE SUMMARY

It is proposed to extend the Zengeza Sewage Treatment Works (STW) in Chitungwiza near Harare in order to relieve the overloaded situation currently prevailing at the existing works. The expansion of the STW entails the construction of a biological nutrient removal (BNR) sewage treatment plant which could treat 20Ml/d of raw sewage to a level that would meet Zimbabwe's effluent standards and allow discharge to the Nyatsime River.

The discharge of a high quality effluent from the STW expansions to the Nyatsime River would be a valuable source of water for Harare's water supply storage impoundments downstream (Lakes Chivero and Manyame), particularly in times of drought.

A Preliminary Environmental Impact Assessment (PEIA) has been carried out for the proposed project. The PEIA has identified no fatal environmental flaws for the expansions and the development can, therefore, continue.

The following potential positive and negative environmental impacts have been identified:

Hydrological Impacts: The water levels in the Nyatsime River will increase by 20Ml/d downstream of the STW if the full quantity of treated effluent from the STW expansions is discharged to the river. This will provide valuable water to downstream impoundments for re-use as a water supply, particularly in times of drought. At the public consultation meeting to discuss the project, farmers expressed a desire to receive the treated effluent from the new plant, especially since the infrastructure to receive the effluent is in place. These competing demands will need to be balanced.

Aquatic Ecology Impacts: The increase in flow will favour species which are better equipped to live under continuous flow conditions. Species which prefer flow regimes which fluctuate seasonally may thus be detrimentally affected. The aquatic environment has already been severely impacted in the Nyatsime River and the Upper Manyame River Basin, due to urban development and other anthropogenic activities. Furthermore, the existing STW was already discharging surplus effluent, which could not be handled by the pumps carrying effluent to Imbwa Farm, into the Nyatsime River prior to August 1995. Thus the aquatic ecology in the Nyatsime River is not expected to be significantly impacted due to changes in flow.

Water Quality Impacts: The new plant will be designed to meet Zimbabwe's Water Effluent and Wastewater Standards. (eg COD < 60 mg/l; Total - N < 10 mg/l) This will permit discharge to the Nyatsime River and will be a considerable improvement on the quality of effluent previously

discharged from the existing STW. It is expected, however, that the discharge from the STW expansions will still contribute to nutrient levels and concentrations in the catchment downstream of the STW, although this contribution will be less than previously experienced. The cumulative impact of all the pollution sources in the catchment will mean that only a marginal improvement in water quality conditions downstream will occur. It is also likely that eutrophic conditions will continue to persist in the downstream impoundments. The improvement at the Zengeza STW, however, should make a significant contribution towards better pollution control in the catchment.

Waste Impacts: The disposal of wastewater sludge for agricultural use appears to be the most feasible and environmentally acceptable disposal option in the short term. The back-up disposal option of using unlined storage pits is not deemed environmentally acceptable because of the risk of groundwater and surface water contamination.

Air Pollution, Aesthetics, Noise and Vibration Impacts: The impacts in these areas are expected to be minimal and mainly temporary whilst construction takes place. As a result of the expansions to the STW, odours should be reduced due to the more efficient operation of the existing STW.

Social Impacts: Employment opportunities will be created by the construction and operation of the STW expansions. No access control to the STW site poses a safety risk and allows illegal dumping of waste to occur. Currently no provision is made for limiting development in close proximity to the STW site.

Although no fatal environmental flaws have been identified in the proposed project, the following actions are recommended to ensure environmental concerns are minimised:

- A structured and regular water quality monitoring programme should be put in place to ensure the effluent discharged to the Nyatsime River from the STW expansions meets Zimbabwe's effluent standards.

- An equitable agreement needs to be reached regarding the discharge and use of the treated effluent from the STW expansions between local farmers and the relevant Authorities. The water demands for irrigation and storage in downstream impoundments (eg for water supply and recreation) should be carefully managed to try and satisfy all needs.

- An acceptable and secure long term sludge disposal means must be found. The demand from local farmers or other potential users for the dried sludge produced at the expansions to the STW needs to be established. This will prevent potential future storage and disposal problems and allow for future

planning.

- The sludge produced at the expansions to the STW needs to be regularly sampled so that the agricultural uses to which the sludge can be applied are established. Sampling of groundwater and surface water resources near to where the sludge is used should also take place to ensure contamination does not occur.

- The environmental impacts of transport of the sludge to its final use should also be closely managed and controlled to prevent public nuisance.

- Grit and screenings from the STW should not be buried on site but disposed of safely at the nearby Chitungwiza landfill because of a high potential for ground water contamination, as should any other waste produced during the operation of the expansions to the STW.

- The STW site should preferably be fenced and access to the site controlled.

- The creation of a buffer zone around the STW will help minimise the impacts on any future developments to the south of the STW site.

- The final design for the expansions to the STW should be critically reviewed to ensure environmental acceptability.

- The conceptual environmental management plan (EMP) should be revised and updated once the final design has been completed and evaluated. Relevant sections of the EMP should form part of the tender documentation for construction of the STW expansions.

TABLE OF CONTENTS

ZENGEZA SEWAGE TREATMENT WORKS EXPANSIONS
PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT

1. INTRODUCTION

Chitungwiza is an urban growth point situated approximately 25 km to the south of Zimbabwe's capital city, Harare. The Chitungwiza Municipality owns and operates the Zengeza Sewage Treatment Works (STW), which is located in the south-west of the municipal area (Figure 3.1) and presently treats all the sewage generated in Chitungwiza. The STW is situated adjacent to the Nyatsime River, upstream of this river's confluence with the Manyame River. The Manyame River subsequently flows into Lake Chivero and Lake Manyame, the principal water supply storage dams for Harare and its surrounding urban centres.

The Zengeza STW has been identified as a point pollution source in the Upper Manyame River Basin and poor quality effluent from this plant, together with other point and diffuse pollution sources, has led to a deterioration in the water quality in the catchment.

JICA dispatced a Study Team to prepare a Masterplan for Water Pollution Control in the Upper Manyame River Basin. This study highlighted the need to extend and improve the Zengeza STW as a "priority project" in meeting the urgent needs of water pollution control in the Upper Manyame River Basin.

As part of the above mentioned study, an Initial Environmental Examination (IEE) for the proposed expansions to the Zengeza STW was carried out. The IEE was prepared to conform with the requirements of JICA as well as covering the requirements of a Prospectus (a report detailing that a "prescribed activity" is being considered), as specified in the Environmental Impact Assessment (EIA) Policy of Zimbabwe's Ministry of Environment and Tourism (1994). The IEE scooped the most significant impacts expected to arise from the proposed project and thus began to address some of the issues that would need to be considered in a Preliminary Environmental Impact Assessment (PEIA), the second step, after a Prospectus, required by Zimbabwe's EIA Policy.

Draft Terms of Reference for the PEIA were prepared in the IEE and were subsequently amended because of the fast track nature of the project and because much work had already been completed during the earlier investigations. The PEIA report has been compiled in accordance with the requirements set out in the General Environmental Impact Assessment Guidelines (1995), published by Zimbabwe's Ministry of Environment and Tourism.

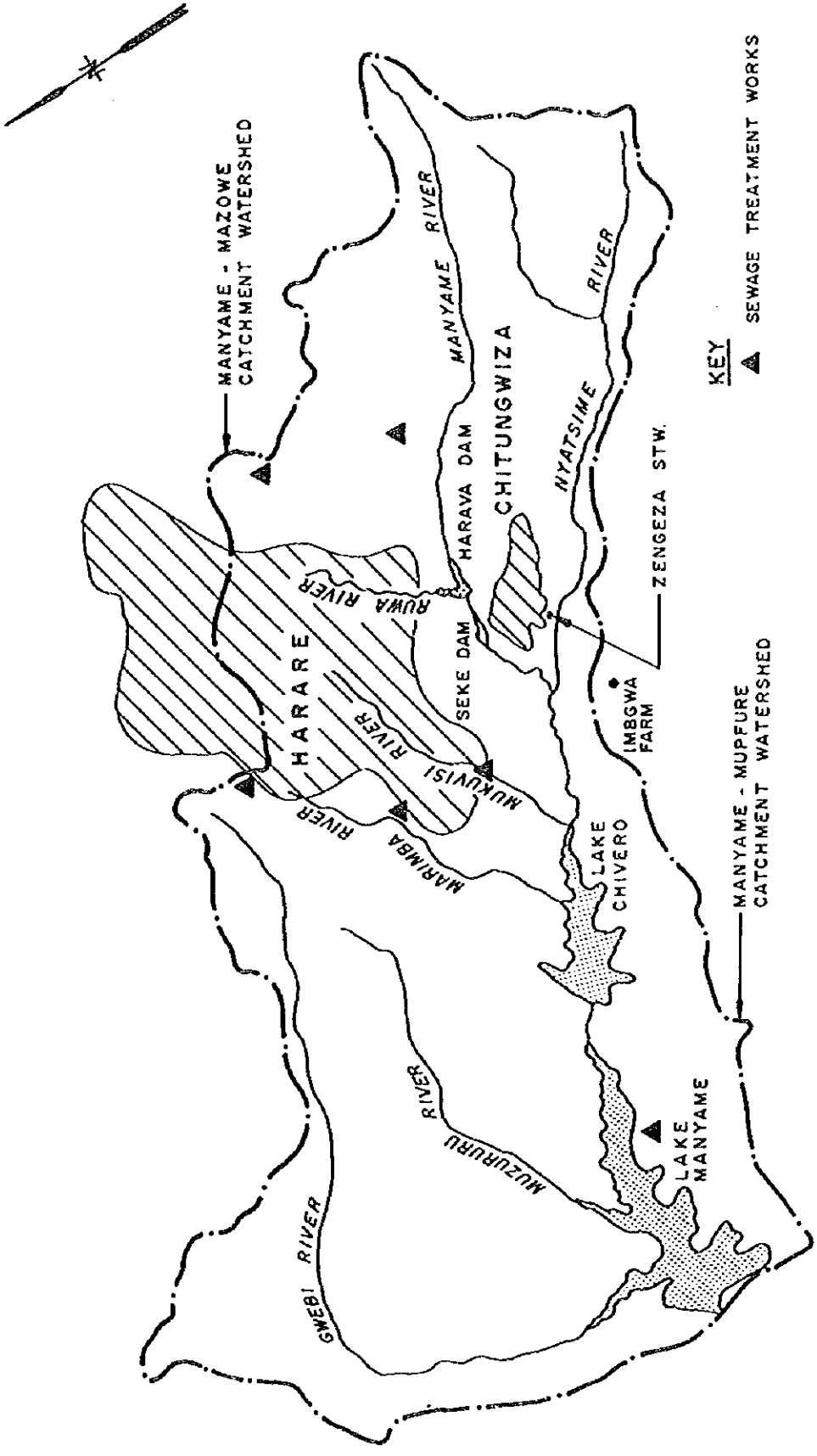


Figure 1.1 : Upper Manyame River Basin

2. PROJECT DESCRIPTION

2.1 Status Quo at Zengeza STW

The existing Zengeza STW is heavily overloaded, being designed for about 20Ml/d but currently treating an estimated flow in excess of 36Ml/d. The effluent is presently treated in anaerobic ponds and trickling filters prior to being pumped to the Government owned Imbgwa Farm, approximately 7 km away from the Zengeza STW in the Mupfure River catchment, where it is used for irrigation after passing through a series of maturation ponds. In the past, surplus effluent was discharged to the Nyatsime River when the pumps carrying the treated effluent to the Imbgwa Farm could not handle the full load. This surplus effluent was, however, of poor quality and expansions to the maturation ponds at Imbgwa Farm, together with an increase in the capacity of the pumps, recently permitted discharges to the river to cease. Since August 1995, no effluent has been discharged directly into the Nyatsime River, but untreated sewage still finds its way into local water courses as surface run-off, especially during the rainy season, due to the fact that the STW and certain sewers in Chitungwiza cannot cope with the full sewage flow.

Sludge is presently removed from the anaerobic ponds at the STW on an annual basis, whereupon it is dried in sludge drying beds before being stockpiled on site. Local farmers occassionally remove some of this dried sludge for use as fertiliser.

New anaerobic ponds with a treatment capacity of 7Ml/d have recently (August 1996) been commissioned at the Zengeza STW. The effect of these ponds will be to provide for more storage capacity at the works (27Ml/d), but the total flow will still be fed through the existing biological filters.

2.2 Proposed Expansions to Zengeza STW

A biological nutrient removal (BNR) plant has been proposed for construction at the Zengeza STW to treat approximately 20Ml/d sewage from the Chitungwiza area. In order to ensure a more environmentally acceptable discharge of treated effluent into the Nyatsime River, the effluent from the BNR plant will be treated to comply with the effluent discharge standards specified in Zimbabwe Government Notice No 687 of 1977. Due to the scarcity of water in the Harare metropolitan area, a high quality effluent from the expansions to the Zengeza STW would be an important source of water for the impoundments downstream (Lakes Chivero and Manyame) during times of drought.

After implementation of the upgrade, the total capacity of the STW will be approximately 40Ml/d. The expansions would therefore eliminate the present overloaded situation and permit the rest of the plant to operate more efficiently as well. The new plant will only treat domestic sewage. All industrial

effluent will be treated by the existing STW.

The following physical structures will form part of the proposed expansions at the Zengeza STW :

- a screen/grit chamber;
- six primary sedimentation tanks;
- two biological nutrient removal (BNR) activated sludge bioreactors;
- four final sedimentation tanks;
- two gravity sludge thickeners;
- two sludge digester tanks;
- six sludge drying beds ;
- a roofed dried sludge storage yard; and
- a laboratory.

A final decision regarding the possible provision of sludge disposal pits adjacent to the BNR plant remains to be taken. This will depend on the marketability of the dried sludge produced to local farmers. In the event of failure of the BNR plant, effluent will be diverted through the existing STW and pumped to the maturation ponds at Imbgwa Farm. The project is in the preliminary design stage; a suitable site has been identified, a treatment process proposed and a preliminary layout of the expansions prepared. A summary of the project description is given in Table 2.1 below and a layout of the proposed expansions is shown in Figure 2.1.

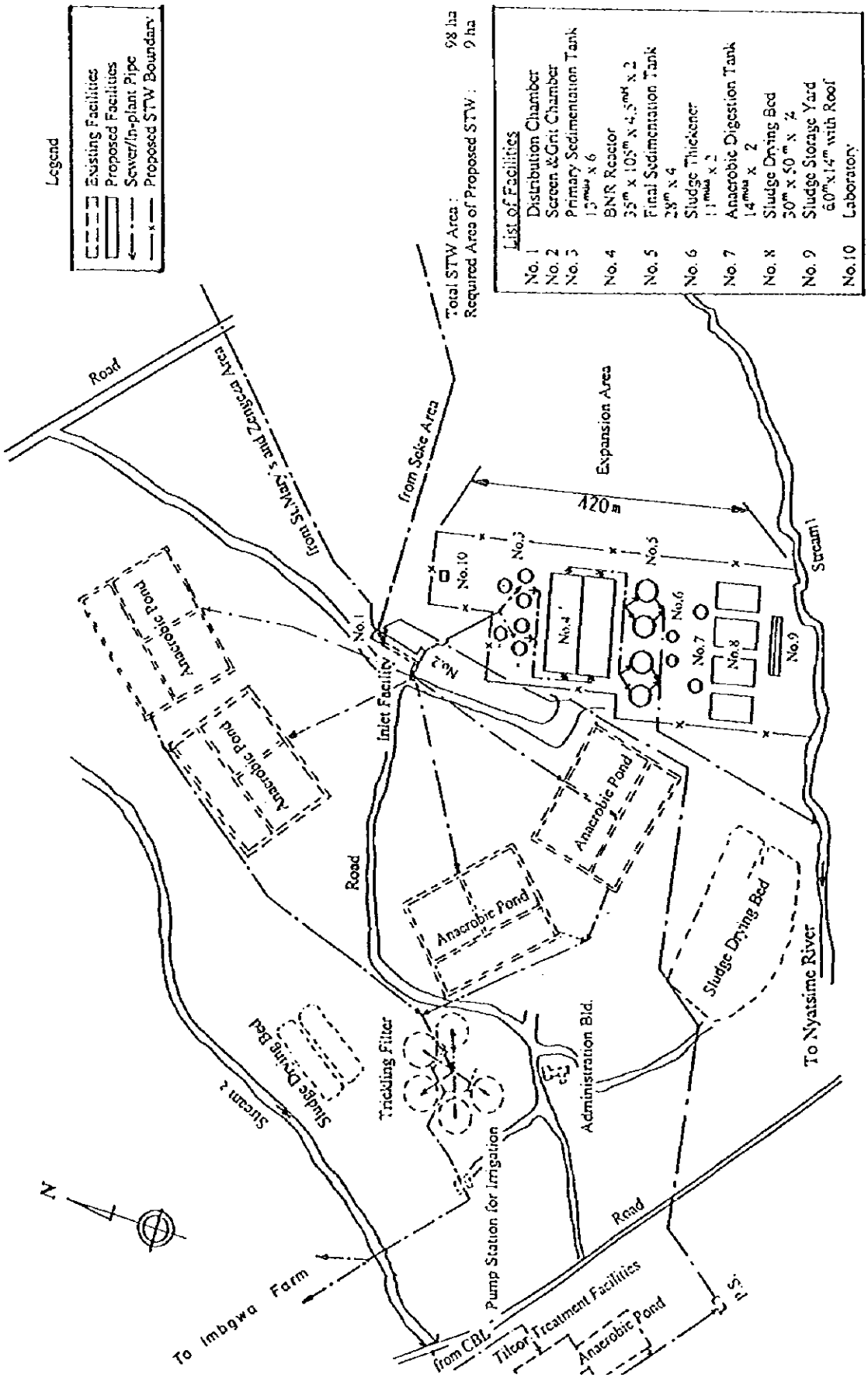


Figure 2.1 Layout Plan of Proposed Facilities (20,000 m³/day capacity)

Table 2.1 Tabular Summary of the Project Description

ITEM	CONTENTS
Project Name	Rehabilitation/Expansion Project for the Zengeza Sewage Treatment Works
Background	The existing influent flow rate at the Zengeza STW in Chitungwiza Municipality is in excess of 30 Ml/day, while its capacity is only 20,4 Ml/day. The STW is overloaded. Treatment effectiveness is low and this causes adverse environmental impacts, such as odour problems and degradation of the receiving water environment. Thus the STW need to be expanded.
Objective	Construct BNR (Biological Nutrient Removal) unit to improve effluent water quality that will allow it to be discharged to the Nyatsime River and consequently contribute to an increase in the incoming water volume to Lake Chivero, a valuable water source.
Location	Chitungwiza Municipality, near Harare, Zimbabwe
Relevant Government Organisations	Ministry of Local Government, Rural and Urban Development; Chitungwiza Municipality
Beneficiaries	Approximately 400,000 people
Design Criteria	Preliminary design initiated but not finalised
Project Type	Construction
Service Area	Area: 4,200 ha Population Served: 400,000 persons Current Flow Rate: 30 Ml/day
Waste Water Collection System	Separate sewer system
Treatment Plant (Current)	Existing Method: Anaerobic Pond, Trickling Filter, Pump Station, Maturation Pond, Irrigation Capacity : 20,4 Ml/day
Sludge Treatment and Disposal (Current)	Sludge Drying Bed, Stockpiling, Removal by Farmers
Treatment Plant (Expansion - proposed)	Proposed Method: Primary Sedimentation, BNR Unit, Final Sedimentation, Discharge to River Capacity : 20 Ml/day
Sludge Treatment and Disposal (Expansion -proposed)	Gravity Thickener, Sludge Drying Bed, Sludge Storage Yard or Disposal Pits, Removal by Farmers
Pipelines	Conduit
Water Body to Receive Treated Effluent	Nyatsime River

3. ENVIRONMENTAL PLANNING AND DESIGN

In order to maximise the opportunities for good environmental planning and design in the Zengeza STW expansions project, Study Team has worked closely with the Chitungwiza Municipality.

An Initial Environmental Examination (IEE) of the site for the proposed STW expansions, carried out as part of the Masterplan for Water Pollution Control in the Upper Manyame River Basin (JICA Study Team, 1996), provided guidance for the preliminary design for the new BNR plant at Zengeza.

This PEIA report has expanded on the findings of the IEE, based on the preliminary design supplied, and will provide further guidance in finalising their detailed design for the BNR plant.

Because of the fact that the existing STW are already severely overloaded and as a consequence of the fast track nature of the project, the approach adopted in the environmental investigations has necessarily been largely qualitative in nature, or based on readily available quantitative data. The methodology adopted in the PEIA included:

- A review of available existing literature on the Upper Manyame River Basin of relevance to the PEIA, including sections of the report on the Masterplan for Water Pollution Control in the Upper Manyame River Basin.

- Site visits to the Zengeza STW, Lakes Chivero and Manyame, the Chitungwiza landfill site and points on the Nyatsime River immediately upstream and downstream of the STW.

- *Ad hoc* discussions with Mr M Khosla (Director of Engineering Services, Chitungwiza Municipality), Mr P Mbira (Principal Water and Sewage Engineer, Chitungwiza Municipality), Mr R Lock (Member of the Water Pollution Advisory Board) and members of the operations staff at the Zengeza STW.

- An analysis of the preliminary design for the BNR plant at Zengeza.

- A public consultation meeting with Interested and Affected Parties (see Chapter 4).

During the Zengeza STW site visits, a checklist of environmental features was used to identify potential impacts. Once identified, these potential impacts were investigated in more detail and their significance evaluated (see Chapter 6). Based on these evaluations, recommendations (Chapter 9) have been made to guide the design Project Managers and the relevant Authorities in finalising the design for

the expansion of the STW.

A preliminary environmental management plan (EMP) has also been compiled (Chapter 7) based on the preliminary design. This should be refined and expanded once the final design has been completed and evaluated.

4. PUBLIC CONSULTATION

A public consultation meeting was held on 6 December 1996 in the offices of the Chitungwiza Municipality to discuss and solicit views on the proposed project and to raise and document environmental concerns. The notification and invitations to the public meeting were organised by the Chitungwiza Municipality and the Study Team.

Interested and affected parties who attended the meeting included representatives of Government Ministries and Departments, local authorities, consultants, the University of Zimbabwe, local farmers and members of the Study Team

Most of the issues and concerns raised at the meeting related to the impacts of treated effluent and sludge disposal on the surrounding environment. A summary of all the environmental concerns raised at the meeting is provided in Table 4.1 below.

Table 4.1 Summary of Environmental Concerns and Issues Raised at the Public Consultation

AREA OF CONCERN	MATTERS RAISED
DISCHARGE OF TREATED EFFLUENT	How important was the discharge of treated effluent to the river system in terms of overall water usage in the catchment? Could the effluent not be better utilised for irrigation?
	There was sufficient farmland available in the vicinity of the STW to accept all the treated effluent for irrigation.
	The pumping system for carrying treated effluent to Imbgwa Farm could now handle over 50 Ml/d. This capacity would not be used if the effluent from the BNR plant was discharged to the Nyatsime River. Canals had also been recently constructed to carry effluent to the neighbouring Luthrie/ Ellerton Farms
	What was the self-purification capacity of the Nyatsime and Manyame Rivers? Knowledge of this aspect would assist in assessing the impact of the effluent on the river system. Would the new plant address the water hyacinth problem?
	No monitoring of the quality of the treated effluent presently used for irrigation at Imbgwa Farm was being carried out. Thus the impact on ground-water and whether run off was reaching the river system was unknown.
	There was no provision for tertiary treatment at the BNR plant. Although the treated effluent might meet the Regulations issued under the Water Act, the bacteriological quality of the effluent could still be harmful to downstream users. In particular, it could be a risk if used to irrigate dairy cattle pasture and crops eaten raw, as well to those using the river system for recreation.
SLUDGE DISPOSAL	How would the grit and screenings from the STW expansions be disposed of? The current practice of disposal on site was questioned because of the potential effects on groundwater and the future use of the site once the STW was decommissioned.
	There was concern that the option of the sludge being used by farmers for soil conditioning might not be viable since the market had not been tested. In the event of farmers not removing the sludge, storage would become a problem.
	The proposed back-up system of disposal pits adjacent to the STW expansions was considered environmentally unacceptable. If the pits were unlined, there was a potential threat to the groundwater and the adjacent river system Use of the sludge for agricultural applications was considered the most viable option in terms of the recycling of waste. But the sludge needed to be tested in terms of nutrient and metal content before a decision on its use could be taken. Application to blue gum plantations was one option frequently adopted in Zimbabwe which could be considered.
OTHER	Given the high population growth of Chitungwiza and the fact that the existing STW was already overloaded, concern was expressed that the STW expansions would not offer sufficient capacity to 2015 as predicted by the Study Team.

AREA OF CONCERN	MATTERS RAISED
	The problems of burst pipes and an overloaded reticulation system in Chitungwiza should also be addressed.
	Stormwater run-off and leaks from the new plant should be adequately controlled.
	Concern was raised about informing the residents of Chitungwiza about the project since they were not represented at the meeting. The Chitungwiza Municipality should ensure residents were aware of the project and the PEIA report should be made available for comment
	Mitigating measures to address identified environmental problems should be clearly outlined.
	Expansion of the STW would mean alternative uses of the land required for the expansion would be foregone.

No further comments or issues regarding erosion, noise and air pollution and the positive impacts identified in the documentation handed out at the meeting were raised.

5. ENVIRONMENTAL SETTING

Within the context of the proposed project, the affected environment is described on two levels: i) the site itself where the proposed expansions to the Zengeza STW will be located; and ii) the river system and surrounding environment into which the final effluent will be discharged.

5.1 Site Description of Proposed Zengeza STW Expansions

The proposed site earmarked for the construction of the new BNR plant is unutilized land, owned by the Chitungwiza Municipality, at the Zengeza STW. The identified site lies to the east of the existing anaerobic ponds and inlet works (see Figure 2.1 and Figure 5.1). The area is underlain by granite rocks with a sandy soil cover. Part of the area was previously used as a borrow pit for road construction materials and the surface has been disrupted (photographs 1 and 2).

The remainder of the site has a number of termitaria around which small scale agriculture of maize has previously been practised (photograph 3). Domestic solid waste has been illegally dumped at random on the site due to a lack of fencing and no access control to the area (photograph 4). The natural environment of the whole site has therefore been altered to a greater or lesser degree and the site is already severely impacted. No endangered flora or fauna were observed during several site visits to the STW, nor were any ruins or cultural assets of conservation value identified on the site. A tabular summary of the site description is given in Table 5.1.

Table 5.1 Tabular Summary of Site Description Information

ITEM		CONTENTS
Project Name		Rehabilitation/Expansion of Zengeza Sewage Treatment Works
Social Environment	Affected Communities	Industry and housing located near the STW
	Land Use	Peri-urban and urban
	Economy/Transportation	Industrial sites / housing near the STW; site bounded by Nyatsime River, two local streams and Chitungwiza Road
Natural Environment	Topography/ Geology and Soils	No distinguishing feature; site comprises sandy soils and has been disturbed by localised quarrying and farming
	Valuable Flora and Fauna	None
	Valuable Ruins and Cultural Assets	None
Environmental Pollution	Complaints	Offensive odours affect nearby industries and residential areas; Nyatsime River polluted by poor quality effluent in past; local streams adjacent to STW polluted by overloaded sewer system
	Proposed Countermeasurs	Rehabilitation/Expansion project for the STW

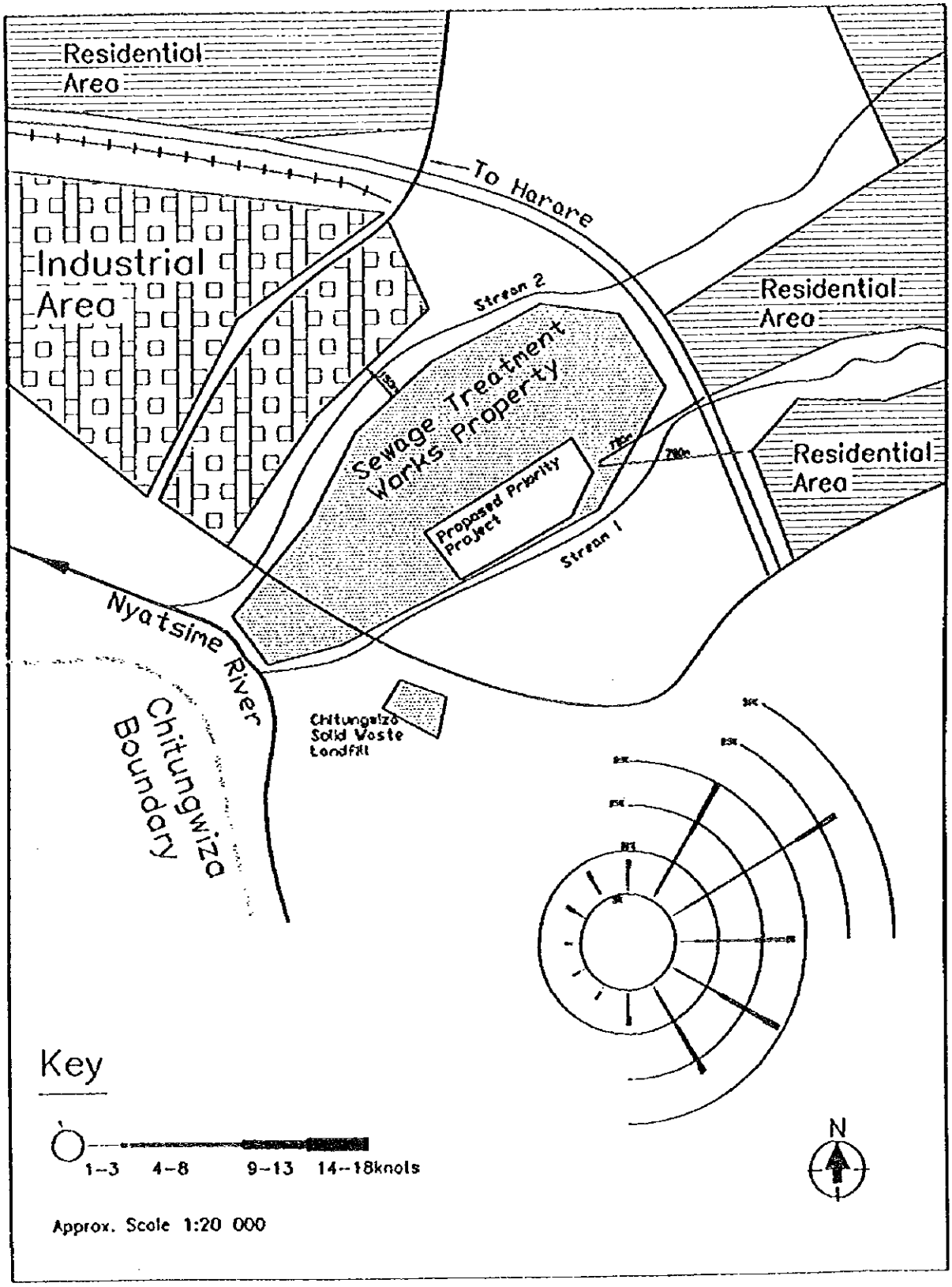


Figure 5.1: Diagram of land around the Zengeza STW. Also indicated are the annual wind directions measured at the airport, the closest measuring point.

Photograph 1 : Site on which BNR plant will be constructed.
Note disruption of surface area.

Photograph 2 : Borrow pit on proposed site used previously
for road construction material

Photograph 3 : View of proposed site showing termitaria and previous small scale agricultural activity

Photograph 4 : Illegal dumping of waste on proposed site

The Chitungwiza solid waste landfill site is situated nearby to the south of the Zengeza STW. Undeveloped land to the south-west and south-east of the works is earmarked for a mixture of residential and industrial development. The Nyatsime River (photographs 5 and 6) forms the southern boundary of the STW whilst small streams draining the Chitungwiza area form the eastern (photograph 7) and western (photograph 8) boundaries of the STW. The Chitungwiza Road forms the northern boundary.

The land use around the Zengeza STW falls into three categories: industrial, residential and open space. The Tilcor industrial area is the closest land use with a number of factories situated about 150 m from the western boundary of the existing STW's anaerobic ponds and sludge drying beds. Figure 5.1 shows the location of the Zengeza STW in relation to the surrounding industrial and residential areas. Communal farm land is found upstream of the STW and commercial farmland directly downstream.

5.2 Description of the River System and Environment Downstream of Zengeza STW

The effluent from the proposed BNR plant will be discharged into the Nyatsime River, a tributary of the Manyame River. The Upper Manyame River Basin has therefore been considered as the broader environmental setting for this PEIA, since the effluent will have an impact on the water quality of the water courses downstream of the discharge point as well as on the downstream users of the river system.

The Upper Manyame River Basin (see Figure 1.1,) covers the city of Harare as well as portions of Mashonaland East, Mashonaland West and Mashonaland Central. The basin covers a total of 3,900 km^2 of which approximately 551 km^2 are urban areas.

5.2.1 Physical Environment

Meteorology

The Department of Meteorological Services monitors various meteorological parameters at the Belvedere Weather Station in Harare. Table 5.1 gives the monthly averages (calculated over 30 years) of three key meteorological parameters which reflect typical conditions experienced in the Upper Manyame River Basin.

Table 5.2 Monthly Meteorological Data for Harare

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

The climate of the study area can be divided into three distinct seasons, these being summer, winter and spring. December to April can be classified as "summer" which is a wet, hot season during which most of the rainfall occurs. "Winters" are usually cool and dry and last from May up to August while September to November is a hot and dry "spring".

The mean total annual rainfall is approximately 820 mm but this can vary considerably from year to year. Annual rainfall of as little as 440 mm and as high as 1 200 mm have been recorded in the past. Winds in the area are generally easterly in direction and light winds with a wind speed of over 4 knots are common to the area. Figure 5.1 gives an indication of the annual wind direction and speed experienced at the Zengeza STW.

Topography and Geology/Soils

The Upper Manyame River Basin is generally a gently undulating featureless plain. Most of the area lies at an altitude between 1,400 and 1,500 m above mean sea level (MSL), with the lowest point being approximately 1,300 m above MSL.

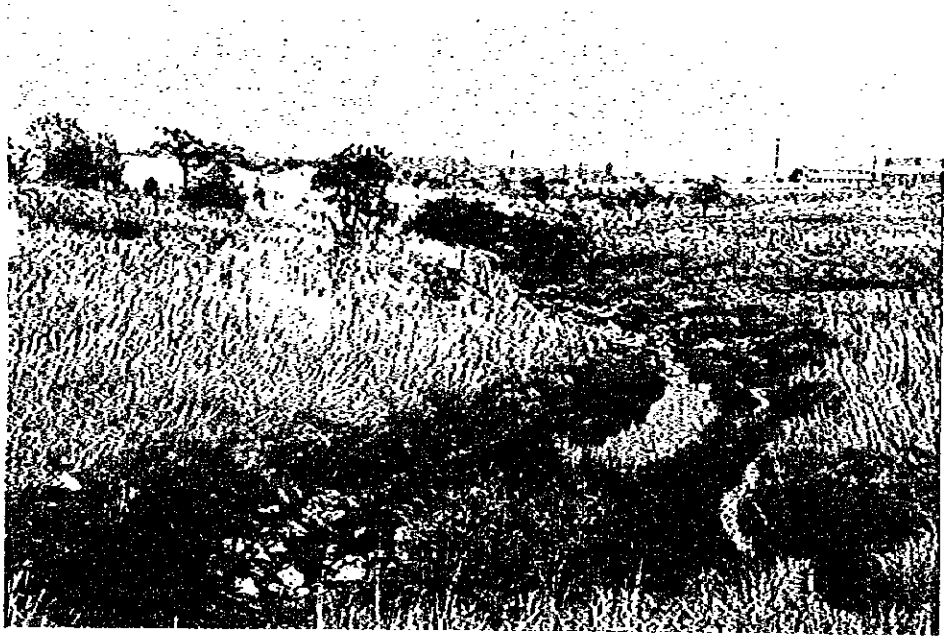
The Basin is generally underlain by Archaean age rocks that form part of the Zimbabwe Basement Complex. Two main geological regions can be differentiated in the area; the Upper Catchment (towards the eastern side) and the Lower Catchment (the western side including Lake Manyame).

The Upper Catchment is underlain by rocks of the Older Gneiss Complex. These rocks contain small inclusions of schistose rocks, comprised of meta-sediments and meta-volcanics of Bulawayan Age A small part of this Upper Catchment is underlain by granite. The Lower Catchment is almost entirely underlain by granite except for areas to the north and north-west of the basin, where metasediments and meta-volcanics of Burawayan Age occur.

Photograph 5 : View of Nyatsime River and Stream 2 confluence looking upstream

Photograph 6 : View of Nyatsime River and Stream 2 confluence looking downstream

Photograph 7 : View of Stream 1 looking south.
This stream forms the eastern boundary of the STW site.



Photograph 8 : View of Stream 2 looking south.
This stream forms the western boundary of the STW site.

The underlying granitic geology of most of the area has given rise to light textured, sandy soils.

Hydrology

The Department of Meteorological Services as well as the Hydrological Bureau of the Department of Water Resources and Development maintains a network of river and groundwater monitoring stations. An extensive monitoring program of various hydrological parameters in the catchment area is carried out.

Apart from the Nyatsime River, there are five other tributaries in the Upper Manyame River Basin area. The main characteristics of these tributaries, as well as the Manyame River itself are shown in Table 5.2 overleaf. The four main impoundments in the area are Lake Manyame, Lake Chivero, Seke Dam and Harava Dam (see Table 5.3 overleaf and Figure 1.1,).

Table 5.3: Characteristics of Rivers in the Catchment Area

River	Length (km)	Catchment Area (km^2)
Manyame	131.0	3,930
Gwevi	83.0	680
Nyatsime	56.0	590
Muzururu	35.0	320
Marimba	16.5	230
Mukuvisi	23.5	230
Ruwa	24.0	180

Table 5.4 : Lakes and Dams in Upper Manyame River Basin

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

Raw water is abstracted from Lake Manyame, Lake Chivero and Seke Dam for the water supply to Harare and surrounding centres. Seven STWs also discharge treated effluent into the catchment (see Figure 1.1,).

The river flows fluctuate seasonally and the largest flows occur during the summer months. Water is let out of the dams to compensate for low flow conditions during the winter months. The total annual run-off of the Manyame River varies from about 21,000 Ml to 800,000 Ml with an average of approximately 305,000 Ml.

Abstraction and discharge from Lake Manyame account for about 60% of the total outflow while approximately 30% is lost by evaporation. Groundwater inflows and outflows are considered to be minimal.

5.2.2 *Natural Environment and Ecology*

The Upper Manyame River Basin falls into Natural Region II in the Agro-Ecological classification of Zimbabwe, considered to be the most intensive farming region of the country. As a result of both intensive agriculture and urban development, the natural environment has been modified to a large extent throughout most of the Basin.

Flora

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

Scattered throughout the woodlands are large termitaria usually covered with a dense thicket of woody vegetation.

Fauna

Before development took place, most of the large mammals found in Zimbabwe occurred in the Upper Manyame River Basin, but agriculture and urban development have made the area unsuitable for the larger animals, which can now only be found in game parks. Outside these game parks, antelope, baboons and monkeys still occur as well as a range of smaller carnivores and omnivores. Many of these smaller animals are primarily nocturnal and seldom seen.

Despite deforestation and agriculture, many of Zimbabwe's 640 species of birds can still be found in the area. The construction of dams and a more secure supply of water from STW overflows in the catchment area have led to an increase in the number of water fowl. Reptiles and amphibians are also well represented in the sandy soil habitat of the study area.

Aquatic Ecology

The normal ecology of the Upper Manyame River Basin has been severely disturbed by urban run off

and discharges from both point and diffuse pollution sources. Species diversity has been substantially reduced as a consequence.

The eutrophication of the Upper Manyame River system, and Lake Chivero in particular, has led to a proliferation of blue green algae, such as *Microcystis* and *Anabaena*, and floating aquatic plants such as water hyacinth (*Eichornia crassipes*), water lettuce (*Salvinia molesta*) and water fern (*Azolla filliculoides*). These plants interfere with commercial fishing and recreational usage on Lake Chivero (Environment 2000, 1996).

Various counter-measures have been used in the past to combat the growth of the water hyacinths, for example chemical spraying, manual removal and biological control. The latter, making use of a weevil (*Neochetina eichhorniae*), is showing promising results. Rooted macrophytes such as *Lagarosiphon major* are also very common in the lakes and these aquatic systems also have diverse populations of aquatic fauna.

Approximately 28 species of fish are found in the Upper Manyame River Basin (Marshall, 1982). The eutrophication of Lakes Chivero and Manyame have resulted in high fish productivity and commercial fishing is practised in these two impoundments. Pollution stemming from anthropogenic activities, however, coupled with thermal stratification of these impoundments can cause fish deaths as occurred in Lake Chivero in March-April 1996.

Water Quality

The water courses and impoundments in the Upper Manyame River Basin have been subject to several significant environmental impacts over the years, mainly due to poor quality treated effluent being discharged into the catchment's rivers. The impoundments in the catchment are considered to be eutrophic and algal blooms occur frequently. Several fish kills have also been documented in the past.

The water quality of the impoundments is characterised by high total nitrogen (T-N) and total phosphorous (T-P) concentrations, which exceed the critical eutrophication levels of T-N < 0.3 mg/l and T-P of < 0.02 mg/l. The COD concentration is three to six times higher than that allowable for drinking water. Heavy metals have been detected in the water bodies, but the concentrations are within the WHO health standards for drinking water. No agricultural chemicals such as pesticides were detected during a recent study of the Basin .

The present water pollution levels of organic substances in the impoundments and rivers in the Basin were found to be within the allowable levels for fishing purposes. The recent improvements in water quality in the Upper Catchment have mainly been attributed to countermeasures instigated in 1995,

when it was decided to cease effluent discharge from the Zengeza STW into the Nyatsime river.

A feature of the larger reservoirs in the Basin (Lakes Chivero and Manyame) is the marked thermal stratification that occurs as the surface water warms during the summer. Two discrete layers of different temperature form; the lower layer is colder and accumulates nutrients released from decaying organic matter. Anaerobic conditions occur in this layer. At the start of the cool season, the water temperature in the warm layer drops and the thermal stratification disappears. Intermixing of the water takes place and nutrients trapped in the lower layers are released, resulting in algal blooms in the upper layers of water. The oxygen deficient water rising from the bottom may also be responsible for the fish kills experienced in Lake Chivero, but this has not been confirmed and it is also thought that ammonia toxicity could have been a reason for the deaths.

A water pollution analysis and projection, in which point and non-point pollution sources from human and natural sources was taken into account, was done for the Basin (refer to Appendix "Contribution of Zengeza STW to Water Pollution") The analysis in consideration of staged expansion of existing sewerage systems through the future (see Table 5.5) indicates that the impoundments in the Basin are impacted by various sources of pollution. If no action is taken to combat this pollution it could be expected that the water quality in the impoundments, especially Lake Chivero and Lake Manyame, will deteriorate even further.

The impoundments are presently utilised for potable water supply to the surrounding areas, recreation and commercial fishing. Continued pollution would thus severely impact these users. Changes in the quality of the raw water received at the treatment works could require a change of the treatment processes needed for efficient treatment of the water, resulting in additional capital investments. The high organic content of the water (due to the high algal concentrations) could also increase the risk of the formation of trihalomethanes (THM) if the water is chlorinated before distribution. These THMs pose a potential health risk.

Table 5.5 Projected Future Pollution Loads for Impoundments in Upper Manyame Basin

Lake/Dam	Proposed Water Quality Standards		Present Level	Scenario 1 (High Population Growth)		Scenario 2 (Low Population Growth)	
	2005	2015		2005	2015	2005	2015
T-N (mg/l)							
Seke/Harava	<0.4	<0.2	0.65	0.73	0.83	0.71	0.80
Lake Chivero	<0.4	<0.2	0.51	0.77	0.94	0.66	0.86
Lake Manyame	<0.4	<0.2	0.75	0.74	0.76	0.73	0.74
T-P (mg/l)							
Seke/Harava	<0.05	<0.01	0.07	0.08	0.11	0.08	0.11
Lake Chivero	<0.10	<0.01	0.27	0.46	0.55	0.41	0.51
Lake Manyame	<0.03	<0.01	0.04	0.04	0.04	0.04	0.04
COD (mg/l)							
Seke/Harava	<10	<6	20.63	22.31	31.18	21.86	30.57
Lake Chivero	<16	<6	25.30	38.65	44.77	35.51	42.69
Lake Manyame	16	<6	22.70	20.30	21.44	19.91	21.02

Continued fish kills could also result in a ban on fishing (as has happened in the past) and this would impact the commercial fishing on the lakes, resulting in increased unemployment in the area. The proliferation of algae and aquatic plants such as the water hyacinth would have a negative impact on any recreation (both contact and non-contact) at the lakes.

5.2.3 *Human and Social Environment and Land Use*

The population residing in the study area is estimated at about 1 870 000, of which 92% is urbanised. Chitungwiza, a post Independence urban development, has a population of approximately 400 000.

The settlement densities of the area are amongst the highest in Zimbabwe, accounting for 47% of the national urban population. The area also has one of the highest population growth rates in the country (6.5% to 8.1% per year) and the average net income for households in the area is substantially higher than the national average.

Land use in the overall area comprises cultivated land, grazing land, forest land and residential and commercial (urban) land. About 65% of the area is vegetated, 20% is cultivated and the remaining 15% comprises urban development.

6. ASSESSMENT OF ENVIRONMENTAL IMPACTS

6.1 Introduction

Both potential positive and negative environmental impacts related to the expansion of the Zengeza STW were identified in the Initial Environmental Examination. These impacts have been addressed in more detail in the PEIA.

The potential negative impacts investigated were:

- effluent discharge to the Nyatsime River (Section 6.2);
- the disposal of waste sludge (Section 6.3);
- erosion and stormwater control (Section 6.4); and
- air pollution, aesthetics, noise and vibration (Section 6.5)

The potential positive impacts investigated were:

- improved quality of effluent discharge (Section 6.2);
- reduction in odours (Section 6.3);
- water re-use (Section 6.2); and
- employment opportunities (Section 6.6)

Each of these impacts is dealt with below in the Section numbers indicated above.

6.2 Effluent Discharge to the Nyatsime River

The discharge of 20Ml/d of effluent from the proposed BNR plant to the Nyatsime River will have an impact on the aquatic environment in the rivers and impoundments downstream of the Zengeza STW, even if the discharge meets the present Zimbabwe Water Effluent and Wastewater Standards issued under the Water Act. Areas of concern are:

- the effect on riverine and aquatic ecosystems;
- the effect of the discharge on the Water Rights/Common Rights of downstream users;
- possible hygiene/disinfection related issues caused by the presence of faecal coliforms in the effluent;
- the effect of discharging the effluent on the water quality of the rivers and lakes downstream of the discharge point.

Effect on Downstream Aquatic Ecosystems

The release of treated effluent from the expansions to the Zengeza STW will obviously affect the flow regime downstream of the STW, which in turn will affect the viability of aquatic life. Certain species equipped to thrive in continuous flow conditions will flourish in place of those species which prefer flow regimes which fluctuate with the seasons.

However, the Upper Manyame River Basin is already a severely impacted catchment and prior to August 1995, the Nyatsime River had already been receiving effluent from the existing Zengeza STW. It can be safely predicted, therefore, that the impact of the discharge to the Nyatsime River of the treated effluent from the expansions to the STW on the aquatic environment would not be particularly significant, given the already severely affected nature of the catchment.

Effect of Discharge on Downstream Water/Common Rights

The following Water Rights have been identified on the Nyatsime River between its confluence with the Duri River (upstream of the Zengeza STW) and the confluence with the Manyame River (downstream of the Zengeza STW)

• W/R:9554 (Final Grant)	Property Tantallon. Abstract 1 litre/second up to 4,5 Ml between 1st October and 31st December. Priority Date : 30/9/71
• W/R : 9127 (Final Grant)	Seke Communal Land. Abstract 228m³/day and return 205m³/day for sand pumping. Use 5,8 Ml/day. Priority Date : 4/10/70
• W/R : 8805	Seke Communal Land. Quarrying and Industrial purposes. Abstract 50 000 gal/day to 12 million gal/yr. Priority Date : 4/11/69
• W/R : 9553	Property : Dunottar. Abstract 1 litre/sec up to 4,5 Ml from 1st October to 31st December Priority Date : 30/9/71
• W/R : 10035	Longlands. Abstract 144m³/day from 1st October to 31st December. Priority Date : 19/2/73

Although it is unknown whether use of the above Water Rights is still current, the effect of discharging treated effluent into the Nyatsime River should prove favourable for these users, providing abstractors of the river water are not using it to irrigate dairy pasture or edible crops which may be eaten raw or taken to market without washing. The bacteriological contamination levels of the discharged effluent (see below) could pose a health risk in the case of such use, as it also could to recreational users of the

river downstream of the STW.

Treated Effluent Hygiene/Disinfection Issues

From previous experience with similar systems, the final effluent from the proposed BNR plant can be expected to have a faecal coliform concentration of 10^4 - 10^5 counts/100 ml. At present there is no standard/guideline in Zimbabwe for faecal coliform concentrations in effluent discharge, although this is currently under review (in neighbouring South Africa, the guideline for effluent discharge to the natural environment is 1 000 counts/100 ml). No data are readily available on the present levels of faecal coliforms in the Nyatsime River. However, a concentration > 1 000 counts/100 ml is unacceptable, under the South African guidelines, for partial contact recreation (canoeing, angling, etc), whereas a concentration of 150 counts/100 ml is the limit for full contact recreation (swimming etc). The limit for drinking water is zero.

As there is as yet no effluent standard in Zimbabwe for microbiological concentrations, no provision has been made for tertiary treatment of the effluent in the design of the proposed expansions to the STW. However, in the interests of public health, treatment of the final effluent to decrease pathogens such as faecal coliforms is advisable. The two most viable methods of treatment are disinfection by chlorination or treatment in maturation ponds. In view of the nature of the problems already existing at the Zengeza STW (underfunding, lack of staff, etc), treatment in maturation ponds is regarded as the better option for the future plan.

Effect of Discharge on Water Quality of Downstream Rivers and Lakes

The average dry weather flow of the Nyatsime river is 33 Ml/d, and therefore a continuous additional flow of 20 Ml/d will alter the flow regime. During periods of severe drought the Nyatsime River stops flowing in the dry season. Under these conditions the effluent would form 100 % of the flow in the river. The effluent would thus provide a valuable water resource to downstream impoundments which could then be reused for water supply to the Harare area.

The present STW at Zengeza are severely overloaded and thus the quality of the effluent being discharged into the Nyatsime River prior to August 1995 caused a negative impact in the river, especially in terms of ammonia and phosphate concentrations, as indicated in Figures 6.1 and 6.2.
These time series graphs show total ammonia and ortho-phosphate concentrations in the Nyatsime River upstream and downstream of the discharge point from the STW. The concentrations of these nutrients are of concern as they cause eutrophication. The Nyatsime River joins the Manyame River downstream from the Zengeza STW and the Manyame River then flows into Lake Chivero, which is severely eutrophied.

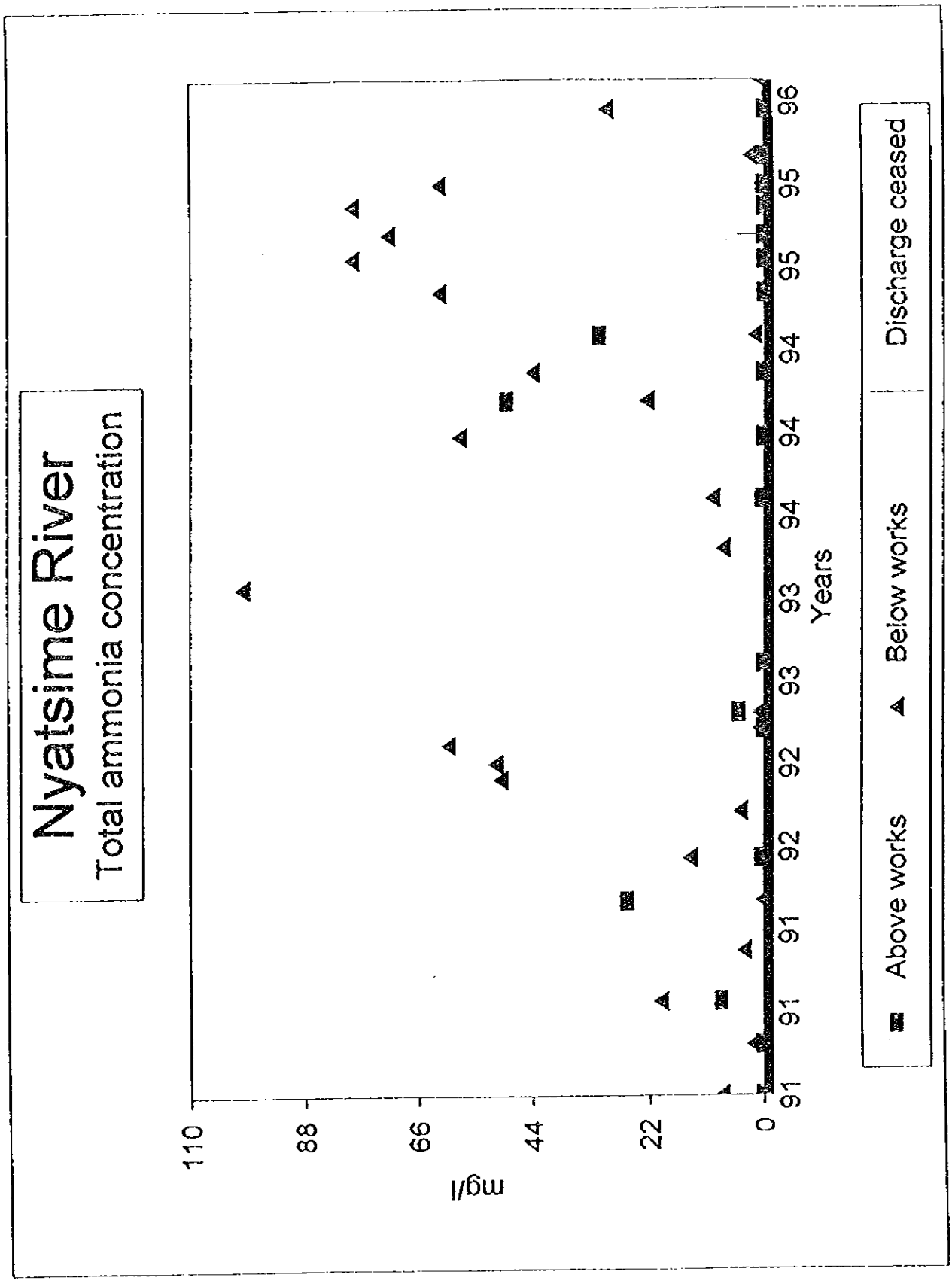


Figure 6.1: Total ammonia concentration in the Nyatsime River upstream and downstream from Zengeza STW

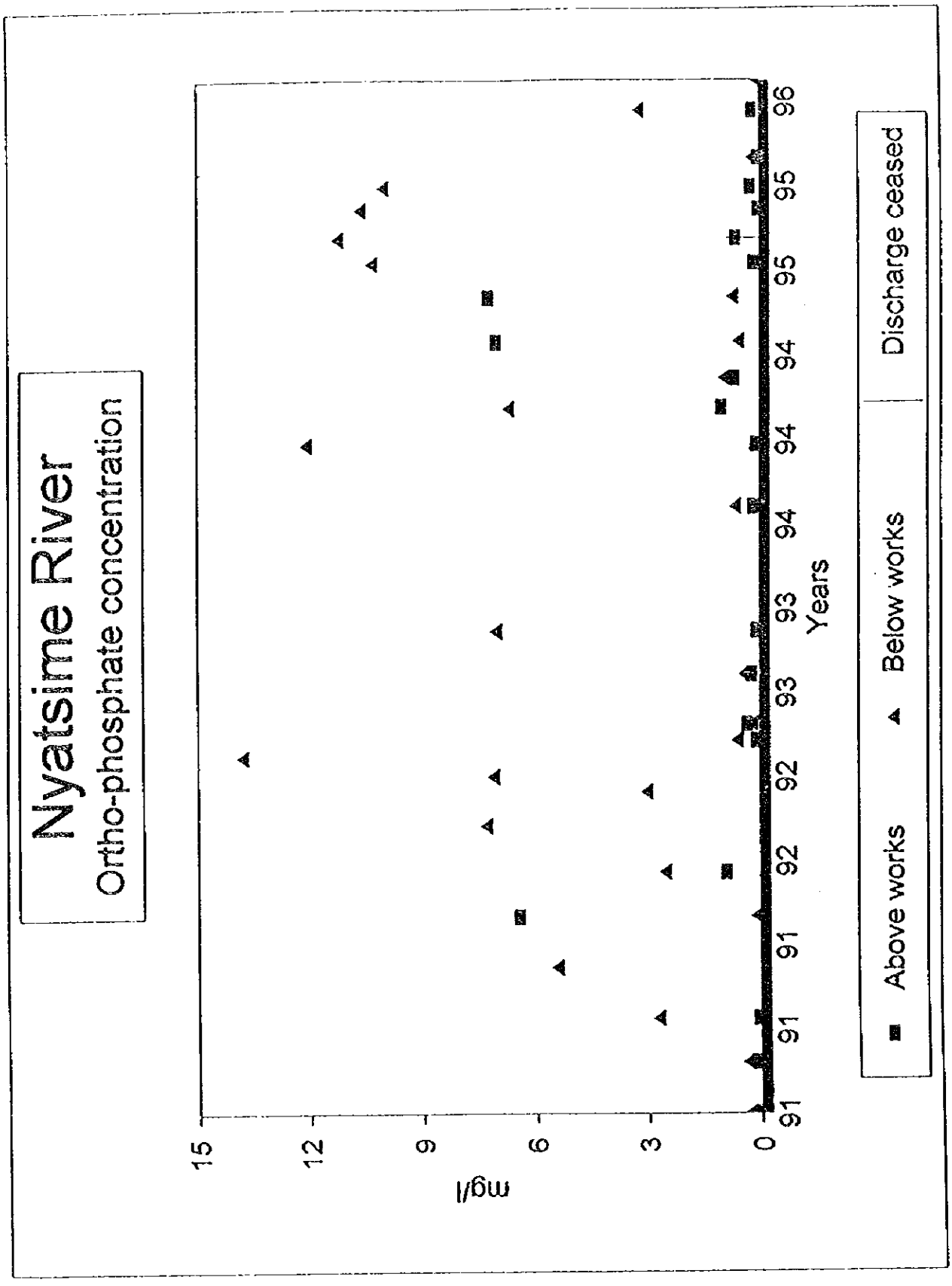


Figure 6.2: Ortho-phosphate concentration in the Nyatsime River upstream and downstream from Zengeza STW

Concern about the nutrient levels being discharged from the Zengeza STW resulted in termination of effluent discharge to the Nyatsime river in August 1995, whereafter the water quality in the Nyatsime river improved significantly

It is planned that the effluent from the extended STW will comply with the Water Effluent and Wastewater Standards (Water Act, 1976), and thus it should not have a significant negative impact on the water quality in the river. This theory is confirmed to a certain extent when the potential water quality downstream of the point of discharge from the extended STW, as well as downstream of the confluence with the Manyame River, is calculated, and compared to the water quality in the Nyatsime River upstream of the point of discharge, and in the Manyame River upstream of the confluence (Table 6.1).

Table 6.1 Observed and Potential Water Quality Concentrations in the Nyatsime and Manyame Rivers.

	Effluent water quality [c] (Zengeza expansions)	Nyatsime upstream from extended works[a]	Nyatsime downstream from extended works[b]	Manyame River upstream from confluence with Nyatsime River[a]	Manyame River downstream from confluence[b]
Flow rate (Ml/d)	20.0	33.9	53.9	40.0	93.9
Total nitrogen (mg/l)	10.00	0.13	3.79	0.112	2.22
Free and saline ammonia	± 4.00 [d]	0.1	1.54	0.08	0.92
Phosphate (mg/l)	1.00	2.00	1.63	1.21	1.45
pH	9.00	6.97	7.72	6.93	7.38

[a] Dry weather annual average flow and concentrations (Concentrations monitored by City of Harare (CHDW))
[b] Calculated concentrations assuming that the effluent concentrations comply with the standard.
[c] Worst case scenario based on upper limits of effluents standard.
[d] Typical concentration from BNR Plant.

From Table 6.1 it can be seen that ortho-phosphate concentrations in the Nyatsime River will be diluted by the effluent from the extended STW. Ortho-phosphate concentrations in the Manyame River, downstream from the confluence with the Nyatsime River may, however, increase slightly. Hence, the expansion of the works and associated effluent discharge will not alter the phosphate load on Lake Chivero significantly.

It appears that the increase in total ammonia concentrations could be more significant. The concentration of free and saline ammonia is of specific concern, as excessive concentrations (> 0.2 mg/l) of free ammonia can be harmful to aquatic life. Unfortunately it is not possible to calculate free ammonia concentrations, as these are exponential functions of both water temperature and pH. Although pH readings have been taken on a regular basis, no water temperature data are readily available. However, it is known that the free ammonia component of free and saline ammonia concentrations increase sharply above pH 7.5 and water temperatures greater than approximately 17-18°C. From Table 6.1 it would seem that, if the effluent from the extended STW is discharged at a maximum pH of 9, the resultant pH downstream of the discharge point will be 7.38. Although the water temperature is not known, it could exceed 17-18°C during summer. In combination with a pH of 7.7 and a total ammonia concentration of 1.54, the resultant free ammonia concentration would probably be higher than 0.2 mg/l, i.e it could be harmful to aquatic life.

An assessment of the total ammonia concentrations measured upstream from the effluent discharge point during the period 1991 to 1996 (Figure 6.1) revealed that the concentrations generally were low (< 1 mg N/l). However, extremely high concentrations of 26.0; 49.0 and 36.5 mg N/l were observed on three occasions (January 1992, September 1994 and January 1995). High ammonia concentrations usually are indicative of raw sewage on the Nyatsime River. Since the sewer system in Chitungwiza is currently inadequate to deal with the amount of sewage it receives, with raw sewage overflowing on to the streets and finally into the rivers, the high ammonia concentrations in the Nyatsime River (upstream from Zengeza) may be indicative of sewer spillage. This theory is to a certain extent supported by the occasionally high (30 mg/l) ammonia concentrations observed in the two little streams originating in the urban areas of Chitungwiza and flowing adjacent to the STW works into the Nyatsime River.

The expansions to the STW will discharge into the Nyatsime River, which flows into the Manyame River, and then into Lake Chivero. During the 1960s Lake Chivero was severely eutrophic. However, after improvements to water pollution control in the catchment, the Lake reached a mesotrophic state in the late 1970s. At present the Lake indirectly receives water from 7 wastewater treatment plants, and is regarded as hypertrophic. Lake Chivero may be exceptionally sensitive to eutrophication, as it does not stratify very strongly during summer (temperature difference between the top and bottom waters averages about 5°C). As a result, internal nutrients are not totally sealed off in the hypolimnion during summer, but may escape to the epilimnion where it is available for algal growth. Also, in a study done on Lake Chivero (Thornton and Nduku, 1982) it was found that the (weak) thermocline is situated at about 10 metres, whilst incoming rivers tend to disperse at a depth of about 5 metres. Thus the nutrient load from the incoming rivers will be immediately available for algal growth, and not only at overturn, as would be the case if the rivers dispersed deeper down into the hypolimnion. The water quality of the incoming rivers are therefore of primary concern as a contributing factor to the eutrophication of Lake Chivero.

6.3 Sludge Disposal

The proposed sludge disposal method is agricultural as a soil conditioner. To this end, a covered storage area has been included in the preliminary design to hold 2 months of dried sludge which would then be available to local farmers to come and remove and apply to their land.

The use of wastewater sludge in agriculture is generally beneficial, but applications must be carefully controlled to minimise risks to workers, livestock and crops, and the danger of contamination of the soil and groundwater by heavy metals, pathogens and chemicals present in the sludge. Increasing concentrations of certain elements in wastewater sludges to levels higher than found in soils and their accumulative nature in soils, can create a potential health hazard. This is especially a concern in areas where sludge is used for fertilisation of crops intended for consumption by humans or animals.

Although it is planned that the BNR plant would only treat domestic sewage, and thus the metal content of the waste sludge should be relatively low, it would be necessary to implement a monitoring programme whereby the sludge is regularly tested to identify to what agricultural uses it could be safely applied and at what rates. Such practice should also be applied to sludge produced at the existing STW.

Further investigations are also required to establish whether there is a market for the sludge on the surrounding farms. If demand for the sludge is weak, the 2 month storage capacity would be insufficient and the proposed back-up system of unlined storage pits adjacent to the BNR plant is deemed environmentally unacceptable because of the pollution threat to groundwater and the Nyatsime River. Such a back-up system would also necessitate double handling of the sludge and would require adequate stormwater management to prevent pollution. Soil samples taken from the site earmarked for the expansion of the STW intersected the water table at two points between 0,6 metres and 5 metres confirming the risk of groundwater pollution should sludge be disposed of on site.

Alternative sludge disposal options include:

- co-disposal with domestic and/or industrial waste;
- incineration;
- composting; and
- drying, pellitization/brick making.

Co-disposal of wastewater sludge with domestic waste at the nearby Chitungwiza landfill could be considered, but the disposal site should preferably be lined and well managed. This site is not presently lined and there is a shortage of trucks to transport cover material to the site. Mixing wastewater sludge

and domestic refuse leads to an increase in the moisture content of the waste. This increases the mobility of organic and inorganic chemicals within the landfill and the potential for groundwater and surface water pollution increases. Co-disposal also results in increased gas production. Leachate control and regular soil covering and compaction of the waste would be required with this disposal option.

Incineration is generally regarded as a sludge disposal option at STWs serving large conurbations. In this process, the sludge is burned at a high temperature (900 ° C) and reduced to a sterile ash which is disposed of at a landfill. However, the process has potential air-quality impacts in terms of the emission of residual wastewater sludge components and combustion products.

Composting of sewage sludge is becoming an increasingly attractive option, particularly in developed countries, but it requires an adequate supply of bulking agent (eg garden waste, wood chips) to mix with the sludge, careful management and control during the composting process and a proven market for the final product. This disposal option is also relatively land hungry requiring an area which is preferably lined and covered. Capital costs to establish a composting plant can be substantial and sufficiently trained staff would be required to manage the plant. This disposal option is best practised on a regional scale where economies of scale can be enjoyed.

In the case of drying and pelletization/brickmaking, the sludge is dewatered, dried and formed into pellets or briquettes, which can be used as a fuel source, or used in the production of bricks. Sufficient support from private sector industrial concerns would need to be sought to make this disposal option viable.

Given the urgent need to select an environmentally acceptable disposal option, the agricultural use of the sludge would appear to be the most favourable option provided the sludge is tested and guidance given to what use the sludge may be applied. Any application should comply with the Regulations contained in the Public Health Act and other Standards adopted elsewhere (eg Code of Practice for Agricultural Use of Sewage Sludge, UK, 1984). Useful guidance could also be obtained from examining practice at other BNR plants in Zimbabwe. Sludge disposal to blue-gum plantations is currently proving a popular disposal option.

The use of sewage sludge in agriculture, unless properly managed, can be offensive to the public. Considerations include transport routes, the locations of sludge applications and the methods of delivery and spreading. The movement of sludge by trucks from the STW to agricultural areas could lead to complaints of noise and smell in built-up areas. All sludge loads should be adequately maintained or covered. Transport routes should also be carefully chosen to minimise public inconvenience. Sludge application rates to agricultural land should be limited by either the nitrogen

requirement of the crop to be cultivated or the metal content of the sludge. Boreholes close to the area where the sludge is applied should be regularly monitored to indicate whether groundwater or surface water contamination is taking place.

Provided the environmental concerns described above can be overcome, the agricultural use of sewage sludge is favoured. If popular, consideration could be given to levying a fee for use of the sludge in order to establish a value for the product.

The commissioning of the new plant should considerably reduce the odours commonly experienced at the existing STW by alleviating the presently overloaded situation. If the sludge drying beds and storage area are well managed, odour generation at the BNR plant should be minimised.

Odour levels could also be reduced by planting certain trees and bushes that excrete aromatic oils that absorb odours. A suitable tree would be lemon eucalyptus *(eucalyptus citriodora).* Suitable small plants would be lemon verbena *(Lippia citriodora)* and camphor basil. The latter is a perennial shrub indigenous to Zimbabwe. These plants could form part of the landscaping plan for the STW expansions and could be irrigated using the treated effluent from the plant.

6.4 Erosion and Stormwater Control

Due to the site already being highly impacted because of the excavation activities for road construction materials, surface run-off is already severely affected. The drainage of the site must be considered during design and construction to ensure that erosion is prevented. Stormwater control should include management of any spillages or overflows at the STW expansions. Cognisance has been taken of this in the environmental management plan (EMP) detailed in Chapter 7. The land moving activities anticipated for this project are not expected to cause any possibility of land subsidence. From the slope of the land on the site, there is no anticipated risk of landslides or cave-ins.

6.5 Air Pollution, Aesthetics, Noise and Vibration

The expansions proposed for the STW will not result in any people being resettled or moved. This is because the land to be used is already owned by the Chitungwiza Municipality and is at present an unused portion of the STW. However, areas to the south of the STW are earmarked for future urban development. Consideration should thus be given to creating a buffer zone around the STW which would assist in minimising the environmental impacts of the new plant on any future surrounding communities. Such a buffer zone may also be required in the event of a decision to implement tertiary treatment of the effluent (see Section 6.3) at the plant in the future.

Possible air pollution could be caused during construction and operation of the new plant. Dust and air pollution activities caused by construction will be minimised by controls contained in the EMP. There is a very slight risk of the release of aerosols generated in the BNR unit. The plant design should minimize the possibility of this happening. STW staff should receive adequate training in the response to such an event.

The construction of the expansions is likely to have a limited temporary impact on the aesthetics in the area. These will be minimised by controls contained in the EMP. Once constructed, the plant is expected to only have a limited negative appearance, and will not disrupt the skyline or any existing landscape features. Any slight negative impact should be limited by appropriate landscaping.

The project is not expected to have any negative impacts on existing transportation routes or public infrastructure. The main road leading to the STW (Chitungwiza Road) is of a high standard and any additional traffic using the route during construction is unlikely to affect the traffic flow significantly. Appropriate signage will need to be used during construction if a significant number of heavy vehicles will be entering and leaving the site. This would assist in preventing possible accidents because of vehicles travelling at high speed along the Chitungwiza Road.

The proposed project is expected to have minimal impact on the surrounding communities due to noise and vibration during the construction phase, provided construction activities take place during normal working hours. If work is conducted at night and over weekends and should blasting be necessary, the scheduling of activities should be done with due consideration for residents in the area. Equipment selected for the works should conform to noise limitation standards. During operation of the new plant, pumps and aerators should be screened by reflection boards where necessary to reduce noise levels.

6.6 Employment Opportunities

Construction of the expansions to the STW is not expected to have any negative impacts on the economic activity or structure in the area. Positive impacts of the project on the local economy are expected to include the employment of local labour during the construction phase of the project and permanent jobs in the Chitungwiza Municipality for the operation and maintenance of the new plant. The number of jobs that could be created during construction, albeit temporary, is not known at this stage in the planning. However, it is expected that approximately 50 permanent positions will be created for the operation and maintenance of the new STW expansions.

7. ENVIRONMENTAL MANAGEMENT PLAN

7.1 Introduction

This chapter outlines a conceptual environmental management plan (EMP) which covers the design, construction, commissioning, operational and decommissioning phases of the Zengeza STW expansions. The EMP is provisional in nature since it has been compiled based on the preliminary design provided by the Study Team. Once the final design has been completed, a more detailed and rigorous EMP should be drawn up.

7.2 Environmental Management Philosophy, Policy and Objectives

Currently, the Chitungwiza Municipality does not have an environmental management policy relating to its activities and developments. An Environmental Policy is a public statement of the environmental values of an organisation; it conveys these environmental values to its employees, demonstrates to stakeholders the importance that senior management attaches to environmental management, and provides a guiding framework for conducting the organisation's business activities in an environmentally-compatible manner.

Environmental objectives are employed in order to focus efforts to implement an Environmental Policy and could include the following:

- to implement integrated wastewater management;
- to promote environmental protection and social upliftment;
- to comply with legal environmental standards;
- to measure and report on the environmental performance of the organisation;
- to ensure transparency and community involvement in environmental issues;
- to maintain active involvement in local water and wastewater management, pollution prevention and environmental education; and
- to improve staff awareness of the Environmental Policy and encourage their participation in the active implementation of the policy.

Following the adoption of an Environmental Policy, a comprehensive environmental management system or Environmental Management Programme (see Figure 7.1) should be developed to co-ordinate all environmental management issues.

The philosophy behind the Environmental Management Programme is for it to become an effective means

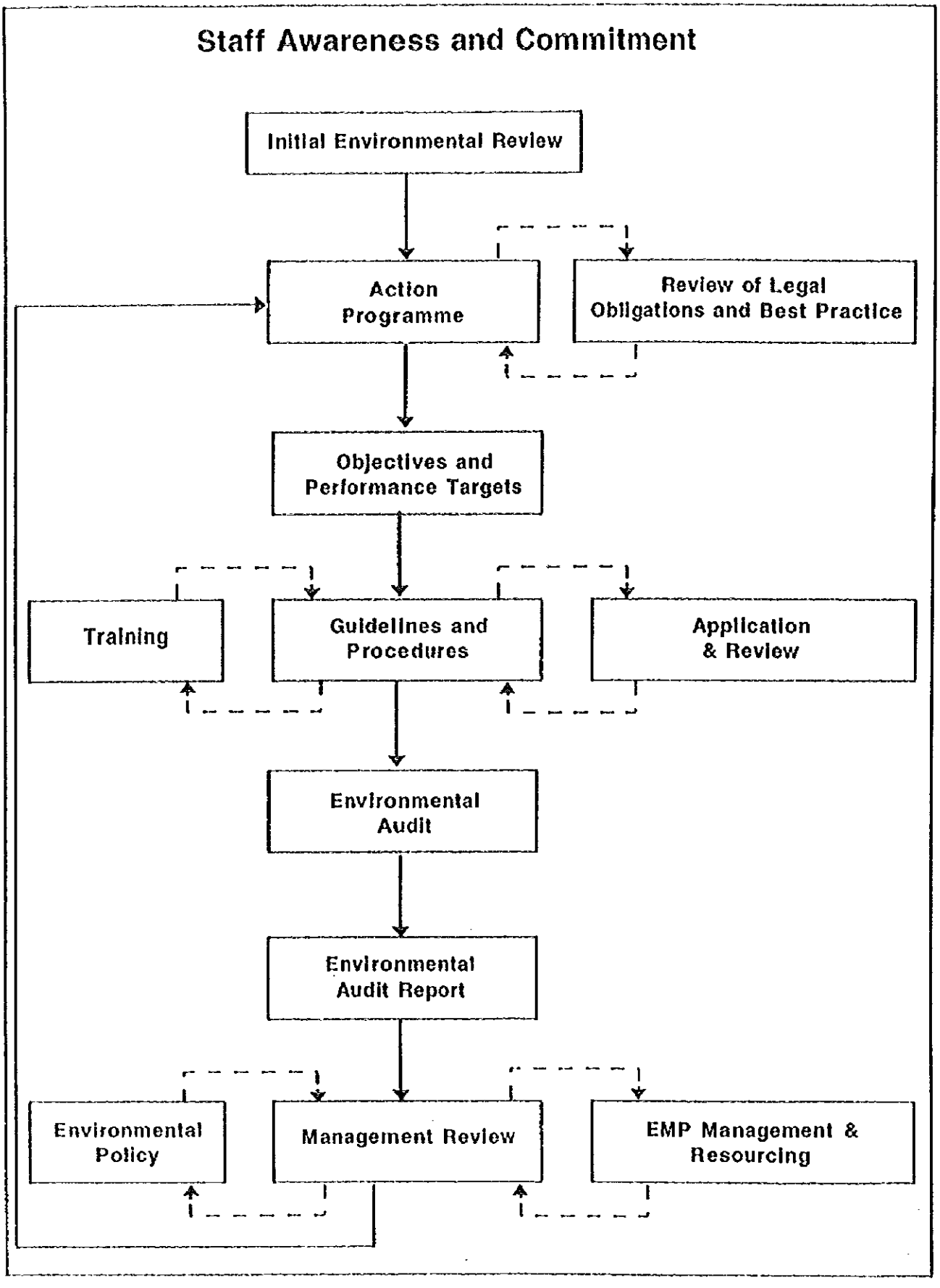


FIGURE 7.1 : ENVIROMENTAL MANAGEMENT PROGRAMME

of managing environmental performance by enabling the identification of critical environmental issues, the development of action plans to address these issues, the establishment of environmental performance indicators and the setting of targets, measuring this performance, raising environmental awareness amongst staff and providing appropriate training.

The purpose of the Environmental Management Programme is to translate Environmental Policy into practice by putting in place workable systems, structures and tools to achieve integrated and consistent management of all environmental initiatives. Although at present the Chitungwiza Municipality does not have an Environmental Management Programme, a conceptual Environmental Management Plan has been formulated for the Zengeza Sewage Treatment Works (STW) expansions, to address the immediate needs, as well as to develop an approach for a future Environmental Management Programme.

7.3 Scope of the EMP

This EMP deals with the following components of the life cycle of the planned STW expansions and modifications of the existing works:

- *Design*: The preliminary design of the planned expansions and modifications is virtually complete

- *Construction and Commissioning*: A preliminary Environmental Specification for Construction has been compiled and should form part of the tender documentation. A system of bonuses and fines to encourage compliance with the Specification is suggested.

- *Operation and Maintenance*: Environmental guidelines have been compiled to ensure environmentally acceptable practices during operation and maintenance.

- *Decommissioning*: Guidelines have been developed for eventual decommissioning. This includes the dismantling of equipment and buildings, and the rehabilitation of the site.

- *Auditing*: Standard environmental auditing practices are proposed.

7.4 Duties and Responsibilities of the Zengeza STW Officer

The Project Manager of PMO will be ultimately responsible for implementing and enforcing the Environmental Management Plan (EMP) and its specifications. The Assistant Works Superintendent in the Zengeza STW may be appointed as "Environmental Officer (EO)" to assume the environmental management issues subsequent to the project implementation.

The main functions of EO include the following :

Construction Stage

- brief the Contractor's staff about the requirements of the Environmental Specifications;
- advise the Project Manager (or his Assistant Resident Project Manager) about the interpretation, implementation and enforcement of the Environmental Specifications and other related environmental matters; and
- undertake periodic audits of adherence to the environmental specifications at the site and communicate environmental policy issues to the Project Manager.

Operation and Maintenance Stage

- ensure compliance with the environmental requirements of the Environmental Management Plan (EMP);
- brief the operational and maintenance staff about the requirements of the EMP;
- interpret, implement and enforce the EMP and other related environmental matters;
- attend internal meetings; and
- undertake periodic audits of adherence to the EMP at the STW and communicate environmental policy issues to the STW Works Superintendent.

It is, furthermore, proposed that the appointed EO be trained by an external consultant pror and during the construction phase.

7.5 Environmental Management during Design

The final design for the proposed expansions and modifications has not yet been completed. It is, however, assumed that the design will take due cognisance of the recommendations made in the PEIA report. In addition, during review of the preliminary design, a number of potential problems were identified which could lead to environmental impacts during the operation and maintenance of the expansions to the Zengeza STW (see Section 7.7).

7.5.1 Final Effluent Quality

The raw sewage characteristics as identified by recent monitoring programs indicate a sewage composition which should be amenable to full treatment by standard BNR technology. The indicated average concentrations of several of the parameters e.g. Flow Rate, Total Kjeldahl Nitrogen and Total Alkalinity, are such that any reasonable changes in these concentrations with time could have a detrimental effect on the overall final effluent quality, and therefore the quality of the recipient water

body. It is therefore recommended that detailed design should ensure that the variation of parameter concentrations may be adequately managed to ensure that Operational Environmental Targets (see Section 7.8.6) are always met.

7.5.2 Sludge Disposal

The proposed BNR treatment plant configuration will generate large volumes of primary and waste sludges which must be adequately disposed of. It is common experience that economic, efficient sludge disposal is usually more difficult to achieve than production of a high quality final treated effluent, even though the sludge is really only a by-product of the main process. Therefore, it is important that during detailed design, careful attention is paid to ensuring that the selected methods of sludge handling, treatment or stabilization, and disposal will at all times meet the specified Operational Environmental Targets (see Section 7.8.6). Detailed design must also aim towards ensuring that the method of final sludge disposal is sustainable for the foreseeable future, say the initial outlook period of the treatment plant which we understand is about 20 years, within the constraints of existing applicable legislation (see Section 7.8.1).

7.6 Environmental Management during Construction

In order to ensure environmentally acceptable construction activities, an Environmental specification was compiled which needs to be included in the mechanical and civil works contract tender documents.

7.6.1 General Environmental Specification

The cost of complying with the requirements in this Section shall be included in the tendered price.

Incentives for Compliance with Environmental Specification

It is proposed that an environmental bonus shall apply for the period for which the Contractor is established on site. After a period of 30 days grace from the date upon which the Contractor establishes the site, the Contractor will start each month with a full bonus. For each transgression of the Environmental Specification, the Contractor will be fined which shall be deducted from the monthly bonus. Bonuses shall be paid on a quarterly basis.

Monitoring and Assessment of Compliance

The environmental management performance of the Contractor will be reviewed on a weekly basis by the Project Manager during each weekly safety meeting. The Contractor will be deemed not to have

complied with the Environmental Specification if: there is evidence of negligence or recklessness resulting in the contravention of any of the clauses, both within and outside the boundaries of the site; the Contractor fails to comply with corrective or other instructions by the Project Manager within a time specified by the Project Manager at the weekly review meetings; or the Contractor fails to respond adequately to complaints from the public.

Compliance with the requirements of the Standards Association of Zimbabwe (SAZ)

All environmental clauses stated in the SAZ 254 (1984) "Standard Specifications for Civil Project Managering Construction" and SAZ (1984) "Code of Practice for use with Standardised Specifications for Civil Project Managering Construction and Contract Documents", as amended in this document, shall be complied with by the Contractor. Where the Environmental Specification is in conflict with the Standard Specification, the Environmental Specification shall apply. The environmental clauses of the SAZ Standard Specification shall be monitored and enforced by the Project Manager in consultation with the EO.

7.6.2 Site Establishment and Management

General

The Contractor shall take into account the following identified limitations and recommendations made in the Preliminary Environmental Impact Assessment (PEIA) for the Zengeza STW expansions when establishing or working on the construction site:

General: the soils of the area are prone to erosion due to water migration.

Traffic routes to working areas: care should be taken not to destroy site vegetation by construction vehicles.

Staff ablution facilities: overflowing of ablution facilities will have a negative impact on the site.

Stormwater control measures: care should be taken not to pollute stormwater run-off disposal during construction activities; polluted water should be contained on the site.

Pollution control:

- Discharges of hazardous chemicals on the site or to the stormwater system is prohibited.

- Soil erosion caused by construction activities shall be kept to a minimum. Care should be taken in the siting of construction facilities and materials.
- Dust pollution from drilling activities shall be kept to a minimum by using dust suppression techniques, such as the spraying of water on the affected area.

Management of waste: litter and solid waste, mainly due to constructional activities, shall be confined to areas designated for that specific use by the EO.

The Contractor shall draw-up a plan of all parts of the construction site, showing the layout of site establishment, topsoil stockpiles, planned access and circulation routes, etc. The plan shall be submitted to the EO and the Project Manager for comment and approval before site establishment commences.

Every precaution should be taken, in accordance with this specification, to prevent pollution of air, soil, ground and surface water as a result of construction or associated activities at all locations covered by the contract.

Housekeeping

The Contractor shall ensure that the Contractors camp and working, areas are kept clean and tidy at all times. The Project Manager shall inspect these areas on a regular basis.

Demarcated Areas and Fencing

Routes for temporary access and haul roads shall be located within the approved demarcated areas and vehicle movement shall be confined to these roads. Movement of vehicles outside the designated working areas shall not be permitted without authorisation from the Project Manager.

All construction activities shall be restricted to working areas designated on the drawings and/or demarcated and approved by the Project Manager. Materials, including spoil, shall only be stockpiled on designated areas.

Fences as indicated in the drawings and construction specification shall be maintained throughout the construction period. All temporary fencing as indicated by the Project Manager shall be removed on completion of the contract.

Fire Risk and Burning

Burning of vegetation including tree trunks and stumps cut during site clearing and establishment shall not be permitted unless authorised by the Project Manager. Woody material should either be given to the surrounding community or to the site staff for fuel to be used in the site camp. All vegetation not disposed of by means of the above shall be removed to a landfill site designated by the local authority.

The Contractor shall ensure that the risk of fire at any location on the site is kept to a minimum.

The Contractor shall supply fire fighting equipment in proportion to the fire risk presented by the type of construction and other on-site activities and materials used on site. This equipment shall be kept in good operating order.

Open fires for heating and cooking shall only be permitted in protected areas designated by the Project Manager for this purpose.

No fires will be allowed adjacent to the boundary fence, either inside or outside the STW.

Storage of Fuel and Other Materials

Fuel, lubricants, transmission and hydraulic fluids shall only be stored in designated areas.

7.6.3 Control of Damage to Plants and Animals

In principle, the preference is to minimise damage to natural habitats within the designated area. In practice however it is sometimes unavoidable, in which case the aim is to rehabilitate the disturbed land according to the rehabilitation plan or the EO's instructions.

Destruction of Plants

Plants within the site shall only be moved or removed in accordance with the landscape rehabilitation plan. Removal, damage or disturbance of any plant outside the designated area is not permitted. Indigenous vegetation should be retained or transplanted where appropriate.

Gathering of firewood outside the designated area shall not be permitted.

Disturbance of Animals

Any animals resident within the site shall not be killed nor unnecessarily disturbed. Where sensitive species occur these shall be translocated by the relevant conservation authority.

7.6.4 Control of Damage to Soil and Water

Topsoil

Topsoil shall be stripped from the areas as indicated below prior to the commencement of site establishment and construction and stockpiled for use in reinstatement and rehabilitation:

- roads;
- any part of the site where berms are to be constructed from overburden, subsoil and excavated materials;
- any area upon which structures, buildings and hardstandings are to be constructed;
- any area which is to be used for temporary storage of materials including topsoil stockpiles;
- areas which could be polluted by any aspect of the construction activity; and
- areas designated for the dumping of spoil.

The Contractor shall ensure that subsoil and topsoil are not mixed during stripping, excavation, reinstatement and rehabilitation.

Stripping of topsoil shall be undertaken in such a way as to minimise erosion by wind or runoff.

Areas from which topsoil is to be removed shall be cleared of any foreign material which may come to form part of the topsoil during removal including bricks, rubble, any waste material, litter, excess vegetation and any other material which could reduce the quality of the topsoil.

Topsoil shall be stockpiled in areas designated by the Project Manager. Where required the stockpiles shall either be vegetated or covered by a suitable fabric to prevent erosion and invasion by weeds.
Topsoil shall be stripped from the above areas to a depth not exceeding 300 mm from the original ground level unless otherwise specified by the Project Manager, after clearing and grubbing of the area is complete.

Streams and Nyatsime River

Site staff shall not be permitted to use the side streams which flow on the eastern and western boundary of the STW property and the adjacent Nyatsime River for the purpose of bathing, washing of clothing or vehicles nor disposal of any type of waste.

The side streams and the Nyatsime River shall not be used for construction activities such as washing of equipment or disposal of any type of waste unless authorised by the Project Manager.

The Contractor shall not in any way modify nor damage the banks or bed of the side streams, the Nyatsime River and drainage lines, unless required as part of the construction project specification.

Where the modification or disturbance of the side stream bank or bed and the Nyatsime River is unavoidable or is required in terms of the contract (e.g. pipeline scour chambers), the disturbance of the water body shall be kept to a minimum, particularly as regards the removal of riparian vegetation and opening up of the stream channel.

Control of Pollution

As a minimum requirement all waste emissions (hazardous, airborne, liquid and solid) from the site shall be kept within the limits of standards set in terms of relevant national and local pollution legislation and regulations.

General

No waste of a solid, liquid or gaseous nature shall be emitted from the site without approval by the Project Manager.

Accidental pollution incidents shall be reported to the Project Manager immediately after they occur and shall be cleaned-up (to the satisfaction of the Environmental Officer) by the Contractor or a nominated clean-up organisation at the expense of the Contractor.

Soil

Vehicle and plant maintenance shall be confined to the areas demarcated for this purpose. Should any fuel, oil transmission or hydraulic fluids be spilled onto the soils the Project Manager shall be informed immediately.

Water

The Project Manager will monitor the quality of water bodies on/and adjacent to the site if deemed necessary and instructed by the EO.

Air

All reasonable measures should be taken to minimise air emissions in the form of smoke, dust and gases.

7.6.5 Management of Waste

In practice all wastes arising from construction activities are to be handled, transported and disposed of in accordance with the relevant regulations. All efforts should be made to minimise, reclaim or recycle waste, and failing that, dispose of it in a manner licensed by the local authority for that purpose.

Sewage

The Contractor shall provide sanitation facilities in the form of chemical toilets at the camp, office, workshop and construction site for staff and visitors. No other form of sanitation will be permitted unless a connection to the sewer main is possible.

Wastewater

All runoff from fuel depots, workshops, truck washing areas and wash water from concreting vehicles and other equipment shall be collected and directed through oil traps to settlement ponds. The settlement ponds shall be suitably lined at the Contractor's expense if required in the opinion of the EO.

Wastewater may not be disposed of directly into drainage lines, streams or rivers. The Contractor shall provide suitable retention and filtration structures (which shall be properly maintained) for the collection of wastewater.

Washing and changing facilities shall be provided by the Contractor. All run-off from these washing and/or changing facilities shall be contained and/or connected to the site sewer reticulation network to the satisfaction of the Project Manager.

Solid Waste

Definition: "Refuse" refers to all construction waste (such as rubble, cement bags, waste cement, timber, cans, other containers, wires and nails), household and office waste.

Refuse shall be collected and stored in demarcated, fenced areas in skips and/or bins. The fenced areas or containers should be designed to prevent refuse from being blown out by wind and should be strategically and conspicuously placed throughout the site.

Wherever possible waste that is recyclable is to be recycled.

Refuse shall be disposed of at the Chitungwiza Waste Dumping Site which is situated 2 km away by the shortest route from the construction site. The rates submitted by the Contractor for disposal of material off site shall include all transportation and disposal costs. Refuse shall not be buried nor burned on site.

Construction rubble shall be disposed of in demarcated spoil dumps or at the disposal site approved by the EO.

Hazardous Wastes

Definition: Hazardous wastes are those which are proven to be toxic, corrosive, explosive, flammable, carcinogenic, radioactive, poisonous or as determined by the Hazardous Substances and Articles Act (Chapter 15:05) as amended.

Discharges of hazardous chemicals (such as paint, turpentine and oil), as declared under the Hazardous Substances and Articles Act as amended, on the site or to the stormwater system are prohibited.

Potentially hazardous raw and waste materials shall be handled and stored on-site in accordance with the manufacturer's specification and relevant legal requirements.

The following hazardous waste products shall be disposed at the nearest available hazardous waste disposal facility:

- cement;
- diesel, petroleum, oil and lubricants;
- explosives;
- drilling fluids;
- pesticides;

- concrete additives; and
- water purification chemicals.

7.6.6 Management of Stormwater

The aim is to minimise soil loss from the site due both to wind and water.

Stormwater

At all stages of the contract, stormwater control measures as specified by the Project Manager shall be applied to keep soil on-site by minimising

- erosion of temporary stockpiles of topsoil and permanent spoil dumps;
- erosion from construction roads, excavations and borrow pits;
- silt-laden run-off from all areas stripped of vegetation, including excavation surfaces and stockpiles of spoil and topsoil;
- contaminated run-off from storage areas;

thereby preventing it from entering water courses.

Natural stormwater run-off which is not polluted by site operations shall be diverted around spoil dumps and topsoil stockpiles.

Where stormwater has accumulated in the workings and needs to be pumped out, it must be disposed of into the side streams in such a way that erosion does not occur along the course of its passage.

Control of Erosion

At all stages of the contract, erosion of bare soil, other excavation surfaces and stockpiles of topsoil and spoil shall be prevented by the application of erosion control measures as specified by the Project Manager.

Should erosion occur due to negligence on the part of the Contractor to apply the above measures, the Contractor will be responsible for reinstatement of the eroded area to its former state at his own expense. Any surface water pollution occurring as a result of this negligence will be cleaned up by the Contractor or a nominated clean-up organisation at the expense of the Contractor.

Cross and side stormwater drainage measures shall be constructed on access and haul roads to the site and on roads within the site.

The Contractor shall ensure that run-off from access and haul roads, and that diverted into cross and side drains, does not cause erosion.

Rehabilitation

At all excavation sites, the soil excavated shall be replaced after completion of the construction activity, and revegetated with indigenous grass within 30 days, to the satisfaction of the EO.

All construction sites will be cleaned and rehabilitated to their original state and/or to the satisfaction of the EO.

7.7 Environmental Management during Commissioning

Commissioning is a time of high environmental risk and operational and construction staff should be particularly vigilant in order to minimise this risk.

The EO shall familiarise himself with the commissioning terminology and procedures as described in the Tender Documentation. During commissioning the EO, in close cooperation with the STW Manager and the Contractor, shall ensure that safety devices (eg. monitoring equipment, warning signs, and fire extinguishers) are in place and in working order. Should any detrimental activity take place the EO shall give appropriate warning (eg. to all site personnel) and ensure that the commissioning tests are terminated and impacts are ameliorated.

Treated effluent will be used during wet commissioning of pumps and tanks, and therefore, equipment failures and/or pipe leaks (if any) during performance tests are not expected to have a negative environmental impact.

7.8 Environmental Management during Operation and Maintenance

7.8.1 Applicable Legislation

Environmental legislation which has to be complied with during operation and maintenance includes the following :

National Legal Framework

- Water Act (Chaper 20:22)
- Forest Act (Chapter 19:05)
- Natural Resources Act (Chapter 20:13)
- Factories and Work Act (Chapter 14:08)
- Hazardous Substances and Articles Act (Chapter 15:05)
- Public Health Act (Chapter 15:09)
- Atmospheric Pollution Prevention Act (Chapter 20:03)
- Noxious Weeds Act (Chapter 19:07)
- Fertilisers, Farm Feeds and Remedies Act (Chapter 18:12)
- Public Health (Effluent) Regulations
- Water (Effluent and Wastewater Standards) Regulations
- Others

As indicated in Section 3.2 (2), Chitungwiza Municipality is far lagged behind in legal arrangement. It is therefore recommended to establish a "Task Force" which takes charge of reviewing/ updating the existing regulations & standards, and/or formulating new legislation. The following are the statutory by-laws and regulations which are urgently needed to be enacted or provided at municipal level :

- Trade Effluent Control By-laws
- Model Building By-laws
- Waste Management By-laws

7.8.2 Legal Risks

Legal risks pertaining to the planned expansions and modifications to which the Zengeza STW and to which the Chitungwiza Town Council and its staff can be exposed to include:

Sludge Discharge into Stormwater System

All spills into the stormwater system are to be reported to the EO who will take appropriate action (i.e. inform the Department of Water Resources and Development and arrange the necessary clean-up).

Release of Sub-standard Effluent to Nyatsime River

Any such release shall be reported to the EO who will take appropriate action (ie inform Department of Water Resources and Development).

7.8.3 Potential Causes of Negative Environmental Impacts During Operation and Maintenance

The following equipment malfunctions and/or operational errors may, *inter alia*, give rise to negative environmental impacts and should be timeously addressed and ameliorated in consultation with the EO:

- malfunction of sludge pumps;
- blockage of sewers;
- malfunction of primary settling tanks;
- malfunction of aeration equipment;
- malfunction of sludge thickeners;
- malfunction of final clarifiers;
- operator error; and
- power failure.

7.8.4 Environmental Risks Associated with Works Operation and Maintenance

This Section describes the environmental risks associated with the STW operation and maintenance of the expansions to the Zengeza STW.

Release of Volatile Organic Compounds to Atmosphere

Although there will be some stripping of Volatile Organic Compounds (VOCs) at the final clarifier weirs and aeration tank, which may result in low concentrations of volatiles in the air, it is not expected that these low concentrations will have a negative effect on the immediate (STW staff) and surrounding environment.

Discharge of Sludge into Stormwater System

The stabilised sludge comprises mainly stabilised organics, mineral material, high ammonia and phosphorus and some non-toxic chemicals. The risk to the environment (in case of a spill) could be a health risk depending on the microbioligical quality of the sludge as well as negative aesthetics (malodorous and visual pollution).

It is recommended that a sludge retention structure be installed to minimise the risk of sludge discharge to the Nyatsime River, for example a berm could be built down gradient of the sludge drying beds and dry sludge storage area.

Groundwater Pollution from Seepage through Land Irrigated with Treated Effluent

This is currently practised at the existing STW and will be employed as a backup in the event of failure of the BNR plant. It has not resulted in any recorded pollution of the groundwater to date. However, the Imbgwa Farm area needs to be regularly monitored to determine whether groundwater pollution is occurring.

It is recommended that borehole be monitored on or near the Imbgwa Farm to facilitate the monitoring of groundwater quality.

Release of Sub-standard Effluent to Nyatsime River

Process upsets as a result of power failure, operator error and/or failure of the BNR equipment could result in the release of inadequately treated effluent to the Nyatsime River. The effluent quality should, therefore, be routinely monitored to ensure compliance with legal standards.

7.8.5 Financial Planning for Operation and Maintenance

The Zengeza STW operating and maintenance budget must make provision for compliance with the EMP and the amelioration of environmental incidents.

Provision must also be made in terms of the insurance of the STW to cover environmental disasters and associated legal and clean-up costs.

7.8.6 Operational Environmental Targets

The following environmental targets are set for the Zengeza STW:

- compliance with the Water Act effluent water quality standards at all times;
- no sludge discharge to the stormwater system or the Nyatsime River;
- compliance with relevant environmental legislation (see Section 7.8.1); and
- no environmental incidents (eg. significant releases of untreated effluent).

7.8.7 Environmental Operational and Maintenance Procedures

The environmental operational and maintenance procedures to protect the environment are described below.

- *Housekeeping:* the EO shall ensure that all buildings and working areas are kept clean and tidy at all times.

- *Storage of Fuel and Other Materials:* fuel, lubricants, transmission, hydraulic fluids, and chemicals shall only be stored in designated areas.

- *Control of Pollution:*

  - All solid, liquid or gaseous discharges from the Zengeza STW shall be in compliance with the Acts and Regulations cited in Section 7.8.1

  - Accidental pollution incidents shall be reported to the EO immediately when they occur. The EO shall notify the relevant authorities as well as arrange appropriate amelioration.

  - Vehicle and plant maintenance shall be confined to the areas demarcated for this purpose. Should any fuel, oil, transmission or hydraulic fluids be spilled onto the soil, the EO shall be informed and appropriate clean-up actions will be implemented.

- *Control of damage to vegetation :*

The following environmental requirement shall be complied with:

  - No person shall disperse noxious any weed in the area and a fine can be imposed. The EO shall ensure appropriate weed control measures on the STW site.

- *Air quality management:*

The following environmental requirement shall be complied with:

  - No waste, vegetation or any other material other than what is incinerated, shall be burnt on the STW, in compliance with smoke control regulations published by the local authority and according to the Atmospheric Pollution Prevention Act (Chapter 20:30).

- *Water quality management:*

The EO shall ensure that the following environmental requirements are complied with:

- Precaution shall be taken that no surface or groundwater becomes polluted. Any deliberate or unplanned pollution of water is an offence according to the Water Act, (Chapter 2:22) and punishable.

- Operational and maintenance staff shall not be permitted to use the Nyatsime River adjacent to the STW, or treated effluent water from the STW (except for irrigation of designated areas) for the purposes of bathing, washing of clothing, vehicles, operational and maintenance equipment nor disposal of any other waste.

- Should an incident occur which can cause water pollution, especially if it affects the Nyatsime River, the Department of Water Resources and Development shall be contacted immediately. Cleaning up shall take place in consultation with the Department.

• *Solid Waste Management:*

The following environmental requirements shall be adhered to:

- All practical procedures concerning solid waste management are to be regulated.

- No person shall discard or dump any litter at the Works. The EO shall at all times ensure that containers are provided for discarding litter by staff and visitors.

• *Land management:*

The following environmental requirements shall be adhered to:

- The EO shall ensure that no soil erosion or invasion of declared weeds and/or invader plant(s) take place, especially on rehabilitated areas.
- Should pesticides be used for controlling weeds or vegetation at any place on the STW, the provisions of the Fertilisers, Farm Feeds and Remedies Act or similar Act apply. Should the pesticides be applied by subcontractors, the EO shall ensure that their Operators are properly registered. Should the Zengeza STW staff be used for this application, the EO shall ensure that they are properly trained.
- Prevent and combat any veld fires.
- Rehabilitated areas shall be suitably maintained after completion of construction.

- *Hazardous waste management:*

Hazardous wastes are those which are specified as being toxic, corrosive, explosive, flammable, carcinogenic, radioactive, poisonous or classified in accordance with the Hazardous Substances and Articles Act Chapter 15:05). The following environmental requirements shall apply:

- All potential hazardous waste generated at the site including diesel, petroleum, oil and lubricants; pesticides; and effluent disinfectants shall be removed and disposed by an approved subcontractor to an approved disposal site.

- Potentially hazardous raw and waste materials shall be handled and stored on-site in accordance with the manufacturer's specification and in accordance with the Hazardous Substances and Articles Act.

- *Control of Noise:*

The following environmental requirement shall apply:

- Noise emanating from operational activities shall not be disturbing noise. The sound level from the site measured at the nearest dwelling must not exceed the ambient noise level by more than a significant amount. Pumps and aerators should be screened by reflection boards where necessary to reduce noise levels.

- *Response to Public Complaints:*

- The EO shall respond to queries and complaints from the public regarding operational activities, *inter alia*, by: documenting the details of such communications and submitting the information to the STW Manager for entry into a complaints register and taking appropriate remedial action in consultation with the STW Manager and the Chitungwiza Municipality.

7.8.8 Environmental Monitoring Programme

The environmental performance of the operation and maintenance at the STW will be reviewed on a monthly basis by the EO. Operational staff will be deemed not to have complied with the EMP if:

- there is evidence of negligence or recklessness resulting in the contravention of any of the

environmental requirements as set out above, both within and outside the boundaries of the site;

- the operational staff fail to comply with corrective or other instructions by the EO within a specified time; or

- the operational staff fails to respond adequately to complaints from the public.

The STW design and operation and maintenance procedure make provision for a number of monitoring systems. For example, treated effluent water discharged to the Nyatsime River shall be monitored in compliance with the requirements of the Department of Water Resources and Development. In addition to formal monitoring, environmental problems could also be detected by visual observations and by smell.

The EO shall maintain a record of environmental incidents, copies of which shall be forwarded to the STW Manager on a monthly basis.

7.9 Environmental Management during Decommissioning

Environmental requirements associated with the eventual decommissioning of the STW expansions and modifications will include ensurance that:

- all recyclable rubble and solid waste (eg. scrap metal, cables, bottles, cans, plastic residues) be collected and disposed of through a licensed recycling company;

- all non-recyclable rubble and solid waste be collected and disposed of at the nearest available landfill site;

- replanted with indigenous local grass; and

- the topsoil does not contain invasive plants.

7.10. Environmental Reporting

Environmental reporting is part of the duties of the EO. This reporting will be in compliance with the requirements of the regulatory authorities.

7.11 Environmental Auditing Procedure

The EO will undertake a regular (say annual) environmental audit of the STW and amend the EMP as appropriate in consultation with the Ministry of Environmental and Tourism. The results of the audit will be made available to interested parties.

External auditing may take place at unspecified times.

8. RESOURCE EVALUATION

A detailed economic evaluation of the environmental costs and benefits of the project has not been possible due to the fast track nature of the project. In addition, most of the environmental costs and benefits are intangible or subjective issues which cannot be easily measured or evaluated in monetary terms.

The capital costs for the BNR plant is estimated to be about Z$200m and also the operating costs, will be increased, whilst the environmental costs of the new plant can be broadly interpreted as being very minor during the construction period with an increase in waste disposal quantities during operation (both treated effluent and wastewater sludge). The PEIA has indicated that the increased waste load can be handled in an environmentally acceptable manner provided the recommendations made in Chapter 9 are followed. On balance, the environmental benefits of the new plant will outweigh the environmental costs in that the overload on the existing STW will be relieved and a better quality effluent will be produced from the new plant, whilst that from the existing STW can also be expected to improve. If the sludge disposal issues can be satisfactorily resolved, together with the equitable use of the treated effluent, then the expansions to the STW should greatly improve the present situation. Should the sewage reticulation system in Chitungwiza also be upgraded and adequately maintained and providing sufficient funds and trained manpower are available to run the BNR plant, then the environmental benefits of the proposed project should be considerable.

9. CONCLUSION AND RECOMMENDATIONS

9.1 Conclusions

A Preliminary Environmental Impact Assessment (PEIA) has been conducted for the expansion of the Zengeza STW. The PEIA has identified no fatal environmental flaws for the expansions and the development can, therefore, proceed from the environmental perspective.

The following potential significant positive and negative environmental impacts have been identified:

Hydrological Impacts: The water levels in the Nyatsime River will increase by 20Ml/d downstream of the STW if the full quantity of treated effluent from the STW expansions is discharged to the river. This will provide valuable water to downstream impoundments for re-use as a water supply, particularly in times of drought. At the public consultation meeting to discuss the project, farmers expressed a desire to receive the treated effluent from the new plant, especially since the infrastructure to receive the effluent is in place. These competing demands will need to be balanced.

Aquatic Ecology Impacts: The increase in flow will favour species which are better equipped to live under continuous flow conditions. Species which prefer flow regimes which fluctuate seasonally may thus be detrimentally affected. The aquatic environment has already been severely impacted in the Nyatsime River and the Upper Manyame River Basin, due to urban development and other anthropogenic activities. Furthermore, the existing STW was already discharging surplus effluent, which could not be handled by the pumps carrying effluent to Imbgwa Farm, into the Nyatsime River prior to August 1995. Thus the aquatic ecology in the Nyatsime River is not expected to be significantly impacted due to changes in flow.

Water Quality Impacts: The new plant will be designed to meet Zimbabwe's Water Effluent and Wastewater Standards. (eg COD < 60 mg/l; Total - N < 10 mg/l) This will permit discharge to the Nyatsime River and will be a considerable improvement on the quality of effluent previously discharged from the existing STW. It is expected, however, that the discharge from the STW expansions will still contribute to nutrient levels and concentrations in the catchment downstream of the STW, although this contribution will be less than previously experienced. The cumulative impact of all the pollution sources in the catchment will mean that only a marginal improvement in water quality conditions downstream will occur. It is also likely that eutrophic conditions will continue to persist in the downstream impoundments. The improvement at the Zengeza STW, however, should make a significant contribution towards better pollution control in the catchment.

Waste Impacts: The disposal of wastewater sludge for agricultural use appears to be the most feasible and environmentally acceptable disposal option in the short term. The back-up disposal option of using unlined storage pits is not deemed environmentally acceptable because of the risk of groundwater and surface water contamination.

Air Pollution, Aesthetics, Noise and Vibration Impacts: The impacts in these areas are expected to be minimal and mainly temporary whilst construction takes place. As a result of the expansions to the STW, odours should be reduced due to the more efficient operation of the existing STW.

Social Impacts: Employment opportunities will be created by the construction and operation of the STW expansions. No access control to the STW site poses a safety risk and allows illegal dumping of

waste to occur. Currently no provision is made for limiting development in close proximity to the STW site.

9.2 Recommendations

Although no fatal environmental flaws have been identified in the proposed project, the following actions are recommended to ensure environmental concerns are minimised:

- A structured and regular water quality monitoring programme should be put in place to ensure the effluent discharged to the Nyatsime River from the STW expansions meets Zimbabwe's effluent standards.

- An equitable agreement needs to be reached regarding the discharge and use of the treated effluent from the STW expansions between local farmers and the relevant Authorities. The water demands for irrigation and storage in downstream impoundments (eg for water supply and recreation) should be carefully managed to try and satisfy all needs.

- An acceptable and secure long term sludge disposal means must be found. The demand from local farmers or other potential users for the dried sludge produced at the expansions to the STW needs to be established. This will prevent potential future storage and disposal problems and allow for future planning.

- The sludge produced at the expansions to the STW needs to be regularly sampled so that the agricultural uses to which the sludge can be applied are established. Sampling of groundwater and surface water resources near to where the sludge is used should also take place to ensure contamination does not occur.

- The environmental impacts of transport of the sludge to its final use should also be closely managed and controlled to prevent public nuisance.

- Grit and screenings from the STW should not be buried on site but disposed of safely at the nearby Chitungwiza landfill because of a high potential for ground water contamination, as should any other waste produced during the operation of the expansions to the STW.

- The STW site should preferably be fenced and access to the site controlled.

- The creation of a buffer zone around the STW will help minimise the impacts on any future

developments to the south of the STW site.

- The final design for the expansions to the STW should be critically reviewed to ensure environmental acceptability.

- The conceptual environmental management plan (EMP) should be revised and updated once the final design has been completed and evaluated. Relevant sections of the EMP should form part of the tender documentation for construction of the STW expansions.

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APPENDIX

CONTRIBUTION OF ZENGEZA STW TO WATER POLLUTION

1. General

The Zengeza Sewage Treatment Works (hereinafter referred to as "the Zengeza STW") is discharging around 36,000 m^3/day of treated effluent at present. Since August 1995, all of the effluent is sent to the maturation pond for irrigation use at the Imbgwa farm locating outside of the Upper Manyame River Basin (hereinafter referred to as "the UMRB"). This arrangement is useful to reduce the pollution load causing the water pollution in the UMRB, while it also bring the reduction of river flow. Even after this arrangement, there was several accidents that the effluent was discharged to the nearby Nyatsime river due to fault of pumps.

The improvement and expansion project of the Zengeza STW bring increase of effluent discharged to the Nyatsime river, while the adverse effect will be brought to the water pollution status in the UMRB. This study was prepared to identify the degree of contribution of the Zengeza STW to water pollution in the UMRB. Accomplishments of water pollution analysis obtained through the Study on UMRB Water Pollution Control Master Plan (hereinafter referred to as "the Study") were referred to and fully utilised in this report. Therefore, the results of analysis were presented for the year 2005 though the target year of the urgent project is 2000.

2. Concept of Water Pollution Analysis

2.1 Rivers

The water pollution study for the rivers is conducted through the analysis of existing data, water quality examination results through this study, and previous pollution study reports. Water quality index to be used is BOD (Biochemical Oxygen Demand) for the analysis of the rivers.

The pollution load generated at pollution sources is discharged to the environment through treatment facilities such as sewage treatment plants, septic tanks, industrial wastewater treatment facilities, etc. Then discharged load is further reduced in conduits and streams before flowing into rivers due to infiltration, sedimentation, natural oxidation, and so on. The reduced pollution load at the inflow point is called as the concentrated load, and the ratio of discharged load to the concentrated load is called as the concentration ratio. The concentrated load and the run-off load reaching from upstream of the river is further reduced due to natural self-purification phenomena by sedimentation, absorption, biological decomposition, etc. The ratio of concentrated load to the run-off load is called as the pollution load remaining ratio, and the ratio

of the run-off load to the discharged load is called as the run-off ratio. Figure 2.1.1 shows a concept of pollution load flow system.

In this study, pollution load remaining ratios of each river were derived through the present pollution analysis of rivers to apply in the future pollution analysis. Concentrated pollution load is estimated using frame values, unit pollution load and assumed concentration ratio. Run-off load is estimated based on the existing data on flow rate and water quality of rives.

2.2 Lakes/Dams

The water pollution study for the lakes is also conducted through the analysis of collected data and previous pollution study reports. Water quality indices to be used for analysis of the lakes and dams are T-N (Total Nitrogen), T-P (Total Phosphorus) and COD (Chemical Oxygen Demand). COD is utilised to eliminate the influence of algae in examination of BOD.

The Vollenweider Model was adopted for water pollution simulation model in terms of T-N, T-P and inflow-COD.

Pollution analysis in terms of COD was conducted for the inflow-COD to the lake and the secondary produced COD mainly produced by phytoplankton in the lake. The inflow-COD was analysed using the Vollenweider model, and the secondary produced COD by the ΔCOD method.

The ΔCOD method was introduced assuming that the difference (ΔCOD) between the lowest COD value in the year and the average COD value is equivalent to the secondary produced COD. It was also assumed that increase of COD caused by elution from sediment in the lake is considered in this concept. In the Study, the lowest COD was measured as S-COD (Soluble COD - to eliminate algae's activities). The secondary produced COD in the future was estimated using projected pollution loads in terms of T-N and T-P, and the relationship between ΔCOD, T-N and T-P at present.

Average values were used as input data to this model assuming that water quality in the lake is stable and uniform. Thus, the lake was regarded as a kind of black box with a completely mixed condition and inflow nutrient load was assumed to be balanced with the water quality of the lakes.

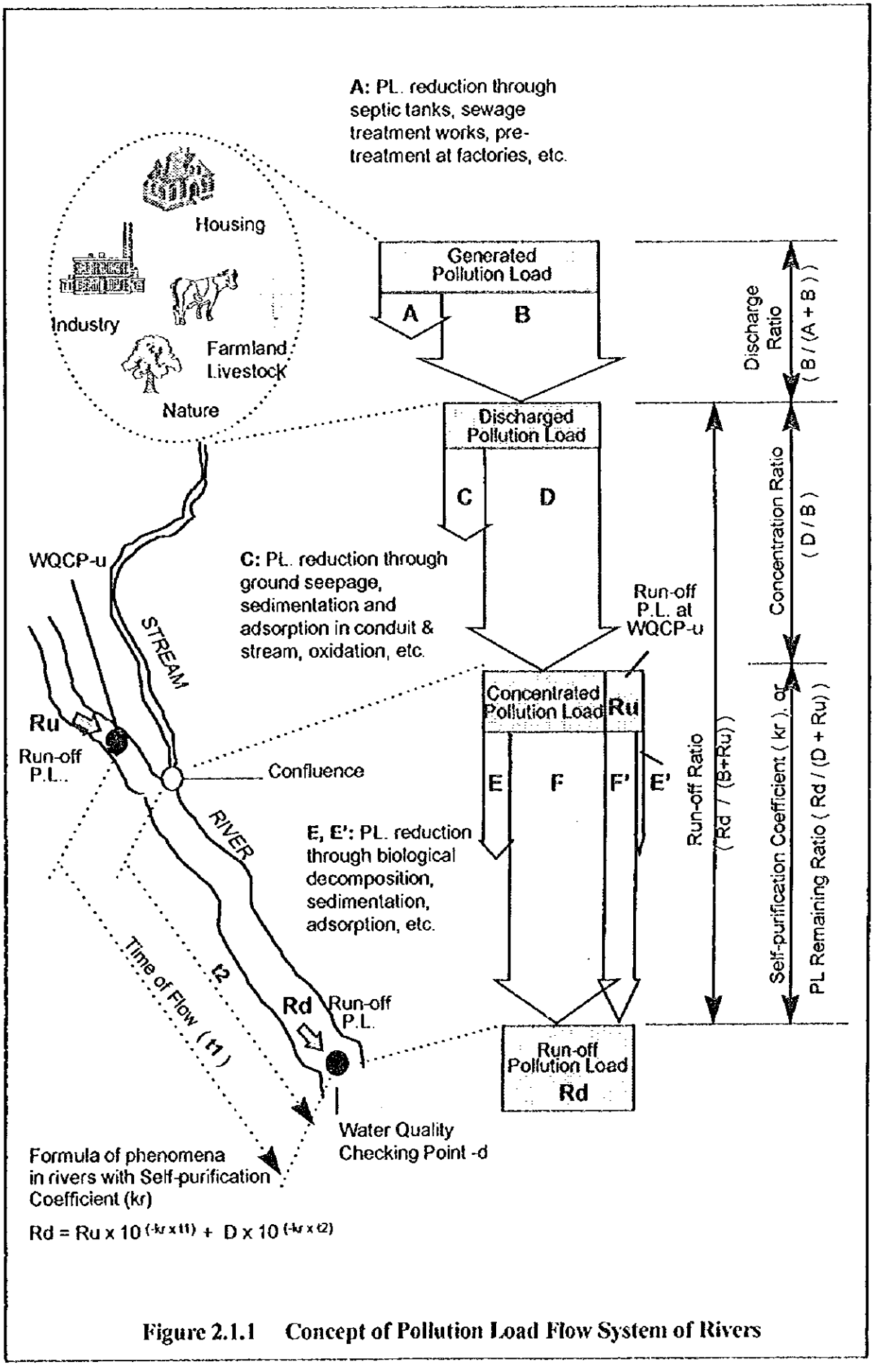

Figure 2.1.1 Concept of Pollution Load Flow System of Rivers