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List of Abbreviations and Expressions

Abbreviation or expression	*Description*
AASIP	Addis Ababa Sanitation Improvement Project
AAWSA	Addis Ababa Water and Sewerage Authority
ADLI	Agricultural Development-Led Industrialization
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CSA	Central Statistical Authority
CSE	Conservation Strategy of Ethiopia
COBWAS	Community Based Water Supply and Sanitation Project
DI	Ductile Iron
EDF	European Development Fund
EIA	Environmental Impact Assessment
EMU	Environmental Monitoring Unit (AAWSA)
EPA	Environmental Protection Agency
EPB	Environmental Protection Bureau (Addis Ababa City Administration)
ETB	Ethiopian Birr
EPE	Environmental Policy of Ethiopia
EU	European Union
EURO	Euro, currency of the European Union
FDRE	Federal Democratic Republic of Ethiopia
GoE	Government of the Federal Democratic Republic of Ethiopia
HP	High Performance
IRR	Internal Rate of Return
MEDAC	Ministry of Economic Development Cooperation
MPWFAA	Masterplan Study for the Development of Wastewater Facilities for the City of Addis Ababa (1993)
NPV	Net Present Value
P.e.	Population equivalent
TDS	Total Dissolved Solids
ToR	Terms of Reference
TSS	Total Suspended Solids
UASB	Upflow Anaerobic Sludge Blanket
UNDO	United Nations Industrial Development Organisation
VIP	Ventilated Improved Pit
WID	Women in Development
WHO	World Health Organization
WTCZ	Warm Temperate Climate Zone
WWTW	Wastewater Treatment Works

1 INTRODUCTION

1.1 This Report

This report is the Executive Summary of the Wastewater Masterplan, which has been updated for the Addis Ababa Water and Sewerage Authority (AAWSA). The Masterplan is a revision and update of the previous Masterplan prepared in 1993. It includes the results of studies, investigations and outline designs made in order to develop a strategy for the sewerage for the whole of Addis Ababa.

This report is in four volumes:
Volume I: Waste Water Masterplan - Executive Summary;
Volume II: Waste Water Masterplan - Existing situation;
Volume III: Waste Water Masterplan - Main Report;
Volume IV: Waste Water Masterplan - Appendices.

It must be emphasised that this report is an update of the 1993 Masterplan. Therefore, this report must be read in conjunction with the 1993 Masterplan. Many of the conclusions and recommendations contained in that report are still valid today.

1.2 Scope of work

The scope of works for the update of the Wastewater Masterplan study are defined in the terms of reference as:

“The consultant shall review and update the Masterplan study for the development of wastewater facilities for the city of Addis Ababa.

He shall identify priorities and recommend a sanitation project for possible financing by the European Development Fund (EDF) or by others."

The recommended project may be multi-component.

The cost estimate should not exceed Ecu 35 million. It is not expected that EDF alone will finance the implementation of all the recommended works/ services. Rather it is intended that this study should facilitate decision for financing in the sanitation sub-sector by EDF and by other multi-lateral and bi-lateral financing agencies.”

1.3 Objectives

The objective of the Masterplan is to improve the standard of living health of the citizens of Addis Ababa. To achieve this objective the Wastewater Masterplan must address the following issues.

1. Implementation and improvement of on site sanitation (by community based water and sanitation project).
2. Collection and disposal of sludge from septic tanks and dry pit latrines.
3. Improvement of sewer connections in sewered areas.
4. Provision of sewerage to un-sewered areas in Addis Ababa.
5. Treatment of collected sewage.

This updated Masterplan includes items 2 to 5 above. On-site sanitation was excluded as it is a separate component.

1.4 Implementation Results

Implementation of the updated Wastewater Masterplan will result in the provision of sanitation services to Addis Ababa in 2020 as presented below.

Population served by sewers	960,000
Population served by septic tanks	1,366,000
Population served by dry pit latrines	1,366,000

Government, Institutional and commercial connected	16,800
Hotels and hospitals connected	175
Main Industries connected	58
Small and medium industries connected	1,250
Total number of connections	145,000
Average sewage flow (m^3/day)	160,000
Annual septic tank sludge collected and treated (m^3)	454,000
Annual dry pit contents collected and disposed of (m^3)	61,500

With approximately 2000 connections and foul sewage flows of approximately 1,500m^3/day at present the construction and operation of the proposed sewage system will make a considerable contribution to improving the health and standard of living of the population in Addis Ababa.

1.5 Urbanisation and Population Development

The main purpose of preparing Masterplans is to bring about a better standard of living, be it in the economic sector, health sector, or social sector for the population. The actual population size of a given urban centre at any time in the future is of paramount importance in the preparation of a Masterplan as well as well during its implementation.

The official population projections, based upon the results of the 1994 census have been prepared by the CSA and became available only in 1999.

Methodology

In the preparation a Masterplan for a given city or urban centre a major problem is the delimitation of the city boundaries. Once the boundaries of the city are defined, the next step is to assess and forecast the growth in population (the population dynamics). Finally, when the overall population has been projected, the (internal) distribution of the population within the city boundaries has to be assessed.

The purpose of a population growth forecasts at city level is to anticipate the changes in population size and characteristics. There are two main methods of forecasting population growth.

- Projecting the population using mathematical functions applied to population growth rates, which are usually calculated, based on historic data. Among the common mathematical functions are linear, exponential and logistic functions;

- Cohort component method: This procedure takes into account the future effects of the components of population growth i.e. mortality, fertility and migration. Based on past information, assumptions are made about future trends in these components.

The projections made in the context of the 1994 Wastewater Masterplan Study (MPWFAA), the Water Supply Stage III-A study (AAWSP III) and the Urban Masterplan used mathematical functions for the population projections. The MPWFAA used the results of the 1984 census as their baseline and the AAWSP III and Urban Masterplan used the results of the 1994 census. In all cases only one growth scenario was developed.

Comparison of results

The population growth forecasts in the MPWFAA are relatively old and are not now considered reliable. Comparison of the three population growth scenarios of the CSA with the single growth forecasts of the AAWSP III and Urban Masterplan show some alarming differences, especially at the end of the water supply project horizon. The projections prepared by the different studies are shown in Figure 1-1.

As can be seen, comparison of the AAWSP III and the Urban Masterplan population forecasts for the year 2010 - 2020, shows a substantial difference even with the high variant of the CSA projection.

From a demographic point of view, the discrepancy occurred due to the different methods employed in the projection. AAWSP III and the Urban Masterplan used mathematical models with probably exponential functions. This can be observed from Figure 1-1, where the curve tends to move upwards after a few years. The CSA projection results seem more plausible as they are based on assumptions that tried to foresee the impact of the population policy of 1993 and the women policy of 1993.

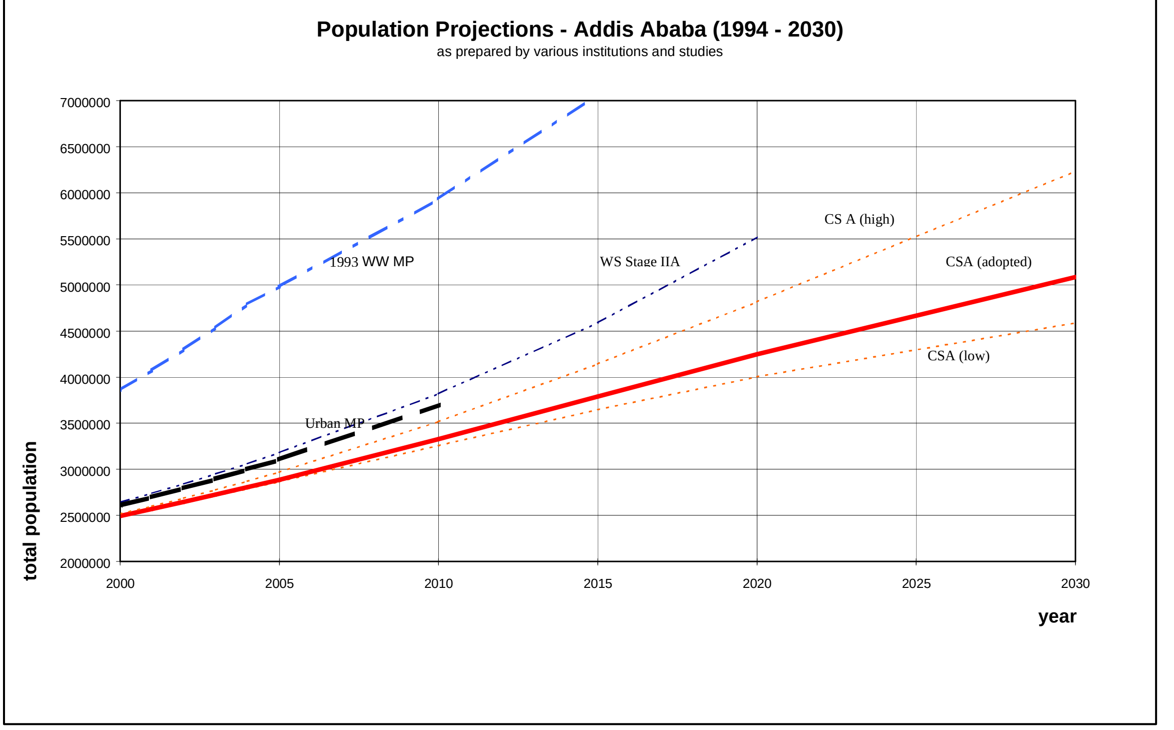

Figure 1-1 Population projection Addis Ababa (different studies)

In Table 1-1 it can be seen that at present about 52% of the population (1.2 million people) live in approximately 10% of the urban area. Given the fact that the overall development strategy of the Urban Masterplan foresees almost zero growth in the existing core area, by 2020 the population living in the city centre will amount to about 1.3 million people but will then represent only 32% of the total population of the city.

In the medium term, the expansion areas immediately surrounding the urban area of Addis Ababa and Akaki will absorb the population growth. When they reach their saturation level (between 100 and 200 persons/ha) the growth will overflow to the future expansion areas lying to east, south west and rural Akaki areas. At the design horizon of 2020 the predicted population for Addis Ababa is 4.25 million.

Table 1-1 Population projection per sewer catchment

Sewer command area	Area (ha)	percentage of city area	2000 Total population	Percentage of total population	2005 Total population	Percentage of total population	2010 Total population	Percentage of total population	2015 Total population	Percentage of total population	2020 Total population	Percentage of total population
Addis Ababa	**53,915**		**2,495,000**		**2,887,000**		**3,328,000**		**3,792,000**		**4,246,000**	
Kaliti	**19,465**	36%	**2,050,790**	82%	**2,247,090**	78%	**2,397,630**	72%	**2,446,290**	65%	**2,478,180**	58%
			442,090		***533,220***		***574,330***		***584,530***		***591,600***	
Ka-A	6,840		927,680		957,320		964,970		960,710		954,050	
Ka-A sevice area existing network			*165,540*		*189,430*		*198,770*		*200,950*		*202,560*	
Ka-B	5,660		880,180		976,120		1,019,090		1,026,890		1,029,800	
Ka-B sevice area existing network			*276,550*		*343,790*		*375,560*		*383,580*		*389,040*	
Ka-C	3,830		201,510		259,750		338,230		360,520		377,640	
Ka-D	3,135		41,420		53,900		75,340		98,170		116,690	
Bole	**16,955**	31%	**242,210**	10%	**309,270**	11%	**461,700**	14%	**719,810**	19%	**995,690**	23%
Bo-A	7,085		209,030		268,800		335,820		388,190		433,480	
Bo-B	5,550		29,060		35,890		89,820		208,820		325,700	
Bo-C	1,420		1,500		1,680		15,680		56,740		109,220	
Bo-D	2,900		2,620		2,900		20,380		66,060		127,290	
Akaki	**17,495**	32%	**202,000**	8%	**330,640**	11%	**468,670**	14%	**625,900**	17%	**772,130**	18%
Ak-A	5,955		42,900		90,880		138,360		185,770		219,450	
Ak-B	6,300		129,260		189,360		223,770		251,440		276,580	
Ak-C	5,240		29,840		50,400		106,540		188,690		276,100	

For definition of service area boundaries see section 2.2.

1.6 Water Supply

Addis Ababa has a potable water supply since 1901. The water supply consumption data in 1998 is shown in Table 1-2. It should be noted that the present number of customers (2001) is 180,000.

Table 1-2 Water supply customer consumption

Description	No. of connections	Total consumption	<15m^3/ month	16-40m^3/ month	>40m^3/ month
Domestic	102,900	2,663,800	1,133,600	660,200	870,000
Industry	1,000	284,300	12,000	12,700	259,600
Others	13,100	2,303,000	156,600	155,600	1,990,800
Public fountains	50	5,000	500	800	3,700
Total	**117,050**	**5,256,100**	**1,302,700**	**829,300**	**3,124,100**

To assess the future demand for water, the first step was to make an assessment of the current consumption and service levels. The current situation can be summarised as follows:

- The current (2000) average domestic consumption amounts to about 22 litres/capita/day.
- People with in-house services (about 4% of the population) use on average between 80 and 100 litres/capita per day, while the remaining population with access to safe drinking water (94%) are served by yard connections and use between 15 and 30 litres/capita per day.
- Non-domestic use, excluding industrial water use is substantial and amounts to about 25 litres/capita day.
- The industries use about 7 litres/capita per day of which about 40% is provided by AAWSA and the remaining amount is produced by the industries themselves (deep wells).
- Actual net demand is estimated as 75 litres/capita/day.
- Water sold is on average 52 litres/capita/day

Present water supplies are approximately 180,000 m^3/day. Following development of the Gerbi and Sibilu dams and associated treatment plants the projected capacity in 2010 will be approximately 850,000 m^3/day. This increase in capacity will have a significant affect on the wastewater generated within the city. Water sold is forecast to increase from 125,000 m^3/day in 2000 to 460,000 m^3/day in 2020, 80% of which can be expected to be discharged as sullage and black water.

1.7 Sanitation

Sanitation services figures in Addis Ababa are shown in Table 1-3.

Table 1-3 Distribution of toilet facilities by housing unit Addis Ababa (1994 CSA)

Type of sanitary facility	Flush Toilet Private	Flush Toilet Shared	Pit Latrine Private	Pit Latrine Shared	No sanitary facility	Not Stated
No.	30,113	14,815	67,895	169,732	89,508	3,679
Percentage	8%	4%	18%	45%	24%	1%

It can be seen that the majority of the population Addis Ababa use either septic tanks or dry pit latrines.

1.7.1 Existing Sewer System

The existing sewer system is located in the Kaliti catchment. The trunk sewers have a total length of approximately 30 km with approximately 90 km of secondary sewers and laterals. The number of people connected to the existing sewer system is about 13,000 (see Figure 2-4) with institutional and commercial connections contributing a further 27,000 p.e.

According to AAWSA records, there are about 1800 connections on to the existing sewer system. As the first sewers were completed in 1982 it can be seen that the rate of connections is very low and has not improved since 1993.

AAWSA is trying to improve the sanitation situation, however their efforts have been limited by severe budget constraints. The system of faecal sludge collection and disposal has been improved by increasing overall the capacity of sludge collection trucks, construction of sludge transfer stations and construction of drying beds and sludge lagoons at Kaliti and Kotebe. AAWSA is also slowly expanding the network of secondary sewer lines in order to give more people access to the sewerage system.

1.7.2 Waste Water Treatment

The sewage effluent is treated in a waste water treatment works at Kaliti, which consist of two treatment trains each with two facultative and two maturation ponds in series. The existing recirculation system of the treatment works is currently not in use. The capacity of the treatment works was quoted in the original design document as 7,600 m³/day with a Biochemical Oxygen Demand (BOD_5) load of 3,500 kg/day.

Even though, the design capacity of the works is about 7600m³/d, recent records show that the average daily dry season flow is 4,500m³/d. Based on a total sewer length of 120km and an average infiltration rate of 0.25litres/second/km it can expected that infiltration is approximately 3,000m^3/day. Sewage flows are thus 1,500m^3/day. The average monthly inflow at the Kaliti plant is shown in Figure 1-2. This figure gives a clear indication that during the rainy season surface water inflow can double dry season flows.

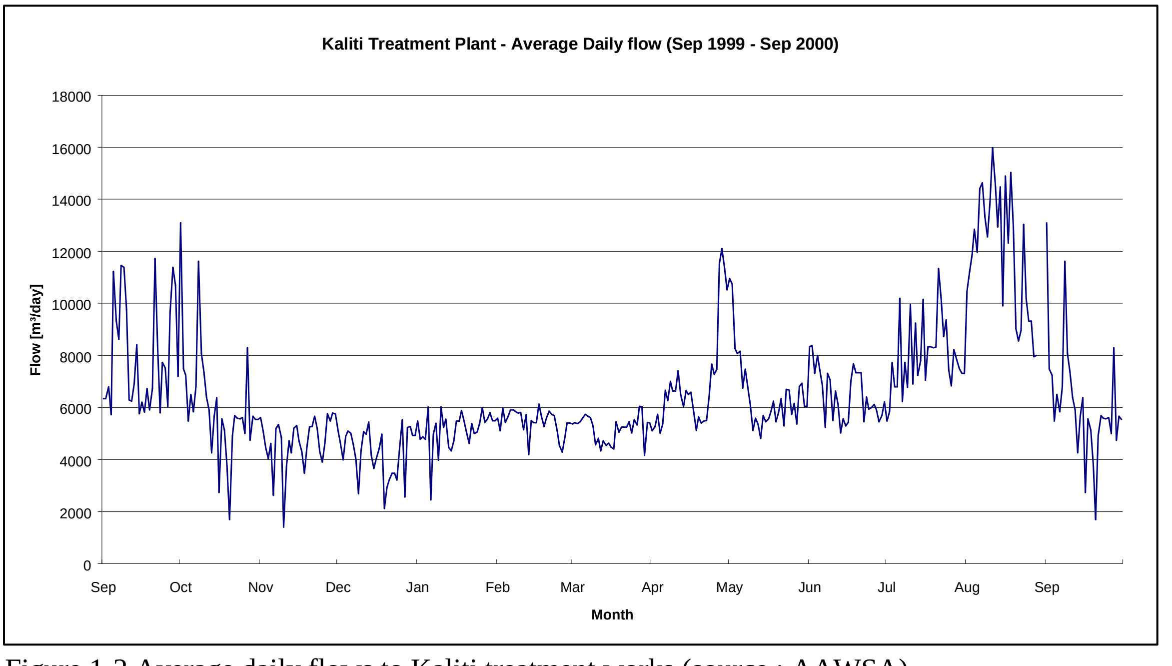

Figure 1-2 Average daily flows to Kaliti treatment works (source : AAWSA)

1.7.3 On-site Sanitation Facilities

The majority of the population of Addis Ababa uses either septic tanks or dry pit latrines. The environmental sanitation case study for Addis Ababa, conducted in 1997, indicated that about 210,000 people were using septic tanks and 1,460,000 people used individual or shared dry pit latrines.

One of the disadvantages of on-site sanitation is that emptying of the pit or the tank is required. This causes problems in the densely populated areas of Addis Ababa, as the access to the tanks or pits is difficult. Following the recommendations of the 1993 Masterplan, six 3m³ vacuum trucks and twelve small portable pumps and tankers were purchased to empty dry pit latrines in difficult areas. Due to the poor condition of most of the access tracks, steep gradients and poor pumping characteristics of the dry pit latrine contents, the operation of the portable pumps has been discontinued. The transfer stations are however used by the 3m³ vacuum trucks.

The sludge of these small trucks is taken to one of the four transfer stations and transferred into a large truck. The standard procedure to empty a pit latrine is to add water to the pit and liquefy the contents to allow them to be pumped. This only liquefies part of the contents leaving most solids in the pit.

1.7.4 Sludge disposal

The sludge from the dry pit latrines and the septic tanks is treated in Kaliti and Kotebe. The sludge drying beds and lagoons in Kaliti are able to treat approximately125,000 m³/year of sludge and consists of 8 drying beds and one sludge storage lagoon. The sludge disposal facility at Kotebe has the capacity to treat approximately 150,000 m³/year and consists of 20 drying beds and 10 lagoons.

The sludge lagoons are used in the rainy season to store sludge until the dry season. From the sludge lagoons the sludge can be pumped to the drying beds. The sludge cannot be directly used as a fertilizer for agriculture as it is contaminated with pathogens and helminth (intestinal worm) eggs.

1.7.5 Public Health in Addis Ababa

Diseases related to poor sanitation have been relatively constant for the last three years in Addis Ababa. In the past few years an increase in the incidence of helminth diseases has been reported. The level of diseases is highest in the four most densely populated Kebeles where poor conditions of sanitation like overflowing toilets, high sullage flows, decomposing garbage and the absence or inadequate supply of potable water is relatively common. Also the poor level of nutrition and the low standard of living of the inhabitants of these areas increases their susceptibility to diseases.

As Addis Ababa has a highland climate with moderate temperatures and little rainfall outside the rainy season, the rate of diseases related to poor sanitation is lower than could be expected.

1.7.6 Gender and Development

The total Projected population of Addis Ababa for 2001 is 2,500,000 of which 1,333,000 are female, i.e. 52 per cent, compared to 48% male population. Although women form majority of the population, the isolation of women from all forms of development and lack of attention to the gender based roles that people in a community play, has been one of the major constraints to the success of various development programs in Addis Ababa. The provision of adequate sanitation is of much more importance to women than to most men.

1.8 EIA for Recent Sanitation Projects

Environmental Impact Assessments (EIA) have been carried out for the following:

- Sludge Treatment Facility at Kotebe;
- Sludge Treatment Facility at Kaliti;
- Sludge Transfer Stations (4 sites);
- Sludge Collection Equipment (used for collection of sludge).

The main environmental issues and proposed mitigation measures at Kotebe and Kaliti Sludge Treatment Facilities can be summarised as:

1. *Health and Safety*
   Training and awareness program for workers related to handling hazardous materials, together with the provision of adequate protective clothing and medical services.
2. *Bad Odours*
   Creation of a buffer zone between residential areas and drying beds and lagoons.
3. *Contamination of Water Resources*
   Proper dried sludge disposal at sanitary landfill sites and disposal of seepage water.
4. *Attraction of sites to birds, wild animals and insects*
   Proper disposal of dried sludge at sanitary land fills sites and management of vegetation to limit attraction to wildlife.
5. *non-aesthetic views*
   Creation of a buffer zone between residential areas and sludge treatment facilities.
6. *Impacts on Land Value*
   Minimisation of operation nuisances/improvement of operational management and improvement of landscape and environmental aesthetics.
7. *Bird Strike Hazard*
   - Kotebe site should be kept as it is now (no hiding places for birds, no nesting opportunities, no seeds to feed on);
   - dykes to be walked between drying beds or lagoons on a regular daily bases to disturb roosting;
   - cut grass and weeds on dykes and slopes to a maximum height of 3 cm;
   - cause additional disturbance by the presence of a herd of grazing animals ;
   - patrols around the dykes and drying beds to chase away birds, on a regular daily basis;
   - firing shell crackers, additional use of a shotgun, to remove individual birds;
   - removal of trees and shrubs from around the ponds, drying beds and sludge lagoons to an extent of 20 m from all sides, to prevent roosting and nesting by birds of prey, Herons and Cormorant species;
   - clear the sites of all rubbish, originating from sludge, as it attracts scavenger animals and birds.

It must be appreciated that both treatment sites are less attractive to bird life than the adjacent agricultural areas.

Environmental Issues and proposed mitigation measures, related to Sludge Transfer Stations:

- improve the design of the Transfer Stations;
- timely replacement of old hoses and bad connectors. Regular cleaning of the Transfer Stations and proper disposal of waste to a storage bin for disposal;
- planting of trees to improve aesthetics;
- Diversion of area where sludge spills occur to a storage tank to be emptied by a vacuum truck

2 THE MASTERPLAN

2.1 Sludge Collection and Disposal

The collection of sludge from the city is constrained by the following problems:

- Poor access (narrow, steep unpaved roads) for suction trucks to reach and empty sludge from septic tanks and pit latrines.
- Sludge removal is difficult especially from the dry pit latrines, as the sludge contains a lot of extraneous matter such as plastic, clothing etc. and is a solid.

Sludge transfer stations

Due to the Problems in removing sludge from the dry pit latrines and the difficulty in operating the small portable pumps the existing transfer stations are operating considerably below capacity. With the recommended change in strategy for dry pit latrine emptying, no further transfer stations are proposed.

Septic tanks

The present strategy to use vacuum trucks to empty septic tanks is working well at present and should be continued. The volumes of sludge to be collected and treated are presented in Figure 2-1. It should be noted that the sludge contains only 0.5% of solids. This is substantially less than normal, and is thought to be due to the poor construction of the septic tanks and soakage pits. It is recommended that with the introduction of HP vacuum trucks, when the existing standard vacuum tankers need replacement, AAWSA should withdraw from emptying septic tanks.

Dry Pit Latrines

Emptying of dry pit latrines is however proving much more difficult. Even though the volume of dry pit latrine sludge transported to Kaliti and Kotebe is substantial, much of the volume is thought to be water added to the pit to enable the sludge to be pumped. As the dried excreta in the pits, especially after a number of years is solid this procedure is failing to remove a substantial amount of the sludge. In Figure 2-1, the projection of the quantity of dry pit sludge is shown. Analysis of samples of dry pit latrine sludge discharged from the tankers show that the sludge contains 95% water (8m^3 of sludge contains only 400 litres of dry pit sludge).

The recommended procedure elsewhere in the world is to use a high performance vacuum truck, which removes the dry material using air to convey the material. The sludge can be moved up to 100m away using this procedure. The dry material would be disposed of to a sanitary landfill. It is recommended that at least one tanker is purchased to ensure that the procedure is appropriate for use in Ethiopia.

In Figure 2-1 is also shown the total wet sludge volume for dry pits and septic tanks, when dry pit latrines are not emptied using a High Performance vacuum truck but using an conventional vacuum truck and adding water to empty the pit latrines.

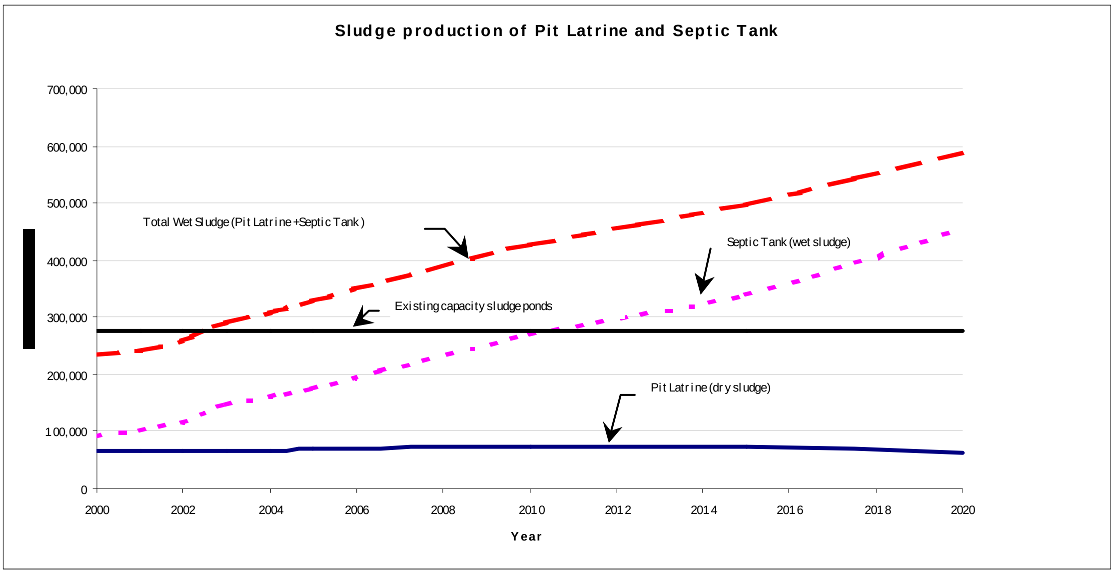

Figure 2-1 projected sludge production of Pit latrine and Septic Tank

Figure 2-1 assumes that the sludge collection efficiency ranges from 80% in 2000 to 95% 2020 for pit latrines and 90% in 2000 to 95% in 2020 for septic tanks.

It can be seen that especially in a wet year the capacity of the treatment works has been reached. Either an additional sludge treatment works must be constricted or alternative sludge disposal options implemented.

To reduce the amount of septic tank sludge to be treated in the sludge treatment facilities, a pilot forestry project is recommended. Within this forestry project, a part of the septic tank sludge will be used to irrigate Eucalyptus trees. It is proposed that a concrete header tank, a lined distribution ditch and a system of earth drains be constructed.

Another recommended pilot project is to inject the septic tank sludge into the Kaliti sewer system at a pilot sludge injection point. With a water content of 99.5% the additional sludge load on the facultative ponds will be negligible.

By implementing both projects, the amount of sludge to the sludge treatment facilities will significantly be reduced and can be expected not to exceed the capacity of the existing works.

Sanitary Landfills
The amount of dried sludge from the drying beds is estimated to be about 15,000 m^3/year. With the large increase in sludge from the dry pit latrines, disposal of the sludge to sanitary landfill sites at Kaliti and Kotebe will be required.

The recommended sludge disposal scheme using a High Performance Vacuum trucks is shown in Figure 2-2.

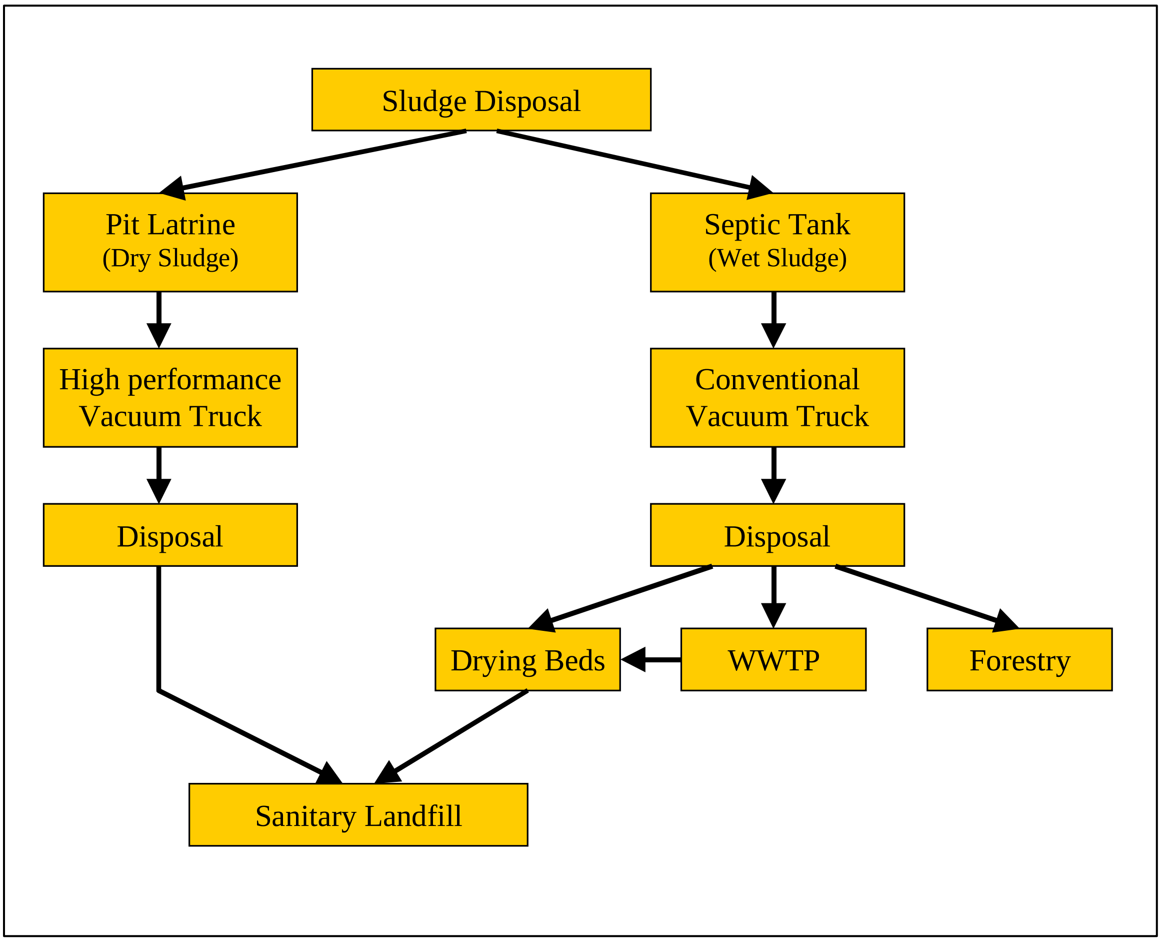

Figure 2-2 proposed Sludge disposal scheme

Assuming that the use of HP vacuum trucks proves successful the recommend implementation schedule and costs are shown in Table 2-1.

Table 2-1 Estimated costs for HP vacuum trucks

Sludge collection equipment	Cost (Birr)	Cost (Euro)
1 number HP vacuum trucks as pilot		
2002	1,500,000	196,078
11 number HP vacuum trucks		
2004	16,500,000	2,157,125
12 number HP vacuum trucks		
2014	18,000,000	2,352,941

2.2 Sanitation

One of the sewer design criteria requested by AAWSA is that where possible the sewer system is to be a gravity system i.e. no pumping stations are to be included in the new design. Because the average altitude in the north of Addis Ababa is higher than the average altitude in the south, this is relatively easily obtained. Inspection of the topographic maps has enabled the area to be divided into river catchments and sub catchments. These catchments are identical to the sewer catchments.

The city of Addis Ababa is spread over three main catchments. Each catchment is separated from the next by a ridge of high ground. These catchments are:

- Kaliti catchment;
- Eastern catchment;
- Akaki catchment;

These catchments have been subdivided into sub-catchments that correspond to the service areas used in the design.

2.2.1 Assumed domestic and non-domestic flows and BOD loads

Domestic:
The domestic connections can be divided in to residences and apartment blocks.

Average number of people for one connection:
Residence: 5.6 persons
Apartment blocks: 110 persons (approximately 20 apartments per block)

Also the water consumption differs between people living in an apartment and people living in a residence. Assuming that 80% of the water supply of people connected to the sewer system will end up in the sewer system, Table 2-2 shows the average domestic flow in to the sewer system.

Table 2-2 Average domestic flow to sewer

Year	2000	2005	2010	2015	2020
Residence [litres/capita/day]	74	80	88	96	112
Apartment blocks [litres/capita/day]	64	72	76	84	96

It has been assumed that the average BOD load will not change in time and has a value of 45 grammes/capita/day.

Non-Domestic
The flow and BOD load to the WWTW per connection for the non-domestic users will not change a lot in time, therefore constant loads and flows for the various non-domestic users were assumed. The assumptions of these non-domestic load and flows are shown in Table 2-3.

Table 2-3 Average non-domestic flow and BOD load to WWTW

	Average flow to sewer [m³/connection/day]	**Average BOD load [kg/connection/day]**
Government, Commercial	2	0.55
Hotels, hospitals, etc.	50	9
Main industries	200	450
Medium & small industries	2	1

Note:- The figures above are sector wide average values, individual discharges will vary significantly with major consumers having much higher discharges and smaller consumers discharging much less.

2.2.2 Kaliti catchment

For the Kaliti catchment, wastewater quantities for the three horizons (2005, 2010 and 2020) have been assessed. The assessments have taken into account the distribution of the population over the sewer district, the assumed development of connections to the sewer system and the projected hydraulic and BOD load. A summary of this assessment is given in Table 2-4.

Table 2-4 Summary of future connections and hydraulic and BOD loads for the Kaliti catchment

Kaliti Sewer Catchment						
year	Unit	**2000**	**2005**	**2010**	**2015**	**2020**
Population in catchment	pers.	2,050,150	2,184,750	2,297,920	2,408,610	2,478,670
growth	%	-	6.6%	5.2%	4.8%	2.9%
Connections to sewer system						
Domestic	no.	1,839	5,696	14,188	39,246	66,487
Government, Commercial	no.	54	2,040	3,190	7,255	9,260
Hotels, hospitals, etc.	no.	7	8	15	52	85
Industrial						
main industries	no.	0	11	16	26	31
medium & small industries	no.	4	105	175	360	530
Total		***1,904***	***7,860***	***17,584***	***46,939***	***76,393***
Flow into sewer system						
Domestic	m³/day	886	3,867	9,313	27,921	54,385
Government, Commercial	m³/day	243	4,080	6,380	14,510	18,520
Hotels, hospitals, etc.	m³/day	490	520	750	2,600	4,250
Industrial						
main industries	m³/day	0	2,200	3,200	5,200	6,200
medium & small industries	m³/day	16	210	350	720	1,060
Total		***1,635***	***10,877***	***19,993***	***50,951***	***84,415***
BOD load of sewer system						
Domestic	kg/day	548	2,262	4,961	13,573	22,754
Government, Commercial	kg/day	107	1,122	1,755	3,990	5,093
Hotels, hospitals, etc.	kg/day	189	202	210	468	765
Industrial						
main industries	kg/day	0	4,950	7,200	11,700	13,950
medium & small industries	kg/day	4	105	175	360	530
Total		***848***	***8,641***	***14,301***	***30,091***	***43,092***
Population Equivalent		18,845	192,017	317,794	668,692	957,606

Note: - the 2000 flows and pollutant loads are based on observed data. The current institutional and commercial customers are major consumers and as such have higher flows and pollutant loads than would be given using the average values in Table 2-4. The domestic connections also have much lower flows and pollutant loads than those given in Table 2-2.

The growth of the population in the Kaliti catchment is relatively small (see Table 2-4). The strategy therefore focuses on serving the existing population in the catchment. The strategy is divided into three stages of construction.

It should be noted that the predicted pollution load is heavily dependent on the connection of the main industries in the catchment, especially between 2005 and 2010, where the pollution load of the main industries represent over 50% of the total load.

Stage 1
The existing sewer and treatment system has some spare capacity, it is therefore possible to connect a significant amount of people to the sewer system without any major additions to the main sewer system and no increase in the capacity in the waste water treatment works.

Emphasis is therefore placed on constructing lateral sewer lines to enable people to connect within the service area of the existing sewer system. This expansion of the number of people connected to the sewer system will continue until the capacity of the existing wastewater treatment works is reached. (See Figure 2-3).

Stage 1 works
Construction of laterals and secondary sewers to serve an area of 1,448 hectares, the length of the new sewers will be approximately 37 km.

Stage 2
In stage 2 the service area will be expanded with extra trunk lines will be built and connected to the existing sewer system. The construction of lateral sewers will continue to enable more people to connect to the sewer system. The stage 2 service area has been assessed as that area that can be connected before the capacity of the existing trunk sewers is exceeded (see Figure 2-3).

Initially the capacity of Kaliti WWTW will be doubled by the construction of anaerobic ponds upstream of the existing ponds. With the continued extension of the sewer network, the capacity of the extended Kaliti wastewater treatment works will be reached and additional capacity has to be constructed. As the new sludge drying beds have been constructed in the space allocated for the works, expansion will be difficult and expensive to expand the Kaliti WWTW on the existing location, therefore a new WWTW will need to be constructed. The location of this new WWTW (Akaki II) will be within the Akaki catchment. To connect the Kaliti catchment to the Akaki II WWTW, a 7 km long trunk sewer will need to be constructed.

Stage 2 works
Construction of 40 km trunk sewers within the Kaliti catchment plus the construction of a 7 km trunk sewer from Kaliti to Akaki II. (5.5 km of this sewer will be used as the trunk sewer for Akaki stage 3 sewerage). Construction of laterals and secondary sewers for an area of 2,470 hectares, the length of the new sewers will be approximately 86 km. Construction of Akaki II WWTW due to flows coming from Kaliti catchment.

Stage 3
In this stage the emphasis will lay on connecting the areas that are further away from the existing sewer system. These areas are the Mercato area, the area up to Hope Enterprise and the area up to the Embassy of USA. In stage 2 the capacity of the existing sewer system will have been reached, so to permit further expansion in the stage 2 service area, the capacity of the stage 2 sewer system will need to be supplemented by diverting flows to the stage 3 sewers (see
).

The stage 3 trunk sewers will need to be built all the way from the treatment works to the above-mentioned areas. The construction of secondary and lateral sewers will continue.

As the trunk sewers are constructed and flows increase the treatment capacity at Akaki II will need to be progressively extended.

Mercato area
According to the Urban Masterplan the Mercato area will be completely redeveloped in the near future. The design of this western sewer line with associated secondary and lateral sewers will need to be revised and be undertaken once the development proposals are completed.

Stage 3 works
Construction of 62 km trunk sewers. Extension of Akaki II WWTW in phases. Construction of laterals and secondary sewers for an area of 3,547 hectares, the length of the new sewers will be approximately 124 km.

Costs
The costs for the implementation of the proposed sewer works in the Kaliti catchment in stage 1 2 and 3 are tabulated in Table 2-5, Table 2-6 and Table 2-7 (1 Euro = 7.65 Birr). For the purpose of this cost estimate wastewater treatment using stabilisation ponds has been assumed.

Table 2-5 Stage 1 sewerage costs in the Kaliti catchment

Description	Estimated cost (Birr)	Estimated cost (Euro)
Provision of secondary lines & laterals	11,733,171	1,533,748
Rehabilitation of existing siphons	1,770,336	231,416
Rehabilitation of Karamara main line	683,052	89,288
Sanitary Landfill	1,164,000	152,157
Pilot septic tank sludge injection point	240,331	31,416
Mitigation measures for ongoing projects	6,341,750	828,987
Design and Supervision 7.5%	1,644,948	215,026
Land and property compensation	1,682,000	219,869
Contingency 10%	2,525,959	330,191
Total Stage 1	**27,785,546**	**3,632,098**

Table 2-6 Stage 2 sewerage costs in the Kaliti catchment

Description	Estimated cost (Birr)	Estimated cost (Euro)
Expansion of Kaliti WWTW by anaerobic ponds	6,981,704	912,641
Mekanisa Trunk Line and laterals	13,130,712	1,716,433
Rwanda Trunk Line and laterals	1,569,576	205,173
Bole Tele-22 Round Trunk Line and laterals	11,167,363	1,459,786
Lafto Trunk Line and laterals	13,671,308	1,787,099
Meskel Square- Gotera Trunk Line and laterals	12,939,483	1,691,436
Post office-AAWSA Trunk Line and laterals	6,735,352	880,438
Kaliti Diversion sewer to Akaki II WWTW	16,085,400	2,102,667
Akaki II WWTW phase 1	63,831,160	8,343,942
Design and Supervision, 7.5%	10,958,404	1,432,471
Land and property compensation	3,693,000	482,745
Contingency 10%	16,076,346	2,101,483
Total Stage 2	**176,839,809**	**23,116,315**

Table 2-7 Stage 3 sewerage costs in the Kaliti catchment

Description	Estimated cost (Birr)	Estimated cost (Euro)
Mercato interceptor and laterals	110,928,255	14,500,426
Ayer Tena Interceptor and laterals	9,264,900	1,211,098
North-eastern interceptor and laterals	59,363,308	7,759,910
Expansion of Akaki II WWTW all phases	429,000,000	56,078,431
Design and Supervision, 7.5%	45,641,735	5,966,240
Land and property compensation	13,878,750	1,814,216
Contingency 10%	66,807,695	8,733,032
Total Stage 3	**734,884,642**	**96,063,352**

The estimated sewerage costs for the implementation of stages 1, 2 and 3 in the Kaliti catchment are 939,500,000 Ethiopian Birr equivalent to 122,800,000 Euro.

If trickling filters are constructed instead of wastewater stabilisation ponds for the second and subsequent phases at each works, the capital cost will be 660,000,000 Birr (86,000,000 Euro).

Figure 2-3 Kaliti catchment stage 1+2

Figure 2-4 Kaliti catchment stage 3

2.2.3 Eastern catchment

For the Eastern catchment wastewater quantities for the three horizons (2005, 2010 and 2020) has been assessed. The assessments have taken into account the distribution of the population over the sewer district, the assumed development of connections to the sewer system, the projected hydraulic load and BOD load. A summary of this assessment is given in Table 2-8.

Table 2-8 Summary of future connections and hydraulic and BOD loads for the Eastern catchment

Eastern Sewer Catchment						
year	Unit	2000	2005	2010	2015	2020
Population in catchment	pers.	243,020	386,250	561,570	749,820	957,860
growth	%	-	58.9%	45.4%	33.5%	27.7%
Connections to sewer system						
Domestic	no.	0	1,973	6,036	16,313	34,625
Government, Commercial	no.	0	405	990	2,475	4,335
Hotels, hospitals, etc.	no.	0	2	6	35	75
Industrial			0	0	0	0
main industries	no.	0	1	2	3	4
medium & small industries	no.	0	40	60	135	250
Total		***0***	***2,421***	***7,094***	***18,961***	***39,289***
Flow into sewer system						
Domestic	m³/day	0	1,340	3,958	11,607	28,332
Government, Commercial	m³/day	0	810	1,980	4,950	8,670
Hotels, hospitals, etc.	m³/day	0	100	300	1,750	3,750
Industrial						
main industries	m³/day	0	200	400	600	800
medium & small industries	m³/day	0	80	120	270	500
Total		***0***	***2,530***	***6,758***	***19,177***	***42,052***
BOD load of sewer system						
Domestic	kg/day	0	784	2,108	5,643	11,854
Government, Commercial	kg/day	0	223	545	1,361	2,384
Hotels, hospitals, etc.	kg/day	0	18	54	315	675
Industrial						
main industries	kg/day	0	450	900	1,350	1,800
medium & small industries	kg/day	0	40	60	135	250
Total		***0***	***1,515***	***3,667***	***8,804***	***16,964***
Population Equivalent		0	33,659	81,483	195,640	376,969

As there is no sewer system in the Eastern catchment, the starting point of the strategy is to construct a new wastewater treatment works and sewer system.

As can be seen in Table 2-8 the growth of the population the Eastern catchment will increase in 20 years by a factor 4.

Stage 1
The first action is to construct a treatment works.

Construction of the trunk sewers will start at the treatment works and expand upstream together with the construction of secondary and lateral sewers to enable people to connect to the system (see Figure 2-6).

Stage 1 works
Construction of 23 km trunk sewers and construction of phase 1 Eastern WWTW. Construction of laterals and secondary sewers for an area of 1,220 hectares, the length of the new sewers will be approximately 43 km.

Stage 2
To extend the sewer network, new trunk lines will need to be built. These new sewer lines will connect to the stage 1 sewer system. Construction of lateral and secondary sewer lines will continue in this stage (see Figure 2-6).

Stage 2 works
Construction of 19 km trunk sewers. Construction of laterals and secondary sewers for an area of 1,592 hectares, the length of the new sewers will be approximately 56 km.

Stage 3
The last development areas will be served by constructing new trunk sewers and associated secondary and lateral sewers. The number of people able to connect to the sewer system will increase enormously in this stage (see Figure 2-6). During this stage, the treatment works will need to be progressively extended.

Stage 3 works
Construction of 31 km trunk sewers and extension of Eastern WWTW phases 2 and 3. Construction of laterals and secondary sewers for an area of 2,305 hectares, the length of the new sewers will be approximately 81 km.

Costs
The estimated costs for the implementation of the proposed sewer works in stages 1, 2 and 3 for the Eastern catchment are shown in Table 2-9,.Table 2-10 and Table 2-11.

Table 2-9 Stage 1 sewerage costs in the Eastern catchment

Description	**Estimated cost (Birr)**	**Estimated cost (Euro)**
Construction of treatment works	57,200,000	7,477,124
Building and Miscellaneous works for the WWTW	2,390,300	312,458
Eastern terminal trunk sewer	12,164,772	1,590,166
CMC interceptor and laterals	19,384,208	2,533,883
ILRI interceptor and laterals	7,344,847	960,111
Kotebe Interceptor and laterals	11,786,451	1,540,713
Ayat Interceptor and laterals	7,341,098	959,621
Construction of Access road & bridges	3,200,000	418,301
Sanitary landfill	1,164,000	152,157
Sludge disposal site (Forestry pilot scheme)	500,000	65,359
HP Vacuum truck	1,500,000	196,078
Laterals excluded by Interbeton	10,850,000	1,418,301
Design and Supervision, 7.5%	10,111,926	1,321,820
Land and property compensation	2,812,350	367,627
Contingency 10%	14,774,995	1,931,372
Total Stage 1	**162,524,947**	**21,245,091**

Table 2-10 Stage 2 sewerage costs in the Eastern catchment

Description	**Estimated cost (Birr)**	**Estimated cost (Euro)**
Construction of treatment works	57,200,000	7,477,124
CMC interceptor and laterals	4,759,224	622,121
Kotebe Interceptor and laterals	5,234,469	684,244
Gergi interceptor and laterals	11,018,035	1,440,266
East Bole interceptor and laterals	12,889,481	1,684,900
Ayat Interceptor and laterals	19,603,305	2,562,524
Design and Supervision, 7.5%	8,302,839	1,085,338
Land and property compensation	2,671,350	349,196
Contingency 10%	12,167,870	1,590,571
Total Stage 2	**133,864,573**	**17,496,284**

Table 2-11 Stage 3 sewerage costs in the Eastern catchment

Description	Estimated cost (Birr)	Estimated cost (Euro)
Kotebe Interceptor and laterals	889,557	116,282
Gerji interceptor and laterals	14,339,000	1,874,379
East bole interceptor and laterals	14,972,170	1,957,146
Sludge disposal site (Forestry scheme) Phase II	6,300,000	823,529
Sludge disposal site (Forestry scheme) Phase III	6,200,000	810,458
Construction of Access road & Bridge (forestry)	2,600,000	339,869
Expansion of treatment works	85,800,000	11,215,686
Design and Supervision 7.5%	9,832,555	1,285,301
Land and property compensation	2,921,850	381,9416
Contingency 10%	14,385,513	1,880,459
Total Stage 3	**158,240,645**	**20,685,052**

The estimate sewerage costs for the implementation of stages 1, 2 and 3 in the Eastern catchment are 454,700,000 Birr equivalent to 59,500,000 Euro.

If trickling filters are constructed instead of wastewater stabilisation ponds for the second and subsequent phases at each works the capital cost will be 370,000,000 Birr (48,000,000 Euro).

Figure 2-5 Kaliti catchment stage 1,2 & 3

2.2.4 Akaki catchment

For the Akaki catchment, wastewater quantities for the three horizons (2005, 2010 and 2020) have been assessed. The assessments have taken into account the distribution of the population over the sewer district, the assumed development of connections to the sewer system, the projected hydraulic load and BOD load. A summary of this assessment is given in Table 2-12.

Table 2-12 Summary of future connections and hydraulic and BOD loads for the Akaki catchment

Akaki Sewer Catchment							
year	Unit	2000	2005	2010	2015	2020
Population in catchment	pers.	201,830	316,000	468,510	633,570	809,470
growth	%	-	56.6%	48.3%	35.2%	27.8%
Connections to sewer system						
Domestic	no.	0	1,575	5,136	12,284	25,176
Government, Commercial	no.	0	320	830	1,855	3,170
Hotels, hospitals, etc.	no.	0	0	3	9	15
Industrial			0	0	0	0
main industries	no.	0	4	10	17	27
medium & small industries	no.	0	4	205	310	470
Total		***0***	***1,903***	***6,184***	***14,475***	***28,858***
Flow into sewer system						
Domestic	m³/day	0	1,079	3,365	8,736	20,578
Government, Commercial	m³/day	0	640	1,660	3,710	6,340
Hotels, hospitals, etc.	m³/day	0	0	150	450	750
Industrial						
main industries	m³/day	0	800	2,000	3,400	5,400
medium & small industries	m³/day	0	8	410	620	940
Total		***0***	***2,527***	***7,585***	***16,916***	***34,008***
BOD load of sewer system						
Domestic	kg/day	0	632	1,792	4,247	8,609
Government, Commercial	kg/day	0	176	457	1,020	1,744
Hotels, hospitals, etc.	kg/day	0	0	27	81	135
Industrial						
main industries	kg/day	0	1,800	4,500	7,650	12,150
medium & small industries	kg/day	0	4	205	310	470
Total		***0***	***2,612***	***6,981***	***13,308***	***23,107***
Population Equivalent		0	58,040	155,130	295,731	513,499

As there is no sewer system in the Akaki catchment, the starting point of the strategy is to construct a new wastewater treatment works and sewer system.

As can be seen in Table 2-12 the growth of the population in the Akaki catchment will increase in 20 years by a factor of 4.

The predicted growth in pollution loads is heavily dependent on the connection of the main industries. They contribute over 50% of the total BOD load in the Akaki catchment.

The Akaki Catchment can be divided into two areas, Lower Akaki and Upper Akaki to allow a gravity flow sewer system in the Akaki area. The sewage from the Lower Akaki area will flow by gravity to the Akaki I treatment works. The sewage from the Upper Akaki area will discharge to the Akaki II treatment works.

Stage 1
The first action is to construct the Akaki I treatment works. Due to the flows coming from the Kaliti catchment to the Akaki catchment, the Akaki II treatment works will also need to be constructed.

Construction of the trunk sewers will start at the treatment works and expand upstream together with the construction of secondary and lateral sewers to enable people to connect to the system (see Figure 2-6).

Stage 1 works
Construction of 13 km trunk sewers and construction of phase 1 of Akaki I WWTW. Construction of laterals and secondary sewers for an area of 1,143 hectares, the length of the new sewers will be approximately 40 km.

Stage 2
The Upper Akaki area will discharge to the Akaki II treatment works which will need extension (in this stage the Akaki II treatment works will serve both Kaliti and Akaki).

To extend the Akaki sewer network, new trunk lines will need to be built. These new sewer lines will connect to the stage 1 sewer system. Construction of lateral and secondary sewer lines will continue in this stage (see Figure 2-6).

Stage2 works
Construction of 20 km trunk sewers and construction of phase 1 of Akaki II WWTW. Construction of laterals and secondary sewers for an area of 1,609 hectares, the length of the new sewers will be approximately 56 km.

Stage 3
The last development areas will be served by constructing new trunk sewers and associated secondary and lateral sewers. The number of people who could be connected to the sewer system will increase enormously in this stage (see Figure 2-6). Akaki I WWTW will need to be progressively expanded to 150,000 p.e. capacity.

Stage 3 works
Construction of trunk 15 km sewers. Extension of both Akaki I and Akaki II WWTW's. Construction of laterals and secondary sewers for an area of 1,506 hectares, the length of the new sewers will be approximately 53 km.

Costs

The estimated costs for construction of the proposed sewer works in stages 1, 2 and 3 for the Akaki catchment are shown in Table 2-13 , Table 2-14 and Table 2-15.

Table 2-13 Stage 1 sewerage costs in the Akaki catchment

Description	**Estimated cost (Birr)**	**Estimated cost (Euro)**
Construction of Akaki 1 WWTW	64,574,745	8,441,143
Akaki main Interceptor and laterals	10,058,264	1,314,806
Akaki west Interceptor and laterals	11,461,735	1,498,266
Akaki east interceptor and laterals	3,297,348	431,026
Design and Supervision, 7.5%	6,704,407	876,393
Land and property compensation	2,070,750	270,686
Contingency 10%	9,816,725	1,283,232
Total Stage 1	107,983,974	14,115,552

Table 2-14 Stage 2 sewerage costs in the Akaki catchment

Description	**Estimated cost (Birr)**	**Estimated cost (Euro)**
Expansion of Akaki II WWTW	57,200,000	7,477,124
Akaki west Interceptor and laterals	13,304,737	1,739,181
Akaki east interceptor and laterals	7,108,655	929,236
Saris Interceptor and laterals	26,510,184	3,465,384
Design and Supervision, 7.5%	*7,809,268*	*1,020,819*
Land and property compensation	*2,597,500*	*339,542*
Contingency 10%	*11,453,034*	*1,497,129*
Total Stage 2	**125,983,379**	**16,468,416**

Table 2-15 Stage 3 sewerage costs in the Akaki catchment

Description	**Estimated cost (Birr)**	**Estimated cost (Euro)**
Akaki west interceptor and laterals	4,775,558	624,256
Saris Interceptor and laterals	3,609,009	471,766
Bole Bulbula interceptor and laterals	10,936,392	1,429,594
Expansion of Akaki I WWTW	28,600,000	3,738,562
Expansion of Akaki II WWTW	143,000,000	18,692,810
Design and Supervision, 7.5%	14,319,072	1,871,774
Land and property compensation	4,730,000	618,301
Contingency 10%	20,997,003	2,744,706
Total Stage 3	**230,967,035**	**30,191,769**

The estimated sewerage costs for the implementation of stages 1, 2 and 3 in the Akaki catchment are 465,700,000 Birr equivalent to 60,800,000 Euro.

If trickling filters are constructed instead of waste water stabilisation ponds for the second and subsequent phases at each works the capital cost will be 340,000,000 Birr (47,000,000 Euro).

Figure 2-6 Eastern catchment stage 1, 2 and 3

2.3 Wastewater Treatment

2.3.1 Domestic Wastewater

At the present time the principal sources of domestic wastewater are the residential districts and predominantly public institutional facilities. Other important sources of wastewater include commercial facilities and recreation areas.

Domestic sewage flow in residential areas is characterised by very low wastewater discharge rates with regard to the standard of living of the population.

The average water demand for people living in the better housing ranges between 80 and 130 litres per person per day. This depends on the sanitation facilities installed and the availability of storage tanks to overcome shortages in water supply. On average 80% of the water supply will be discharged as wastewater.

Wastewater flows from institutional facilities are essentially domestic in nature. The quantity produced depends on the type and the size of each facility.

See Section 2.2.1 for assumed flows and pollutant loads.

2.3.2 Industrial Wastewater

In contrast to domestic wastewater, where the composition, in terms of Biochemical Oxygen Demand (BOD), nitrogen (N) and phosphorus (P), is generally known, industrial sewage is very much dependent on the particular type of industry.

An inventory of the industries was therefore made and information collected about the processes, flow, COD, BOD, N, P, heavy metals, pH, toxic compounds, temperature, etc. Based on this information the industrial pollutant loads has been calculated.

AAWSA supplied information concerning water supplies to existing industries. Based on this information the industries with a high water consumption and processes with a high amount or highly concentrated wastewater discharge were visited. Detailed information was collected concerning the water and wastewater situation and to obtain an insight in to the future expected wastewater production.

See Section 2.2.1 for assumed flows and pollution loads.

2.3.3 Forecast to the waste water treatment works

As stated in the previous section, the city of Addis Ababa will in the future have four waste water treatment works, one in Kaliti catchment (existing) one in the Eastern catchment and two in the Akaki catchment. The flow to the treatment works will depend on the connection rate within the catchment.

2.3.4 Kaliti WWTW

The existing Kaliti WWTW has a capacity of approximately 40,000 population equivalent (p.e.). The original design states that by using recirculation, the capacity of the existing ponds can be increased to 100,000 p.e. Assuming this capacity is correct, by constructing an anaerobic pond in front of each of the existing trains of ponds, the capacity of the Kaliti treatment works can be increased to 180,000 p.e. The original wastewater treatment works made provision for an additional two trains of ponds to be constructed. The space for one train has however been used to construct the sludge treatment ponds. It will therefore be difficult to construct an additional train of ponds in the remaining area. It is recommended that the surplus flow to Kaliti treatment works be diverted to Akaki II WWTW.

The analysis to select the most appropriate treatment option is given below in Table 2-16.

Table 2-16 Kaliti catchment – Treatment or diversion disposal options

Item	Option	Advantages	Disadvantages	Risks	Assumptions
K1	Increase WWTW capacity by using recirculation of treated effluent	Pumping station already constructed	Increase in power & operating costs. Increased risk of failure	Failure of pumping station will overload WWTW	Original design calculation correct
K2	Increase WWTW capacity by installing UASB plant upstream	Easily constricted in available area, will double capacity of WWTW.	Skilled operation required Medium capital cost. Increased operating cost	Failure will overload WWTW	Plant is suitable for type of sewage
K3	Increase WWTW capacity by installing anaerobic ponds upstream	Low capital cost. Unskilled operation. Little increase in operating cost. Will double capacity of WWTW.	It improperly operated odours could occur. Difficult to locate in available area	Ponds not desludged regularly	Design loading rates applicable in Addis Ababa
K4	Increase WWTW capacity by constructing additional train of ponds	Will add 50% to existing capacity and with either UASB or anaerobic ponds will add 50% of uprated capacity	Difficult to construct as better half of expansion area taken by new sludge treatment works. No further expansion possible	Flooding in river could affect works	Original design calculations correct Land available
K5	Divert flows in excess of capacity to Akaki II WWTW	Allows for unlimited expansion of treatment capacity at Akaki II	Increased size of sewers needed in Akaki catchment	Failure of trunk sewer could pollute river.	Trunk sewer will operate without silting at initial low flows Land available at Akaki II
K6	Abandon Kaliti WWTW	Frees up area for industrial development. Reduces number of WWTW	Significant additional capital cost. Large pond area to be infilled.	Reduction in flexibility of treatment.	Land available at Akaki II
K7	Construct mechanical plant for increased loads	WWTW stays at Kaliti. Akaki II not needed for Kaliti	Increased operating cost. Mechanical plant	No experience in operating mechanical plant.	Additional land available if necessary.
K8	Construct ponds at Akaki II	Low operating cost	high capital cost		land available

The estimated total capital costs to meet the 2020 demands and the 2020 operating costs of each of the above options are given in Table 2-17.

Table 2-17 Estimated cost for waste water treatment options in Kaliti catchment

Item	Option	Capital costs (Birr)	Annual operating costs (Birr)
K1	Increase WWTW capacity by using recirculation of treated effluent	Nil	800,000
K2	Increase WWTW capacity by installing UASB plant upstream	12,000,000	650,000
K3	Increase WWTW capacity by installing anaerobic ponds upstream	6,6000,000	150,000
K4	Increase WWTW capacity by constructing additional train of ponds	30,000,000	75,000
K5 [1)]	Divert flows in excess of capacity to Akaki II WWTW	20,000,000	100,000
K6 [2)]	Abandon Kaliti WWTW	100,000,000	NA
K7 [3)]	Construct mechanical plant for increased loads	290,000,000	25,000,000
K8[3)]	Construct ponds at Akaki II	350,000,000	3,000,000

1) Trunk sewer cost only (50% of cost should be allocated to Akaki sewerage)
2) Cost of replacement treatment works at Akaki II
3) Additional 700,000 per capacity required to meet 2020 flows

Due to the higher capital cost of the UASB plant (K2) the construction of Anaerobic Ponds (K3) is recommended.

Due to the difficulty in extending Kaliti (K4) the recommended option is to divert flows to Akaki II and build a waste stabilisation pond system.

In the load to and the capacity of the existing Kaliti treatment works is shown. It can be seen that in 2005 the maximum capacity of the plant will be reached if the stage I and II sewer construction works are implemented as scheduled and that the diversion of flow to the Akaki II WWTW should start. The diverted loads will range from 130,000, 480,000 to 780,000 p.e. in 2010, 2015 and 2020 respectively.

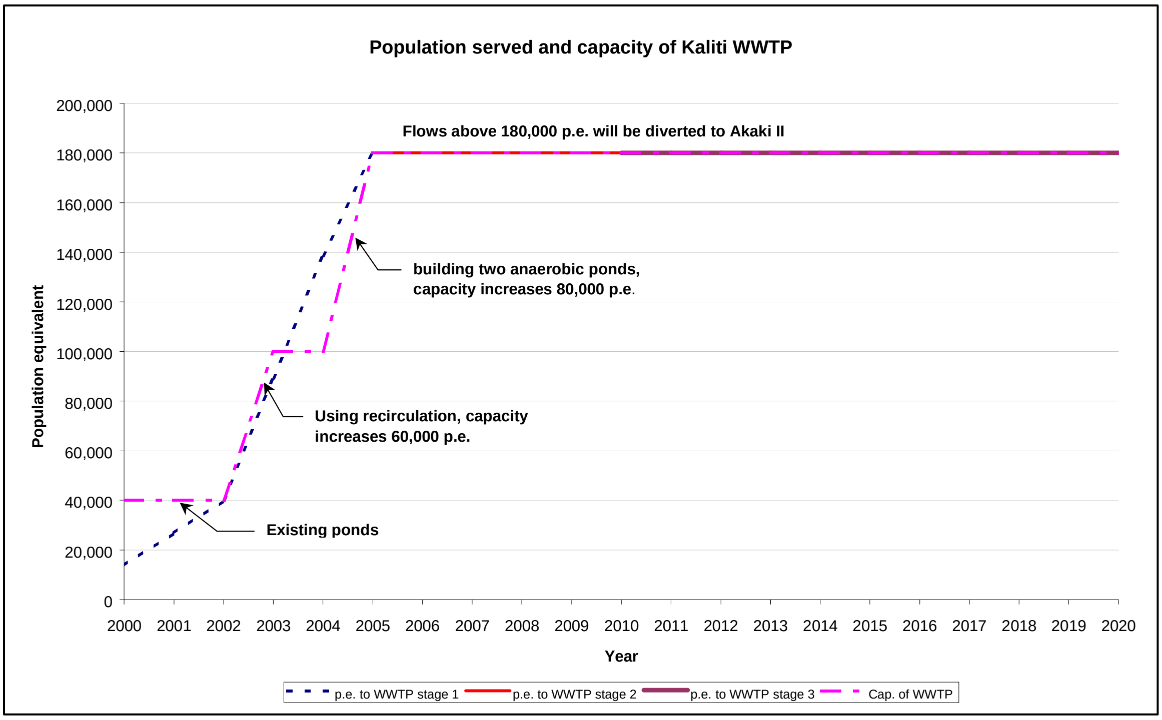

Figure 2-7 Population served and capacity of Kaliti WWTW

2.3.5 Eastern Catchment WWTW

This will be a new works and the analysis to select the most appropriate option is given below in Table 2-18.

Table 2-18 Eastern Catchment – Treatment or diversion options

Item	Option	Advantages	Disadvantages	Risks	Assumptions
E1	WWTW at Bole	Stand alone operation. Akaki II plant does not need to be built so early. Failure of plant only affects eastern catchment	An additional WWTW to operate. Additional sludge treatment works required. Additional land required.	Lack of trained operators	Land available
E2	Trunk sewer to Akaki II WWTW	Reduces number of WWTW	Long trunk sewer required. Cost of treatment works still similar. Failure of Akaki II plant would affect two catchments. High capital cost.	Failure of sewer line would pollute river	Sewer line feasible along river. Sewer operates without siltation during early years. Land available
E3	Pumping station for East Bole flows with works at Kotebe.	No additional land required. Terminal trunk sewer 3km shorter	High capital and operating cost of pumping station	Power or mechanical failure of pumping station. Failure of rising main	Flows can be accurately predicted. Land available for pumping station

The estimated total capital costs to meet the 2020 demands and the 2020 annual operating costs of each of the above options is given in Table 2-19.

Table 2-19 Estimated cost for treatment options in Eastern catchment

Item	Option	Capital cost (Birr)	Annual Operating cost (Birr)
E1	WWTW in catchment	57,000,000	750,000
E2 [1)]	Trunk sewer to Akaki II WWTW	22,000,000	500,000
E3	Pumping station for East Bole flows with works at Kotebe.	66,000,000	1,200,000

1) Does not include cost of treatment works at Akaki (same cost as option E1)

It is recommended that a waste stabilisation pond system be constructed within the Eastern Catchment. The option to convey flows to Akaki II is not economic, as the saving in operating cost will not repay the cost of the trunk sewer.

The saving in land purchase cost (approximately Birr 1.4 Million) does not justify the construction of a pumping station for the East Bole flows and keeping the treatment works at Kotebe.

In Figure 2-8 are the projected flows and the proposed capacity of the Eastern WWTW shown. From the figure it can be seen that a capacity of 100,000 p.e. will meet the demand until the year 2012. After this the capacity of the plant will need to be increased to 200,000 p.e., which will be sufficient until the year 2016. An additional increase of 100,000 p.e. in the year 2016 is necessary to deal with the 2020 demands.

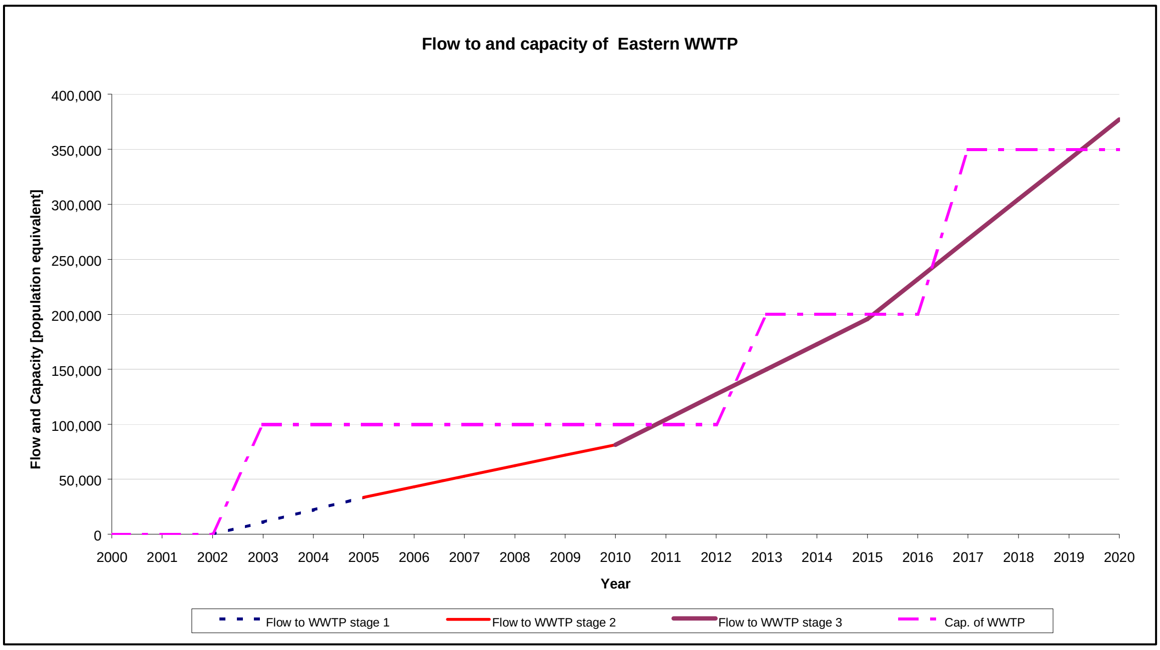

Figure 2-8 Flow and capacity of Eastern WWTW

2.3.6 Akaki catchment WWTW

In the Akaki catchment two wastewater treatment works will need to be built. The first wastewater treatment works to be built will be Akaki I. The location of this treatment works is such that all flow from the Lower Akaki catchment can reach it by gravity. However the available space is limited, therefore it is not possible to expand the works to meet the year 2020 demand. To deal with this demand another location is available at Akaki II, which is located on the plain at the west side of the little Akaki River. All flows from the Upper Catchment will therefore be taken to Akaki II WWTW. It is therefore proposed that all flows from the upper catchment be taken to Akaki II WWTW.

The analysis to select the most appropriate option is given below in Table 2-20.

Table 2-20 Akaki Catchment – Treatment or disposal options

Item	Option	Advantages	Disadvantages	Risks	Assumptions
A1	Construct first treatment ponds followed by mechanical plant at Akaki I	Only one WWTW required in Akaki catchment. Gravity flow to works	Mechanical plant required for p.e. > 150,000. Akaki II still required for Kaliti	No experience in operating mechanical plant. Pollution of well field aquifer	Land available. Mechanical plant acceptable. Geotechnical conditions ok.
A2	Construct Akaki I WWTW for lower catchment and Akaki II for upper catchment	No pumping required. Mechanical plant not required. Gravity flow to works.	Two WWTW required Higher operational cost.	Pollution of well field aquifer	Geotechnical conditions ok. Land at two sites available.
A3	Construct only Akaki II WWTW with gravity sewer line connection.	Only one WWTW. No risk of pollution of well field aquifer	High capital cost of connecting trunk sewer. Pipe bridge across Akaki river. Deep excavation across ridge. Pumping Station required in wet season	Pipe bridge across Akaki river. Deep excavation across ridge. Break in sewer line pollutes river Part of WWTW in Lake Aba Samual flood plain	Geotechnical conditions ok. Land available Plant can be protected from flooding
A4	Construct only Akaki II WWTW with lower Akaki pumped to WWTW	Only one WWTW. No risk of pollution of well field aquifer Lower capital cost	Higher operating costs. Large pumping station required.	Failure of pumping station pollutes river. Operation of pumping station	Geotechnical conditions ok. Land available

The total capital costs to meet the predicted 2020 demand and the 2020 annual operating costs of these options are giving in Table 2-21.

Table 2-21 Estimated costs for treatment options in Akaki catchment

Item	Option	Capital costs (Birr)	Annual operating cost (Birr)
A1	Construct first treatment ponds followed by mechanical plant	400,000,000	38,000,000
A2	Construct Akaki I WWTW for lower catchment and Akaki II for upper catchment	620,000,000	750,000
A3	Construct only Akaki II WWTW with gravity sewer line connection.	720,000,000	1,500,000
A4	Construct only Akaki II WWTW with lower Akaki pumped to WWTW	629,000,000	22,250,000

With waste stabilisation ponds as treatment works it can be seen that the most cost effective option is to construct treatment works at both the Akaki I and Akaki II locations.

The following strategy is recommended, first Akaki I is built with a capacity of 100,000 population equivalents. In the year 2012 the works will reach its capacity therefore an expansion of another 50,000 p.e. is necessary. The total capacity of the Akaki I WWTW will be 150,000 p.e.

In Figure 2-9 Projected flows to and the capacity of Akaki I WWTW are shown.

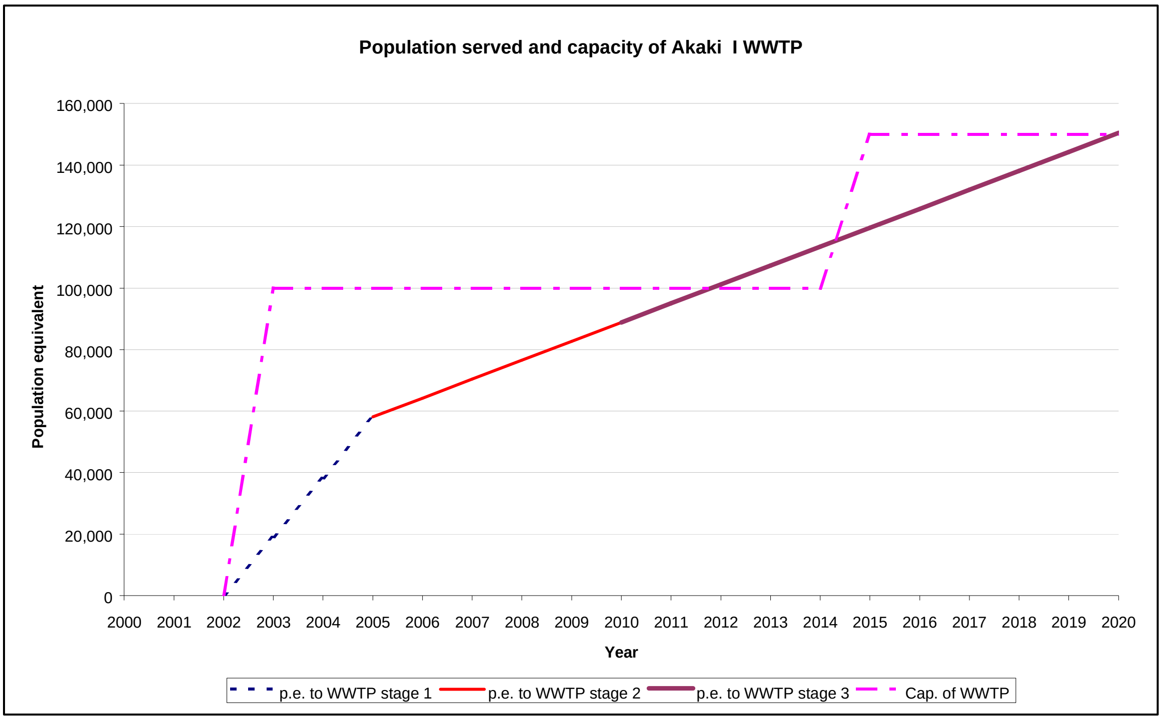

Figure 2-9 Flow and capacity to Akaki I WWTW

The Akaki II WWTW will serve two catchments, Kaliti (>180,000 p.e.) and the Upper Akaki area. In Figure 2-10 the projected flows to and the proposed capacity of the Akaki II WWTW is shown. In the year, 2004 part of the flows from the Kaliti catchment will need to be diverted to the Akaki II WWTW.

From 2004 until 2010 the proposed capacity of the Akaki II WWTW is 100,000 p.e., in 2008 the capacity will need to be increased up to 300,000 p.e. In 2012 the capacity will need to be increased by 300,000 p.e. the capacity will thus be 600,000 p.e. Another increase of the capacity of 300,000 p.e. will be needed in the year 2015. The capacity of the Akaki II treatment works will need to be 1,100,000 p.e. in the year 2019.

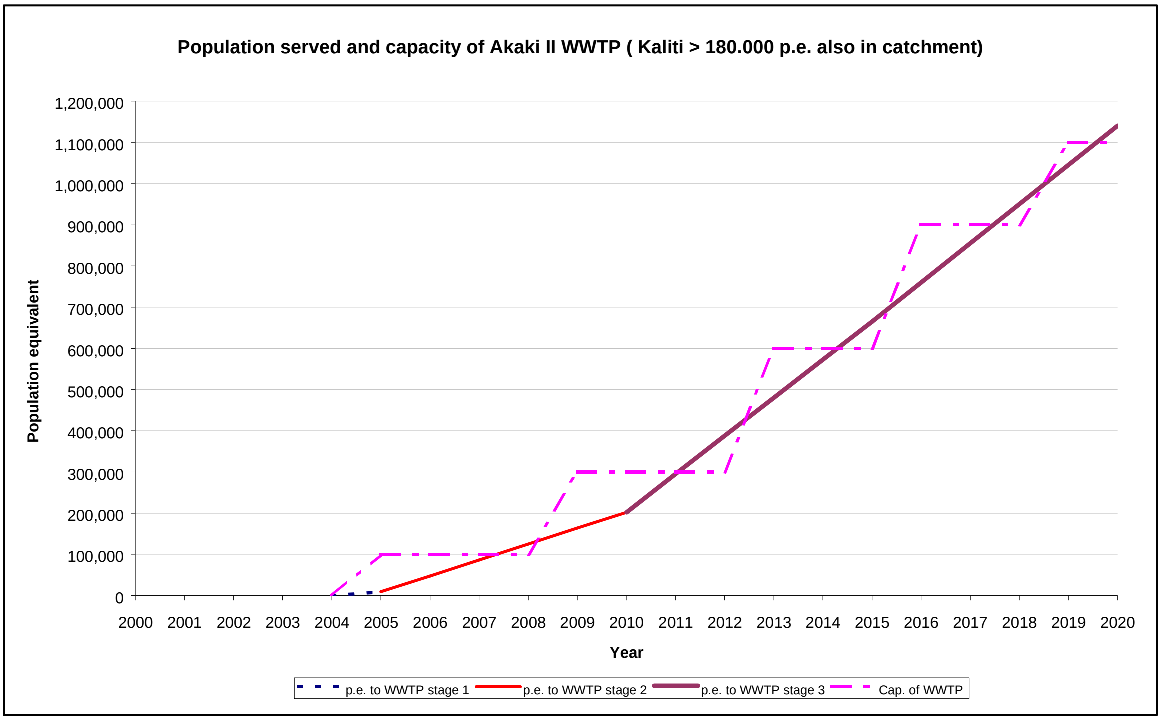

Figure 2-10 Flow and capacity of Akaki II WWTW

2.3.7 Descriptions of different waste water treatment processes

In the updated Masterplan the following wastewater treatment processes are considered:

- Waste Stabilisation Ponds;
- Conventional Activated Sludge;
- Extended Aeration - Oxidation Ditch;
- Sequencing Batch Reactor;
- Trickling Filter.

and for initial treatment processes:

- Upflow Anaerobic Sludge Blanket (UASB);
- Anaerobic ponds.

2.3.8 Evaluation of different treatment options

A detailed description of each individual treatment process is included I the main report. A summary of the advantages and disadvantages for each process is given in Table 2-22.

Table 2-22 Advantages and disadvantages of the individual treatment processes

Advantages	Disadvantages
Waste stabilisation ponds • negligible energy consumption • simple operation with low maintenance requirements • low sludge production • significant bacteriological and Helminth egg removal	• large area of land required • possible odour and mosquito problems • algae growth affects effluent quality • medium construction costs
Conventional activated sludge • small land requirement • widely used and proven technology	• primary and secondary sedimentation required • skilled operation necessary • large quantity of unstable sludge produced • high proportion of mechanical and electrical equipment necessary • high energy consumption • additional sludge treatment required
Oxidation ditch (Carousel) • small land requirement • robust process and proven technology • relatively simple operation • production of stabilised sludge • nitrogen reduction readily achievable	• high proportion of mechanical and electrical equipment necessary • high energy consumption • medium construction cost • secondary sludge treatment required
Sequencing batch reactor (SBR) • small land requirement • proven technology • relatively simple operation • production of stabilised sludge • nitrogen reduction readily achievable • moderate investment	• high proportion of mechanical and electrical equipment necessary • high energy consumption • medium construction cost • skilled operation needed
Trickling filter • low energy consumption • relatively low mechanical and electrical equipment • simple operation • Moderate land requirement	• relatively large quantity of unstable sludge produced • additional sludge treatment required • possible odour and fly problem • poor effluent quality concerning nitrification • Primary and secondary sedimentation required
Upflow anaerobic sludge blanket (UASB) • small land area required • generation of methane gas suitable for energy production • low volume of stabilised sludge • relatively low investment	• limited experience with this process for treating domestic wastewater • high ambient temperature required • secondary treatment required after reactor to achieve effluent standard • skilled operation required • medium energy consumption
Anaerobic pond • negligible energy consumption • simple operation with low maintenance requirements • low sludge production • low construction cost	• medium land requirement • possible odour problems

2.3.9 Recommendations for WWTW

Of the five treatment processes considered above, the conventional activated sludge process and sequencing batch reactor both have a high energy consumption, have a high proportion of mechanical and electrical equipment and need skilled operation. For these reasons these two processes are not considered suitable for use in Ethiopia.

The remaining three treatment processes have been financially compared in Section 3.4 and it can be seen that the trickling filter treatment process has the lowest capital cost and the waste stabilisation pond treatment ponds has the lowest operating cost. The waste stabilisation pond treatment process is more robust i.e. has a wider tolerance to variation in the incoming hydraulic and pollutant load than the trickling filter treatment process and is therefore more suitable for the phase I treatment works. Following construction of the phase I works, the effluent quality and quantity can be measured and the construction of trickling filters considered for phase II. The waste stabilisation ponds are also much more tolerant of low flows and pollutant loads allowing for a slower than anticipated connection rate as observed at Kaliti.

The carousel plant with a high capital and running cost is not considered suitable at the present time.

The recommended option for the first phase of Akaki I, Akaki II and the Eastern catchment is to construct waste stabilisation pond systems at each location.

2.4 Ranking of Components

The outline design of the sewers showed where sewers were required to serve the anticipated populations. These sewers were then classified into three stages:

- Stage 1 trunk sewers which must be constructed first i.e. trunk sewers upstream of the treatment works.
- Stage 2 trunk sewers which must connect to a stage 1 sewer and have stage 3 sewers upstream
- Stage 3 trunk sewers at the head of the system.

The trunk sewers were then prioritised to assist in determining a preferred order of construction. To assist in this process, each trunk sewer was scored using the following system (see Table 2-23).

Table 2-23 Breakdown of Scores for Prioritising Sewer phasing

	Description	Points	Remarks
1	**Cost Per capita Connected**	**30**	
1.1	Up to 2005 0 to 1000 20 - 0 pts	20	Based on 2005 population
1.2	Up to 2020 0 to 1000 10 - 0 pts	10	Based on 2020 population
2	**Expected Type of Catchment Development**	**25**	
2.1	Industrial / Commercial	10	Based on expected water consumption
2.2	High standard Domestic	10	In-house connections
2.3	Medium standard Domestic	5	In-house connections
2.4	Low standard Domestic	0	Either none or yard connections
3	**Environmental Impact**	**25**	
3.1	In area vulnerable to GW pollution	5	Thickness of impermeable clay
3.2	Area causing SW pollution	5	Impermeable soils
3.3	Located within the well field protection zone	5	Proximity to well field & GW flow path
3.4	Non-effectiveness of on-site sanitation	10	Impermeability of soil
4	**Infrastructure support**	**20**	
4.1	Provision of Sewers before extensive development	10	Extent of development in planned extension area
4.2	Certainty of WS & Integrated development	10	Areas where extension of water supply and integrated development planned
	Total	**100**	

Based on the scores a preferred order of construction was developed in each catchment (noting that a stage 2 sewer must connect to a stage 1 sewer and a stage 3 sewer to a stage 2 sewer).

Kaliti

Based on the scoring outlined above, the interventions in Kaliti catchment are shown in Table 2-24. It is proposed that the stage II works be split in to major interventions item K 1 to K8 as the first intervention and K 9 to K11, K16 and K17 as the second intervention. Outside the 35m Euro budget are the stage III items K12 to K14 and K17. Note that the expansion of Akaki II WWTW would be in stages following observed demand.

Table 2-24 Kaliti catchment implementation priority

Catchment	Description of works	Stage	Population Equivalent served (2020)	Estimated cost [ETB]	Cost /Capita Connected	Score	Implementation Order	Cummulative Cost (Birr)	Cummulative Cost (Euro)
Kaliti									
K1	Provision of Secondary Lines & Laterals for connections	I	60,000	15,696,625	262	63	1	15,696,625	2,051,846
K2 K3 K4	Sewer rehabilitation, sludge disposal and pilot sludge injection	I		4,589,803		n/a	2	20,286,427	2,651,821
	Mitigation measures for ongoing projects	n/a		7,499,119	n/a	n/a	n/a	27,785,547	3,632,098
K5	Expansion of Kaliti Treatment Plant using Anaerobic ponds	II	100,000	8,255,865	83	n/a	3	36,041,412	4,711,296
K6	Mekanisa/Old Airport	II	45,000	16,090,816	358	62	4	52,132,228	6,814,670
K8	Bole Tele-22 Round	II	46,000	13,464,677	293	59	5	65,596,905	8,574,759
K7	Rwanda	II	9,000	1,916,799	213	58	6	67,513,704	8,825,321
K17	Construction Akaki II phase 1 WWTP	II	100,000	63,831,160	638	n/a	7	131,344,864	17,169,263
K16	Construction of Kaliti to Akaki Trunk sewer	II		19,477,486		n/a	8	150,822,349	19,715,340
K9	Lafto	II	60,750	16,737,167	276	57	9	167,559,516	21,903,205
K10	Meskel Square- Gotera	II	33,750	15,703,099	465	54	10	183,262,615	23,955,897
K11	Post office-AAWSA	II	20,250	8,173,554	404	52	11	191,436,169	25,024,336
K15	Akaki II expansion	III	770,000	518,842,500	674	n/a	12	710,278,669	92,846,885
K13	Ayer Tena Interceptor	III	64,200	11,249,444	175	45	13	721,528,113	94,317,400
K14	North-eastern interceptor and laterals	III	313,000	71,390,336	228	45	14	792,918,449	103,649,471
K12	Merkato interceptor and laterals	III	395,000	133,402,362	338	44	15	926,320,811	121,087,688

Eastern catchment

Based on the scoring outlined above, the interventions proposed in the eastern catchment area are shown in Table 2-25.

The majority of the stage 1 works in this catchment have been excluded from the interventions outlined in this Masterplan as it is hoped that the works will be funded by another donor. The excluded works included the wastewater treatment works and most of the stage 1 trunk sewers.

It is proposed that the current intervention be items E8 to E10, E13 and E17, the stage II trunk sewers and the secondary sewers and laterals excluded from the other intervention.

Items E6, E7, E14, E15, E18 and E19 are outside of the proposed intervention. The expansion of the treatment works would depend on the observed flows and pollutant loads observed within the catchment.

Table 2-25 Eastern catchment implementation priority

Catchment	Description of works	Stage	Population Equivalent served (2020)	Estimated cost [ETB]	Cost /Capita Connected	Score	Implementation Order	Cummulative Cost (Birr)	Cummulative Cost (Euro)
Eastern Proposed Interbeton Intervention									
E16	Preparation sanitary landfill, access road and bridges, forestry pilot project and purchase 1 HP vacuum truck	I		7,525,430		n/a	1	7,525,430	983,716
E1	Construction of treatment plant Stage 1	I	100,000	72,005,530	572	n/a	2	79,530,960	10,396,204
E2	Eastern terminal trunk sewer	I	208,500	14,704,942	112	62	3	94,235,902	12,318,419
E4	ILRI interceptor and Laterals	I	23,000	8,878,551	342	61	5	103,114,453	13,479,013
E5	Kotebe Interceptor and laterals	I	30,500	14,247,624	403	56	6	117,362,077	15,341,448
E3	CMC interceptor and laterals	I	26,500	23,431,896	578	57	9	140,793,973	18,404,441
Eastern									
E17	Laterals excluded by Interbeton	I	80,000	12,830,125	228			153,624,098	20,081,581
E11	East Bole interceptor and laterals	II	42,000	15,507,737	228	62	4	169,131,835	22,108,737
E10	Gergi interceptor and laterals	II	35,000	13,318,126	275	59	6	182,449,960	23,849,668
E9	Kotebe Interceptor and laterals	II	21,000	6,298,220	420	59	10	188,748,180	24,672,965
E13	Kotebe Interceptor and laterals	III	6,000	1,077,531	228	60	11	189,825,711	24,813,818
E8	CMC interceptor and laterals	II	12,000	5,775,018	474	55	12	195,600,729	25,568,723
E7	Construction of treatment plant 2nd Stage	II	100,000	69,179,000	572	n/a	8	264,779,729	34,611,729
E15	East Bole interceptor and laterals	III	22,000	18,153,281	681	55	13	282,933,010	36,984,707
E14	Gergi interceptor and laterals	III	28,500	17,385,583	503	53	14	300,318,593	39,257,332
E6	Ayat interceptor and laterals	I	2,000	8,900,849	946	48	15	309,219,441	40,420,842
E12	Ayat interceptor and laterals	II	22,000	23,768,473	1,080		15	332,987,914	43.527.832
E18	Extension of Forest by 125 ha	III		17,855,750	n/a	n/a	17	350,843,664	45.861.917
E19	Expansion of WWTW 3rd stage	III	150,000	103,768,500	692		18	454,612,164	59.426.427

Akaki

Based on the scoring outlined above and the strategy that the Akaki catchment is served by two treatment works, the sewer interventions proposed in the Akaki catchment are shown in Table 2-26.

Initially work will be concentrated in the lower Akaki catchment where the current intervention will undertake items A1, A2 and A4. The sewerage of the upper catchment items A3, A5 to A13 would be outside the current intervention. Expansion of both treatment works would depend on flows and pollutant loads observed within the catchments.

Table 2-26 Akaki catchment implementation priority

Catchment	Description of works	Stage	Population Equivalent served (2020)	Estimated cost [ETB]	Cost /Capita Connected	Score	Implementation Order	Cummulative Cost (Birr)	Cummulative Cost (Euro)
Akaki									
A1	Construction of Akaki I WWTP	I	100,000	77,899,636	779	n/a	1	77,899,636	10,182,959
A2	Akaki main interceptor and laterals	I	118,000	12,206,848	103	62	2	90,106,484	11,778,625
A4	Akaki east interceptor and laterals	I	52,500	4,024,239	77	55	3	94,130,723	12,304,670
A5	Construction of Akaki II WWTP Phase 2	II	100,000	69,179,000	692	n/a	4	163,309,723	21.347.676
A8	Saris interceptor and laterals	II	119,000	32,082,543	270	53	5	195,392,266	25,541,473
A11	Saris Interceptor and laterals	III	23,800	4,376,554	184	55	6	199,768,819	26.113.571
A7	Akaki east interceptor and laterals	II	31,000	8,620,485	278	52	7	208,389,304	27,240,432
A3	Akaki west interceptor and laterals	I	39,500	13,853,251	351	49	8	222,242,555	29,051,314
A12	Expansion of Akaki I WWTP	III	50,000	34,589,500	692	n/a	9	256,832,055	33,572,818
A6	Akaki west interceptor and laterals	II	91,000	16,101,351	177	54	10	272,933,406	35,677,569
A9	Construction of Akaki II WWTP next phase	II	250,000	172,947,500	692	n/a	11	445,880,906	58,285,086
A10	Akaki west interceptor and laterals	III	9,600	5,791,197	603	50	12	451,672,104	59,042,105
A13	Bole Bulbula interceptor and laterals	III	35,600	13,262,284	373	46	13	464,934,388	60,775,737

2.4.1 Possible implementation schedule

Based on the implementation priorities and on the requirements for wastewater treatment the following implementation and expenditure schedules have been prepared. See Table 2-27 and Table 2-28.

Table 2-27 Implementation schedule

Table 2-28 Yearly expenditure schedule

2.5 Environmental Screening

The proposed interventions have been assessed for their environmental impacts and allocated as categories A, B and C in conformity with the EU guidelines. See Tables 2-28 up to 2-31.

Table 2-29 Proposed interventions and recommended environmental studies; Kaliti sewer District

Proposed Project	Location	Description of Works	Recommended Environmental Study
Provision of secondary lines & laterals for house connection	all along the existing Kaliti sewer truck lines	provision of PVC pipes of diameter 150 and 200mm including 150mm Y connections for house connection	**A**
Improvement work at Karamara Hotel and Bole interceptor	at Bole Karamara Hotel	upgrading the existing 300mm dia. pipe to a 400mm diameter pipe	**A**
Rehabilitation of existing sewer lines		raising of manholes, provision of overflows, inspection and disconnecting of storm water intrusion points	**A**
Access road	between sludge drying bed to disposal site	gravel road about 0.5 km	**A**
Sanitary land fill site	within Kaliti Wastewater treatment site	disposal site for dried sludge	**C**
Existing pond de-sludging and maintenance	Kaliti treatment works	de-sludging of facultative ponds and related maintenance works	**B**
Septic tank sludge injection point	selected location on the existing sewer line	protected compound with discharge to sewer	**C**
Expansion of Kaliti treatment plant, 2nd stage	within Kaliti treatment works compound	Construct anaerobic ponds upstream of existing facultative ponds.	**C**
Expansion of trunk sewers, secondary lines and laterals	Kaliti Catchment	provision of 200 – 1200mm sewers, including 150mm Y fitting for house connection	**B**
Storm water overflows	Kaliti catchment	Provision to divert flood flows to rivers	**B**
Ayer Tena interceptor secondary sewers and laterals	Ayer Tena	300mm trunk sewer, river crossing	**(B)**
North-East interceptor secondary sewers and laterals	North-East Addis Ababa, Saris	300-100mm trunk sewer, river crossings	**(C)**
Mercato interceptor secondary sewers and laterals	Mercato	300-1000mm trunk sewer, river crossings	**(C)**

A Project: no Environmental Impact Assessment required
B Project: Environmental Management and Monitoring required; mitigation measures to be formulated
C Project: Environmental Impact Assessment required
( ) Not in current project

Table 2-30 Proposed interventions and recommended environmental studies; Eastern Sewer District

Proposed Project	Location	Description of Works	Recommended Environmental Study
Preparation of sanitary land fill site	Kotebe	disposal site for dried sludge	**C**
Construction of treatment plant, 1st phase,	Eastern	WWTW for 100,000 p.e.	**C**
Main trunk sewer, secondary Sewer and laterals, CMC interceptor	Eastern	approx. 6 km trunk sewer has to be laid before connecting this interceptor	**B**
Main trunk sewer, secondary Sewer and laterals, ILRI Interceptor	Eastern	dia. 300mm trunk sewer, river crossings	**B**
Main trunk sewer, secondary Sewer and laterals, Kotebe interceptor	Kotobe	dia. 600 & 400mm trunk sewer ,river crossings	**B**
Eastern terminal trunk sewer	Eastern	6km trunk sewer	**B**
Gergi interceptor, secondary sewers and laterals		400 and 600m trunk sewer, river crossings	**B**
Expansion of treatment plant, 2nd and 3rd phases	Eastern	WWTW for 150,000 p.e.	**(C)**
Ayat interceptor secondary sewers and laterals	Eastern	300-600mm trunk sewer	**(B)**
Pilot forestry project	Kotebe treatment works	Sludge disposal on forest land	**(C)**

A Project: no Environmental Impact Assessment required
B Project: Environmental Management and Monitoring required; mitigation measures to be formulated
C Project: Environmental Impact Assessment required
( ) Not in current project

Table 2-31 Proposed interventions and recommended environmental studies; Akaki sewer District

Proposed Project	Location	Description of Works	Recommended Environmental Study
Construction of access road to Akaki I WWTW	Akaki I WWTW	gravel access road for the construction of the WWTW	**B**
Construction of Akaki I WWTW phase I	upstream of Lake Aba Samuel	Stabilisation ponds to treat 100,000 p.e.	**C**
Akaki main interceptor, secondary sewers and laterals	Akaki town	dia. 800,600 & 400mm trunk line, 150-300mm secondary sewers and laterals, river crossings	**B**
Akaki east interceptor, Secondary sewers and laterals	Western Akaki area	dia. 600 ,500 & 400mm trunk line, 150-300mm secondary sewers and laterals and river crossings	**B**
Construction of access road to Akaki II WWTW	Akaki II WWTW	Gravel access road for the construction of the WWTW	**B**
Construction of Akaki II	North of lake Aba	Stabilisation ponds to treat 100,000	**C**

Proposed Project	Location	Description of Works	Recommended Environmental Study
WWTW phase I	Samuel	p.e.	
Expansion of Akaki II WWTW further phases	North of lake Aba Samuel	Expansion of WWTW to treat 1,000,000 p.e.	**(C)**
Saris interceptor secondary sewers and laterals		300-400mm trunk sewer	**(B)**
Akaki west interceptor secondary sewers and laterals	Akaki town	300-400mm trunk sewer	**(B)**
Expansion of Akaki I WWTW	Upstream of lake Aba Samuel	Expansion of WWTW by 50,000pe	**(C)**
Bole Bulbula interceptor secondary sewer and treatments.	Bole Bulbula	300-400mm trunk sewer	**(C)**

A Project: no Environmental Impact Assessment required
B Project: Environmental Management and Monitoring required; mitigation measures to be formulated
C Project: Environmental Impact Assessment required
( ) Not in current project

Table 2-32 Proposed interventions and recommended environmental studies; various projects

Proposed Project	Location	Description of Works	Recommended Environmental Study
Forestry development	Kotebe	Plot forestry project for sludge disposal	**(C)**
Sludge collection equipment	Various	high power vacuum trucks	**A**
Storm water overflow	Various in Kaliti	provision of station overflows to spill flood flows to river	**B**

A Project: no Environmental Impact Assessment required
B Project: Environmental Management and Monitoring required; mitigation measures to be formulated
C Project: Environmental Impact Assessment required
(C) Project not in current project

3 FINANCIAL AND ECONOMIC ANALYSIS

3.1 Introduction

In accordance with the TOR for the Masterplan, the proposed interventions were subjected to a full financial and economic analysis.

The analyses comprise:
- financial cash flow analysis for *with* / *without* project cases / individual catchments;
- economic cash flow analysis for *with* / *without* project cases / individual catchments;
- NPV / IRR for financial / economic analyses for the project / catchments;
- a provisional project funding for the project / catchments;
- sensitivity tests for key cost and revenue parameters;
- intangible costs and benefits on health, environment and real estate development.

Scenario definitions

with project scenarios

The Masterplan contains a number of (sub) components that will be implemented. The components of the Masterplan to be implemented and their phasing are described in technical detail in sections 3 and 4 and in financial detail in the subsequent subsections of this Section. Included in the *with* project case are the necessary changes in the use of manpower, commodities, repair and maintenance etc. Three basic *with* case scenarios have been identified (see section 1.3.2) reflecting different technical options each providing the same sewerage service level. First, the feasibility of these technical options (scenarios 1-3) is tested, after which the preferred option is treated in further detail. The preferred option is referred to as the *with* case and is compared to the *without* case.

without project scenario

The *without* scenario comprises more than "do nothing". It presumes a "continue the present situation and trends with only a number of essential replacements taking place", i.e.:

- A very limited coverage of customers for sewerage, growing at a slow pace (0.5% p.a.);
- The sewer network / sludge collection as at present, repair / replacement of assets upon breakdown and gradual / limited deterioration of services due to the general ageing of assets;
- As a consequence of the preceding item, operating expenses are expected to rise in order to maintain service at present levels.

For both the *with* and *without* scenarios, the present study concentrates on sewerage and sludge collection activities only. Water supply systems provide an upper limit to these activities.

3.2 Financial analysis

Project investment options - Comparison of treatment types

Three general types of wastewater treatment works have been mutually compared to see which is most economical. These include stabilisation ponds, carrousels and trickling filter types. Units that serve identical quantities of 100,000 person equivalents have been compared over a 20 year period. Figure 3.1 shows how the discounted costs compare for total costs, for investments only and for all operation and maintenance costs.

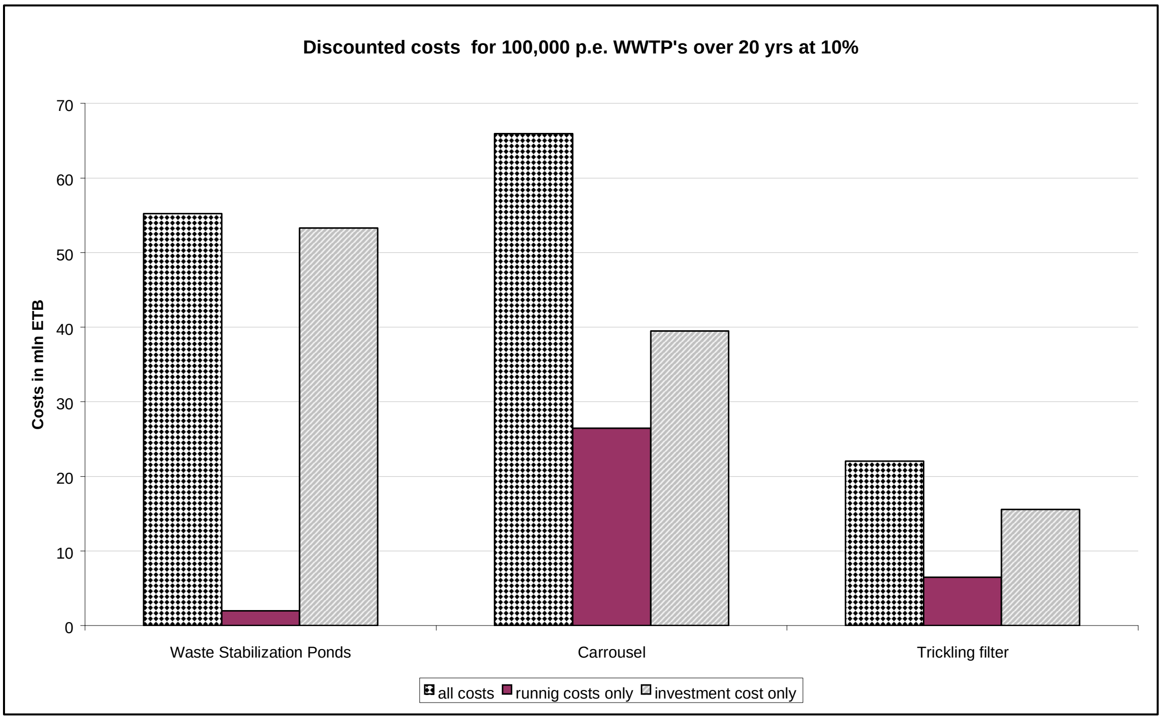

Figure 3.1 Discounted costs (ETB M) for 100,000 p.e. WWTW's 20 yrs, 10%

The graph clearly shows that a trickling filter solution is most economical WWTW when both capital and running costs are taken in to account as a result of the he reduced level of capital costs. Stabilisation ponds have by far the lowest running cost.

The justification for selecting stabilisation ponds rather than the trickling filter are given in Section 4 but can be summarised as:

The waste stabilisation treatment process is the more robust i.e. has a wider tolerance to variation in the incoming hydraulic and pollutant load than the mechanical plants and is thus more suitable for the phase 1 plants. A significant additional advantage is that the ponds produce a high quality effluent with low levels of pathogenic micro-organisms. Effluent from the mechanical plant would require additional treatment to meet the discharge standards for inland waterways.

Project investment options - Main project scenarios

A broad financial analysis has been prepared at project level for three main scenarios each providing the same service level to determine which option will be worked out in detail to be compared to the *without* scenario.

The three *with* scenarios (1-3) are compared to each other and to the *without* scenario (scenario 0) from a costing point of view: investments in new and existing assets, as well as, incremental working capital and operating costs. The analysis concentrates on the comparison of costs since profits are assumed to be equal to all *with* scenarios due to equal service levels provided under these scenarios. Based on the technical options presented before three scenarios have been selected for further analysis:

1. Provision of a sewerage system using waste stabilisation ponds for treatment
2. Provision of a sewerage system using mechanical plant (Carrousels and UASBs)
3. Provision of a sewerage system with the Eastern catchment diverted to Akaki WWTW via a new trunk sewer.

Table 3-1 shows the relevant cost details of the scenarios. It shows that scenario 2 has investments requirements that are about 25% lower than the other two *with* case scenarios. At the same time scenario 2 is characterised by much higher operating costs and hence working capital requirements than scenarios 1 and 3.

Table 3-1 Investment and operating costs comparison of project options (2001 – 2020, ETB millions)

Scenario	Investment new assets	Replacements		Working capital [1]	Operating cost/yr [2]	NPV of all costs [3]
		New assets	Existing			
0	0.0	0.0	19.0	0.0	26.8	155
1	1,829.8	0.0	22.8	2.6	33.8	676
2	1,373.9	52.5	22.8	34.0	186.6	931
3	1,849.8	0.0	22.8	2.6	33.9	691

Note: 1) Incremental working capital requirements for the whole period only; 2) for 2020; 3) NPV at a discount rate of 10%.

Taking all costs in to account scenario 1 is most feasible: NPV is ETB 676 million, 27% lower than #2 and marginally lower than #3. Scenario 0 has by far the lowest costs NPV, only 23% of scenario 1. However, this NPV corresponds to a considerable lower service level. Scenario 1 is hence the preferred scenario (*with* case) and is worked out in detailed comparison with scenario 0 (*without* case).

3.2.1 Project capital investments

The *with* case is characterised by a prolonged period of heavy investments. A summary for project investments is presented in Table 3-2. The table shows investments by catchment, contingencies are included at 10%. The foreign exchange component is 42%. For the *without* case no investment programme is envisaged that will lead to the extension of AAWSA's sanitation operations.

Table 3-2 Project investment summary, *with* case (ETB millions)

Item	Eastern	Akaki	Kaliti	Project
Sewer network	169.1	100.3	304.0	573.3
Treatment works	222.7	284.4	514.1	1,021.2
Sludge [1]	64.7 [3]	0.0	4.2	68.9
Total	456.5	384.7	822.2	1,663.4
Contingencies [2]	45.6	38.5	82.2	166.3
Grand total	502.1	423.2	904.5	1,829.8

Note: 1) collection, treatment and disposal; 2) 10%; 3) all HPVs are included under Eastern to simplify the analysis. Figures may not add up due to rounding.

In the *with* case only the HPV trucks will be replaced once before 2020. They are included in the Eastern catchment, but to be used in Akaki and Kaliti as well. The remaining asset value at the end of the projection period is recovered through residual values: ETB 1,384 million (EUR 180.9 million) for the *with* case and ETB 48 million (EUR 6.3 million) for the *without* case.

Replacement of existing assets is based on the historical purchase value at project start and the percentage that will have to be replaced every year. Percentages of average annual replacement reflect asset life. In general replacement of existing assets is expected to be 25% higher for the *with* case as compared to the *without* case.

The replacement of "sludge works-fleet items" is put to zero as in both *with* and *without* cases AAWSA is expected to let the collection of wet sludge by vacuum trucks be handled by the private sector. Based on these assumptions, replacement of existing assets is expected to amount to fixed amounts of ETB 1.2 million (EUR 0.16 million) per annum for the *with* and ETB 1.0 million (EUR 0.13 million) per annum for the *without* project case throughout the projection period for AAWSA's sanitation activities. (see financial and economic annex Table E3 for all scenarios and all catchments). Funding of the replacement of existing assets is assumed to be arranged for by AAWSA. The foreign exchange component for replacement of fixed assets is estimated at 36-37% for both cases.

The amount fixed in working capital is determined through the level of operations. The incremental changes are included in the cash flow as investments. The residual value is included as a cash inflow in the feasibility analysis. The starting working capital for existing operations is based on the audited annual reports and is initially the same for both cases: 511 days of operating costs, or ETB 13.8 million (EUR 1.80 million), sanitation activities only. It is expected to be gradually reduced from 511 days to 75 days of operating cost by 2007 for the *with* project case (ETB 8.2 million or EUR 1.07 million by 2020). For the *without* case working capital requirements are expected to remain at the present level (511 days). This is expected to result in a slight net reduction of working capital over time to ETB 7.6 million (EUR 0.99 million). Details of working capital requirements are included in the financial and economic annex Tables F1 and F2 for all scenarios and all catchments.

3.2.2 Sludge collection costs and revenues

Sludge collection costs by methods

Costs of sludge collection by high pressure vacuum trucks (HPV) and ordinary vacuum tankers (VAC) have been analysed. The average age of the vehicle and whether or not the cost of capital is included determines cost levels. Cost prices were calculated for fairly new, used and old trucks. Cost prices per trip for age groups are shown in Table 3-3 (see the financial and economic annex for details).

Table 3-3 Sludge collection by 12 m3 HPV or 8 m3 vacuum truck, cost price comparison (ETB/trip)

Truck type	Incl. / excl. capital costs	Fairly new truck (0 – 10 yrs)	Used truck (5 – 15 yrs)	Old truck (10 – 20 yrs)
12 m3 HPV	Including	263	222	189
	Excluding	134	135	138
8 m3 vacuum truck	Including	181	169	153
	Excluding	100	111	122

Cost prices including the effect of aging, becoming lower over time mainly because depreciation and calculated interest are reduced. For a fairly new truck depreciation and interest charges compose 45-50% of the costs, for an old truck this is 21-27%.

A charge of ETB 49 (EUR 6.40) per trip, as prevailing, would cover the costs of fuel and crew only, which is not a sustainable provision of service. Not increasing collection fares would not only mean that provision through new vehicles will become erratic within years, but also that the private companies providing the same service are forced to cannibalise their vehicles and in the medium term withdraw from the business. This would leave the clients as the main losers. Based on above calculations a tariff of at least ETB 155 (EUR 20.25), but preferably ETB 170 (EUR 22.25) seems necessary for septic tanks in, order to operate from a going concern point of view. HPV's incur even more costs and at the same time serve people that are poorer. A tariff subsidy will be required.

Furthermore it is noted that in an economic analysis it makes no difference whether trucks are bought, donated or acquired otherwise, capital costs have to be included in the cost price at all times.

A cost price based on a used truck including the costs of capital employed, i.e. ETB 169/trip (EUR 22.10), seems the most reasonable starting point for determining collection tariffs in the long run. Taking this tariff as starting point, a differentiation according to consumer categories is possible. In this way, 'poor' clients could still pay (much) less than what institutions would pay for the same service.

Sludge collection costs and revenues for project scenarios

In the C-section Tables (all scenarios all catchments) of the financial and economic annex sludge collection costs and revenues are treated in detail. It has been assumed that AAWSA will not replace its VAC fleet and leave collection to others (*with* and *without* cases). For collection by HPV trucks the situation is the other way around: only AAWSA acquires a number of HPVs (*with* cases only).

The number of people using pit latrines (PL) or septic tanks (ST) determines the quantity of sludge produced. PLs are assumed equal in *with* / *without* scenarios. STs vary by case: households that remain unconnected to the sewer system in the *without* case as compared to the *with* case use STs (see financial and economic annex Tables C5 and C6 for all scenarios and all catchments). The number of STs and PLs to be emptied each year are shown in Table 3-4 (financial and economic annex Table C19).

Table 3-4 Septic tanks and pit latrines emptied every year (*with* / *without* case, thousands/year)

Tank/pit	2001	2005	2010	2020
	with/without	***with/without***	***with/without***	***with/without***
Septic tanks	13.1 / 13.1	23.1 / 25.7	35.5 / 42.6	59.8 / 99.7
Pit latrine / vacuum truck	34.2 / 34.2	14.0 / 36.5	20.9 / 37.9	2.0 / 32.4
Pit latrine / HPV	0 / 0	5.6 / 0.0	4.3 / 0.0	8.4 / 0.0
Total	47.3 / 47.3	42.7 / 62.2	60.7 / 80.6	70.1 / 132.0

Note: Figures may not add up due to rounding.

Truck trips by type evolves as in Table 3-5. The main expansion of the HPV fleet is planned for 2014. Total number of trucks operated by 2020 is expected to be about 200 for the *without* case (almost all 6-8 m^3 VACs) and 112 for the *with* case (18 HPVs, the remainder 6-8 m^3 VACs). Fleet size in the *without* case is bigger than in the *with* case because the sludge volume is bigger, while collection is less effective when not using HPVs. For modelling purposes all HPVs have been placed in the Eastern catchment, usage is foreseen in all catchments by share of the number of PLs. See financial and economic annex Table C10 and C11 for all scenarios and all catchments.

Table 3-5 Sludge collection trips by truck type regardless of ownership (*with* / *without* case, thousands of trips/year)

Truck type	2001	2005	2010	2020
	With/without	***with/without***	***with/without***	***with/without***
3 m3 vacuum	3.6 / 3.6	3.2 / 3.2	1.4 / 1.4	0 / 0
6-8 m3 vacuum	43.7 / 43.7	33.8 / 59.0	55.0 / 79.2	61.7 / 132.0
12 m3 HPV	0 / 0	5.6 / 0.0	4.3 / 0.0	8.4 / 0.0
16 m3 vacuum	0.5 / 0.5	0.5 / 0.5	0.2 / 0.2	0 / 0
Total	47.8 / 47.8	43.2 / 62.7	60.9 / 80.8	70.1 / 132.1

Note: Figures may not add up due to rounding.

The tariff modification proposals by Ernst and Young has been applied. Per 2002 AAWSA collection tariffs for domestic STs / PLs rise from ETB 49 to ETB 69 per trip, for commercial entities from ETB 130 (EUR 17) to ETB 196 (EUR 25.65). For commercial providers tariffs remain the same or increase to modified AAWSA levels, hence private STs will remain at ETB 150 and commercial will increase to ETB 196. A tariff of twice the new ST tariff, viz. ETB 138 (EUR 18.05), has been established for emptying by HPV. A higher tariff is reasonable since an HPV empties much deeper than ordinary VACs. The deposit fee at AAWSA's ponds of ETB 15 (EUR 2.00) for third providers is maintained. See financial and economic annex Table General-C12 for full details.

Table 3-6 presents revenues and collection costs for AAWSA and others. The figures show that the sector as a whole is expected to make a small loss in the coming two decades. AAWSA's operations show a small profit, mainly because of the deposit fee imposed on other providers. Was AAWSA to operate the fleet itself, it would show a small loss in the long run. A higher tariff is therefore required. Details are included in financial and economic annex Tables C14, C15 and C17 for all scenarios and all catchments.

Table 3-6 Sludge collection revenues and costs, AAWSA and others (*with* / *without* case, ETB millions/year)

Provider	Item	2001	2005	2010	2020
		with/without	***with/without***	***with/without***	***with/without***
AAWSA	Revenues	1.6 / 1.6	2.9 / 1.7	2.3 / 1.5	3.2 / 2.0
	Costs	4.4 / 4.4	3.7 / 2.2	1.8 / 0.9	1.7 / 0.0
	Net profit	-2.8 / -2.8	-0.8 / -0.5	0.5 / 0.7	1.5 / 2.0
Others	Revenues	3.3 / 3.3	3.8 / 7.6	8.0 / 11.7	9.8 / 20.7
	Costs	3.6 / 3.6	4.0 / 8.2	8.4 / 12.4	10.2 / 21.8
	Net profit	-0.3 / -0.3	-0.2 / -0.5	-0.5 / -0.8	-0.4 / -1.1
All	Revenues	4.9 / 4.9	6.7 / 9.3	10.3 / 13.2	13.0 / 22.7
	Costs	8.1 / 8.1	7.7 / 10.3	10.3 / 13.3	11.9 / 21.8
	Net profit	-3.1 / -3.1	-1.0 / -1.0	0.0 / -0.1	1.1 / 0.9

Note: Figures may not add up due to rounding.

Sewer and sludge connection costs to customers
Customers bear investment and maintenance costs to sewer or sludge infrastructure constructed around their dwellings (house connections to the sewer network and construction of PL / ST). These costs are summarised in Table 3-7 (see annex Table General-D1).

Table 3-7 Sewer and sludge connection and maintenance costs for customers (ETB)

Type	Subtype	Construction cost	Annual maintenance cost
Sewer connection	Apartment	1,800	36
	Residence	600	12
	Small industries	600	12
	Others[1)]	1,800	36
Septic tank	-	13,500	270
Pit latrine	-	4,650	93

Note: 1) including main industries, government buildings, hospitals, commercial and hotels.

Maintenance is taken as 2.0% of construction cost, reconstruction after 30 years as 80% of the original cost. The customer born costs are not included in the financial analysis; they do not pertain to the feasibility of AAWSA. They do appear in the economic analysis, as they are costs to the society. Further details are included in the section on economic cash flow and in the financial and economic annexes D3, D4 and D6 for all scenarios and all catchments, for financial and economic analyses.

Investments by customers in new connections amounts in the long run to ETB 144 million (EUR 18.82 million) p.a. for the *with* case and ETB 274 million p.a. for the *without* case. Replacement of existing connections amounts in the long run to ETB 37 million (EUR 4.84 million) p.a. for both cases (see financial and economic annexes Table D3 and D4 for all scenarios and all catchments).

3.2.3 Operating costs and revenues of AAWSA for sanitation activities

Sewerage and sludge works operating costs

Operating costs of existing assets are based on audited annual reports and remain unchanged. Fixed percentages over investment values have been used to for new assets: for sewer network and treatment plants; 1.5%, for buildings, 2.5%, for HPVs 12% and 3.0% for contingencies. An overview is presented in Table 3-8. Details are included in the financial and economic annex Table F1 for all scenarios and all catchments.

Table 3-8 Sanitation related annual operating cost summary for AAWSA (ETB millions)

Item		2001	2005	2010	2020
		with/without	***with/without***	***with/without***	***with/without***
New assets	Sewerage	0 / 0	2.4 / 0.0	8.9 / 0.0	21.7 / 0.0
	Other	0 / 0	3.3 / 0.0	5.1 / 0.0	12.9 / 0.0
Existing assets	Sewerage	2.4 / 2.4	2.4 / 2.4	2.4 / 2.4	2.4 / 2.4
	Sludge	7.4 / 7.4	5.2 / 5.2	3.9 / 3.9	3.0 / 3.0
Total		9.8 / 9.8	13.2 / 7.6	20.3 / 6.3	40.0 / 5.4

Note: Figures may not add up due to rounding.

Revenues from sanitation activities

Revenues are composed of wastewater and sludge collection incomes. The first will be detailed below. The latter has been treated before, only relevant data will be repeated here. Wastewater income is based on drinking water sold, regardless of the provision of sewerage service and is equal in both *with* and *without* case. The tariff proposal approved by the municipal authorities (Tariff proposal, Ernst & Young, 30.10.2000) has been applied. Table 3-9 depicts the position on wastewater tariffs (see financial and economic annex Table A12 for all scenarios and all catchments). Different tariffs exist for different categories of users, viz. households, industries, hotels etc. Nevertheless, clients seem all allocated to the household category only. Users of public fountains are not charged for sewerage services.

Table 3-9 Wastewater tariff structure, all consumers except public fountains (ETB/m^3)

Tariff slab (m^3/month)	**2001 (historical)**	**2002**	**2003**	**2004**	**2005**	**2006+**
#1: 0 – 7	0.00	0.00	0.00	0.00	0.00	0.00
#2: 7-20	0.08	0.35	0.40	0.45	0.50	0.55
#3: >20	0.17	0.35	0.40	0.45	0.50	0.55

Note: Tariff slab refers to the consumption of drinking water.

Table 3-10 shows details on wastewater income development, for more details see financial and economic annex Tables A14 and A15 for all scenarios and all catchments.

Table 3-10 Wastewater income developments

Item		2001	2005	2010	2020
Drinking water sold (million m^3/month)		2.8	3.6	5.1	11.6
Wastewater incomes (ETB million)	Domestic	0.6	5.6	10.4	31.5
	Non-domestic	3.3	11.6	16.2	30.7
	Total	3.9	17.2	26.6	62.2
Sewerage service related [1)]	*With* case	3%	18%	28%	68%
	Without case	3%	3%	4%	3%

Note: 1) sewerage income related to sewerage services provided.

Income from sludge collection is less important than sewerage income. Income to AAWSA from sludge collection has been calculated before, therefore only a summary of revenues is presented in Table 3-11.

Table 3-11 Summary of income developments for AAWSA (ETB million)

Item	2001	2005	2010	2020
Watewater	3.9 / 3.9	17.2 / 17.2	26.6 / 26.6	62.2 / 62.2
Sludge collection	1.6 / 1.6	2.9 / 1.7	2.3 / 1.5	3.2 / 2.0
Total	5.6 / 5.6	20.1 / 18.9	29.0 / 28.2	65.5 / 64.2

Note: Figures may not add up due to rounding.

3.2.4 Financial project cash flow before funding

Financial project cash flows have been composed and NPV / IRR calculated for the comparison of the *with* / *without* case. Both cases are characterised by increasing costs, rather than increasing revenues. This means that the autonomous IRR / NPV, taken over the net cash flow of a project case only, will not meet the IRR / NPV standard. Only in the comparison of the *with* / *without* case cost savings appear, regarded as project benefits. This is common practice in public infrastructure projects, viz. roads, railways and ports. Generally, the comparison only shows savings in later project years, as the earlier years are characterised by (high) investments.

In particular, wastewater projects are characterised by many indirect costs and benefits. With a high number of benefits outside the direct control of AAWSA this renders the feasibility for AAWSA as an entity as difficult to attain. Moreover, direct revenues from the sewerage tariff are also realised in the *without* case due to their link to the supply of drinking water. Making the *without* case from that viewpoint more financially beneficial than the *with* case since it gives AAWSA the revenues without <u>any</u> investment.

To overcome this paradoxical situation, data are presented showing feasibility on IRR / NPV grounds on different levels. Viz. firstly for AAWSA as an entity, then for AAWSA with the indirect costs and benefits added. (health cost, forgone land cost, costs to customers, sludge collection cost by others and real estate developments, see financial and economic annex Table J1 for all catchments and scenarios).

It should be kept in mind that the feasibility of a project such as the present one is primarily judged by the economic cash flow not the financial cash flow. The financial cash flow is a prelude to the former. The financial cash flow serves to determine funding requirements for the project and the implementing agency. When sufficient funding is available, the agency will not have a financial breakdown due to the project. Table 3-12 shows the results of the analysis of the financial cash flows before finance and tax. More details are included in financial and economic annex Table J1 for all catchments and scenarios.

Table 3-12 Financial cash flows analysis for catchments and project (NPV in ETB million, at a discount rate of 10%)

LINE	**Item**		**Eastern**		**Akaki**		**Kaliti**		**Project**	
1			***with***	***without***	***with***	***without***	***with***	***without***	***With***	***without***
2	Net AAWSA cash flow									
3		NPV	-223	+11	-95	+30	-108	+93	-426	+134
4		IRR	-6.3%	19.9%	-2.3%	1,354%	1.5%	65.2%	-2.2%	56.9%
5		# def. Years[2)]	19	19	17	1	17	1	20	1
6	Net AAWSA cash flow plus added items									
7		NPV	-542	-465	-356	-332	-1,542	-1,652	-2440	-2449
8		IRR	-7.5%	-9.4%	-6.7%	NA.[1)]	NA.[1)]	NA.[1)]	NA.[1)]	NA.[1)]
9	Comparison *with* to *without* for net AAWSA cash flow plus added items.									
10		NPV	-76		-24		+110		+9	
11		IRR	1.9%		3.5%		3,758%		10.5%	

Note: 1) NA. = not available, mathematically impossible to derive. 2) # def. = number of deficit years. Figures may not add up due to rounding.

A few technical remarks can be made with respect to Table 1.17. The IRR is derived through trial-and-error. By mathematical law, the IRR can have multiple solutions or no solution at all. This occurs in particular when the net cash flow over multiple years changes from positive to negative frequently, when a cash flow stream starts with a positive value or when the flow remains negative. The issues described apply to the present analysis.

Table 3-12 shows that from a financial point of view it is most efficient for AAWSA not to implement the project. This renders an autonomous IRR of 57% on project level (line 4, last column), caused by the wastewater revenue flows. Lines 10-11 show the NPV / IRR for the comparison of *with* to *without* cases for individual catchments and the project as a whole. The project as a whole shows feasible from a financial point of view at an IRR of 10.5% (NPV of ETB 9 million).

The above information is used for three purposes. First, based on the above data a provisional project funding has been drawn up for discussion purposes. Second the financial projections and the funding data are used to prepare financial statements for the sewerage and sludge related activities of AAWSA. Finally, the financial cash flow data are converted in economic values to perform an economic evaluation.

3.2.5 Project funding

For the *without* case no loan or grant funding is available, no further cash flow deficits are foreseen.
A provisional funding has been prepared for the *with* case such that deficits before finance as well charges from loans are covered (tax exemption is assumed). Funding consists of two types. First, all project investments in new assets are financed through loans / grants. Secondly, remaining deficits are covered by other means. Loan / grant funding schemes are prepared on a per catchment basis (see financial and economic annex Table J2 for all catchments and scenarios).

Grant finance has been assumed for 2002 – 2005, for ETB 359.4 million (EUR 46.98 million). No charges have been included for grant financing. Loan funding has been assumed to take place in three batches for planning purposes:

- First loan batch: 2006 – 2010;
- Second loan batch: 2011 – 2015; and
- Third loan batch: 2016 – 2020.

Each loan batch is followed by a two year grace period. Repayment takes place in forty equal annual instalments; interest is 2.5% p.a with no commission. The total loan amount is ETB 1,470 million (EUR 192.16 million) for 2006 – 2020.

A like in other countries sanitation is not extremely profitable. Loan repayments are expected to cause cash flow deficits in 2013 - 2019 adding up to ETB 145.6 million (EUR 19.03 million) for which funding needs to be found, preferably without further charges attached to it. Two options have been analysed in detail. One option is to assume funding to be obtained from the municipal or regional government. This would mean a subvention or a participation in AAWSA. A second option is to cover the remaining deficits by postponing loan repayments through postponing loan disbursements. If grant finance can be found for the investment amounts of 2006 – 2007 and 35% of the amount for 2008 (ETB 275.4 million, EUR 36.00 million), then no further deficits are expected to occur until the end of the project period.

3.2.6 Financial statement projections

Sewerage & sludge activities
A summary overview of the projected profit & loss account, the flow of funds and the balance sheet is presented (Table 3-13). More detailed projections are included in financial and economic annex Tables K1, K2 and K3 for all scenarios.

Table 3-13 Profit & loss account projections for sewerage and sludge activities of AAWSA (ETB millions)

		2001		2005		2010		2020	
		with	***without***	***with***	***without***	***with***	***without***	***with***	***without***
	Wastewater	3.9	3.9	17.2	17.2	26.6	26.6	62.2	62.2
	Sludge	1.6	1.6	2.9	1.7	2.3	1.5	3.2	2.0
Income		5.6	5.6	20.1	18.9	29.0	28.2	65.5	64.2
	Sewer & TP	2.4	2.4	4.8	2.4	11.3	2.4	24.1	2.4
	Sludge	11.9	11.9	9.7	7.3	7.0	4.7	10.0	3.0
	Other	0.0	0.0	0.9	0.0	2.7	0.0	5.9	0.0
Operating exp.		14.3	14.3	15.4	9.7	21.1	7.1	40.0	5.4
Operating profit		-8.7	-8.7	4.7	9.2	7.9	21.1	25.5	58.8
	Depreciation	3.7	3.7	12.4	3.8	27.9	2.0	58.1	2.3
	Interest	0.0	0.0	0.0	0.0	9.5	0.0	32.5	0.0
Net profit		-12.5	-12.5	-7.6	5.3	-29.5	19.1	-65.2	56.5

Note: Figures may not add up due to rounding.

For all financial statements it holds true that the *without* case shows better results than the *with* case. This is due to the revenues from wastewater being equal in both cases.

Table 3-14 Flow of funds projections for sewerage and sludge activities of AAWSA (ETB millions)

		2001		2005		2010		2020	
		with	***without***	***with***	***without***	***With***	***without***	***with***	***without***
Income									
	CF/operat.ns[1)]	1.2[2)]	1.2[2)]	4.7	9.2	-1.6	21.1	-7.0	58.8
	Financing								
	Grants	0.0	0.0	147.1	0.0	0.0	0.0	0.0	0.0
	Loan disbursements	0.0	0.0	0.0	0.0	50.7	0.0	139.6	0.0
Total income		1.2	1.2	151.8	9.2	49.1	21.1	132.6	58.8
Expenditure									
	Investments	1.2	1.2	148.3	1.0	51.9	1.0	140.8	1.0
	Working Capital	0.0	0.0	-0.3	-0.4	-0.0	-0.3	0.5	-0.0
	Loan repayments	0.0	0.0	0.0	0.0	0.0	0.0	20.2	0.0
Total expenditure		1.2	1.2	148.0	0.6	51.9	0.7	161.5	1.0
Surplus/deficit		0.0	0.0	3.8	8.6	-2.8	20.4	-28.9	57.8

Note: 1) CF/operations = cash flow from operations; 2) in 2001, the Flow of Funds of financial and economic annex Table K2, a shortfall of ETB 9.9 million is predicted, however, neither the shortfall nor the breakdown of AAWSA has occurred, therefore the shortfall is merged with the surplus on cash flow from operations. Figures may not add up due to rounding.

Table 3-15 Balance sheet projections for sewerage and sludge activities of AAWSA (ETB millions)

		2001		2005		2010		2020	
		With	***without***	***with***	***without***	***With***	***without***	***With***	***without***
Assets									
	Fixed assets	77.5	77.5	415.3	66.0	706.2	59.4	1,383.7	47.8
	Net curr.assets	13.8	13.8	4.3	10.6	4.2	8.8	8.2	7.8
	Cash balance	0.0	0.0	19.5	18.4	13.2	100.2	-23.0	485.3
Total assets		91.3	91.3	439.0	95.1	723.6	168.4	1,368.9	540.7
Liabilities									
	Equity (assets)	93.8	93.8	93.8	93.8	93.8	93.8	93.8	93.8
	Grants	9.9	9.7	369.3	9.7	369.3	9.7	514.9	9.7
	Loans	0.0	0.0	0.0	0.0	403.5	0.0	1,359.3	0.0
	Ret.d earn.gs[1)]	-12.5	-12.5	-24.1	-8.4	-143.1	64.8	-599.1	437.2
Total liabilities		91.3	91.3	439.0	95.1	723.6	168.4	1,368.9	540.7

Note: 1) ret.d earn.gs = retained earnings. Figures may not add up due to rounding.

In the *with* case, the net value in fixed assets grows eighteen fold over the years, the *without* case shows a decrease by almost 40% over time. Although the financial statements for the *with* case do not look like a very profitable organisation, they still show a viable organisation. Sanitation activities in developing countries (including western Europe) all over the world have been only marginally feasible at the start. Affordability with the public is low whereas investments are high and take a long time to mature.

All AAWSA's activities

On request of AAWSA, the consultant has prepared financial statement projections for AAWSA as an entity merged from the financial statement projections in the Tariff Study of 2000 and from the financial statement projections for AAWSA's sanitation activities in the present Sanitation Masterplan. These projections were prepared for the *with* project case only. Merged projections have been limited in time to the shorter of the two (see financial and economic annex Table "E&Y MERGE" D1, D2 and D3).

Table 3-16 Merged Profit & loss account projections for AAWSA as an entity (ETB millions)

		2001	2005	2010
		With	***With***	***With***
Income		83.9	193.3	320.9
Operating expenses		96.2	123.0	163.4
Operating profit		-12.3	70.4	157.6
	Depreciation	24.7	68.6	91.6
	Interest	7.0	17.6	31.8
Net profit		-44.1	-15.9	34.2

Note: Figures may not add up due to rounding.

Since water supply figures show a more flourishing picture than sanitation data. The *with* case for the merged data shows equally better. Income levels are expected to be four times higher for water supply than for sanitation activities. The accumulated losses are expected to be resolved slowly over time.

Table 3-17 Merged Flow of funds projections for AAWSA as an entity (ETB millions)

		2001	2005	2010
		With	***With***	***With***
Income				
	Cash flow/operations[1)]	5.4[2)]	89.6	172.9
	Financing			
	Grants	86.2	214.1	0.0
	Net loans	5.9	154.9	-10.9
Total income		97.5	458.6	161.9
Expenditure				
	Investments	367.0	413.9	51.9
	Working capital	-321.3	22.2	-15.7
Total expenditure		45.7	436.1	36.2
Surplus/deficit		51.8	22.5	125.8

Note: 1) CF/operations = cash flow from operations; 2) in 2001, the Flow of Funds of financial and economic annex, Table K2, a theoretical shortfall of ETB 9.9 million is predicted, neither the shortfall nor the breakdown of AAWSA has occurred, therefore the shortfall is merged with the surplus on cash flow from operations. Figures may not add up due to rounding.

Table 3-18 Merged Balance sheet projections for AAWSA as an entity (ETB millions)

		2001	2005	2010
		with	***With***	***With***
Assets				
	Fixed assets	916.3	1,898.9	2,267.4
	Net curr.assets	371.3	288.9	340.8
	Cash balance	0.0	19.5	13.2
Total assets		1,287.6	2,207.3	2,621.4
Liabilities				
	Equity (assets)	105.3	105.3	105.3
	Grants	999.4	1,626.3	1,626.3
	Loans	395.0	753.5	1,219.9
	Retained earnings	-212.2	-278.0	-330.1
Total liabilities		1,287.6	2,207.3	2,621.4

Note: Figures may not add up due to rounding.

The merged balance sheet shows an AAWSA with high values (ETB 2.27 billion by 2010) in fixed assets and high amounts in outstanding long term loans (ETB 1.22 billion). It should be noted that use of merged financial statements should be done with due reservation.

3.3 Economic analysis

To make an economic analysis therefore two steps have been made:

- The consequences of the project for other actors and the society as a whole have been added to the financial analysis;
- The values used in the analysis have been converted from financial to economic.

The cost and benefit items for third parties with a direct impact on the project include:

- Sludge collection activities by private service providers;
- Sludge and sewer related costs to households and entities;
- Health effects with the general public;
- The costs of forgone land use due to the construction of treatment plants; and
- The impact on the value of real estate in the region.

All items have been converted to economic values using National Economic Parameters and Conversion Factors for Ethiopia (MEDaC, 1998). In general conversion factors amount to 0.80 – 0.90 (see financial and economic annex Table General-A4).

Health benefits
The difference in sanitation related health costs between *with* and *without* cases, treated as a project benefit, is calculated in economic terms at ETB 2.5 million (EUR 0.33 million) for 2005 increasing to ETB 7.1 million (EUR 0.93 million) and ETB 37.4 million (EUR 4.89 million) per annum in respectively 2010 and 2020 (see annex Table G3 for all cases and analyses).

Forgone land use
Capitalized over time (discount rate 10%) the forgone added value realized on land lost for agriculture is ETB 7.9 million (EUR 1.03 million) for the preferred scenario 1 (680 ha). The effects of forgone land use are marginal for the project.

Real estate value development
Value developments have been estimated conservatively, increasing once at 0.5% five years after connection to the sewer network (*with* and *without* cases, annex Table I1 for all cases and all analyses). The *without* case reflects a situation where sewer connections are much more scattered. This overstates the value development due to connections slightly. The effect of the value increase on the project are limited since they take effect only after the fifth project year (2006).

Other benefits
A number of other benefits exist, but remain largely intangible. Although it is obvious that their impacts will influence the project in a positive way, further studies would be needed to estimate the value of such benefits for the general public. Benefits considered are:

- Time and cost savings from improved sewerage and sludge collection with AAWSA clientele;
- Increased productivity of water using industries;
- Improved quality of life and general happiness for citizens;
- Lower clean water treatment costs downstream;
- Recreational options in the region and along the river(s);
- Increased tourism; and
- Improved air quality and reduced odour nuisance.

Economic cash flow

In the financial and economic annexes Tables presenting the same values for financial and economic analyses have identical layouts, they differ in that they have the words ***ECONOMIC ANALYSIS*** written in bold italic capitals over the calendar bar. In addition, in the spreadsheet file financial values have a sky-blue background colour, whereas economic values have a sand-brown background colour.

Only summarised economic cash flows are presented (Table 3-19). Wastewater revenues for which no service is rendered (97% out of 100%)are valued as transfer payments. This will decrease over time to 32% in 2020 in the *with* case. Full quantitative details for economic cash flows are included in economic annex Table J1 (all scenarios and all catchments).

Table 3-19 Economic cash flows analysis for catchments and project (NPV in ETB million, at a discount rate of 10%)

LINE	**Item**		**Eastern**		**Akaki**		**Kaliti**		**Project**	
1			***with***	***without***	***With***	***Without***	***with***	***without***	***With***	***without***
2	Net economic cash flow									
3		NPV	-458	-423	-306	-308	-1,383	-1,540	-2,148	-2,271
4		IRR	-6.6%	-10.8	-6.1%	-10.5%	-9.9%	-13.5%	-8.4%	-12.3%
5	Comparison *with* to *without* for net economic cash flow									
6		NPV	-35		+3		+156		+128	
7		IRR	6.4%		10.6%		3869%		16.5%	

Note: Figures may not add up due to rounding.

Table 3-19 clearly shows the feasibility of the project on economic grounds at an economic IRR of 16.5%. On a per catchment basis, Kaliti and Akaki are feasible, whereas Eastern is marginally feasible with an IRR bigger than zero but below the 10% cut off rate.

3.4 Sensitivity tests

Results of sensitivity tests are represented mainly through changes in the scores of compared (*with* to *without* case) IRR / NPV values.

The effects of modifications to the exchange rate and to the investment amounts are strongly interlinked since a substantial proportion of the project investments are payable in foreign exchange. For any increase in investments by 10%, 6.2% is attributed to treatment works and 3.3% to sewer network. An increase in investments of 10% causes the grand total of the cost estimate to rise from ETB 1,916.0 million (EUR 250.46 million) to ETB 2,107.6 million (EUR 275.50 million).

Modifications in foreign exchange rates can be treated as changes in investments. Foreign exchange shares of treatment works, sewer network, HPVs and buildings and other items are 30%, 60%, 100% and 30% respectively. As a result, a deterioration of the exchange rate of 10% between ETB and major currencies (EUR and USD) will cause the specific item to increase with 10% of the respective foreign exchange component. The cost estimate as a whole is expected to increase by 4.1% in ETB-terms after a devaluation of the ETB by 10%.

Impacts of increases in project investment are measured through increasing the contingency percentages. Results on the financial and economic IRRs and NPVs are presented in Table 3-20. The table shows that the project remains feasible from an economic point of view at an increase in contingencies of 20%.

Table 3-20 Sensitivity of variations in contingencies on investments at project level

Case	Contingencies	Cost Estimate		Financial		Economic	
		ETB m	EUR m	IRR	NPV	IRR	NPV
-10%	0%	1,741.2	227.69	14.5%	73	20.2%	176
Base	10%	1,916.0	250.46	10.5%	10	16.5%	24
+10%	20%	2,090.2	273.23	7.1%	-54	13.4%	72
+20%	30%	2,264.4	296.00	4.1%	-118	10.9%	19

Increases in working capital have been tested. At present AAWSA is operating with around 511 days worth of operating expenses. Three sensitivity cases have been tested:

- Base case: working capital new assets = 75 days, existing assets becomes 75 days (2007+);
- " 150 days": new assets = 150 days, existing assets becomes 150 days (2005+);
- "511 days": new assets = 511 days.

Table 3-21 shows that the different working capital alternatives have only a marginal effect on financial and economic IRR and NPV.

Table 3-21 Sensitivity on variations in working capital requirements at project level

Case	Working capital		Financial		Economic	
	ETB m	EUR m	IRR	NPV	IRR	NPV
Base = 75 days	3.5	1.07	10.5%	10	16.5%	124
150 days	16.4	2.15	10.4%	8	16.3%	122
511 days	56.0	7.32	9.8%	-3	15.6%	113

The interest rate for the loans under the provisional project funding is 2.5% p.a. in the base case. Any increase in interest causes a cost increase of about ETB 95 million (EUR 12.42 million) per percent point. Changes in interest rates have no effect on economic parameters since interest payments are valued as transfer payments (conversion factor of 0.0).

A sensitivity analysis has been made of the indirect project effects concerning health, forgone land use and the development of real estate values. Effects have been tested in a combined effect only: the base case has been compared to increased effects of 10% and 20%. An increased effect of 10% causes the economic IRR to increase by 0.6% point.

Table 3-22 Sensitivity on combined health, forgone land use and real estate effects at project level

Item	Unit	Base	+10%	+20%
Health costs	ETB/case	152.50	167.75	183.00
Forgone land use	ETB/ha/year	500	550	600
Real estate value	Value increase	0.50 – 1.00 %	0.55 – 1.10 %	0.60 – 1.10 %
Impacts				
Financial IRR / NPV		10.5% / 9	11.3% / 24	12.1% / 39
Economic IRR / NPV		16.5% / 124	17.1% / 138	17.7% / 152

Further real increases in tariffs by 10% and 20% have been investigated for wastewater and sludge collection. The development of tariffs under various sensitivity tests is presented in Table 3-23.

Table 3-23 Sensitivity on real tariff increases at project level

Item	Unit	Base	+10%	+20%
Wastewater	ETB/m^3	0.55 (2006+)	0.60 (2007+)	0.65 (2008+)
Sludge collection				
Private ST by AAWSA	ETB	69 (2002+)	76 (2003+)	83 (2004+)
Commercial ST by AAWSA	ETB	196 (2002+)	216 (2003+)	235 (2004+)
PL by VAC	ETB	69 (2002+)	76 (2003+)	83 (2004+)
PL by HPV	ETB	138 (2002+)	152 (2003+)	166 (2004+)
Private ST by non-AAWSA	ETB	150 (2002+)	165 (2003+)	180 (2004+)
Commercial ST non-AAWSA	ETB	196 (2002+)	216 (2003+)	235 (2004+)
Impacts				
Financial IRR / NPV		10.5% / 9.0	10.6% / 10.0	10.5% / 9.0
Economic IRR / NPV		16.5% / 124	16.7% / 129	16.7% / 134

Note: PL = pit latrine; ST = septic tank.

The project shows a relatively low sensitivity for changes in tariffs. This is because wastewater tariffs are collected anyway, regardless of connection to the sewer network.

The effect of a delay in implementation of the project works in beneficial to AAWSA as the payment of loan interest and the increase in operational costs are delayed increased the profits of AAWSA.

In general, the project is said to have passed the sensitivity tests successfully.

4 SUMMARY OF RECOMMENDATIONS

This section summarised the recommendations contained in this Masterplan. The figures in brackets refer to the relevant section of Main Report.

4.1 Sewerage

Recommendation	Section
• Secondary sewers and laterals must be constructed at the same time as their associated trunk sewers	2.9.2
• New developments should be required to construct a sewerage system with a temporary treatment plant.	2.9.3
• All polluting industries and water consumers using more than $30m^3$/month system to be connected to the sewers, where available.	2.8
• Pollutant loads from industries to be consented and pre-treatment undertaken where required.	4.2.4
• Manhole covers to no longer be ventilated. Vent pipes to be installed where necessary	2.8
• Concrete pipes to be used as standard trunk sewers.	2.7.3
• Lateral sewers to be provided to allow Y-connections and stub sewers to be located at all property boundaries.	2.9.2
• Sources of groundwater infiltration to be identified and eliminated.	2.8
• The connection of storm water and roof drains to be identified and removed.	2.9.1
• AAWSA to investigate the use of private/public partnerships to provide sewerage in new developments	2.9.3
• New houses requesting an in-house water supply and with a sewer within 10m must connect to the sewer	2.9.3

4.2 Sludge collection, treatment and disposal

Recommendation	Section
• Dry pit latrines should be emptied using a high performance vacuum trunk and the dry sludge disposed of to a sanitary landfill.	3.1
• Injection of septic tank sludge in to the Kaliti sewer to be undertaken as a pilot project	3.7
• Existing vacuum trucks to only de-sludge septic tanks.	3.2
• New improved screens to be provided at the drying beds and sludge lagoons.	3.5.1
• The pilot forestry scheme to be initiated with immediate effect.	3.5.6
• The use of pour flush latrines to be encouraged, as debris cannot then be added to the dry pits.	3.1
• New sanitary landfills to be constructed at Kaliti and Kotebe treatment work sites.	3.6
• One high power vacuum tank to be purchased as a pilot project.	3.1
• New dry pit latrines to be constructed with lined walls and base	3.1

4.3 Wastewater treatment plants

Recommendation	Section
• First phase of each wastewater treatment plant to be wastewater stabilisation ponds.	4.4.8

• A pilot trickling filter plant to be constructed to assess the suitability of this type of plant for use in Ethiopia.	4.4.8
• Proposals to de-sludge the facultative ponds in Kaliti to be formulated.	3.4.1
• Flows and pollutant loads to be regularly monitored at each works to allow proactive extension of each works	4.5.4

4.4 Institutional

	Section
▪ Implementation of the Environmental Monitoring Unit (EMU).	5.2
▪ Where sewer laterals are provided connections to be undertaken by householder with connection inspected and approved by AAWSA.	2.9.3
▪ Each consumer connected to the sewerage system to be registered.	2.9.1
▪ The enforced connection to sewer by major water consumers to be implemented by a Directive from the Board.	2.8
▪ A Directive from the Board to insist on new developments being sewered.	2.9.3
▪ Staff recruitment and training to be coordinated with new works construction.	5.1
▪ AAWSA to implement the collection of “record drawings” with a locational manhole numbering system	2.10

4.5 Financial

	Section
▪ A flat rate fee to be charged to those consumers connected to the sewerage system.	2.9.2
▪ Differentiated tariffs in sludge collection to allow for affordability among the poor and the better off.	7.3.4
▪ For institutional, commercial, government and similar bodies, the charge for septic tank and dry pit latrine emptying should cover all costs including overheads.	7.3.4
▪ Industries to be charged on both a volume and pollutant load (sewage strength) basis.	7.3.4
▪ Reduce working capital to 75 days.	7.3.3
▪ In association with financial institutions a revolving fund to be set up to provide loans for the cost of connection to the public sewers	2.9.2

4.6 Implementation

The following implementation schedule is recommended for inclusion in the Project Dossier;

Kaliti: Scheme 1

- Construct Kaliti stage 1 secondary sewers and laterals.
- Sewer rehabilitation, sludge disposal and pilot sludge injection.
- Extend Kaliti waste stabilization ponds to 180,000 population equivalent by using anaerobic ponds.
- Construct Kaliti phase 1 of stage 2 sewers:
    - Mekanisa/Old Airport;
    - Bole Tele-22 Round;
    - Rwanda;

Kaliti: Scheme 2

- Construction Akaki II phase 1 WWTW (100,000 p.e.).
- Construction of Kaliti to Akaki Trunk sewer.
- Construct Kaliti phase 2 of stage 2 sewers:
  - Lafto;
  - Meskel Square- Gotera;
  - Post office-AAWSA;

Eastern: Scheme 3

(Recommended Interbeton interventions)

- Preparation sanitary landfill, access road and bridges, forestry pilot project and purchase 1 HP vacuum truck.
- Construct new waste stabilisation ponds in the Eastern Catchment for a capacity of 100,000 population equivalent.
- Construct Eastern stage 1 sewers:
  - Eastern terminal trunk sewer;
  - ILRI interceptor and Laterals;
  - Kotebe Interceptor and laterals;
  - CMC interceptor and laterals.

Eastern: Scheme 4

(Recommended other interventions)

- Construct Eastern stage 1 and 2 sewers:
  - East Bole interceptor and laterals;
  - Gergi interceptor and laterals;
  - Kotebe Interceptor and laterals;

CMC interceptor and laterals

This section summarised the recommendations contained in this Master Plan. The figures in Brackets refer to the relevant section of this report.

Akaki: Scheme 5

- Construct waste stabilization ponds at Akaki I for a capacity of 100,000 population equivalent.
- Construct Akaki stage 1 sewers:
  - Akaki main interceptor and laterals;
  - Akaki east interceptor and laterals;

5 COLOPHON

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