No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF WATER RESOURCES AND IRRIGATION OF THE GOVERNMENT OF THE SOUTHERN SUDAN (MWRI / GOSS)

MINISTRY OF HOUSING, PHYSICAL PLANNING AND ENVIRONMENT OF THE GOVERNMENT OF THE SOUTHERN SUDAN (MHPPE / GOSS)

MINISTRY OF PHYSICAL INFRASTRUCTURE OF THE CENTRAL EQUATORIA STATE (MOPI / CES)

JUBA URBAN WATER SUPPLY AND CAPACITY DEVELOPMENT STUDY IN THE SOUTHERN SUDAN

FINAL REPORT (MAIN)

SEPTEMBER 2009

TOKYO ENGINEERING CONSULTANTS CO., LTD. (TEC)
EIGHT-JAPAN ENGINEERING CONSULTANTS INC. (EJEC)

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PREFACE

The Government of Japan decided to conduct "Juba Urban Water Supply and Capacity Development Study in the Southern Sudan" and entrusted it to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a Study Team headed by Mr. Hirotaka Sato of Tokyo Engineering Consultants from August 2008 to August 2009. The team held discussions with the officials concerned of the Ministry of Water Resources and Irrigation as well as other officials concerned, and conducted field surveys. Upon returning to Japan, the team prepared this final report to summarize the results of the study.

I hope that this report will contribute to development in the Republic of the Sudan, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Sudan for their close cooperation extended to the Study Team.

September 2009,

Mr. Toshiyuki Kuroyanagi
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

Mr. Toshiyuki Kuroyanagi
Director General
Economic Infrastructure Department
Japan International Cooperation Agency

September 2009

Dear Sir,

Letter of Transmittal

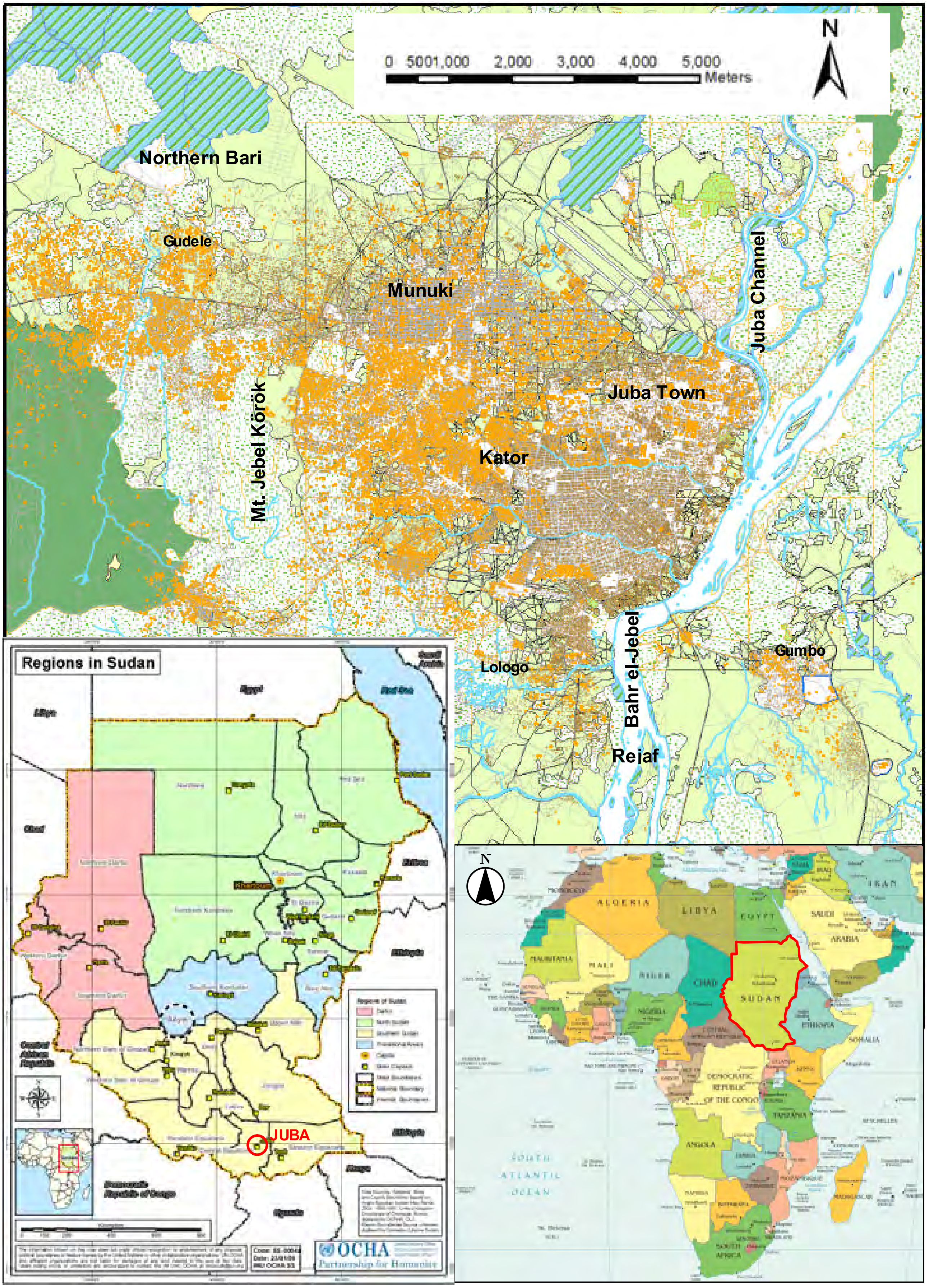
We are pleased to submit herewith the Final Report of "Juba Urban Water Supply and Capacity Development Study in the Southern Sudan". The report compiles the results of the Study and includes the advices and suggestions of the authorities concerned of the Government of Japan and your agency as well as the comments made by the Ministry of Water Resources and Irrigation and other authorities concerned in the Southern Sudan.

The Study was carried out for the purpose of formulating a plan to improve the water supply of Juba and developing the capacity of the water sector in the Southern Sudan. The report includes the existing water supply conditions of Juba, the contents of the master plan and the results of a feasibility study carried out on the priority project. We are truly sure that the results of the Study shall contribute to improving the current severe water supply conditions of Juba.

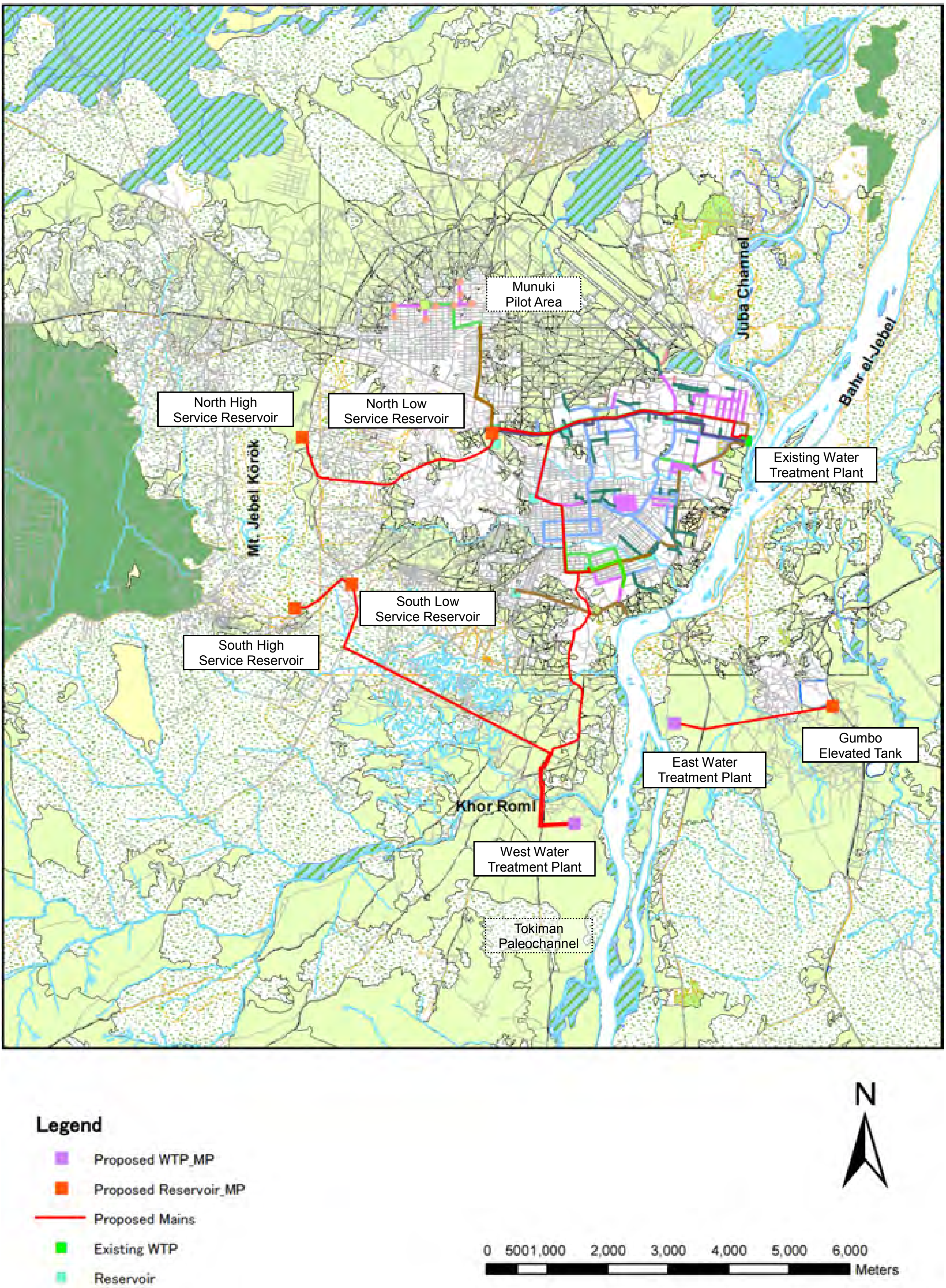
We wish to take this opportunity to express our sincere gratitude to your agency and the Ministry of Foreign Affairs. We also wish to express our deep gratitude to the Ministry of Water Resources and Irrigation as well as other Governmental Agencies concerned in the Southern Sudan for their close cooperation and assistance extended to us during the Study. We hope this report will contribute to the development of the Southern Sudan.

Very truly yours,

Mr. Hirotaka Sato
Team Leader,
Juba Urban Water Supply and Capacity
Development Study in the Southern Sudan



LOCATION MAP



PROPOSED MAIN WATER SUPPLY FACILITIES IN MASTER PLAN

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Acronyms and Abbreviations

AC	Asbestos cement	LC	Local currency
ADCP	Acoustic Doppler Current Profiler	LOD	Limit of detection
bgl	Below ground level	MTC	Multi-service Training Center
CBO	Community based organization	MC&RD	Ministry of Cooperatives and Rural Development
CD	Capacity Development	MDTF	Multi Donor Trust Fund
CES	Central Equatoria State	MDG	Millennium Development Goal
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora	MHPPE	Ministry of Housing, Physical Planning and Environment
CPA	Comprehensive Peace Agreement	MOFEP	Ministry of Finance and Economic Planning
DIP	Ductile iron pipe	MOH	Ministry of Health
DG	Director General	MOPI	Ministry of Physical Infrastructure
DI	Ductile iron	M/P	Master Plan
DMA	District Metered Area	MWRI	Ministry of Water Resources and Irrigation
DSSGDW	Draft Southern Sudan Guidelines for Drinking Water Quality	MSL	Mean sea level
E. Coli.	Escherichia Coliform	NA	Not analyzed
EC	Electrical conductivity	NRW	Non-revenue water
EFS	Environmental Feasibility Study	O&M	Operation and maintenance
EIA	Environmental Impact Assessment	ODA	Official Development Assistance
EIRR	Economic internal rate of returns	OJT	On-the-job training
EM	Electro-magnetic sounding	P, PS	Pump station
EPA	Environmental Protection Act	PCM	Project Cycle Management
ERT	Electrical Resistivity Tomography	PHAST	Participatory Hygiene and Sanitation Transformation
ET	Elevated tank	PTA	Parent-Teacher Association
FC	Foreign currency	PVC	Polyvinyl chloride
FGD	Focus Group Discussion	RAP	Resettlement Action Plan
FIRR	Financial internal rate of returns	ROS	Republic of Sudan
F/S	Feasibility study	SAVOT	Project on Improvement of Basic Skills and Vocational Training
GOSS	Government of Southern Sudan	SDG	Sudanese Pond
GI	Galvanized iron	SEA	Strategic Environmental Assessment
GTZ	German Technical Cooperation	SR	Service reservoir
GV	Guideline Value	SSUWC	Southern Sudan Urban Water Corporation
HRD	Human Resources Development	SWL	Static Water Level
IDP	Internally Disturbed Population	SWOT	Strength, Weakness, Opportunity and Threat
IEC	Information, Education and Communication	TDS	Total dissolved solid
IEE	Initial environmental examination	UFW	Unaccounted-for-water
IFRC	International Federation of Red Cross	UN	United Nations
IUCN	International Union for the Conservation of Nature and Natural Resources	UNMIS	UN Mission in Sudan
JICA	Japan International Cooperation Agency	UNICEF	United Nations International Children's Emergency Fund

Acronyms and Abbreviations

USD	United States dollars	WASH	Water, Sanitation and Hygiene
USAID	United States Agency for International Development	WFP	World Food Program
UWC	Urban Water Corporation	WHOGDW	WHO Guidelines for Drinking Water Quality
VES	Vertical Electric Sounding	WTP(s)	Water treatment plant(s)
VIP	Ventilated Improved Pit	WQ	Water quality
VLF	Very Low Frequency method	WtoP	Willingness to pay

Unit

d	day	L/min	litter per minute
h	hour	m^3/d	Cubic mater per day
hh	household	mg/l	milligram per liter
L	liter	ohm-m	ohm meter
L/c/d	liter per capita per day	ppm	particle per million
L/hh	liter per household	μ S/cm	micro siemens per centimeter
L/hh/d	liter per household per day	y	year
lps	liter per second		

PART I

ASSESSMENT OF EXISTING CONDITIONS

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

After the end of long duration of civil wars, Juba became the capital of the Southern Sudan in September 2005. Since no adequate investment and/or maintenance of urban infrastructure have been carried out for more than 20 years due to civil wars, most facilities are dilapidated and in urgent need of rehabilitation or reconstruction. Under such situation, the Government of the Republic of the Sudan (GOS) requested the Government of Japan (GOJ) a technical cooperation for carrying out "Emergency Study on the Planning and Support for Basic Physical and Social Infrastructure in Juba Town and the Surrounding Areas (hereinafter referred to as "the Emergency Study")." Upon this request, GOJ implemented the Study through Japan International Cooperation Agency (JICA) from February 2006 and prepared a plan of urban infrastructure development targeting the year 2015 and urgent infrastructure projects and implemented a restoration of Juba river port and development of water supply facilities in the north Munuki district as a part of pilot project.

In the Emergency Study, the condition of existing and future internally displaced persons (IDP) returnees was confirmed and the population is expected to increase substantially in the future due to accumulation of urban functions of Juba as a capital city combined with the IDP returnees. Under such conditions, it is expected that urban development would be affected negatively due to shortage of capacity of the basic infrastructure such as road and water supply, increase of unplanned urban land use, expansion of slum areas, environmental deterioration of residential areas, and increase of unemployment in terms of IDP returnees. These urban problems are required to be urgently tackled for sustainable growth of Juba.

In the water supply sector also, no adequate investment and maintenance of urban infrastructures have been carried out for more than 20 years, and most of the facilities are dilapidated and in urgent need of rehabilitation or reconstruction to bring them to their normal condition of operation.

Existing water treatment plant with the design capacity of 5,200 m^3/d was not functioning properly before May in 2009 and its working capacity was very limited. Water distribution network mostly composed of aged asbestos pipes causes high leakage. The water that is not treated adequately in the water treatment plant was supplied to only a small fraction of government offices and households. Most of the households rely on wells and water tankers. Since water in most of the wells is high in salinity and some of wells are polluted, the use of groundwater becomes difficult. Also water tankers selling water to people is mainly raw river water that is not suitable for human consumption.

The project of Rehabilitation of Urban Water Supply, Sewerage and Solid Waste Disposal Systems (hereinafter referred to as “the Emergency Rehabilitation Project”) have been implemented funded by Multi-Donor Trust Fund (MDTF) and the Government of Southern Sudan (GOSS) to rehabilitate part of the existing facilities. Under this project, reconstruction of the existing water treatment plant was completed and inaugurated in May 2009 with the design capacity of 7,200 m^3/d. However, there still exists a large gap between the current water demand and the water supply capacity and GOSS has recognized that increase of water treatment plant capacity by provision of a new intake and treatment plant located upstream of Juba Town in the Bahr el-Jebel and rehabilitation and expansion of distribution network are urgently required.

Based on the results of the Emergency Study, GOSS has requested GOJ implementation of this “Juba Urban Water Supply and Capacity Development Study (hereinafter referred to as “the Study”).” The purpose of the Study is to formulate an implementable short and medium term plan that caters to the needs of the vision of water supply for the Juba and surrounding areas, and to develop the capacity in the water supply sector.

A preliminary study team was dispatched in February 2008 and the request of GOSS on the study, scope of study, contents of the study, etc were confirmed through site survey and discussion. Finally, scope of works (S/W) and minutes of meeting were signed by both parties, based on which this Study was carried out.

1.2 Objectives of the Study

The objectives of the Study are:

- to formulate the master plan of water supply system covering the examination of alternative water sources,
- to conduct a feasibility study for prioritized projects, and
- to support the capacity development of Southern Sudan Urban Water Corporation (SSUWC), CES-Juba (UWC) and other organizations concerned in operation and maintenance (O&M), management, and support to community-based water projects.

1.3 Study Area

Juba Town is located at 4°52' north of the equator and 31°36' east longitude in Central Equatoria State in Southern Sudan, at an altitude of 460m above sea level (see Figure 1.1). The Study covers Juba Town and its surrounding areas extending through an area of about 40 km^2 and having a population of 250,000 in 2005.

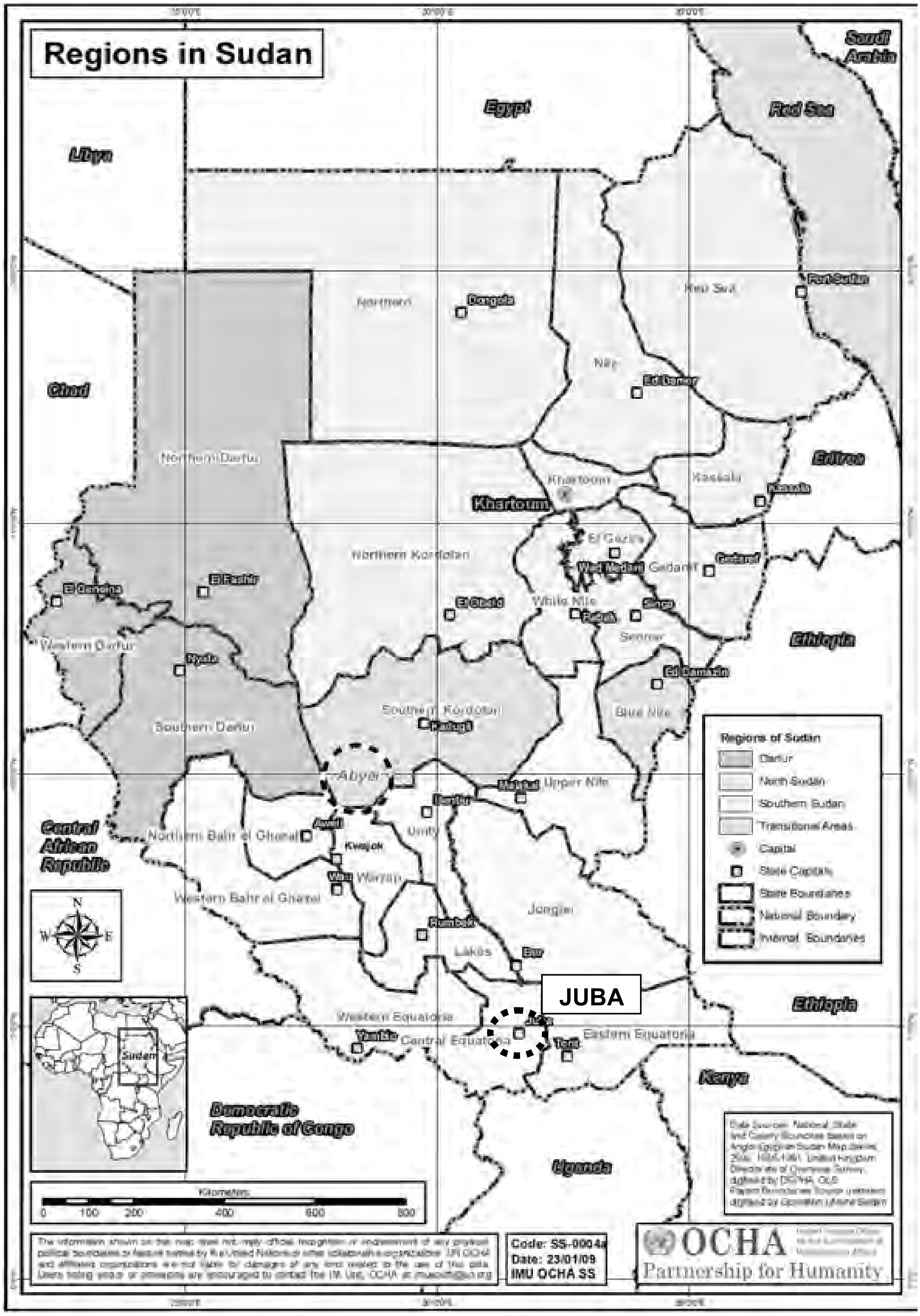
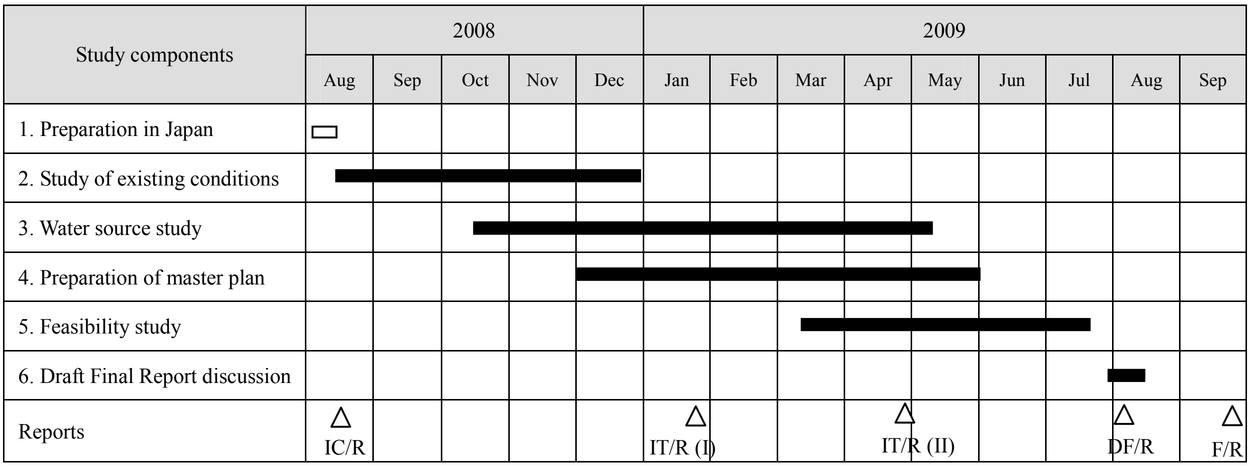


Figure 1.1 Location of Study Area

1.4 Study Schedule

The Study started in August 2008 and completed in September 2009. Figure 1.2 shows the overview of the study schedule.



Note: Inception Report (IC/R), Interim Report (IT/R), Draft Final Report (DF/R), Final Report (F/R)

Figure 1.2 Overall Schedule of the Study

1.5 Relevant Organizations of the Study

(1) Responsible Agency

This Study was initiated by Ministry of Housing, Lands & Public Utilities (MHLPU) / GOSS and in the Scope of Works of the Study, the responsible agency was MHLPU. However, according to the Presidential Decree on 28 July 2008, the responsible organization of urban water supply was changed from MHLPU to Ministry of Water Resources and Irrigation (MWRI), and the title of Ministry of Housing, Lands & Public Utilities was also changed to Ministry of Housing, Physical Planning, and Environment (MHPP&E). Accordingly, MWRI became the overall responsible agency of the Study.

(2) Counterpart Agency

The following are counterpart agencies along with MWRI.

- Southern Sudan Urban Water Corporation (SSUWC)
- Ministry of Physical Infrastructure (MOPI) / Government of Central Equatoria State (CES)

(3) Steering Committee

A Steering Committee (S/C) was formed including the following members chaired by the Undersecretary of MWRI for smooth implementation of the Study. The meetings of Steering Committee were held five times at the submission of Inception Report, Interim Report (I), Interim Report (II) and Draft Final Report, and in the feasibility study. The functions of S/C were as follows.

- Coordination with other relevant stakeholders and community
- Ensuring smooth implementation of the study
- Comments, opinions, and decision makings as required

Title/Organization	Name
Undersecretary (MWRI) - Chair	Eng. Isaac Liabwel
Chairperson / General Manager (SSUWC) Acting Chairperson / General Manager (SSUWC)	Eng. Chamjok Chung Eng. Joseph Ebere Amosa
JICA Sudan Office	Mr. Kenichi Shishido
Director General of Environment (MHPPE)	Mr. Victor Wurda
Director General of Physical Planning (MHPP&E)	Eng. Riek Degoal
Director General of Sanitation Projects (MHPP&E / MWRI)	Eng. Morris Lomodong
Director General of Rural Water Supply and Sanitation (MWRI)	Mr. Peter Mahal Dhieu
D.G. Physical Infrastructure (CES)	Mr. Lewis Gore George
Director of Urban Water Projects (MWRI)	Eng. Laurence Muludyang
Director General of Water and Sanitation (CES)	Eng. Martin Andrew
Area Manager of UWC for Juba	Eng. Joseph Ebere Amosa Eng. Samuel Taban Longa
Executive Director, Juba County (CES)	Mr. Peter Tongun Swaka

(4) Counterpart Team and Technical Committee

The counterparts were assigned as shown in the table below. The counterpart meetings were held periodically or when needed, and the functions of the counterpart were as follows.

- Coordination of the Study with the Study Team
- Assisting the Study Team in data collection
- Work together with the Study Team in preparation of plans, so as to acquire technical capacity (Technology Transfer through OJT)

Member / Functions	Title/Organization	Name
1. Leader	Director, Urban Water Projects, MWRI	Eng. Laurence Muludyang
2. Overall coordination	Director. Coord. MWRI	Ms. Nyasigin Deng
3. Planning, operation and maintenance	UWC-Juba/SSUWC	Eng. Joseph Ebere Amosa Eng. Santurino Tongun
4. Groundwater development specialist	D. D. Rural Water Supply and Sanitation, CES	Eng. Elsama Wani
5. Environmental and social considerations	Assistant Inspector for Environment, MHPPE Inspector for Environment, MHPPE	Mr. Moses Gogonya Cosmes Mr. Gabriel Modi

After the data collection, a technical committee was formed to formulate the Master Plan.

(5) JICA

JICA's administration related to the Study was composed of following members.

Name	Title
Mr. Kenichi Shishido	Resident Representative, JICA Sudan Office
Mr. Kensuke Oshima	Project Formulation Advisor, JICA Southern Sudan Field Office
Mr. Kiyotaka Tamari	Project Formulation Advisor, JICA Southern Sudan Field Office
Mr. Yuichi Sugano	Director, Urban and Regional Development Division II, Urban and Regional Development Group, Economic Infrastructure Department, JICA
Mr. Naomichi Murooka	Senior Program Officer, Urban and Regional Development Division II, Urban and Regional Development Group, Economic Infrastructure Department, JICA

(6) JICA Study Team

The Study Team was composed of the following 11 members.

Assignment	Name
1. Team Leader /Water Supply Planning	Mr. Hirotaka SATO
2. Deputy Team Leader / Water Supply Utility Management Planning	Mr. Naoto TOHDA
3. Water Supply Facility Planning	Mr. Norio TANAKA
4. Water Treatment Plant Planning and Designing	Mr. Shiro JIMBO
5. Water Supply Operation and Maintenance Planning/GIS	Dr. Kumar ALOK
6. Hydrogeological Survey	Mr. Komei OZAKI
7. Geophysical Exploration	Mr. Yasunori ISHIDA
8. Test Drilling Supervision	Mr. Koji TAKAHASHI
9. Environmental and Social Considerations	Mr. Hironori KUROKI
10. Community-based Organization Management / Hygiene Education	Ms. Miho NAKANO
11. Social Survey	Mr. Masahiro SUGAYA

1.6 Structure of the Report

The Final Report is composed of summary, main, drawings and appendix. The main report is comprised of following 3 parts and 24 chapters as shown in Table 1.1:

Part I: Assessment of Existing Conditions

Part II: Master Plan

Part III: Feasibility Study

Table 1.1 Structure of Main Report of Final Report

PART I	ASSESSMENT OF EXISTING CONDITIONS
CHAPTER 1	INTRODUCTION
CHAPTER 2	DESCRIPTION OF STUDY AREA
CHAPTER 3	EXISTING LAND USE AND POPULATION
CHAPTER 4	ASSESSMENT OF WATER SOURCES
CHAPTER 5	EXISTING WATER SUPPLY CONDITIONS
CHAPTER 6	EXISTING INSTITUTION AND ORGANIZATIONS ON WATER SUPPLY
PART II	MASTER PLAN
CHAPTER 1	PLANNING BASIS
CHAPTER 2	WATER SUPPLY FACILITY PLAN
CHAPTER 3	DEVELOPMENT SCHEDULE OF WATER SUPPLY SYSTEM
CHAPTER 4	MANAGEMENT, OPERATION AND MAINTENANCE
CHAPTER 5	CAPACITY DEVELOPMENT
CHAPTER 6	COST ESTIMATION
CHAPTER 7	PROJECT EVALUATION
CHAPTER 8	INITIAL ENVIRONMENTAL EXAMINATION
CHAPTER 9	MUNUKI COMMUNITY WATER AND SANITATION MANAGEMENT
CHAPTER 10	RECOMMENDATION OF WASTEWATER MANAGEMENT
CHAPTER 11	CONCLUSIONS AND RECOMMENDATIONS
PART III	FEASIBILITY STUDY
CHAPTER 1	SCOPE OF PRIORITY PROJECT
CHAPTER 2	FACILITY DESIGN
CHAPTER 3	MANAGEMENT, OPERATION AND MAINTENANCE
CHAPTER 4	IMPLEMENTATION PLAN AND COST ESTIMATION
CHAPTER 5	PROJECT EVALUATION
CHAPTER 6	PRELIMINARY ENVIRONMENTAL IMPACT ASSESSMENT
CHAPTER 7	CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 DESCRIPTION OF STUDY AREA

2.1 Administration System

The administrative organizations in Southern Sudan consist of six levels and each level has roles as given in Table 2.1, although clear definition has not been made.

Table 2.1 Six Levels of Administrative Organizations

Level	Administrative organization	Main roles
1. Central level	GOSS (Government of Southern Sudan)	GOSS is responsible for policy making, planning and investment at national level. GOSS directs state government to implement the government policy and ensure funding. In donor projects, GOSS will coordinate between donor agencies and related organizations and sectors.
2. State level	CES (Central Equatoria State)	CES is responsible to implement the government policy in each state. CES steers and coordinates different organizations within the state. CES is also responsible to coordinate with ministries in GOSS level to attract funds and technical assistance.
3. County level	Juba County	County has very important role of land commissioning. No development shall be done without consent by the authorities of county level.
4. Payam level	Payams	Payam is the lowest administrative level which is closest to the people. Payam will act as coordinator and organizer of community based organizations in water supply projects.
5. Community level	Bomas	Bomas are the main units of local residents although they are not an administrative entity. Boma is an important link between the Payam and residents and will mobilize active participation of community. Boma would be an appropriate unit for community based organization (CBO).
6. Village level	Village and sub-village	As a part of Boma, villages and sub-villages exist in clusters of dwellings. They would also be an appropriate unit for CBO.

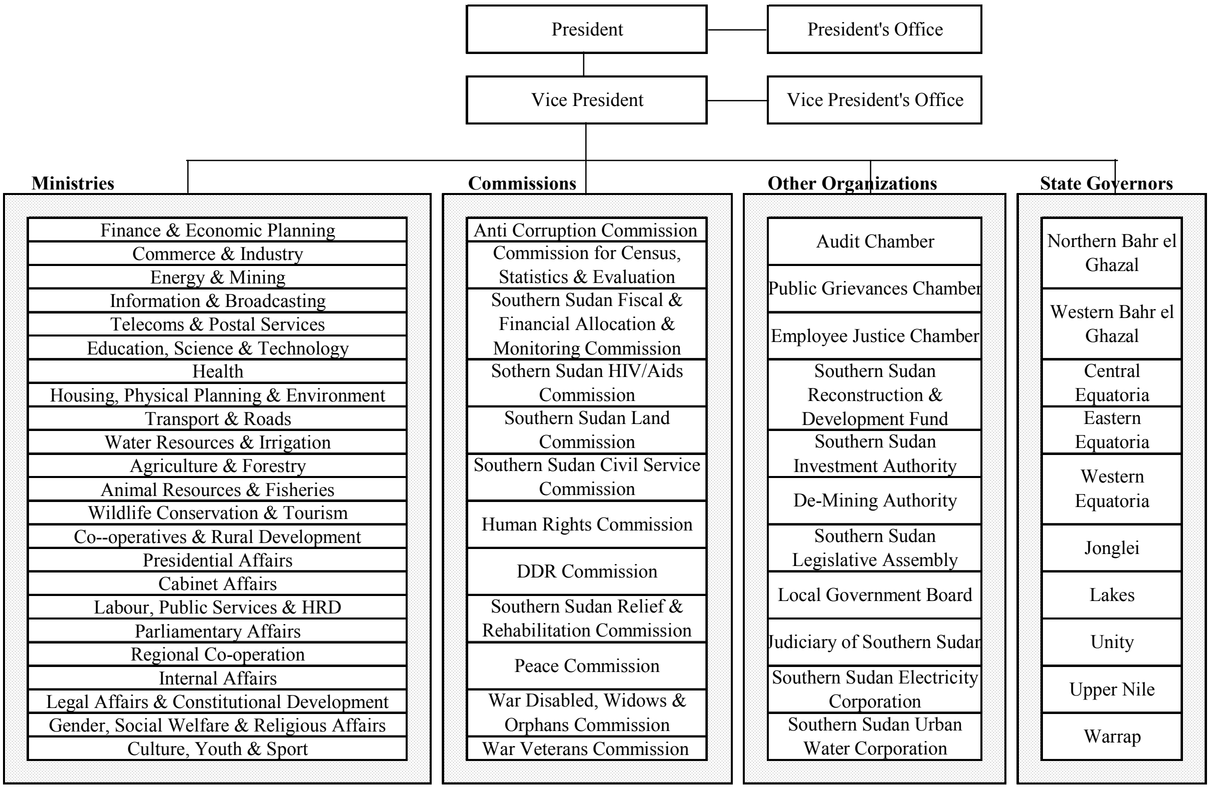
Source: Information from the counterparts to the JICA Study

The organizational structures of the Government of Southern Sudan and the State Government of Central Equatoria are shown in Figure 2.1 and Figure 2.2, respectively.

Southern Sudan is composed of 10 states. The Study Area, Juba and its surroundings, is located in Central Equatoria, which is compose of 6 counties, i.e., Juba, Yei, Kajo Keji, Terakeka, Lainya and Morobo. Juba County comprises of 16 payams. Out of these payams, Juba Town payam, Kator payam, Munuki payam, Lologo and Gumbo in Rejaf payam and Gudele in Northern Bari payam form the urbanized area of the Juba capital region.

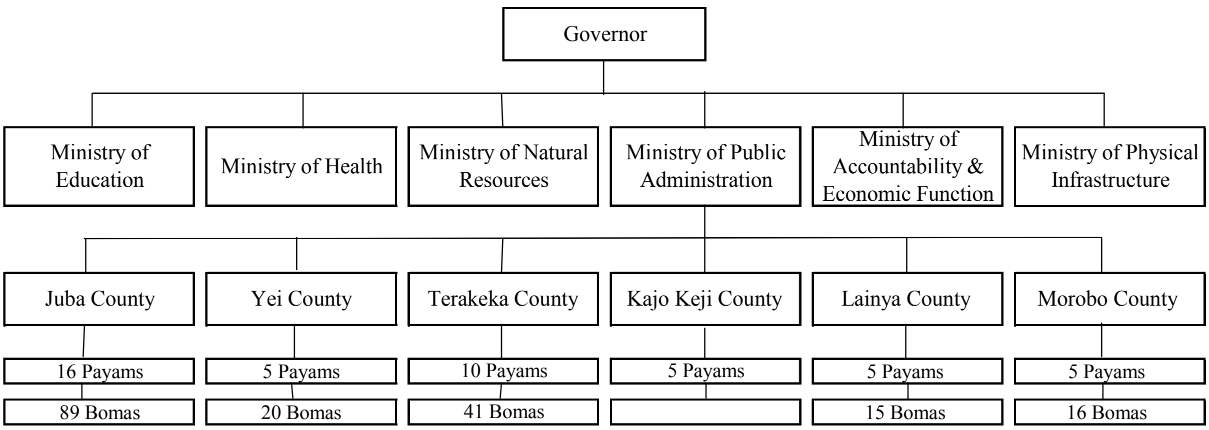
The State Government is composed of six ministries. The Ministry of Physical Infrastructure (MOPI), one of the major counterpart agencies of the Study, is composed of various Directorates and Departments such as Town Planning, Survey, Roads and Bridges, Construction, Housing, as well as Urban Water and Sanitation Corporation and Rural Water Development Corporation.

Currently, the Central Government of Sudan allocates a budget to the Government of Southern Sudan, and the Government of Southern Sudan then allocates a budget to each governmental organizations and State Governments. The State Government then directly funds each County and Payam. Other than the above-mentioned funding stream, each respective Government has its own source of revenue.



Source: Interim Report, Juba Urban Transport Infrastructure and Capacity Development Study in the Southern Sudan, JICA, April 2009

Figure 2.1 Organization of Central Government of Southern Sudan



Source: Interim Report, Juba Urban Transport Infrastructure and Capacity Development Study in the Southern Sudan, JICA, April 2009

Figure 2.2 Organization of Central Equatoria State

2.2 Water Supply Relevant Organizations

The following organizations are related to the water supply in the Government of Southern Sudan.

1) Directorate of Sanitation, Ministry of Housing, Physical Planning, and Environment (MHPP&E)
2) Directorate of Water Supply Projects, Ministry of Water Resources and Irrigation (MWRI/GOSS)
3) Directorate of Rural Water Supply, (MWRI/GOSS)
4) Southern Sudan Urban Water Corporation (SSUWC), (MWRI/GOSS)
5) Directorate of Water Supply and Sanitation (DG WSS), Ministry of Physical Infrastructure (MOPI/CES)

2.3 Demography

The 5th Sudan Population and Housing Census has been conducted and census field enumeration was carried out in November 2007 and the field data has been processed in 2008 and 2009. A priority results were published in mid-2009. According to these results, the total population of Sudan is 39,154,490, out of which the population in Southern Sudan is 8,260,490. Central Equatoria to which the Study Area belongs has a population of 1,103,592 and Juba County has 372,413 persons.

The demographic indicators of Southern Sudan (Southern Sudan SPLM/A controlled area) and Central Equatoria State are summarized in Table 2.2. In Southern Sudan, the life expectancy at birth is only 42 years and the levels of total fertility rates (6.7) and the crude death rate (22/1,000) are high; almost two times higher than those of Uganda.

Table 2.2 Demographic Characteristics of Southern Sudan and Other Cities and Counties

Area	Natural growth rate of population	Life expectancy at Birth	Infant mortality Rates	Under five mortality rates	Crude death rate per 1000	Crude birth rate per 1000	Total fertility rates
SOSUS: Southern Sudan SPLM/A area *1	2.85%	42	150	250	22	50.5	6.7
Central Equatoria *2	-	-	107	141	-	-	-
Uganda	-	52.3	70	136	12.3	48.2	6.8

Source:
*1: Towards a Baseline: Best Estimates of Social Indicators for Southern Sudan, New Sudan Centre for Statistics and Evaluation in Association with Unicef, May 2004
*2: Sudan Household Health Survey (Southern Sudan report), 2006, Government of Southern Sudan

According to the SOSUS MICS 99, 45% (unadjusted) of children under the age of five had diarrhea during a period of 15 days prior to the investigation. This is an extremely high percentage. The range is 37% (Upper Nile) to 52% (Western Equatoria). The 2003 Sentinel Sites Survey, which concentrated even more in the areas with better social service coverage found a diarrhea prevalence of 25%.

2.4 Economy

Main economic activities in Juba City and surrounding areas are commerce, transport and public services, and activities by international organizations such as United Nations (UN), World Food Program (WFP), and UN Mission in Sudan (UNMIS), and bilateral cooperation agencies including United States Agency for International Development (USAID) and JICA. Other various NGOs have emerged specifically to enhance and support special procurement activities for those industries as well as the donor agencies.

About 9 markets are located in Juba City and surrounding areas. Business in most shops is conducted in small and simple frame huts and stalls. However, a small number of shops are operated in rows of permanently built structures. Although the scales and level of markets differ considerably from each other, the items and varieties of commodities are quite similar.

2.5 Natural Conditions

(1) Topography

The areal extent of the Study Area (Figure 2.3) is around 40 km^2. The terrain of the Study Area starts from the foothill of Mt. Jebel Körök with a peak of 744 m above sea level and slopes gently towards east (Figure 2.4). The Study Area (Juba urban area and the surrounding area) is located in the Bahr el-Jebel alluvial plain which has a slope from south-southwest to north-northeast direction in general. The Bahr el-Jebel with an average width between 250 m to 600 m, delineates the city boundary in the east. A gentle slope generally characterizes the area, where outcrops of hard and firm crystalline rocks are found. Among these outcrops of rocks, the most outstanding one is Jebel Körök with 3 km width and 1 km length.

In the rainy season, the flooding water affects an area covering almost 50% of the alluvial plain prompting the emergence of the temporal and seasonal rivers flowing into the Bahr el-Jebel.

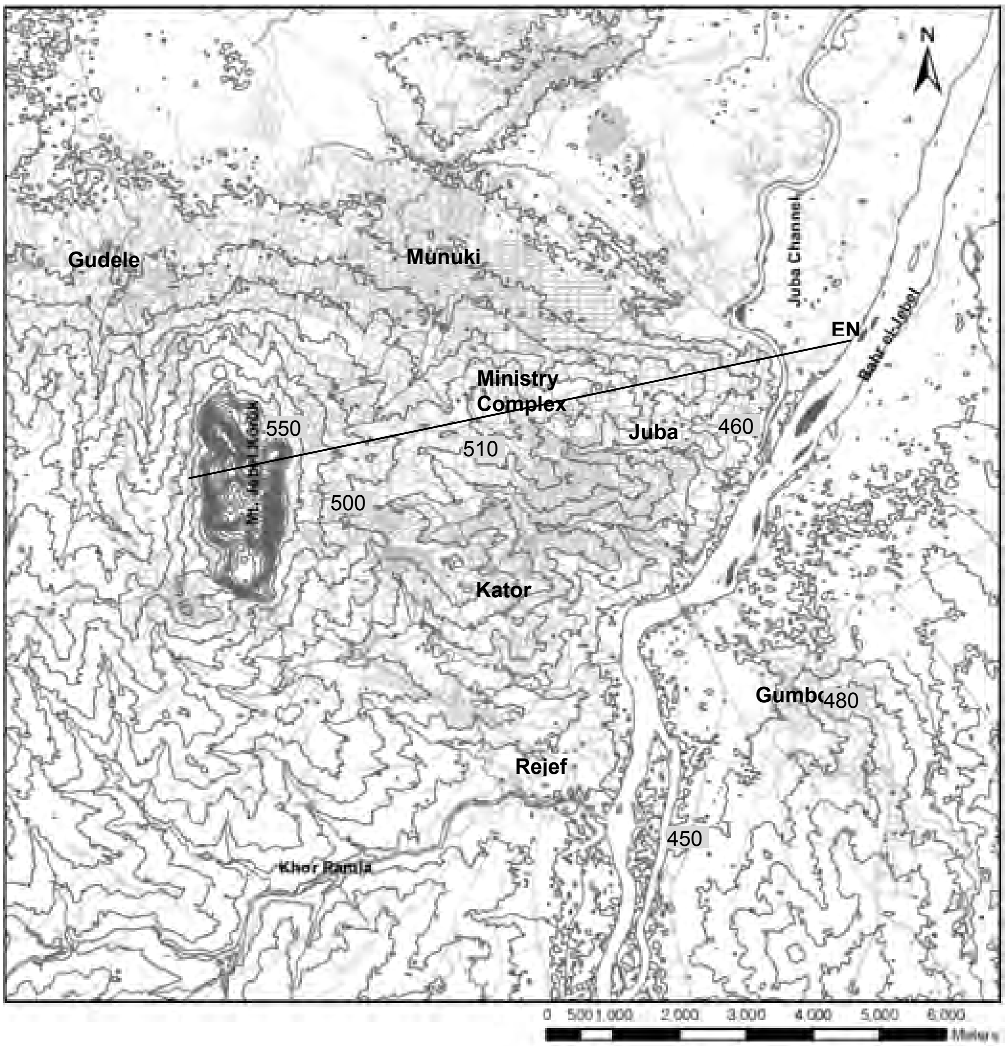


Figure 2.3 Topography of the Study Area

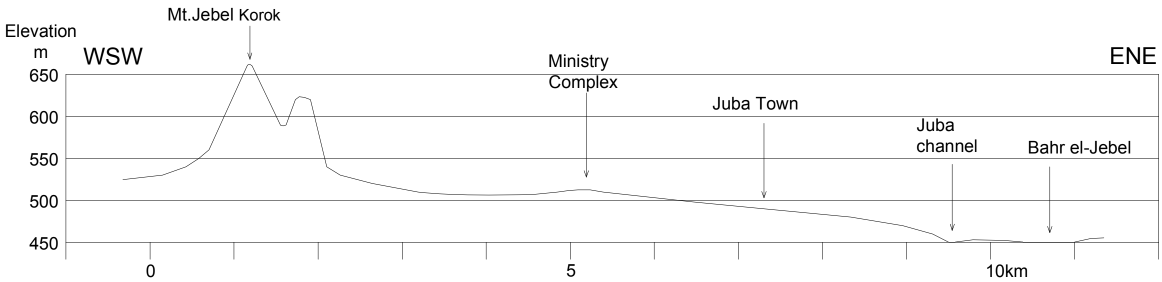


Figure 2.4 General Topographic Section of the Study Area

(2) Climate

In general, the temperature is high throughout the year with distinct characteristics of the dry and rainy seasons.

The monthly rainfall data for years 2005 to 2007 is presented in Table 2.3. Average annual total rainfall during 2005-2007 was around 1,000 mm and in general, the rainy season starts in May and lasts to October. As shown in Table 2.4, the monthly relative humidity in the dry season is around 30 % and that during the rainy season varies from 50 to 70 %.

Table 2.3 Monthly Rainfall Data in 2006 and 2007

(mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
In 2007	Nil	1.0	11.8	117.4	178.8	129.8	194.1	125.5	172.0	74.5	55.5	TR	1,060.4
In 2006	TR	5.5	130	40.8	188	82.1	60.5	265	145	80	35.5	21.5	1,053
In 2005	0	TR	22.8	103.7	173	129.8	189	34.5	56.9	90.6	15.2	0	815

Note: TR=Rain Fall recorded below 0.1(mm)
Source: Sudan Meteorological Authority

Table 2.4 Monthly Relative Humidity Data in 2006

(%)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.
Relative Humidity	28	29	49	51	70	69	70	75	70	65	57	33	55.5

Source: Sudan Meteorological Authority

The average monthly temperature data in 2006 has been presented in Table 2.5. The annual average monthly maximum and minimum temperatures are observed to be 34 °C and 21.6 °C. This large difference between maximum and minimum temperatures attributes to the temperature difference between very hot day time and cool night. The lowest monthly average minimum temperature was mostly recorded in December, while the highest average maximum temperature predominantly occurred either in January or February.

Table 2.5 Average Monthly Temperature by Meteorological Stations for the year 2006

(°C)

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Maximum	38.9	39.5	35.8	35.5	31.3	31.9	31.6	30.5	31.8	33.5	33.5	34.3	34
Minimum	21.9	23.6	23.6	23.9	22.1	21.5	21.1	20.4	20.5	20.8	20.8	18.9	21.6

Source: Sudan Meteorological Authority

CHAPTER 3 EXISTING LAND USE AND POPULATION

3.1 Past and Current Land Use

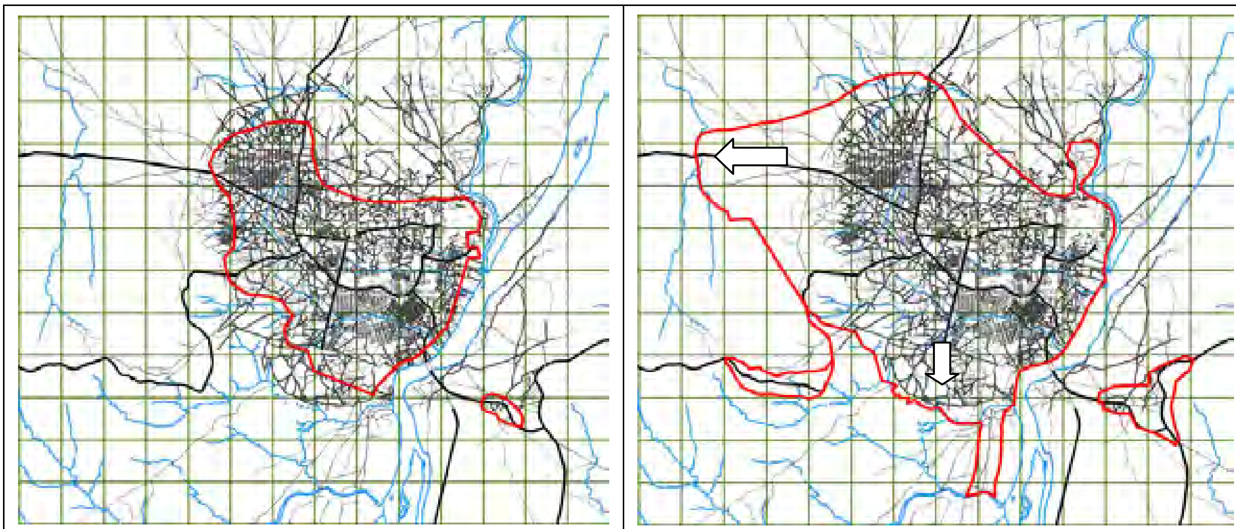
3.1.1 Study Area

Central Equatoria is composed of 6 Counties comprising of Juba, Yei, Terakeka, Kajo Keji, Lainya, and Morobo. Juba County comprises of 11 Payams. Out of those Payams, Juba Town, Kator and Munuki are expected to form Juba Municipality. On the other hand, the urbanized area of Juba has expanded to the outside of these three Payams, i.e., Rejaf and Gudele. The latter area is located in the western area of Munuki. The Study Area is formed by the existing major urbanized area including Juba Town, Kator and Munuki, and future expected urbanized areas including Rejaf and Gudele.

3.1.2 Urbanized Area in 2005 and 2009

"Emergency Study on the Planning and Support for Basic Physical and Social Infrastructure in Juba Town and Surrounding Area in the Southern Sudan, 2007, JICA (JICA Emergency Study)" carried out a land use survey to draw the land use map in 2005, in which the urbanized area of Juba was estimated at approximately 24 km^2.

In the Study, the current (2009) urbanized area was updated through simple site observation. The urbanized area in 2009 along with 2005 is shown in Figure 3.1. The urbanized area in 2009 has been estimated as approximately 52 km^2. Comparing past and current urbanized areas, new urbanized area has been mainly expanded westward and southward. The new urbanized area of Juba has expanded mainly towards Rejaf and Gudele, the outside of Juba, Kator and Munuki Payams.



Urbanized Area in 2005	Urbanized Area in 2009

Figure 3.1 Urbanized Area in 2005 and 2009

3.1.3 Current Land Use

Through the site observation survey by the Study Team, the land use map in 2005 was updated reflecting the change in recent land use patterns including new residential and commercial areas, and a preliminary current land use map has been prepared as shown in Figure 3.2. The extent of the current urbanized area by major land use type is estimated as shown in Table 3.1.

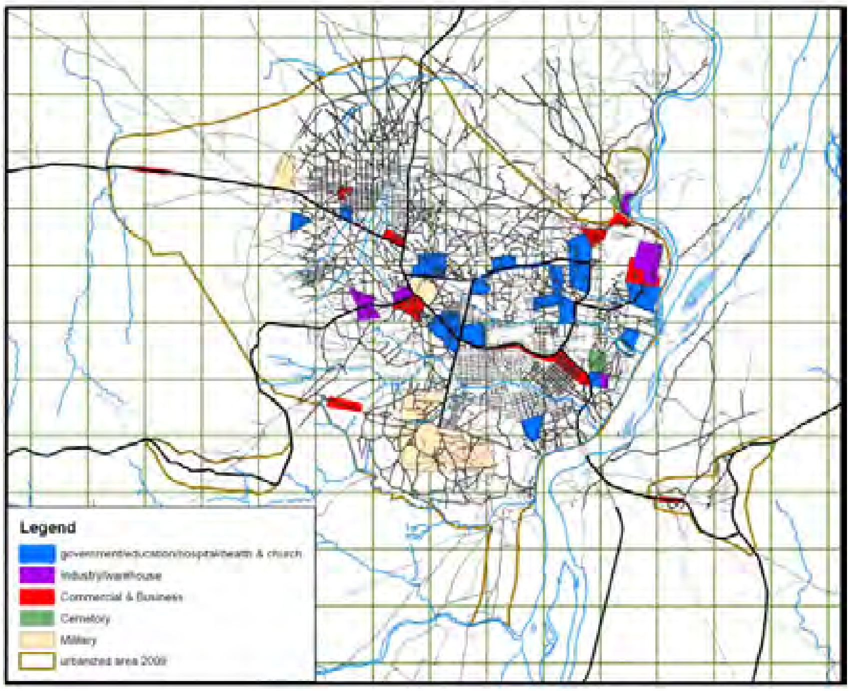


Figure 3.2 Simplified Current (2009) Land Use

Table 3.1 Summary of Major Land Use in Urbanized Area in 2009

No.	Land use	Area (ha)
1	Commercial and Business	100
2	Institution (Government office, Education, Hospital, Church, and Culture)	183
3	Industry	58
4	Military	56
5	Cemetery	20
	Total	417

3.2 Current Population Estimation by the Study Team

Population census for Southern Sudan had not been conducted for long time since 1983 because of the long lasting war. Finally, in December 2007, the national census survey was conducted. However, publication of the result of the census is delayed considerably. According to the Census Office, the results of South and North Sudan were being verified and were expected to be published in 2009.

Therefore, there was no reliable data for estimating the current population, and the current population is unclear. Furthermore, the recent migration trend characterized as the returnees, IDPs and refugees makes estimation of population rather difficult.

Since the complete result of the census had not been published yet as of May 2009 and there was no reliable data, the current population had been estimated in the Study.

In the Study the current population has been estimated adopting the following methodology. First, the border of the future expected urbanized area is delineated by the Study Team. Secondly, the area is sub-divided into a total of 56 districts based on the sub-divisions prepared in JICA Emergency Study for population estimation. The area is constituted by 21 sub-districts in Juba Town payam, 11 sub-districts in Kator payam, 15 sub-districts in Munuki payam, 6 sub-districts in Rejaf payam, and 3 sub-districts in Gudele payam as shown in Figure 3.3. Kator sub-district-12 in JICA Emergency Study was converted to Rejaf-1 and Munuki sub-district-16 was converted to Gudele-1. Two sub-districts in Munuki and five sub-districts in Rejaf have been newly added in the Study, where there was no major urban development in 2005.

The percentage of land use category, type of residential area and degree of development are estimated through field survey. The existing residential area can be divided into two categories; formal settlements where plots are demarcated with proper spaces and land use is organized, and informal settlements where plots are not demarcated and land use is not organized. Basically, permanent buildings of upper and middle income classes are prevalent in demarcated residential area, while temporary/self help houses and traditional style houses of low income class are most common in the non-demarcated residential area.

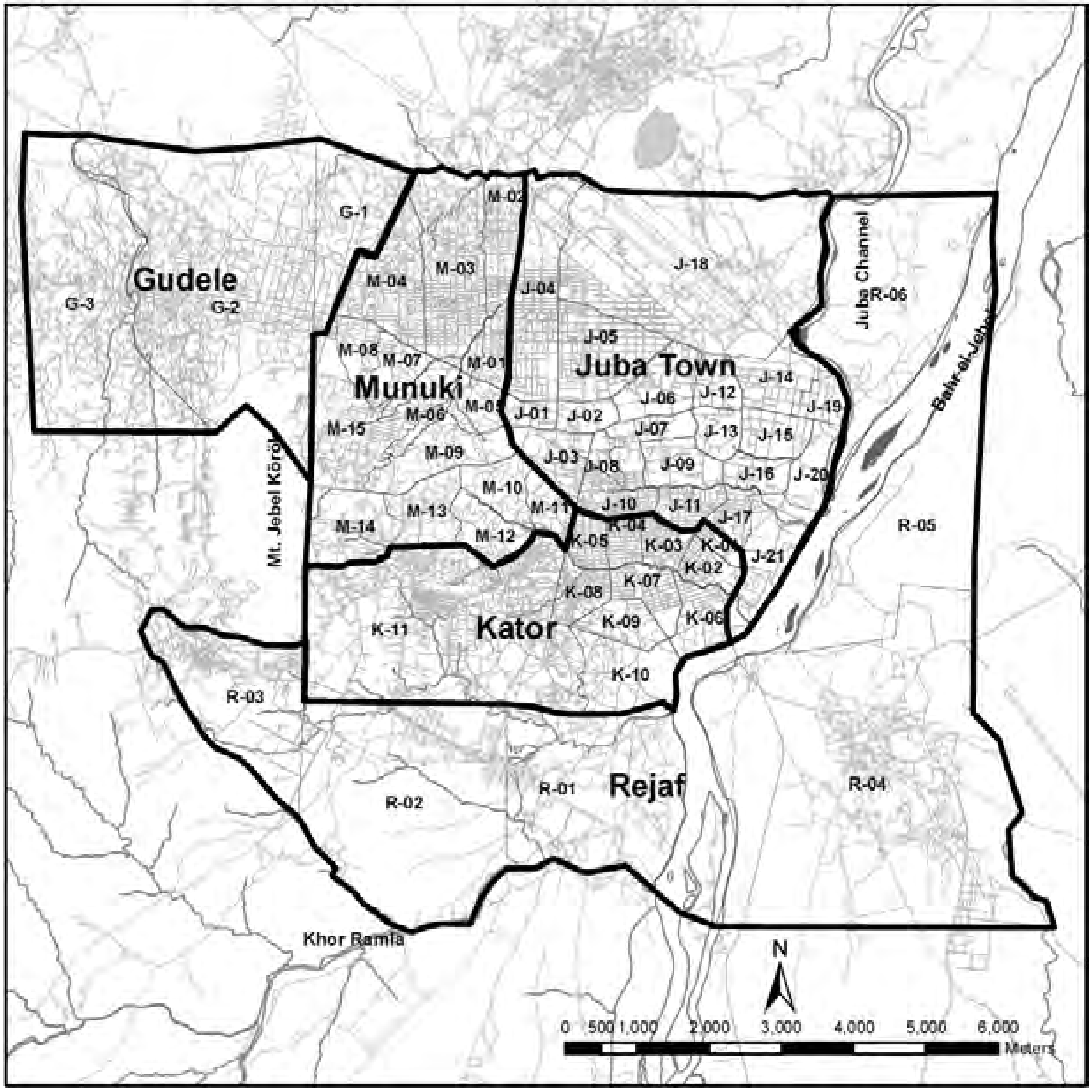


Figure 3.3 Future Urbanized Area and Sub-district of the Study Area

In the Study, the current population was estimated multiplying the area of residential zones by population density estimated by the Study Team.

To estimate the current population density of typical settlement in the residential area, 10 residential sample areas, comprising of 5 organized settlements and 5 unorganized settlements, were selected as pilot areas, and the population was counted through home visit survey. Highly developed areas were chosen from the urbanized area. The results of the survey are summarized in Table 3.2. The survey result estimates the average population density of organized and unorganized residential areas as 180 persons/ha and 222 persons/ha, respectively

Table 3.2 Results of Head Counting in the Sample Areas

Category	District name	Area (ha)	Population (persons)	Density (persons/ha)
Organized land plot area	Juba Town Payam, Hai Thoura	12.5	3,147	252
	Juba Town Payam, Hai Negli	6.4	950	150
	Kator Payam, West Block 6.	10.4	1,784	172
	Kator Payam, Hai Atla-bara	6.4	1,279	200
	Munuki Payam, Kuwait	17.3	2,205	128
Average population density of demarcated area				180
Unorganized land plot area	Juba Town Payam, Hai Zendia	3.3	1,042	317
	Juba Town Payam, Nakisangola	9.8	1,655	168
	Kator Payam, Cassaua	10.8	3,088	286
	Munuki Payam, Dar-salam	8.5	1,338	158
	Munuki Payam, Hai Mauna	9.1	1,637	179
Average population density of non-demarcated area				222

The current population by sub-district was estimated using the result of land use survey and the counted population densities. Consequently, the total population of Juba was estimated to be 406,000 in 2009 and the population distribution is shown in Table 3.4. The Study Team believes that this estimate is most reliable than any other speculation of the current population as this estimate is based on actual site survey and actual head counting, although it is a sample survey.

Table 3.3 shows the summary of the population estimation (in thousands) by payam in 2005 and 2009. During this period, the urban area has mainly extended westward, especially to the west of Munuki, and a new settlement has come up in Rejaf.

Table 3.3 Population Distribution (in thousands) by Payam in 2005 and 2009

Items	Juba	Kator	Munuki	Rejaf	Gudele	Total
Population in 2005	103	69	78	0	0	250
Population in 2009	117	79	117	31	62	406

Source: the Study Team estimate.

A priority result of the 5th Sudan Population and Housing Census conducted in November 2007 were published in July, 2009. According to this result, the census population of the Study Area is much less than that of the Study Team estimate; i.e., 250,000 to 280,000.

In the fourth Steering Committee Meeting, the population to be considered for this Study was discussed and the GOSS and all other members agreed that the Study Team should continue with its own population estimates.

Table 3.4 Estimated Population Distribution in 2009

Payam	District	Area (ha)	Residential area (ha)	Population (persons)
Juba Town	J - 1	30.14	10.55	2,339
	J - 2	33.71	13.48	2,093
	J - 3	71.49	50.04	7,884
	J - 4	205.90	144.13	16,705
	J - 5	144.90	86.94	9,100
	J - 6	80.64	64.51	6,959
	J - 7	63.19	41.07	5,927
	J - 8	32.46	21.10	3,968
	J - 9	64.08	35.24	7,815
	J - 10	40.62	28.43	4,616
	J - 11	42.97	42.97	6,975
	J - 12	43.21	28.09	4,796
	J - 13	42.28	16.91	3,750
	J - 14	78.86	47.32	6,700
	J - 15	58.61	23.44	3,460
	J - 16	47.30	37.84	5,610
	J - 17	42.95	34.36	5,629
	J - 18	709.62	70.96	7,868
	J - 19	36.23	7.25	1,311
	J - 20	64.15	6.42	1,422
	J - 21	101.51	10.15	2,251
	Sub-total	2,034.82	821.21	117,178
Kator	K - 1	17.42	13.94	2,418
	K - 2	46.04	41.44	7,189
	K - 3	33.93	30.54	4,957
	K - 4	29.86	29.86	4,847
	K - 5	38.91	38.91	6,316
	K - 6	65.66	59.09	9,860
	K - 7	60.26	48.21	7,826
	K - 8	51.36	41.09	6,068
	K - 9	50.81	40.65	7,211
	K - 10	165.06	99.04	13,176
	K - 11	829.20	165.84	9,012
	Sub-total	1,388.51	608.59	78,881
Munuki	M - 1	51.77	36.24	5,831
	M - 2	94.10	84.69	8,514
	M - 3	228.70	160.09	19,710
	M - 4	168.60	101.16	10,995
	M - 5	44.99	35.99	7,183
	M - 6	61.64	49.31	8,748
	M - 7	40.95	32.76	5,085
	M - 8	58.69	41.08	3,875
	M - 9	97.93	68.55	10,641
	M - 10	66.47	53.18	9,433
	M - 11	45.54	22.77	2,289
	M - 12	65.59	52.47	6,981
	M - 13	85.05	59.54	7,921
	M - 14	170.00	51.00	4,524
	M - 15	150.00	60.00	5,411
	Sub-total	1,430.02	908.83	117,140
Rejaf (Lologo and Gumbo)	R - 1	514.40	308.64	6,461
	R - 2	773.00	541.10	0
	R - 3	335.00	268.00	2,971
	R - 4	1,617.00	970.20	21,514
	R - 5	499.00	49.90	0
	R - 6	562.00	168.60	0
	Sub-total	4,300.40	2,306.44	30,946
Northern Bari (Gudele)	G - 1	188.81	113.29	10,217
	G - 2	1,027.37	719.16	38,914
	G - 3	485.22	291.13	13,128
	Sub-total	1,701.40	1,123,58	62,259
Total		10,855.15	5,768.65	406,404

3.3 Past Population and Development Trend

The United Nations conducted a head-count census in 1994 and estimated the population at 156,000. JICA Emergency Study estimated the total population of Juba Town and the surrounding areas to be approximately 250,000 with 103,000 in Juba Town Payam, 69,000 in Kator Payam and 78,000 in Munuki Payam as of the year 2005.

The following table summarizes the past population growth using several sources. During the period between 1977 and 2005 for 28 years, the population of Juba has increased at rates of 4.4 % to 4.7 % p.a.

The Study Team estimated the population in 2009 as 406,000 with the distribution of the population as shown in Table 3.5. The population of Juba has increased at 12.5 % per annum after 2005. This drastic increase is attributable more to the socio-dynamic patterns than to natural causes as many refugees and IDPs have returned to Southern Sudan, especially to Juba area, after signing of the CPA.

Table 3.5 Past Population and Estimated Growth Rate

<table>
<tr><th></th><th colspan="2">1977</th><th colspan="2">1994</th><th colspan="2">2005</th><th colspan="2">2009</th></tr>
<tr><td>Population</td><td colspan="2">71.5 [*1]</td><td colspan="2">156 [*2]</td><td colspan="2">250 [*3]</td><td colspan="2">406 [*4]</td></tr>
<tr><td>Annual growth rate (%)</td><td></td><td colspan="2">4.7%</td><td colspan="2">4.4%</td><td colspan="2">12.9%</td><td></td></tr>
</table>

Source:*1 JICA Emergency Study
*2 United Nations head count census
*3 Juba Assessment Town Planning and Administration, USAID
*4 The Study Team estimate

CHAPTER 4 ASSESSMENT OF WATER SOURCES

4.1 Groundwater Sources

4.1.1 Introduction

(1) Outline of Groundwater Study by the Study Team

The Study Team executed a groundwater study for the urban water supply source. This section details on existing groundwater uses, the review of the groundwater investigation report of Tokiman Paleochannel, the natural conditions of the study area, the result of test well construction, groundwater quality analysis, and evaluation of groundwater development potential in the study area. The groundwater study was carried out during October 2008 to April 2009. The items of the field survey for groundwater development in the study area are listed in Table 4.1.

Table 4.1 Groundwater Survey Item in the Study Area

Item	Survey site	Specification	Quantity
Geo-electrical survey	Tokiman Paleochannel	2D resistivity sounding ・ Pole-pole method ・ Wenner method	・ 800 m×4 lines ・ 800 m×1 line
Test well construction	Tokiman Paleochannel	Test Well drilling ・ >300 mm with 8 inch screen pipe	・ 50 m×1 well ・ 100 m×1 well ・ 200 m×1 well
		Observation well drilling ・ >300 mm with 4 inch screen pipe Electrical well logging Pumping test Water sampling	・ 50 m×2 wells ・ 450 m / 5 wells ・ 3 wells ・ 3 samples
Groundwater quality analysis	Tokiman Paleochannel	Laboratory test On site test	・ 11 samples/5 wells ・ 5 samples/5 wells
	Juba city and its surrounding area	Laboratory test On site test	・ 18 samples/18 wells ・ 89 samples/89 wells

(2) Land Use and Community

The Study Team organized Stakeholders' Meeting on November 21st and December 6th 2008, to discuss on approval of the use of the land for test well construction with the stakeholders. The participants were cooperative and constructive opinions were exchanged. The memorandums of meeting are attached in Annex A-2 of Appendix-A.

4.1.2 Review of Past Groundwater Surveys and Study Process of this Study

The result of the hydro-geological survey by IFRC (International Federation of Red Cross) in 2006 indicated that Tokiman Paleochannel may have high potential of groundwater development. Based on the review of the past groundwater studies, the flow of groundwater study by the Study Team are prepared in Figure 4.1.

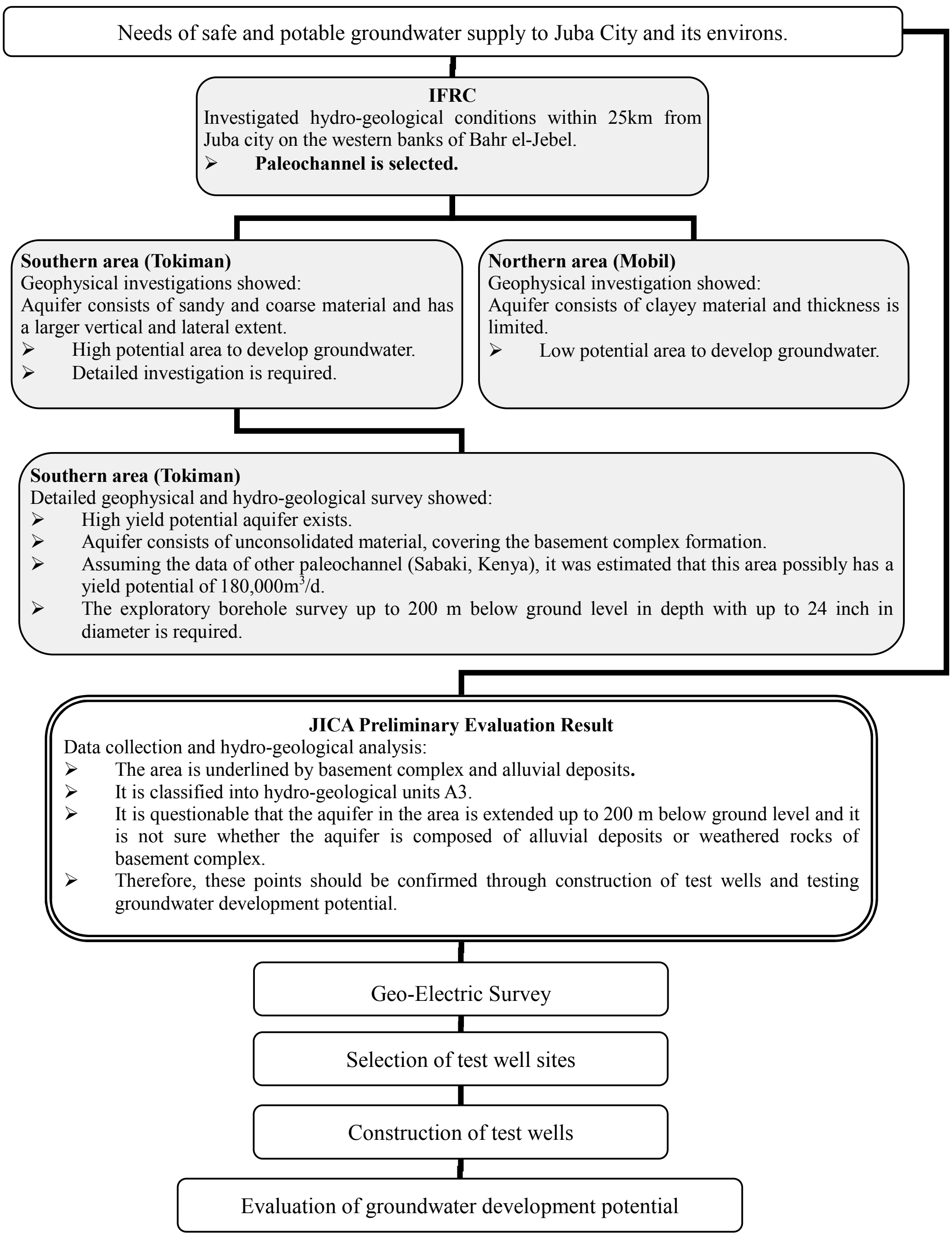


Figure 4.1 Flow of Groundwater Study

4.1.3 Review of Existing Well Data

On the basis of the existing well data, the present conditions of groundwater use in the Study Area are described as follows (see Table 4.2). Existing well data collected from Rural Water and Sanitation Department, MWRI. According to these data, a total of 439 wells are listed consisting of 417 wells in Juba Payam and 22 wells in Rejaf Payam. All wells are equipped with tube-well and hand-pump, and used for drinking and other domestic purposes. The type of wells such as shallow or deep tube-well cannot be identified in the list.

Table 4.2 Existing Well Data in the Study Area

Item	Juba Payam (1977-2008)	Rejaf Payam (1981-1986)	Total
1. Completion of Well			
Successful	292 (70 %)	14 (64 %)	306 (70 %)
Dry	125 (30 %)	8 (36 %)	133 (30 %)
Total	417 (100 %)	22 (100 %)	439 (100 %)
2. Well Yield (m^3/h)			
Max.	7.20	2.10	7.20
Min.	0.10	0.30	0.10
Ave.	1.67	1.16	1.67
3. Static Water Level (m bgl)			
Max.	42.29	21.0	42.29
Min.	1.20	5.80	1.20
Ave.	12.21	12.42	12.21
4. Depth (m bgl)			
Max.	84	93	93
Min.	15	27	15
Ave.	49	55	49

Source: Rural Water and Sanitation Department, MWRI

4.1.4 Natural Condition

(1) Location and Topography

Tokiman Paleochannel (Figure 4.2) is located in Rejaf Payam at about 10 km to the south of the center of Juba Town in the west bank of the Bahr el-Jebel and situated at about 460 m above sea level. Tokiman Paleochannel covers about 3.0 km^2 with about 3 km in length from north to south direction and about 1.0 km wide in east to west direction. The terrain of the paleochannel is supposed to be formed by alluvium of old and present rivers, due to change of river course. The ground level in the south-end of the area is about 3 m above the river surface, while in the north-end has the same level as the river.

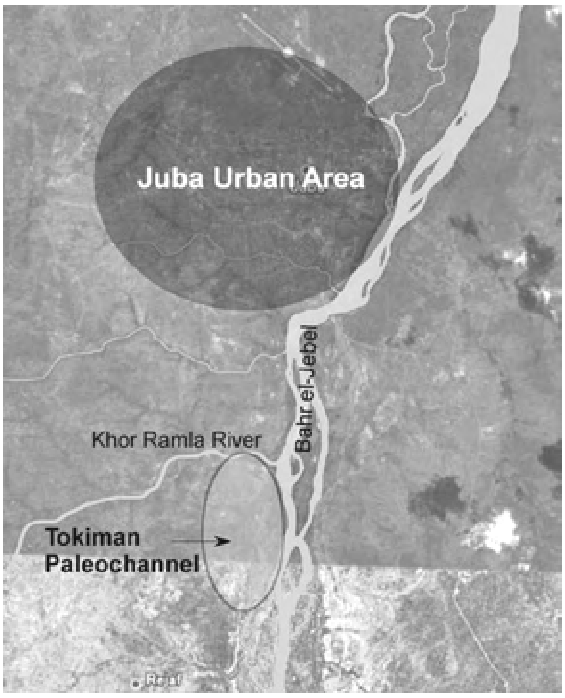


Figure 4.2 Location of Tokiman Paleochannel in Rejaf Payam

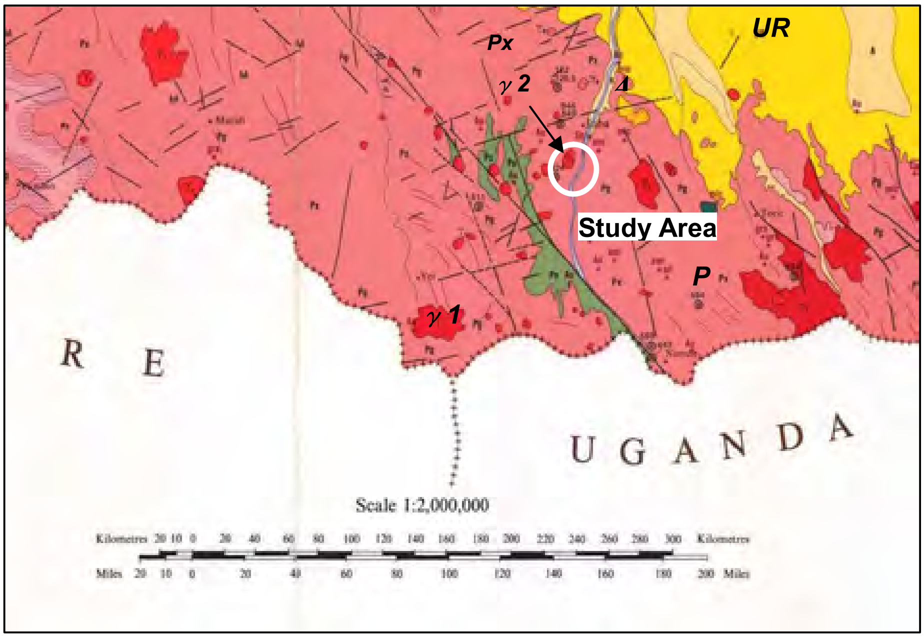
(2) Geology

The stratigraphic classification and the outline of general geology around Tokiman Paleochannel are shown in Table 4.3 and Figure 4.3. Tokiman Paleochannel and its surrounding area can be tectonically and geologically divided into two zones that consist of the alluvial deposits and the Undifferentiated Basement Complex. The alluvial deposit, un-conformably overlying the Undifferentiated Basement Complex, is extensively distributed in the area. The undifferentiated basement complex consists of metamorphic and intrusive rocks of various grades of metamorphism.

Table 4.3 Stratigraphic Classification of the Study Area

Geological age	Geological class	Geological formations
Quaternary (Recent)	A) Alluviums, wadi fills, terraces, delta and swamp deposits	Boulder, Gravel, sand and Silt-Clay
Upper - Lower Middle Proterozoic	Px) Undifferentiated Basement Complex Ps) Undifferentiated Schist Group Pg) Undifferentiated Gneiss Group	Ps) Meta-sediments, marble, quartzites, graphite and mica schists. Pg) Granitic gneisses, migmatites, charrockitic granites, amphibolites and pyroxene granulites.

Source; Geological Map of the Sudan (1981) Geological & Mineral Resources Development of Sudan



Source: Geological Map of the Sudan (1981) Geological & Mineral Resources Development of Sudan

Figure 4.3 Geological Map of the Study Area

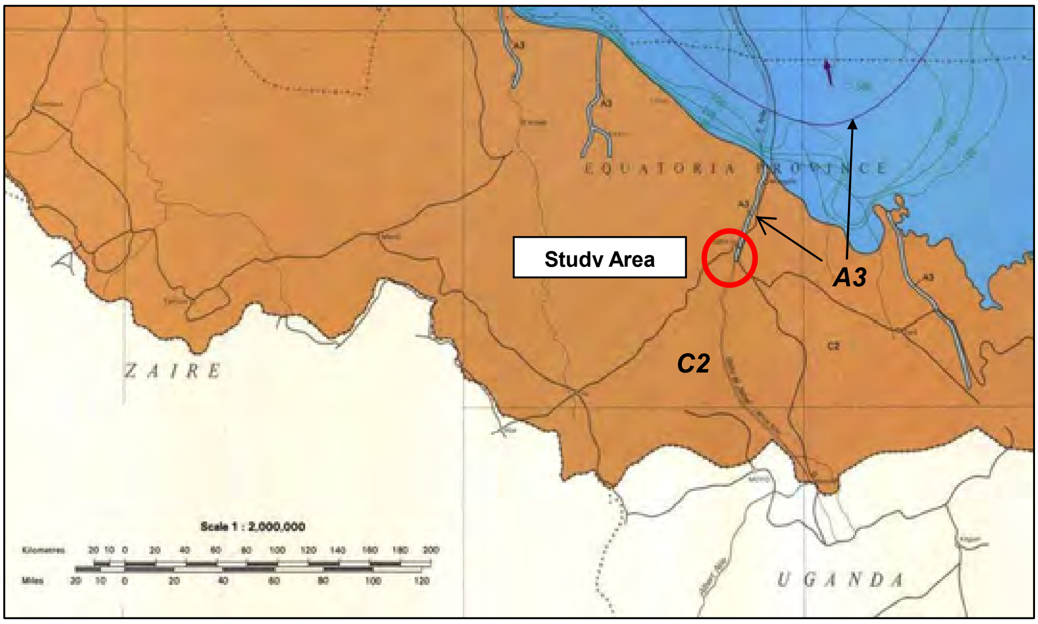
(3) Hydro-geology

According to the hydro-geological map of Southern Sudan, Tokiman Paleochannel is divided into two (2) main groups in terms of hydro-geological importance. Hydro-geological units of Southern Sudan relates between geology and groundwater development of the area. The units in the study area are shown in Table 4.4 and Figure 4.3. Tokiman Paleochannel is classified under A3 and C2 in the hydro-geological units. Feature of the units are summarized as follows (Hydro-geological Map of the Sudan, 1989):

Table 4.4 Clarification of Hydro-geological Units of Tokiman Paleochannel

Hydro-geological unit	Description
A3	Continuous or sub-continuous aquifers of local to sub regional extent, unconsolidated, saturated thickness generally small, permeability variable, water quality generally good, importance generally great and potential variable. Alluvium, Wadi fills and swamp deposits. Note: this unit has generally not been indicated on the map when underlain by unit A1 or A2.
C2	Rocks which are generally none water bearing. Water occurs in fractured or weathered zones. Local perched perennial or ephemeral aquifers may occur as well as thin saturated layers at depth. Hydro geological importance low. Potential very low. Undifferentiated Basement Complex, acid intrusions.

Source: Hydro-geological Map of the Sudan (1989) National Corporation of Rural Water Resources, Sudan



Source: Hydro-geological Map of the Sudan (1989) National Corporation of Rural Water Resources, Sudan.

Figure 4.4 Hydro-geological Map of the Study Area

4.1.5 Result of Test Well Construction

The Study Team constructed three (3) test wells and two (2) observation wells for investigation of geological conditions, potential yield and groundwater quality in Tokiman Paleochannel for planning as an alternative water source for Juba urban water supply.

The locations of test well construction site in the paleochannel were selected based on the result of electrical resistivity survey and are shown in Figure 4.5. Test Well 1 (T-1), Observation Well 1 (O-1) and Observation Well 2 (O-2) are located in the northern part of the paleochannel. Test Well 2(T-2) and Test Well 3 (T-3) are located in the southern part of the paleochannel.

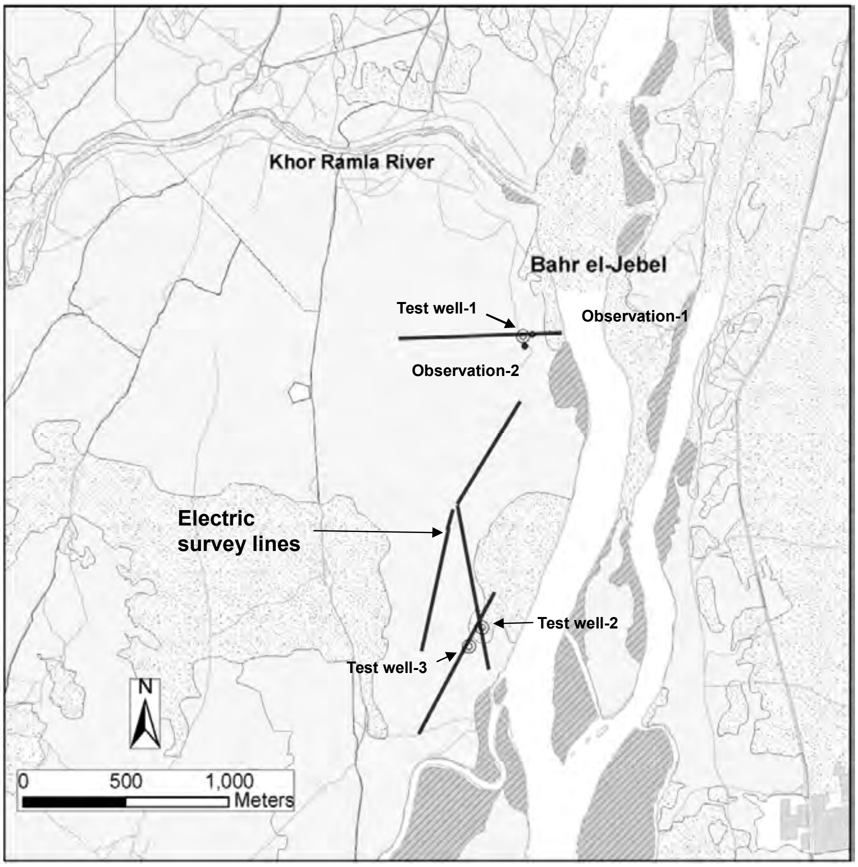


Figure 4.5 Location Map of Test Well Construction Sites in Tokiman Paleochannel

The well construction works consist of drilling, pumping tests, electrical logging and water sampling and analysis. The outline of the specification of test wells and observation wells is shown in Table 4.5.

Table 4.5 Investigation Items of Test Well and Observation Well

Well	Drilling depth	Electrical logging	Pumping test	Water sampling
Test Well-1	50m	・Electrical resistivity ・(long and short normal) ・Spontaneous Potential ・Natural Gamma	・Step drawdown test ・Constant rate test ・Recovery test	Two Samples
Test Well-2	200m			One Sample
Test Well-3	100m			One Sample
Observation Well-1	50m		・Water level measure only	-
Observation Well-2	50m			-

(1) Geological Feature of the Northern Part of Tokiman Paleochannel

The logs of test well and observation wells are attached in Annex A-3. On the basis of the lithological data of T-1, O-1 and O-2, the site can be divided into two geological classes: alluvial deposit and undifferentiated gneiss group. The geological feature of the drilling site and geological section of the northern part of the Paleochannel are shown in Table 4.6 and Figure 4.6, respectively.

The characteristic of aquifers of the site was estimated from the borehole logs of T-1, O-1 and O-2 presented in Annex A-3. Two major aquifers are identified and named as Aquifer 1 and Aquifer 2. Aquifer 1 is unconfined type and whereas Aquifer 2 is distributed in weathered zone and fracture zone of granitic gneiss.

Table 4.6 Geological Feature of Northern Part of Tokiman Paleochannel

Geological class	Geological formation	Aquifer	Groundwater
Alluvial deposit	・Top Soil ・Fine to medium Sand ・Medium to coarse Sand	Aquifer 1	Static water level: 2.4 m-2.6 m.
Undifferentiated Gneiss Group	・Weathered Gneiss ・Slightly weathered Gneiss	Aquifer 2	Distributed along the boundary of Aquifer 1.
	・Granitic fine Gneiss ・Schist (T-1 only)		Distributed in a fracture zone

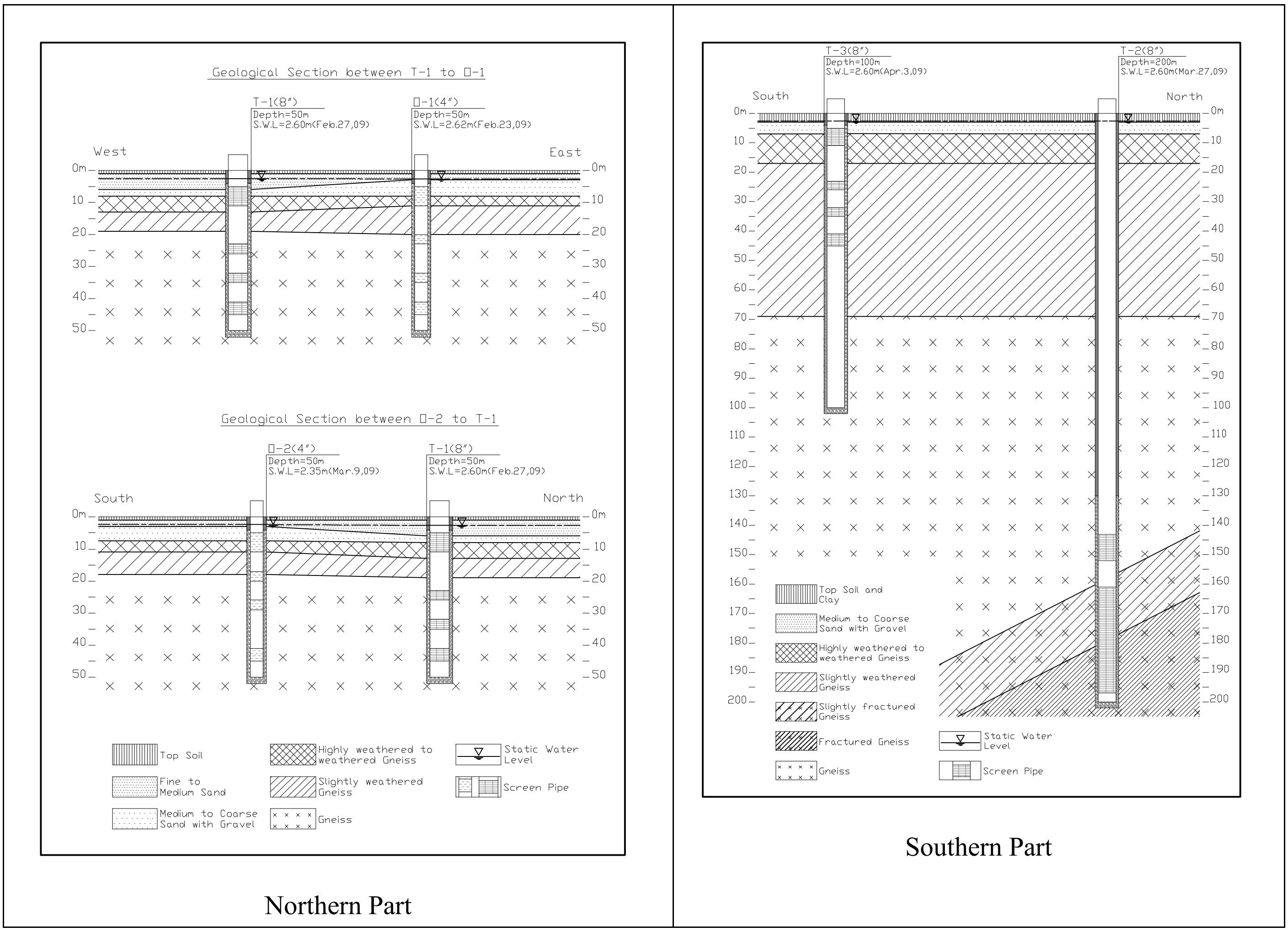


Figure 4.6 Geological Section of of Tokiman Paleochannel

(2) Geological Feature of the Southern Part of Tokiman Paleochannel

The geological section of the southern part of the paleochannel is shown in Figure 4.6. On the basis of the lithological data of T-2 and T-3, the site can be divided into two geological classes: alluvial deposit and undifferentiated gneiss group. Geological feature of the drilling site is shown in Table 4.7.

The southern part of the paleochannel is underlain by alluvial deposit which un-conformably overlies gneiss of undifferentiated gneiss group. There can be found extensive fracture zones at about 150 m below the ground in gneiss.

The characteristic of the aquifers of the site is estimated from the borehole log of T-2 and T-3 presented in the Annex A-3. Three major aquifers are identified and named as Aquifer 1, Aquifer 2 and Aquifer 3. Aquifer 1 and Aquifer 2 are unconfined type and whereas Aquifer 3 is distributed in fracture zone of granitic gneiss and is of confined type.

Table 4.7 Geological Feature of Southern Part of Tokiman Paleochannel

Geological class	Geological formation	Aquifer	Groundwater
Alluvial deposit	Top Soil Medium to coarse Sand	Aquifer 1	Statistic water level: 4.7m
Undifferentiated Gneiss Group	Highly weathered Gneiss Weathered Gneiss Slightly weathered Gneiss	Aquifer 2	Distributed along the boundary of Aquifer 1 and fracture zone
	Slightly fractured Gneiss Fractured Gneiss	Aquifer 3	Distributed in a fracture zone

4.1.6 Groundwater Quality Analysis

Water quality of the samples collected from test wells and existing wells was analyzed in laboratories and field kit and results were compared with the WHO guidelines (WHOGDW) and draft Southern Sudan guidelines (DSSGDW)for drinking water quality.

(1) Result of Water Quality of Test Wells

Results of water quality analysis of the water samples of three test wells in Tokiman Paleochannel are described below and the laboratory test result is tabulated in Table 4.8.

Aquifer	Comparison with the guideline values
1) Aquifer 1	• Water color changed to light brown after 2 or 3 minutes of pumping. • Antimony (Sb), Manganese (Mn), Sodium (Na) and TDS exceed the guideline values.
2) Aquifer 2	• Antimony (Sb), Iron (Fe), and Nitrite (NO_2) slightly exceeds the guideline value
3) Aquifer 3	• Electrical conductivity (EC), Salinity, Antimony (Sb), Chloride (Cr), Nitrate (NO_3), Sodium (Na), Sulfate, TDS exceed the guideline values.

Table 4.8 Laboratory Test Result of Groundwater Quality of Test Wells

Parameter	**WHO GV (mg/l)**	**Draft SS GV (mg/l)**	Test Well 1 (Aquifer 1)	Test Well 2 (Aquifer 3)	Test Well 3 (Aquifer 2)
Aluminum (Al)	0.1-0.2	**0.2**	0.10	0.10	0.05
Ammonia (NH_4)	NS	**NS**	0.01	0.4	0.3
Antimony (Sb)	0.02	**0.005**	0.01	0.01	0.01
Arsenic (As)	0.01	**0.05**	Nil	Nil	Nil
Barium (Ba)	0.7	**0.7**	Nil	Nil	Nil
Boron (B)	0.5	**0.5**	Nil	Nil	Nil
Cadmium (Cd)	0.003	**0.003 - 0.005**	Nil	Nil	Nil
Chloride (Cl)	250	**200**	26	410	26
Chromium (Cr)	0.05	**0.05**	Nil	Nil	Nil
Copper (Cu)	2	**1.5**	Nil	Nil	Nil
Cyanide (CN_2)	0.07	**0.05**	Nil	Nil	Nil
Fluoride (F)	1.5	**1**	0.1	0.52	0.39
Hardness	200	**200**	32	660	120
Hydrogen Sulfide	NS	**NS**	0.1	1	0.2
Iron (Fe)	0.3	**0.5**	2.96	0.02	0.52
Manganese (Mn)	0.4	**0.4**	1.2	0.08	0.06
Lead (Pb)	0.01	**0.01**	Nil	Nil	Nil
Mercury (Hg)	0.006	**0.006**	Nil	Nil	Nil
Molybdenum (Mo)	0.07	**0.07**	Nil	Nil	Nil
Nickel (Ni)	0.07	**0.07**	Nil	Nil	Nil
Nitrate (NO_3)	50	**30**	4.1	5.2	1.3
Nitrite (NO_2)	3	**0.5**	0.25	0.01	0.59
Selenium (Se)	0.01	**0.01**	Nil	Nil	Nil
Sodium (Na)	NS	**100**	488	775	20
Sulfate	250	**200**	0.3	491	7.8
TDS	600	**1,000**	1,358	3,677	197
Zinc (Zn)	3	**3**	0.02	0.04	0.02

Note : SS GV*; UNICEF draft proposal of Southern Sudan water quality guidelines value (Oct. 2008)
Test by Central Water Testing Laboratories of Ministry of Water and Irrigation of Republic of Kenya.
Colored cells indicate the parameter exceeds the guideline values.

(2) Result of Existing Wells

1) Laboratory Test

18 existing wells were selected over the Study Area and the water samples collected from these wells through hand-pump were analyzed by Central Water Testing Laboratories of Ministry of Water and

Irrigation of Republic of Kenya. The result of laboratory test and location map of 18 existing wells is shown in Annex A.5. According to the result, seven (7) parameters exceed the guideline values and the detailed are shown in Table 4.9.

Table 4.9 Results of Water Quality of Existing Wells

Parameter	Nos of samples exceeded	Comparison results
Antimony (Sb)	1 (5.6%)	One sample (0.01 mg/l) at JP001 in MADARA village, JUBA NABARI Boma, JUBA Payam exceeds the guideline value (0.005 mg/l).
Chloride(Cl)	3 (16.7%)	Chloride values range from 3 to 405 mg/l with an average of 117 mg/l. 16.7% of the samples exceed the guideline value (200 mg/l).
Fluoride (F)	2 (11.1%)	Fluoride values range from 0.25 to 1.6 mg/l with an average level of 0.54 mg/l. 11.1% of the samples exceed the guideline value (1 mg/l).
Nitrate (NO_3)	3 (16.7%)	Nitrate values range from 0.12 to 260 mg/l with an average of 38 mg/l. 16.7% of the samples exceed the guideline value (30 mg/l).
Nitrite (NO_2)	1 (5.6%)	One sample (0.62 mg/l) at MP093 in Munuki Payam exceeds the guideline value (0.5 mg/l).
Sodium (Na)	14 (77.8%)	Sodium values range from 35.5 to 754 mg/l with an average of 235 mg/l. 77.8% (14/18) of the samples exceed the guideline value (100 mg/l).
TDS	4 (22.2%)	TDS values range from 369 to 2,300 mg/l with an average of 969 mg/l. 22.2% of the samples exceed the guideline value (1,000 mg/l).
E coli.	14/18(78%)	78 % of the collected samples show the presence of Escherichia coli.

2) On-site Test Result of Existing Wells by Field Kit

On-site test was carried out for 89 existing wells over the Study Area using field kit. The parameters analyzed were pH, EC, TDS, salinity, color, odor and taste. The results of water quality analysis are summarized in Table 4.10. Almost half of the samples exceed the DSSGV in terms of EC, TDS, odor and taste. The taste of these high TSD samples is mainly salty.

Table 4.10 Summary of Groundwater Quality On-Site Analysis Result for Existing Wells

Item	Draft Southern Sudan Guideline Value						
	pH	EC	TDS (mg/L)	Salinity (mg/L)	Color (NTUs)	Odor	Taste
	6.0－8.5	150 mS/m	≦1,000	－	≦15	acceptable	acceptable
Nos of samples exceeding the GV	0 (0%)	38 (43%)	38 (43%)	0 (0%)	2 (2%)	0 (0%)	38 (43%)

4.1.7 Groundwater Development Potential

(1) Hydro-geology of Tokiman Paleochannel

As a result of the ground water study in Tokiman Paleochannel, the groundwater in the area is distributed in Aquifer 1, Aquifer 2 and Aquifer 3. Groundwater distribution and the relationship with geology are summarized in Table 4.11.

Table 4.11 Groundwater Distribution in Tokiman Paleochannel

Aquifer	Distribution	Hydrogeology
Aquifer 1	• From 1 m to about 8 m below the ground. • Extensively distributed in the entire area.	• Consists of alluvial deposits mainly sandy material. • Groundwater level can be observed at the depth of 2 m to 5 m below the ground. • Un-confined groundwater.
Aquifer 2	• About 8 m to 20 m below the ground in the northern part. • About 8 m to 70 m below the ground in southern part.	• Consists of mainly weathered gneiss. • Groundwater distributed along the boundary of Aquifer 1 and weathered zone or fracture zone of gneiss. • Groundwater is confined type and fissure water.
Aquifer 3	• About 160 m to more than 200 m below the ground. • Distributed in the southern part.	• Consists of fractured gneiss. • Confined groundwater. • This groundwater might be locally existed in the area.

Figure 4.7 shows schematic hydro-geological section between Test Well 1 and the Bahr el-Jebel in the northern part of Tokiman Paleochannel. Groundwater level in the area is higher than the water level of the river in the dry season. This characteristic of groundwater table indicates groundwater in the area recharge to the Bahr el-Jebel.

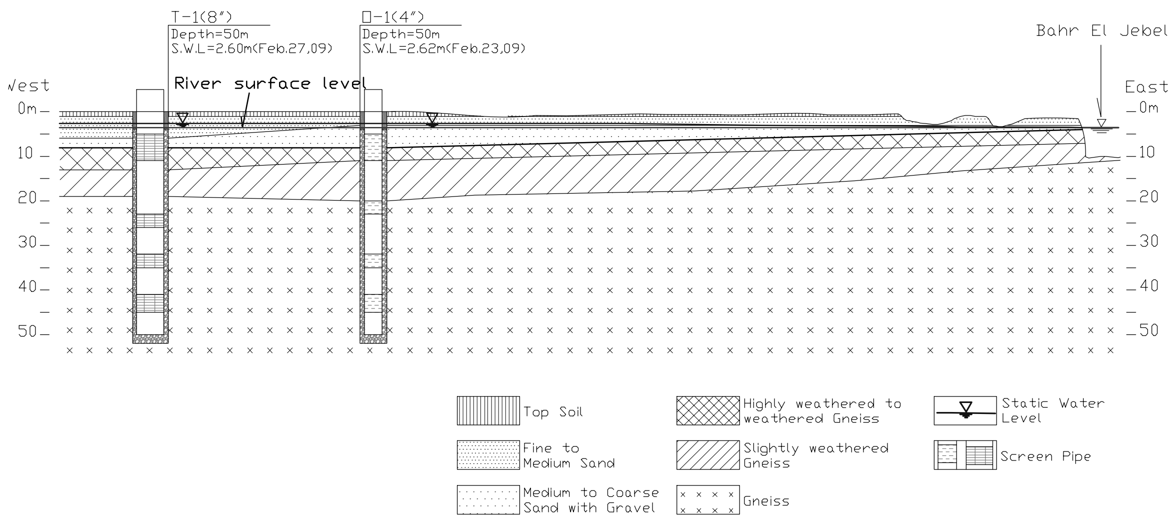


Figure 4.7 Schematic Hydro-geological Section between Test Well 1 and the Bahr el-Jebel

(2) Groundwater Development Potential

Following main points have been found in the Study.

- There is no such aquifer that has thickness of more than 150 m and consists of alluvial deposits with high potential of groundwater discharge directly connected to the Bahr el-Jebel.
- Groundwater is distributed into three types of aquifer in the area.

- Unconfined type of groundwater is distributed into Aquifer 1 in alluvial deposits and low amount of water exists in Aquifer 2 in weathered zone or fractured zone of gneiss.
- Fissure water exists in Aquifer 3 in fractured zone that has confined type of groundwater.
- Iron, Manganese, Antimony, Sodium and TDS in groundwater in Aquifer 1 exceed the guideline values and the color of groundwater is reddish brown.
- Iron, Antimony and Nitrate in groundwater of Aquifer 2 exceed the guideline values.
- Electrical conductivity (EC), Antimony, Chloride, Hardness, Nitrate, Sodium, Sulfate and TDS in groundwater of Aquifer 3 exceed the guideline values.

Groundwater development potential of Tokiman Paleochannel is summaried in Table 4.12. The yield of the groundwater in Tokiman Paleochannel is very low and the water quality is totally not suitable for human consumption in the aquifer 1 and 3 as it exceeds the guideline values to a large degree. As a result, in general, the groundwater is not recommended as water source for urban water supply due to low yield and unsuitable water quality.

Table 4.12 Groundwater Development Potential of Tokiman Paleochannel

Aquifer	Aquifer 1	Aquifer 2	Aquifer 3
Groundwater type	Unconfined groundwater	Confined groundwater and fissure water	Unconfined groundwater and fissure water
Capacity	Q = 230 l/min T = 5.64E^{-03} m^2/sec k = 1.15 E^{-01} cm/sec s = 9.49E^{-10}	Q = 30 l/min T = 3.32E^{-04} m^2/sec k = 6.10E^{-03} cm/sec s = 3.45E^{-08}	Q = 220 l/min T = 3.52E^{-05} m^2/sec k = 7.04E^{-04} cm/sec s = 1.72E^{-01}
Groundwater quality	Iron, Manganese, Antimony, Sodium and TDS value exceeds the guideline value.	Iron, Antimony and Nitrate value exceeds the guideline value.	Conductivity, Antimony, Chloride, Hardness, Nitrate, Sodium, Sulfate and TDS value exceeds the guideline value.

Note: Q (Critical Discharge), T (Transmissivity), k (Hydraulic conductivity), s (Storage coefficient)

4.2 Surface Water Source

4.2.1 Purpose of Evaluation of Surface Water Source

The proposed source of water supply for the study area is the surface water from the Bahr el-Jebel in Juba area. The purpose of assessment of surface water source includes the followings:

- Selection of proposed intake site
- Designing of water treatment plant including intake facility
- Suitability of surface water as drinking water source for Juba in terms of quantity and quality

For this purposes, the following data have been collected:

- Variation of flow rate of the River, especially, minimum flow rate
- Variation of water level in the River, and
- Water quality of the river

4.2.2 Overview of the Bahr el-Jebel

The Bahr el-Jebel ("River of the Mountain", sometimes Mountain Nile) passes through Juba. The river is a main tributary of the White Nile, which is one of the two main tributaries of the Nile, the other being the Blue Nile. In the strict meaning, "White Nile" refers to the river formed at Lake No at the confluence of the Bahr el-Jebel and the Bahr el Ghazal rivers. In the wider sense, "White Nile" refers to the approximately 3,700 kilometers of rivers draining from Lake Victoria into the White Nile proper.

The White Nile River originating from Lake Victoria is known as the Victoria Nile. It flows north and westwards through Uganda, feeding into Lake Kyoga in the center of the country and then out towards west. The river flows into Lake Albert opposite the Blue Mountains in the Democratic Republic of the Congo. The river exiting Lake Albert to the north is known as the Albert Nile.

The river then continues north to Nimule where it enters Sudan and is commonly known as the Bahr el-Jebel. The river then winds through rapids before entering the Sudan plain and the vast swamp of the Sudd. It eventually makes its way to Lake No, where it merges with the Bahr el Ghazal and forms the White Nile. A branch of the river called the Bahr el Zeraf flows out of the Bahr el-Jebel and flows through the Sudd to eventually join the White Nile. The river merges with the larger Blue Nile at Khartoum, and thereafter it is called the Nile. Juba is the southernmost navigable point on the Nile river system.

The flow rate of the Bahr el-Jebel at Juba was measured by Dam Implementation Unit (DIU) from January 2008. According to this data, the maximum flow in 2008 is 1,742 m^3/s in August and the minimum flow is 1,125 m^3/s in April.

4.2.3 Flow Characteristics of the Bahr el-Jebel

The river flow rates have been measured by Dam Implementation Unit (DIU), Juba Branch, Government of Sudan since January 2008, for the purpose of dam construction, and the periodical measurement is continued. In Juba, the location of measurement (monitoring point) is upstream of Juba Bridge where the river has the narrowest stretch. The DIU uses Acoustic Doppler Current Profiler (ADCP) for flow measurement. The Study Team collected 45 measured river flow data at the Juba monitoring point after the start of the measurement.

The ADCP data collected is tabulated in Appendix-B and is shown in Figure 4.8. Table 4.13 summarizes the data of the minimum and maximum flow. The minimum and maximum flow rates during this period are 1,125 m^3/s or 97.2 million m^3/d and 1,742 m^3/s or 150.5 million m^3/d, respectively. The depth of the river ranges between 4.0 m to 6.5 m from the bed.

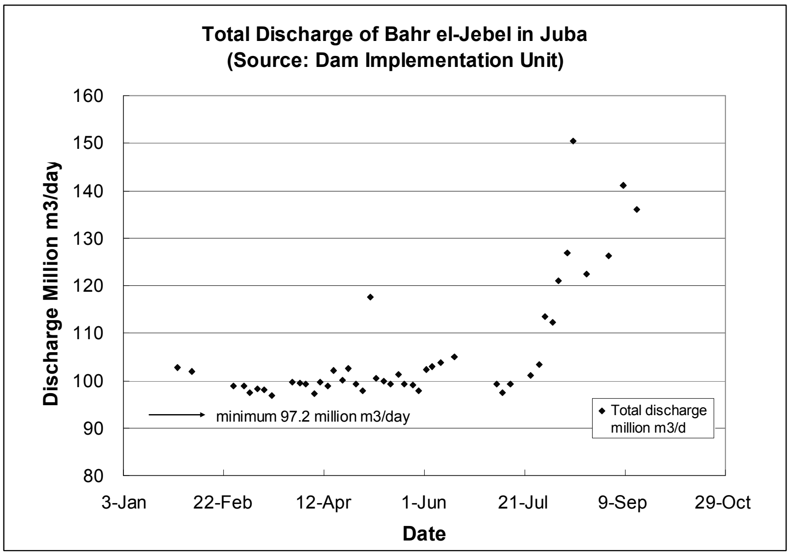


Figure 4.8 Total Discharge Rate of Bahr el-Jebel in 2008

Table 4.13River Flow Data of the Minimum and Maximum Flows

Date	Surface width m	Section area m^2	Mean velocity m/s	Max velocity m/s	Mean depth m	Max depth m	Adjusted mean gauge m	Total discharge m^3/s	Total discharge million m^3/d
7-Apr	260	1148	1.07	2.07	4.04	5.28	12.29	1125	97.20
14-Aug	257	1269	1.37	2.19	4.93	6.54	13.03	1742	150.51

Source: Dam Implementation Unit (DIU)

Additionally, following data was collected to understand the historical water levels of the river.

- Daily water levels
  - ✧ in the high flow year (1963 and 1964)
  - ✧ in the average flow year (1973)
  - ✧ in the low flow year (1982)
- Daily water levels in 2007 and 2008

Figure 4.9 shows a historical water level in the Bahr el-Jebel. The highest and lowest water levels were 16.5 m in 1964 and 12.38 m in 1982. The water levels in average flow year range between 14.16 m and 13.22 m.

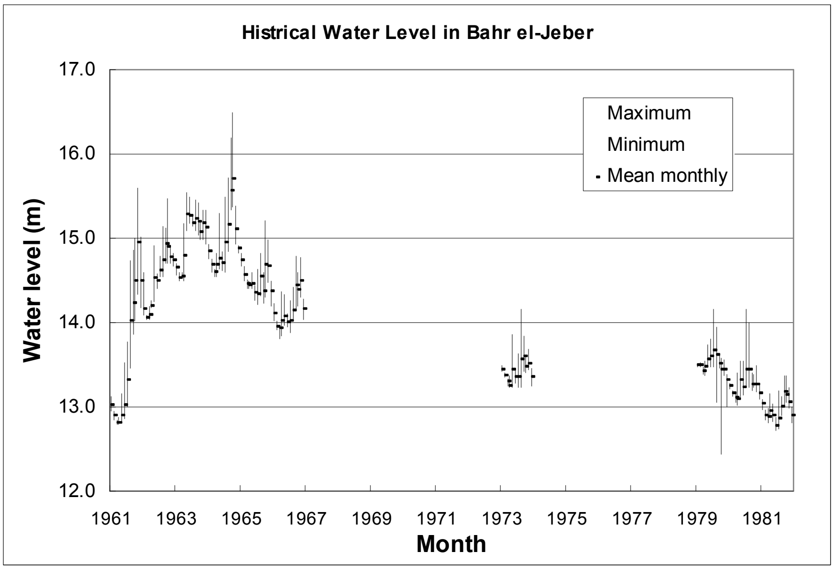


Figure 4.9 Historical Water Level in the Bahr el-Jebel

Figure 4.10 shows the daily fluctuation of water level in 2007 to 2009. The lowest and highest water levels are approximately 12 m and 14 m, respectively. Comparing the historical water levels, the recent water levels have been declining.

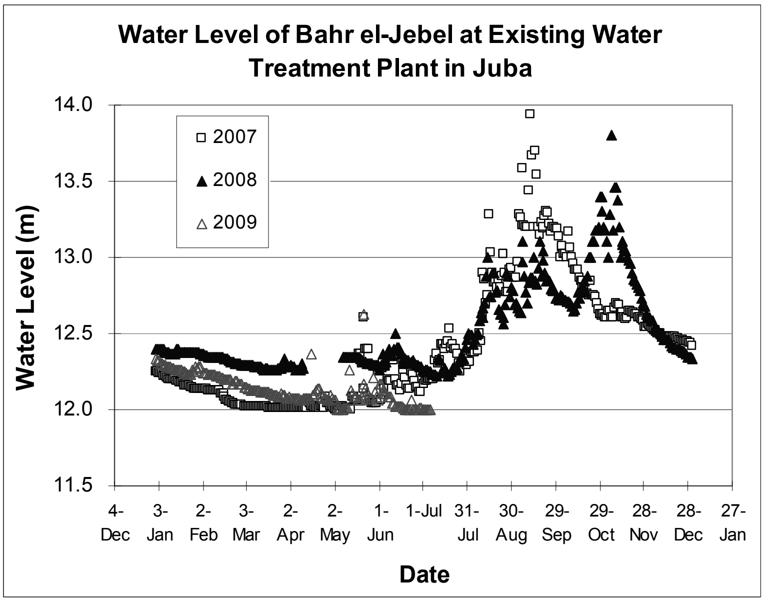


Figure 4.10 Water Level of the Bahr el-Jebel at Location near Existing Water Treatment Plant

4.2.4 Impact of Surface Water Intake

As estimated in Chapter 1 of Part II Master Plan, the water demand of target Service Area in 2025 is estimated as 237,000 m^3/d. This amount is equivalent to 0.25 % of 97.2 million m^3/d, the lowest flow rate of the river for year 2008. Compared to the quantity of water withdrawal from river for human consumption, the river flow rate is a huge quantity. Therefore, the water intake for water supply to Juba will cause negligible impact on the river flow.

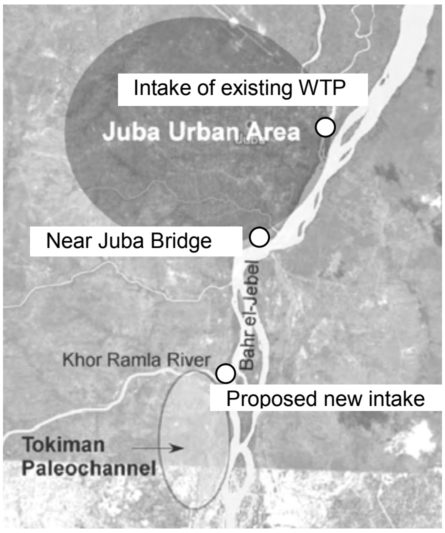
4.2.5 Water Quality of Surface Water

(1) Sampling Points

Water sampling from surface water of the Bahr el-Jebel was carried out at 3 locations to assess the suitability of the sources as drinking water source and water quality analysis was carried out in laboratories and using field test kit. The following are sampling points.

1) Tributary of the Bahr el-Jebel (Juba Channel) at existing water treatment plant intake
2) The Bahr el-Jebel near Juba Bridge
3) The Bahr el-Jebel upstream of Juba Urbane Area at Tokiman (Proposed new water treatment site)

The detail contents of water quality analysis are given in Appendix-B.



(2) Results of Water Quality Analysis

The results of water quality analysis for the samples collected in the several months including rainy and dry seasons along with the guideline values of WHO and Southern Sudan (draft) for drinking water quality are given in Appendix-B.

In general, the qualities of surface water at 3 sampling points indicate that the water is good as a source for conventional water treatment.

The following table shows comparison of the WHO and draft Southern Sudan guidelines for drinking water quality with the results of water quality analysis for samples in several months. In terms of the result of rainy season sample in October in 2008, the following parameters exceed the guidelines.

- Aluminum at all 3 sites
- Antimony at the existing water treatment plant sites
- Iron at the existing water treatment sites

Table 4.14 Results of Water Quality Analysis

(mg/l)

Parameter	WHO GV	Draft SS GV	Existing WTP				Near Juba Bridge		Proposed new intake		
			Oct. 2008	Feb. 2009	Jul. 2009	Jul. 2009	Oct. 2008	Feb. 2009	Oct. 2009	Feb. 2009	Jul. 2009
			Raw water			Treated water	Raw water		Raw water		
Aluminum	0.1-0.2	0.2	**0.40**	0.2	0.05	0.02	**0.62**	0.05	**0.52**	0.05	0.02
Antimony	0.02	0.005	**0.06**	**0.01**	**0.01**	**0.01**	Nil	Nil	Nil	Nil	Nil
Iron	0.3	0.5	**0.60**	0.28	0.35	0.14	0.48	0.22	0.48	0.24	0.42

Note: GV: guideline values

The concentration levels of aluminum and iron could be reduced below the guideline values after conventional water treatment with using coagulation, sedimentation and rapid filtration.

In terms of the dry season results, only antimony exceeds at existing water treatment site. Comparing with the WHO guidelines, however, Antimony in the dry season is below the guideline value. Water quality in the dry season is better than that in the rainy season. Possibly, excessive Aluminum and Iron contents could originate from washout of soil in the rainy season. It is recommended that these three parameters be monitored periodically and treatability of these parameters be assessed.

As a reference, a water sample from the existing water treatment plant site in May 2008 was collected and Antimony was analyzed in Tokyo, Japan. The result is below 0.005 mg/l.

As of microbiological parameters, total coliforms are 500 – 1100 count/ml. Based on the river classification in terms of water quality in Japan, this level of total coliforms is classified as Class A and is categorized as a good source of drinking water using conventional water treatment.

The concentration of agro-chemicals analyzed was below the detectable level and pollution by agro-chemical cannot be identified in surface water samples analyzed in this Study.

CHAPTER 5 EXISTING WATER SUPPLY CONDITIONS

5.1 Existing Condition of Water Supply Service

(1) Type of Water Supply Service in the Study Area

In the Study Area, the following types of water supply services are used by the residents. The present conditions of each service are briefly explained as below.

- Water supply by house connection (UWC)
- Water supply by public tap (UWC: water source is piped water)
- Public well equipped with hand pump
- Water venders
  - ✧ Water tanker
  - ✧ Jerry can vender by bicycle
- Private well

(2) Water Supply House Connection through Pipe (UWC)

Raw water for water treatment plant is taken from the Bahr el-Jebel and the treated water is distributed through distribution network. The existing production capacity of the old treatment plant is estimated to be 3,500m^3/d. The detailed conditions of existing facilities are described in the following chapter. Assuming the leakage ratio of 40 %, the average per capita consumption is 30 L/c/d, as 30 % of the treated water is supplied to non-domestic users, and the serviced population is estimated to be 49,000 persons. The existing water supply facilities are shown in Figure 5.1.

(3) Public Well Equipped with Pubic Tap

Public wells were constructed mainly by UNICEF and NGOs. There are approximately more than 400 public wells spread over the urbanized area as shown in Figure 5.2. Out of these wells, 150 wells are in good operational condition, and the others have minor or major facility problems in structure and equipment. These structural problems attribute to the lack of maintenance. There is a concern in the quality of well water as drinking water due to high salinity. The quantity of well water is limited and production is reduced in the dry season. People tend to use water from venders (water tanker and jerry can) who take water from the river due to the factors including inconvenience in terms of far location of public wells, long waiting time in queue, high salinity of well water, even in cases when these wells are accessible, etc. Total serviced population is estimated to be 210,000 through the inventory survey of Louis Berger Group. Assuming 70 % of wells are operational, the actual service population is 147,000 persons.

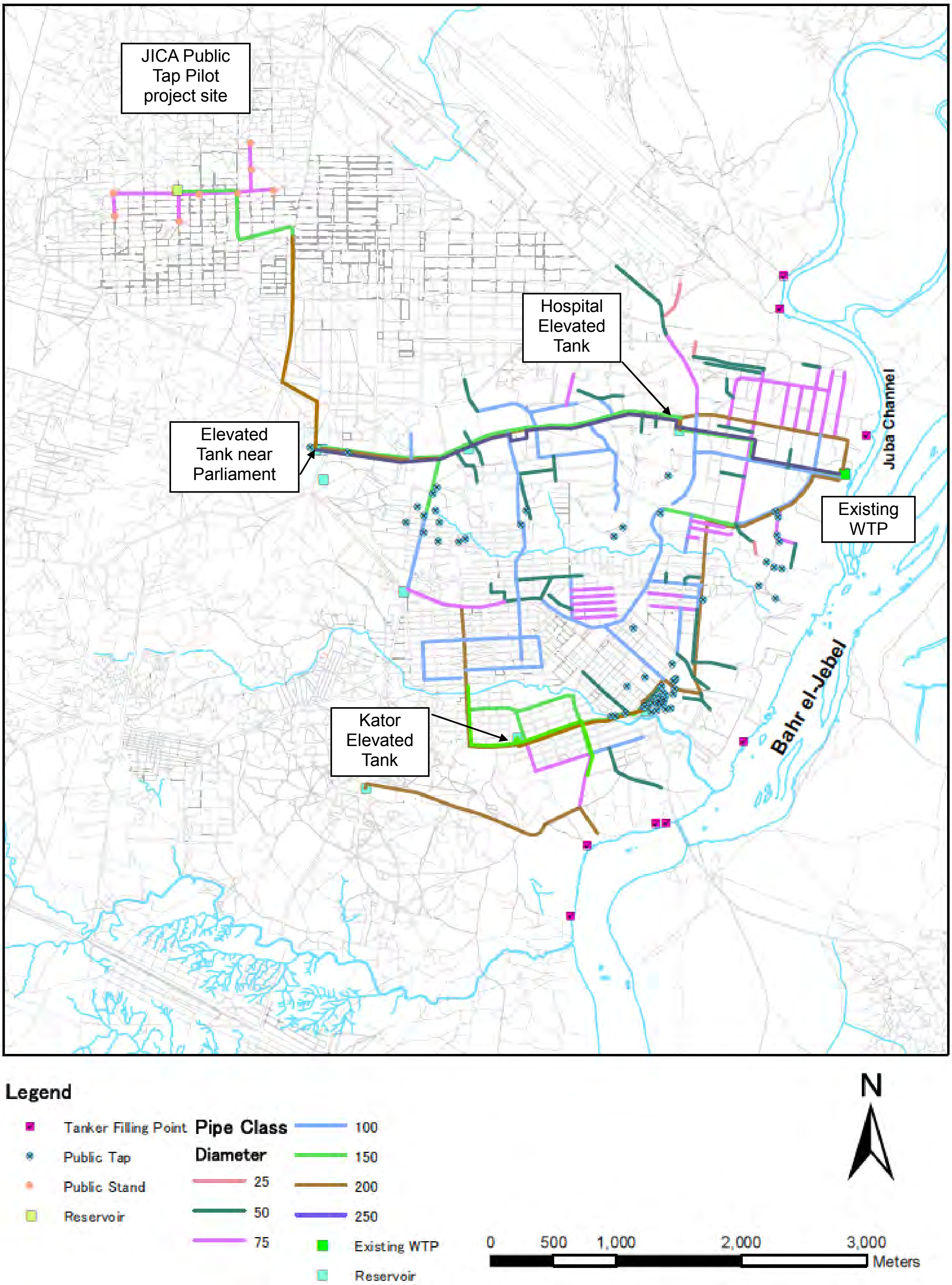


Figure 5.1 Existing Water Supply Facilities and Water Intake Station of Water Venders

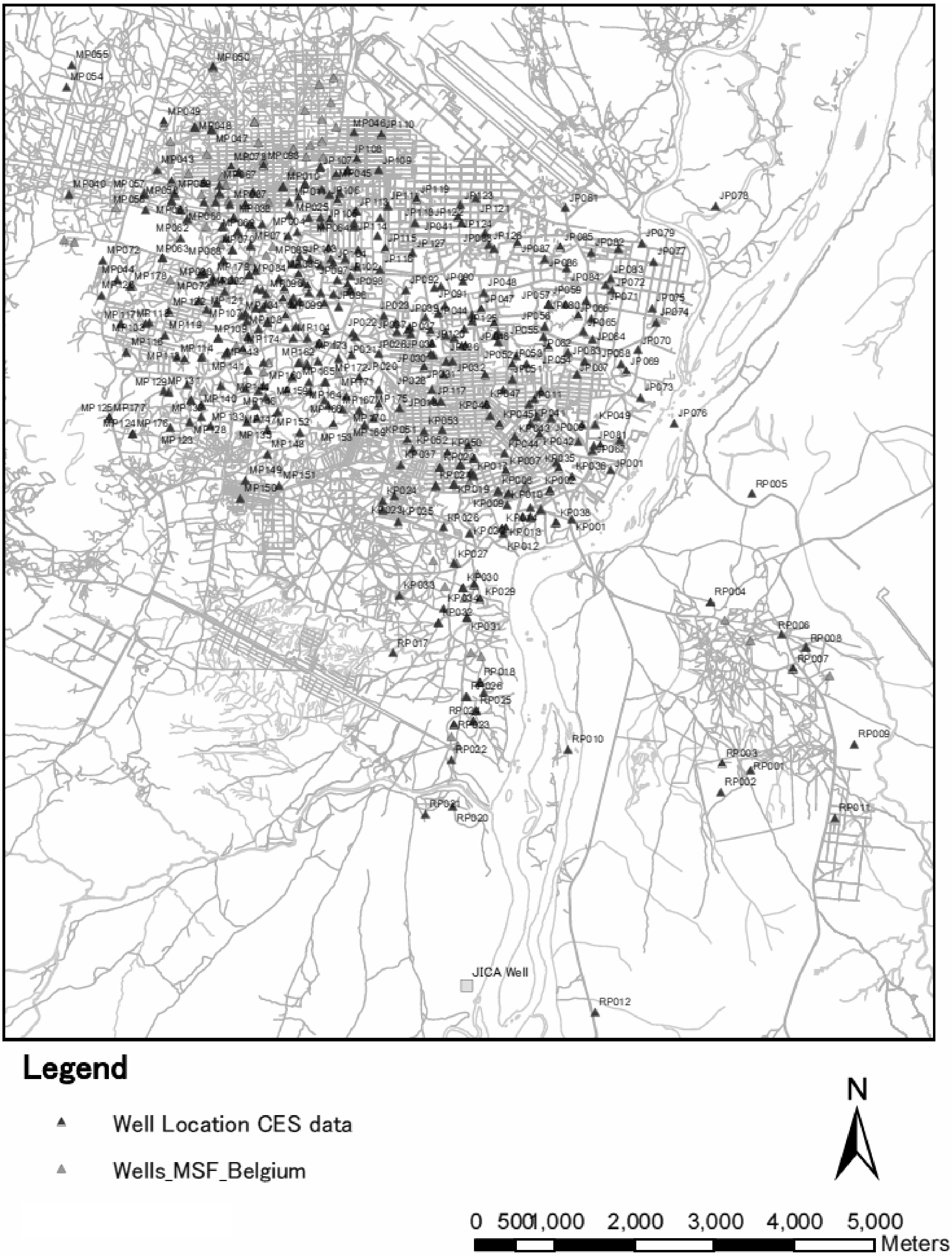


Figure 5.2 Location of Public Wells

(4) Water Tanker

There are seven intake pumping station locations for water tankers along the western bank of the Bahr el-Jebel as shown in Figure 5.1. At these stations, raw river water is directly filled into water tanker using engine pump and chlorine provided by USAID fund is injected into tank for disinfection. The chlorination is managed by a NGO. These water tankers are operated by the private sectors. The quality of water distributed by the water tankers is not assured by any adequate regulation.

Water tanker venders carry water to large number of consumers and to the areas where jerry can venders using bicycles are not accessible because of long distance from the river intake. The capacity of these tanks is 4 m^3 or 5 m^3. The price of water pumped is 10 SDG per 4 m^3 tanker and 12.5 SDG per 5 m^3 tanker. The venders of water tanker sell the water at a price of 5 to 10 SDG per 200 L drum depending on the distance from the river intake station.

The daily average number of water tankers chlorinated is shown in Figure 5.3. Daily 400 to 650 water tankers take chlorinated water for selling at 7 stations. Therefore, sold water volume is estimated to be between 1,600m^3/d to 2,400 m^3/d. Assuming that the average per capita consumption is 30 L/c/d and 80 % of the water is supplied to the residents, the serviced population by water tanker is estimated to be 64,000 persons.

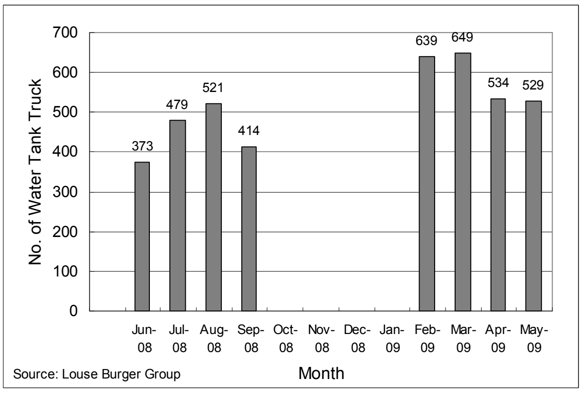


Figure 5.3 Daily Average Number of Water Tankers Chlorinated

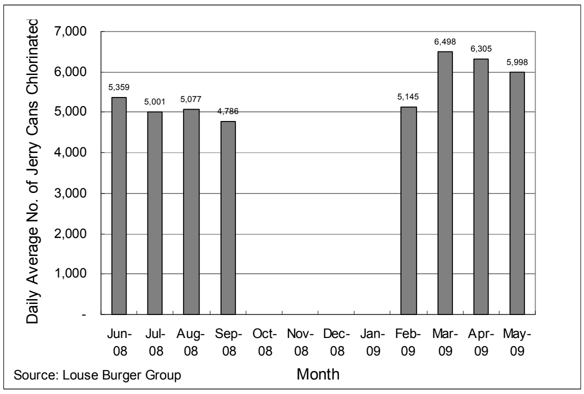


Figure 5.4 Daily Average Number of Jerry Cans Chlorinated

(5) Jerry Can Venders

The daily average number of jerry cans chlorinated is shown in Figure 5.4. All along the river, fetching water by 20 liter jerry cans is a common practice. There are three stations along the western bank of the river as shown in Figure 5.1, where chlorine provided by USAID is added. Most of the venders carry eight jerry cans (160 kg) by bicycles at a time. These sites are managed by a NGO.

The supply area of jerry can venders is limited to the areas close to the river. At 3 stations, 5,000 – 6,500 jerry cans are filled in a day and the supply amount is calculated as 100 to 135 m^3/d. Assuming that the average water consumption per capita is 10 L/c/d, the serviced population is estimated to be 10,000 to 13,500 persons.

(6) Overall Water Supply Scheme

The overall water supply scheme in the Juba urban area and population coverage estimate is summarized in Table 5.1. According to this estimate, 56 % of the population is supplied by public wells; the highest coverage. The coverage of the piped water supply service by UWC is 13 %.

Table 5.1 Estimated Overall Water Supply Scheme in Juba

Type	Description of water supply and assumptions for estimation of supply capacity and service population	Approx. estimated net supply for domestic users (m^3/d)	Estimated service population	Ratio
Water supply by pipe (UWC)	Before the inauguration of MDTF project in May 2009			
	• The source of water is the river. • The capacity of WTP was estimated as 3,500 m^3/d. • Old WTP was not functioned and treated water was not drinkable. • Service population was estimated using 26 L/c/d (JICA household survey), 50% of effective water rate and half volume supplied for domestic users.	875 (1,750 for all users)	34,000	13%
	After the inauguration of MDTF project in May 2009			
	• The capacity of WTP is 7,200m^3/d. • The service population is assumed same as before completion of rehabilitation of WTP. • The estimated per capita consumption is 53 L/c/d.	1,800 (3,600 for all users)	34,000	13 %
Public well	• The source of water is groundwater. • The water in many wells is of high salinity. • There are approximately 400 wells (Only 150 wells are acceptably operational). • Assuming 70 % of wells are operational. • 30 L/c/d is assumed.	4,410	147,000	56%
Water tanker	• The source of water is the river without treatment. • 7 intake stations. • 400-650 tanker/d x 4 – 5 m^3 (1,600-2,600m^3/d). • 80 % is supplied to the domestic users. • 30 L/c/d is assumed. • Free chlorination is provided.	2,080 (2,600 for all users)	69,000	26%
Jerry can vender	• The source of water is the river without treatment. • 3 intake stations and on average 5,000 cans per day. • The capacity is 100 - 135 m^3/d. • Free chlorination is provided. • 10 L/c/d is assumed	135	14,000	5%
	Total	8,425	264,000	100 %

Note: Total service population is different from the total population estimated by the Study Team.

5.2 Existing Water Supply System

Southern Sudan Urban Water Corporation (SSUWC) was established in 1937 with an aim of providing clean potable water to colonial administrators before independence of Sudan. In 1972-1983, the Government of Sudan with other international agencies like GTZ carried out the improvements of the water supply treatment facilities and distribution networks, which increased the capacity of the water supply to 5,200 m^3/d and covered almost the entire old Juba Town (Malakia, Hai Jalaba, Amarat, Kosti, Nimara Talata and Atlabara). This water supply conditions had continued during war until the signing of CPA.

5.2.1 Existing Water Supply Facilities

(1) Old Water Supply System

Main existing water supply facilities in Juba were constructed in 1983. The raw water for water treatment plant is taken from Juba Channel, which is a subsidiary stream of the Bahr el-Jebel. The original capacity of existing treatment plant was 7,200m^3/d. However, half of the existing facilities were demolished to secure the land for a new treatment plant funded by MDTF. The construction of this water treatment plant started in 2006 and completed in May 2009.

The major facilities in old treatment plant which is not operational after the starting the operation of MDTF plant are summarized in Table 5.2, the process flow is shown in Figure 5.5.

Table 5.2 Summary of the Existing Treatment Facilities

Facility	Units (standby)	Specification	Remarks
Intake Bridge	1	Steel Floating-type	
Intake Pump	3(2)	50 lps * H 55 m	24 hours operation if power is supplied (Daily average is 18 hours)
Sedimentation Tank	1	RC	Not working
Chlorine Doser	1		Under repair
Filtration Tank	5	Steel	Not working
Clear Water Reservoir	4	RC	Capacity is not adequate

Note: The status as of December 2008.

Two of the three raw water pumps were operated before demolishment of the existing plant for the rehabilitation work. Currently, one raw water pump is operated based on the capacity of treatment plant. The operation hour of raw water pump is 24 hours in principle, but the average of actual operation hour is 18 hours due to failure of grid power supply and maintenance of generators. The actual production of the existing treatment plant is estimated to be 3,500 m^3/d as of December 2008 through evaluation of the capacity and operation hour of those raw water pumps.

Based on the retention time, the surface loading rate of sedimentation tank and the filtration rate of rapid sand filters, the capacity of the existing treatment plant is estimated to be 5,000 m^3/d. The problems of existing old treatment plant (not functional anymore) are summarized below:

- Alum is added to sedimentation tank only twice in a day; in the morning and afternoon manually. Chemical clarification does not function at all due to inadequacy of mixture and coagulation.
- Filtering system does not function at all because there is almost no gravel and sand in the filters, and machines are broken.
- Chlorination equipment is under repair and is currently nonoperational.

The plant does not purify raw water at all; raw water just passes through the plant and is distributed to the city, although there is a little sedimentation in sedimentation tank and reservoir tank.

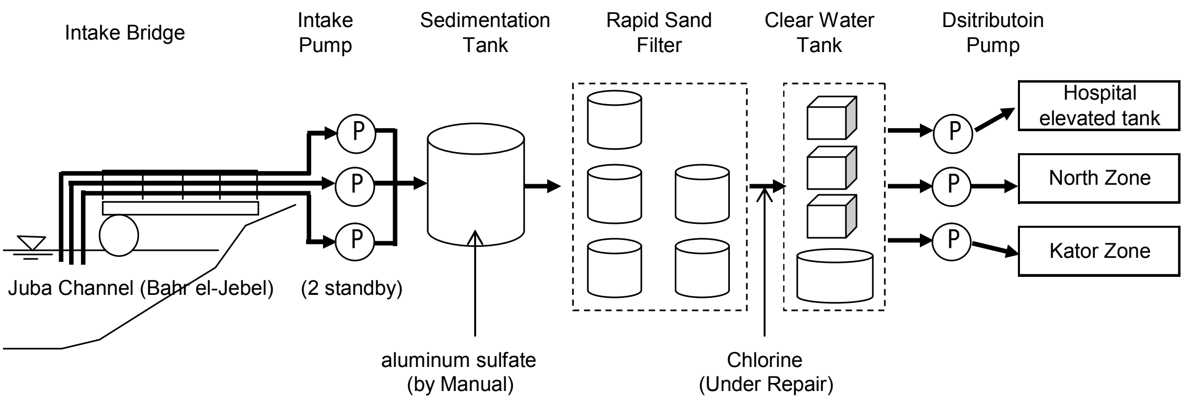


Figure 5.5 Process Flow Sheet of Existing Treatment Facilities (As of December 2008)

Three transmission pumps are installed at the site of the existing water treatment plant. These pumps convey the water to the following 3 areas.

- To the hospital elevated tank
- To the north supply zone
- To Kator supply zone

Each pump is routinely operated for 8 hours a day by rotation. Booster pump, which is installed in hospital overhead service reservoir site, conveys the water to parliament overhead service reservoir and the water is supplied to the government area by gravity. The information on existing old transmission facilities are summarized in Table 5.3.

Table 5.3 Existing Transmission Facilities

Facility	Units (standby)	Specification	Remarks
1. Existing WTP Site			
1) High Lift for Hospital directly	1	50 lps*H55 m	8 hours operation (8:00 – 16:00)
2) High Lift for North Zone	1	50 lps*H55 m	8 hours operation (16:00 – 24:00)
3) High Lift for Kator Zone	1	50 lps*H55 m	8 hours operation (0:00 – 8:00)
2. Hospital Elevated Tank Site			
1) High Lift for Hospital directly	2(1)	50 lps*H55 m	8 hours operation (9:00 – 17:00)

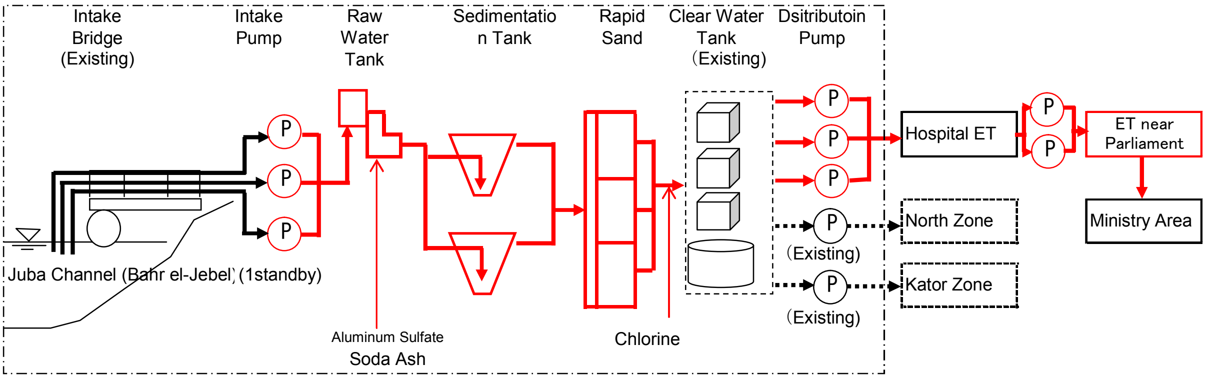
(2) Multi Donner Trust Fund (MDTF) Facilities and New Water Supply System

The rehabilitation of the existing water supply system including renewal of treatment plant with a capacity of 7,200 m^3/d, and the construction of transmission and distribution facilities to supply the water to the government area were implemented by MDTF fund. The construction of these facilities was completed and became operational at the end of May in 2009. The information on newly constructed facilities is summarized in Table 5.4.

Table 5.4 Water Supply Facilities Financed by MDTF

Facility	Dimension/Type
1. Treatment Plant	
Raw water pump	158 m^3/hr*H20.7m*3(1 standby)
Raw Water Tank	RC(elevated tank), W4.8m*4.8m*H2.9m*1
Dosing Device House	RC(2 floor), Alum and Soda-ash doser
Sedimentation Tank	RC W10.25m*L10.25m* 7.5 D*2
Filtration Tank	RC W3.4m*L4.0m*4
Chlorination Dosing Device	
Clear water pump	150 m^3/hr*H47.1m*3(1 standby)
2. Pump Station in Hospital	
Booster pump	150 m^3/hr*H67.4m*3(1 standby)
3. Reservoir near Parliament	
Reservoir	RC Elevated Tank 250m^3
4. Main Pipeline	
WTP – Hospital – Parliament	DCIP 300 mm*5,000m

The water transmission facilities constructed are planned to supply water only to the government offices and facilities from the elevated tower located near the parliament. Therefore, the existing pumps are operated to supply the water to other areas. The flow of the water supply system of MDTF fund along with existing facilities is shown in Figure 5.6 and a general layout of the water treatment plant is shown in Figure 5.7. The schematic layout of the existing transmission system and supply zones is shown in Figure 5.8.



Note: Red and black colors indicate the water supply facilities constructed by MDTF fund and the existing facilities, respectively.

Figure 5.6 System Flow of MDTF Facilities (as of May 2009)

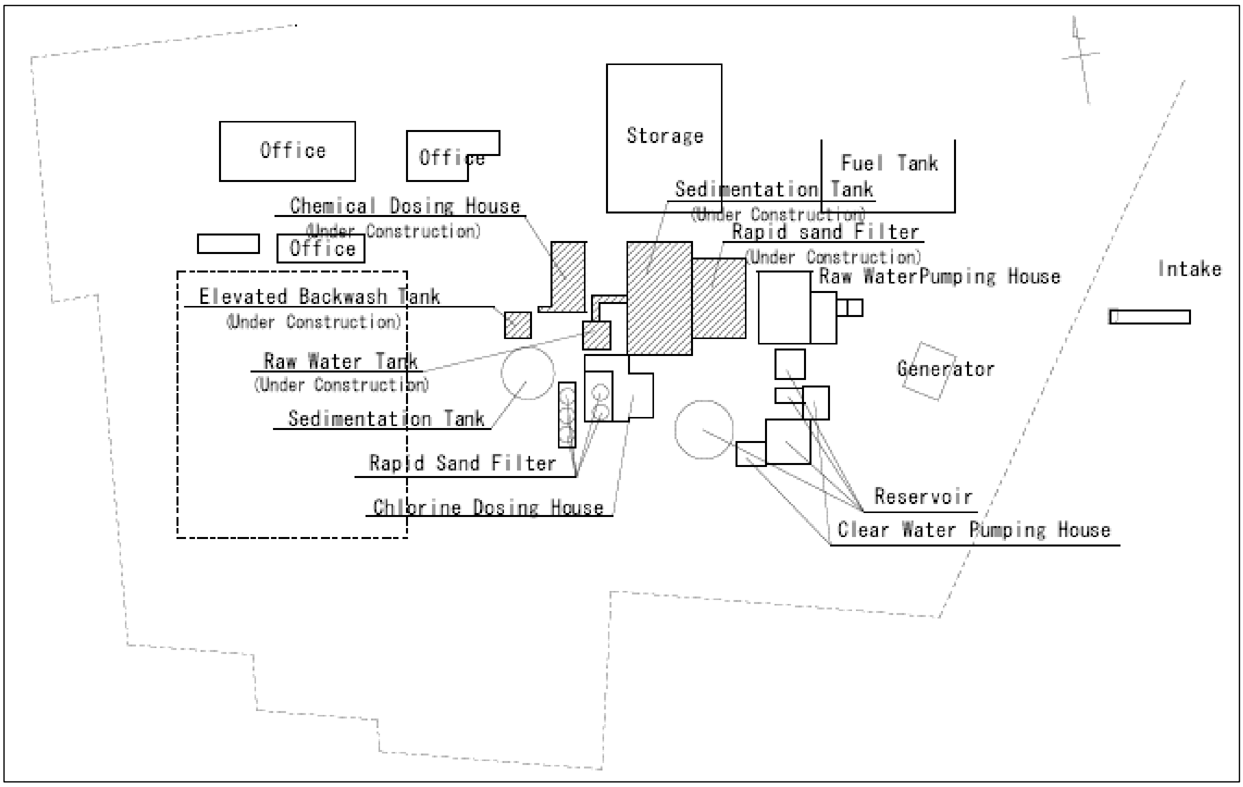


Figure 5.7 General Layout of the Existing Treatment Plant

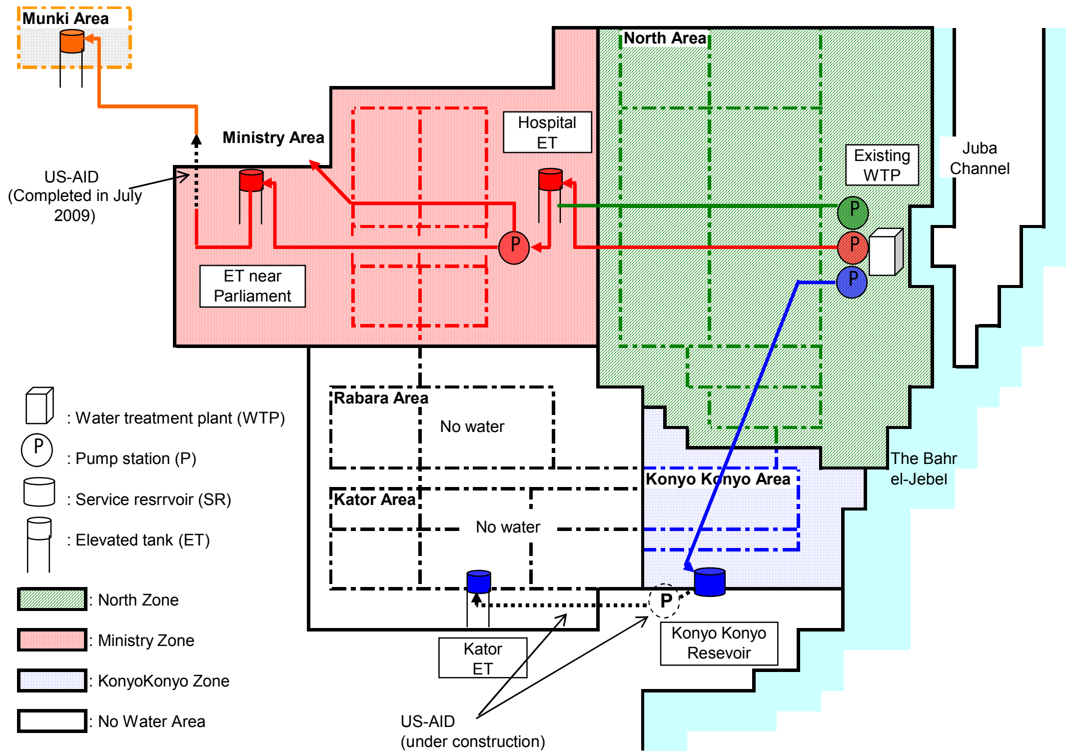


Figure 5.8 Systematic Layout of Existing Transmission System and Supply Zones

(3) Distribution Facilities

Service reservoirs and elevated tanks, which are located near the hospital and parliament, are operational, but the other tanks and reservoirs are not functional. The existing distribution reservoirs are summarized in Table 5.5.

Table 5.5 Existing Service Reservoirs and Elevated Tanks

No.	Location	Units	Capacity (m^3)	Material	Type	Year	Remarks
1	Hospital	3	210, 125, 85	Metallic	Elevated tank	1983	Operational
2	Parliament	1	210	Metallic	Elevated tank	1978	Operational
3	Customs	3	85 each	Metallic	Elevated tank	1969	Not functioning
4	Radio Juba	1	210	Metallic	Elevated tank	2003	Not functioning
5	Kator	1	250	Metallic	Elevated tank	2007	Not functioning yet
6	Konyo Konyo	1	300	Concrete	Ground	2007	Not functioning yet
7	Munuki	1	25	FRP	Elevated tank	2006	Not functioning yet

The total length of distribution network is approximately 51 km. The majority of network was installed before 1972 and is composed of asbestos pipes, except a few PVC and GI pipes. Those pipes have trouble with frequent leakage due to fragility to shock and their installation at shallow depth. The leakage ratio is estimated to be more than 50 % at normal water pressure, considering the conditions of pipelines. Due to pressure drop caused by leakage, water cannot be distributed to the areas such as Kator which are located at far distance from the treatment plant. In addition, there is a concern of contamination due to intrusion of sewage due to negative pressure in pipe.

(4) Service Facilities

The number of current subscribers is 2,765 as shown in Table 5.6. The tariff system is fixed charge according to the category shown below and water meter is not installed. UWC has a plan to install about 2,000 customer water meters which have been provided by MDTF.

Table 5.6 Number of Subscribers in 2008

Category	No of consumers
First Class	316
Second Class	1,037
Third Class	800
Stand Pipes	38
Hospital	44
NGO	79
Restaurant	29
School	20
Hotel	68
Government Unit	36
New Connection	298
Total	2,765

5.2.2 On-going Water Supply Projects

USAID is now implementing the project, Sudan Infrastructure Services Project Juba (SISP-Juba) from 2008. Under the project, the facilities listed in Table 5.7 are under construction and are expected to be operational in 2009.

Table 5.7 Facilities under Construction funded by USAID

Facility	Dimension/Type	Locations/Routes
For Kator Area		
Booster Pump house Booster Pump	4m x 5.5m x 1 6 inch x 2	Konyo Konyo service reservoir site
Transmission main	u-PVC 1,100m	Konyo Konyo SR to Kator ET
Distribution pipe	u-PVC 2,000m	Kator ET to tap stand
Public stand post		
For Munuki Area		
Transmission main	u-PVC 1,200m x 8 inches	Existing pipe to Munuki ET
Others		
Tank	3 sites	3 location along river
Chlorination tank	6 sites	

In this project, transmission pumps are planned to be installed at the existing Konyo-Konyo service reservoir site to transmit the water to the elevated tank in Kator. New transmission main from Konyo-Konyo service reservoir to Kator elevated tower is planned to be installed and new distribution pipes are also planned to be installed to supply water to new public stand posts. Konyo-Konyo service reservoir and Kator elevated tank are currently not functioning as the water does not reach to these reservoirs even though they are connected to the existing pipelines.

In Munuki area, installation of a transmission main is on-going in June 2009 to supply water from the existing network to the elevated tank in Munuki, which was constructed under the pilot project of the JICA Emergency Study. The reservoir is currently not functional as the planned water source of constructed wells contains higher concentration of arsenic than the WHO guideline value and consequently the constructed wells were abandoned.

5.3 Estimation of Current Water Balance of UWC Water

5.3.1 Components of Non-revenue Water

The following are definitions and explanation of principal components of water balance and NRW of International Water Association (IWA).

System Input Volume	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption	Revenue Water
			Billed Non-metered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unbilled Non-metered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Metering Inaccuracies	
		Real Losses	Leakage on Transmission and/or Distribution Mains	
			Leakage and Overflows at Utility’s Storage Tanks	
			Leakage on Service Connections up to Customers’ Meters	

Source: IWA Best Practice” Water Balance and Terminology

- Non-Revenue Water is the difference between system input volume and billed authorized consumption
- Authorized Consumption is the annual volume of metered and/or non-metered water taken by registered customers, water suppliers, and others who are implicitly or explicitly authorized to do so for residential, commercial, and industrial purposes. It includes water that is exported.
  - ✧ Unbilled Authorized Consumption can include water used for firefighting or free water distributed at standpipes or provided to religious institutions. (usually a minor component of water balance)
- Water Losses can be identified by calculating the difference between system input volume and authorized consumption. They consist of apparent losses and real losses.
  - ✧ Apparent Losses result from unauthorized consumption (illegal consumption) and all types of inaccuracies associated with metering, such as malfunctioning water meters, estimated water consumption (when meters are not working), and misreading water meters.
  - ✧ Real Losses result from losses at mains, service reservoirs, and service connections (up to the point of customer metering). The annual volume lost through all types of leaks, bursts, and overflows depends on their individual frequencies, flow rates, and duration. Experience has shown that most leakage results from service connections, and to a large extent this is due to poor construction.

5.3.2 Water Balance

(1) Baseline Summary

To estimate the water balance in the water supply system in Juba, a baseline of the network is summarized as follows:

- Production
  - System Input: 3,500 m^3/d before the completion of MDTF water treatment plant
  - System Input: 7,200 m^3/d after the completion of MDTF water treatment plant
- Network Condition
  - Age of most of the network is 30 years
  - Materials of many pipe is asbestos cement
  - Lack of capital investment for repairs for a long time
  - Lack of O & M resources
  - Joints – Most joints are leak prone, lead caulked joints (probably)
  - Substantial leakage on service pipes (probably)
  - Substantial illegal connections (high possibility)
- Cause of NRW
  - Old pipes
  - Corroded old tanks in treatment plants
  - Bad maintenance and operation of pumps and treatment plants
  - Illegal connections
  - Non official use
- Current measure of NRW reduction
  - No measure as of May 2009
- Service level
  - Most areas have very low or no pressures
  - Large areas have intermittent supplies
  - Valve operation limits supply to some areas (probably)
  - Demand exceeds supply
- Water Supply Department Operations
  - No NRW control plan & activity
  - Repair teams under –equipped
  - Passive leakage control
  - Lack of regulation and or enforcement for consumers
- Flow Measurement
  - No production or distribution zone flow metering

- Consumers
  - No metering as of June 2009
  - Fixed water rate
- Network Data
  - Maps incomplete and out of date
- Existing equipment for leakage detection
  - No equipment

(2) Estimation of Current Water Balance

Based on the existing available information of UWC of Juba, it is not possible to estimate water balance for the Water Supply System due to lack of reliable data as stated in baseline summary, especially of flow data. Therefore, the water balance is estimated as follows and as shown in Table 5.8, based on the limited information, assumptions and experience and data in Japan and other countries.

- Current leakage (real loss) ratio: 40 % in transmission, distribution mains and service pipes
- Current apparent losses: 10 % mainly by illegal connections
- Current unbilled authorized consumption: 10 %, public offices and religious institutions

Based on the estimated figures in Table 5.9 and Table 5.10 for production of old and new water treatment plans, the Study Team guessed that 3,600 m^3/d or 50 % of the current produced water is not used for consumption and 4,680 m^3/d (60 %) does not earn any money after operation of MDTF facilities.

Table 5.8 Estimation of Water Balance for the Water Supply System (%)

<table>
<tr><td rowspan="9">System Input Volume (100%)</td><td rowspan="4">Authorized Consumption (50%)</td><td rowspan="2">Billed Authorized Consumption (40%)</td><td>Billed Metered Consumption (0%)</td><td rowspan="2">Revenue Water (40%)</td></tr>
<tr><td>Billed Non-metered Consumption (40%)</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption (10%)</td><td>Unbilled Metered Consumption (0)</td><td rowspan="7">Non-Revenue Water (60%)</td></tr>
<tr><td>Unbilled Non-metered Consumption (10%)</td></tr>
<tr><td rowspan="5">Water Losses (50%)</td><td rowspan="2">Apparent Losses (10%)</td><td>Unauthorized Consumption (10%)</td></tr>
<tr><td>Metering Inaccuracies (0%)</td></tr>
<tr><td rowspan="3">Real Losses (40%)</td><td>Leakage on Transmission and/or Distribution Mains (10%)</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks (0%)</td></tr>
<tr><td>Leakage on Service Connections up to Customers' Meters (30%)</td></tr>
</table>

Table 5.9 Estimation of Water Balance for the Water Supply System in December 2008 (m^3/d)

<table>
<tr><td rowspan="9">3,500</td><td rowspan="4">1,750</td><td rowspan="2">1,400</td><td>0</td><td rowspan="2">1,400</td></tr>
<tr><td>1,400</td></tr>
<tr><td rowspan="2">350</td><td>0</td><td rowspan="7">2,100</td></tr>
<tr><td>350</td></tr>
<tr><td rowspan="5">1,750</td><td rowspan="2">350</td><td>350</td></tr>
<tr><td>0</td></tr>
<tr><td rowspan="3">1,400</td><td>350</td></tr>
<tr><td>0</td></tr>
<tr><td>1,050</td></tr>
</table>

Table 5.10 Estimation of Water Balance for the Water Supply System after Operation of MDTF Water Treatment Plant (m^3/d) in June 2009

<table>
<tr><td rowspan="9">7,200</td><td rowspan="4">3,600</td><td rowspan="2">2,880</td><td>0</td><td rowspan="2">2,880</td></tr>
<tr><td>2,880</td></tr>
<tr><td rowspan="2">720</td><td>0</td><td rowspan="7">4,680</td></tr>
<tr><td>720</td></tr>
<tr><td rowspan="5">3,600</td><td rowspan="2">720</td><td>720</td></tr>
<tr><td>0</td></tr>
<tr><td rowspan="3">2,880</td><td>720</td></tr>
<tr><td>0</td></tr>
<tr><td>2,160</td></tr>
</table>

5.4 Results of Socio-Economic Survey on Water Use

5.4.1 Objectives and Methodology

The objective of the socio-economic survey is to investigate social living conditions and awareness of people about the water supply services through questionnaire. The target area of the socio-economic survey is Juba Town and surrounding areas. The number of households selected for the questionnaire survey is 269 households in 5 communities, i.e. Juba Town, Kator, Munuki, Lologo and Gumbo. The surveyed households are selected according to the level of urbanization and the economic situation that is estimated by housing condition.

The interviewed households were selected at random, representing a fair distribution between the different areas of Juba town and the surrounding areas. However, the samples are possibly composed of high and middle income households since surveyors were reluctant to visit low security area such as IDP sites, where low income families reside.

Survey method is described below.

1) Survey team is composed of men and women in consideration of the culture and custom of the Study area.
2) Field survey is carried out by visiting and interview investigation of target households by the survey team.

The socio-economic survey for household was started on 7th October 2008, and the fieldwork was carried out from 9th October 2008 to 4th November 2008. The results of the socio-economic survey are summarized below.

5.4.2 Results of Household Survey

(1) Socio-economy

< Type of House and Family Size>

81 percent of the houses surveyed are traditional type of house built by thatched roof and mud wall; 12 percent is self-help type; and 7 percent is concrete structure type.

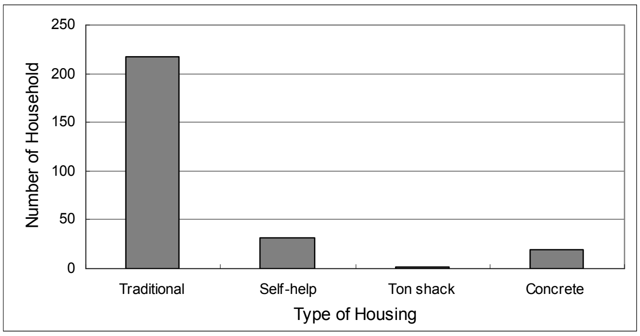


Figure 5.9 Type of House Surveyed

The average family size in the interviewed household is 7.8 person/household; the range is from 2 person to 22 persons per household), and a large proportion of interviewed households has a family size of 6 persons.

Figure 5.10 Family Size of Interviewed Household

<Income of Household>

Average monthly income of household is 1,257 SDG/month/household and the minimum and maximum monthly incomes are 150 SDG/month and 14,000 SDG/month, respectively. Two thirds of all households fall in the range between 500 SDG/month and 1,749 SDG/month.

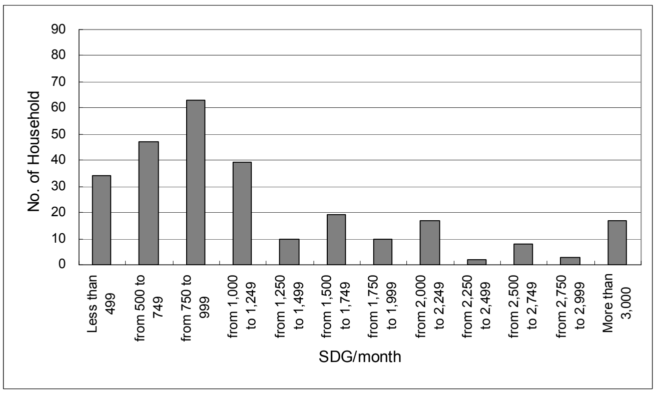


Figure 5.11 Monthly Income of Household

<Major Problems of Household>

Related to the question of what kind of problems their family is facing, 57 % of households responded that the significant problem they are facing relates to water supply, for example access to safe water, and it is presumed that the demand for water supply improvement are very high. The second in series of problems are lack of development of road and electricity and the third problems are low income and lack of medical facilities.

Table 5.11 Major Problems of Household

Major problems of household	1st	2nd	3rd	1st (No.)	Total (No.)
1. Water supply (Dirty, scarcity, distance to water ,etc)	57%	20%	6%	152	217
2. No Development (Poor Roads / Electronics, etc)	13%	22%	16%	34	124
3. Poverty (Low Incomes / No Money ,etc)	6%	12%	12%	16	72
4. Lack of Health Treatment, Medical care, Health Facilities	2%	8%	21%	5	71
5. Educational Service (No school/School fees ,etc)	4%	10%	10%	12	60
6. Diseases (Sickness) / Health problem	5%	5%	9%	14	45
7. Others problem	13%	22%	26%	35	146

(2) Existing water source, supply method and use

〈Water Sources〉

The water supply methods of the surveyed households include piped water, public taps and water tanker. Most of the households use private water tankers as water sources, followed by public borehole with hand pumps. 60.9% of households are using both of these water sources. Some of the households are using the rain water and river water to cover shortage in water available to them.

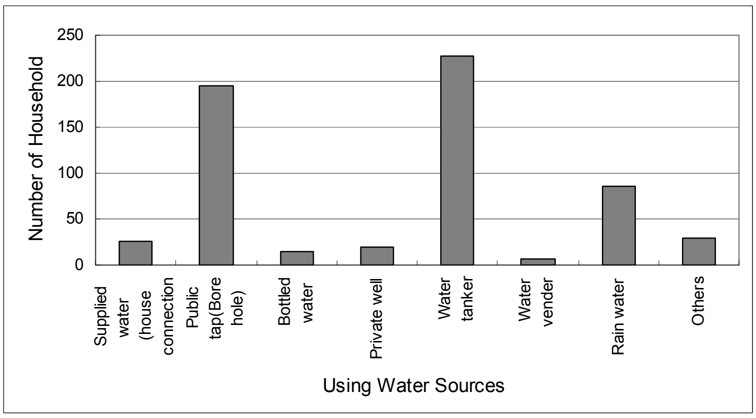


Figure 5.12 Water Sources

<Water Consumption by Use>

The estimated household unit water consumption (including bottled water) is 259 litter/household/d (L/hh/d); 232 l/hh/d in rainy season and 286 l/hh/d in dry season. Approximately, 63 percent of households are concentrated in the range between 100 l/hh/d and 300 l/hh/d. The average unit consumption per capita is 30 L in rainy season and 36 L in dry season with average of 33 L. About 70 % of the households use 10 to 40 L/c/d. These figures are not measured water consumption but estimated value by assumptions. A household or a person additionally wants 146 L or 19 L daily. Estimated total water requirements per household or per person are 405 L or 52 L daily.

Table 5.12 Average Unit Water Consumption for Household and Person

Ave. Water Consumption	Unit	Rainy Season	Dry Season	Ave.	Additional water requirement	Total water requirement
1. Water Consumption /household	L/hh/d	232	286	259	146	405
2. Water Consumption per capita	L/c/d	30	36	33	19	52

Table 5.13 Estimated Water Consumption Per Capita

Main water source	Dry season	Rainy season	Average
House connection	29	23	26
Public taps	37	28	32.5
Tanker truck	38	33	35.5
Average	36	30	33

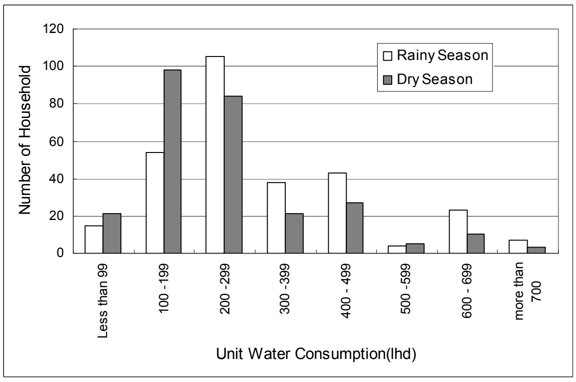


Figure 5.13 Household Unit Water Consumption

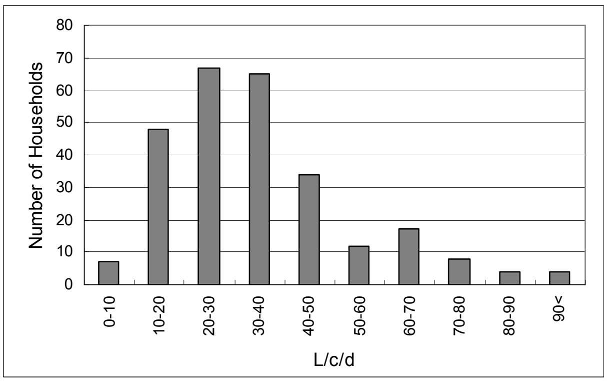


Figure 5.14 Water Consumption per Capita

As shown in the table below, water is mostly fetched by wife and daughter. Fetching water is responsibility of women but not men. Husband and son hardly fetch water.

Table 5.14 Water Fetching Person in Household

(No. of households)

Husband	Wife	Daughter	Son
5	192	148	14

<Water Supply Service Hour>

In the water supply services of UWC, the actual water supply duration is restricted by power failure, the shortage of capacity and poor maintenance of water supply facilities. Based on the results of the interview survey, average of households using supplied water is 7 hours. The service hours of public tap and bore hole with hand pumps is also restricted depending on community. The average distance to water sources from household is 281 m, and average fetching time is 66 minutes. The water tanker's selling hour is also unsteady, and the purchase of water may not be possible sometimes. Consequently, many households have storage tanks in the form of drum (200L) or plastic container which are used to store the water.

<Supply Water Quality>

The water quality items which the customer can judge are color, unclean, smell and the taste. Approximately, 70% of households (including hand pump users) replied that their main water sources are unclean. Generally, the water quality of bore holes in Juba town is clean with respect to color and turbidity compared to water supplied by the water tankers. However, some households are not able to use water from borehole because of salinity issue and therefore, need to purchase water from water tanker for their livelihood.

< Problem and Need of Water Supply Service>

Over 90% of households expressed dissatisfaction with the current water supply condition, for both main and supplemental water sources. It is judged that lack of the fundamental facilities of water supply services is a big problem. The water tanker's cost ranges between 4 SDG/200L and 7 SDG/200L (Ave.5 SDG/200L and 0.5-1.0 SDG/one Jerry can (20L)) which is also reflected by the results that 142 households expressed the cost to be high.

Table 5.15 Satisfied with the current water condition

(No. of households)

Category	Main water sources	Supplemental water sources
Yes	7	21
No	262	221

Table 5.16 Problems of Water Supply Services (Main water sources)

Items		Nos. of households	Ratio of respondent
Water supply quantity/service pressure		69	26%
Service hour		134	50%
Served water quality	Unclean	190	71%
	Taste(high salinity)	36	13%
	Color	39	13%
Water Tariff		120	45%
Distance of water sources		151	56%

Note: Multiple answers

<Drinking Water>

To the question about pre-treatment of drinking water, 142 households responded that they drink water after addition of chlorine tablets and powder. It may be attributed to the effect of free distribution of chlorine and public awareness activities by NGO and other donors. However, 30 % of households responded that they use drinking water without any treatment. Many water tankers are selling water after the addition of the chlorine provided by USAID.

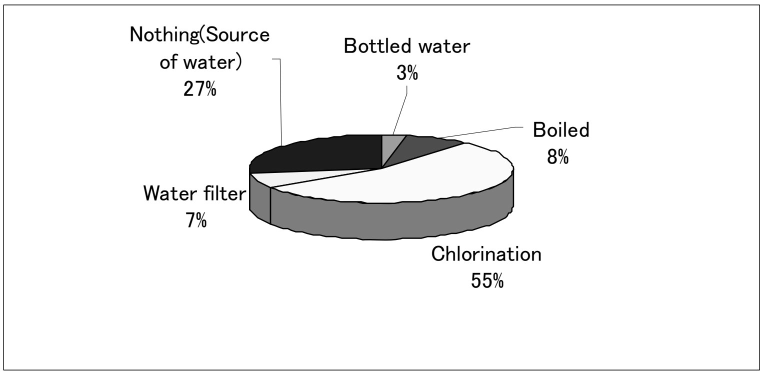


Figure 5.15 Modes of Treatment before Drinking Water

(3) Willingness to Pay for Improved Water Supply Services

Based on the results of the Socio-economic Survey, information on willingness of people to pay for the water supply services are obtained as follows.

<Current Monthly Expenditure on Water>

The average monthly expense on water for households is 132 SDG. As shown in Figure 5.16, there are different categories depending on used water sources. Of the households that pay less than 50 SDG/month for water, 73% use public borehole with hand pump as with source of water. On the other hand, of those households which pay more than 100 SDG/month for water, 78% use water tanker as main water source.

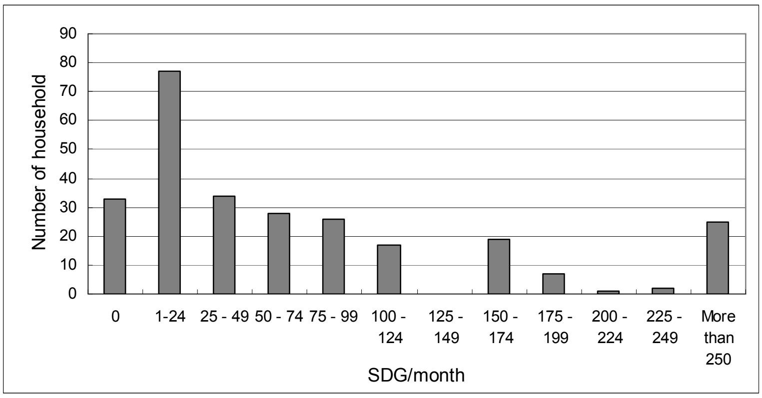


Figure 5.16 Household Monthly Expenditure on Water

<Willingness to Pay for Current Water Services>

33 households (12%) refused the payment for the current water condition. It may be one of the reasons that some households have not paid for the water. 236 households (88%) are willing to pay for the current water services, and average of willingness to pay for the water supply service under the current services condition is 80 SDG/household/month. This willingness to pay amount is lower than the average of current payment. (The average existing expense on water is 132 SDG/household /month). It is judged that many households are not satisfied with the current water supply condition.

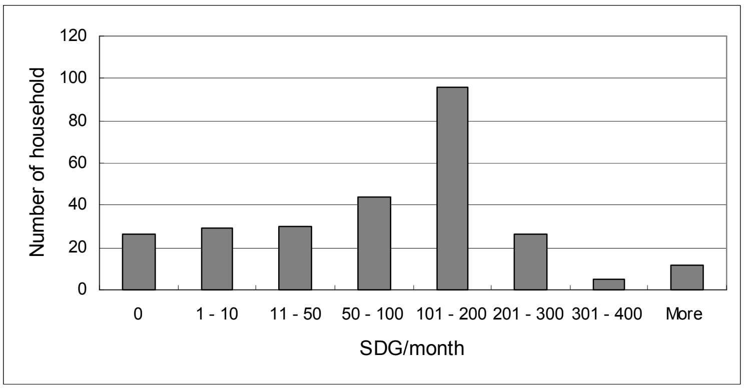


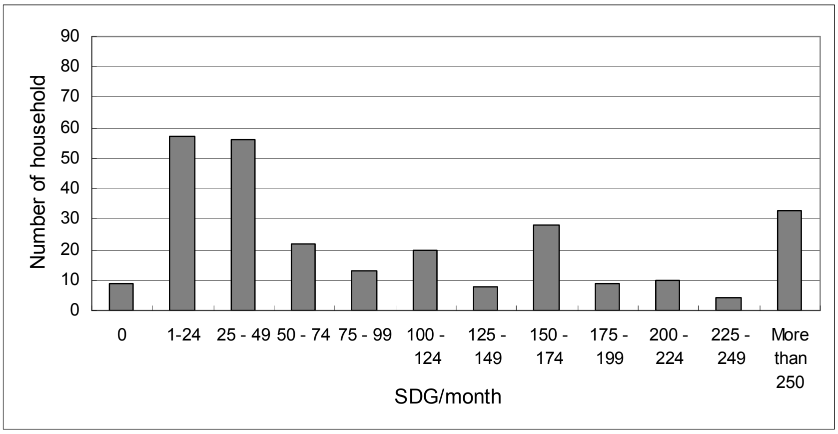
Figure 5.17 Willingness to Pay for Current Water Supply Services

< Willingness to Pay for Satisfied Water Supply Service >

Nine households refused payment for even satisfied water supply services, they can’t pay because of insufficient income and they think that the water has to be provided free.

From results of 269 interviewed households, average of willingness to pay for the satisfied water supply service is 110 SDG/household/month. The amount of willingness to pay for the satisfied water supply service is 18% less than the current payment as water charge. However, the current average payment is higher than in case of Tokyo Japan with average payment of 46 SDG/household/month.

Moreover, it is expected that, with the satisfactory level of water supply, 89 % of households will use water at consumption of 146 L/hh/d and thereby increase consumption by 52%.

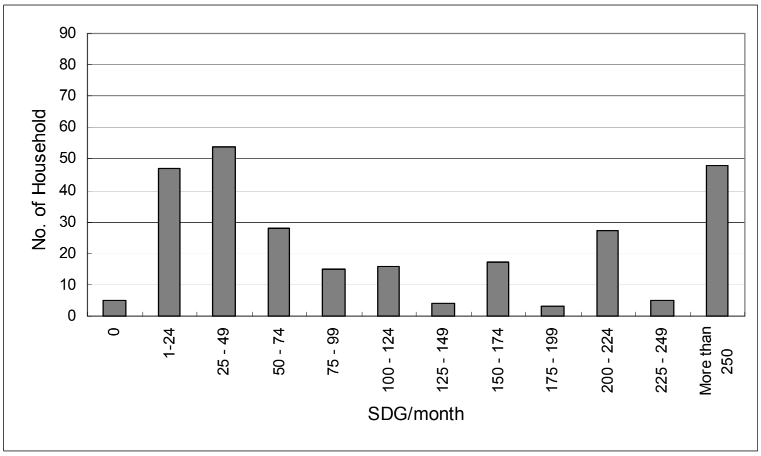


Satisfied water supply service (clean, safe and enough amount)

Figure 5.18 Willingness to Pay for Satisfied Water Supply Services

Five households refused payment for even satisfied continuous water supply services, they can't pay because of insufficient income and they think that the water has to be provided free.

Average of willingness to pay for the satisfied continuous water supply service is 134 SDG/household/month. This amount of willingness to pay is almost same as the current average water cost of a household.



Satisfied continuous water supply service
(clean, safe and enough amount of water through pipe for 24 hours)

Figure 5.19 Willingness to Pay for Satisfied Continuous Water Supply Services

The average willingeness to pays by water supply services are summaried in Table 5.17.

Table 5.17 Summary of Average Willingness to Pay and Current Cost for Water

Water supply service level	Willingness to pay (SDG/month)
1. For water supply under current condition	80
2. For satisfied water supply service (clean, safe and enough amount)	110
3. For satisfied continuous water supply service (clean, safe and enough amount of water through pipe for 24 hours)	134
4. Average current water cost (actual)	132

257 households out of 265 households expressed their willingness to pay for installation of water meter and only 5 households show unwillingness to pay for meter installation.

(4) Sanitation

<Sanitary Condition>

From the 269 surveyed households, 29% (78) of the households responded that they did not have internal toilet facilities. These households are using their neighboring facilities or defecate in fields. For 191 households who had toilet facilities, 80% of them are using pit latrine type toilet.

Table 5.18 Households with No Toilet

Item	Public toilet	Neighboring toilet	Field/ outside
What kind of toilet do you use	1	30	41

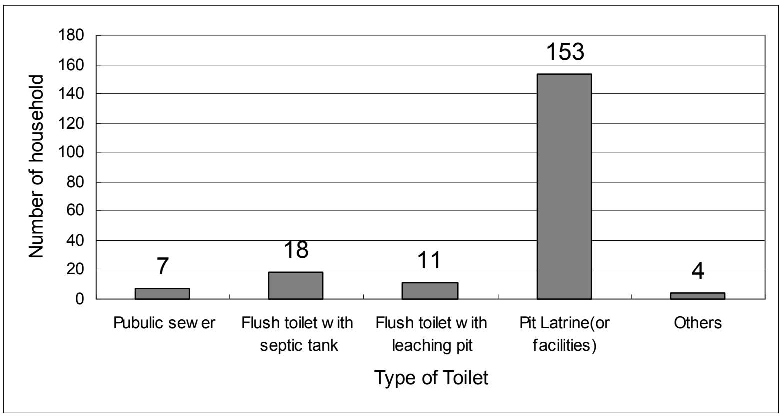


Figure 5.20 Type of Toilet

(5) Health

On average, 1.8 persons, 2 persons and 3.8 persons in total have contracted water related disease and/or malaria in a household in 2008.

Table 5.19 Family Diseases in 2008

Item	Adult	Children	Total
How many persons contracted the disease in this year (person/hh)	1.8	2.0	3.8

Figure 5.21 shows the percentages of cases in which one of family members had been infected with some of water related diseases and/or malaria during the year of 2008. Only 3 % households responded that they have not been infected with any of water related diseases and malaria. Depending on their living environment and sanitation, in 91% of households some members have been infected with malaria. In case of 51% of households, member had contacted diarrhea, and in 35% of households member had contacted typhoid. The average total cost for hospital, medicine and transportation was 333 SDG/household/year.

Figure 5.21 Diseases in Households

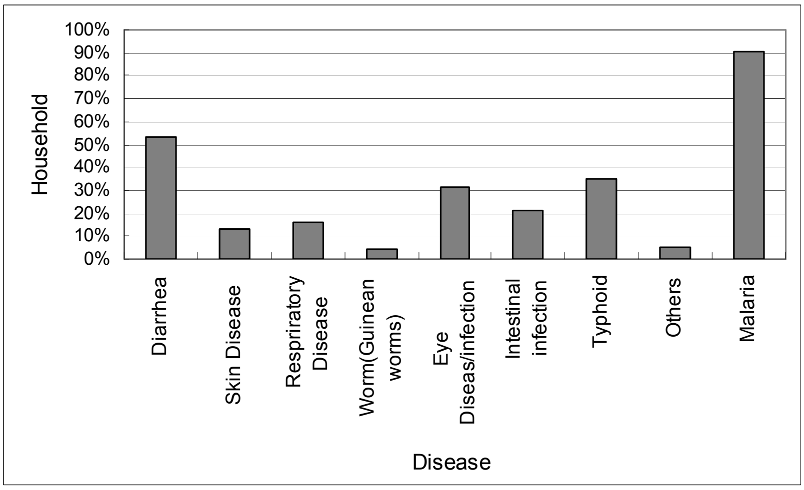


Table 5.20 Medical Cost of Family Disease

Item	Hospital	Medicine	Transportation (to Hospital)	Total
Treatment cost of disease (SDG/year)	100	175	58	333

CHAPTER 6 EXISTING INSTITUTION AND ORGANIZATIONS ON WATER SUPPLY

6.1 Institution and Organization

6.1.1 Outline of Water Supply related Organizations and Institutions

Urban and rural water supply is administrated by Ministry of Water Resources and Irrigation (MWRI/GOSS) since GOSS ministries were reformed in July 2008. Main roles of MWRI are policy making, planning and investment on water supply and sanitation. Ministry of Health (MOH/GOSS) also takes a role of hygiene promotion from viewpoint of public health. In the state level, Ministry of Physical Infrastructure (MOPI/CES) is the implementing organization according to the GOSS policy. The organizations related to water sector are summarized in Table 6.1.

Table 6.1 Summary of Roles of Related Organizations

Organization	Role
Ministry of Water Resources and Irrigation (MWRI) / GOSS	Mandate administrative organization of GOSS level to make national policy on water resources management and urban and rural water supply.
Southern Sudan Urban Water Corporation (SSUWC)	Public utility to provide clean water to urban citizens of Southern Sudan
Ministry of Health (MOH) / GOSS	Administrative organization of GOSS level responsible for public health. Hygienic promotion is performed by MOH.
Ministry of Physical Infrastructure (MOPI) / CES	Administrative organization of state level to implement the government policy within the state.
Private water vendors	Although it is informal sector, they have significant role for Juba citizens, since only 13% of citizens have access to public water supply and the rest majority depend on the private water tankers.

6.1.2 MWRI – Organization Responsible for Planning and Construction

The Ministry of Water Resources and Irrigation (MWRI) of Government of Southern Sudan (GOSS) is the organization responsible for formulating policy on water supply, planning and establishment of the water supply facilities related to urban water supply. The department responsible for rural water supply and sanitation services was initially located in the Ministry of Cooperatives and Rural Development of GOSS whereas the department related to urban water supply and sanitation was a part of Ministry of Housing, Physical Planning and Environment (MHPPE) of GOSS. Recently, these division handling urban and rural water supply and sanitation have been relocated to MWRI. For the projects funded by the donor agencies in urban water supply sector, MWRI on behalf of the GOSS coordinates between the donors and related local organizations. The Organization chart of the

MWRI/GOSS is shown in Figure, in which Southern Sudan Urban Water Corporation (SSUWC) is administrated directly under the Minister.

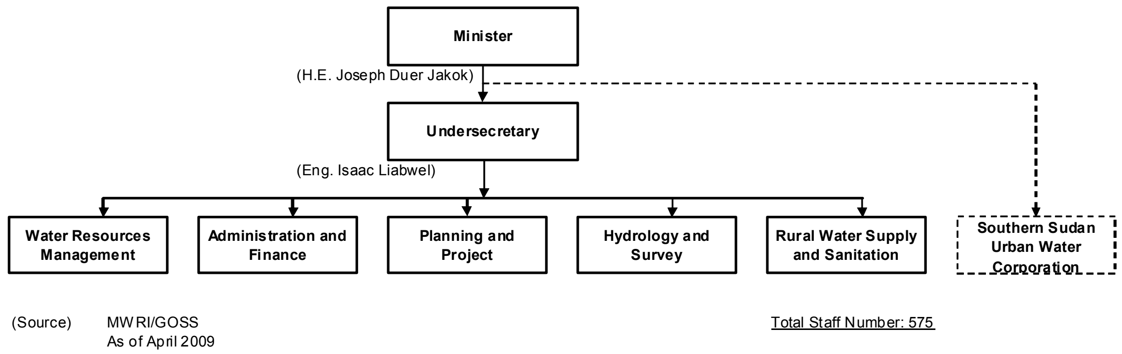


Figure 6.1 Organization Chart of the Ministry of Water Resources and Irrigation /GOSS

6.1.3 Southern Sudan Urban Water Corporation

Under MWRI, Southern Sudan Urban Water Corporation (SSUWC) is mandated as the official urban waterworks of Southern Sudan and the organization responsible for providing water supply services to urban citizens of Southern Sudan. As of September 2008, "SSUWC Provisional Order, 2008", which grants legal basis and governance of SSUWC, is to be submitted to the national Council of Ministry to adopt the Order for issuance by the President of Southern Sudan. Objectives of SSUWC are stated in the Order as follows:

<u>Objectives of SSUWC</u>

- Utilization of the available water resources economically to provide for the Southern Sudan's long and short term water demand and to realize its development in proportion to the growing needs
- Benefit from international development in industry and water supply
- To realize annual revenues that will enable it execute its development plans at such rates

Source: SSUWC Provisional Order, 2008"

The organization comprises headquarters office (HQ) and three branch offices of Juba, Malakal and Wau. The organization chart of SSUWC is shown in Figure 6.2. The Board of Directors is formed above SSUWC HQ to draw general policy and supervise the SSUWC. The Board is chaired by the Minister of Water Resources and Irrigation and members are appointed by the President and Council of Ministries. The Board members include general manager of SSUWC and representatives from related ministries of GOSS.

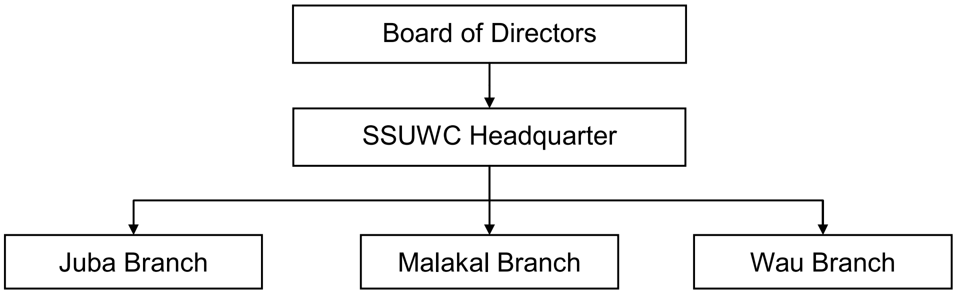
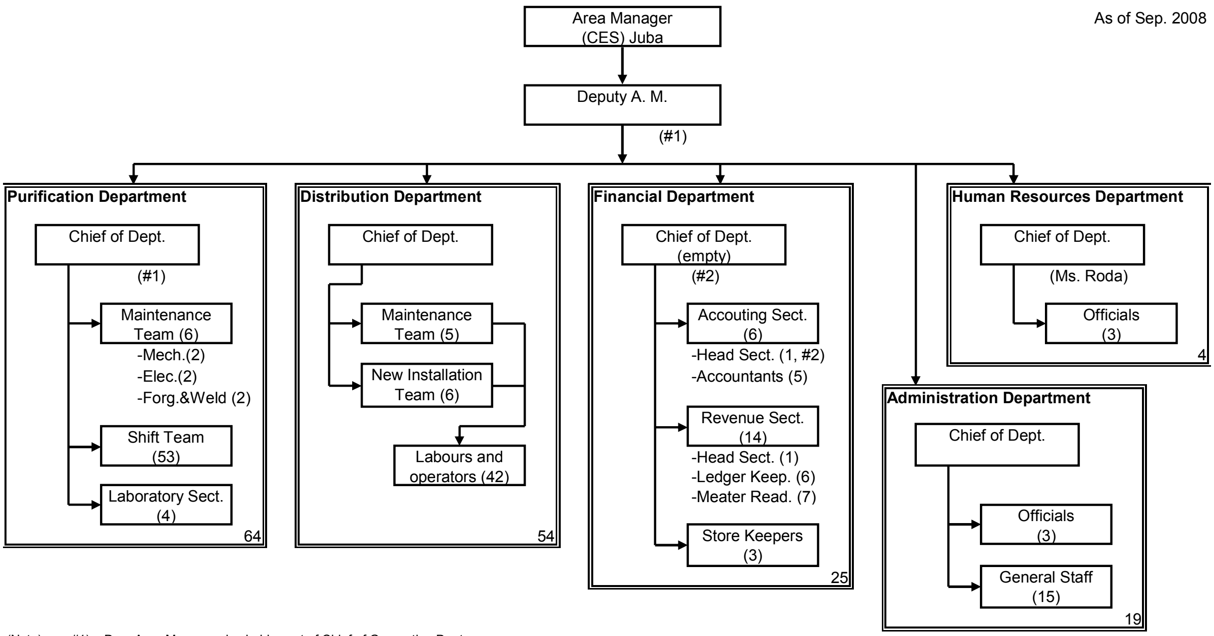


Figure 6.2 Organization Chart of SSUWC

6.1.4 Southern Sudan Urban Water Corporation –Juba Station

Public water supply services for urban part of Juba are performed by the SSUWC - Juba Station (hereinafter referred to as "UWC-Juba"), located in the premises of the only existing water treatment plant, which is one of the three branches of SSUWC. The organization chart of UWC-Juba is shown in Figure 6.3. For carrying out activities related to water supply, SSUWC-Juba has five (5) departments including purification, distribution, financial, human resources, and administration and altogether has a total of about 167 staff members in these departments as of September 2008. The overall goal of UWC-Juba and objectives of the five departments are summarized in Table 6.2.



(Note) #1) Dep. Area Manager also holds post of Chief of Generation Dept.
#2) Chief of Financial Dept. is currently empty and acted for by Head of Accounting Sect.

Total Staff Number: 167

(Source) SSUWC (CES) Juba

Figure 6.3 Organization Chart of SSUWC-Juba Station

Table 6.2 Summary of Objectives of UWC-Juba and Departments

Overall Goal	"Provision of clean and sufficient water to all Juba citizens under self-sustaining management"	
Objective of Department	− Purification:	− Producing safe drinking water
	− Distribution:	− Distributing clean water with sufficient volume and pressure
	− Financial:	− Selling water at reasonable tariff and manage under self-autonomous accounting
	− Human Resources:	− Employing and developing human resources
	− Administration:	− Office administration of UWC

(Source) "SSUWC Provisional Order, 2008" modified by the Study Team

The main roles of these staff members are to produce safe and sufficient water and to distribute to users in sufficient quantity and pressure. Due to poor infrastructures, organization, and inappropriate operation and maintenance, supplied water at present is neither sufficient in terms of quantity nor in terms of quality. Due to internal disturbances, no major construction works were undertaken for long time, nor have proper operation and maintenance activities been undertaken for existing facilities. However, after signing of CPA, activities have been initiated to improve condition of water supply services in Juba. In this direction, the construction of a new water treatment plant has been almost completed at the location of existing old water treatment plant and was commissioned in May 2009.

For sustainable water supply services, existing and developed facilities shall require appropriate operation and maintenance in order to provide good quality services to the customers and to increase the life of facilities.

6.2 Operation and Maintenance of Existing Water Supply Facilities

6.2.1 Existing Old Water Supply Facilities

The existing intake was constructed in 1980s and is a floating pontoon structure that withdraws water from the Juba Channel. The raw river water is conveyed through two DN200 ductile iron and one DN150 steel suction pipes. There are 3 raw water pumps that deliver water from the intake to the clarifiers (sedimentation tank) and rapid gravity filters. The flow meter at the raw water PS is broken and therefore no measurement is carried out for raw water inflow to the plant. The treatment process does not include flash mixing or coagulant and flocculation. Coagulant is dosed manually into sedimentation tanks and clarifier. The sedimentation tanks and filters in the old WTP are in corroded and filters lack media. The gas chlorinator at the plant is broken and therefore, disinfection is not carried out at present.

Treated water at WTP is stored in three ground level reservoirs. There are 3 clean water pumps that are used to convey water to the overhead service reservoir near Juba Teaching hospital and to overhead service reservoir near the Parliament. Also using these pumps, the water is conveyed to the areas of Kator and Konyo Konyo.

This old WTP has been abandoned now and water treatment is carried out through the treatment plant developed under MDTF Project having a capacity of 7,200 m3/d. The newly established facilities include 3 new water intake pumps (2working and 1 standby) and 3 high lift clear water pumps (2working and 1 standby). Treated water is pumped to the elevated tanks near hospital and to the new elevated tank near Parliament from where water is distributed through old distribution networks. A part of the treated water from treatment plant is also conveyed to the distribution networks using old clear water pumps.

6.2.2 Current Practices of Water Supply Management

Urban water supply in Juba town is managed at the grassroots level by staff-members of Southern Sudan Urban Water Corporation, Juba Office located in the premises of existing water treatment plant. This office is headed by Area Manager and has five departments including Purification, Distribution, Financial, Administration, and Human Resources departments.

1) Operation

The operation of old WTP (not functional anymore) is described below. In case of the old WTP, the raw water is withdrawn from Juba branch of the Bahr el-Jebel (popular name for stretch of River White Nile between Nimule and Malakal). The water is passed through one cylindrical settling tank where coagulant is also applied. Effluent from settling tank is passed through filter and filtered water is stored in storage tanks from where it is pumped to distribution lines going to areas near Hospital, Legislative Assembly, Konyo Konyo, and Juba University. Preliminarily treated water is pumped thrice a day, morning, afternoon and evening for duration of 2-4 hours each, totaling daily water supply duration to be about 6-12 hours/d. Power is not available for about 6-7 hours a day and during power failure generator is operated.

Operation and maintenance activities are carried out in three shifts. In the existing practices, the shifts are categorized as 7 am to 2 pm, 2 pm to 8 pm, and 8 pm to 7 am. Most of the operation and maintenance activities are undertaken in the day shift. In the night shifts, only pumps and valves at the WTP are operated based on the requirements. The number of staff members involved in operation and maintenance of the existing old WTP are presented in Table below.

Table 6.3 Staff-members of SSUWC-Juba for Operation and Maintenance of Facilities

Departments	Composition of Staff Members				Total
Production	Manager	Engineers	Technician	Operators	
Shift 1 (7am~3pm)	1	1	10	28	
Shift 2 (3pm~10pm)			5		
Shift 3 (10pm~7am)			5		
Others (including standby staff)			9	4	
Sub-total	1	1	29	32	63
Distribution			Technician	Operators	
Shift 1	1	3	11	40	
Sub-total					55
Total					118

Alum is added to the raw water in settling basin. Every day, two (2) bags totaling 100 kgs of alum are added in the morning at 7 am. In rainy season, alum is added twice daily, 2 bags in the morning and 2 bags in the evening.

There are 3 clear water pumps and normally, 2 out of these 3 pumps are working simultaneously and one of the pumps is standby. There exist three clear water surface reservoirs. The water from three clear water reservoirs is pumped to different areas.

Due to the long duration of internal disturbance, it has not been possible to maintain laboratory facilities in WTP and therefore water quality sampling or testing is not carried out for the raw and treated water at present. Also monitoring of water quality at the water taps or in distribution system is not practiced in existing situation.

2) Maintenance

The existing treatment, storage and distribution facilities are very old. Some of the pumps have been replaced in last few years under assistance of overseas development funds. However, appropriate maintenance has not been undertaken during period of internal disturbances for long time. Only reactive (crisis) maintenance is carried out and there is no preventive (routine) maintenance works in practice. In distribution system, leakage is often observed and due to poor maintenance, sometimes the pipelines could be seen above the ground level along the road. Currently, new WTP and overhead reservoirs are being constructed. On completion, when these new facilities start working using existing old network, occurrence of leakage is expected to increase significantly because of increased pressure.

For the existing WTP, and pumps at the WTP, regular maintenance is not carried out appropriately. Greasing of the pumps is normally carried out after 2 days. Minor repairing works are also generally carried out by UWC themselves. One sedimentation tank and five filters are cleaned once every month. In rainy season, they are cleaned every 15 days. The sludge removed from the sedimentation and filtration tanks is not disposed off appropriately and it is just spread on the ground nearby.

In case of any breakdown in distribution networks, when it is reported either by the customer or observed by the UWC staff-members, assessment is made by the UWC technicians. Based on the feedback of assessment, and upon discussion with the technician and engineers, the manager decides about which spare parts and other items would be required for repairing that particular breakdown and instructs the technician to go to the market and get Proforma invoice for the required items. The manager checks the Proforma invoice and approves it. Upon approval, the technician takes it to the accounting section and gets the money required for the purchase. The technician purchases and brings the receipt that is submitted to the accounting section. A record of the receipt is maintained in the accounting section. Also small equipments required for repairing and maintenance works are purchased upon requirement and stock is not maintained appropriately. Major part of time on maintenance goes for leakage repairing, distribution networks being very old. Based on the information obtained from UWC, it takes on average about 3-4 hours to repair the leakage for them.

3) Operation and Maintenance Manual/Work Records

Operation and maintenance manual is neither available at WTP office for the old WTP structures nor at any of the pumping stations. It is expected that on the start of the new WTP constructed under MDTF, O&M manual shall be prepared and provided by them.

At present, not many records are maintained regarding the operation and maintenance activities of water supply facilities. Records are only available related to the attendance of the staff-members, income and expenses. In case when any major breakdown occurs, it is recorded. In normal cases, the records are only available in the form of receipt of the items purchased for repairing and small maintenance works.

Flow meters are not available for measurement of inflow to and treated water from WTP and therefore flow is not being measured and no records are maintained. No pumping records are maintained either for raw water or treated water pumps. Record is only maintained for hours of electricity generator operation, including the information on fuel used and hours of operation.

Water quality analysis is not carried out under current practices and therefore, no records are available for raw water and treated water quality at WTP. Monitoring of raw water quality is important for the operation of treatment process such as coagulant and disinfectant addition. On the other hand, monitoring of treated water quality from the WTP and in the distribution networks is important for assessment of treatment processes performance and for distribution of safe water to the customers.

As a whole, a system needs to be developed for record-keeping and record sheet formats need to be prepared for maintaining record of operation and maintenance activities of water supply systems.

4) Water Charge Billing and Collection, and Maps

As mentioned earlier, there exists financial department in UWC Juba office that is undertaking activities of billing and water tariff collection. It has a list of water customers that is used for billing based on flat rates for different categories of users. As of now, there is no meter installed for the customers. Flat water rate is charged in the present condition on monthly basis per connection. There are 7 meter readers who are responsible for handing over the bills and collecting the money from the customers. At the time of handing over the bills, they also confirm if the water is being received at the users end.

The revenue section of the finance department has 6 ledger keepers to maintain ledger indicating the billing for each customer including the arrears. All these databases are prepared manually only and information on accounts is not compiled in digital form using computer as of April 2009.

The maps including information on water supply facilities such as WTP, service reservoirs, pumping stations, water supply zones, distribution networks, connected households, customers, etc., are very useful for proper operation, maintenance and management of water supply system. The digital data on maps of existing old and new water supply facilities and related features are not available. In future, when the system and covered area gets very extensive, it would be difficult to keep a track of related activities without application of digital database.

5) Staff Training

Due to unstable condition and financial reasons, no training has been carried out for various levels of staff members related to operation and maintenance of the water supply facilities. Therefore, many of these staff-members lack desired level of knowledge on proper operation and maintenance of the facilities. Thus, it would be beneficial to related staff-members to undergo capacity development programs on operation and maintenance of facilities including processes of water treatment plant, pumps, pipelines, service reservoirs, etc.

6) Spare Parts and Coagulants Availability

The spare parts and equipment is very essential for appropriate and timely operation and maintenance of the existing facilities. However, in the existing condition, equipment and spare parts are not appropriately stocked. Whenever, there is a need to repair or carry out minimum maintenance works, required items are purchased from the local market.

The stock of alum is maintained for 15 days (30 bags). Due to the chlorine application equipment not in order, chlorine is not applied in existing condition and therefore, chlorine is not stored.

7) Monitoring of Water Quality Supplied by Water Tankers

Existing water supply facilities does not cater to the needs of entire town and this leads to purchase of water by the users from water tankers. Most of these water tanks are privately owned and these tanks are filled up using water from Bahr-el-Jebel River. While filling up the tanks, liquid chlorine is also added to the tanks. However, there is no agency that monitors the water quality supplied by these tanks. It is advisable that water quality from these tanks be monitored to avoid any outbreak of diseases.

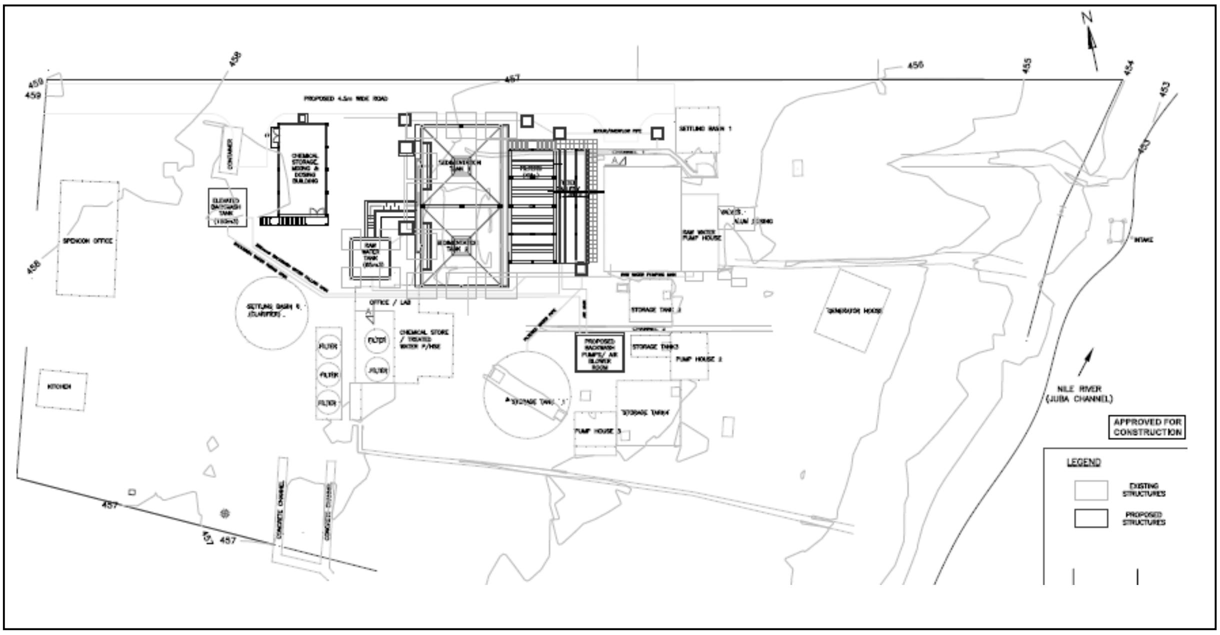
Some of the photographs illustrating operation and maintenance activities of existing water supply facilities are presented below.

		
View of storage room for spare parts at WTP	Another storage for spare parts	Water supply pipelines visible on ground
		
Water supply pipelines visible on ground	Leakage repair works in progress	Leakage repair works take major part of time
		
Leakage and broken pipes	Private water tanks drawing water from river	Another view of water tank filling

6.2.3 Water Supply Facilities of MDTF Project

(1) New Water Supply Facilities under MDTF Project

The new water supply facilities including water treatment plant (with a capacity of 7,200 m^3/d), raw water and clear water pumps at WTP, new reservoir near teaching hospital and parliament, transmission mains from new WTP to the teaching hospital tank and from hospital tank to the new elevated tank near the parliament, etc., is completed and has started operation since May, 2009. The new installations at WTP include raw water pumps (including suction and delivery pipework, electrical and instrumentation), raw water rising mains, raw water tank, 2 sedimentation tanks, 4 filters, and chlorination tank. The new treatment facilities make use of existing clear water reservoir at the old WTP. A schematic layout of the existing old WTP and new facilities at the same location is presented below. Three (3) raw water pumps and three (3) treated water pumps have been installed at the new WTP each with a capacity of 150 m^3/h. Of these, 2 are working and 1 standby. Also, three booster pumps (2 working and one standby) have been provided near the elevated tower with capacity of 150 m^3.



Source: MDTF Project

Figure 6.4 Layout of Existing Old and New Water Treatment Plant

(2) Operation and Maintenance of MDTF Facilities

On completion, the water treatment facilities is being operated and maintained by the Contractor for a period of one year. During this period, the operators and engineers of UWC are to be trained in all aspects of the operation and maintenance of the plant. The Contractor shall also prepare a comprehensive Operation and Maintenance Manual and the facilities shall be operated in accordance with this Manual. As of June 2009, the operation and maintenance manuals and as built drawings are still under preparation.

The Contractor is expected to provide the following services for efficient operation and maintenance:

(a). Operate the facilities to produce required quantity of water, to the required level of treated water quality standard. The operation is to be carried out by qualified operators fully conversant with all aspects of the processes, the plant and associated controls and instrumentation, and shall have at least 10 years working experience in the operation of treatment works.

(b). The resource and administration system to be established to provide the necessary, store, control and use consumables for operation of the plant and to ensure timely payment for the consumables, electricity, wages, etc.

(c). The provision of consumables, including all chemicals, stationary, etc., shall be made.

(d). A stock of consumables for about 4-6 months (at average rate of use) to be stored on site. The same stock shall be held after 12 months operation of the plant.

(e). A monthly report to be prepared and submitted including detail information on operation of works, tests and monitoring of performance, etc. The report shall include following item:

- (i) Water quality analysis results
- (ii) Graphs of collected data
- (iii) Result of routine tests
- (iv) Full details of power used
- (v) Full details of staff utilizations
- (vi) Full details of sludge and drying
- (vii) Full details of sludge disposal
- (viii) Full details of consumables used
- (ix) Full details of all maintenance carried out on plant and electrical works

During the operation and maintenance period, the Contractor is to provide supervisory and specialized personnel skilled and experienced in all aspects of the operation and maintenance of facilities. The Contractors staff is expected to be sufficient to operate the facilities during day and night time. Unskilled laborers, valve operators and other unskilled staff to assist the Contractor in operation and maintenance of the facilities are provided by the UWC. The staff of UWC also participates in the facilities performance monitoring.

According to the plan, the Contractor is expected to propose a schedule of permanent staff positions to be filled, with the qualifications and experiences, 6 months in advance of the start of the O&M of facilities. Upon approval by the engineer and UWC, suitable staff will be appointed by UWC to fill these posts for full time training from the start of the O&M. The Contractor shall train these individuals generally in all aspects of the O&M of the facilities for one year O&M period. It is noticed that the Contractor of MDTF projects has already submitted a list of proposed personnel to the SSUWC along with their responsibilities, qualifications and experiences, to whom the Contractor would like to provide on-the-job training during one year O&M. The list includes production manager (1), water supply inspector (1), water quality controller (1), water supply operator (4), pump attendant (3), Chemical attendant (4), water guard/line patroller (2), and grounds man/security guard (3). A list of such staff has already been selected by the SSUWC to be trained by the Contractor in all the aspects of O&M.

(3) Water Quality Monitoring

The contractor is to produce water complying with the treated water quality standards of WHO's Guidelines for Drinking Water Quality. It is planned to carry out the following tests and measurements as a part of O&M activities:

- Temperature, Total dissolved solids, pH (bench and portable), Turbidity, Suspended solids, Hardness, Alkalinity, Dissolved oxygen, Color

It is also planned to carry out the following activities regularly and include the results in monthly report:

- Copies of all records of all operation activities shall be submitted for the month to claim payment for services
- Estimate the water requirement for the day and set the rate of flow and establish the water level in clear water reservoirs
- Carry out regular jar tests and determine the appropriate coagulant dosing rate
- Set dosing rate and ensure good flocculation in the plant
- Check head loss across the filters, and backwash when head exceeds 1.2m
- Monitor chemicals in store and order more supplies as appropriate
- Monitor and maintain the plant records
- Collection of samples and deliver every second week for tests by an independent laboratory with all parameters to be within the maximum allowable limits, including tests for E.Coli, fecal coliform, and total plate counts.

It is also planned to monitor treated water quality for which the following tests are to be carried out with specific frequencies as listed in Table below.

Table 6.4 Water Quality Test for Treated Water

Parameters	Frequency of sampling and analysis (during first 3 months of operation)	Frequency of sampling and analysis (during first 3 months of operation)
Turbidity	8 hrs	8 hrs
Color	8 hrs	8 hrs
pH	Continuous	Continuous
Residual Chlorine	Continuous	Continuous
Odor/Taste	7 days	7 days
Conductivity	7 days	7 days
TDS	7 days	7 days
Total Alkalinity	7 days	1 month
Total Hardness	7 days	1 month
Aluminum, Calcium, Iron	7 days	1 month
Magnesium, Sodium, Potassium, Chloride, Sulphate, Fluoride, Zinc, Nitrate, Cadmium, Copper, Cyanide, Lead, Manganese	1 month	1 year
Total coliform	7 days	1 month
Total bacteria	7 days	1 month
Faecal coliform	7 days	1 month

All mechanical and electrical plant shall be inspected daily, and if any unusual phenomena are observed, it should be corrected after inspection by engineers.

Records of each item of plant shall be kept and all maintenance procedures shall be noted. The contractor shall submit a preventive maintenance manual and preventive maintenance activities record book at the time of operational acceptance, and these documents shall be updated at least every three months.

(4) Laboratory Equipment under MDTF Project

The contractor is expected to provide the following laboratory equipments for water quality monitoring.

- pH meters (bench type and portable)
- Spectrophotometer (bench model)
- Color comparator
- Laboratory balances of different ranges (0.1 to 10 kg)
- Chemical balance
- All glassware required to perform tests
- All glassware and reagents required to make up standard solutions. It will include burettes, pipettes, measuring flasks or various sizes, volumetric flasks, etc.
- Selected reagents required to perform tests for a period of 12 months
- Stirrers

- Jar test apparatus (6 stirrers) complete with necessary beakers, etc.
- Thermometers (electronic type)
- Electric distiller and 20L water storage containers complete with rubber hose connections to water supply, etc.
- Gas supply and Bunsen burners
- Vacuum pump, filter funnels, sampling bottles, etc
- Oven & refrigerator
- Routine record and analysis record books for capturing data in a durable material for a full years records

Of these the following equipments and reagents are already supplied by the Contractor:

S. No.	Item	Quantity
1	Electronic weight balance (accuracy of 0.0001g)	1
2	Tongs	1
3	Turbidity meter	1
4	Aluminium Tray	1
5	Wire loop	1
6	Vacuum flask	1
7	Durham tubes	1
8	Filter funnel	1
9	pH meter - Bench	1
10	Spectrophotometer	1
11	Color comparator	1
12	Lab balance (range of 0.1-10kg)	1
13	Chemical balance	1
14	Glassware to perform various tests	1
15	Stirrers	1
16	Burettes	1
17	Beakers	1
18	Stirrers	6
19	Thermometers	1
20	Electric distiller	1
21	Gas supply and Bunsen burner	1
22	Vacuum pump	1
23	Sampling bottles	1
24	Oven	1
25	Refrigerator	1
26	Analysis books	5
27	All relevant reagents	

(5) Water Quality of Treated Water at New Water Treatment Plant

The water quality parameters have been measured by the Study Team at different stages of treatment facilities on several days and the obtained results are presented below. It can be observed that treated water quality parameters at new water treatment facilities are almost within the Guidelines values of WHO. The measured data is given in Appendix-B.

Water quality parameters have also been measured by the Study Team at various water taps and the result is presented in table below. In some cases, the values are not in desired limit perhaps due to remaining stagnant in pipe for long time or due to sediments accumulation in old pipes. Otherwise, the water quality is not bad. The measured data is given in Appendix-B.

6.2.4 Weakness in Operation and Maintenance

The existing water supply facilities and equipment in Juba are obsolete and inadequate at present and the operation and maintenance system is not functioning properly due to insufficient technical capacity of staff of UWC, education/trainings and regulation and planning for operation and maintenance. Just at the end of May, 2009, the new water treatment plant, pumping stations, transmission lines and elevated tank (constructed under MDTF) has been commissioned.

It was observed in field visits of UWC-Juba that existing organization and practices of operation and maintenance followed by the UWC has several weaknesses that could be improved gradually. It would be important to mention the following weaknesses faced by the existing structure and practices.

- There is lack of sufficiently educated and skilled staff.
- No regular or preventive maintenance is performed, only reactive or crisis maintenance is in practice.
- Operation and maintenance records are not maintained properly. The records are only in the form of expenses on required materials. There is lack of computers in the organization.
- Operation and maintenance manual is not available at either WTP or PSs.
- Job responsibilities of the staff members are not well-defined and listed.
- Appropriate maps showing existing water supply facilities and users are not available.
- Sufficient training is not provided to all levels of staff.
- Water distribution facilities are very old and the distribution network has high level of leakage.
- The capacity of existing facilities is very low to cater to the increasing demand.
- No monitoring of water quality is being carried out either for raw water or treated water in existing water supply system including water supplied by the private water tanks.

Numerous tasks lie ahead in order to improve the existing condition of water supply services in Juba town. Existing facilities supply water to only small ratio of population living in town and that too without appropriate treatment due to poor condition of facilities and operation and maintenance activities. Hence, great deal of efforts would be needed to provide more effective operation and maintenance of waterworks in Juba for safe and sufficient water to increasing population in Juba town.

- There is a need to increase capacity of water treatment works and distribution facilities to cater to the needs of increasing demand in Juba.
- Appointment of more staff with appropriate skills is required. Provision of regular training and

skill development of staff-members is essentially required.

- Preparation of operation and maintenance manual is required for proper O & M.
- Job responsibilities of staff members are required to be clearly defined.
- Database management including preparation of operating records, maps, customer database, etc., is needed.
- Development of proper maintenance including both preventive/routine and reactive/crisis maintenance is required.

6.3 Capacity Assessment of Urban Water Corporation

6.3.1 Capacity Assessment by SWOT Analysis

Capacity Assessment (CA) was carried out by focusing on UWC which plays key roles of Juba urban water supply. UWC is generally characterized by institutional weakness, inefficient O&M, insufficient infrastructure and severe financial constraints. To figure out the current status of UWC, SWOT (Strength, Weakness, Opportunity and Threat) analysis is carried out and the results are shown below and the summary is shown in Table 6.5.

Table 6.5 SWOT Analysis of UWC

	Positive factor	Negative factor
Internal environment	**S**TRENGTH S-1 Well functioning command line S-2 Staff responsibility and loyalty S-3 Training demand and potential leader S-4 Technical appropriateness S-5 Low language barrier	**W**EAKNESS W-1 Dependent constitution (lack of autonomy) W-2 Insufficient O&M practice W-3 Inefficiency in business process W-4 Financial weakness W-5 Poor human resources development
External environment	**O**PPORTUNITY O-1 Institutional setup O-2 Government commitment O-3 Donor assistance O-4 Intensive water demand O-5 Friendly relations with neighboring countries	**T**HREAT T-1 Lack of laws and regulation T-2 Insufficient involvement of state and Payam authorities T-3 Public awareness T-4 Political unrest

(Note) Each factor is explained in the following part.

STRENGTH (Internal positive factor)

S-1 Well functioning command line

- Command line is functioning from top management to worker level.

S-2 Staff responsibility and loyalty

- Staff shows high sense of responsibility and loyalty to their job.
- There are many staff members with experience of over 15 years.

S-3 Training demand and potential leader

- All staff members have strong demand of training opportunity.
- There are some collage/ university graduate employees, who have better potential of leading future UWC.

S-4 Technical appropriateness

- Applicable technology of the existing water supply system seems suitable and manageable by the local staff.

S-5 Low language barrier

- Most staff members are capable of communicating in English, which enables to find more training resources without language barrier.

WEAKNESS (Internal negative factor)

W-1 Dependent constitution (lack of autonomy)

- Management policy is subject to decision by upper authority (board of directors)
- Financially fully dependent on GOSS

W-2 Insufficient O&M practice

- Lack of knowledge and skill.
- Lack of equipment, spare parts, etc.

W-3 Inefficiency in business process

- Lack of job description, work flow manual
- Lack of work record process and documentation practice
- Lack of information storage, e.g. drawings, monthly report, etc.

W-4 Financial weakness

- Lack of revenue, caused by low tariff, flat rate system, low collection rate
- Lack of subsidy by GOSS
- Lack of verifiable financial statement in accordance with international accounting standard

W-5 Poor human resources development

- No systematic training curriculum and trainers. New employee is trained only through OJT by their senior colleagues.
- Many staff members feel some dissatisfaction with incentives (salary, promotion, etc.)

OPPORTUNITY (External positive factor)

O-1 Institutional setup

- “Water Policy” is formulated to direct principles on water resources management.
- “Provisional Order of SSUWC” is to be soon submitted to the cabinet which clarifies legal status and institutional framework on SSUWC.

O-2 Government commitment

- The government authorities in all levels of central, state and Payam recognize water supply improvement as the high priority and commit their efforts.

- Local authorities are cooperative and helping to water project.

O-3 Donor assistance

- Rehabilitation works by MDTF and USAID are implemented.
- JICA and GTZ are going to support capacity development.

O-4 Intensive water demand

- Only 13% is reportedly served with public water service.
- Rapidly increasing population
- Bad quality of alternative domestic water source (esp. water tanker)
- Expensive water cost (water tanker)

O-5 Friendly relations with neighboring countries

- Foreign experts may be recruited for technical assistance, project management, etc.
- Training course can be utilized in Kampala, Nairobi, etc.

THREAT (External negative factor)

T-1 Lack of laws and regulation

- No provision of water law, water quality standards, design standards, etc. in Southern Sudan.

T-2 Insufficient involvement of state and Payam authorities

- Roles between central (GOSS) and states (CES) levels are still unclear.
- Information is not shared well among parties concerned. Especially, coordination and involvement of state and Payam authorities seems insufficient, who are the important stakeholder in project implementation.

T-3 Public awareness

- Not many people want to pay water charge. (because of poor water service, low willingness and affordability)
- It is estimated that there are many undetected illegal connection.

T-4 Political unrest

- While political situation in Southern Sudan is still unstable, population is rapidly growing in Juba. Urban infrastructure is largely behind the demand.

6.3.2 Capacity Assessment by Check List

In parallel with SWOT analysis, assessment of UWC's capacity is carried out by using standard check list as given in Table 6.6.

Table 6.6 Capacity Assessment Checklist

Category	Criteria	Evaluation (3 grades)	Remarks
Institution	Is there clear institutional framework on water supply?	B	"Provisional Order of SSUWC" is under progress of approval by Assembly.
	Are there appropriate laws and regulations related to water supply?	B	Although, there are currently no drinking water quality standard, design criteria and laws on water resources, they are to be established.
Organization	Is management policy decided dependently on the superior organizations?	C	Policy decision is made dependently by MWRI/GOSS and SSUWC HQ.
	Does the top of the waterworks recognize problems correctly?	B	Although they are aware of issues, they are too busy on daily job to take dynamic action.
	Is there a future vision of waterworks? And is the vision shared among the staff?	B	Although "Provisional Order" is to be regarded as a vision in the future, it is not shared at staff level.
	Do the waterworks make self-supporting effort?	B	Although they are well aware of necessity to improve themselves, they are too busy on daily job to take dynamic action.
	Are external organizations used practically and cooperated with?	C	The cooperation with the external organization seems not active.
Authority	Does the waterworks have the authority to appoint and dismiss management personnel?	B	SSUWC HQ has the authority of personnel affairs of the UWC Juba's senior official.
	Does the waterworks have the authority to reform the organization?	B	SSUWC HQ has the authority upon consent by the Board of Directors.
	Does the waterworks have the authority to employ and assign the personnel?	B	UWC has the authority to employ and assign. But it is restricted by the budget constraints from GOSS.
	Does the waterworks have the authority to outsource any work under subcontract?	C	Basically UWC is not authorized. It is dependent on decision by SSUWC HQ.
	Is there any penalty clause to a nonpayment customer and illegal user? And does the waterworks have the authority to stop water supply service?	B	Although there is a penalty clause, water supply stopping is hardly performed, especially for public organizations because of inadequate power.
Planning	Is there planning section in the waterworks?	C	There is no planning section in UWC. But the MWRI/GOSS water supply section is taking charge.
	Does the planning section have sufficient authority and capability?	C	- Ditto -
	Is there superior plan (e.g. master plan)?	B	Although "Water Policy (waiting for approval by the assembly)" is regarded as the superior plan, clear numeric target is not given.
	Are there design standards and approval criteria?	B	Although there are no standards in Southern Sudan, they are to be formed.
	Is coordination with the other related projects done appropriately?	B	MWRI/GOSS is to coordinate with other projects. But cooperation with MOH/GOSS or CES governments seems inadequate.
	Is there sufficient accumulation of knowledge and experience on similar projects?	B	Although MHPPE/GOSS (currently transferred to MWRI) is implementing the rehabilitation project of MDTF, information on project experience is not shared well with UWC.
Construction	Is there construction section in the waterworks?	B	The distribution department of UWC is assigned to construct pipelines and install water meters. However, it works mainly on pipe repair works of ground leakage, as reactive maintenance.
	Does the construction section have sufficient authority and capability?	B	The chief of distribution department controls field work under his authority. But the chief lacks authority to employ personnel and procure necessary parts and materials.

Category	Criteria	Evaluation (3 grades)	Remarks
	Are there machineries and vehicles necessary for construction work?	B	There are vehicles to mobilize personnel and equipment to the site. However, construction equipment and machineries are insufficient. Most work is done manually.
	Is the proper technology used for the existing facilities?	C	There remains a lot of asbestos cement pipes used which cause leakage so frequently.
	Are the as-built drawings and technical specifications properly stored and maintained?	C	Almost no drawings remain, which can be referred to.
O&M	Is there O&M section in the waterworks?	A	The purification department (64 persons) and the distribution department (54 persons) are assigned for O&M of water supply facility.
	Does the O&M section have sufficient authority and capability?	B	The chiefs of both departments control field work under their authority. But the chiefs lack authority to employ personnel and procure necessary parts and materials.
	Is there any center for storing and supplying of materials and consumables?	B	Materials are stored in the storage of UWC. And storekeeper keeps inventory record by using slip order. But storage is dirty and in poor condition.
	Are the materials kept and supplied properly?	B	Due to budget constraints, necessary materials, e.g. treatment chemicals, are not supplied as necessary.
	Is water quality control performed appropriately?	C	Chemical dosing for water treatment is not properly done, mainly due to lack of treatment chemical. And water quality analysis is not done due to lack of laboratory equipment. As a result, water quality control is not appropriately done.
	Are the O&M guideline and manual prepared?	C	There is no O&M guideline and manual.
	Is the proper technology used, considering the capability of O&M staff?	A	Conventional technology is applied to the facility, which is manageable by local staff.
Finance	Is the customer ledger properly maintained and is information management done appropriately?	C	Although the ledger is maintained in handwriting, it is inefficient and there are possibly many mistakes.
	Is the system of water charge billing and collection established? And does it work appropriately?	C	Although water charge billing and collection system is established, water meters are currently not installed and flat rate is employed. Collection rate is very low.
	Is there a section to control accounting information and prepare long-term financial plan?	C	The financial department is to take charge. However, there are no financial statements according to international accounting standards.
	Is the financial account of waterworks possibly self-supporting?	C	UWC depends on great part of expenditure, that is mainly for personnel expenses, by subsidy from GOSS.
	Is asset management performed appropriately?	C	There is no asset register.
Human Resource	Is there clear job description?	C	The job description is not stipulated.
	Is the O&M manual prepared?	C	There is no O&M manual.
	Is human resources development program implemented by staff level?	C	There is no systematic human resources development program. Staff training is performed only through OJT.
	Is the required number of engineers secured?	B	New employment is restricted by the budget constraint of GOSS.

(Note) Grade A: “Good”, B: “Conditional”, C: “Bad”

6.4 Financial Conditions of UWC-Juba

UWC earns income from water sales and installation fee for new connection. These incomes are paid into a government pool account managed by Ministry of Finance and Economic Planning (MOFEP) and SSUWC is financially dependent on subsidy from GOSS. Subsidies are received by SSUWC HQ and transferred to each branch office upon request as shown in Figure 6.5. UWC depends on government subsidy which covers mostly personnel expenses. Accounting system of SSUWC is based on division system, composed of the headquarters and three branch offices. SSUWC-CES-Juba manages the financial account under its control.

UWC prepares pay-sheet to request subsidy on monthly basis. After confirmation of remittance, UWC submits monthly report attached with bank receipt. Also expenditure report is submitted every six months. Although accounting audit is required by regulation, it has not yet been done.

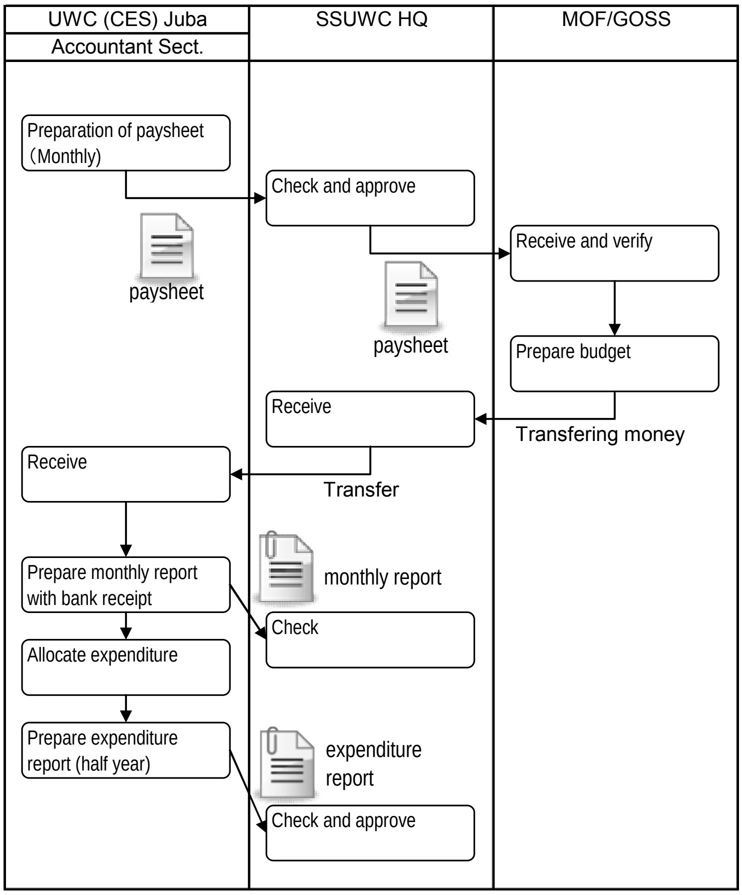


Figure 6.5 Fund Flow Process

Since water meters are currently not installed to customers, flat rate is applied depending on category of customers, as water tariff shown in Table 6.7. Tariff is proposed by UWC and approved by the Board of Directors of SSUWC. Then it would be taken into effect after decision by the Assembly.

Table 6.7 Water Tariff for Fiscal Year 2008

Category	No. of customers	Tariff (SDG/month)
First class	316	18
Second class	1037	15
Third class	800	9
Stand pipes	38	60
Hospitals	44	56
NGOs	79	100
Restaurants	29	100
Schools	20	56
Hotels	68	56
Government Units	36	56
New connections	298	255 (per connection)

Source: SSUWC-Juba Financial Department

Water charge billing and collection is performed as illustrated in Figure 6.6. According to financial department of UWC, only approx. 50% of customers respond to the bill on time. Hence, considerable amount of arrears by the remaining half of customers continue as account receivable, which is depressing cash flow of UWC. Although there is a regulation of penalty in the form of the customer who doesn't pay bills for three months would be fined and disconnected, disconnection is hardly carried out. The reason being some customers frighten UWC staff and for public offices it is more difficult to handle the situation due to inadequate power of UWC. In fact, accumulation of account receivable by the public offices is significantly high; approx. USD 200,000 (as of February 2006, stated in old currency of SDD 42.9 million). It has reportedly accumulated for years and practically regarded as bad debt.

Also, there are many cases in which customers refuse to receive bills for insufficient water supply condition. In that case, bill amount is discounted upon negotiation, which often causes record errors in ledger because it is maintained manually.

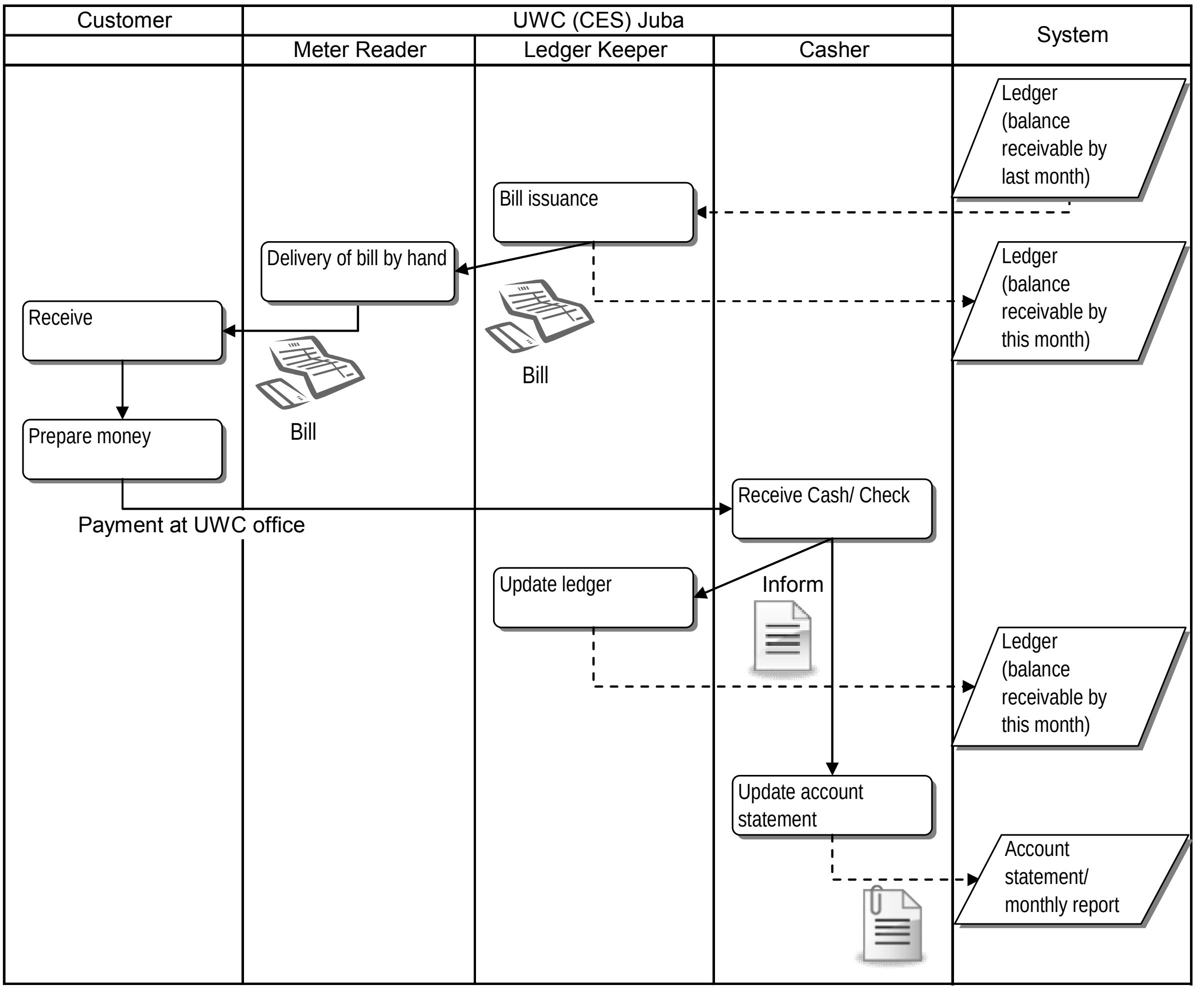


Figure 6.6 Flow Chart of Water Charge Billing and Collection

As UWC depends on government subsidy which covers mostly personnel expenses, UWC's operational expenditures are limited to UWC's own income, such as water sales and new connection fees. The statement of income and expenditure is shown in Table 6.8. It should be noted that this statement doesn't include the government subsidy and personnel expenses, which are not disclosed.

Table 6.8 Income and Expenditure Statement (Fiscal year 2007, Jan-Dec. 2007)

(SDG)

Income		Expenditure	
Water sales	233,697	Operating materials and spare parts	93,265
Deposit	48,331	Repair and maintenance	65,209
New connection	28,378	Fuel, lubricant, power	56,882
Re-connection	10,178	Stationary	9,182
Labor fee	46,862	Communication (Telephone)	5,127
Saddle cost	14,427	Meal allowance	25,951
		Incentive allowance	52,071
		Overtime compensation	31,479
		Travel allowance	1,172
		Loan, advance & contribution	10,167
Total income	381,873	Total expenditures	350,505

Source: JICA Preliminary Study Report, March 2008

On assumption that average staff salary is approx. SDG1000 per month and 167 staff in total, personnel expenses is estimated to be around SDG 2.0 million per year. Given that subsidy is not provided, UWC’s annual revenue (year 2007) can cover only 16% of total estimated expenditure (approx. SDG 2.3 million, includes estimated personnel expenses plus annual expenditure (2007)). This tentative calculation implies financial situation of UWC would be seriously vulnerable if the government would not continue subsidy.