THE STATE OF ERITREA

ASMARA WATER SUPPLY AND SEWERAGE DEPARTMENT

(AWSSD)

PROJECT COMPLETION REPORT

ON

ASMARA WATER SUPPLY INFRASTRUCTURE

(DATA COLLECTION AND MANAGEMENT)

PROJECT

IN THE STATE OF ERITREA

DECEMBER 2016

JAPAN INTERNATIONAL COOPERATION AGENCY

YACHIYO ENGINEERING CO., LTD.

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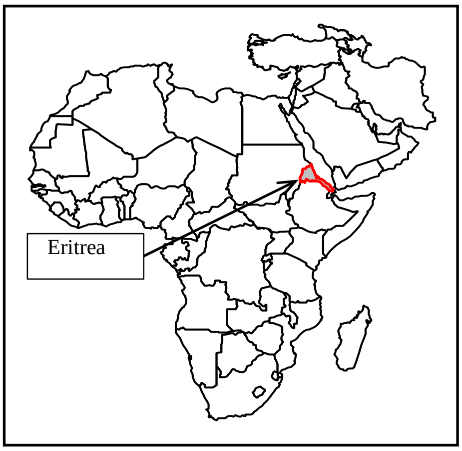
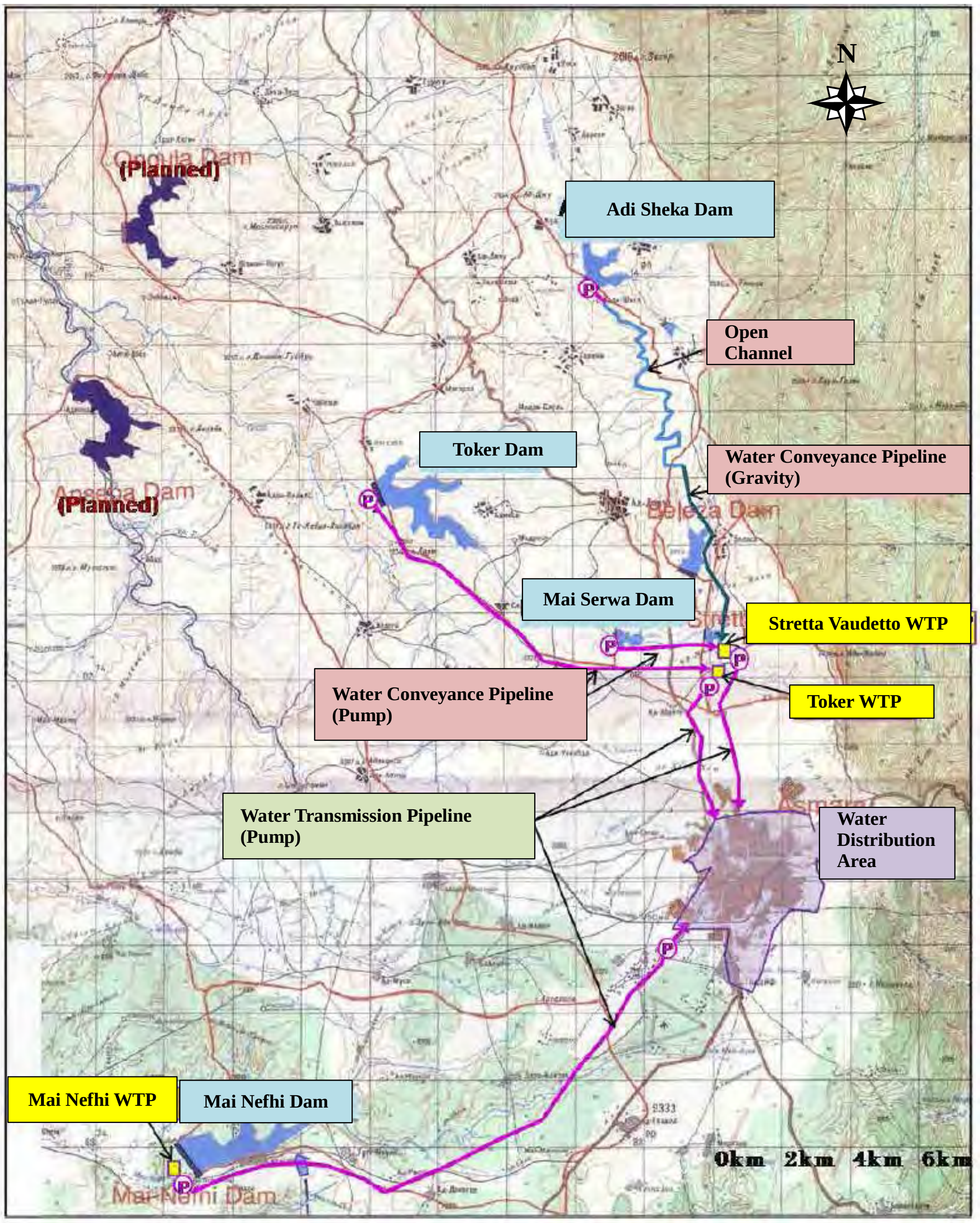
Exchange Rate applied in this Report

USD 1.00 = JPY 100.61、USD 1.00 = ERN 15.00
（As of October 2016）

Eritrea

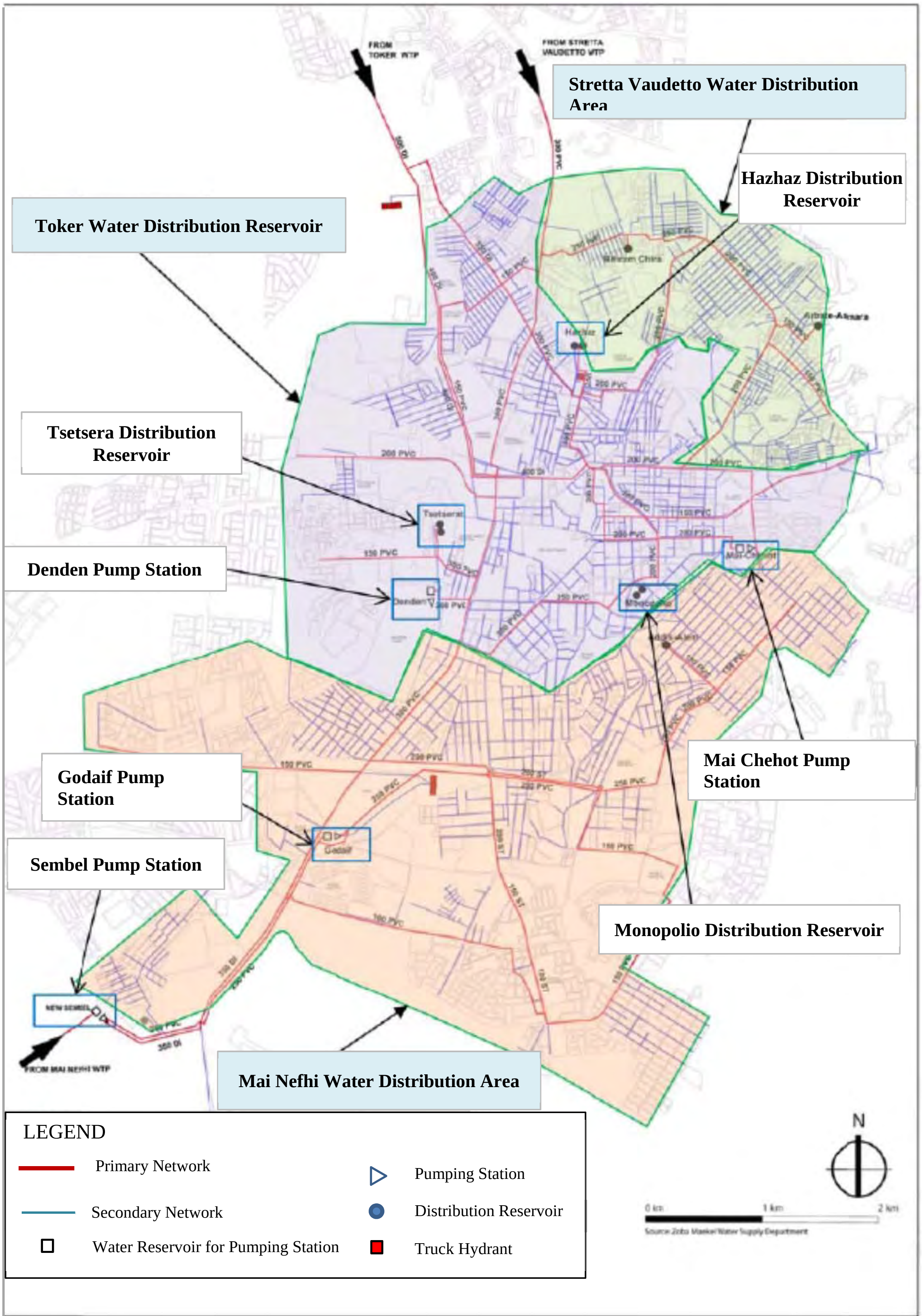


Africa



Source：The Preparatory Survey on the Project for Asmara Water Supply Development in the State of Eritrea, JICA

Figure 1　The Location of Main Water Facilities in Asmara City



Source: The Preparatory Survey on the Project for Asmara Supply Development in the State of Eritrea, JICA

Figure 2 The Location of Main Water Distribution Facilities in Asmara City

Photographs

Initial Joint Investigation

Kick off Meeting

Training of Water Flow Metering

Training of Water Quality Analysis

1st Interim Meeting

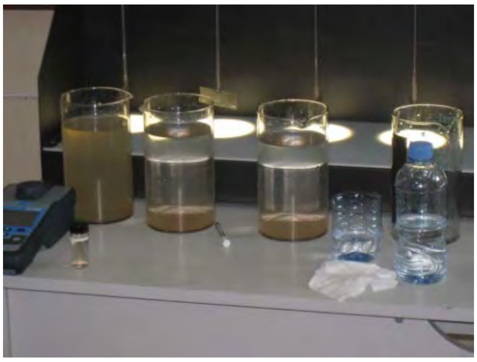
24 hours Water Flow Metering

Training of Pipe Detector

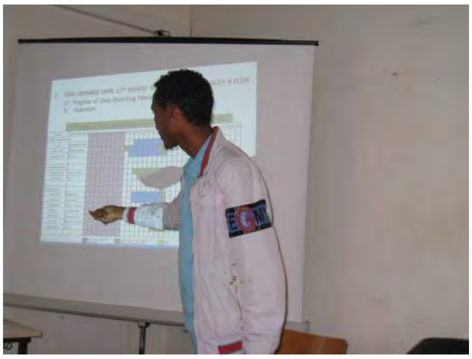
Simple Topographic Survey of Pipeline

Photographs

Demonstration of Jar Test and Water Treatment Process



Demonstration of Jar Test and Water Treatment Process



2nd Interim Meeting

Trial of Water Quality Improvement in Toker WTP（Cleaning of Flocculation Basin）

Trial of Water Quality Improvement in Toker WTP (Flocculation before Cleaning)

Trial of Water Quality Improvement in Toker WTP（Flocculation after Cleaning:　The difference of water color is observed.）

3rd Interim Meeting　(Data Recording Sheet Collecting & Summarizing)

Ending Meeting　(Phase-1)

Project Completion Report on Asmara Water Supply Infrastructure
(Data Collection and Management) Project
in the State of Eritrea

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3. Material for Kick-off Meeting
4. Material for 1st Interim Meeting
5. Material for 2nd Interim Meeting
6. Material for the Demonstration of Jar Test and Treatment Process
7. Material for 3rd Interim Meeting
8. Material for Ending Meeting (Phase-1)
9. Material for Follow-up Meeting
10. Recommended Plan for Operation & Maintenance for Water Supply in Asmara
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Abbreviation

AWSSD	Asmara Water Supply and Sewerage Department
CAD	Computer Assisted Drawing
CP	Counterpart
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
LCD	Litter/Capital/Day
MoLWE	Ministry of Land, Water and Environment
MoND	Ministry of National Development
OJT	On the Job Training
O&M	Operation and Maintenance
S.V.	Stretta Vaudetto
WHO	World Health Organization
WRD	Water Resource Department
WTP	Water Treatment Plant

SUMMARY

SUMMARY

1. Background

Asmara is the capital city of the State of Eritrea. Its population reaches 400 thousand. Due to the aged and damaged facilities, the existing water supply capacity is insufficient for the water demand. Share of the population served by piped water is only 47%.

To overcome the present problem, the Government of Eritrea requested the Japan’s Grant Aid in 2013 for rehabilitation and expansion of the existing water treatment facilities. As a result of preliminary surveys in August 2010 and August 2014, and “Preparatory Survey on the Project for Asmara Water Supply Development” from March to June in 2015 on the corresponding request, the survey team judged that the feasibility of corresponding Grand Aid Project was low due to the lack of operation and maintenance capability and the necessary data to proceed to basic design. It was confirmed by the Japanese and the Eritrean sides with the minutes of discussion made in the above preparatory survey (June 2015) that improvement of operation and maintenance system was prioritized than the facilities’ rehabilitation / expansion.

It was agreed that the Eritrean side took actions as priority regarding “basic information management such as collecting data for water quality and volume, and recording and utilizing the collected data” which was highly prioritized to operate and maintain the existing facilities. The Eritrean side, accordingly, requested a technical cooperation on dispatching experts from Japan in October 2015.

In accordance with the corresponding request, Japan International Cooperation Agency (hereinafter referred to as JICA) commenced “Asmara Water Supply Infrastructure (Data Collection and Management) Project in the State of Eritrea” in May 2016.

2. Overall Goal, Project Purpose and Outputs

The Project was implemented under the following goals. Overall Goal, Project Purpose and Outputs are described below. The Project activities are divided into four (4) groups and implemented as shown in the next page.

Implementation Organization	Asmara Water Supply and Sewerage Department (AWSSD)
Overall Goal	Basic information, which is necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.
Project Purpose	Collection and management system of information, which is necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).
Outputs	Output 1: Methods of data recording and management, and water quality management are improved for the target water storage facilities. Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants. Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution. Output 4: Collected information is unitarily managed and stored as data by AWSSD.

Activity for Operation Management	• 1-1 Arrangement of daily record sheets for water resource conservation (patrol, cleaning, water quality, etc.) at the dam lakes (Toker, Adi Shieka, S.V, Mai Nefhi). • 1-3 Arrangement of daily record sheets (inspection, repair, etc.) for the dam bodies. • 2-3 Arrangement of daily record sheets (inspection, repair, water quality, water flow, operation hours) in 3 water treatment plants. • 3-2 Arrangement of daily record sheets (inspection, repair, water flow rate) at water conveyance, transmission, distribution facilities and water stations. • 3-3 Arrangement of daily record sheets (inspection, repair, flow rate and operation hours) in pump stations. • 4-1 Management and utilization of collected information and data. • 4-2 Preparation of operation and maintenance plan (including information management).
Activity for Water Quality Management	• 1-2 Implementation of water quality analysis (pH, turbidity, EC, analysis schedule, visual inspection, etc.) at the dam lakes. • 2-2 Implementation of water quality analysis (pH, turbidity, EC, odor, visual inspection, E-coli, fecal bacteria, residual chlorine) in 3 water treatment plants.
Activity for Water Distribution Management	• 2-1 Implementation of scheduled water flow metering for inlet and outlet waters at 3 water treatment plants (S.V., Toker and Mai Nefhi). • 3-1 Implementation of scheduled water flow metering for inlet and outlet waters at water conveyance, transmission, distribution facilities and water stations.
Activity for Facility Information Management	• 2-4 Arrangement of drawings and documents of 3 water treatment plants. • 3-4 Arrangement of drawings and documents of water conveyance, transmission and distribution facilities. • 3-5 Arrangement of drawings and documents of water conveyance, transmission and distribution pipelines.

Source: JICA Expert Team

3. Schedule

The Project schedule is shown below.

During May to July 2016	Procurement and dispatch of the equipment
During July to September 2016	Work in Eritrea (phase-1): - Training of water flow metering and quality analysis - Preparing daily record sheets to record data - Improvement of data collection and management method - Training of simple topographic survey method and drawing
During October to November 2016	Preparing operation & maintenance plan (draft)
During November to December 2016	Work in Eritrea (phase-2): - Confirmation of outputs - Exchange of opinion about operation & maintenance plan (draft)

4. Achievement of Goals

In the result of the Project, Asmara Water Supply and Sewerage Department (hereinafter referred to as AWSSD) staff acquired the skill of water flow metering and water quality analysis. The information of operation and maintenance in major facilities was recorded in daily record sheets. The records were gathered regularly, summarized and stored in the headquarters. Simple topographic survey at pipelines was invented and drawings were getting organized based on collected information through such simple topographic survey. Project summary and achievement levels are shown as Table S-1. It is expected for AWSSD to continue and improve the activities.

Table S-1 Project Summary and Achievement Levels

Project Summary	Achievement Levels
[Overall Goal] Basic information, which is necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.	1) Planning and Supervision Unit was assigned as the responsible section for information management. 2) The preparation of daily record sheets was started at each facility. It was commenced that the records were gathered and stored in the headquarters.
[Project Purpose] Collection and management system of information, which is necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).	1) The system that Planning and Supervision Unit in Water Supply Division collected and managed information was developed. Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started. 2) The responsible persons were assigned for facility information management and water quality analysis respectively in Planning and Supervision Unit of AWSSD. 3) It was commenced that the record sheets of each facility were gathered to the headquarters, and the information was summarized and stored in Planning and Supervision Unit.
Output 1: Methods of data recording and management, and water quality management are improved for the target water storage facilities.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in water storage facilities (Stretta Vaudetto, Toker and Mai Nefhi). 2) Simple method for water flow metering was invented for daily records. 3) Water quality team was organized and trained. Water quality analysis was started in water storage facilities. 4) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and the scheduled flow rate metering was started.
Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in water treatment plants. 2) Simple method for water flow metering was invented for daily records. 3) Water quality management team was organized and trained. Water quality analysis was started in water treatment plants. 4) The staff in water treatment plants and water quality management team acquired the skill to analyze the basic parameters of water quality. 5) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and scheduled flow rate metering was started. 6) Water quality improvement trial was implemented in Toker water treatment plant and it was confirmed that improvement was possible by a simple method.
Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in each facility. 2) Simple method for water flow metering was invented for daily records. 3) The water quality management team was started to analyze and record water quality in service reservoirs. 4) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and scheduled flow rate metering was started. 5) Information of pipelines having no drawing was collected and drawings were getting organized based on such collected information.
Output 4: Collected information is unitarily managed and stored as data by AWSSD.	1) Planning and Supervision Unit of AWSSD was assigned as the responsible section for information management. The responsible persons in charge of facility information management and water quality management were assigned separately. 2) Collection of the record sheets from each facility was started. Data storage and information management were commenced by Planning and Supervision Unit.

Source: JICA Expert Team

CHAPTER 1 INTRODUCTION

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1.1 Background

Asmara is the capital city of the State of Eritrea. Its population reaches 400 thousand. Due to the aged and damaged facilities, the existing water supply capacity is insufficient for the water demand. Share of the population served by piped water is only 47%.

To overcome the present problem, the Government of Eritrea requested the Japan's Grant Aid in 2013 for rehabilitation and expansion of the existing water treatment facilities. As a result of preliminary surveys in August 2010 and August 2014, and "Preparatory Survey on the Project for Asmara Water Supply Development" from March to June in 2015 on the corresponding request, the survey team judged that the feasibility of corresponding Grand Aid Project was low due to the lack of operation and maintenance capability and the necessary data to proceed to basic design. It was confirmed by the Japanese and the Eritrean sides with the minutes of discussion made in the above preparatory survey (June 2015) that improvement of operation and maintenance system was prioritized than the facilities' rehabilitation / expansion.

It was agreed that the Eritrean side took actions as priority regarding "basic information management such as collecting data for water quality and volume, and recording and utilizing the collected data" which was highly prioritized to operate and maintain the existing facilities. The Eritrean side, accordingly, requested a technical cooperation on dispatching experts from Japan in October 2015.

In accordance with the corresponding request, Japan International Cooperation Agency (hereinafter referred to as JICA) commenced "Asmara Water Supply Infrastructure (Data Collection and Management) Project in the State of Eritrea" in May 2016.

1.2 Overall Goal, Project Purpose and Outputs

Overall Goal, Project Purpose and Outputs of the Project are described as below.

Overall Goal	Basic information, which is necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.
Project Purpose	Collection and management system of information, which is necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).
Outputs	Output 1: Methods of data recording and management, and water quality management are improved for the target water storage facilities. Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants. Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution. Output 4: Collected information is unitarily managed and stored as data by AWSSD.

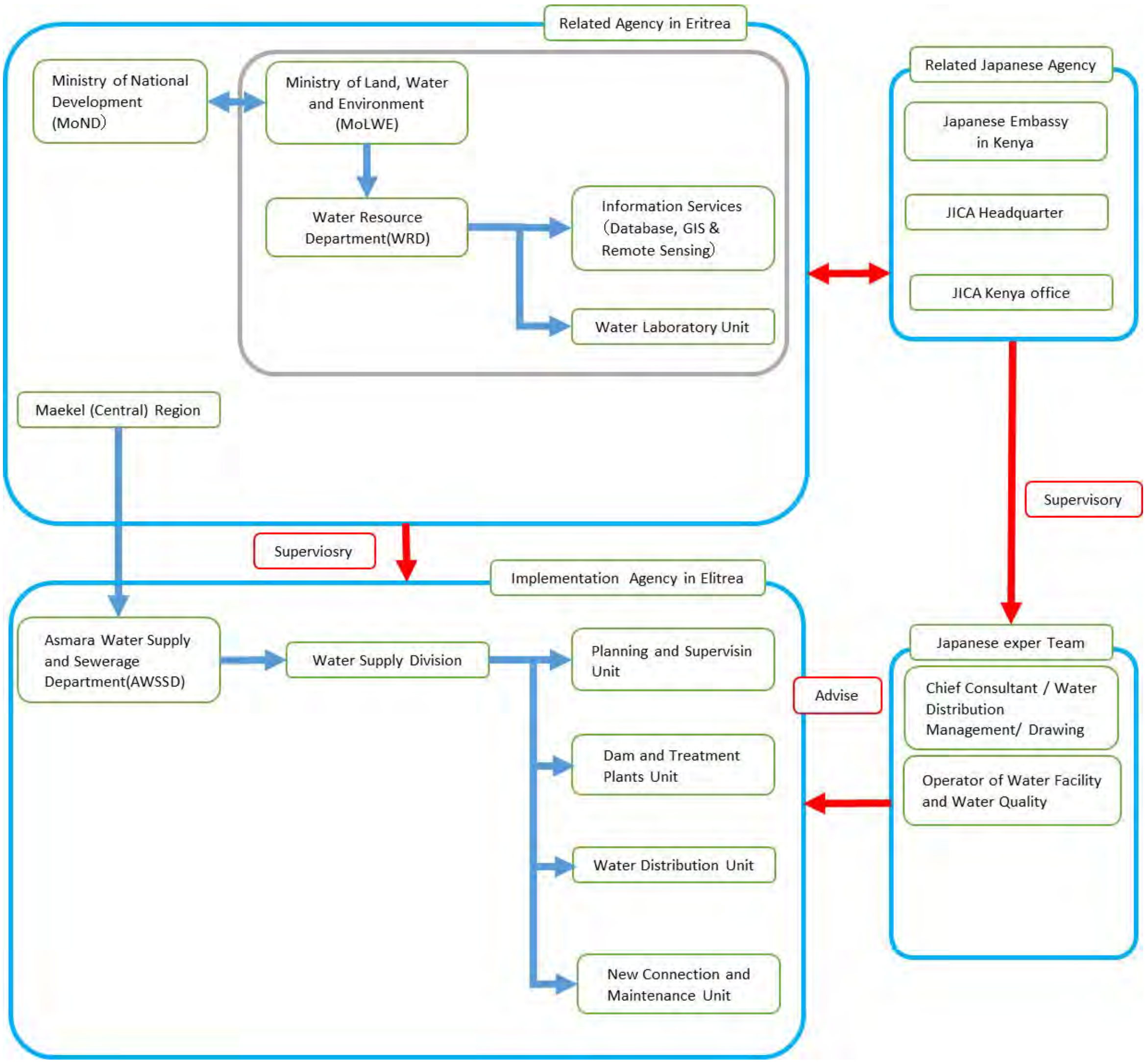
1.3 Target Area

The Target area for the Project is the water service zone in Asmara city and water supply facilities in Asmara city including dams, intake facilities, water conveyance facilities, water treatment plants (hereinafter referred to as WTPs) and water transmission / distribution facilities. The target area of the Project are referred in Figure 1 "The Location of Main Water Facilities in Asmara City" and Figure 2 "The Location of Main Water Distribution Facilities in Asmara City" in the beginning of the report.

1.4 Implementation Structure of the Project and Related Agency

Asmara Water Supply and Sewerage Department (hereinafter referred to as AWSSD) is the counterpart agency of the Project. Implementation structure of the Project and related agency is described in Figure 1-1. The organization chart of AWSSD is shown in Figure 1-2.

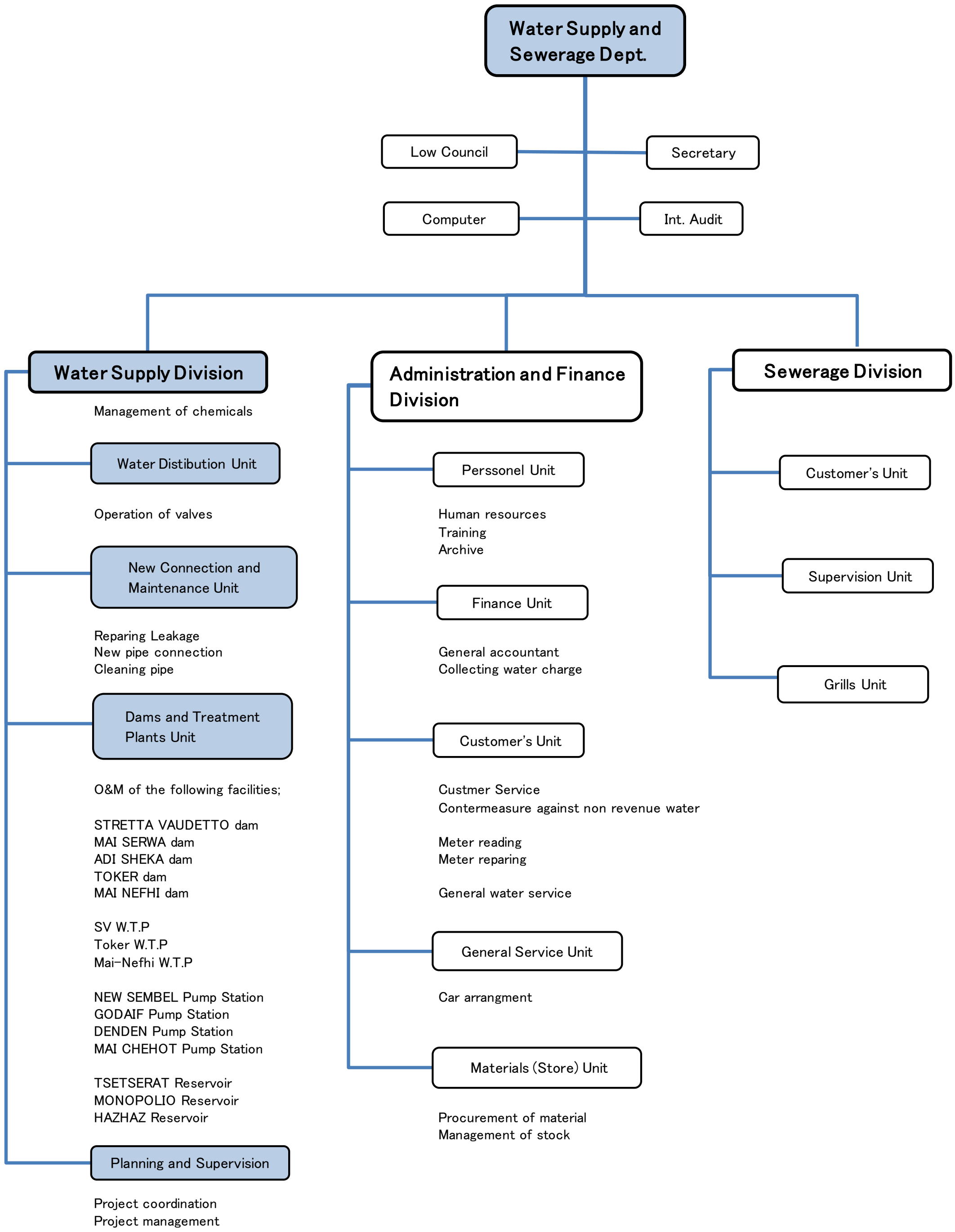
To implement the Project, AWSSD arranged Counterpart (hereinafter referred to as CP) teams. The CP team organized the Project team with JICA expert team. CP team members are described from page 1-4.



Source: JICA Expert Team

Figure 1-1 Implementation Structure of the Project and Related Agency

AWSSD Organizational Chart



Source: JICA Preparatory Survey on the Project for Asmara Water Supply Development and Confirmed by AWSSD

Figure 1-2 Organization Chart of AWSSD

[Project Management Team]

A management team for the Project was organized at the initial stage of the Project. The team member is listed in Table 1-1.

Table 1-1 Project Management Team

Name	Qualification	Position/Section
Mr. Gherekidan Ghirmazion	Engineering	Director General / AWSSD
Mr. Kidane Kiflemariam	Engineering	Head of Water supply Division
Mr. Yohannes (John) Mulu	Geometry/Advisor	Head of Sewerage Divison / Head of Planning and Supervision Unit

Source: JICA Expert Team

[Water Quality Management Team]

Water quality management team was organized to manage water quality in water supply facilities. The member is listed in Table 1-2.

Table 1-2 Water Quality Management Team

Name	Qualification	Position/Section
Mr. Tadesse Berhe	Chemical Technology	In charge of water quality analysis
Ms. Feruz Tekle	Survey	In charge of water quality analysis
Mr. Yikealo Araia	Chemical Technology	In charge of water quality analysis
Mr. Amanuel Fessahaye	Survey	New Connection and Maintenance Unit
Mr. Samsom Kiflezghi	Survey	Water Distribution Unit
Ms. Tsenat Mehari	Survey	Water Distribution Unit
Ms. Helen Yemane	Geometry	Water Distribution Unit

Source: JICA Expert Team

[Facility Information Team]

Facility information team was organized to update and manage the information of facilities such as drawings of water supply facilities and pipelines. The member is listed in Table 1-3.

Table 1-3 Facility Information Team

Name	Qualification	Position/Section
Mr. Abiel Kiflay	Civil engineering	Planning and Supervision Unit
Ms. Adiam Yohannes	Civil engineering	Planning and Supervision Unit
Mr. Awelkier Hiyabu	Drafting	Planning and Supervision Unit
Mr. Abraham Dawit	Drafting	Planning and Supervision Unit
Ms. Asmait Beraki	Drafting	Planning and Supervision Unit
Mr. Samuel Beyene	Survey	Planning and Supervision Unit

Name	Qualification	Position/Section
Ms. Semhar Fikre	Survey	Planning and Supervision Unit
Ms. Helen Teklehaimanot	Survey	Planning and Supervision Unit
Mr. Henok Tsehaye	Survey	Planning and Supervision Unit
Mr. Yonas Neamn	Drafting	Planning and Supervision Unit
Mr. Mulgheta Beraki	Survey	New Connection and Maintenance Unit
Mr. Maebel Tesfamariam	Survey	New Connection and Maintenance Unit
Ms. Azamit Rasu	Drafting	New Connection and Maintenance Unit

Source: JICA Expert Team

[Water Distribution Team]

Water distribution team was organized to collect the data on water service and water distribution volume. The member is listed in Table 1-4.

Table 1-4 Water Distribution Team

Name	Qualification	Position/Section
Mr. Michael Temesghen	Technic	Water Distribution Unit
Mr. Biniam Ghebre	Survey	Water Distribution Unit
Mr. Efrem Wengisteab	Drafting	Water Distribution Unit
Ms. Lettu Costantinos	Geometry	Water Distribution Unit
Ms. Natznet Mesghena	Survey	Water Distribution Unit

Source: JICA Expert Team

1.5 Outline of Present Water Supply Conditions

Present conditions of water supply are described in Appendix-10. Outline of the conditions are summarized below.

(1) Water Supply System

AWSSD distributes the water to the Asmara city by three systems, namely Stretta Vaudetto (hereinafter referred to as “S.V.”), Toker and Mai Nefhi systems. The location of system is illustrated in Figure 1 and Figure 2. Water is taken from dam lakes and the water is treated per system respectively. Treated water is distributed by gravity or pumps. Besides the piped water supply, AWSSD distributes the water through water tank trucks for uncovered population by the pipeline networks.

Design capacity of the systems, based on 24 hours operation, are shown in Table 1-5.

Table 1-5 Design Capacity of Water Treatment Plants

Water Treatment Plant	S.V.	Toker	Mai Nefhi	Total
Design Capacity (m^3/d)	8,000	18,000	20,000	46,000

Data source: AWSSD

(2) Summarized Conditions for Water Supply

According to information of year 2015, the water supply conditions are summarized as Table 1-6.

Table 1-6 Present Water Supply Conditions

No.	Item / Indicator	Value	Remark
1	Water Production in 2015		
1-1	S.V. WTP (m^3/year)	519,100	1,422 m^3/d
1-2	Toker WTP (m^3/year)	2,561,000	7,016 m^3/d
1-3	Mai Nefhi WTP (m^3/year)	3,062,343	8,390 m^3/d
1-4	Total (m^3/year)	6,142,443	16,829 m^3/d
2	Water Distribution by Pipelines (m^3/year)	5,569,634	15,259 m^3/d
3	Water Distribution by Water Tank Trucks (m^3/year)	572,809	1,569 m^3/d
4	Water Consumption of Piped Water (m^3/year)	2,405,402	6,590 m^3/d
5 = 3 + 4	Billed Water Volume (m^3/year)	2,978,211	8,159 m^3/d
6 = 1 - 5	Non-revenue Water Volume (m^3/year)	3,164,232	8,669 m^3/d
7 = 6 / 1	Non-revenue Water Ratio (%)	52%	
8	Service Population (Population in service area)	427,429	39 LCD
9	Number of Connection	34,203	
10	Service Population by Piped Water	202,824	Number of connection x 5.93
11= 10 / 8	Share of Population Served by Piped Water	47%	

Note: WTP = Water Treatment Plant, LCD = L / Capita / Day. “5.93” is the number of persons per connection calculated in 2016.
Data source: AWSSD

(3) Issues

Present issues are summarized as follows:

- Due to electricity interruptions, troubles on equipment / devices, water shortage, etc., actual production of water is around 40% of the design capacity. Improvement of electricity distribution, rehabilitation / repair of water supply facilities and enhancement of O&M capacity are necessary.
- Chemical dosing facilities at WTP are broken-down. The chemicals, therefore, are not dosed appropriately. Due to inappropriate chemical dosing, chemical coagulation is not properly conducted and water quality of treated water is not acceptable for drinking purpose. Appropriate water quality management and operation are required as well as necessary devices.
- Daily water quality analysis is not provided and activity is rarely organized for water quality improvement. System for water quality analysis and water quality management is necessary.
- Due to inappropriate data management on water flow, it is difficult to know actual water production and operation efficiency. Data management system on water flow, metering and recording, is necessary.
- The existing facilities are aged and rehabilitation / repairs are required. However, it is difficult to prepare appropriate plans due to insufficient information on the existing facilities. Management system for technical information is necessary.

CHAPTER 2 PROJECT ACHIEVEMENT

CHAPTER 2 PROJECT ACHIEVEMENT

Achievement levels of the Project are shown in Table 2-1 and Table 2-2.

Table 2-1 Project Indicator and Achievement Levels

Project Summary	Indicator	Achievement Levels
[Overall Goal] Basic information, which is necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.	In each facility of AWSSD, daily operations are recorded and the records are managed in AWSSD.	1) Planning and Supervision Unit was assigned as the responsible section for information management. 2) The preparation of daily record sheets was started at each facility. It was commenced that the records were gathered and stored in the headquarters.
[Project Purpose] Collection and management system of information, which is necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).	In major facilities of AWSSD, daily operations are commenced and recorded. AWSSD commences to collect and manage the records.	1) The system that Planning and Supervision Unit in Water Supply Division collected and managed information was developed. Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started. 2) The responsible persons were assigned for facility information management and water quality analysis respectively in Planning and Supervision Unit of AWSSD. 3) It was commenced that the record sheets of each facility were gathered to the headquarters, and the information was summarized and stored in Planning and Supervision Unit.
Output 1: Methods of data recording and management, and water quality management are improved for the target water storage facilities.	Daily record sheets are prepared in each water storage facility.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in water storage facilities (Stretta Vaudetto, Toker and Mai Nefhi). 2) Simple method for water flow metering was invented for daily records. 3) Water quality team was organized and trained. Water quality analysis was started in water storage facilities. 4) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and the scheduled flow rate metering was started.
Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants.	Daily record sheets are prepared in each water treatment plant.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in water treatment plants. 2) Simple method for water flow metering was invented for daily records. 3) Water quality management team was organized and trained. Water quality analysis was started in water treatment plants. 4) The staff in water treatment plants and water quality management team acquired the skill to analyze the basic parameters of water quality. 5) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and scheduled flow rate metering was started. 6) Water quality improvement trial was implemented in Toker water treatment plant

Project Summary	Indicator	Achievement Levels
		and it was confirmed that improvement was possible by a simple method.
Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution.	Daily record sheets are prepared at water intakes, conveyance, transmission and distribution facilities.	1) Daily record sheets in which the contents were sustainable for AWSSD were organized and daily records (pump operation time, etc.) were started in each facility. 2) Simple method for water flow metering was invented for daily records. 3) The water quality management team was started to analyze and record water quality in service reservoirs. 4) The persons in charge of water flow metering acquired the metering skill for ultrasonic flowmeters and scheduled flow rate metering was started. 5) Information of pipelines having no drawing was collected and drawings were getting organized based on such collected information.
Output 4: Collected information is unitarily managed and stored as data by AWSSD.	Daily records are stored and managed in AWSSD.	1) Planning and Supervision Unit of AWSSD was assigned as the responsible section for information management. The responsible persons in charge of facility information management and water quality management were assigned separately. 2) Collection of the record sheets from each facility was started. Data storage and information management were commenced by Planning and Supervision Unit.

Source: JICA Expert Team

Table 2-2 Project Outputs and Achievement Levels

	Project Outputs	Achievement Levels	Inputs
1	**Output 1: Methods of data recording and management and water quality management are improved for the target dam lakes.**		**[Japanese side]** 1) Japanese Experts ・Chief consultant/ water distribution management/ drawing ・Operator of water facilities/ Water quality management ・Coordinator/ assistant of water distribution management and drawing 2) Procurement of equipment **[Eritrean side]** 1) Counterparts ・Management team (including Director General of AWSSD and Head of Water Supply Division) ・Project coordinator ・Water quality management team ・Water distribution team ・Facility information team 2) Project office 3) Equipment 4) Necessary information
1-1	Arrangement of daily record sheets for water resource conservation (patrol, cleaning, water quality, etc.) at the dam lakes (Toker, Adi Shieka, S.V, Mai Nefhi).	Facility information team was organized. The daily record sheets in which the contents were sustainable for AWSSD were prepared and daily records (water level, sludge level, etc.) were started in the dam lakes (Adi Sheka, Stretta Vaudetto, Toker and Mai Nefhi).	
1-2	Implementation of water quality analysis (pH, turbidity, EC, analysis schedule, visual inspection, etc.) at the dam lakes.	Water quality management team was organized and trained. Water quality analysis was started in the dam lakes.	
1-3	Arrangement of daily record sheets (inspection, repair, etc.) for the dam bodies.	Facility information team was organized. The daily record sheets in which the contents were sustainable for AWSSD were prepared and daily records (pump operation hours, outlet volume, etc.) were started in the dam lakes (Adi Sheka, Stretta Vaudetto, Toker and Mai Nefhi).	
2	**Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants.**		
2-1	Implementation of scheduled water flow metering for inlet and outlet waters at 3 water treatment plants (S.V., Toker and Mai Nefhi).	Water distribution team was organized. Water flow metering by ultrasonic flowmeters was trained and scheduled water flow metering was started in water treatment plants. The plan for scheduled flow rate metering was prepared.	
2-2	Implementation of water quality analysis (pH, turbidity, EC, odor, visual inspection, E-coli, fecal bacteria, residual chlorine) in 3 water treatment plants.	Water quality management team was organized and trained. Water quality analysis was started in water treatment plants.	
2-3	Arrangement of daily record sheets (inspection, repair, water quality, water flow, operation hours) in 3 water treatment plants.	Facility information team was organized. The daily record sheets in which the contents were sustainable for AWSSD were prepared and daily records (pump operation hours, outlet volume, etc.) were started in water treatment plants. Simple method for water flow metering was invented for daily records in water treatment plants.	
2-4	Arrangement of drawings and documents of 3 water treatment plants.	Facility information team was organized. Information such as pump specifications and location relationship of pumps was confirmed. The availability of drawing including Auto-CAD was confirmed and the drawings' list was prepared.	

Project Outputs		Achievement Levels	Inputs
3	**Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution.**		
3-1	Implementation of scheduled water flow metering for inlet and outlet waters at water conveyance, transmission, distribution facilities and water stations.	Water distribution team was organized. Water flow metering by ultrasonic flowmeters was trained and scheduled water flow metering was started in facilities on water intakes, conveyance, transmission and distribution. The plan for scheduled water flow metering was prepared.	
3-2	Arrangement of daily record sheets (inspection, repair, water flow rate) at water conveyance, transmission, distribution facilities and water stations.	Facility information team was organized. The daily record sheets in which the contents were sustainable for AWSSD were prepared and daily records (pump operation hours, etc.) were started in facilities such as the intake, water conveyance, water transmission facilities. Simple method for water flow metering was invented for daily records.	
3-3	Arrangement of daily record sheets (inspection, repair, flow rate and operation hours) in pump stations.	Facility information team was organized. The daily record sheets in which the contents were sustainable for AWSSD were prepared and daily records (pump operation hours, etc.) were started in facilities. Simple method for water flow metering was invented for daily records.	
3-4	Arrangement of drawings and documents of water conveyance, transmission and distribution facilities.	Facility information team was organized. Information such as pump specification, vertical relation of pumps and water distribution areas and demands was confirmed. The availability of drawings including AutoCAD was confirmed and the drawings' list was prepared.	
3-5	Arrangement of drawings and documents of water conveyance, transmission and distribution pipelines.	Information such as type of pipes and diameter for water conveyance, water transmission and water distribution was confirmed. Usage of metal locater, pipe detector, GPS, etc. was trained. It was started to specify location of pipes having no drawing. Drawings including the valve location were also started according to acquired information.	
4	**Output 4: Collected information is unitarily managed and stored as data by AWSSD.**		
4-1	Management and utilization of collected information and data.	Planning and Supervision Unit was assigned as the responsible section. It was commenced that the record sheets were collected and stored in the headquarters.	
4-2	Preparation of operation and maintenance plan (including information management).	Through confirmations and discussions with JICA expert team, operation & maintenance plan (draft) was prepared.	

Source: JICA Expert Team

CHAPTER 3 ACTIVITY FOR OUTPUTS

CHAPTER 3 ACTIVITY FOR OUTPUTS

Activities of the Project were divided into four (4) groups as shown in Figure 3-1. The activities were mainly implemented during the phase-1 of work in Eritrea (from July to September, 2016). During the phase-2 of work in Eritrea (from November to December, 2016), follow-up actions were took place to confirm continuity of improvement activities, explain of Operation and Maintenance Plan (draft) and exchange opinions regarding the plan.

Activity for Operation Management	• 1-1 Arrangement of daily record sheets for water resource conservation (patrol, cleaning, water quality, etc.) at the dam lakes (Toker, Adi Shieka, S.V, Mai Nefhi). • 1-3 Arrangement of daily record sheets (inspection, repair, etc.) for the dam bodies. • 2-3 Arrangement of daily record sheets (inspection, repair, water quality, water flow, operation hours) in 3 water treatment plants. • 3-2 Arrangement of daily record sheets (inspection, repair, water flow rate) at water conveyance, transmission, distribution facilities and water stations. • 3-3 Arrangement of daily record sheets (inspection, repair, flow rate and operation hours) in pump stations. • 4-1 Management and utilization of collected information and data. • 4-2 Preparation of operation and maintenance plan (including information management).
Activity for Water Quality Management	• 1-2 Implementation of water quality analysis (pH, turbidity, EC, analysis schedule, visual inspection, etc.) at the dam lakes. • 2-2 Implementation of water quality analysis (pH, turbidity, EC, odor, visual inspection, E-coli, fecal bacteria, residual chlorine) in 3 water treatment plants.
Activity for Water Distribution Management	• 2-1 Implementation of scheduled water flow metering for inlet and outlet waters at 3 water treatment plants (S.V., Toker and Mai Nefhi). • 3-1 Implementation of scheduled water flow metering for inlet and outlet waters at water conveyance, transmission, distribution facilities and water stations.
Activity for Facility Information Management	• 2-4 Arrangement of drawings and documents of 3 water treatment plants. • 3-4 Arrangement of drawings and documents of water conveyance, transmission and distribution facilities. • 3-5 Arrangement of drawings and documents of water conveyance, transmission and distribution pipelines.

Source: JICA Expert Team

Figure 3-1 Activity Groups for the Project

Target facilities for the Project are shown in Table 3-1.

Table 3-1 Target Facilities

System	S.V.	Toker	Mai Nefhi
Facility Name	Adi Sheka dam	Toker dam	Mai Nefhi dam
	S.V. WTP	Toker WTP	Mai Nefhi WTP
		Mai Chehot pump station	New Sembel pump station
		Denden pump station	Godaif pump station
		Monopolio service reservoir	
		Tsetserat service reservoir	
		Algen camp	

Source: JICA Expert Team

3.1 Activity for Operation Management

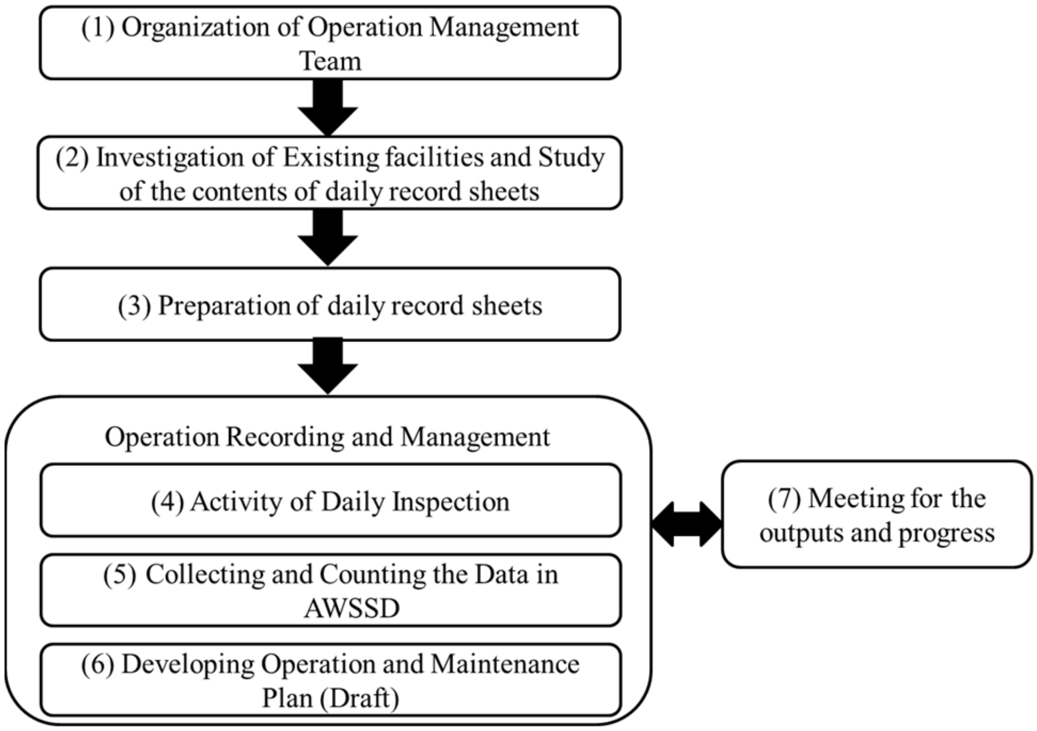
[Objectives]

Based on the output "Methods of data recording and management are improved in water supply facilities", following items were implemented.

- CP members and facility operators come to be able to make and manage the records.
- The system that the records in the each facility are collected to AWSSD once a week is organized.
- The system that the record is verified and stored in AWSSD is organized.
- Operation and Maintenance Plan (draft) is developed.

[The Contents of Activities]

Implementation process for the Project is shown in Figure 3-2.



Source: JICA Expert Team

Figure 3-2 Implementation Process of Activities for Operation Management

(1) Organization of Operation Management Team

Because there was close relationship between the water quality and operation management of water supply facilities, the system that aforementioned water quality team in Table1-2 and facility information team in Table1-3 implement collectively was organized. Water quality team was in charge of the activities related to water quality and facility information team was in charge of the activities related to water volume and facility information. The team and facility operators in each facility took the main responsibility for developing daily record sheets.

(2) Investigation of the Existing Facilities and Study of Contents of Daily Record Sheets

Each facility was investigated to decide the items to write down the daily record sheets. Main investigation items are below.

- Structure and layout of facilities
- Current recording system
- Metering points of water quality and water volume of daily records

Current recording system was below.

- In each facility, dosed chemical volume and pump operation time were roughly recorded, but they were not accurate.
- Above information was recorded in AWSSD every quarter.

(3) Preparation of the Daily Record Sheets

The items that recorded in daily record sheets were decided in the range where facility operators could continue, considering activity period of the Project and sustainability of activities by CP members.

The recording items are shown below. The formats of daily record sheets are shown in Table 3-2, Table 3-3 and Table 3-4 for example. All formats of record sheets are attached in Appendix-10.

- The water level in dams and distribution reservoirs
- Pump operation hours
- Water inlet volume and outlet volume in WTPs and service reservoirs (Estimation used with simple method)
- Water quality
- Dosing volume of chlorine and coagulant
- Consumable volume of diesel
- Special notes of check, repair, allophone, etc.

(4) Activity of Daily Records

JICA expert team and opeation management team visited every water supply facility and trained facility operators to record data such as water level, pump operation hours and something abnomal in dam. Because there were many places where metering instruments like a flow meter were not installed, water volume metering was simpleified by recording overflow depth of weir and pump operation hours, and converting with the relation between water flow and pump operation verified in the Project and formula between overflow depth of weir and water flow.

It was judged to be difficult for facility operators to record technical contents such as abonormaility and trouble of mechanical equipment. Instead, it was introduced to record nontechnical matters such as electricity failure, abnomal noise, temeperature, etc. in reamarks or blank area in the daily record sheets.

Herewith facility operators came to be able to record daily operation more exactly than before. However unexact records or errors were still found here and there. Planning and Supervision Unit in AWSSD is planning to continiously train them.

(5) Collecting and Counting the Data in AWSSD

It was decided that daily record sheets in water supply facilities were collected. The system was orgainzed that CP members in Planning and Supervision Unit input corresponding data to a computer in AWSSD and count and manage the data for each system (S.V., Toker and Mai Nefhi). Collected data is shown in Appendix-10. The examples of collecting data are shown in Table 3-5 and Figure 3-3.

Table 3-2 Example of Daily Record Sheets-1 (Toker Dam)

Daily Operation Check Sheet　　Toker Intake Facility

Date.________

1.Toker Dam　　Person Checked ____　　Time Checked________

Facility Name	Items	Value/Condition		Note.
Toker Dam	Water Level		m	① Max.46m

2.Transmission Pump (Diezel Engine Pump)
Pump 1
Designed Capacity 990m3/hr×239mH

	Time（**: **）	Operaing Time（ hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				990m3/hr × Total Operating Time (hr)

Pump 2
Designed Capacity 990m3/hr×239mH

	Time（**: **）	Operaing Time（ hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				990m3/hr × Total Operating Time (hr)

3. Fuel Consumed　Person Checked ____　　Time Checked________

Name of Chemicals	Height of Fuel		Volume		Note/Person Checked
Diesel		m		m3	②= 28.26× ①

Source: JICA Expert Team

Table 3-3 Example of Daily Record Sheets-2 (Toker WTP)

Daily Operation Check Sheet Toker WTP

Date.______________________

1.Water Source and Flow Rate Person Checked ____________ Time Checked ______________________

Designed Capacity 18,000m3/day

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Source	From Adi Sheka Dam				レ or ×
	From Tokar Dam				レ or ×
	Water Level against weir		cm		
	Flow Rate		m³/hr	750 m^3/hr	

2. Intake Volume

From Adisheka Dam

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				250m3/hr × Operating Hour (hr)

From Toker Dam

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				990m3/hr × Operating Hour (hr)

3.Inlet Flow Rate of WTP

Parshall Flume	Flow at Inlet				レ or ×
	Flow Rate		m³/hr	750 m^3/hr	①

4.Inlet Volume of WTP

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				① × Operating Hour (hr)

Source: JICA Expert Team

Table 3-4 Example of Daily Record Sheets-3 (Toker WTP)

5.Transmission Pump
Pump 2
Designed Capacity 450m3/hr×65mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

※A

Pump 3
Designed Capacity 450m3/hr×65mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

※B

6. Water Volume of Clean Water Tank (After transmission pump is finally stopped at the day)

	Time (**: **)	Water Level (%)	Volume (m3)	Note/Person Checked
At the time of pump stopped				② ※Total Capaciy is 3,000m3
At the time of valve closed				③ '= Water level at the time of valve opened next day
②-③				

※C

7. Water Production Volume
Water production volume= A+B+C ______ m3

8. Chemicals Person Checked ______ Time Checked ______

Name of Chemicals	Volume Used		Note
Alum		kg	
Gas Chlorine		–	Please check ㆑ when cylinder of gas chlorine is replaced
			1 cylinder of gas chlorine is 157kg

Source: JICA Expert Team

Table 3-5 Inlet Volume of Raw Water and Water Transmission Volume in Toker WTP

Date				9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug
			Unit							
Receiving Water	Water Source	Adi Sheka Dam	m3/day	4,900	3,500					
		Toker Dam	m3/day	9,405	6,650	8,250	8,250	8,250	7,600	7,125
		Total	m3/day	14,305	10,150	8,250	8,250	8,250	7,600	7,125
Inlet of WTP			m3/day	2,100	6,400	6,750	4,350	4,950	4,800	6,000
Production Water			m3/day	1,995	3,150	4,500	4,050	4,680	3,600	5,400
Chemical Used		Alum	kg	300	300	300	300	300	300	300
		Chlorine (When replaced)	kg							レ

Source: JICA Project Team

(6) Developing Operation and Maintenance Plan (Draft)

CP members in Planning and Supervision Unit took the main responsibility to investigate the current water supply situation in AWSSD in collaboration with JICA expert team. Investigation was conducted by analyzing basic information in collected data and existing documents such as population, water supply volume and financial situation. "Urgent Plan for Operation & Maintenance" was developed mainly including the contents of the daily record sheets organized in the Project and collection and management of data. The items whose improvement is required but it takes long time to secure funds or develop a detailed plan were written in "Operation & Maintenace Plan in Further Stages." The results of the above were organized as "Operation and Maintenance Plan (Draft)." The meeting to explain and exchange opinion regarding the O&M plan was conducted in November 2016.

The O&M plan developed in the Project is shown in Appendix-10 and contents are shown in Table 3-6.

(7) Meeting for Progress and Output

CP members reported progerss and outputs of the activities in the meeting where Director General of AWSSD attended and progress and outputs of the activities were confirmed.

[Output]

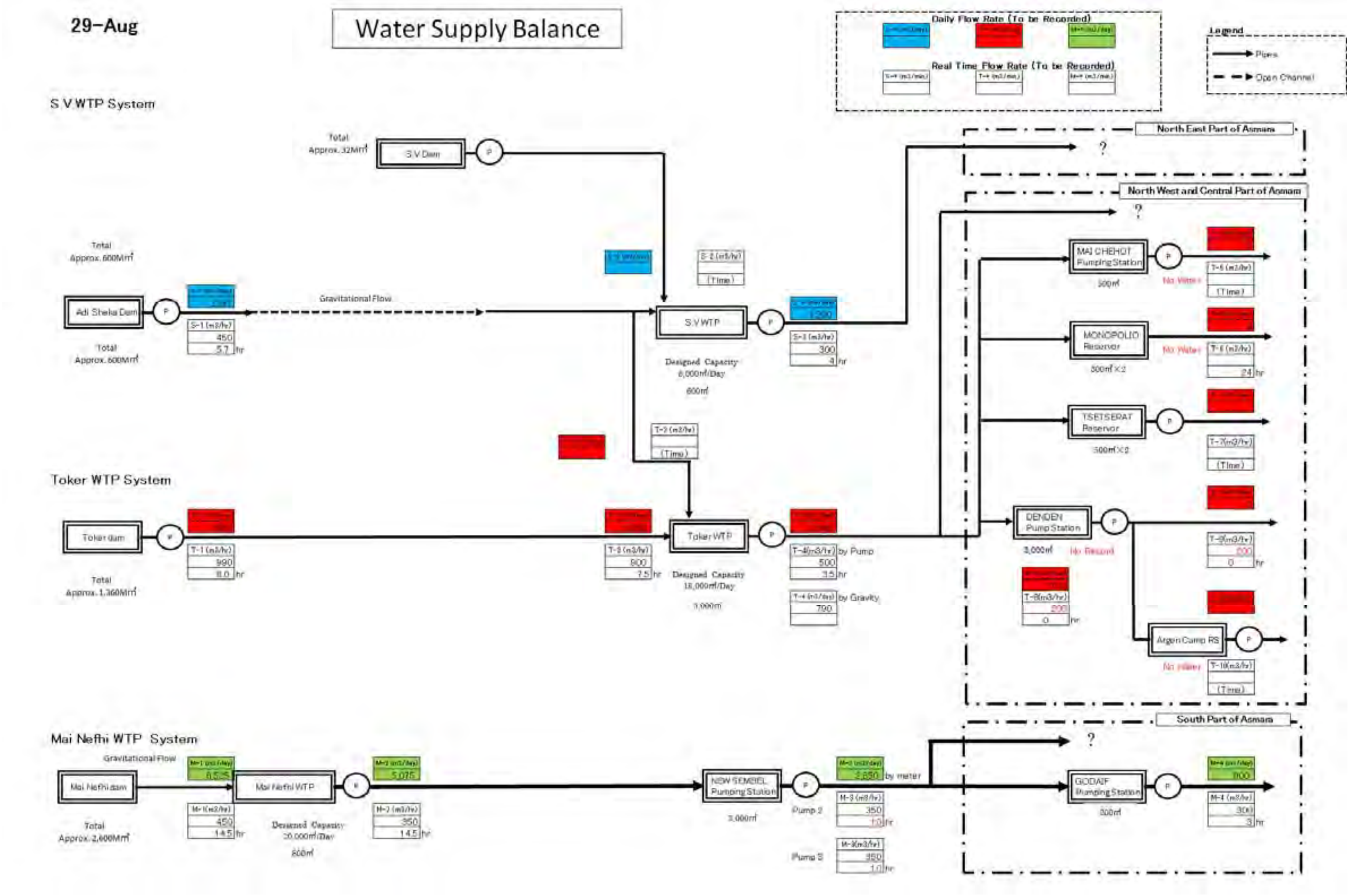
(1) The Conventionalization of Daily Record Sheets in Each Facility

Operators in water supply facilities came to record pump operation hours, water volume, water level, etc. and it was confirmed that they continue recording as of November 2016. CP members' awareness to maintain the operation as per schedule by recording activities was improved.

(2) The Conventionalization of Collecting Daily Record Sheets and Counting the Data in AWSSD.

Operators in water supply facilities came to deliver periodically daily record sheets to AWSSD and CP members came to count the data in AWSSD. It was confirmed that they continued their activities as of November 2016.

The data was stored in a computer of Planning and Supervision Unit and utilized for grasping performance and planning as necessary.



Source: JICA Project Team

Figure 3-3 Water Flow from Water Sources to Distribution Zones

Table 3-6 Contents of Operation and Maintenance Plan (Draft)

Section	Contents
1. Background	・ Referred information and data ・ Contents of Recommended plan for operation & maintenance
2. Current situation and issues	・ Basic systems for water supply ・ Volume of water distribution / distribution ・ Water quality ・ Organization and finance ・ Maintenance of facilities and procurement of consumables and spare parts and reparis
3. Urgent plan for operation & maintenance	・ Water distribution management (demand, water flow metering and recording, water level observation in distribution reservior, recording of water supply volume, vehicle, management of water flow data) ・ Water quality management (water quality standard for drinking water, monitoring items of water quality, management of water quality data, improvement of facility and operation) ・ Daily record sheets and data management ・ Urgent improvement of organization ・ Stocks of materials
4. Operation & maintenance plan in further stages	・ Installation of new flowmeter ・ Water quality laboraotry and equipment ・ Vehicles for patroling and monitoring the O&M activies ・ Improvement of facilities ・ Standard operational procedure ・ Reduction of non revenue water ・ Organization and finance ・ Maintenance of facilities and stock of materials
5. Recommendation	・ Coagulant dosing system ・ Flocculation and sedimentation system ・ Electric power back-up system ・ Sludge management ・ Awareness on water quality

Source: JICA Expert Team

[Issue] Improvement of Accuracy of Data

Operators in the water supply facilities started to record, but the accuracy of the data shall be improved. It is required that CP members continuously train the exact records to operators in water supply facilities.

3.2 Activity for Water Quality Management

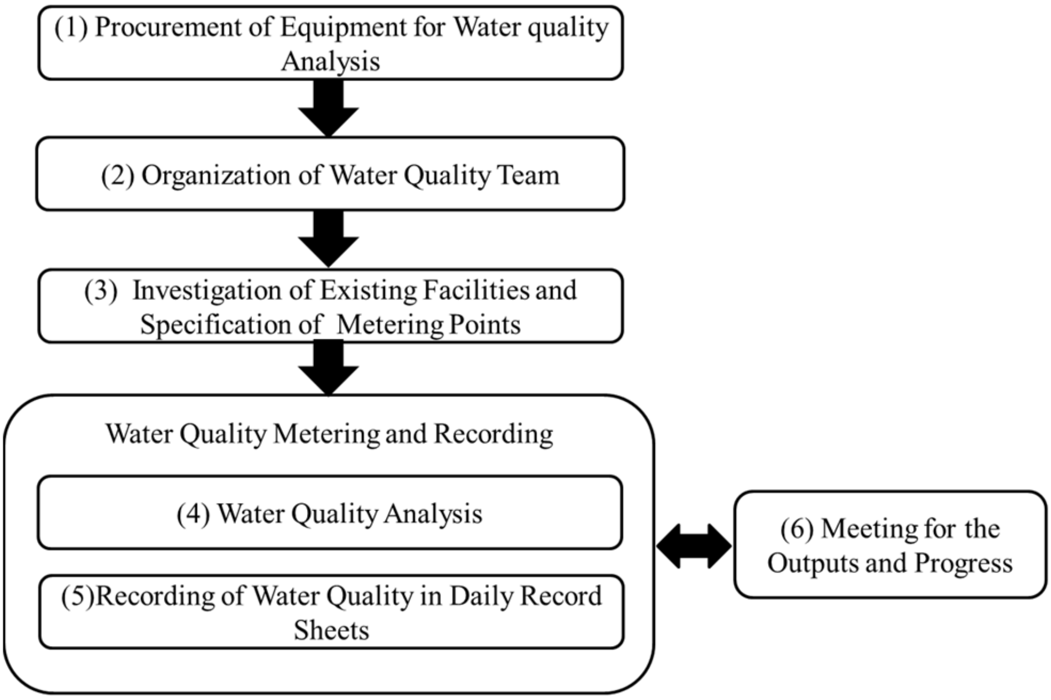
[Objectives]

In collaboration with Activity for Operation Management, following items were simultaneously implemented.

- Water quality comes to be analyzed in each facility.
- Water quality comes to be recorded in daily record sheets.
- The system that the records are verified and stored in AWSSD is organized.

[The Contents of Activities]

Implementation process for the Project is shown in Figure 3-4.



Source: JICA Expert Team

Figure 3-4 Implementation Process of Activity for Water Quality Management

(1) Procurement of Equipment for Water Quality Analysis

As mentioned in Chapter 5, instruments for water quality analysis such as a portable type water analysis device (pH, EC, residual chlorine), a turbidity meter, bacteria paper and coliform paper were procured for the Project.

(2) Organization of Water Quality Management Team

As mentioned in Section 3.1, water quality team (Table 1-2) was organized and started the activities for water quality management. Daily record of water quality analysis was conducted by facility operators in WTPs and dams. The system was established that CP members of water quality team in the headquarters instructed that operators recorded water quality analysis and submitted it periodically, and CP members confirmed and stored water quality data sorted by each system.

(3) Investigation of Existing Facilities and Specification of Metering Points

Through the investigation of the existing facilities, metering points of water quality (sampling points) in each facility was determined. Sampling points are shown in Table 3-7.

(4) Water Quality Analysis

After metering points were decided, training of water quality analysis in each facility was conducted as on the job training (herein after referred as "OJT"). According to training progress, the training style was gradually changed into the style that CP members in water quality team instructed facility operators directly. Training situation is shown in Figure 3-5.

Table 3-7 Water Quality Analysis Points

	Water Storage Facility	WTP		Water Distribution Facility
Target Facility	Adi Sheka dam Toker dam Mai Nefhi dam	S.V. WTP Toker WTP Mai Nefhi WTP		Algen camp Denden pump station Godaif (EXPO) pump station Maichehot pump station Monopolio service reservoir New Sembel pump station Testserat service reservoir
Metering Target	Raw water	Raw water	Treated water	Treated water
Recording and Metering Items	Weather Water temperature pH Electric conductivity Turbidity Color Odor	Weather Water temperature pH Electric conductivity Turbidity Color Odor	Weather Water temperature pH Electric conductivity Turbidity Color Odor Residual chlorine (Free, Total) Bacteria E- coli	Weather Water temperature pH Electric conductivity Turbidity Color Odor

Source: JICA Expert Team

Source: JICA Expert Team

Figure 3-5 Situation of Water Quality Analysis in WTP

(5) Recording of Water Quality in Daily Record Sheets

Recording of water quality in each facility was implemented simultaneously with OJT of water quality analysis. The progress of the activity was confirmed regularly by CP members of water quality team in AWSSD. CP members visited each water storage facility and WTP, confirmed situation and encouraged facility operators to continue the activities.

Water quality analysis in water distribution facilities were directly implemented by water quality team. They collected daily record sheets once a week, checked errors and summarized. Summarized data is shown in Appendix-10. Summary table is shown as Table 3-8.

Table 3-8 Example of Summary of Water Quality Record in WTPs

Sample	Parameter		S.V. WTP				Toker WTP				Mai Nefhi WTP			
			No. of Day	Ave.	Max.	Min.	No. of Data	Ave.	Max.	Min.	No. of Data	Ave.	Max.	Min.
Raw Water	Temperature	℃	7	20.3	24.6	18.5	19	18.1	20.4	17.0	5	21.6	23.5	20.1
	pH	–	5	8.0	8.5	6.3	19	7.4	8.0	7.0	17	6.8	8.1	4.3
	Electrical Conductivity	uS/cm	6	246	270	225	19	186	245	167	17	233	504	149
	Turbidity	NTU	7	57.4	78.2	28.9	19	>172	>1000	12.6	17	>375	>1000	81
	Color	–	7	–	–	–	19	–	–	–	17	–	–	–
	Smell	–	7	–	–	–	19	–	–	–	17	–	–	–
Treated Water	Temperature	℃	7	20.3	22.2	19.1	18	18.7	21.3	17.1	5	21.5	23.5	20.3
	pH	–	7	7.7	8.2	6.7	18	7.2	7.4	6.8	17	6.8	7.7	5.7
	Electrical Conductivity	uS/cm	7	228	249	187	18	187	244	167	17	183	213	150
	Turbidity	NTU	7	18.7	28.6	11.7	18	55.8	86.3	17.3	17	>221	>1000	40
	Color	–	6	–	–	–	18	–	–	–	17	–	–	–
	Smell	–	7	–	–	–	18	–	–	–	17	–	–	–
	Residual Chlorine (Free)	mg/L	0	–	0.0	0.0	18	0.6	2.2	0.0	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	0	–	0.0	0.0	18	0.6	2.2	0.0	17	1.7	8.8	0.0
	Bacteria	cells/ml	2	–	–	–	13	–	–	–	7	–	–	–
	Total Coliform	cells/ml	2	–	–	–	13	–	–	–	7	–	–	–

Source: JICA Project Team

(6) Meeting for the Outputs and Progress

CP members reported progerss and outputs of the activities in the meeting where Director General of AWSSD attended and progress and outputs of the activities were confirmed.

[Output]

(1) Improvement of the Skill of Water Quality Analysis

Through the Project, CP members and facility operators came to be able to analyze water quality, which was confirmed in daily record sheets.

(2) Conventionalization of Water Quality Record

In water supply facilities, analyzing and recording of water quality came to be implemented on a daily basis, which was not implemented before. Operators in water supply facilities came to deliver periodically daily record sheets to AWSSD and CP members came to count the data in AWSSD. It was confirmed that they continue their activities as of November 2016.

CP members' awareness on water quality was improved by recording water quality, and the activity for improvement of water quality was started as mentioned in Chapter 6.

[Issue] Improvement of Accuracy of Data

Operators in the water supply facilities started to record, but the accuracy of the data shall be improved. It is required that CP members continuously train to facility operators to improve accuracy of data.

3.3 Activity for Water Distribution Management

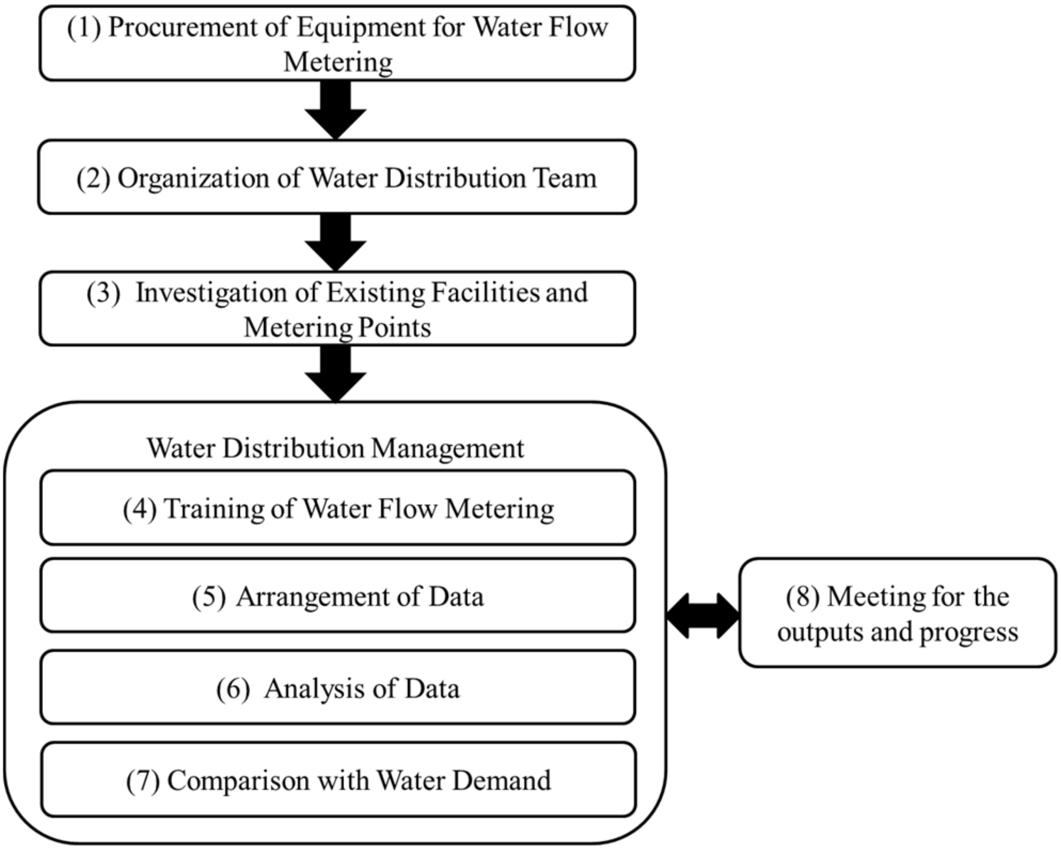
[Objectives]

In collaboration with Activity for Operation Management, following items were simultaneously implemented.

- Metering of inlet/outlet volume in each facility comes to be recorded periodically.
- Estimated water flow in daily record sheets comes to be verified.

[The Contents of Activities]

Implementation process for the Project is shown in Figure 3-6.



Source: JICA Expert Team

Figure 3-6 Implementation Process of Activity for Water Distribution Management

(1) Procurement of Equipment for Water Flow Metering

As mentioned in Chapter 5, two (2) portable ultrasonic flowmeters were procured for the Project.

There were not enough amounts of flowmeters for permanent installation. Portable ultrasonic flowmeters were intended to be used for verification when water flow analysis was periodically implemented by CP members. Water flow volume written in daily record sheets was estimated from the data of ultrasonic flowmeter as mentioned Section 3.1.

(2) Organization of Water Distribution Team

After discussion with AWSSD, water distribution team was organized for implementation of metering and analysis of water flow in each facility as mentioned above in Table 1-4.

(3) Investigation of Existing Facilities and Metering Points

In order to specify metering points of water flow in each facility, the existing facilities were investigated. Main metering points specified in the Project are shown in Figure 3-7 and Table 3-9.
In general, metering points were decided in the following locations.

1) Inlet volume: inlet pipes before reception chambers
2) Outlet volume: outlet pipes after pumps


Source: JICA Expert Team

Figure 3-7 Example of Metering Point of Water Flow
(Left: Inlet of S.V. WTP; Right: Outlet of New Sembel Pump Station)

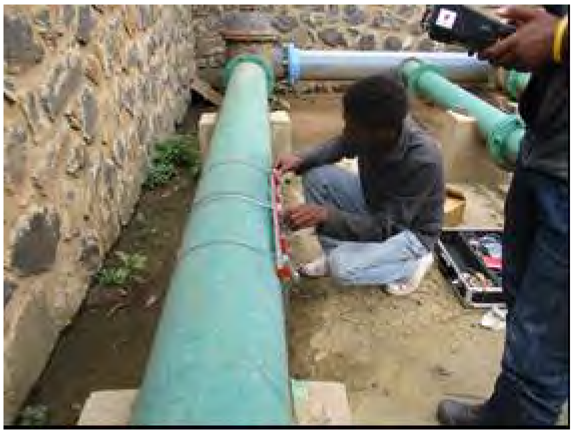
Table 3-9 Metering Points of Water Flow with Ultrasonic Flowmeter

System	S.V.	Toker	Mai Nefhi
Metering points	Adi Sheka dam outlet	Toker dam outlet	Mai Nefhi WTP inlet
	S.V. WTP inlet	Toker WTP inlet	Mai Nefhi WTP outlet
		Toker WTP outlet	New Sembel pump inlet
			New Sembel pump outlet
			Godaif pump inlet
			Godaif pump outlet

Source: JICA Expert Team

(4) Training of Water Flow Metering (Implemented as OJT)

Water flow metering was started just after metering points were specified. The situation of installation of water flowmeter and metering training is shown in Figure 3-8. Training was implemented as OJT style. Because of a layout of pipeline or aging pipes, metering results were not frequently available. In these cases, other available metering points were searched and determined.

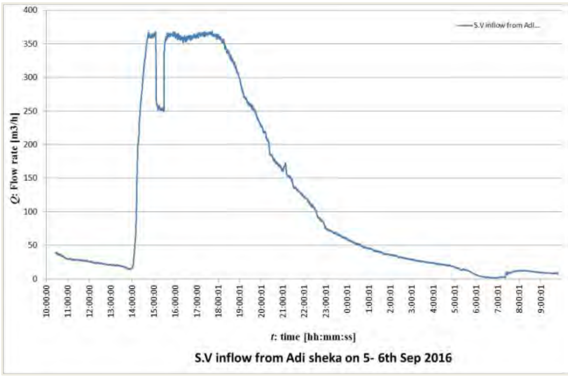



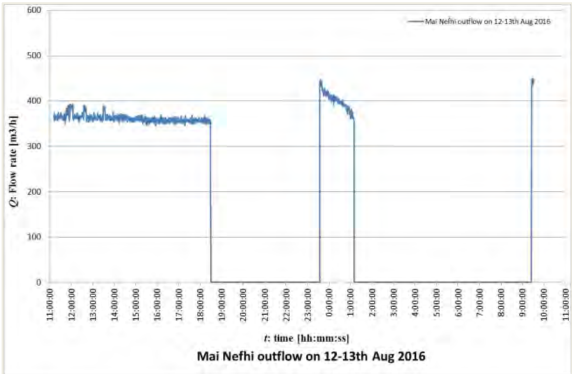
Source: JICA Expert Team

Figure 3-8 Training of Installation of Water Flowmeter

(5) Arrangement of Data

After water flow metering, training to make a graph of water flow changing to confirm the data was implemented. Examples of graph are shown in Figure 3-9 and the results of water flow metering are shown in Table 3-10.





Source: JICA Project Team

Figure 3-9 Graph of Example of Result of Water Flow Analysis

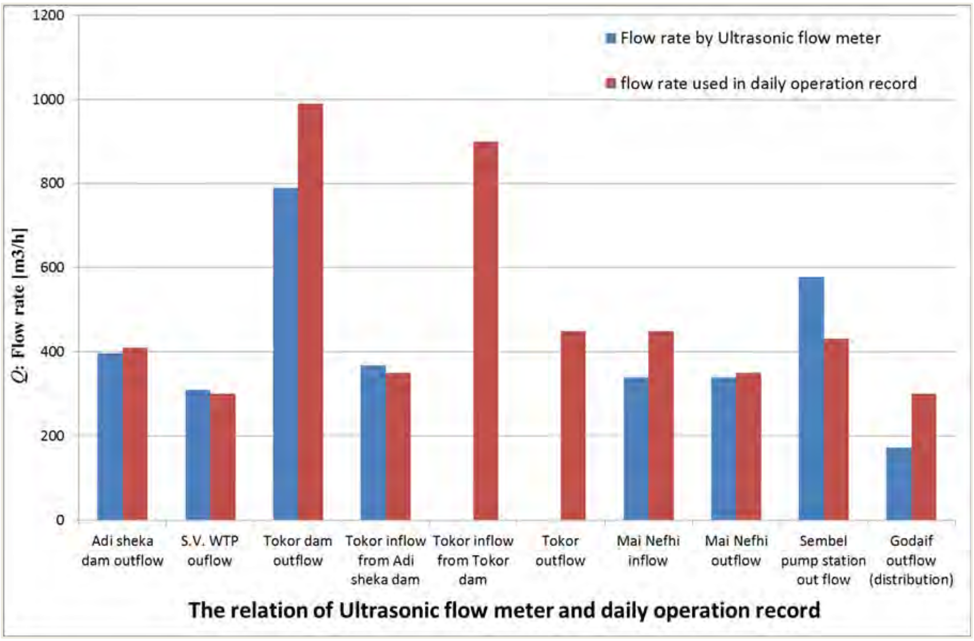
Table 3-10 Results of Water Flow Analysis

Metering Points	Date	Flow Rate [m^3/h]
Adi Sheka dam outlet	16-17th August	397
S.V. WTP inlet	5-6th September	360
Toker dam outlet	24-25th August	790
Adi Sheka dam to Toker WTP inlet	3-4th August	360
Toker WTP outlet	3-4th August	537
Mai Nefhi WTP inlet	13-14th August	340
Mai Nefhi WTP outlet	13-14th August	370
New Sembel pump station inlet	8th September	247
New Sembel pump station outlet	8-9th August	588
Godaif pump station inlet	9th September	221
Godaif pump station outlet	30th August	172

Source: JICA Project Team

(6) Analysis of Data

Based on the collected data, estimated water volume written in daily record sheets of each facility was verified by data analysis (comparison with capacity of pumps and existing water flow meters). Staff in water distribution unit was decided to take over the activity of verification. An example of data analysis result is shown in Figure 3-10.



Source: JICA Project Team

Figure 3-10 Example of the Verification Result of Water Flow Metering

(7) Comparison with Water Demand

Water supply volume in WTPs collected in daily record sheets and water demand volume was compared by facility information team for the following purpose:

- Clarification of the required water supply volume and sufficiency degree for demand.
- Awareness rising on necessity of water flow metering through confirmation of sufficiency.

Demand volume was calculated by using water service population in each distribution zone and unit water supply volume. Water supply population was decided in consideration of both statistics and connection amount of water supply because the border of distribution zone does not match to governmental one.

The result of comparison with water demand is shown in Table 3-11. AWSSD came to realize that approximate 85% of the required volume was supplied. Planned water supply volume per unit was decided as below.

- Those who were connected to water distribution pipe: 50L per capita per day (hereinafter referred to as “LCD”)
- Those who received a service of water tank trucks: 15LCD

(8) Meeting for the Outputs and Progress

CP members reported progerss and outputs of the activities in the meeting where Director General of AWSSD attended and progress and outputs of the activities were confirmed.

Table 3-11 Water Demand and Distributed Volume per Distribution Zone

WTP	Distribute Zone	Population			Water Demand (m^3/d)			Distribution (Aug 2016)	
		Total	By Pipe	By Truck	Pipe 50LCD	Truck 15LCD	Total	(m^3/d)	% by Demand
S.V.	Direct	400,000	50,459	189,588	2,523	2,844	13,365	11,376	85%
Toker	Direct		87,955		4,398				
	Tsetserat		7,510		376				
	Monopolio		4,316		216				
	Denden		7,449		372				
	Algen Camp		1,727		86				
Mai Nefhi	Direct (villages)		7,472		374				
	New Sembel		28,268		1,413				
	Godaif		15,256		763				
Total			210,412		10,521				

Notes: LCD = L/Capita/Day
Source: JICA Project Team

[Output]

(1) Improvement of the Skill of Water Flow Metering

Through the Project, CP members came to be able to meter water flow, make graphs and analyze data, which enables to verify estimated water supply volume in WTPs. The output is confirmed with water flow metering records.

(2) Awareness Raising on Water Distribution Management

CP members came to grasp water demand in each distribution zone and it followed improvement of awareness on distribution management.

[Issue] Improvement of Accuracy of Water Flow Metering and Securing of Proper Metering Points

The skill of water flow metering was improved but metering points were still limited. Ultrasonic flowmeters were not always applicable because of a layout of pipeline or aging pipes. Replacement of pipes and installation of stationary type water flowmeter will be required in the near future.

3.4 Activity for Facility Information Management

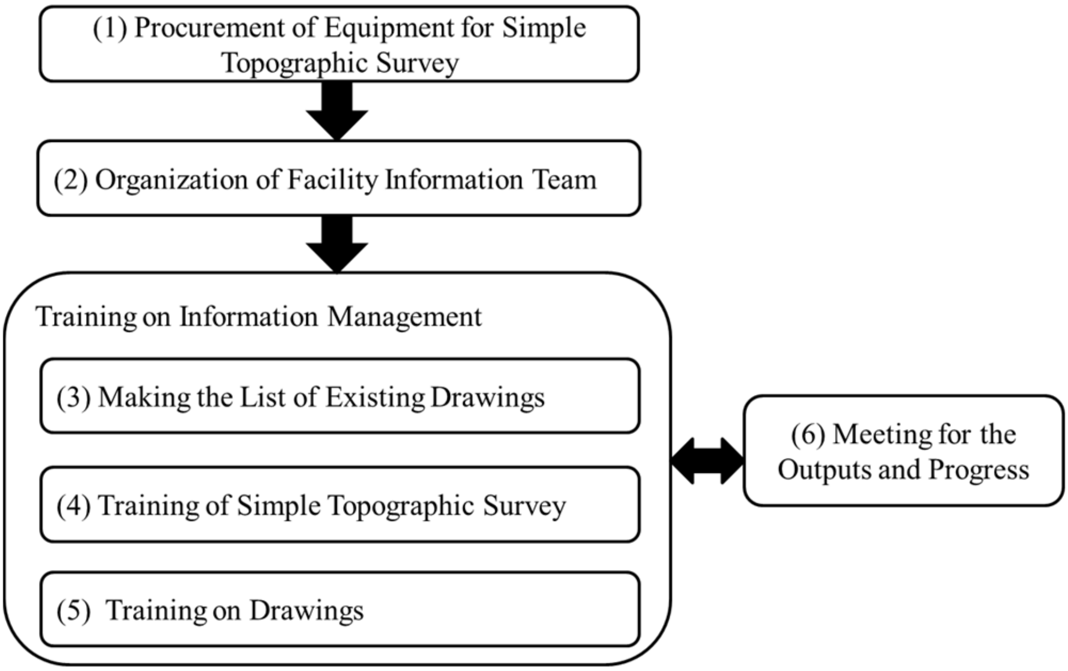
[Objectives]

Based on the output “Collected information is managed and stored as data by AWSSD”, following items were implemented.

- CP members organize information and create an environment for easy access to information.
- CP members are well understood the importance of information management.
- CP members come to be able to invest deficient information and draw (simple topographic survey and drawing).

[The Contents of Activities]

Implementation process for the Project is shown in Figure 3-11.



Source: JICA Expert Team

Figure 3-11 Implementation Process of Activity for Facility Information Management

(1) Procurement of Equipment for Simple Topographic Survey

As mentioned in Chapter 5, a metal pipe locator, a non-metallic pipe locator, a metal locator, two (2) GPS devices, Auto-CAD, and a set of computers were procured for the purpose of investigation of pipes, location survey, training of drawing and data management.

(2) Organization of Facility Information Team

Facility information team was organized in order to update and manage information such as drawings of WTPs and pipelines. Team members are shown as before in Table 1-3.

(3) Making the List of Existing Drawings

In AWSSD, the existing technical information (ex. drawings) regarding main facilities such as WTPs was not enough accessible and there was no way to find out the location of missing files (or even their existence). Because of the situation, technical matters were not fully taken over. To secure the accessibility of technical information, every existing drawing should be stored in Planning and Supervision Unit. As the first step, the existing drawings were confirmed and listed. The list is shown in Appendix-11.

(4) Training of Simple Topographic Survey

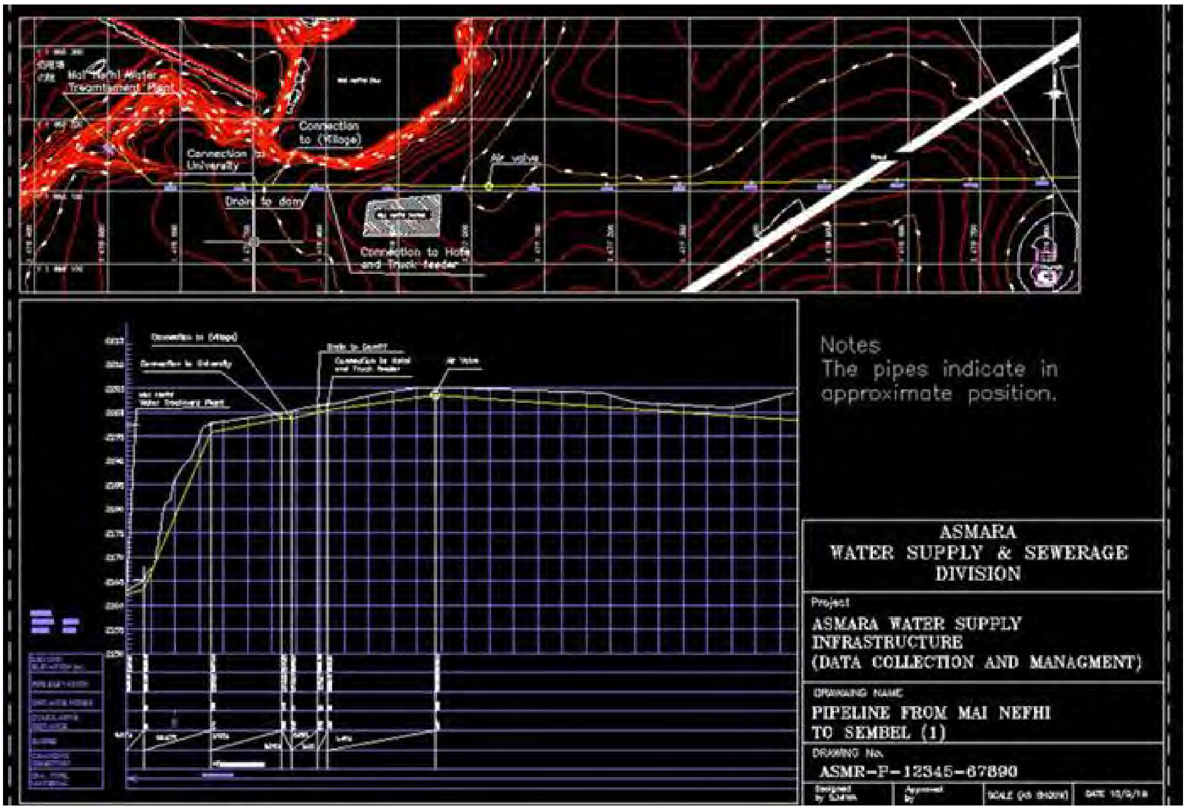
Among the facilities whose drawings were missing, firstly main pipelines were started to be drawn. The information of pipelines without drawings was not organized but some members who work for a long time just remembered. Therefore, the activity to specify the location of the existing pipelines was started at the beginning. Training to use instruments to specify the location of pipes was also implemented. After finishing the detection of pipe location, position coordinates were recorded with GPS. The situation of training is shown in Figure 3-12.

Source: JICA Project Team

Figure 3-12　Training Situation of Simple Topographic Survey

(5)　Training on Drawings

After simple topographic survey, training of drawing pipelines was implemented. At that time, water pipelines between Mai Nehi WTP and New Sembel pump station was illustrated by using the location data of GPS and base maps of Asmara. Example of drawing is shown in Figure 3-13.



Source: JICA Project Team

Figure 3-13　Example of Drawing of Pipelines

(6) Meeting for the Outputs and Progress

CP members reported progerss and outputs of the activities in the meeting where Director General of AWSSD attended and progress and outputs of the activities were confirmed.

[Output]

(1) Clarification of Existing Information and Arrangement of Drawings

Existing drawings were clarified and CP members in Planning and Supervision Unit surely recognized the importance of information management and information collection. The existing drawings were stored and managed by Planning and Supervision Unit and accessibility of these drawings was secured. The result of the activity was confirmed by the list of drawings.

(2) Drawing and Updating the Information based on Simple Topographic Survey of Pipelines

The skill of simple topographic survey and drawing was improved and CP members came to be able to draw path diagram of pipelines briefly. The result was confirmed by drawing activities.

[Issue] Arrangement of Information in WTPs

The information of old facilities like S.V. WTP does not exist in paper. For technique succession and maintenance of facility, drawings and related documents must be accessible. However, restoration of that absent technical information can be conducted only by skillful experts. It is difficult to arrange such experts for the activity so far but in the near future, comprehensive information of water supply system will be required and restoration of the information by experts will be inevitable.

CHAPTER 4 ACTUAL IMPLEMENTATION SCHEDULE

CHAPTER 4 ACTUAL IMPLEMENTATION SCHEDULE

4.1 Actual Implementation Schedule

The initial schedule and actual implementation of the Project are shown in Figure 4-1.

			2016: 4	5	6	7	8	9	10	11	12
				Work in Japan		Work in Eritrea			Work in Japan	Work in Eritrea	Work in Japan
[100]	Work in Japan										
[101]	Procurement and dispatch of the equipment for investigation	Schedule									
		Implementation									
[102]	Preparation of questionnaire	Schedule									
		Implementation									
[103]	Preparation of work plan	Schedule									
		Implementation									
[200]	Work in Eritrea										
[201]	Specific activities in Eritrea										
[201-1]	Discussion and submission of work plan	Schedule									
		Implementation									
[201-2]	Investigation of existing water service facilities	Schedule									
		Implementation									
[201-3]	Investigation of existing water service and distribution condition	Schedule									
		Implementation									
[201-4]	Confirmation of the situation of drawing arrangement of facilities	Schedule									
		Implementation									
[201-5]	Interim meeting	Schedule									
		Implementation									
[201-6]	Assistance of daily inspection	Schedule									
		Implementation									
[201-7]	Assistance of water flow metering	Schedule									
		Implementation									
[201-8]	Assistance to input the data about water quality and water flow to make reports	Schedule									
		Implementation									
[202]	Activities for outputs										
(1)	Output1: Activities for [Methods of data recording and management, and water quality management are improved for the target dam lakes.]										
(1-1)	Arrangement of daily record sheets for water resource conservation (patrol, cleaning, water quality, etc.) at the dam lakes (Toker, Adi Shieka, S.V, Mai Nefhi).	Schedule									
		Implementation									
(1-2)	Implementation of water quality analysis (pH, turbidity, EC, analysis schedule, visual inspection, etc.) at the dam lakes.	Schedule									
		Implementation									
(1-3)	Arrangement of daily record sheets (inspection, repair, etc.) for the dam bodies.	Schedule									
		Implementation									
(2)	Output2: Activities for [Methods of data recording and management, and water quality management are improved for the target water treatment plants.]										
(2-1)	Implementation of scheduled water flow metering for inlet and outlet waters at 3 water treatment plants (S.V., Toker and Mai Nefhi).	Schedule									
		Implementation									
(2-2)	Implementation of water quality analysis (pH, turbidity, EC, odor, visual inspection, E-coli, fecal bacteria, residual chlorine) in 3 water treatment plants.	Schedule									
		Implementation									
(2-3)	Arrangement of daily record sheets (inspection, repair, water quality, water flow, operation hours) in 3 water treatment plants.	Schedule									
		Implementation									
(2-4)	Arrangement of drawings and documents of 3 water treatment plants.	Schedule									
		Implementation									
(3)	Output3: Activities for [Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution.]										
(3-1)	Implementation of scheduled water flow metering for inlet and outlet waters at water conveyance, transmission, distribution facilities and water stations.	Schedule									
		Implementation									
(3-2)	Arrangement of daily record sheets (inspection, repair, water flow rate) at water conveyance, transmission, distribution facilities and water stations.	Schedule									
		Implementation									
(3-3)	Arrangement of daily record sheets (inspection, repair, flow rate and operation hours) in pump stations.	Schedule									
		Implementation									
(3-4)	Arrangement of drawings and documents of water conveyance, transmission and distribution facilities.	Schedule									
		Implementation									
(3-5)	Arrangement of drawings and documents of water conveyance, transmission and distribution pipelines.	Schedule									
		Implementation									
(4)	Output4: Activities for [Collected information is unitarily managed and stored as data by AWSSD.]										
(4-1)	Management and utilization of collected information and data.	Schedule									
		Implementation									
(4-2)	Preparation of operation and maintenance plan (including information management).	Schedule									
		Implementation									
[203]	Ending meeting (phase-1)	Schedule									
		Implementation									
[204]	Preparation and submission outline of operation and maintenance plan (idea of field note)	Schedule									
		Implementation									
[205]	Provision of procured equipments	Schedule									
		Implementation									
[300]	Work in Japan										
[301]	Assistance on water flow and water quality data submitted by AWSSD	Schedule									
		Implementation									
[302]	Preparation and submission of operation and maintenance plan	Schedule									
		Implementation									
[303]	Preparation of project completion report	Schedule									
		Implementation									
[400]	Work in Eritrea										
[401]	Report and discussion of final report and operation and maintenance plan	Schedule									
		Implementation									
[500]	Work in Japan										
[501]	Preparation and submissioin of project completion report	Schedule									
		Implementation									

Source: JICA Expert Team

Figure 4-1 The Initial Schedule and Actual Implementation of the Project

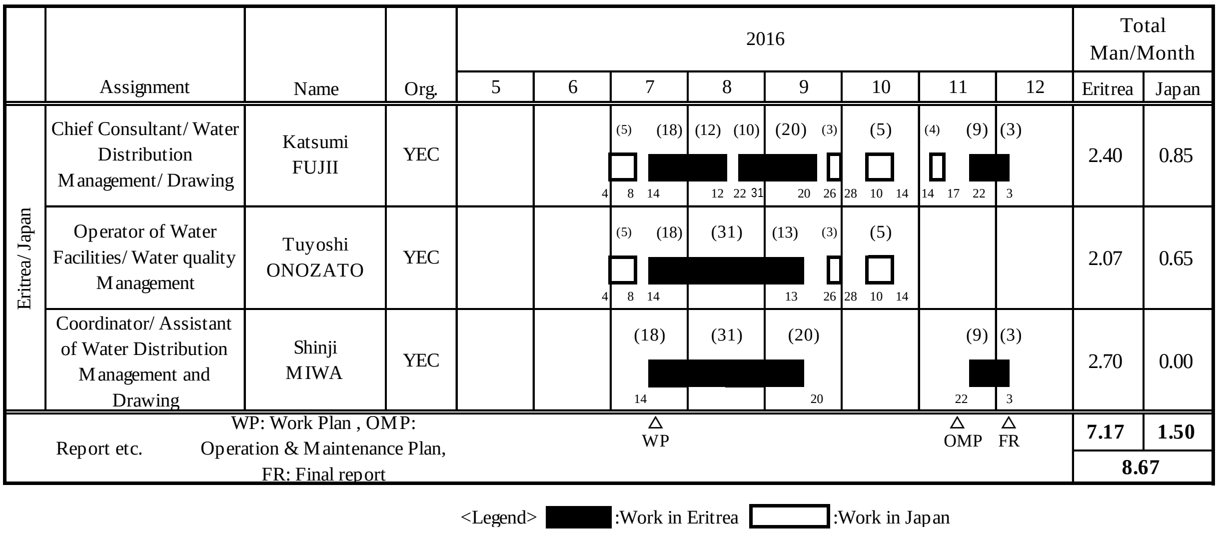
CHAPTER 5 ACTUAL INPUTS

CHAPTER 5 ACTUAL INPUTS

5.1 Input by Japanese Side

5.1.1 JICA Expert Team

JICA experts were dispatched as shown in Figure 5-1.



Source: JICA Expert Team

Figure 5-1 Dispatch of Experts

5.1.2 Procurement of Equipment

It was required to meter the water flow and quality to collect the operation data and to manage the collected information for the Project. Therefore, the equipment for water flow and quality metering were procured as shown in Table5-1. Moreover, pipe / metal locators and GPS devices were procured for simple topographic survey.

Table 5-1 Procured Equipment for the Project

No.	Item	Qty.	Procured Location	Procured/ Selected Data	Purpose
1	Portable ultrasonic flowmeter	2sets	Japan	27th May 2016	To meter the inlet and outlet volume of water supply facilities.
2	Metal pipe locator	1set	Japan	27th May 2016	To detect pipes, which are made by metal such as ductile cast iron pipes and so on.
3	Non-metallic pipe locator	1set	Japan	27th May 2016	To detect pipes, which are made by nonmetal such as PVC pipes and so on
4	Metal locator	1set	Japan	27th May 2016	To detect valves, manholes, etc.
5	GPS	2sets	Japan	8th June 2016	To meter the location / coordinates of pipelines, valves, air valves, etc.
6	Portable type water analysis device（pH, EC）	6sets	Japan	30th May 2016	To analyze pH and EC in water supply facilities.
7	Turbidity meter	6sets	Japan	30th May 2016	To analyze the turbidity in water supply facilities.

No.	Item	Qty.	Procured Location	Procured/ Selected Data	Purpose
8	Portable type water analysis device (residual chlorine)	3sets	Japan	30th May 2016	To analyze the residual chlorine in water supply facilities.
9	Bacteria paper, total coliform paper, incubator	3sets	Japan	30th May 2016	To analyze bacteria and total coliform.
10	A set of computer devices	1set	Japan	17th June 2016	To record and manage the collected data and information.

Source: JICA Expert Team

5.2 Input by Eritrean Side

From the Eritrean side, CP members were assigned to implement the Project. They made the Project activities as a part of quotidian works. Accordingly, there was no special provision of manpower, equipment and construction works.

CHAPTER 6 DEVICE AND LESSON ON PROJECT IMPLEMENTATION

CHAPTER 6 DEVICE AND LESSON ON PROJECT IMPLEMENTATION

6.1 Device on Project Implementation

(1) Improvement of the Motivation on Water Quality Management (Water Quality Improvement Activity in WTP)

In the existing facilities, activities on water quality improvement were barely implemented and the water quality of WTP was almost the same as raw water. Under such situation, it was difficult for facility operators to keep their motivation for activities and recognize the importance of water quality analysis. Therefore, in the Project, water quality standard was firstly explained and activities for water quality improvement were implemented with a simple method.

1) Awareness Rising on the Necessity of Water Quality Analysis

Before the Project started, water quality was not metered in AWSSD. Operators in the facilities had no experience of water quality analysis and awareness on necessity of water quality analysis was low. Firstly the Project was started to grasp the whole picture of issues in the facilities through comparison between the water quality in WTP and the standard of water quality in World Health Organization (hereinafter referred as "WHO"), which could make the operators recognize the necessity of water quality management.

JICA expert team explained that there was close relationship between operation management and water quality. It promoted awareness rising on the importance of water quality monitoring leading to proper facility operation and finding issues.

2) Demonstration of Jar Test and Treatment Process Lectures

In the water supply facilities of Asmara city, coagulants were not appropriately dosed and just mixed roughly. Flocs were not grown in the flocculation basin. CP members and operators in WTPs didn't recognize even the general idea of flocculation. A lecture of treatment process including a demonstration of coagulation and sedimentation process with jar test was conducted for the following purpose.

- Explanation of the necessity of coagulation and sedimentation process
- Explanation of the proper way to dose coagulants
- Grasp of existing capacity of facilities and improvement methods of operation

In the corresponding lecture, facility operators understood: (1) proper dose of coagulants made flocs as bigger as visible to the naked eye, (2) it was relatively easy to decrease turbidity less than 10NTU. Through the demonstration, the necessity of proper dose of coagulants, rapid mixing and flocculation was recognized.

3) Water Quality Improvement Trial in Toker WTP

As the purpose of both improvement of awareness on water quality management and water quality improvement itself in WTPs, the following improvement trials were conducted. Toker WTP having comparatively high awareness of issues was selected as the pilot site.

a) Cleaning of Flocculation, Sedimentation and Filter Basins

Although it passed for almost 15 years since Toker WTP had started to operate, water in basins had never drawn off for cleaning, and neither replaced the sand filter. Therefore, huge amount of sludge sedimentation was appeared when water in basins was drawn off. To get rid of the sludge, cleaning was implemented such as sludge removal, washing with pressured water and racking out sands.

b) Directly Dosing of Coagulant to Mixing Basins with Manual Operation

In the existing three WTPs, due to breakage of chemical dosing facilities, facility operators commonly used to dose solid coagulants directly into receiving basins and just mix it. Management or metering of dose was not conducted (ex: a bag of coagulant (appx. 50kg) was dosed in the morning and another bag in the afternoon). Flocs were not properly grown in every WTP. In the case that a bag of 50kg coagulant was dosed all at once, coagulants propagated immediately but the effect of coagulant was disappeared within around an hour. In order to gain a proper result, the batch dosing method was changed into the separate dosing: a set of 8kg coagulants converted to 4g-Al_2O_3 at a time was dosed per 30 minutes (in the case of 500m^3/h.)

c) The Result of Improvement Trial

As the result of trial, flocculation and coagulant-sedimentation process were visually recognized. As shown in Table 6-1 and Figure 6-1, good results were obtained regarding turbidity after sedimentation (3-9NTU). AWSSD recognized that sedimentation was effective and AWSSD started to deal with the same kind of improvement in other two WTPs.

Table 6-1 Result of Trial for Water Quality Improvement in Toker WTP

Sample	Turbidity before (Average of August 2016)	Turbidity after		
		14th September 2016 (Regular analysis)	15th September 2016 (Regular analysis)	14th September 2016 (Reference)
Raw Water	>172 NTU *	32.9 NTU	36.5 NTU	
After Sedimentation	45.91 NTU	6.81 NTU	3.15 NTU	9.38 NTU
After Rapid Filtering				6.40 NTU
Clear Water Basin	55.8 NTU	59.3 NTU	27.3 NTU	

Source: Project Team
* The reason why Turbidity of raw water on August is high (>172NTU) is shown below.
1. Raw water turbidity is high, because August is in rainy season.
2. More than 1,000NTU of turbidity was experienced twice in August. The average value was, therefore, large. If ignoring these two days, the average value of August is 74.6NTU.

Source: Project Team

Figure 6-1 Result of Trial for Water Quality Improvement in Toker WTP (Flocculation Basin Left: before Trial, Right: after Trial)

On the other hand, as shown in Table 6-1, turbidity in the clear water basin got worse (27-59NTU), compared with the one in a filter basin. The reason was assumed that (1) the clear water basin was not cleaned up because it could not stop and (2) sludge in the clear water basin was spattered due to direct injection of chlorine gas. AWSSD clearly recognized the importance of cleaning in clear water basins.

(2) Improvement of Motivation on Water Flow Metering (Comparison between Water Distribution Volume and Water Demand)

Regarding water flow metering as well as water quality analysis and management, it was difficult to keep operators' motivation to continue activities without obtaining the effective results by water flow metering. Consequently planned water demand in each distribution area was estimated and sufficiency degree of water supply was grasped in comparison with actual water supply volume. The purpose in the Project is shown below. CP members recognized the necessity of water flow metering and continue the activities to confirm sufficiency.

- Clarification of water demand in each distribution zone
- Confirmation of actual sufficiency of water supply/distribution volume against water demand
- Reference for operation plan of WTPs and water supply schedule in each distribution zone

(3) Flexible Adjustment of Activities' Schedule

The schedule of water flow monitoring was made but frequently interrupted because of electric failure, breakdown of pumps, water shortage or aging pipes. In order to continue developing CP members' capacity and storing data, water flow metering was conducted as far as possible and schedule was flexibly adjusted. Although it took a long time to complete water flow metering in all major water supply facilities, CP members developed their capacity by gaining continuous experience of water flow metering.

(4) Sustainable Contents of Daily Record Sheets

Daily record in each facility was not sufficient and only operation hours of pumps were recorded. Project period was limited and work in Eritrea for improvement activities was only for 2 months. In this condition, "data collecting and information management" by CP members and facility operators were prioritized and items of daily record sheets were selected as far as they could continue. As a result, sustainability of the activity was increased.

(5) Improvement of CP Members' Awareness and Motivation through Meetings

Progress meetings with two weeks interval were held to report the progress of activities by Project team to managers including Director General. CP members themselves reported directly to Director General and Head of Water Supply Division, which was following to development of their self-initiative and motivation for the Project. In the meeting when the result of water quality improvement trial in Toker WTP was reported, the heads of S.V. WTP and Mai Nefhi WTP also attended and improvement effect was shared. Through these activities, trial experience in pilot activity was propagated among other WTPs and other WTPs also started trial.

(6) Share of "Experience of Improvement"

As the result of demonstration of jar test, treatment process lecture and water quality improvement trials, CP members realized "facilities could be improved." It helped CP members proceed to the further improvement activities. Thanks to visible results, AWSSD highly evaluated the Project and CP members. CP members and facility staffs were not only received an explanation of improvement method or estimated effect but also experienced visible result by themselves, which contributed to improve their self-initiative.

6.2 Lesson on Project Implementation

(1) Procurement of Maintenance Parts Required for O&M and Flexible Adjustment of Activities' Schedule

Some mechanical/electrical parts and equipment are not manufactured in Eritrea, and major maintenance parts are required to import from abroad every time the parts needed. In Eritrea, commodity parts can be procured but parts in low demand or special designed parts are hardly obtained. During the Project, a broken pump was not repaired for a long time and it prevented the Project team metering water quality and water flow. As the result, it became difficult to implement the activities as per schedule planned at beginning of the Project and schedule was adjusted in accordance with the situation at that time. Project schedule shall be arranged with consideration for inaction of facilities in advance. Also in making up O&M plan, duration of parts' procurement shall be considered, which required several months.

(2) Communication Conditions

In Asmara city, internet environment was little developed. In AWSSD, internet facility was not installed and oversea calls were unstable. Limited accessibility of communication prevented JICA expert team and AWSSD contacting and collecting technical information from Japan or abroad. Under the current communication condition, it is difficult to implement technical cooperation longer, which is required supervision from Japan. In the case of long-term activities, special internet facility shall be installed in the project office.

(3) Conditions of Electric Power

During the Project, not only daily planned electric failure but also sudden electric failure were frequently happened. Sudden electric failure as well as the breakage of pumps had large affect to activity schedule. When water flow was metered in Mai Nefhi WTP, sudden electric failure at the night was happened. Drainage pumps stopped and ultrasonic flowmeter was broken due to water infiltration. Condition of electric power, especially frequent electric failure, shall be considered in similar projects.

CHAPTER 7 VARIOUS MEETINGS

CHAPTER 7 VARIOUS MEETINGS

7.1 Meetings for Introduction and Report of Progress and Outputs for the Project

Meetings were held to report progress and outputs for the Project as shown in Table 7-1.

Table 7-1 Summary of Meetings for the Project

Item	Date	The Contents of Meetings
Kick off meeting	22nd July 2016	➢ Explanation of the purpose, contents and inputs of the Project ➢ Agreement between JICA expert team and AWSSD about the contents of work plan
1st interim Meeting	8th August 2016	➢ Report of progress of activities till the beginning of August ➢ Explanation of the obtained data (water quality and water flow) ➢ Explanation of the activities of daily inspection and data recording sheets ➢ Extraction of issue to get into routine activity
2nd interim Meeting	22nd August 2016	➢ Report of the situation of collecting daily record sheets till the middle of August ➢ Report of the situation of water flow rate obtained by ultrasonic flowmeter ➢ Discussion on points to be improved
3rd interim Meeting	9th September 2016	➢ Confirmation of the situation of data collection and data summarizing as well as points to be improved
Ending Meeting (phase-1)	16th September 2016	➢ Report of the situation of data collection and data summarizing for major facilities ➢ Report of simple topographic survey of pipelines and preparation of drawings ➢ Report of the list of the existing drawings ➢ Explanation of estimation of water demand in each water distribution zone ➢ Report of trial for water quality improvement in Toker WTP
Follow-up Meeting	22nd November 2016	➢ Report of the ongoing situation of data collection and data summarizing ➢ Report of the situation of drawings preparation ➢ Report of trial of water quality improvement in WTPs

Source: JICA Expert Team

7.2 Other Meetings

Other various meetings were held as shown in Table 7-2.

Table 7-2 Other Meetings Held in the Project

No.	Date	The Contents of Meetings
Demonstration of Jar Test and Treatment Process	27th August 2016	➢ Presentation for necessity of coagulation-sedimentation process ➢ Presentation for necessity of coagulant dosing ➢ Demonstration of jar test ➢ Confirmation of capability of the existing facilities and proposal of operation improvement method
Management Team Meeting	30th August 2016	➢ Confirmation of outputs for phase-1 ➢ Confirmation of outputs to be achieved before phase-2 ➢ Confirmation of various points to be improved
Explanation on O&M Plan (Draft)	22nd November 2016	➢ Explanation and opinion exchanges on O&M plan (draft) ➢ Suggestion of urgent plan and further plan

Source: JICA Expert Team

CHAPTER 8 ISSUE AND RECOMMENDATION

CHAPTER 8 ISSUE AND RECOMMENDATION

As mentioned in the Chapter 3, the Project Purposes were achieved. AWSSD are steadily taking steps toward the Overall Goal. In order for AWSSD to develop better ability to operate and maintain water supply facilities and to collect and manage related data, the following activities shall be suggested.

(1) Keeping the Motivation and Improvement of Awareness

There is no doubt that CP members' awareness of collecting and managing data was improved through the Project. It is important to continue output meetings conducted in the Project so as to keep their motivation for activities. CP members realize the necessity more deeply to collect data and manage information by gaining successful experience such as a trial of water quality improvement implemented in the Project. AWSSD shall continue the periodical meetings and the improvement trials to keep the motivation of the staffs who involve in the improvement activity.

(2) Improvement of the Ability to Collect and Analyze Data

It is required for operators in water supply facilities to properly record data in order to collect and manage it. AWSSD headquarters' staff need to train the operators continuously and also need to improve knowledge of water quality, water volume and water supply facilities, and ability to find abnormal numeric, absurdity and defectiveness. The headquarters' staff members shall consider to get trainings from experts having enough academic backgrounds and / or dispatched experts from international organizations.

(3) Revision of the Water Tariff

In spite of inflation of prices in recent years, the water tariff remains from 2003. It is recommended to revise the water tariff to properly manage and rehabilitate the facilities with income from the water tariff.

(4) Establishment of Water Quality Management Section

Currently there is no special section to instruct the water quality improvement. There is no laboratory to verify water quality analysis results obtained in WTPs. It is recommended to establish water quality management unit as the organization for instruction of water quality management, which enables to increase monitoring items of water quality and to monitor the water quality periodically in water distribution network.

(5) Official Organization of "Dams and Treatment Plants Unit" and "Planning and Supervision Unit"

"Dams and Treatment Plants Unit" and "Planning and Supervision Unit" are practically organized but not officially. In order to clarify the budget distribution and the responsibility, these units are recommended to be approved as official organizations.

(6) Water Flowmeter

Water flow was sporadically metered with portable equipment in the Project. It is recommended to install flowmeters in all main facilities and to meter the flow rate all the time to confirm water service and operation efficiency on a steady basis.

(7) Securement of Consumable and Spare Parts

Spare parts of mechanical and electrical facilities such as pumps are not stored. Under the present situation, the required parts are procured on each occasion that the equipment / devices are broken. It is required to store some spare parts to improve operating rate of facilities and to ensure the required water distribution volume.

(8) Securement of Transportation to Collect Data and Manage Information

CP members implement the activities by using the vehicles of JICA expert team in the Project. There is no exclusive vehicle for the activities and it may cause a suspension of the activities. It is required to prepare the exclusive vehicle for the activities to continue to collect data and manage information.

(9) Fixing of Inadequacy of Facilities

Due to shortage of various instruments and inadequate pumps, not only water service but also the activities to make and collect records become difficult. It should be considered as further issue to equip proper instruments and pumps. Furthermore, installation of chemical dosing facilities has a potential to develop a data-based management system of operation and water distribution.

Appendixes

1. Minutes of Meeting (Technical Note）
2. Minutes of Meeting (Technical Note (No.2))
3. Material for Kick-off Meeting
4. Material for 1st Interim Meeting
5. Material for 2nd Interim Meeting
6. Material for the Demonstration of Jar Test and Treatment Process
7. Material for 3rd Interim Meeting
8. Material for Ending Meeting (Phase-1)
9. Material for Follow-up Meeting
10. Recommended Plan for Operation &Maintenance for Water Supply in Asmara
11. The List of Existing Drawings

Appendix-1: Minutes of Meeting (Technical Note)

Appendix 1-1

Technical Notes on

Asmara Water Supply Infrastructure (Data Collection and Management) Project

In response to the request from the Government of the State of Eritrea (hereinafter referred to as "Eritrea"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") decided to conduct Asmara Water Supply Infrastructure (Data Collection and Management) Project (hereinafter referred to as "the Project") and send a JICA expert team (hereinafter referred to as "the Team") from 15 July to 19 September 2016.

The Team and the Eritrean side discussed work plan for the Project from 19 July to 22 July 2016. As a result of discussions, the Team and the Eritrean side confirmed the items described in attached sheets.

Asmara, 26 July 2016

Katsumi Fujii
Chief Consultant / Water Distribution Management / Drawings Management
JICA Expert Team

Ghebrekidan Ghirmatzion
Director General
Asmara Water Supply and Sewerage Department (AWSSD)

(Witness)

Mebrahtu Iyassu
Director General
Water Resources Department
Ministry of Land, Water and Environment

ATTACHMENT

1. Objective of the Project

The objective of the Project is to institutionalize collecting precise data and storing information in order to secure proper operation and maintenance of the Asmara water supply system.

2. Implementing Agency

The Implementing Agency is Asmara Water Supply and Sewerage Department (hereinafter referred to as "AWSSD").

3. Overall Goal, Project Purpose and Output

The both side agreed the Overall Goal, Project Purpose and Output as follows.

Overall Goal	Basic information, necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.
Project Purpose	Collection and management system of information, necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).
Output	Output 1: Methods of data recording and management, and water quality management are improved for the target dam reservoirs. Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants. Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution. Output 4: Collected information is managed and stored as data by AWSSD.

4. Target Facilities for Data Management

Target facilities are as shown below and Annex-1 and 2.

System	Stretta Vaudetto (S.V.) WTP System	Toker WTP System	Mai Nefhi WTP System
Dam, Dam reservoir	Adi Sheka Dam, S.V. Dam, Mai Serwa Dam	Toker Dam	Mai Nefhi Dam
Water Conveyance	Adi Sheka Dam ⇒ S.V. WTP Mai Serwa Dam ⇒ S.V. WTP	Toker Dam ⇒ Tokar WTP	Mai Nefhi Dam ⇒ Mai Nefhi WTP
WTP	Stretta Vaudetto (S.V.) WTP	Toker WTP	Mai Nefhi WTP
Water Transmission	S.V. WTP ⇒ Hazhaz Distribution Reservoir	Toker WTP ⇒ Hazhaz Distribution Reservoir, Mai Chehot Pump St., Monopolio Distribution Reservoir, Tsetserat Distribution Reservoir, Denden Pump Station	Mai Nefhi ⇒ Sembel Pump Station Sembel Pump Station ⇒ Godaif Pump Station, Denden Pump Station
Water Distribution		Hazhaz Distribution Reservoir, Mai Chehot Pump St., Monopolio Distribution Reservoir, Tsetserat Distribution Reservoir, Denden Pump Station, Maitemenai Water Station	Sembel Pump Station, Godaif Pump Station, Mai Nefhi Water Station, Sembel Water Station, EXPO Water Station

6. Project Implementation Schedule

The Team explained to the Eritrean side that the expected implementation schedule is as attached in **Annex-3**.

7. Main points discussed on the issue of the Project component

7-1) Work Plan

The Team explained the work plan as well as objective and requested undertakings by AWSSD. The Eritrean side agreed on the work plan.

7-2) Function of Laboratory in Water Resources Department, Ministry of Land, Water and Environment

The Eritrean side stated that the water quality analysis has been conducted in the laboratory of Water Resources Department, Ministry of Land, Water and Environment. As for the function of the mentioned laboratory, both sides agreed that it should be a regulatory / monitoring laboratory for AWSSD. Since a self-management system is required for AWSSD to assure the water quality, the equipment to be provided by the Team for water quality analysis should be placed in AWSSD and its staff members should be trained for water quality management.

7-3) Number of Water Flow Meters to be provided

The Eritrean side requested the Team to provide more flowmeters to be installed at all necessary points of bulk flow metering. The Team answered that the ultrasonic water flowmeters will be utilized to verify the existing flowmeters and pumping capacities. Once the existing flowmeters and pumping capacities are verified, estimated water flows are able to be recorded in a daily operation sheet. However, considering the location of the water sources, the Eritrean side proposed to have additional water flowmeters so as to avoid inconvenience and unnecessary cost of transport.

7-4) Procurement of Consumables for Water Analysis Equipment

Testing papers for Coliform and Bacteria, reagent for residual chlorine and standard solution of pH / electrical conductivity are consumables and to be procured by AWSSD after the Project to sustain continuous activity for water quality management. The Eritrean side requested the Team to be a bridge between AWSSD and manufacturers for the necessary procurement, to make it sustainable. The Team answered and requested as follows:

- It is difficult for the Team to be a bridge after the Project.
- The Team will provide a list of contact address for procurement.
- The consumables can be procured through local trading companies.

7-5) Technical Cooperation for Leakage Management

The Eritrean side stated that the leakage is one of the most serious issues for improvement of the business efficiency. Moreover, the Eritrean side requested JICA to conduct a technical cooperation for leakage management and leak detection in the next step. JICA side commented, also from that aspect, that the total production volume from water treatment plants and distribution volume of the service reservoirs are important items to be monitored. The Team answered that the request will be delivered to JICA headquarters.

7-6) Technical Cooperation for Prevention of Water Resources Pollution

The Eritrean side stated that the pollution of water resources (dam reservoirs) has become serious. AWSSD, however, has no monitoring equipment for pollutions such as oil, fertilizer and pesticides. The Eritrean side requested to conduct a technical cooperation for prevention of water resources pollution as well as equipment provision. The Team answers that the request will be delivered to JICA headquarters.

7-7) Notice to All related Managers of AWSSD Facilities

JICA side requested AWSSD to instruct the managers of all dams, water treatment plants and pump stations to conduct / facilitate the Project. AWSSD accepted the request and inform them of the Project activities.

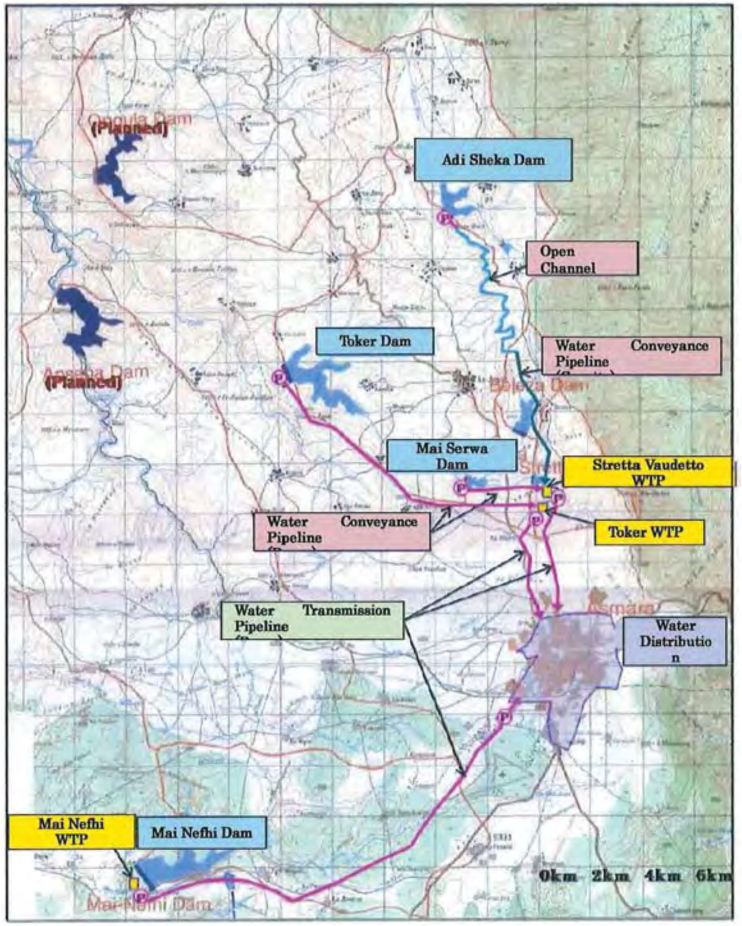
8. Undertakings of the Eritrean side

The Team explained to the Eritrean that its undertakings be as listed in **Annex-4**, and the Eritrean side understood and agreed to execute them.

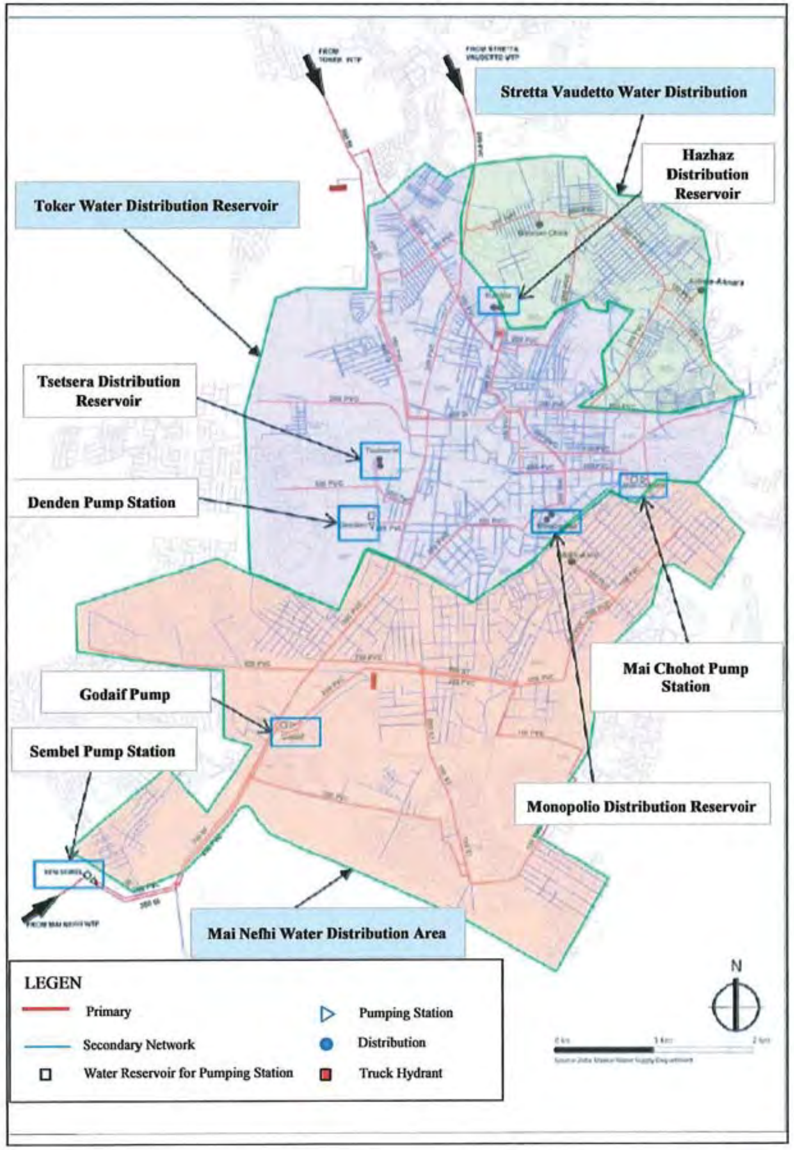
(End)

Annex-1	Project Sites Map
Annex-2	Map of Water Distribution Facilities in Asmara
Annex-3	Implementation Schedule
Annex-4	Undertaking by the Eritrean side
Annex-5	Attendance of the kick-off meeting held on 22 July 2016

Annex-1 Project Site Map



Annex-2 Map of Water Distribution Facilities in Asmara



Annex-3 Implementation Schedule

No	Activity		2016: 7	8	9	10	11	12
1	**Preparation**							
1-1		Discussion on Work Plan	■					
1-2		Team-up	■					
1-3		Initial survey on facilities and present situation	■					
2	**Metering Plan**							
2-1		Detail Plan of metering / monitoring points	■					
2-2		Final draft of daily recording sheet	■					
2-3		Preparation of site rounding schedule	■					
3	**Practice and Site Rounding**							
3-1		Water flow		■				
3-2		Water quality and WTP operation		■				
3-3		Drawings		■				
3-4		Data Recording and analysis		■				
4	**Output Confirmation (Preparation of Field Notes)**							
4-1		Confirmation of metering result and analysis			■			
4-2		Listing up issues of the Project activities			■			
4-3		Listing up issues on improvement of operational procedures and facilities			■			
5	**Recommendation on Operation and Maintenance Plan**							
5-1		Confirmation of continuity for the Project activities				■		
5-2		Recommendation on Operation and Maintenance Plan				■		
5-3		Submission of Final Report						▲

Annex-4 Undertaking by the Eritrean side

1. Selection and Assignment of C/P members

   AWSSD shall select and assign engineers / technicians who will be managers / key persons of AWSSD, as counterpart (C/P) members. AWSSD shall provide the C/P members always for site activities and shall instruct site workers about the Project activities through the above mentioned engineers / technicians.

2. Information related to Water Supply

   AWSSD shall provide necessary information for the Project such as maps, drawings, photos, data for water supply.

3. Safety Management & ID card

   AWSSD shall provide security information and necessary facilitation for safety conditions of JICA experts and shall provide identification cards (ID cards) for JICA Experts, if necessary.

4. Office Space

   AWSSD shall provide office spaces to work together for data input and analysis as well as meeting.

5. Maintenance of Equipment

   AWSSD shall maintain properly the equipment provided by JICA side as well as procurement of consumables of equipment and maintenance of PC software.

Annex-5 Attendance of the kick-off meeting held on 22 July 2016

Date and Time: 9:00AM - 10:30AM, 22 July 2016

Place: Seminar Room of AWSSD

No.	Name	Organization	Position	Telephone Number
1	Mebrahtu Iyassu	WRD	Director General	120404/07120609
2	Efrem Teferi	WRD	Water Quality Engineer	07156208
3	Ghebrekidan Ghirmatzion	AWSSD	Director General	07127721
4	Tekeste Tsegai	AWSSD	Head of Finance and Administration Division	07278766
5	Kidane K/ Mariam	AWSSD	Head of Water Supply Division	07152347
6	Fetsum Araya	AWSSD	Head of Toker Water Treatment Plant	07185424
7	Yohannes Mulu	AWSSD	Geometra / Advisor	07136941
8	Abiel Kiflay	AWSSD	Civil Engineer	07428827
9	Adiam Yohanes	AWSSD	Civil Engineer	07485982
10	Matiwos berhane	AWSSD	Electrical Engineer	07160293
11	Tadese Berhe	AWSSD	Water Quality Engineer	07401065
12	Yikealo Araya	AWSSD	Chemical Technician	07523137
13	Masahito Miyagawa	JICA Kenya office	Representative	+254-727-796557
14	Tsuneo Tsuruzaki	JICA Eritrea Liaison office	Resident officer of JICA / Expert of High Education Program	07162603
15	G. Michael Stephanos	JICA Eritrea Liaison office	Liaison Officer	07114219
16	Katsumi Fujii	JICA Expert team	Chief Consultant / Water distribution management / Drawing management	07264081
17	Tsuyoshi Onozato	JICA Expert team	Operator of Water Facility / Water quality management	07127751
18	Shinji Miwa	JICA Expert team	Coordinator / Assist to Water distribution management / Drawing management	07119097
19	Michael Zerai	JICA Expert team	Assistant coordinator	07165647
20	Magda Mehari Araia	JICA Expert team	Assistant coordinator	07139034

WRD: Water Resources Department, Ministry of Land, Water and Environment

AWSSD: Asmara Water Supply and Sewerage Department

JICA: Japan International Cooperation Agency

Appendix-2: Minutes of Meeting (Technical Note (No.2))

Technical Notes (No. 2) on
Asmara Water Supply Infrastructure (Data Collection and Management) Project

In response to the request from the Government of the State of Eritrea (hereinafter referred to as "Eritrea"), the Japan International Cooperation Agency (hereinafter referred to as "JICA") has conducted Asmara Water Supply Infrastructure (Data Collection and Management) Project (hereinafter referred to as "the Project") since 19 July 2016.

At the end of the Project, from 24 November to 2 December 2016, the JICA Expert Team (hereinafter referred to as "the Team") and the Eritrean side confirmed the outputs of the Project and discussed further improvement in operation conditions of water supply facilities. Results of confirmations and discussions made by the Team and the Eritrean side are described in attached sheets.

Asmara, 2 December 2016

Katsumi Fujii	Ghebrekidan Ghirmatzion
Chief Consultant / Water Distribution Management / Drawings Management	Director General
JICA Expert Team	Asmara Water Supply and Sewerage Department (AWSSD)

Appendix 2-1

ATTACHMENT

1. Condition of Data / Information Management System for Water Supply

On 25 November 2016, Asmara Water Supply and Sewerage Department (hereinafter referred to as "AWSSD") presented progress of their activities that have been conducted for data / information management. The attendances of the presentation meeting are listed in Annex-1. The Team and AWSSD confirmed the following in the presentation meeting:

(1) Collection, summarization and storage of data / information for water flow and quality have been conducted since the middle of September 2016 under self-management basis of AWSSD.

(2) Monthly summary of data / analysis is arranged in forms invented in the Project. The monthly summary for September 2016 was reported internally in AWSSD on 13 October 2016. The summary for October 2016 was presented on 25 November 2016 in front of the Team.

(3) The Team confirmed that data collection and analysis for water distribution are extended to distributed volume by water tank trucks.

(4) The Team also confirmed that the analysis is developed for water distribution volumes to villages, in which the water flow metering is difficult.

(5) Both sides confirmed that Planning and Supervision Unit of AWSSD will continue the training on data collection / management for themselves and operators of facilities since inappropriate acquisitions and inputs of data have been still observed.

(6) Both sides confirmed that the collection, summarization and storage of data / information for water flow and quality became steady and AWSSD will continue it as a permanent work for water supply operation.

2. Drawings of Major Pipelines

To make the information more useful, AWSSD has commenced to input the data in GIS software. Data input for the following routes are completed:

- From Mai Nefhi water treatment plant (hereinafter referred to as "WTP") to Sembel P.S.
- From Adi Sheka dam to S.V. WTP

In November 2016, AWSSD is working for the following route:

- From Toker dam to Toker WTP

3. Trial of Water Quality Improvement

Following the trail held at Toker WTP in September 2016, AWSSD conducted the same improvement for water quality at S.V. WTP and Mai Nefhi WTP in October and November respectively.

(1) S.V. WTP

In October 2016, AWSSD drained all the water of the secondary sedimentation basins and cleaned them up. AWSSD is planning to clean the flocculation basins and the primary sedimentation basins soon. Water quality

Appendix 2-2

data of the 2nd half of October 2016 indicates no significant improvement of water quality in turbidity. The following actions are recommended to be undertaken immediately.

1) To clean the flocculation basins, primary sedimentation basins, sand filters and clear water basin.
2) To dose alum more frequently at around 30 min. interval.

(2) Mai Nefhi WTP

In 22 November 2016, AWSSD drained all the water of the sedimentation basins and cleaned them up. The WTP doses 50kg of alum at 2 - 3 hrs. interval. Improvement of water quality is visually confirmed in color. The turbidity metered on 26 November 2016 is shown below:

Sample	Turbidity (26 Nov. 2016)
Raw Water	30.7 NTU
Line-1 After Sedimentation	10.3 NTU
Line-2 After Sedimentation	9.97 NTU
Clear Water Basin	4.76 NTU

The following actions are recommended to be undertaken immediately for further improvement.

1) To put stairs and fence at the water receiving basin to keep safety for alum dosing work.
2) To repair the exiting dosing system of alum.
3) To dose alum more frequently at around 30 min. interval.
4) To modify the chlorination point to clear water basin from water receiving basin.

(3) Toker WTP

The WTP modified the dosing pipeline of activated carbon to be used for alum dosing at the water receiving basin. The WTP doses the alum by the modified pipeline and pump. Nevertheless, the WTP has continued manual dozing at around 30 min. interval during electricity interruption. The turbidity metered in October 2016 is shown below:

Sample	Turbidity Before (Average of Aug)	Turbidity After			
		14 Sep Regular Analysis	15 Sep Regular Analysis	Reference 14 Sep Special	Average of Oct
Raw Water	>172 NTU	32.9 NTU	36.5 NTU		15.5 NTU
Line-1 After Sedimentation	45.91 NTU	6.81 NTU	3.15 NTU	9.38 NTU	11.4 NTU
After Filtering				6.40 NTU	7.3 NTU
Clear Water Basin	55.8 NTU	59.3 NTU	27.3 NTU		6.7 NTU

The following action is recommended to be undertaken immediately for further improvement.

1) To dose appropriate volume of alum according to flow and quality of raw water.

4. Recommended Plan for Operation and Maintenance

The Team presented "recommended plan for operation and maintenance" on 25 November 2016, which was prepared based on analyzed data / information obtained in July - September 2016. The Team and AWSSD exchanged opinions on the plan. AWSSD agreed on the recommended plan and the both sides confirmed that the "urgent plan for operation and maintenance" has been substantially commenced in the Project. In addition, AWSSD stated that it will start preparation works to realize the "operation and maintenance plan for further stages".

5. Delivery of the Equipment

The Team delivered the equipment, which was procured for the Project, to AWSSD (see Annex-3). Both sides conformed that AWSSD will undertake the following:

(1) To use the equipment appropriately for operation and maintenance of water supply.
(2) To use the equipment carefully to prevent any damages.
(3) To bear all necessary costs for maintenance and repair of the equipment.
(4) To bear all necessary costs to renew / update PC software.
(5) To bear all necessary costs for consumables of the equipment.

6. Results of Other Discussions

Both sides discussed actions to be taken as a next step and exchanged opinions as follows.

6-1 Request from AWSSD

AWSSD would like to conduct following projects under the Japanese cooperation:

(1) Replacement of all pumps for the water supply facilities to keep stable water supply and to increase the distribution volume.

(2) Establishment of a central laboratory of water quality
 1) to verify the analysis results of WTPs,
 2) to give instructions to WTPs for water quality management, and
 3) to monitor the water quality in the water distribution networks.

(3) Rehabilitation or upgrading of chemical dosing system (coagulant and chlorine) to dose the chemicals appropriately.

(4) Rehabilitation or upgrading of WTPs to have more stable and efficient water treatment.

(5) Technical cooperation on installation and maintenance of pumps, leak detections, non-revenue water management, and other necessary items for the infrastructure projects mentioned above.

6-2 Response and recommendation of the Team

The Team responded and recommended the following:

(1) The Team does not deny necessity of the projects requested by AWSSD. Infrastructure projects are, however, difficult to be immediately undertaken by JICA assistances due to frequent outages of electricity supply, improper dosage of chemicals and unsafe quality of water, which were listed in the minutes of discussions signed on 5 June 2015 for the Preparatory Survey of Asmara Water Supply Development in the State of Eritrea. However, AWSSD mentioned that the electricity supply will be improved soon.

(2) Considering the present conditions of water quality management, a technical cooperation project is recommended as shown below:
 1) Technical assistance to conduct appropriate dosage of coagulant in terms of volume and frequency according to water flow and turbidity.
 2) Installation of chlorinator and technical assistance to dose chlorine appropriately.

(3) The Team will deliver the requests of AWSSD mentioned in clause 6-1 to JICA headquarters as well as the recommendation of the Team mentioned in clause 6-2. Moreover, the Team will discuss the future assistance of Japan, taking the above discussion results into consideration.

(End)

Annex-1 Attendance of the confirmation meeting for the Project Outputs held on 25 November 2016
Annex-2 Attendance of the opinion exchange meeting for O&M plan held on 25 November 2016
Annex-3 Certificate of handover for the Equipment

25th November 2016

Attendance of the confirmation meeting for the Project Outputs

No.	Name	Organization	Position
1	Tsehaye Woldeab	AWSSD	Head of Administration & Finance Division
2	Kidane Kifremariam	AWSSD	Head of Water Supply Division
3	Yohannes Mulu (John)	AWSSD	Head of Sewerage Division / Head of Planning & Supervision Unit
4	Tekeste Tsegai	AWSSD	Head of Personal Unit
5	Estifanos Andezion	AWSSD	Head of Finance Unit
6	Biniam G/Yesus	AWSSD	Head of Toker Dam
7	Fetsum Araia	AWSSD	Head of Toker WTP
8	Tadese Berhe	AWSSD	Chemical Engineer
9	Mikael Temeseyen	AWSSD	Technician
10	Efrem Wengisteab	AWSSD	Surveying & design
11	Biniam Ghebre	AWSSD	Surveying & design
12	Abiel Kiflay	AWSSD	Civil Engineer
13	Adiam Yohannes	AWSSD	Civil Engineer
14	Yikealo Araia	AWSSD	Chemical Engineer
15	Abraham Dawit	AWSSD	Drafting

25th November 2016

Attendance of the opinion exchange meeting for O&M plan

No.	Name	Organization	Position
1	Tsehaye Woldeab	AWSSD	Head of Administration & Finance Division
2	Kidane Kifremariam	AWSSD	Head of Water Supply Division
3	Yohannes Mulu (John)	AWSSD	Head of Sewerage Division / Head of Planning & Supervision Unit
4	Tekeste Tsegai	AWSSD	Head of Personal Unit
5	Biniam G/Yesus	AWSSD	Head of Toker Dam
6	Fetsum Araia	AWSSD	Head of Toker WTP
7	Tadese Berhe	AWSSD	Chemical Engineer
8	Mikael Temeseyen	AWSSD	Technician
9	Efrem Wengisteab	AWSSD	Surveying & design
10	Biniam Ghebre	AWSSD	Surveying & design
11	Abiel Kiflay	AWSSD	Civil Engineer
12	Adiam Yohannes	AWSSD	Civil Engineer
13	Yikealo Araia	AWSSD	Chemical Engineer
14	Samul Beyene	AWSSD	Surveying

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ADMINISTRATION OF MAAKEL REGION

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ASMARA WATER & SEWERAGE DEPT.

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ASMARA

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Ref.

CERTIFICATE OF HANDOVER

ATTENTION: Mr. Katsumi Fujii
Chief Consultant
Yachiyo Engineering Co., Ltd.

PROJECT TITLE: "Asmara Water Supply Infrastructure (Data Collection and Management) Project in the State of Eritrea"

This is to certify that the equipments in the attached list have been handed over properly as of 25 November, 2016 to Asmara Water Supply and Sewerage Department (AWSSD).

NAME: Mr. Gherekidan Ghirmazion
TITLE: Director General
ORGANIZATION: Asmara Water Supply and Sewerage Department
DATE: 25 November, 2016

Cc:

- ✓ **Admin and Finance AWSSD**

Appendix 2-5

EQUIPMENT LIST

No.	Item	Specification	Qty.
1	Potable Type Ultra-sonic Flowmeter	Applicable Diameter: 65A～500A	2 Sets
2	Detection Device for Metal Pipe	Transmitter Frequency: 83kHz 27kHz 8kHz Mix, Receiver Frequency: 83kHz 27kHz 8kHz Radio mode	1 Set
3	Detection Device for Non-Metal Pipe	Transmitter Frequency 50～500Hz, Receiver Frequency: 80～500Hz	1 Set
4	Detection Device of Metal	Detection Circuit: Canbel Bridge Transmission Frequency: 9.75kHz	1 Set
5	GPS		2 Sets
6	Potable Type Water Analysis Device (pH, EC)	pH meter: Range of Measurement 0.0～14.0pH EC meter: Range of Measurement 0.1～10S/m	6 Sets
7	Turbidity Meter	Theory: 90 scattering light / transmitted light measurement typed, Range of Measurement 0～1000NTU 0～100 degree	6 Sets
8	Potable Type Water Analysis Device (Residual Chlorine)	Methods: DPD Method, Range of Measurement 0.02～2.00mg/L, 0.1～8.0mg/L	3Sets
9	Bacteria Paper, Total Coliform Paper, Incubator		3 Sets
10	A Set of Computers	Desktop Type PC, A3 Size Printer, CAD software etc.	1 Set

Appendix-3: Material for Kick-off Meeting

Asmara Water Supply Infrastructure (Data Collection and Management) Project

WORK PLAN

JULY 2016

JICA EXPERT TEAM

1

1. PRESENT CONDITIONS ON WATER VOLUME

Items			S.V. System	Toker System	Mai Nefhi System	Total	% against Water Demand in 2015
			m^3/day	m^3/day	m^3/day	m^3/day	%
Water Demand							
Water Demand in 2015※1		A	Approx. 6,000	Approx. 15,000	Approx. 14,000	Approx. 35,000	
Water Production Capacity							
Water Source	Available Intake Capacity		Approx. 9,000	Approx. 16,000	Approx. 17,000	Approx. 42,000	
	In case 10% loss is considered	B	Approx. 8,000	Approx. 14,000	Approx. 15,000	Approx. 37,000	
Water Treatment Plant	Water Production in 2014		Approx. 2,000	Approx. 8,000	Approx. 9,000	Approx. 19,000	Approx. 50%
	Design Capacity	C	8,000	18,000	20,000	46,000	
	Available Water Production Capacity (Smaller one, B or C)		Approx. 8,000	Approx. 14,000	Approx. 15,000	Approx. 37,000	Approx. 110%

※1 Based on assumption of 50L/capita/day, coverage 80% and 30% leakage.

2

2. PRESENT CONDITIONS ON WATER QUALITY

Item	Unit	S.V. WTP			Mai Nefhi WTP		Toker WTP		Water Quality Stand-ard in Eritrea	WHO Guide-line
		Raw Water	Raw Water	Purified Water	Raw Water	Purified Water	Raw Water	Purified Water		
		AdiSheka Dam	MaiSerwa Dam		Mai Nefhi Dam		Tokar Dam			
Turbidity	NTU	3		6	3	1	3	2	<10	≦5
Electro Conduct.	uS/cm	266		320	260	315	285	314	<3000	(1,500)
pH	-	8.1		7.8	7.5	7.2	8.3	8.3	5.5-9.5	
TDS	mg/L	168		214	165	196	190	177	<2000	(1,000)
Total Hard.	mg $CaCO_3$/L	109		128	115	112	142	120		
Total Alkalinity	mg $CaCO_3$/L	99		120	87	50	146	101	<600	
Total Coliform	-	Many		Detect	Many	Not Detect	Many	Detect	Not Detect	Not Detect
Color	-			Colored		Accept-able		Accept-able	<20	≦15
Odor	-			smell		Accept-able		Accept-able		
Residual Chlorine	mg/L			Approx. 0.1		Approx. 5		1 or less		
Fecal Bacteria	-			Detect		Not Detect		Not Detect	Not Detect	

3

3. PROBLEMS

Water Volume

- Because of no metered data on water volume, water flows are not accurately recorded. It is difficult to find necessary points for improvement / repair.
- WTP design capacity is enough for population. However, water supply flow is not sufficient. (WTP is not able to be operated in 100% capacity.)

Water Quality

- Water quality is not monitored daily. Quality is not assured.
- Water quality is not good for some parameters.

Insufficient Information

- For facilities.
- For operation.
- For maintenance.

4. ISSUES

- To record condition of facilities.
- To meter daily the performances of water supply, especially in water flow and quality.
- To find necessary points for improvement / repair.
- To provide a menu for improvement / repair.

Improvement / modification of operational procedures.

Improvement of facilities.

4

5. PURPOSE OF PROJECT & PROJECT DESIGN

Overall Goal	Basic information, necessary for grasping the existing conditions on operation and maintenance of water supply facilities in Asmara, is collected and managed.
Project Purpose	Collection and management system of information, necessary for grasping operation and maintenance conditions on water supply facilities in Asmara, is introduced by Asmara Water Supply and Sewerage Department (AWSSD).
Output	Output 1: Methods of data recording and management, and water quality management are improved for the target dam lakes. Output 2: Methods of data recording and management, and water quality management are improved for the target water treatment plants. Output 3: Methods of data recording and management are improved for the target facilities on water intakes, conveyance, transmission and distribution. Output 4: Collected information is managed and stored as data by AWSSD.

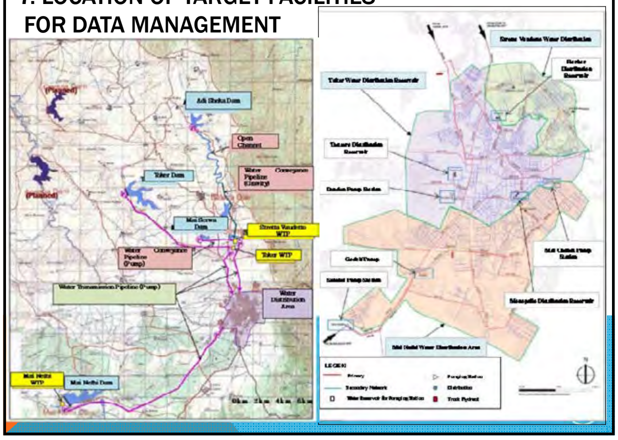
5

6. TARGET FACILITIES FOR DATA MANAGEMENT

System	Stretta Vaudetto (S.V.) WTP System	Toker WTP System	Mai Nefhi WTP System
Dam, Dam lake	Adi Sheka Dam, MaiSerwa Dam	Tokar Dam	Mai Nefhi Dam
Water Conveyance	Adi Sheka Dam ⇒ S.V. WTP Mai Serwa Dam ⇒ S.V. WTP	Tokar Dam ⇒ Tokar WTP	Mai Nefhi Dam ⇒ Mai Nefhi WTP
WTP	Stretta Vaudetto (S.V.) WTP	Toker WTP	Mai Nefhi WTP
Water Trans-mission	S.V. WTP ⇒ Hazhaz Distribution Reservoir	Toker WTP ⇒ Hazhaz Distribution Reservoir, Mai Chehot Pump St., Monopolio Distribution Reservoir, Tsetserat Distribution Reservoir, Denden Pump Station	Mai Nefhi ⇒ Sembel Pump Station Sembel Pump Station ⇒ Godaif Pump Station, Denden Pump Station
Water Distribution		Hazhaz Distribution Reservoir, Mai Chehot Pump St., Monopolio Distribution Reservoir, Tsetserat Distribution Reservoir, Denden Pump Station, Maitemenai Water Station	Sembel Pump Station, Godaif Pump Station, Mai Nefhi Water Station, Sembel Water Station, EXPO Water Station

6

7. LOCATION OF TARGET FACILITIES FOR DATA MANAGEMENT



8. BASIC APPROACH

- Procurement of Equipment (done in Japan)

- Discussion on work plan and team-up
- Initial survey on facilities and present situation

- Water flow metering at key points
- Water quality analysis in treatment process and taps
- Improvement of daily operational procedure and recording sheet

- Practice on flow/quality recording as well as daily operation
- Abstraction of issues to improve the operation conditions
- Recommendation on Operation and Maintenance Plan

8

9. MAJOR & SPECIFIC ACTIVITIES

Activities

- Confirm the water supply data and existing drawings.
- Confirm the service population and area, and water demand.
- Investigate major facilities and the operational condition.
- Decide the metering point of water quality and flow.
- Prepare daily monitoring / recording sheet.
- Scheduled metering of water quality and flow.
- Data analysis on water distribution flow.
- Simple topographic survey of pipeline route for water conveyance , transmission and distribution using GPS and prepare drawings.
- Improve the drawing of water treatment plant.
- Find the issues on water service and improvement.

Assistance of JICA Expert Team

- Assist AWSSD in selecting locations / points to be metered for water flow and quality.
- Provide examples of data recording form / daily inspection sheet.
- Assist AWSSD in recording data and conditions of facilities.
- Provide trainings on equipment usage for water flow, qualities, etc.
- Provide trainings on usage of Auto-CAD and capability of DWGs preparation.
- Assist AWSSD in data analysis on water supply conditions.
- Provide draft plans to improve operation and maintenance.

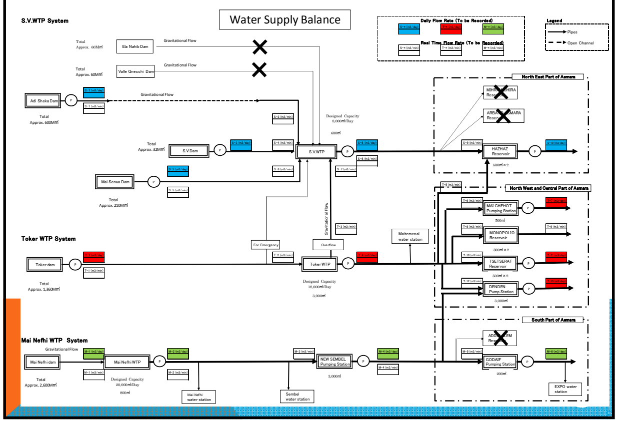
9

10. TENTATIVE SCHEDULE

No	Activity		2016: 7	8	9	10	11	12
1	Preparation							
1-1		Discussion on Work Plan	■					
1-2		Team-up	■					
1-3		Initial survey on facilities and present situation	■					
2	Metering Plan							
2-1		Detail Plan of metering / monitoring points	■					
2-2		Final draft of daily recording sheet	■					
2-3		Preparation of site rounding schedule	■					
3	Practice and Site Rounding							
3-1		Water flow		■	■			
3-2		Water quality and WTP operation		■	■			
3-3		Drawings		■	■			
3-4		Data Recording and analysis		■	■			
4	Output Confirmation (Preparation of Field Notes)							
4-1		Confirmation of metering result and analysis			■			
4-2		Listing up issues of the Project activities			■			
4-3		Listing up issues on improvement of operational procedures and facilities			■			
5	Recommendation on Operation and Maintenance Plan							
5-1		Confirmation of continuity for the Project activities				■		
5-2		Recommendation on Operation and Maintenance Plan				■		
5-3		Submission of Final Report						▲

10

11. KEY WORK: 11-1 RECORD OF WATER FLOW



11-2 WATER FLOW METERING

To meter the water flows at significant points of pipelines such as;

- Outlet of pump.
- Outlet of clear water basin / distribution reservoir.
- Starting / ending points of water conveyance / transmission pipeline.

Training on Flowmeter usage is provided by JICA experts.

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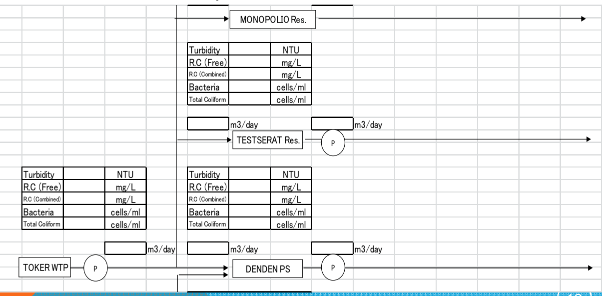
11-3 RECORD WATER QUALITY

- ◆ For treatment process.
- ◆ For distribution process.



13

11-4 WATER QUALITY METERING

- ◆ Temperature.
- ◆ pH.
- ◆ Electrical Conductivity.
- ◆ Turbidity.
- ◆ Residual Chlorine.
- ◆ Bacteria / Coliform.

Training on equipment usage is provided by JICA experts.

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11-5 IMPROVE OPERATION / RECORD

2.Intake Pump（Diesel Engine Pump）

※Before Started　　Person Checked

Item	Value/Condition		Value/Condition Designed	Note
Pump 1			16.6m3/min×235mH	
〈Engine+Fuel Tank〉				
Error Message			None	
Leakage of Fuel			None	
Fuel Level		L		
〈Pump〉				
Leakage from Pipe				
Outlet Pressure		kPa		
Inlet Valve			Open	
Outlet Valve				Opening Scale of Valve
Pump 2			16.6m3/min×235mH	
〈Engine+Fuel Tank〉				
Error Message			None	
Leakage of Fuel			None	
Fuel Level		L		
〈Pump〉				
Leakage from Pipe				
Outlet Pressure		kPa		
Inlet Valve			Open	
Outlet Valve				Opening Scale of Valve

Pump 1

Time Started	

Pump 2

Time Started	

11-6 IMPROVE DRAWINGS MANAGEMENT

- ◆ Identify pipeline (simple topo survey).
  ⇒ Preparation of DWGs (maps) by Auto-CAD.
- ◆ Collect all existing DWGs.
  ⇒ Improvement of Filing system.
- ◆ Update exiting DWGs according to site confirmations.

Training on equipment usage / Auto-CAD operation is provided by JICA experts.

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11-7 EXTRACTION OF ISSUES / RECOMMEND O&M PLAN

Extract Issues for

- ◆ Water balance (leakage, loss, etc.)
- ◆ Assurance of water quality.
- ◆ Conditions of facilities and recording system.

Recommendations for

- ◆ Organization.
- ◆ Flow metering program.
- ◆ Water quality monitoring program.
- ◆ Procedure of daily inspection.
- ◆ Meters to be installed.

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11-8 MANAGEMENT OF PERFORMANCE INDICATOR (PI)

Part 1: PIs for Coverage, Water Volumes and Service Quality

Unit water production volume (L / person / day)

Service coverage of water supply (%)

Capacity of water reservoir (hours)

Frequency of inappropriate water quality (%)

Load factor for maximum daily flow (%)

Part 2: PIs for Business Efficiency

Effective utilization ratio of raw water (%)

Revenue water ratio (%)　Non-revenue water ratio(%)

Electricity consumption per water production (kWh / m^3)

Chlorine consumption per water production (g / m^3)

Alum consumption per water production (g / m^3)

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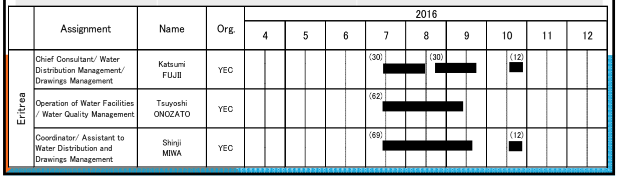
12. EQUIPMENT TO BE PROVIDED BY JICA SIDE

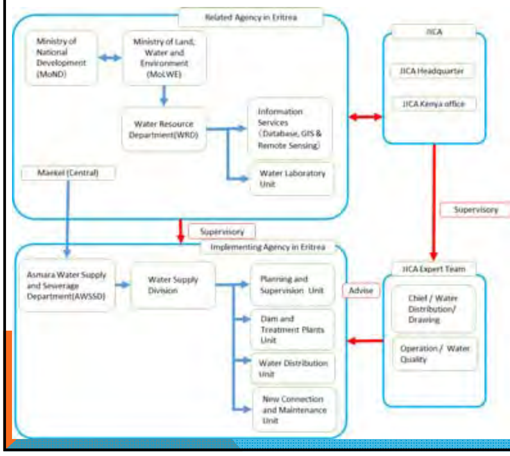
No.	Item	Qty.
1	Potable Typed Ultrasonic Flowmeter	2 Sets
2	Metal Pipe Detector	1 Set
3	Non-Metal Pipe Detector	1 Set
4	Metal Detector	1 Set
5	GPS	2 Sets
6	Potable pH / EC Meter	6 Sets
7	Turbidity Meter	6 Sets
8	Potable Residual Chlorine Meter	3Sets
9	Bacteria and Coliform detection Equipment (Incubator and testing paper)	3 Sets
10	A Set of Computers (Desktop PC, A3 Size Printer, CAD, etc.)	1Set

13. JICA EXPERTS

Name	Role	Organization
Katsumi FUJII	Chief Consultant/Water Distribution Management/Drawings Management	Yachiyo Engineering Co., Ltd.
Tsuyoshi ONOZATO	Operation of Water Facilities / Water Quality Management	Yachiyo Engineering Co., Ltd.
Shinji MIWA	Coordinator/Assistant to Water Distribution and Drawings Management	Yachiyo Engineering Co., Ltd.



14. IMPLEMENTING STRUCTURE



15. ORGANIZATION FOR PROJECT (TEAM-UP)

Team	Members	JICA Expert
Project management team	Head of AWSSD Head of Water Supply Division Heads of Units in Water Supply Division	K. FUJII
Water distribution team	Head of Water Distribution Unit Members of Water Distribution Unit	K. FUJII S. MIWA
Water quality / water treatment team	Head of Dams and Treatment Plants Unit Members of Dams and Treatment Plants Unit	T. ONOZATO
Facility information team	Head of New connection and maintenance unit Head of Dams and Treatment Plants Unit Head of Water Distribution Unit Members of the above units	S. MIWA K. FUJII

16. UNDERTAKINGS OF AWSSD

1. Selection and Assignment of C/P members
   To select and assign engineers / technicians who will be managers / key persons of AWSSD.
   To instruct site workers through the above mentioned engineers / technicians.
   To provide C/P members always for site activities.
2. Information related to Water Supply
   To provide necessary information for the Project such as maps, drawings, photos, data for water supply.
3. Safety Management & ID card
   To provide security information and necessary facilitation for safety conditions of JICA experts.
   To provide identification cards (ID cards) for JICA Experts, if necessary.
4. Office Space
   To provide office spaces to work together for data input and analysis as well as meeting.
5. Maintenance of Equipment
   To maintain properly the equipment provided by JICA side.
   To procure consumables for the equipment.
   To bear maintenance cost of PC software.

Appendix-4: Material for 1st Interim Meeting

Asmara Water Supply Infrastructure (Data Collection and Management) Project

1ST INTERIM MEETING

AUGUST 2016
JICA EXPERT TEAM
COUNTERPART TEAM

1

CONTENTS

2

1. PROGRESS AND DATA OBTAINED
1-1 GENERAL

(1) Learnt flowmeters installation
(2) Obtained flow data for initial verification on key pump stations
(3) Learnt water quality analysis
(4) Obtained water quality data for WTPs
(5) Checked the existing drawings
(6) Be studying GPS utilization
(7) Be studying the water distribution systems and demands

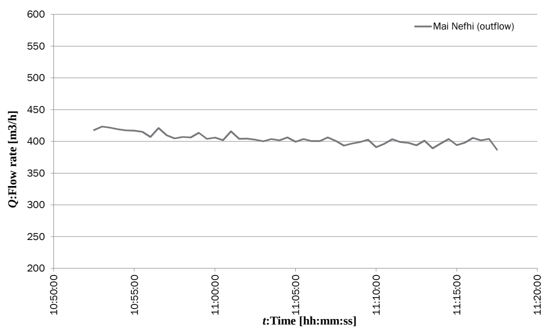

3

1-2 DATA OBTAINED BY FLOWMETERS

	Measured Location	Pump Specification	Existing Flow Meter	Ultrasonic Flow Meter	Remarks
Flow rate	S.V. (Vari Neki) inflow from S.V. dam	450m^3/h	-	**309m^3/h**	
	S.V. outflow	500m^3/h	290m^3/h	**313m^3/h**	
	Toker inflow from Adi Sheka Dam	450m^3/h	-	**343m^3/h**	
	Toker outflow	450m^3/h	-	**686m^3/h**	Due to direct distribution
	Mai Nefhi inflow	Gravity	-	**226m^3/h**	Due to adjusting valve
	Mai Nefhi outflow	500m^3/h	420m^3/h	**404m^3/h**	


4

1-2 DATA OBTAINED BY FLOWMETERS



Flow Rate in outflow of Mai Nefhi WTP on 30th July 2016

1-3 DATA OBTAINED BY WATER QUALITY EQUIPMENT

1. S.V. Water Treatment Plant

Result of Water Quality Analysis (From July 20 to August 2)

Date			20-Jul	25-Jul	28-Jul	2-Aug	WHO Guideline valume
Time			11:00	10:00	10:00	17:00	
Weather			Fine	Fine	Fine	Cloudy	
Water Source			S.V. Dam	Adi Sheka Dam	S.V.Dam	Adi Sheka Dam	
Measuring Point	Parameter	Unit					
Raw Water	Temperature	℃	21.9	19.5	20.3	22.6	
	pH	–	8.30	7.37	7.78	8.89	
	Electrical Conducitivity	uS/cm	294	60	288	234	
	Turbidity	NTU	12.6	>800	13.9	62.7	
	Color	–	No	Brown	Yellow	No	
	Smell	–	No	No	No	No	
Treated Water	Temperature	℃	23.8	20.1	20.6	18.3	
	pH	–	7.78	7.65	7.64	7.69	
	Electrical Conducitivity	uS/cm	289	287	264	225	
	Turbidity	NTU	13.0	10.2	8.52	33.6	5 NTU or less
	Color	–	No	No	No	No	
	Smell	–	No	No	No	No	
	Residual Chlorine (Free)	mg/L	>2.0	0.16	0	0.13	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	>2.0	0.17	0.14	0.26	
	Bacteria	cells/ml		36	50	0	
	Total Coliform	cells/ml		40	50	0	ND

Water Sampling

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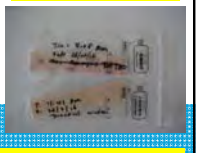
1-3 DATA OBTAINED BY WATER QUALITY EQUIPMENT

2. Toker Water Treatment Plant

Result of Water Quality Analysis (From July 21 to July 29)

Date			21-Jul	26-Jul	29-Jul	WHO Guideline valume
Time			14:00	10:00	10:00	
Weather			Fine	Cloudy	Cloudy	
Water Source			Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	
Measuring Point	Parameter	Unit				
Raw Water	Temperature	℃	18.7		18.0	
	pH	–	8.80		7.95	
	Electrical Conducitivity	uS/cm	296		256	
	Turbidity	NTU	26.9		23.3	
	Color	–	No		Yellow	
	Smell	–	No		No	
Treated Water	Temperature	℃	19.7	19.1	19.9	
	pH	–	8.33	6.88	6.98	
	Electrical Conducitivity	uS/cm	315	223	235	
	Turbidity	NTU	8.5	207	32.1	5 NTU or less
	Color	–	No	Yellow	Yellow	
	Smell	–	No	No	No	
	Residual Chlorine (Free)	mg/L	0.05	0.04	8.8	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	0.24	0.17	8.8	
	Bacteria	cells/ml	0	6	0	
	Total Coliform	cells/ml	0	0	0	ND

Bacteria/Coliform Test



(In July 26, Upside : Bacteria Downside: Coliform)

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1-3 DATA OBTAINED BY WATER QUALITY EQUIPMENT

3. Mai Nefhi Water Treatment Plant

Result of Water Quality Analysis (From July 20 to July 30)

Date			20-Jul	27-Jul	30-Jul	WHO Guideline valume
Time			14:00	10:00	10:00	
Weather			Cloudy	Rain	Rain	
Water Source			Mai Nephi Dam	Mai Nephi Dam	Mai Nephi Dam	
Measuring Point	Parameter	Unit				
Raw Water	Temperature	℃	21.5	25.0	25.0	
	pH	–	6.37	6.60	6.97	
	Electrical Conducitivity	uS/cm	293	184	167	
	Turbidity	NTU	46.9	800>	443	
	Color	–	Yellow	Yellow	Yellow	
	Smell	–	No	No	No	
Treated Water	Temperature	℃	21.7	25.0	25.0	
	pH	–	7.14	5.89	6.47	
	Electrical Conducitivity	uS/cm	304	213	175	
	Turbidity	NTU	18.1	85.8	156	5 NTU or less
	Color	–	No	Yellow	No	
	Smell	–	No	No	No	
	Residual Chlorine (Free)	mg/L	0	0	7.8	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	0.14	0.18	8.8	
	Bacteria	cells/ml		0		
	Total Coliform	cells/ml		12		ND

Instruction of Water Quality Analysis

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1-3 DATA OBTAINED BY WATER QUALITY EQUIPMENT

1. Delivery Condition of Water Quality Equipment

Facility	Equipment Delivered	Qty.	Measurable Parameter
S.V. WTP	pH/EC meter	1	pH, Electro-conductivity, Turbidity, Residual Chlorine (Total, Free), Bacteria, Coliform
	Turbidity meter	1	
	Residual chlorine meter	1	
	Simple analysis paper for Bacteria (100 pcs.)	1	
	Simple analysis paper for Coliform (100pcs.)	1	
Toker WTP	pH/EC meter	1	pH, Electro-conductivity, Turbidity, Residual Chlorine (Total, Free), Bacteria, Coliform
	Turbidity meter	1	
	Residual chlorine meter	1	
	Simple analysis paper for Bacteria (100 pcs.)	1	
	Simple analysis paper for Coliform (100pcs.)	1	
Mai Nephi WTP	pH/EC meter	1	pH, Electro-conductivity, Turbidity, Residual Chlorine (Total, Free), Bacteria, Coliform
	Turbidity meter	1	
	Residual chlorine meter	1	
	Simple analysis paper for Bacteria (100 pcs.)	1	
	Simple analysis paper for Coliform (100pcs.)	1	
Adi Sheka Dam	pH/EC meter	1	pH, Electro-conductivity, Turbidity
	Turbidity meter	1	

Instruction of Water Quality Analysis to the Person in Charge of Adi Sheka Dam

2. Water Quality Equipment in Standby in the Central Office

Equipment	Qty.	Note
pH/EC meter	2	Original Plan: ・pH/EC meter(1) and Turbidity meter (1) for Toker Dam ・pH/EC meter(1) and Turbidity meter (1) for Mai serwa Dam ※Equipment for Mai serwa Dam is going to be used for central office, because the dam can not be used due to pump damage for the time being.
Turbidity meter	2	

We are ready to start daily water quality monitoring for each water facility.

9

2. PROGRAM OF DAILY WORKS AND RECORDS
2-1 PURPOSE AND ACTIVITIES TO BE DONE

(1) To accumulate and analyze data, and to inform the general public of water supply performance.

(2) To confirm and assure daily the water supply performance by the top management of AWSSD.

(3) To find issues for modification of operation / repair / rehabilitation / new facilities construction.

(1) To have routine works of daily metering and data recording.

(2) To have data collection and analysis system.

(3) To update drawings of the existing facilities to make problems / issues clear.

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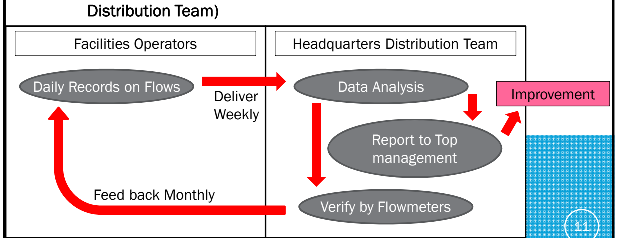
2-2 WATER DISTRIBUTION MANAGEMENT (1)

(1) To make demand estimation per zone clear. (To do once per year by Facilities Team).

(2) To confirm the daily balance between demand and distributed flow. (To do once per week by Distribution Team)

(3) To records daily in-flow / out-flow of all key facilities by estimating means. (To do daily by operation records at facilities)

(4) To verify periodically the estimating means by flowmeters. (by Distribution Team)



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2-2 WATER DISTRIBUTION MANAGEMENT (2)

Activities in the Project

(1) Demand confirmation by Facilities Team.

(2) 24hrs flow metering by Water Distribution Team and verification of estimating means of In-flow / Out-flow.

(3) Daily records on water flow (estimated) by each facilitiy (dam, WTP, pump station).

(4) Daily and monthly report of water flow by Water Distribution Team .

(5) Listing-up issues on water distribution.

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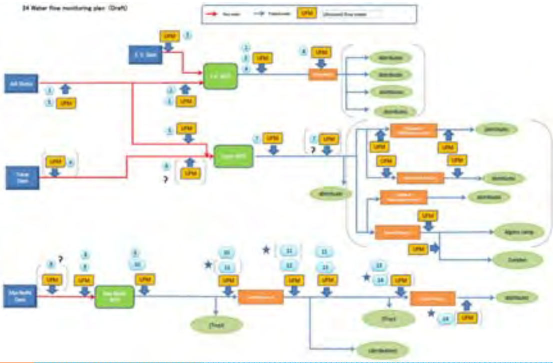
24 HOURS FLOW METERING PLAN



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24 HOURS FLOW METERING PLAN (DRAFT)

1	8-9th. Aug	Sembel P.S. outflow ~ Flow in the branch to distribution area
2	10-11th. Aug	Adi sheka dam outflow ~ S.V WTP inflow
3	12-13th. Aug	Adi sheka dam outflow ~ Toker inflow
4	15-16th. Aug	Toker inflow ~ Toker outflow
5	17-18th. Aug	Toker outflow ~ Toker distribution * Location must be found.
6	19-20th. Aug	Mai Nefhi inflow – Mai Nefhi outflow
7	22-23rd. Aug	Mai Nefhi Outflow ~ Sembel P.S. inflow *Digging is required.
8	24-25th. Aug	Sembel P.S. flow to Godaif P.S ~ Godaif P.S. inflow
9	26-27th. Aug	S.V. dam outflow ~ S.V. WTP outflow *Digging is required.
10	29-30th. Aug	S.V. inflow from Adi sheka ~ S.V. WTP outflow
11	31st -1st. Sep	S.V WTP outflow ~ BORBORIELA *Cleaning is required.
12	2-3rd. Sep	Toker dam
13	5th. Sep ~	Distribution area ~

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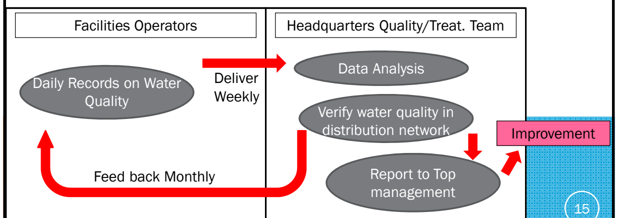
2-3 WATER QUALITY & FACILITY OPERATION (1)

(1) To analyze water quality daily. (To do every day at WTPs)

(2) To confirm the daily water quality at Headquarters. (To do once per week)

(3) To records daily operation conditions (incl. flow estimation) at all key facilities (dam, WTP, pump station). (To do daily by operation records)

(4) To modify operation mode such as chemical dozing. (To do by WTPs)



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2-3 WATER QUALITY & FACILITY OPERATION (2)

Activities in the Project

(1) Water quality monitoring by each facility (dam, WTP, pump station).

(2) Daily records on operation conditions (incl. flow) by each facility (dam, WTP, pump station).

(3) Daily and monthly report of water quality by Water Quality / Treatment Team.

(4) Modification of operation mode by WTPs.

(5) Listing-up issues on water distribution.

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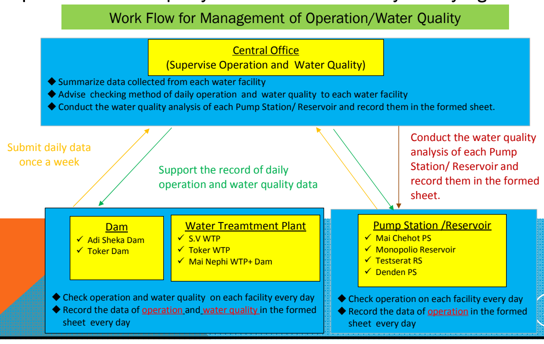
2-3 WATER QUALITY & FACILITY OPERATION (3)

Daily Activities and Operation Records ;

- From tomorrow, we will start the recording, reporting, data summarizing of operation and water quality data on each water facility as daily regular works.

Work Flow for Management of Operation/Water Quality



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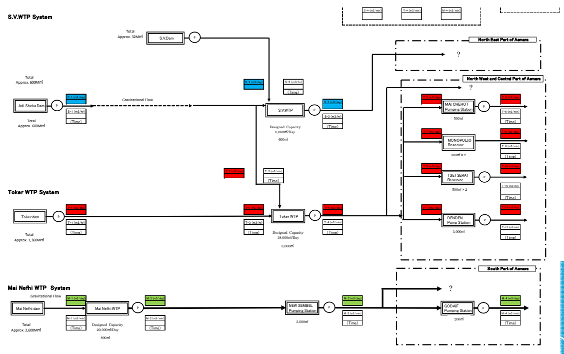
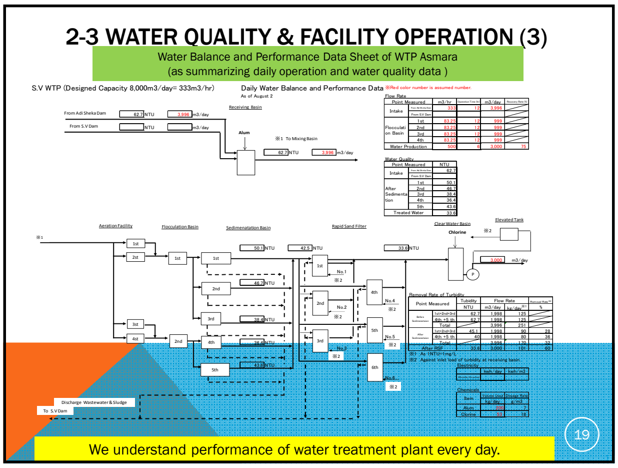
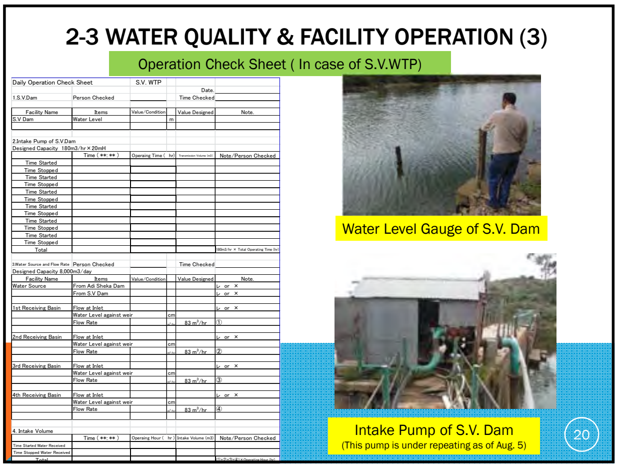
2-3 WATER QUALITY & FACILITY OPERATION (3)

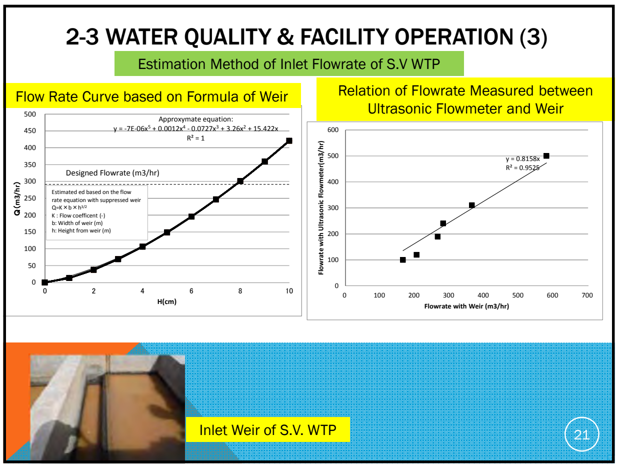
Water Supply Balance in Asmara (as summarizing daily operation data)

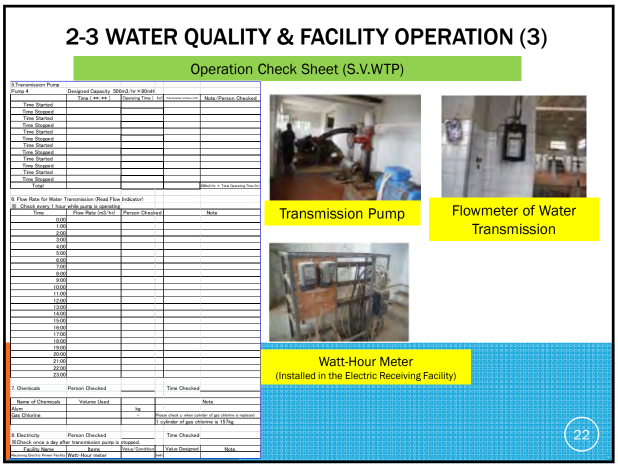


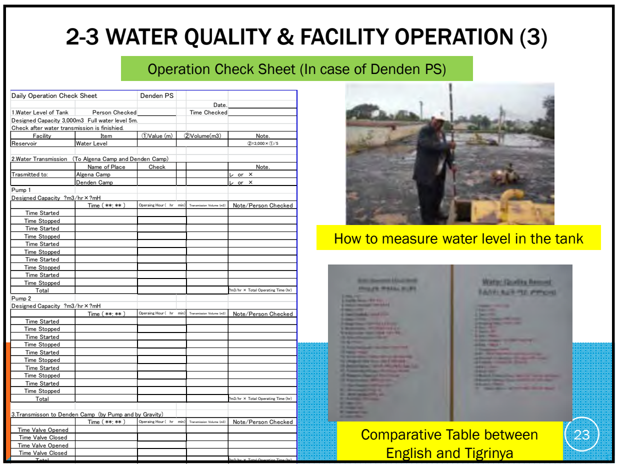
We understand how much volume each facility produced every day.

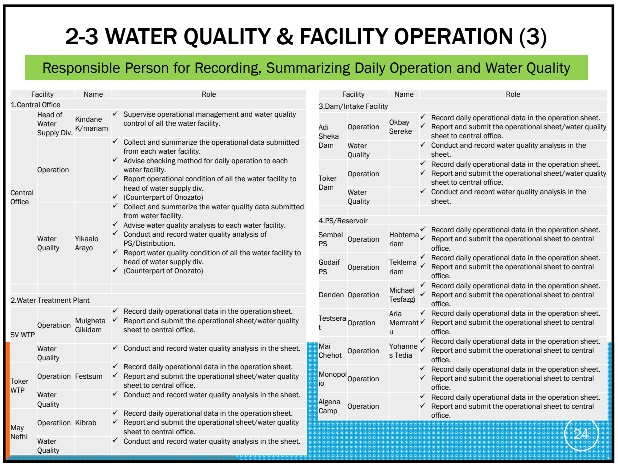

2-3 WATER QUALITY & FACILITY OPERATION (3)
Water Balance and Performance Data Sheet of WTP Asmara
(as summarizing daily operation and water quality data)
S.V WTP (Designed Capacity 8,000m3/day= 333m3/hr)
Daily Water Balance and Performance Data
We understand performance of water treatment plant every day.
19


2-3 WATER QUALITY & FACILITY OPERATION (3)
Operation Check Sheet (In case of S.V.WTP)
Daily Operation Check Sheet
S.V. WTP
Water Level Gauge of S.V. Dam
Intake Pump of S.V. Dam
(This pump is under repeating as of Aug. 5)
20


2-3 WATER QUALITY & FACILITY OPERATION (3)
Estimation Method of Inlet Flowrate of S.V WTP
Flow Rate Curve based on Formula of Weir
Relation of Flowrate Measured between Ultrasonic Flowmeter and Weir
Approximate equation:
y = -7E-06x⁵ + 0.0012x⁴ - 0.0727x³ + 3.26x² + 15.422x
R² = 1
Designed Flowrate (m3/hr)
Q (m3/hr)
H(cm)
y = 0.8158x
R² = 0.9526
Flowrate with Weir (m3/hr)
Inlet Weir of S.V. WTP
21


2-3 WATER QUALITY & FACILITY OPERATION (3)
Operation Check Sheet (S.V.WTP)
Transmission Pump
Flowmeter of Water Transmission
Watt-Hour Meter
(Installed in the Electric Receiving Facility)
22


2-3 WATER QUALITY & FACILITY OPERATION (3)
Operation Check Sheet (In case of Denden PS)
Daily Operation Check Sheet
Denden PS
How to measure water level in the tank
Comparative Table between English and Tigrinya
23


2-3 WATER QUALITY & FACILITY OPERATION (3)
Responsible Person for Recording, Summarizing Daily Operation and Water Quality
Facility
Name
Role
1.Central Office
2.Water Treatment Plant
3.Dam/Intake Facility
4.PS/Reservoir
24

2-4 FACILITIES INFORMATION

(1) To calculate water demand per distribution zone. (Once per year by Facilities Team)

(2) To determine water distribution plan (daily average m3 / day per distribution zone). (Once per year by Facilities Team)

(3) To update and to make drawings for the existing facilities. (by Facilities Team).

(4) To make list of drawings.

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2-4 FACILITIES INFORMATION (2)

Activities in the Project

(1) Demand calculation per distribution zone.

(2) Comparison of the demand with distributed flow and consumption.

(3) Simple topographical survey for major pipelines and make drawings. (from 23rd August ~)

(4) Confirm the facilities with the existing drawings and update them if necessary.

(5) List the existing drawings.

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3. ISSUES ON THE DAILY ROUTINE WORKS IN/AFTER THE PROJECT

(1) Good initiatives of the top management to continue the daily data recording and analysis. ⇒ To request flow / quality / operation records of the teams every day.

- Assignment of good leaders at Headquarters
- Confirmation of activities everyday

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(2) Good management of data to show to every stakeholders such as governmental agencies, customers, investors, planners.

- Summary Sheet (daily, monthly, yearly)

(3) Good inputs for daily routine works such as cars, man powers, consumables, etc.

- Good team leaders
- Cars for flowmeter, water quality, topo survey teams
- Periodical procurements of consumables before stock out

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Appendix-5: Material for 2nd Interim Meeting

Asmara Water Supply Infrastructure (Data Collection and Management) Project

2ND INTERIM MEETING

AUGUST 2016

JICA EXPERT TEAM

COUNTERPART TEAM

1

CONTENTS

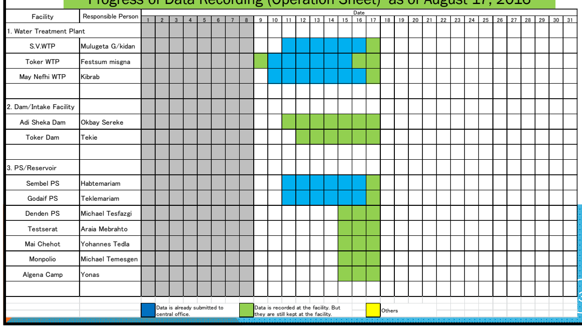
2

1. DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW

(1) Progress of Daily Recording Operation & Water Quality

1) Operation

Progress of Data Recording (Operation Sheet) as of August 17, 2016



3

1. DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW

(1) Progress of Daily Recording Operation & Water Quality

1) Operation

Result of Operation (Toker WTP※1) from Aug 9 to Aug 15

Date				9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug
			Unit							
Receiving Water	Water Source	Adi Sheka Dam	m3/day	4,900	3,500					
		Toker Dam	m3/day	9,405	6,650	8,250	8,250	8,250	7,600	7,125
		Total	m3/day	14,305	10,150	8,250	8,250	8,250	7,600	7,125
Inlet of WTP			m3/day	2,100	6,400	6,750	4,350	4,950	4,800	6,000
Production Water			m3/day	1,995	3,150	4,500	4,050	4,680	3,600	5,400
Chemical Used		Alum	kg	300	300	300	300	300	300	300
		Chlorine (When replaced)	kg							レ

※1 Designed capacity is 18,000m³/day

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1. DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW

(1) Progress of Daily Recording Operation & Water Quality

1) Operation

Result of Operation (S.V WTP ※1) from Aug 11 to Aug 16

Date				11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug
			Unit						
Receiving Water	Water Source	Adi Sheka Dam	m3/day	No Record	No Record	No Record	No Record	No Record	No Record
		S.V Dam	m3/day						
		Total	m3/day						
Production Water			m3/day	1,200	1,950	2,700	1,500	3,000	3,750
Chemical Used		Alum	kg	0	0	100	0	100	0
		Chlorine (When replaced)	kg						

※1 Designed capacity is 8,000m³/day.

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1. DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW

(1) Progress of Daily Recording Operation & Water Quality

1) Operation

Result of Operation (May Nephi WTP ※1) from Aug 10 to Aug 16

Date			10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug
		Unit							
Receiving Water	Mai Nephi Dam	m3/day	6,075	8,813	10,800	3,450	8,175	10,388	9,038
Production Water (Estimated by Pump)		m3/day	5,400	7,833	9,600	3,067	7,267	9,233	8,033
Production Water (Estimated by Meter)		m3/day	No Record	No Record	No Record	3,230	6,271	7,853	6,410
Chemical Used	Alum	kg	600	600	600	600	600	600	600
	Chlorine (When replaced)	kg		レ					

※1 Designed capacity is 20,000m³/day.

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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(1) Progress of Daily Recording Operation & Water Quality

1) Operation

Result of Operation (New Sembel PS) from Aug 11 to Aug 16

Date	Unit	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug
Tranmission Volume(Estimated by Pump)	m3/day	7,408	3,967	3,383	9,742	3,238	3,938
Transmission Pump (Estimated by Meter)	m3/day	4,938	2,787	1,950	4,020	4,800	

Result of Operation (Godaif PS) from Aug 11 to Aug 16

Date	Unit	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug
Tranmission Volume(Estimated by Pump)	m3/day	2,450	1,750	1,400	350	2,450	2,800

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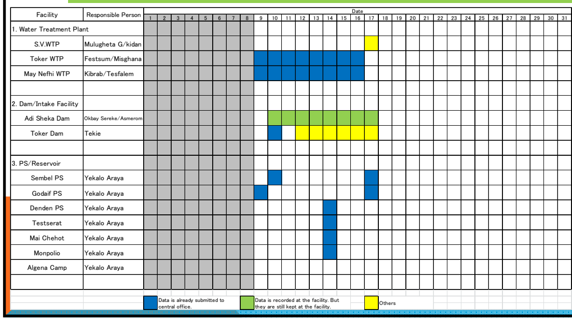
1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(1) Progress of Daily Recording Operation & Water Quality

2) Water Quality

Progress of Data Recording (Water Quality Sheet) as of August 17, 2016



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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(1) Progress of Daily Recording Operation & Water Quality

2) Water Quality

Result of Water Quality (Toker WTP) from Aug 9 to Aug 16

Measuring Point	Parameter	Unit	9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	WHO Guideline valume
Time			10:50	8:00	8:00	8:00	11:20	8:00	9:00	8:00	
Weather			Rain	Rain	Cloudy/Sun	Fine	Fine	Fine	Fine	Fine/Cloud	
Water Source			Adi Sheka Dam	Adi Sheka Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	
Raw Water	Temperature	℃	18.4	18.5	17.0	18.1	18.6	17.8	18.1	20.4	
	pH	−	7.95	7.98	7.85	7.35	7.37	7.16	7.04	7.51	
	Electrical Conducitivity	uS/cm	267	268	178	168	189	219	192	170	
	Turbidity	NTU	71.4	72.4	90.7	98.3	87.7	142.0	85.5	12.6	
	Color	−	No	Brown	High	No	Brown	Brown	Brown	Brown	
	Smell	−	No	No	No	No	No	No	No	No	
Treated Water	Temperature	℃	21.2	22.2	19.4	17.3	18.9	17.7	19.9	20.5	
	pH	−	7.03	7.03	7.36	7.27	7.24	7.22	7.23	7.35	
	Electrical Conducitivity	uS/cm	263	263	244	167	225	179	168	178	
	Turbidity	NTU	20.9	20.1	17.3	86.3	39.8	77.2	74.9	73.9	5 NTU or less
	Color	−	No	No	No	High	No	Brown	Brown	No	
	Smell	−	No	No	Chlorine Smell	No	No	No	No	No	
	Residual Chlorine (Free)	mg/L	2.2	2.2	0.97	0.28	0.11	0.07	0.24	0.08	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	2.2	0.2	1.39	1.19	0.53	0.12	0.32	0.21	
	Bacteria	cells/ml	0	0	0	0	0	0	0		
	Total Coliform	cells/ml	0	0	0	0	0	0	0		ND

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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(1) Progress of Daily Recording Operation & Water Quality

2) Water Quality

Result of Water Quality (S.V. WTP) in Aug 17

Measuring Point	Parameter	Unit	17-Aug	WHO Guideline valume
Time			15:16	
Weather			Cloudy	
Water Source			Adi Sheka Dam	
Raw Water	Temperature	℃	24.6	
	pH	−	8.46	
	Electrical Conducitivity	uS/cm	243	
	Turbidity	NTU	78.2	
	Color	−	No	
	Smell	−	No	
Treated Water	Temperature	℃	21.1	
	pH	−	7.99	
	Electrical Conducitivity	uS/cm	249	
	Turbidity	NTU	19.4	5 NTU or less
	Color	−	No	
	Smell	−	No	
	Residual Chlorine (Free)	mg/L	0.18	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	0.54	
	Bacteria	cells/ml		
	Total Coliform	cells/ml		ND

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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(1) Progress of Daily Recording Operation & Water Quality

2) Water Quality

Result of Water Quality (Mai Nefhi WTP) from Aug 9 to Aug 16

Measuring Point	Parameter	Unit	9-Aug	10-Aug	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	WHO Guideline valume
Time			16:28	13:52	20:00	18:00	18:00	18:00	18:00	15:30	
Weather			Rain	Rain		Fine		Fine	Fine	Fine	
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	
Raw Water	Temperature	℃	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	
	pH	−	6.83	5.06	7.29	7.68	5.24	8.11	7.81	6.95	
	Electrical Conducitivity	uS/cm	172	214	203	153	392	161	166	228	
	Turbidity	NTU	325	379	524	354	361	245	272	369	
	Color	−	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
	Smell	−	No	No	No	No	No	No	No	No	
Treated Water	Temperature	℃	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	
	pH	−	6.60	6.67	6.94	6.99	7.68	7.58	7.71	6.15	
	Electrical Conducitivity	uS/cm	179	170	166	161	159	178	168	199	
	Turbidity	NTU	156	166	268	448	309	101	230	49.8	5 NTU or less
	Color	−	No	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	No	
	Smell	−	No	No	No	No	No	No	No	No	
	Residual Chlorine (Free)	mg/L	8.8	0	6.4	7.0	0	0	0	8.3	(0.1mg/L or more)
	Residual Chlorine (Total)	mg/L	8.8	0	5.0	0	0	0	0	8.8	
	Bacteria	cells/ml	0	0	0	5					
	Total Coliform	cells/ml	0	0	0	2					ND

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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(2) Progress of Flowrate Measurement Using Ultra-Sonic Flowmeter

THE OBTAINED DATA OF 24 HOURS FLOW METERING

1	3-4th. Aug	Tokor inflow - Tokor outflow
2	8-9th. Aug	Sembel P.S. outflow - Flow in the branch to distribution area
3	11-12th. Aug	Mai Nefhi Outflow
4	12-13th. Aug	Mai Nefhi inflow
5	16-17th. Aug	Adi sheka dam outflow

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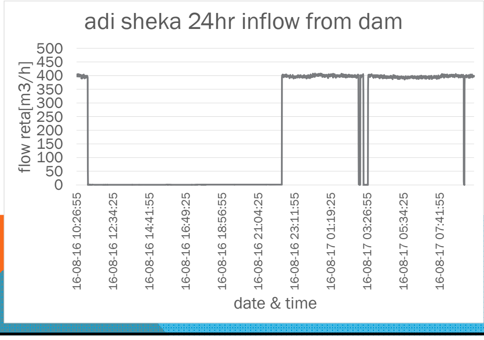
1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(2) Progress of Flowrate Measurement Using Ultra-Sonic Flowmeter

24 HOURS FLOW METERING IN ADI SHEKA DAM

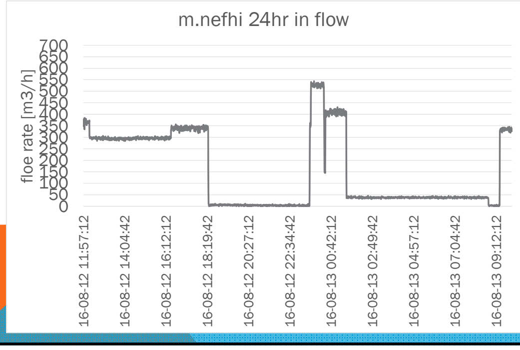


13

1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(2) Progress of Flowrate Measurement Using Ultra-Sonic Flowmeter

24 HOURS FLOW METERING IN MAI NEFHI INFLOW



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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(2) Progress of Flowrate Measurement Using Ultra-Sonic Flowmeter

SUMMARY OF 24 HOURS FLOW METERING

24 hour metering summary

		Measuring date	Average flow rate during 24hours metering [m3/h]	Total water volume for 24 hours metering [m3]
S.V. system	Adi sheka dam outflow	16-17th Aug		
	S.V. WTP inflow from Adi sheka dam		237.06	1250.492
	BORBORIELA (distribution)			
Tokor system	Tokor inflow from Adi sheka dam	3th-4th Aug	282.137	6472.701
	Tokor outflow	3th-4th Aug	537.38	4630.429
	Tokor distribution			
Mai Nefhi system	Mai Nefhi inflow	13th-14th Aug	339.837	3047.207
	Mai Nefhi outflow	12th-13th Aug	675.021	16211.77
	Sembel pump station inflow			
	Sembel pump station out flow	8th-9th Aug	588.799	3380.69
	Sembel distributin area	8th-9th Aug	204.243	1181.21
	Godaif outflow (distribution)			

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1. **DATA OBTAINED UNTIL 17TH AUGUST REGARDING WATER QUALITY & FLOW**

(2) Progress of Flowrate Measurement Using Ultra-Sonic Flowmeter

PLAN

1. To continue to obtain the current actual data (from Dam and distribution etc.)
2. To confirm the correlation between Ultrasonic flow meter and current measuring instrument (flow meter and weir level etc.) in each facility
3. To obtain more data several times to get the capacity (inflow and outflow volume) in the W.T.P

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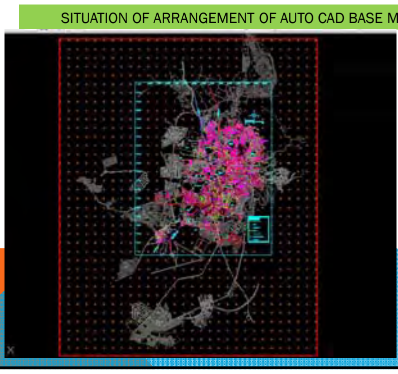
2. **SITUATION OF ARRANGEMENT FOR THE AUTO CAD BASE MAP, DEMAND CALCULATION (POPULATION & CONSUMPTION) PER DISTRIBUTION ZONE**

SITUATION OF ARRANGEMENT OF AUTO CAD BASE MAP



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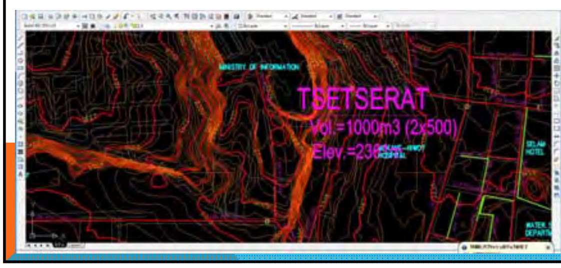
2. **SITUATION OF ARRANGEMENT FOR THE AUTO CAD BASE MAP, DEMAND CALCULATION (POPULATION & CONSUMPTION) PER DISTRIBUTION ZONE**

AUTOCAD DRAWINGS AND BASE MAP

- Contour lines of Asmara city
- Asmara water supply pipe lines
- And combination of the above two gives a reliable information
- For the elevation and direction of pipe lines.



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2. SITUATION OF ARRANGEMENT FOR THE AUTO CAD BASE MAP, DEMAND CALCULATION (POPULATION & CONSUMPTION) PER DISTRIBUTION ZONE

CONSUMPTION AND DEMAND

Depending on the standard water supply per capital per day

Estimated population

Gives the demand

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3. ANSWERS TO THE QUESTIONNAIRE (REQUESTED BY JICA EXPERT TEAM)

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4. SITUATION OF DAILY RECORDING WORKS (LIST UP GOOD/BAD FACILITIES AND ANALYSIS OF REASONS)

Recommendation Regarding Operation and Water Quality Team

1. S.V. WTP

- No person assigned for water analysis.
- The workers are too aged to support the site responsible person (Eng. Mulgeta).
- Number of sampling points are seven .
- So he needs additional staff especially for water quality analysis.
- There is no laboratory room.

2. Mai Nefhi WTP

- The person in charge of water analysis does not master how to use the measuring equipment and how to record the data yet.

3. Toker Dam

- The person in charge of water analysis does not master how to use the measuring equipment and how to record the data yet.

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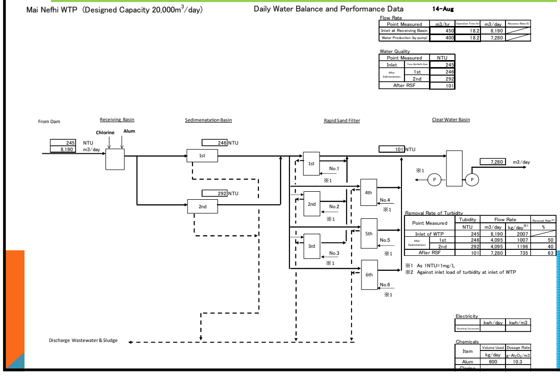
5. THE SUMMARY OF WATER FLOW AND QUALITY PER SYSTEM.

Daily Water Balance and Performance Data (Mai Nefhi WTP) in August 14



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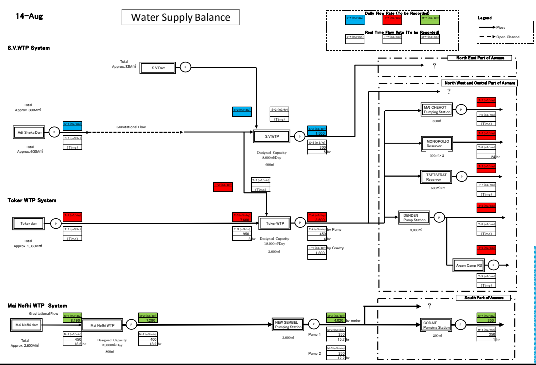
5. THE SUMMARY OF WATER FLOW AND QUALITY PER SYSTEM.

Daily Water Supply Balance of All the Water Facility in Asmara in August 14



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6. NECESSARY POINTS TO BE IMPROVED FOR THE PROJECT ACTIVITIES

1. Improvement of Facility

(1) Regarding measuring flowrate using ultra sonic flowmeter

- To excavate the place to measure water flow rate in Godaif outflow
- To fid the excavate point for several hours measurement in S.V. outflow
- Submersion under water

(2) Others

- Install sampling tap in intake pipe from Mai Nefhi Dam (We are currently taking the sample for raw water from center well of sedimentation tank.)

2. Improvement of Water Quality

- Verify the design of 3 WTP and propose the appropriate operation (By JICA expert team)
- Conduct jar test to grasp weather turbidity in raw water can be coagulated appropriately or not using aluminum sulfate and/or polymer being currently used. (By JICA expert team)

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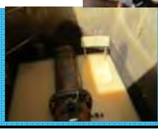
6. NECESSARY POINTS TO BE IMPROVED FOR THE PROJECT ACTIVITIES

SUBMERSION UNDER WATER OF INSTRUMENTAL

a. Submersion under water or one of two instrumentals for Ultrasonic flow meter on 12th Aug 2016
b. This instrumental is not working now.
c. Under confirming about the possibility of guarantee for repair
d. Water flow team continue to measure with the other instrumental
e. Please corporate the defend method to avoid submersion under the water (24 hours inspection, putting the guard man etc.)



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Appendix-6: Material for the Demonstration of Jar Test and Treatment Process

Asmara Water Supply Infrastructure (Data Collection and Management) Project

REPORT OF COAGULATION & SEDIMENTATION TEST(JAR TEST) AND PROPOSE THE OPERATION

AUGUST 2016

JICA EXPERT TEAM

TSUYOSHI ONOZATO

CONTENTS

1. REPORT OF COAGULATION AND SEDIMENTATION TEST (JAR TEST) USING RAW WATER ON TOKOR WTP

(1) Purpose
We grasp whether we can conduct coagulation and sedimentation appropriately using coagulant currently being used.

(2) Date Conducted
August 23, 2016

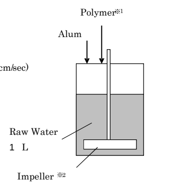
(3) Sample Used

Sample	Tokor WTP, Raw Water	–
Water Temp.	17.4	℃
pH	7.2	–
Turbidity	58	NTU
Electro Conductivity	177	uS/cm
Color	Some Color	–

1. REPORT OF COAGULATION AND SEDIMENTATION TEST (JAR TEST) USING RAW WATER ON TOKOR WTP

(4) Methods

Raw Water 1L
↓
Rapid Mixing Approx. 120rpm (=Approx. 48cm/sec)
← Added alum
↓
Approx. 1min Measurement of pH
← Added polymer※1
↓
Slow Mixing Approx. 50rpm (=Approx. 20cm/sec)
↓
Approx. 10min
↓
Wait Approx. 10 min
・Measured sedimentation velocity and checked the performance of coagulation※3
↓
Took the supernatant and measured the turbidity



※2 Dimension of Paddle 76mm×27mm

※1 Added polymer only at the necessary condition

※3 Measured sedimentation velocity and checked the performance of coagulation with visual estimation. Judged the performance as follows; Completely coagulated : ○, Coagulated but not completely coagulated : △, Not coagulated: ×

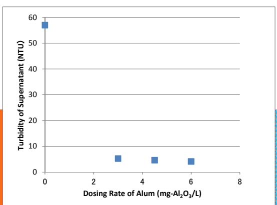
1. REPORT OF COAGULATION AND SEDIMENTATION TEST (JAR TEST) USING RAW WATER ON TOKOR WTP

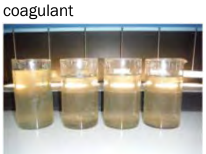
(5) Results

1) In case alum (only 1 chemical) is used as coagulant

No.		1	2	3	4
Dosing Rate of Alum (mg-Al_2O_3/L)		0	3	4.5	6
Dosing Rate of Polymer (mg/L)		–	–	–	–
pH after Alum is added		7.2	7.2	7.0	6.8
Performance	Turbidity	57	5.2	4.6	4.1
	Coagulation	×	○	○	○
	Sedimentatoin Velocity (mm/min)	–	150	100	50

Turbidity after Coagulation and Sedimentation





Condition Just After Flocculation (No.1～No. 4 from Left Side)

Condition After Sedimentation for 10 min (No.1～No. 4 from Left Side)

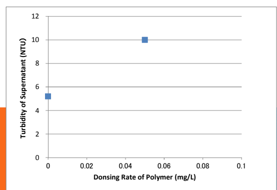
1. REPORT OF COAGULATION AND SEDIMENTATION TEST (JAR TEST) USING RAW WATER ON TOKOR WTP

(5) Results

2) In case alum +Polymer (2 coagulant) are used as coagulant

No.		1	2	3
Dosing Rate of Alum (mg-Al_2O_3/L)		0	3	3
Dosing Rate of Polymer (mg/L)		–	0	0.05
pH after Alum is added		7.2	7.2	7.2
Performance	Turbidity	57.0	5.2	10
	Coagulation	×	○	○
	Sedimentatoin Velocity (mm/min)	–	150	250

Turbidity after Coagulation and Sedimentation



Condition Just After Flocculation (No.2 and No. 3 from Left Side)

1. REPORT OF COAGULATION AND SEDIMENTATION TEST (JAR TEST) USING RAW WATER ON TOKOR WTP

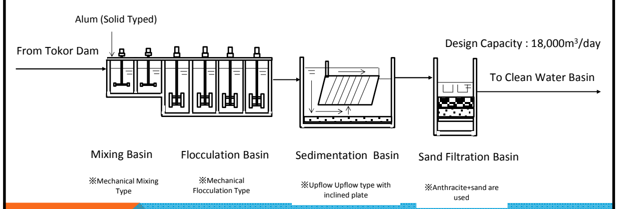
(6) Conclusion

- Without any addition of alkali regent, by conducting rapid mixing and slow mixing following the addition of 3mg-Al_2O_3/L of aluminum sulfate (1 coagulant), turbidity in the raw water could be coagulated appropriately and it could be treated to approximate 5 NTU or less after sedimentation.
- By adding polymer in addition to aluminum sulfate, we could make most of flocs bigger and could make the sedimentation velocity higher. But a part of turbidity was stayed in the supernatant as choroid even after coagulation and sedimentation were conducted. Therefore, the turbidity became higher than that of the sample without polymer .

3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(1) TOKOR WTP

SCHEMATIC FLOWSHEET OF TOKOR WTP



3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(1) TOKOR WTP

STUDY OF DESIGNED (DESIGNED CAPACITY 18,000M³/DAY)

Facility	Existing WTP		Design Criteria of Japanse Water Treatment Plant for Drinking Water
	Specification	Design Condition	
Mixing Basin	1.6mW×1.6mL×1.6mH×2 basins (Total volume 8.2m3) Mechanical mixer installed for each basin ※Mixers are not currently working.	Retention Time: $8.2m^3$÷$18,000m^3$/day×1440=0.65min ※Design condition for mixing is unknown.	Retension Time: 1〜5min G value※1: 100 1/sec or more
Flocculation Basin	4mW×4mL×3.5mH×4 basins /line×2 lines (Total volume $448m^3$) Mechanical flocculator installed for each basin ※Some of flocculators are not currenlty working.	Retention Time: $448m^3$÷$18,000m^3$/day×1440=35min ※Design condition for mixing is unknown.	Retension Time: 20〜40min G value: 10〜75 1/sec or more GT value※2: 23,000〜210,000(-)
Sedimentation Basin※4	11.6mL×6.4mW×3.5mH /line×2 lines (Total surface area 148 m^2, Total volume $519m^3$) Upflow type with inclined plate	Surface load: $18,000m^3$/day÷$461m^2$※3÷1440×1000=27mm/min Upflow velocity: $18,000m^3$/day ÷148 m^2÷1440×1000 = 84mm/min Retension Time: $519m^3$÷$18,000m^3$/day×24hr = 0.7hr (=41min)	In case of upflow typed sedimentation with inclined plate (In case only aluminum sulfate is applied) Surface load: 7〜14mm/min Upflow velocity: 80mm/min or less ※Distance between the bottom of tank and the bottom of inclined plate should be 1.5m or more.
Sand Filter Basin	2.4mW×3.0mL×2 ponds/basin×6 basins (Total surface area 86.4 m^2) 2 kind of sands (anthracite+sand) are applied.	Linear velocity: $18,000m^3$/day÷$86.4m^2$=208m/day	In case 2 kind of sands (anthracite + sand) are applied. Linear velocity: 240m/day or less

※1, ※2 G value and GT value means the indicator for degree of mixing.
※3 We assumed that inclined plate of 8mL×6.4mW×0.9mH/basin ×2 basins are installed.
※4 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000 mg/L
<Sludge generation per day>
$18,000m^3$/day×(100mg/L+5mg-Al203/L×1.53)÷10,000(g/m^3)=194m3-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
$519m^3$×1/3÷194m3-sludge/day = 0.9 days

3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(1) TOKOR WTP

CHARACTERISTICS OF DESIGNED

- The sedimentation basin is designed with relatively high surface load by installing inclined plate .
- Therefore surface area and volume of sedimentation basin are relatively small. (Designed RT= 0.7 hr)
- But sludge needs to be discharged from sedimentation basin at a short interval because volume of basin is small. In case turbidity of raw water is 100 NTU, sludge have to be discharged once a day at least.
- Because upflow typed inclined plate is installed at the right angle against the flow, the flow is completely blocked if sludge is accumulated on the bottom of sedimentation basin.

3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

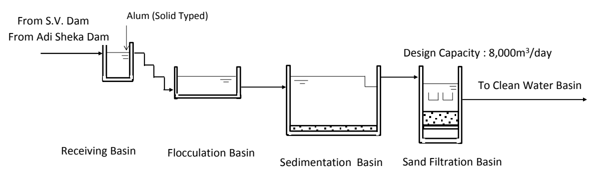
(1) TOKOR WTP

HORIZONTAL FLOW TYPED SEDIMENTATION BASIN WITH INCLINED PLATE

3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(2) S.V. WTP

SCHEMATIC FLOWSHEET OF S.V. WTP



3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(2) S.V. WTP

STUDY OF DESIGN (DESIGNED CAPACITY 8,000M³/DAY)

Facility	Existing WTP		Design Criteria of Japanse Water Treatment Plant for Drinking Water
	Specification	Design Condition	
Mixing Basin	None ※There are 4 receiving basins and 4 aeration basin (step typed)	-	Retention Time: 1～5min G value※1: 100 1/sec or more
Flocculation Basin	0.45mW×20mL×0.4mH×19channels/line×2 lines (Total volume 137 m^3) ※There are no baffle plates.	Retention Time: $137m^3$÷$8,000m^3$/day×1440=25min ※GT value is very low.(no agitation device)	Retention Time: 20～40min G value: 10～75 1/sec or more GT value※2: 23,000～210,000(-)
Sedimentation Basin ※3	<1st Sedimentation> 1st: 9.0mW×19.6mL×5mH 2nd: 9.0mW×19.6mL×5mH 3rd: 5.9mW×18.0mL×5mH 4th: 5.9mW×18.0mL×5mH 5th: 9.0mW×19.6mL×5mH (Total surface area 742m2, Total volume 3,706m3) <2nd Sedimentation> 4mW×7.5mW×2.9m×6basins	Surface load: $8,000m^3$/day÷$742m^2$÷1440×1000=7.5mm/min Retention Time: $3,706m^3$÷$8,000m^3$/day×24hr =11.1hr	In case of sedimentation without inclined plate (In case only aluminum sulfate is applied) Surface load: 15～30mm/min
Sand Filter Basin	2.2mW×2.5mL×2 ponds/basin×6 basins (Total surface area $66m^2$)	Linear velocity: $8,000m^3$/day÷$66m^2$=121m/day	In case 1 kind of sand is applied. Linear velocity: 120m/day or less

※1, ※2 G value and GT value means the indicator for degree of mixing.
※3 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000 mg/L
<Sludge generation per day >
$8,000m^3$/day×(100mg/L+5mg-Al2O3/L×1.53)÷10,000(g/m^3)=$86m^3$-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
$3,706m^3$×1/3÷$86m^3$-sludge/day = 14.4days

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3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(2) S.V. WTP

CHARACTERISTICS OF DESIGNED

- The sedimentation basin has relatively big volume. (Designed RT=11.1 hr, Designed SRT=14.4 days in case turbidity of raw water is 100 NTU)

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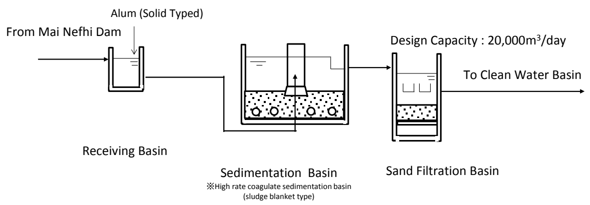
3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(3) MAI NEFHI WTP

SCHEMATIC FLOWSHEET OF MAI NEFHI WTP



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3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(3) MAI NEFHI WTP

STUDY OF DESIGN

Facility	Existing WTP		Design Criteria of Japanse Water Treatment Plant for Drinking Water
	Specification	Design Condition	
Mixing Basin	None ※Function of flocculation is included in sedimentation basin.	-	Retention Time: 1～5min G value※1: 100 1/sec or more
Flocculation Basin	None ※Function of flocculation is included in sedimentation basin.	-	Retention Time: 20～40min G value: 10～75 1/sec or more GT value※2: 23,000～210,000(-)
Sedimentation Basin ※1	High rate coagulate sedimentation basin (sludge blanket type) 13.6mW×12.4mL×3.8mH×2basins (Total surface area $337m^2$, Total volume $1282m^3$)	Surface load: $20,000m^3$/day÷$337m^2$÷1440×1000=41mm/min Retention Time: $1,282m^3$÷$20,000m^3$/day×24hr =1.5hr	In case of high rate coagulate sedimentation basin with sludge blanket type (In case only aluminum sulfate is applied) Surface load: 40～60mm/min
Sand Filter Basin	7.6mW×3.7mL×6 basins (Total surface area $168m^2$)	Linear velocity: $20,000m^3$/day÷$168m^2$=119m/day	In case 1 kind of sand is applied. Linear velocity: 120m/day or less

※2 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000 mg/L
<Sludge generation per day >
20,000m3/day×(100mg/L+5mg-Al_2O_3/L×1.53)÷10,000(g/m^3)=$215m^3$-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
$1,282m^3$×1/3÷$215m^3$-sludge/day = 2.0days

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3. STUDY THE DESIGN OF 3 WTP (TOKOR, S.V. MAI NEFHI) AND PROPOSE THE APPROPRIATE OPERATION

(3) MAI NEFHI WTP

CHARACTERISTICS OF DESIGNED

- (According to the manufacture's manual) sedimentation basin has 3 functions, that is, mixing with coagulant and flocculation in addition to sedimentation.
- (According to the manufacture's manual) turbidity can be removed in the sedimentation basin at high speed sedimentation (Surface load= 41mm/hr) by sludge blanket operation.

※Sludge blanket operation means the operation that turbidity in the inlet is separated at high speed by contacting with sludge accumulated in the bottom of basin.

Characteristics of sludge blanket operation is ;

- In case turbidity in raw water is high, accumulated sludge on the bottom of sedimentation tank often overflows from weir of effluent.
- In case turbidity in raw water is low, sludge is not accumulated on the bottom of sedimentation basin and turbidity in raw water often overflows from weir of effluent.
- Discharging rate of sludge has to be controlled so that some accumulated sludge can be kept on the bottom of sedimentation tank. Therefore skilled technique is required for discharging sludge.

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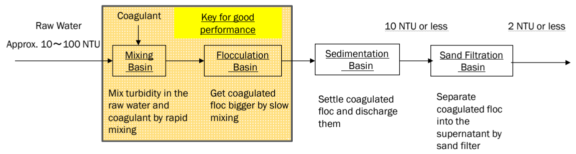
4. PROPOSAL OF DOSING ALUMINIUM SULPHATE (ALUM) IN TOKOR WTP USING EXISTING POWDERED ACTIVATED CARBON DOSING EQUIPMENT

WATER TREATMENT PROCESS WHICH DECEASES TURBIDITY FROM 10～100NTU TO DRINKING WATER LEVEL



REQUIRED ITEM FOR GOOD COAGULATION AND FLOCCULATION

- Rapid mixing (between turbidity and coagulant)
- Slow mixing (for flocculation)
- Add coagulant at appropriate dosing rate

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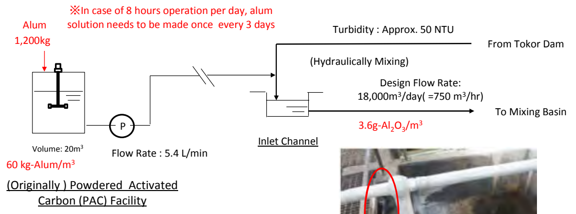
4. PROPOSAL OF DOSING ALUMINIUM SULPHATE (ALUM) IN TOKOR WTP USING EXISTING POWDERED ACTIVATED CARBON DOSING EQUIPMENT

PROPOSAL OF DOSING ALUMINUM SULFATE (ALUM) IN TOKOR WTP
USING EXISTING CHEMICAL FACILITY



Inlet Channel from Tokor Dam

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Appendix-7: Material for 3rd Interim Meeting

Asmara Water Supply Infrastructure (Data Collection and Management) Project

3RD INTERIM MEETING

AUGUST 2016

JICA EXPERT TEAM

COUNTERPART TEAM

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CONTENTS

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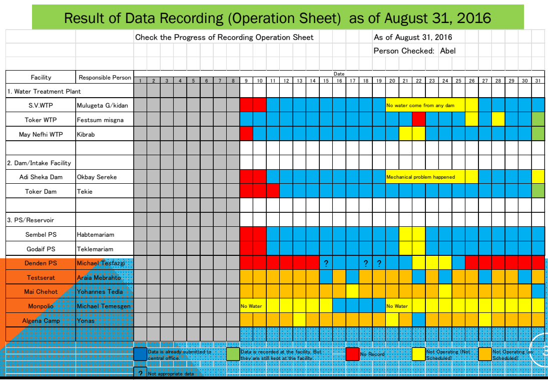
1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Data Recording (Operation Sheet) as of August 31, 2016



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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Water Level in Each Dam
(From Aug.11 to Aug.31)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Ave.	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	21	21	11.4	11.6	11.4	Max.=17.8m
Tokor Dam	21	19	17.6	17.8	17.3	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	21	18	17.1	17.8	16.2	Max.=35m

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Intake Volume from Each Dam
(From Aug.11 to Aug.31)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded							
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	21	13	1	7	6.9	10.4	3,461	500	12,007	Intake volume is estimvated by water meter. Not work due to mechanical problem of pump from Aug.20 to Aug.25 and electric power outage in Aug 31.
Tokor Dam	21	19	2	0	7.7	7.7	7,607	990	23,760	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimvated by opening time of intake valuve(hr) × rated flow rate against opening ratio of intake valuve(m^3/hr) Not operated due to the problem of electric facility in Sembel PS from Aug.21 to Aug.22
Total							17,803			

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Receiving Water Volume in Each WTP
(From Aug.11 to Aug.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	0	14	7	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Inlet volume is not recorded. Water is not received from Adi Sheka dam due to mechanical problem of pump in Adi Sheka dam from Aug.20 to Aug.25
Tokor WTP	Adisheka Dam	21	1	1	19	0.2	4.3	76	350	8,400	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Water is received from Adisheka dam from Aug.9 to Aug.10 and Aug.30. Water is received from Tokor dam from Aug.9 to Aug.30. But water is not received from Tokor dam in Aug.18 due to mechanical problem of pump in Tokor dam.
	Tokor Dam	21	18	2	1	6.9	7.3	6,225	900	21,600	
Mai Nefhi WTP	Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimvated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work due to electrical problem on Sembel PS from Aug.21 to Aug.22
Total								-			

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Water Production in Each WTP (From Aug.11 to Aug.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	14	0	7	5.5	8.2	1,643	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Aug.20 to Aug.25
Tokor WTP	Adi Sheka Dam/Tokor Dam	21	14	2	5	4.4	5.6	2,217	500	12,000	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water in Aug.18. Trasmission pump was stopped due to electric power outage in Aus.19, 20, 26 and 28 .
							(By Gravity)	2,479			
							(Total)	4,696			
Mai Nefhi WTP	Mai Nefhi Dam	21	8	11	2	14.2	17.8	5,037	354	8,499	Water production volume is estimated by water meter. Not work due to electrical problem on Sembel PS from Aug.21 to Aug.22
Total								11,376			

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Used Chemical in Each WTP (From Aug.11 to Aug.31)

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded										
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced
S.V WTP	21	7	7	7	21.4	5.4	128.6	17.9	2.5	0	0	0	0
Tokor WTP	21	18	2	1	284.2	43.3	1,038.6	60.5	8.5	24.9	3.8	91.2	5.3
Mai Nefhi WTP	21	18	1	2	420.0	33.5	804.3	95.3	13.3	31.6	2.1	50.5	6.3

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Water Distribution in Each Pump Station/Reservoir (From Aug.11 to Aug.31) -Tokor WTP Distribution Area-

Name of Pump Station/Reservoir		Result of Operation							Note.
		Number of Data Recorded					Averaged Flowrate per Day		
		Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
			Recorded	Not Recorded	Not Scheduled	as Scheduled			
		Days	Days	Days	Days	Days	m^3/day	m^3/day	
Denden PS	To Algene Camp	21	0	8	3	10	–	–	・Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr) ・Not work due to not receiving water from Tokor WTP from Aug.22 to Aug.24. ・There are no recorded data of the transmision volume for Algena Camp because the operator does not master how to record the operation yet.
	To Denden Camp	21	3	5	3	10	306	1,633	
Mai Chehot PS		21	1	0	2	18	32	675	Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.30
Testserat Res.		21	6	4	0	11	20	56	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Monopolio Res.		21	3	0	18	0	15	103	Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.15 and Aug. 20 to Aug. 31.
Algena Camp		21	1	0	3	17	7	145	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Denden PS. From Aug.11 to August 21 and from Aug.23 to Aug.31

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Result of Water Distribution in Each Pump Station/Reservoir (From Aug.11 to Aug.31) -Mai Nefhi WTP Distribution Area-

Name of Pump Station/Reservoir	Number of Data Recorded					Averaged Flowrate per Day		Note.
	Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
		Recorded	Not Recorded	Not Scheduled	as Scheduled			
	Days	Days	Days	Days	Days	m^3/day	m^3/day	
Sembel PS	21	17	2	2	0	2,860	3,197	Water production volume is estimated by water meter Not work due to electric facility problem from Aug.21 to Aug.22
Godaif PS	21	19	0	2	0	1,294	1,430	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water by electric facility problem in Sembel PS from Aug.21 to Aug.22

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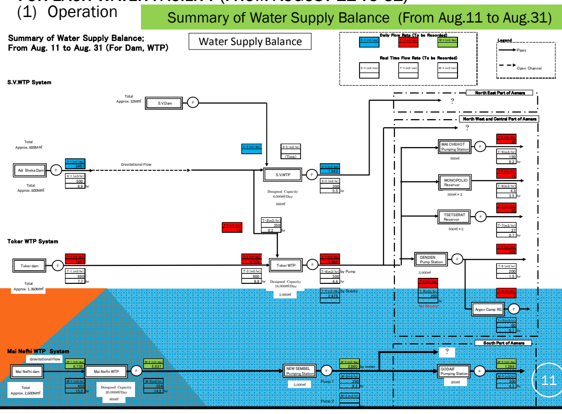
1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

Summary of Water Supply Balance (From Aug.11 to Aug.31)



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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

As an Example of Utilizing the Operation Data -Comparison between Capacity of Existing Facility and Current Operation-

1. Intake Facility and WTP

Facility	Capacity of Existing Facility	Result of Flow Rate	Reason of Difference between Capacity and Result
1.Intake Facility			
Adi Sheka	500m^3/hr × 10hr※2 × 1pump = 5,000m^3/day	500m^3/hr × Approx.7hr × 1pump = 3,500m^3/day	・Malfunction of intake Pump ・Not working due to electrical power cut not intentionally conducted
Tokor	Engine Pump 990m^3/hr × 20hr × 1pump =Approx. 20,000m^3/day	990m^3/hr × Approx.8hr × 1pump = Approx.7,900m^3/day	(・Operated in accrodance with the opration of Tokor WTP)
Mai Nefhi	※Intake water can be taken by gravity. (In case the recovery rate of WTP is 80%, designed intake volume is equivalent to 25,000m^3/day)	450m^3/hr × Approx. 15hr = 6,800m^3/day	(・Operated in accrodance with the opration of Mai Nefhi WTP)
Total	Approx. 50,000 m^3/day	Approx.18,000 m^3/day	
2.WTP			
S.V.	333m^3/hr(=8,000m^3/day) × 8hr※2=2,664 m^3/day	300m^3/hr(=8,000m^3/day) × Approx.5.5hr=1,600 m^3/day	・Due to the stoppage of intake pump in Adi Sheka
Tokor	750m^3/hr(=18,000m^3/day) × 8hr※2=6,000 m^3/day	500m^3/hr × Approx.4.4hr=Approx. 2,200m^3/day (By Pump) 200m^3/hr × Approx.12.5hr=Approx.2,500m^3/day (By Gravity) Total Approx.4,700m^3/day	・Due to the stoppage of transmission pump by electric power cut not intentionally conducted.
Mai Nefhi	833m^3/hr(=20,000m3/day) × 24hr※2=20,000 m^3/day	350m^3/hr × Approx.14hr= Approx.4,900m^3/day	・Flow rate could not be increased because coagulation could not be conducted appropriately and suludge blanket opration could not be conducted. ・Due to the stoppage of Sembel PS by electric facility problem of Sembel PS.
Total	28,664 m^3/day	Approx. 11,000 m^3/day	

※1 Design capacity excludes the loss of flow rate due to the stoppage by electrical power cut intentionally conducded by electric power company

※2 Designed operation time means the time operated only with commercial electric power supply.

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(1) Operation

As an Example of Utilizing the Operation Data
-Comparison between Capacity of Existing Facility and Current Operation-

2. Water Distribution Facility

1. Tokor WTP Distribution Area

Name of Pump Station/Reservoir		Original Operational Methods and Capacity of Water Transmission: Operational Methods	Original Operational Methods and Capacity of Water Transmission: Water Transmission Volume	Water Transmission Volume (Operational Result)	Reason of Difference between the Original Plan and Result
Denden PS	To Algene Camp	・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to Algene camp for 3 days and to Denden camp for 3 days for 1 week.	Approx. 200m³/hr × Approx.3.6hr × 3day/1week × 1pump=Approx.310m³/day (Ave.)	(No Recorded Data in Current)	
	To Denden Camp		Approx.200m³/hr × Approx.3.6hr × 3day/1week × 1pump=Approx.310m³/day (Ave.)	Approx.200m³/hr × Approx.3.6hr × 3day/1week × 1pump=Approx.310m³/day (Ave.)	
Mai Chehot PS		・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to higher area for 1 day per 1 week.	Approx.150m³/hr × Approx.4.5hr × 1day/week × 1pump=Approx.100m³/day (Ave.)	Approx.150m³/hr × Approx.4.5hr × 1day/3weeks × 1pump=Approx.30m³/day (Ave.)	Shortage of water transported from Tokor WTP
Testserat Res.		・Receiving water from Tokor WTP approxymate once every 3 months ・Transporting water to higher area for 2～3 days per 1 week.	Approx.30m³/hr × Approx.1.6hr × 3day/1week × 1pump=Approx.20m³/day (Ave.)	Approx.30m³/hr × Approx.1.6hr × 3day/1week × 1pump=Approx.20m³/day (Ave.)	
Monopolio Res.		・Receiving water from Tokor WTP approxymate 3 days every 2 weeks. ・Transporting water to lower area by gravity everyday.	Approx.4.3m³/hr × 24hr × 7day/1week=100m³/day (Ave.)	Approx.4.3m³/hr × 24hr × 1day/1week=15m³/day (Ave.)	Shortage of water transported from Tokor WTP A lot of water is leaked.(According to the informaiton from the operator)
Algena Camp		・Receiving water from Denden PS for 3 days per 1 week. ・Transporting water to the residence in the camp once a week.	Approx.60m³/hr × 2.5hr × 3day/1week=Approx.60m³/day (Ave.)	Approx.60m³/hr × 2.5hr × 1day/3week=Approx.7m³/day (Ave.)	Shortage of water transported from Tokor WTP

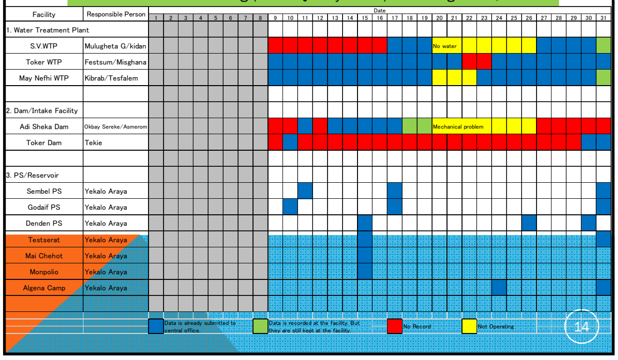
2. Mai Nefhi WTP Distrirbution Area

Name of Pump Station/Reservoir	Original Operational Methods and Capacity of Water Transmission: Operational Methods	Original Operational Methods and Capacity of Water Transmission: Water Transmission Volume	Water Transmission Volume(Result)	Reason between the Original Plan and Result
Sembel PS	・Receiving water from Mai Nefhi WTP for 24 hours everyday. ・Transporting water to the Godafi PS and the other area for 24 hours everyday .	Approx. 350m³/hr × Approx.24hr × 7day/1week × 2pumps=Approx.16,800m³/day (Ave.)	Approx.350m³/hr × Approx.8hr × 7day/1week × 1pump=Approx.2800m³/day (Ave.)	Shortage of water trasported from Mai Nefhi WTP Operational stoppage of Sembel PS due to malfunction of electric facility in Sembel PS
Godaif PS	・Receiving water from Sember PS for 24 hours everyday. ・Transporting water to the Godaif area etc. for 24 hours everyday .	Approx.300m³/hr × Approx.24hr × 7day/1week × 1pump=Approx.7,200m³/day (Ave.)	Approx.300m³/hr × Approx.4.3hr × 7day/1week × 1pump=Approx.1,300m³/day (Ave.)	Shortage of water volum trasported from Sembel PS

1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Data Recording (Water Quality Sheet) as of August 31, 2016



1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-Dam- (From Aug.11 to Aug.31)

Adisheka Dam

Date		11-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	No. of Data	Ave.	Max.	Min.
Time		10:00	8:00	6:30	9:00	10:00	11:30				
Weather		Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy				
Water Source		Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam				
Person Checked		Asmerom	Okbay	Okbay	Okbay	Okbay	Okbay				
Parameter	Unit										
Temperature	℃	18.7	18.1	18.2	18.6	18.5	18.1	6	18.4	18.7	18.1
pH	–	8.0	8.0	8.0	7.9	8.0	8.0	6	8.0	8.0	7.9
Electrical Conducitivity	uS/cm	255	371	374	370	365	365	6	350	374	255
Turbidity	NTU	36.1	36.1	36.1	36.2	36.2	36.0	6	36.1	36.2	36.0
Color	–	No	No	No	No	No	No	6	–	–	–
Smell	–	No	No	No	No	No	No	6	–	–	–

Tokor Dam

Date		10-Aug	30-Aug	31-Aug				No. of Data	Ave.	Max.	Min.
Time		10:33	20:00	20:00							
Weather		Rainy	Cloudy	Cloudy							
Water Source		Tokor Dam	Tokor Dam	Tokor Dam							
Person Checked		Tekie	Tekie	Tekie							
Parameter	Unit										
Temperature	℃	17.3	19.7	18.9				3	18.6	19.7	17.3
pH	–	7.5	4.5	4.4				3	5.5	7.5	4.4
Electrical Conducitivity	uS/cm	204	202	195				3	200	204	195
Turbidity	NTU	127.0	34.3	32.2				3	64.5	127.0	32.2
Color	–	No	No	No				3	–	–	–
Smell	–	No	No	No				3	–	–	–

1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-WTP- (From Aug.11 to Aug.31)

1. S.V WTP

Date			17-Aug	18-Aug	19-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			15:16	16:30	20:00	11:30	10:45	18:00	7:00					
Weather			Cloudy	Rainy	Cloudy	Sunny	Sunny	Cloudy	Sunny					
Water Source			Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam					
Person Checked			Yikaalo	Mulugheta	Mulugheta	Mulugheta	Mulugheta	Abraham	Mulugata					
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	24.6	19.2	22.4	18.5	18.9	18.6	19.8		7	20.3	24.6	18.5
	pH	–	8.46	6.32	8.24		8.34		8.42		5	8.0	8.5	6.3
	Electrical Conducitivity	uS/cm	243	225	248		247	270	244		6	246	270	225
	Turbidity	NTU	78.2	71.5	74.6	64.2	42.7	28.9	41.4		7	57.4	78.2	28.9
	Color	–	No	No	No	No	No	No	No		7	–	–	–
	Smell	–	No	No	No	No	No	No	No		7	–	–	–
Treated Water	Temperature	℃	21.1	22.2	19.8	19.7	19.1	20.1	20.1		7	20.3	22.2	19.1
	pH	–	7.99	7.08	6.68	7.81	8.10	8.15	8.15		7	7.7	8.2	6.7
	Electrical Conducitivity	uS/cm	249	219	240	187	231	237	234		7	228	249	187
	Turbidity	NTU	19.4	20.2	28.6	11.7	19.5	15.2	16.6	5 NTU or less	7	18.7	28.6	11.7
	Color	–	No	No	No	No		No	No		6	–	–	–
	Smell	–	No	No	No	No	No	No	No		7	–	–	–
	Residual Chlorine (Free)	mg/L	–	–	–	–	–	–	–	(0.1mg/L or more)	0	#DIV/0!	0.0	0.0
	Residual Chlorine (Total)	mg/L	–	–	–	–	–	–	–		0	#DIV/0!	0.0	0.0
	Bacteria	cells/ml				9	7				2	–	–	–
	Total Coliform	cells/ml				3	2			ND	2	–	–	–

1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-WTP- (From Aug.11 to Aug.31)

2. Tokor WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	20-Aug	21-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	30-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			8:00	8:00	11:20	8:00	9:00	8:00	8:30	9:30	8:00	8:30	8:30	8:15	8:45	9:00	10:00	9:30	9:00	9:00	9:00					
Weather			Cloudy/Sunny	Sunny	Sunny	Sunny	Sunny	Sunny/Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Adi Sheka Dam	Toker Dam	Toker Dam					
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana					
Measuring Point	Parameter	Unit																								
Raw Water	Temperature	℃	17.0	18.1	18.6	17.8	18.1	20.4	18.9	17.6	17.1	17.8	17.5	17.4	17.1	18.9	19.8	18.2	17.0	17.7	18.1		19	18.1	20.4	17.0
	pH	–	7.85	7.35	7.37	7.16	7.04	7.51	7.15	7.3	7.0	7.1	7.17	7.51	7.28	7.5	7.5	7.2	8.0	7.9	7.4		19	7.4	8.0	7.0
	Electrical Conducitivity	uS/cm	178	168	189	219	192	170	168	167	192	186	181	179	175	180	181	206	245	182	184		19	186	245	167
	Turbidity	NTU	90.7	98.3	87.7	142	85.5	12.6	122	97.6	>1000	>1000	73	76	48	67.9	74.4	54.8	62.6	29.9	50		19	>172	>1000	12.6
	Color	–	High	No	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	No	No	No	Brown	No	No		19	–	–	–
	Smell	–	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Grass	No	No		19	–	–	–
Treated Water	Temperature	℃	19.4	17.3	18.9	17.7	19.9	20.5	18.7	17.5	17.7	17.7	17.1	17.5	17.7	20.4	21.3	19.2	19.5		18.1		18	18.7	21.3	17.1
	pH	–	7.36	7.27	7.24	7.22	7.23	7.35	7.42	7.21	6.79	6.92	7.07	7.15	6.95	7.2	7.4	7.1	7.2		7.3		18	7.2	7.4	6.8
	Electrical Conducitivity	uS/cm	244	167	225	179	168	178	172	176	176	176	179	196	183	191	183	187	188		192		18	187	244	167
	Turbidity	NTU	17.3	86.3	39.8	77.2	74.9	73.9	65	62.4	76.0	85.1	76.3	57.5	42.4	37.5	33.8	37	33.3		29.4	5 NTU or less	18	55.8	86.3	17.3
	Color	–	No	High	No	Brown	Brown	No	No	No	No	No	No	No	No	No	No	No	No		No		18	–	–	–
	Smell	–	CHlorine Smell	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	chlorine		chlorine		18	–	–	–
	Residual Chlorine (Free)	mg/L	0.97	0.28	0.11	0.07	0.24	0.08	0.01	0.1	1.98	1.94	0.37	0.01	1.02	0.15	0.07	2.15	0.58		0.43	(0.1mg/L or more)	18	0.6	2.2	0.0
	Residual Chlorine (Total)	mg/L	1.39	1.19	0.53	0.12	0.32	0.21	0.18	0.18	0.07	0.03	0.55	0.03	1.06	0.28	0.19	2.2	0.82		0.83		18	0.6	2.2	0.0
	Bacteria	cells/ml	0	0	0	0	0		0				Detect	Detect	1	ND	ND	ND	ND				13	–	–	–
	Total Coliform	cells/ml	0	0	0	0	0		Detect				Detect	ND	3	ND	ND	ND	ND			ND	13	–	–	–

1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-WTP- (From Aug.11 to Aug.31)

3. Mai Nefhi WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			20:00	18:00	18:00	18:00	18:00	15:30	18:00	18:00	18:00	18:00	18:00	18:00	7:00	18:00	14:00	18:00	18:00					
Weather				Sunny		Sunny	Sunny	Sunny	Sunny	Sunny	Rain	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam					
Person Checked			Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfaalem	Tesfaalem	Tedros	Tesfaalem	Tesfaalem					
Measuring Point	Parameter	Unit																						
Raw Water	Temperature	℃													20.5	23.5	22.7	20.1	21.2		5	21.6	23.5	20.1
	pH	–	7.29	7.68	5.24	8.11	7.81	6.95	6.91	5.72	4.31	6.53	7.01	7.32	4.26	7.57	7.01	7.83	7.89		17	6.8	8.1	4.3
	Electrical Conducitivity	uS/cm	203	153	392	161	166	228	250	203	163	149	284	183	504	265	216	202	245		17	233	504	149
	Turbidity	NTU	524	354	361	245	272	369	286	>1000	>1000	530	109	104	148	90.1	80.6	807	101		17	>375	>1000	81
	Color	–	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Brown	Brown	Brown	Brown	Brown		17	–	–	–
	Smell	–	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		17	–	–	–
Treated Water	Temperature	℃													20.4	23.5	21.9	20.3	21.6		5	21.5	23.5	20.3
	pH	–	6.94	6.99	7.68	7.58	7.71	6.15	6.42	6.58	6.00	5.71	6.89	6.98	6.13	6.61	6.93	7.46	6.65		17	6.8	7.7	5.7
	Electrical Conducitivity	uS/cm	166	161	159	178	168	199	183	162	150	187	177	178	213	209	211	208	210		17	183	213	150
	Turbidity	NTU	268	448	309	101	230	49.8	133	677	>1000	67.4	86.1	86.5	40.2	49.1	56.4	81.7	66.5	5 NTU or less	17	>221	>1000	40
	Color	–	Yellow	Yellow	Yellow	Yellow	Yellow	No	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Brown	Brown	Brown	Brown	Brown		17	–	–	–
	Smell	–	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		17	–	–	–
	Residual Chlorine (Free)	mg/L	6.4	7.0	0	0	0	8.3	5.3	1.0	0	0.9	0	0	0.0	0.0	6.8	0.0	0.0	(0.1mg/L or more)	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	5.0	0	0	0	0	8.8	2.6	1.0	0	1.1	0	0	3.0	0.0	0.0	7.0	0.0		17	1.7	8.8	0.0
	Bacteria	cells/ml	0	5					ND	ND	6	ND						10			7	–	–	–
	Total Coliform	cells/ml	0	2					ND	ND	4	ND						0		ND	7	–	–	–

1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-Pump Station and Reservoir- (From Aug.11 to Aug.31)

1. Sembel PS and Godaif PS

Sembel PS

Date		11-Aug	17-Aug	31-Aug		WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		15:25	9:13	9:30						
Weather		Rainy	Sunny	Sunny						
Coming From		Mai Nefhi WTP	Mai Nefhi WTP	Mai Nefhi WTP						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.4	20	22.3			3	20.6	22.3	19.4
pH	–	7.68	6.95	6.79			3	7.1	7.7	6.8
Electrical Conducitivity	uS/cm	367	201	110			3	226	367	110
Turbidity	NTU	144	163	43.3		5NTU or less	3	117	163	43
Color	–	No	No	No			3	–	–	–
Smell	–	No	No	No			3	–	–	–

Godaif PS

Date		10-Aug	17-Aug	31-Aug		WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		16:28	9:50	10:00						
Weather		Rainy	Cloudy	Sunny						
Coming From		Sembep PS	Sembel PS	Sembel PS						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.3	22	23.6			3	21.6	23.6	19.3
pH	–	8.4	7.1	7.19			3	7.6	8.4	7.1
Electrical Conducitivity	uS/cm	326	192	233			3	250	326	192
Turbidity	NTU	66.2	185	50.4		5NTU or less	3	101	185	50
Color	–	No	No	No			3	–	–	–
Smell	–	No	No	No			3	–	–	–

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-Pump Station and Reservoir- (From Aug.11 to Aug.31)

2. Denden PS and Testserat RS

Denden PS

Date		15-Aug	26-Aug	30-Aug		WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		9:17	9:30	2:40						
Weather		Sunny	Sunny	Sunny						
Coming From		Tokor WTP	Tokor WTP	Tokor WTP						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.5	19.9	24.1			3	21.2	24.1	19.5
pH	–	7.96	7.06	6.87			3	7.3	8.0	6.9
Electrical Conducitivity	uS/cm	278	251	259			3	263	278	251
Turbidity	NTU	46.6	19.5	17.1			3	28	47	17
Color	–	No	No	No			3	–	–	–
Smell	–	No	No	No			3	–	–	–

Testserat RS

Date		15-Aug	31-Aug			WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		10:31	9:00							
Weather		Sunny	Sunny							
Coming From		Tokor WTP	Tokor WTP							
Person Checked		Yikaalo	Yikaalo							
Parameter	Unit									
Temperature	℃	19.7	19.8				2	19.8	19.8	19.7
pH	–	8.04	7.13				2	7.6	8.0	7.1
Electrical Conducitivity	uS/cm	344	283				2	314	344	283
Turbidity	NTU	0.99	0.94			5NTU or less	2	1	1	1
Color	–	No	No				2	–	–	–
Smell	–	No	No				2	–	–	–

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1. SUMMARY OF THE RESULT REGARDING OPERATION AND WATER QUALITY FOR EACH WATER FACILITY (FROM AUGUST 11 TO 31)

(2) Water Quality

Result of Water Quality
-Pump Station and Reservoir- (From Aug.11 to Aug.31)

3. Mai Chehot PS and Monopolio RS

Mai Chehot RS

Date		15-Aug				WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		10:45								
Weather		Sunny								
Coming From		Tokor WTP								
Person Checked		Yikaalo								
Parameter	Unit									
Temperature	℃	19.9					1	19.9	19.9	19.9
pH	–	8.09					1	8.1	8.1	8.1
Electrical Conducitivity	uS/cm	284					1	284	284	284
Turbidity	NTU	3				5NTU or less	1	3	3	3
Color	–	No					1	–	–	–
Smell	–	No					1	–	–	–

Monopolio RS

Date		15-Aug				WHO Guideline volume	No. of Data	Ave.	Max.	Min.
Time		16:00								
Weather		Sunny								
Coming From		Tokor WTP								
Person Checked		Yikaalo								
Parameter	Unit									
Temperature	℃	20					1	20.0	20.0	20.0
pH	–	8.35					1	8.4	8.4	8.4
Electrical Conducitivity	uS/cm	181					1	181	181	181
Turbidity	NTU	66.6				5NTU or less	1	67	67	67
Color	–	No					1	–	–	–
Smell	–	No					1	–	–	–

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2. CONFIRMATION OF DAILY AND MONTHLY OUTPUT REGARDING THE ACTIVITY OF RECORDING , COLLECTING AND SUMMARIZING THE OPERATION AND WATER QUALITY DATA

(1) Operation

1) Daily Output

	Name of Data Sheet	Purpose of Sheet	Number of Data Sheet Prepared
1	Operation data sheet	• Grasp daily operational condition of each facility	Total 12 sheets <Dam> Adi Sheka, Tokor <WTP> S.V., Tokor, Mai Nefhi <PS and RS> Sembel PS, Godaif PS, Denden PS, Testserat RS, Mai Chehot PS, Monopolio RS, Algena Camp RS
2	Daily Water Balance and Performance Data Sheet	Grasp daily water balance and performance of each WTP.	Total 3 sheets <WTP> S.V., Tokor, Mai Nefhi
3	Water Supply Balance Sheet	Grasp daily overall water supply balance from Dam to distribution	Total 1 sheet

2. CONFIRMATION OF DAILY AND MONTHLY OUTPUT REGARDING THE ACTIVITY OF RECORDING , COLLECTING AND SUMMARIZING THE OPERATION AND WATER QUALITY DATA

(1) Operation

2) Monthly Output

	Name of Data Sheet	Purpose of Sheet	Number of Data Sheet Prepared
1	Summary of Operation data	• Grasp averaged flow rate etc. each facility on the monthly basis	Total 3 sheets ・Monthly summary sheet for Adi Sheka, Tokor Dam ・Monthly summary sheet for S.V., Tokor, Mai Nefhi WTP ・Monthly summary sheet for the following PS and RS; Sembel PS, Godaif PS, Denden PS, Testserat RS, Mai Chehot PS, Monopolio RS, Algena Camp RS
2	Monthly Water Supply Balance Sheet	Grasp monthly overall water supply balance from Dam to distribution	Total 1 sheet

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2. CONFIRMATION OF DAILY AND MONTHLY OUTPUT REGARDING THE ACTIVITY OF RECORDING , COLLECTING AND SUMMARIZING THE OPERATION AND WATER QUALITY DATA

(2) Water Quality

1) Daily Output

	Name of Data Sheet	Purpose of Sheet	Number of Data Sheet Prepared
1	Water Quality Data sheet	• Grasp daily water quality condition of each facility	Total 12 sheets <Dam> Adi Sheka, Tokor <WTP> S.V., Tokor, Mai Nefhi <PS and RS> Sembel PS, Godaif PS, Denden PS, Testserat RS, Mai Chehot PS, Monopolio RS, Algena Camp RS

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2. CONFIRMATION OF DAILY AND MONTHLY OUTPUT REGARDING THE ACTIVITY OF RECORDING , COLLECTING AND SUMMARIZING THE OPERATION AND WATER QUALITY DATA

(2) Water Quality

2) Monthly Output

	Name of Data Sheet	Purpose of Sheet	Number of Data Sheet Prepared
1	Summary of water quality data	• Grasp averaged flow rate etc. each facility on the monthly basis	Total 3 sheets ・Monthly summary sheet for Adi Sheka, Tokor Dam ・Monthly summary sheet for S.V., Tokor, Mai Nefhi WTP ・Monthly summary sheet for the following PS and RS; Sembel PS, Godaif PS, Denden PS, Testserat RS, Mai Chehot PS, Monopolio RS, Algena Camp RS

2. CONFIRMATION OF DAILY AND MONTHLY OUTPUT REGARDING THE ACTIVITY OF RECORDING , COLLECTING AND SUMMARIZING THE OPERATION AND WATER QUALITY DATA

(3) Message for Mr.Abel (Chief Coordinator of Recording Operation Data)and Mr.Yikaloo (Chief Coordinator of Recording Water Quality Data)

- Most important procedure is to exactly record the real data in the paper and to put them in the excel file among this task.
- Once you receive the daily operation and water quality data from each person of each facility, put the data in the excel sheet immediately.
- The received data is comparing with the previous data and find the incomprehensible and/or the abnormal data etc. in the data.
- If you find the incomprehensible and/or the abnormal data etc., you should contact the person of each facility and clarify them immediately.

We hope that you keep recording operational data and water quality data and you utilize them effectively.

Appendix-8: Material for Ending Meeting (Phase-1)

Asmara Water Supply Infrastructure (Data Collection and Management) Project

ENDING MEETING

RESULTS OF PROJECT

SEPTEMBER 2016
JICA EXPERT TEAM
COUNTERPART TEAM

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CONTENTS

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1. ACTIVITIES DONE

1. Training for water quality analysis (equipment usage)
2. Training for water flow rate verification (ultrasonic water flowmeter usage)
3. Training for simple topographic survey for pipeline (equipment usage)
4. Daily data recording at key stations (for water flow and quality) as well as recording forms
5. Preparation of data summary for water flow and quality
6. Check and list of the existing drawings
7. Estimation of water demand and comparison with water flow
8. Confirmation of water treatment process and improvement trial

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2. WATER FLOW RECORD SUMMARY

(1) Water level of Dam

Result of Water Level in Each Dam
(From Aug.11 to Aug.31)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Ave.	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	21	21	11.4	11.6	11.4	Max.=17.8m
Tokor Dam	21	19	17.6	17.8	17.3	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	21	18	17.1	17.8	16.2	Max.=35m

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(2) Water Intake at Dams

Result of Intake Volume from Each Dam
(From Aug.11 to Aug.31)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded							
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	21	13	1	7	6.9	10.4	3,461	500	12,007	Intake volume is estimvated by water meter. Not work due to mechanical problem of pump from Aug.20 to Aug.25 and electric power outage in Aug 31.
Tokor Dam	21	19	2	0	7.7	7.7	7,607	990	23,760	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimvated by opening time of intake valuve(hr) × rated flow rate against opening ratio of intake valuve(m^3/hr) Not operated due to the problem of electric facility in Sembel PS from Aug.21 to Aug.22
Total							17,803			

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(3) Water Receiving at WTPs

Result of Receiving Water Volume in Each WTP
(From Aug.11 to Aug.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	0	14	7	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Inlet volume is not recorded. Water is not received from Adi Sheka dam due to mechanical problem of pump in Adi Sheka dam from Aug.20 to Aug.25
Tokor WTP	Adisheka Dam	21	1	1	19	0.2	4.3	76	350	8,400	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Water is received from Adisheka dam from Aug.9 to Aug.10 and Aug.30. Water is received from Tokor dam from Aug.9 to Aug.30. But water is not received from Tokor dam in Aug.18 due to mechanical problem of pump in Tokor dam.
	Tokor Dam	21	18	2	1	6.9	7.3	6,225	900	21,600	
Mai Nefhi WTP	Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimvated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work due to electrical problem on Sembel PS from Aug.21 to Aug.22
Total								–			

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(4) Water Production at WTPs

Result of Water Production in Each WTP (From Aug.11 to Aug.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	14	0	7	5.5	8.2	1,643	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Aug.20 to Aug.25
Tokor WTP	Adi Sheka Dam/Tokor Dam	21	14	2	5	4.4	5.6	2,217	500	12,000	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water in Aug.18. Trasmission pump was stopped due to electric power outage in Aus.19, 20, 26 and 28 .
							(By Gravity)	2,479			
							(Total)	4,696			
Mai Nefhi WTP	Mai Nefhi Dam	21	8	11	2	14.2	17.8	5,037	354	8,499	Water production volume is estimated by water meter. Not work due to electrical problem on Sembel PS from Aug.21 to Aug.22
Total								11,376			

(5) Water Distribution of Service Reservoirs (Toker System)

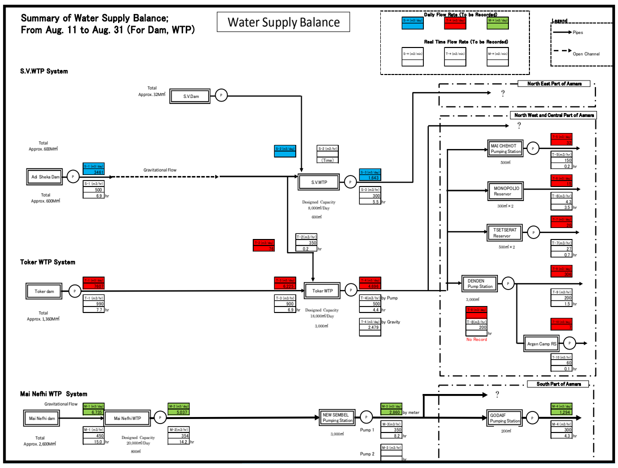
Result of Water Distribution in Each Pump Station/Reservoir (From Aug.11 to Aug.31) -Tokor WTP Distribution Area-

Name of Pump Station/Reservoir		Result of Operation							Note.
		Number of Data Recorded					Averaged Flowrate per Day		
		Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
			Recorded	Not Recorded	Not Scheduled	as Scheduled			
		Days	Days	Days	Days	Days	m^3/day	m^3/day	
Denden PS	To Algene Camp	21	0	8	3	10	–	–	･Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr) ･Not work due to not receiving water from Tokor WTP from Aug.22 to Aug.24. ･There are no recorded data of the transmision volume for Algena Camp because the operator does not master how to record the operation yet.
	To Denden Camp	21	3	5	3	10	306	1,633	
Mai Chehot PS		21	1	0	2	18	32	675	Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.30
Testserat Res.		21	6	4	0	11	20	56	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Monopolio Res.		21	3	0	18	0	15	103	Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.15 and Aug. 20 to Aug. 31.
Algena Camp		21	1	0	3	17	7	145	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water from Denden PS. From Aug.11 to August 21 and from Aug.23 to Aug.31

(6) Water Distribution of Service Reservoirs (Mai Nefhi System)

Result of Water Distribution in Each Pump Station/Reservoir (From Aug.11 to Aug.31) -Mai Nefhi WTP Distribution Area-

Name of Pump Station/Reservoir	Number of Data Recorded					Averaged Flowrate per Day		Note.
	Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
		Recorded	Not Recorded	Not Scheduled	as Scheduled			
	Days	Days	Days	Days	Days	m^3/day	m^3/day	
Sembel PS	21	17	2	2	0	2,860	3,197	Water production volume is estimated by water meter Not work due to electric facility problem from Aug.21 to Aug.22
Godaif PS	21	19	0	2	0	1,294	1,430	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work due to not receiving water by electric facility problem in Sembel PS from Aug.21 to Aug.22



(7) Findings and Issues for Water Flow

① Incorrectness of recorded data ⇒ Difficult for summarizing works ⇒ More trainings of site members and more management of HQ members

② Large gap between inlet and outlet flows of Toker WTP ⇒ Incorrectness of flow rate assumption, especially Toker WTP outlet (difficult to estimate due to several operation modes) ⇒ More verification works for flow rate ⇒ More precise record for operation condition (especially discharging modes and in-taken water storage at regulation pond)

③ Large gap between production of Mai Nefhi WTP and output of New Sembel Pump Station ⇒ Flow verification of branch lines to villages

④ To add data of water station (truck station) to make the summary sheet more practical.

3. VERIFICATION OF WATER FLOW RATE

Target

- To get actual water volume
- To decide the flow rate in each site for daily operation record
- To compare with other parameter (pump specification)

SITUATION MEASURING SITE

	Short time measurement	24 hours measurement
Adi sheka dam		✓
SV(vali neki) dam	✓	
S. V. WTP inflow (from adi sheka)		✓
S. V. WTP outflow	✓	
S. V. distribution	–	–
Tokor dam		✓
Tokor WTP inflow (fron Tokor dam)		
Tokor WTP inflow (fron Adi sheka dam)		✓
Tokor WTP outflow		✓
Tokor distribution (mai temanay)	✓	
Tokor distribution (near Truck hydrant)	✓	
Denden outflow	–	–
Mai chehot outflow	–	–
Monopolio outflow	–	–
Tseterat outflow	–	–
Mai nefhi WTP inflow		✓
Mai nefhi WTP outflow		✓
Sembel inflow	✓	
Sembel outflow		✓
Sembel to distribution		✓
Godaif inflow	✓	
Godaif outflow	✓	

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24 hour metering summary

		Measuring date	Average flow rate during 24hours metering [m3/h]	Total water volume for 24 hours metering [m3]	Pump wokring hours	Pump specrification [m3/h]	Estimated Total water volume from pump wokring hours [m3]	Flow rate from meter [m3/h]	Total volume from meter [m3]
S.V. system	Adi sheka dam outflow	16-17th Aug	396.9961678	4575.380833	12:15 hr	450	5512.5		7397
	S.V. dam outflow								
	S.V. WTP inflow from Adi sheka dam		360	1250.492		450			
	S.V. WTP ouflow								
Tokor system	BORBORIELA (distribution)								
	Tokor dam outflow		789.5512273	6309.830225	8 hr	990	7920		
	Tokor inflow from Tokor dam								
	Tokor inflow from Adi sheka dam	3th-4th Aug	360	6472.701					6283.3
	Tokor W.T.P outflow(pump)	3th-4th Aug	537.38	4630.429	3:50 hr	450 m3 /h			2572.5
	Tokor distribution(Mai Temenay)		392.1467019	526.1301583					
	Tokor distribution(Truck hydrant) gravity		255.6044894	100.1117583					
	Tokor distribution(Truck hydrant)pump		427.4620222	160.2982583					
Mai Nefhi system	Mai Nefhi inflow	13th-14th Aug	339.837	3047.207	9:30 hr	by gravity			
	Mai Nefhi outflow	12th-13th Aug	286.284715	8134.093558	24 hr	500 m3/h	12000		7204.7
	Sembel pump station inflow		246.7802708	98.71210833	0:36hr				
	Sembel pump station out flow	8th-9th Aug	588	3380.69	5:50 hr	500 m3/h	2900		
	Sembe(after branch to distributin area)	8th-9th Aug	204.243	1181.21	5 hr				
	Expo inflow		220.5902708	88.23610833	0:30 hr				
	Expo outflow (distribution)		171.8100331	216.1942917	1:15 hr	300 m3/h	375		

OUR OBSERVATION

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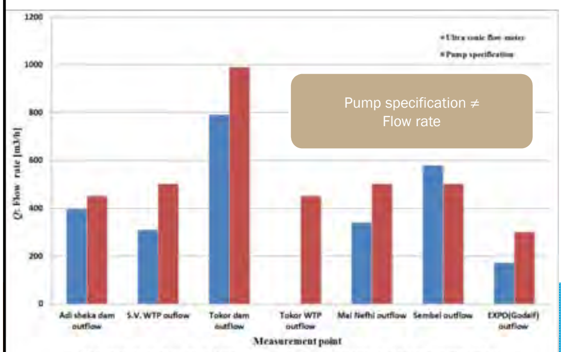
VERIFICATION OF RESULT FOR PUMP OUTPUT



The relation on flow rate between ultra sonic flow meter and pump specification

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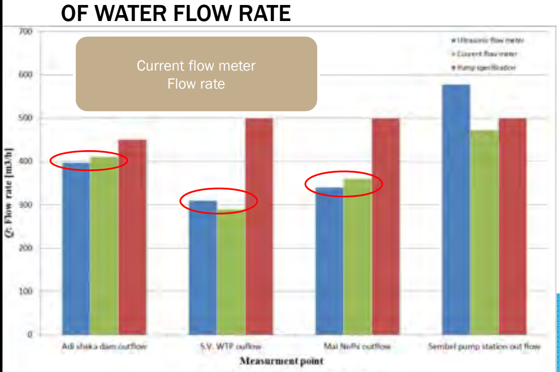
VERIFICATION OF RESULT FOR EXISTING MEANS OF WATER FLOW RATE



The relation among flow meter

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THE RESULT COMPARED TO FLOW RATE USED IN DAILY OPERATION RECORD

The relation of Ultrasonic flow meter and daily operation record

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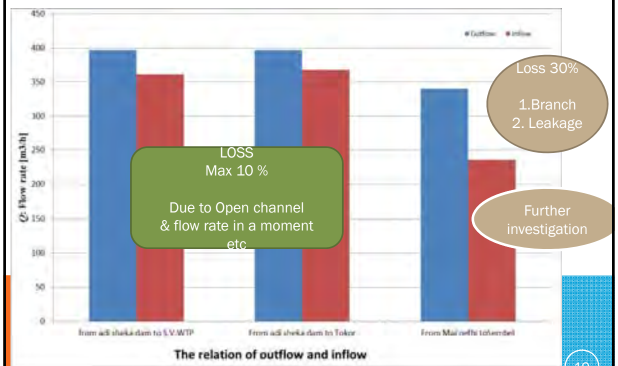
THE WATER VOLUME FROM OUTFLOW TO INFLOW



The relation of outflow and inflow

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NEXT PLAN TILL NOVEMVER

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MONTHLY FLOW RATE MONITORING (9 -11)

To measure flow rate in major point every month

Target
To assure the water flow volume
To improve the accuracy of the obtained data
To catch the trend monthly
To grasp any abnormality

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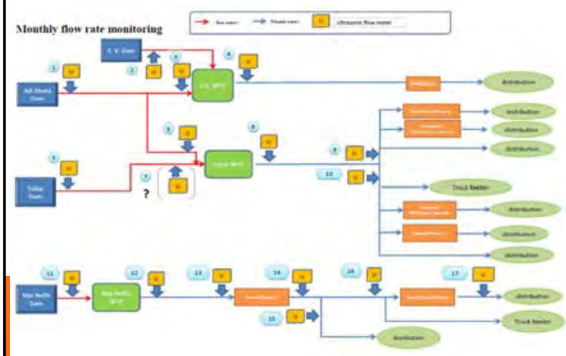
MEASURED SITE FOR MONTHLY FLOW RATE MONIRING



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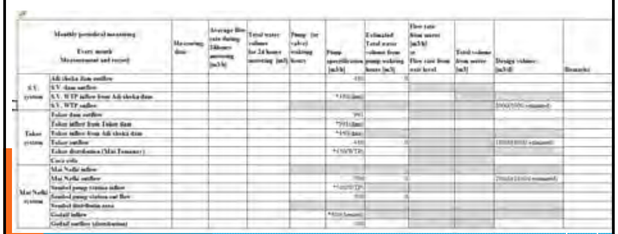
OUTPUT

◆Summery sheet (below sheet)
◆Graph
◆Report for analysis



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4. WATER QUALITY RECORD SUMMARY

(1) Water Quality at Dams

Result of Water Quality
-Dam- (From Aug.11 to Aug.31)

Adisheka Dam

Date		11-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	No. of Data	Ave.	Max.	Min.
Time		10:00	8:00	6:30	9:00	10:00	11:30				
Weather		Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy				
Water Source		Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam				
Person Checked		Asmerom	Okbay	Okbay	Okbay	Okbay	Okbay				
Parameter	Unit										
Temperature	℃	18.7	18.1	18.2	18.6	18.5	18.1	6	18.4	18.7	18.1
pH	–	8.0	8.0	8.0	7.9	8.0	8.0	6	8.0	8.0	7.9
Electrical Conducitivity	uS/cm	255	371	374	370	365	365	6	350	374	255
Turbidity	NTU	36.1	36.1	36.1	36.2	36.2	36.0	6	36.1	36.2	36.0
Color	–	No	No	No	No	No	No	6	–	–	–
Smell	–	No	No	No	No	No	No	6	–	–	–

Tokor Dam

Date		10-Aug	30-Aug	31-Aug				No. of Data	Ave.	Max.	Min.
Time		10:33	20:00	20:00							
Weather		Rainy	Cloudy	Cloudy							
Water Source		Tokor Dam	Tokor Dam	Tokor Dam							
Person Checked		Tekie	Tekie	Tekie							
Parameter	Unit										
Temperature	℃	17.3	19.7	18.9				3	18.6	19.7	17.3
pH	–	7.5	4.5	4.4				3	5.5	7.5	4.4
Electrical Conducitivity	uS/cm	204	202	195				3	200	204	195
Turbidity	NTU	127.0	34.3	32.2				3	64.5	127.0	32.2
Color	–	No	No	No				3	–	–	–
Smell	–	No	No	No				3	–	–	–

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(2) Water Quality at WTPs

Result of Water Quality
-WTP- (From Aug.11 to Aug.31)

1. S.V WTP

Measuring Point	Parameter	Unit	17-Aug	18-Aug	19-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			15:16	16:30	20:00	11:30	10:45	18:00	7:00					
Weather			Cloudy	Rainy	Cloudy	Sunny	Sunny	Cloudy	Sunny					
Water Source			Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam					
Person Checked			Yikaalo	Mulugheta	Mulugheta	Mulugheta	Mulugheta	Abraham	Mulugata					
Raw Water	Temperature	℃	24.6	19.2	22.4	18.5	18.9	18.6	19.8		7	20.3	24.6	18.5
	pH	–	8.46	6.32	8.24		8.34		8.42		5	8.0	8.5	6.3
	Electrical Conducitivity	uS/cm	243	225	248		247	270	244		6	246	270	225
	Turbidity	NTU	78.2	71.5	74.6	64.2	42.7	28.9	41.4		7	57.4	78.2	28.9
	Color	–	No	No	No	No	No	No	No		7	–	–	–
	Smell	–	No	No	No	No	No	No	No		7	–	–	–
Treated Water	Temperature	℃	21.1	22.2	19.8	19.7	19.1	20.1	20.1		7	20.3	22.2	19.1
	pH	–	7.99	7.08	6.68	7.81	8.10	8.15	8.15		7	7.7	8.2	6.7
	Electrical Conducitivity	uS/cm	249	219	240	187	231	237	234		7	228	249	187
	Turbidity	NTU	19.4	20.2	28.6	11.7	19.5	15.2	16.6	5 NTU or less	7	18.7	28.6	11.7
	Color	–	No	No	No	No		No	No		6	–	–	–
	Smell	–	No	No	No	No	No	No	No		7	–	–	–
	Residual Chlorine (Free)	mg/L	–	–	–	–	–	–	–	(0.1mg/L or more)	0	#DIV/0!	0.0	0.0
	Residual Chlorine (Total)	mg/L	–	–	–	–	–	–	–		0	#DIV/0!	0.0	0.0
	Bacteria	cells/ml				9	7				2	–	–	–
	Total Coliform	cells/ml				3	2			ND	2	–	–	–

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2. Tokor WTP

Measuring Point	Parameter	Unit	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	20-Aug	21-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	30-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			8:00	8:00	11:20	8:00	9:00	8:00	8:30	9:30	8:00	8:30	8:30	8:15	8:45	9:00	10:00	9:30	9:00	9:00	9:00					
Weather			Cloudy/Sunny	Sunny	Sunny	Sunny	Sunny	Sunny/Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Adi Sheka Dam	Toker Dam	Toker Dam					
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana					
Raw Water	Temperature	℃	17.0	18.1	18.6	17.8	18.1	20.4	18.9	17.6	17.1	17.8	17.5	17.4	17.1	18.9	19.8	18.2	17.0	17.7	18.1		19	18.1	20.4	17.0
	pH	-	7.85	7.35	7.37	7.16	7.04	7.51	7.15	7.3	7.0	7.1	7.17	7.51	7.28	7.5	7.5	7.2	8.0	7.9	7.4		19	7.4	8.0	7.0
	Electrical Conducitivity	uS/cm	178	168	189	219	192	170	168	167	192	186	181	179	175	180	181	206	245	182	184		19	186	245	167
	Turbidity	NTU	90.7	98.3	87.7	142	85.5	12.6	122	97.6	>1000	>1000	73	76	48	67.9	74.4	54.8	62.6	29.9	50		19	>172	>1000	12.6
	Color	-	High	No	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	No	No	No	Brown	No	No		19	-	-	-
	Smell	-	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Grass	No	No		19	-	-	-
Treated Water	Temperature	℃	19.4	17.3	18.9	17.7	19.9	20.5	18.7	17.5	17.7	17.7	17.1	17.5	17.7	20.4	21.3	19.2	19.5		18.1		18	18.7	21.3	17.1
	pH	-	7.36	7.27	7.24	7.22	7.23	7.35	7.42	7.21	6.79	6.92	7.07	7.15	6.95	7.2	7.4	7.1	7.2		7.3		18	7.2	7.4	6.8
	Electrical Conducitivity	uS/cm	244	167	225	179	168	178	172	176	176	176	179	196	183	191	183	187	188		192		18	187	244	167
	Turbidity	NTU	17.3	86.3	39.8	77.2	74.9	73.9	65	62.4	76.0	85.1	76.3	57.5	42.4	37.5	33.8	37	33.3		29.4	5 NTU or less	18	55.8	86.3	17.3
	Color	-	No	High	No	Brown	Brown	No	No	No	No	No	No	No	No	No	No	No	No		No		18	-	-	-
	Smell	-	Chlorine Smell	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	chlorine		chlorine		18	-	-	-
	Residual Chlorine (Free)	mg/L	0.97	0.28	0.11	0.07	0.24	0.08	0.01	0.1	1.98	1.94	0.37	0.01	1.02	0.15	0.07	2.15	0.58		0.43	(0.1mg/L or more)	18	0.6	2.2	0.0
	Residual Chlorine (Total)	mg/L	1.39	1.19	0.53	0.12	0.32	0.21	0.18	0.18	0.07	0.03	0.55	0.03	1.06	0.28	0.19	2.2	0.82		0.83		18	0.6	2.2	0.0
	Bacteria	cells/ml	0	0	0	0	0		0				Detect	Detect	1	ND	ND	ND	ND				13	-	-	-
	Total Coliform	cells/ml	0	0	0	0	0		Detect				Detect	ND	3	ND	ND	ND	ND			ND	13	-	-	-

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3. Mai Nefhi WTP

Measuring Point	Parameter	Unit	11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	23-Aug	24-Aug	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			20:00	18:00	18:00	18:00	18:00	15:30	18:00	18:00	18:00	18:00	18:00	18:00	7:00	18:00	14:00	18:00	18:00					
Weather				Sunny		Sunny	Sunny	Sunny	Sunny	Sunny	Rain	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam					
Person Checked			Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfaalem	Tesfaalem	Tedros	Tesfaalem	Tesfaalem					
Raw Water	Temperature	℃													20.5	23.5	22.7	20.1	21.2		5	21.6	23.5	20.1
	pH	-	7.29	7.68	5.24	8.11	7.81	6.95	6.91	5.72	4.31	6.53	7.01	7.32	4.26	7.57	7.01	7.83	7.89		17	6.8	8.1	4.3
	Electrical Conducitivity	uS/cm	203	153	392	161	166	228	250	203	163	149	284	183	504	265	216	202	245		17	233	504	149
	Turbidity	NTU	524	354	361	245	272	369	286	>1000	>1000	530	109	104	148	90.1	80.6	807	101		17	>375	>1000	81
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		17	-	-	-
Treated Water	Temperature	℃													20.4	23.5	21.9	20.3	21.6		5	21.5	23.5	20.3
	pH	-	6.94	6.99	7.68	7.58	7.71	6.15	6.42	6.58	6.00	5.71	6.89	6.98	6.13	6.61	6.93	7.46	6.65		17	6.8	7.7	5.7
	Electrical Conducitivity	uS/cm	166	161	159	178	168	199	183	162	150	187	177	178	213	209	211	208	210		17	183	213	150
	Turbidity	NTU	268	448	309	101	230	49.8	133	677	>1000	67.4	86.1	86.5	40.2	49.1	56.4	81.7	66.5	5 NTU or less	17	>221	>1000	40
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	No	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No		17	-	-	-
	Residual Chlorine (Free)	mg/L	6.4	7.0	0	0	0	8.3	5.3	1.0	0	0.9	0	0	0.0	0.0	6.8	0.0	0.0	(0.1mg/L or more)	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	5.0	0	0	0	0	8.8	2.6	1.0	0	1.1	0	0	3.0	0.0	0.0	7.0	0.0		17	1.7	8.8	0.0
	Bacteria	cells/ml	0	5					ND	ND	6	ND						10			7	-	-	-
	Total Coliform	cells/ml	0	2					ND	ND	4	ND						0		ND	7	-	-	-

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(3) Water Quality at Service Reservoirs

Result of Water Quality
-Pump Station and Reservoir- (From Aug.11 to Aug.31)

1. Sembel PS and Godaif PS

Sembel PS

Parameter	Unit	11-Aug	17-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		15:25	9:13	9:30					
Weather		Rainy	Sunny	Sunny					
Coming From		Mai Nefhi WTP	Mai Nefhi WTP	Mai Nefhi WTP					
Person Checked		Yikaalo	Yikaalo	Yikaalo					
Temperature	℃	19.4	20	22.3		3	20.6	22.3	19.4
pH	–	7.68	6.95	6.79		3	7.1	7.7	6.8
Electrical Conducitivity	uS/cm	367	201	110		3	226	367	110
Turbidity	NTU	144	163	43.3	5NTU or less	3	117	163	43
Color	–	No	No	No		3	–	–	–
Smell	–	No	No	No		3	–	–	–

Godaif PS

Parameter	Unit	10-Aug	17-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		16:28	9:50	10:00					
Weather		Rainy	Cloudy	Sunny					
Coming From		Sembep PS	Sembel PS	Sembel PS					
Person Checked		Yikaalo	Yikaalo	Yikaalo					
Temperature	℃	19.3	22	23.6		3	21.6	23.6	19.3
pH	–	8.4	7.1	7.19		3	7.6	8.4	7.1
Electrical Conducitivity	uS/cm	326	192	233		3	250	326	192
Turbidity	NTU	66.2	185	50.4	5NTU or less	3	101	185	50
Color	–	No	No	No		3	–	–	–
Smell	–	No	No	No		3	–	–	–

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2. Denden PS and Testserat RS

Denden PS

Parameter	Unit	15-Aug	26-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		9:17	9:30	2:40					
Weather		Sunny	Sunny	Sunny					
Coming From		Tokor WTP	Tokor WTP	Tokor WTP					
Person Checked		Yikaalo	Yikaalo	Yikaalo					
Temperature	℃	19.5	19.9	24.1		3	21.2	24.1	19.5
pH	–	7.96	7.06	6.87		3	7.3	8.0	6.9
Electrical Conducitivity	uS/cm	278	251	259		3	263	278	251
Turbidity	NTU	46.6	19.5	17.1		3	28	47	17
Color	–	No	No	No		3	–	–	–
Smell	–	No	No	No		3	–	–	–

Testserat RS

Parameter	Unit	15-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		10:31	9:00					
Weather		Sunny	Sunny					
Coming From		Tokor WTP	Tokor WTP					
Person Checked		Yikaalo	Yikaalo					
Temperature	℃	19.7	19.8		2	19.8	19.8	19.7
pH	–	8.04	7.13		2	7.6	8.0	7.1
Electrical Conducitivity	uS/cm	344	283		2	314	344	283
Turbidity	NTU	0.99	0.94	5NTU or less	2	1	1	1
Color	–	No	No		2	–	–	–
Smell	–	No	No		2	–	–	–

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3. Mai Chehot PS and Monopolio RS

Mai Chehot RS

Parameter	Unit	15-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		10:45					
Weather		Sunny					
Coming From		Tokor WTP					
Person Checked		Yikaalo					
Temperature	℃	19.9		1	19.9	19.9	19.9
pH	–	8.09		1	8.1	8.1	8.1
Electrical Conducitivity	uS/cm	284		1	284	284	284
Turbidity	NTU	3	5NTU or less	1	3	3	3
Color	–	No		1	–	–	–
Smell	–	No		1	–	–	–

Monopolio RS

Parameter	Unit	15-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		16:00					
Weather		Sunny					
Coming From		Tokor WTP					
Person Checked		Yikaalo					
Temperature	℃	20		1	20.0	20.0	20.0
pH	–	8.35		1	8.4	8.4	8.4
Electrical Conducitivity	uS/cm	181		1	181	181	181
Turbidity	NTU	66.6	5NTU or less	1	67	67	67
Color	–	No		1	–	–	–
Smell	–	No		1	–	–	–

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(4) Chemical Consumption

Result of Used Chemical in Each WTP
(From Aug.11 to Aug.31)

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded										
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced
S.V WTP	21	7	7	7	21.4	5.4	128.6	17.9	2.5	0	0	0	0
Tokor WTP	21	18	2	1	284.2	43.3	1,038.6	60.5	8.5	24.9	3.8	91.2	5.3
Mai Nefhi WTP	21	18	1	2	420.0	33.5	804.3	95.3	13.3	31.6	2.1	50.5	6.3

(5) Findings and Issues for Water Flow

① No WTP succeeded in water quality instructed by drinking water quality standards ⇒ Frequent cleaning of facilities ⇒ Improvement of chemical dosing ways (continuous dosing of Alum) ⇒ Improvement of chemical dosing equipment (Alum and Chlorine) in the future

② Higher awareness in water quality management is necessary although the securing water quality is costly.

③ Dosing control of chlorine is difficult. ⇒ Rehabilitation of facility or Modification of chlorine to liquid one

④ Incorrectness of analyzed data ⇒ More trainings for site staff members

5. ESTIMATED WATER DEMAND

WTP	Distribute Zone	Population			Water Demand (m^3/d)			Distribution (Aug 2016)	
		Total	By Pipe	By Truck	Pipe 50LCD	Truck 15LCD	Total	(m3/d)	% by demand
S.V.	Direct		50,459		2,523				
Toker	Direct		87,955		4,398				
	Tsetserat		7,510		376				
	Monopolio		4,316		216				
	Denden		7,449		372				
	Algen Camp	400,000	1,727	189,588	86	2,844	13,365	11,376	85%
Mai Nefhi	Direct (villages)		7,472		374				
	New Sembel		28,268		1,413				
	Godaif		15,256		763				
Total			210,412		10,521				

6. CHECK AND LIST OF EXISTING DRAWINGS

(1) Example of list made by Counterpart team

LIST OF DRAWINGS

Item		Scale	Year
Pipeline			
Water bridge for pipeline	Raw-Water transmission between Mai Nefhi-Asmara	1:50	
Net Work			
Asmara supply Network		1:0000	2006
Pump station			
Pump-station with reservoir	New Sembel		1968
Map			
Topographic map	Asmara City area	1:25000	1970
Topographic map	Asmara City area	1:50000	
S.V dam			
Plan		1:500	
Section of dam		1:100	1939

(2) Findings and Issues

① Little drawings for S.V. system and Mai Serwa dam

② Partially stored for Mai Nefhi system

③ Stored in Auto-CAD for design drawings of Toker system

④ Availability of drawings becomes clear.

⑤ Necessity of drawings becomes clear for O&M and knowledge transfer to younger generation.

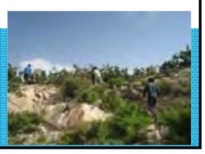
⑥ Difficult to explain the exiting facility to facility planner / designer.

⑦ Preparation of drawings is necessary.

7. SIMPLE SURVEY AND PIPELINE DRAWING

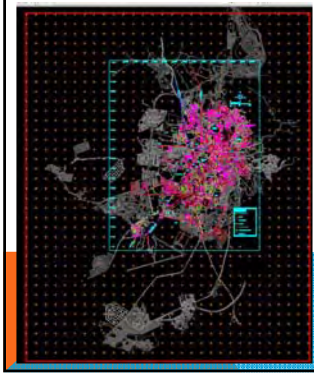
(1) Equipment Training of Metal pipe detector and Site Survey

(2) Identification the coordinate and elevation of pipeline with GPS and Metal pipe detector (from Mai nefhi WTP to Sembel P.S. and from Adi sheka to S.V WTP)



7. SIMPLE SURVEY AND PIPELINE DRAWING

(3) Obtention of base map and contours line



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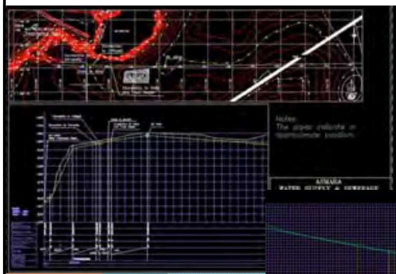
7. SIMPLE SURVEY AND PIPELINE DRAWING

(4) Preparation of pipeline drawing from Mai Nefhi to Sembel P.S.



7. SIMPLE SURVEY AND PIPELINE DRAWING

Next plan

(1) To continue simple survey
-From S.V. WTP to Asmara City

(2) Preparation of more drawings
-From Adi sheka to S.V. WTP
-From S.V.WTP to Asmara city

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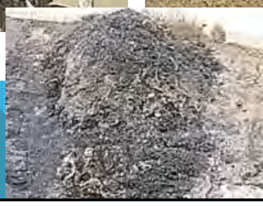
8. TRIAL / ATTEMPT FOR O&M IMPROVEMENT AT TOKER WTP

(1) Cleaning of Flocculation and Sedimentation Basin (Before)

Flocculation

Sedimentation



Filtering Sand

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(1) Cleaning of Flocculation and Sedimentation Basin (Cleaning works)

Filtering sand

Water jet Cleaning

Sludge removal

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(1) Cleaning of Flocculation and Sedimentation Basin (After)

Flocculation

Sedimentation

Colored surface of concrete

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(2) Modification of Alum Dosing Line

Before: Solution concentration 300kg Alum / 20m³

After: Solution concentration 1000 – 1200kg Alum / 20m³

Before: Dosing at Receiving well

After: Dosing at Outlet Chamber of Raw Water Regulation Pond

Reference for Toker Case:

Alum solution: In general 6 – 8% in Al_2O_3

But 6000 - 8000g/m³ to adapt to pump capacity

Alum weight: 6000 or 8000kg / 14% = 43 - 58kg/m³

To simplify: 1200kg Alum to 20m³ tank (60kg Alum/m³) (8000g Al_2O_3/m³)

Assuming 4g Al_2O_3/m³ is necessary for Flocculation ⇒ 2000 times dilution

To treat 750m³/h (12500 L/min) of raw water ⇒ 6.25 L/min pumping for Alum Solution

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(3) Modification of Manual Dosing of Alum

Before: No controlled amount for direct dosing of Alum

After: 8kg Alum per 30min.

Reference for Toker Case:

Assuming 4g Al_2O_3/m³ is necessary for Flocculation

⇒ 4g / 14% = 29g Alum/m³ is necessary

To treat 500m³/h of raw water ⇒ 500 x 29g = 15kg Alum / h is necessary.

To simplify: 8kg Alum @ 30min interval

Key point: Not to empty the Alum bag at one time. To dose little by little for 24hrs.

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(3) Trial Result

Sample	Turbidity Before (Average of Aug)	Turbidity After		
		14 Sep Regular Analysis	15 Sep Regular Analysis	Reference 14 Sep Special
Raw Water	>172 NTU	32.9 NTU	36.5 NTU	
Line-1 After Sedimentation	45.91 NTU	6.81 NTU	3.15 NTU	9.38 NTU
After Filtering				6.40 NTU
Clear Water Basin	55.8 NTU	59.3 NTU	27.3 NTU	

There are pollutants after filter such as clear water basin.

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9. COMMITMENT OF PLANNING & SUPERVISION UNIT

1. To continue recording for water flow, quality and operation condition.
2. To prepare monthly summary and to be ready always for data disclosure to stakeholders.
3. To continue verification of water flow rate.
4. To prepare more drawings, especially pipelines.
5. To prepare consumables for water quality analysis.
6. To instruct WTPs to improve cleaning frequency and Alum dosing.
7. To manage the present team organization and to make responsibilities clear.
8. To suggest a plan for organization enhancement to the top management.

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10. ISSUES FOR OVERALL MANAGEMENT

1. To manage the rainfall data for the last 30 years for evaluating and forecasting water distribution volume as well as water resources condition.
2. To establish a quick procurement system for spare parts and consumables, including consumables for water quality analysis.
3. To deploy necessary vehicles for data collection / management activities.
4. To improve billing data system (customer management system) to be corresponding to distribution zones. ⇒ effective for NRW management
5. To manage the data as performance indicators. To disclose it in public, if possible. (Posting on a wall of AWSSD).
6. To accelerate the tariff improvement to manage rehabilitation / construction.
7. To commence studies for sludge management and countermeasures for chlorine leakage.
8. To enhance and to make the Project team for permanent activities in AWSSD.
9. To reconsider the present grace period (7 months) for the subscriber payment for practical evaluation of water demand and NRW ratio.

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Appendix-9: Material for Follow-up Meeting

ASMARA WATER SUPPLY INFRASTRUCTURE (DATA COLLECTION AND MANAGEMENT) PROJECT

ASMARA OCTOBER 2016

AWSSD COUNTER-PART TEAM

Contents

. Water flow record Summary

- (1) Water level of Dam

Result of Water Level in Each Dam
(From oct.01 to oct.14)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Average	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	14	13	11.37	11.40	11.30	Max.=17.8m
Tokor Dam	14	14	20.00	20.00	20.00	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	14	13	9.00	9.00	0.00	Max.=35m

- Result of Water Level in Each Dam
- (From oct.15 to oct.31)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Average	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	17	16	11.30	11.40	11.20	Max.=17.8m
Tokor Dam	17	16	19.79	20.00	19.50	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	17	15	12.75	9.00	9.00	Max.=35m

(2) Water Intake at Dams

- Result of Intake Volume from Each Dam
- (From oct.01 to oct.14)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Days: Recorded	Working Days: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	14	13	0	1	10	11	4,190	399	9,575	Intake volume is estimated by water meter. Not working on oct.10
Tokor Dam	14	14	0	0	8	8	7,920	990	23,760	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m^3/hr).
Mai Nefhi Dam	14	13	0	1	18	19	8,060	450	10,800	Intake volume is estimvated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work due to electrical problem on oct. 8th.
Total							20,170			

- Result of Intake Volume from Each Dam
- (From oct.15 to oct.31)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	17	16	0	1	14	14	5,602	389	9,344	Intake volume is estimated by water meter. Not work due to electrical power cut on oct.22nd.
Tokor Dam	17	16	0	1	8	8	7,454	990	23,760	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr). Not working on Oct.18th.
Mai Nefhi Dam	17	15	0	2	17	20	7,853	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work on Oct.21 and 22.
Total							20,909			

(3) Water Receiving at WTPs

- Result of Receiving Water Volume in Each WTP
- (From oct.01 to oct.14)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	14	4	2	8	5	16	2,282	418	10,035	Inlet volume is not recorded on dates 4 and 8 October. Not work on Oct.2, 3 ,7 , 9, 10 ,11, 13 and 14.
Tokor WTP	Adisheka Dam	14	12	0	2	1	1	188	350	8,400	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Water is received from Adisheka dam on oct.6 and 7. Water is received from Tokor dam from oct.3 to oct.14. not work on oct.1st and 2nd.
	Tokor Dam	14	12	0	2	7	8	6,574	975	23,394	
Mai Nefhi WTP	Mai Nefhi Dam	14	13	0	1	18	19	8,060	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work on oct.08
Total								17,103			

Result of Receiving Water Volume in Each WTP (From oct.15 to oct.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	17	11	4	2	9	14	4,319	372	8,925	Water is received from SV dam from Oct 21 to Oct 26. not working on Oct. 16 and 22. and not recorded on Oct. 24, 25, 26 &29.
Tokor WTP	Adisheka Dam	17	14	0	3	0	1	144	350	8,400	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Water is received from Adisheka dam on oct. 19 only. Water is received from Tokor dam on the rest of the days. Not work on oct. 17 & 18.
	Tokor Dam	17	14	0	3	6	7	5,882	990	23,760	
Mai Nefhi WTP	Mai Nefhi Dam	17	15	0	2	17	20	7,853	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work on oct. 21 and 22.
Total								18,198			

(4) Water Production at WTPs

- Result of Water Production in Each WTP
- (From oct.01 to oct.14)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	14	6	0	8	4	9	1,104	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work on oct. 2, 3, 7, 9,10,11,13, 14.
Tokor WTP	Adisheka + toker dams	14	12	0	2	10	12	3,681	370	8,870	Water production volume is estimated by operating time of pump + by gravity + amount left in the storage tank. Not work on oct. 1 and 2.
Mai Nefhi WTP	Mai Nefhi Dam	14	13	0	1	18	19	6,269	350	8,400	Water production volume is estimated by pump operating hours. Not work due to electrical problem on oct.8th.
Total								11,053			

Result of Water Production in Each WTP (From oct.15 to oct.31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	17	15	0	2	8	9	2,303	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr) Not work on oct. 16 & 22.
Tokor WTP	Adisheka + toker dams	17	14	0	3	9	11	2,269	242	5,818	Water production volume is estimated by operating time of pump + by gravity + amount left in the storage tank. PUMP IS NOT WORKING DUE TO MECHANICAL PROBLEM
Mai Nefhi WTP	Mai Nefhi Dam	17	15	0	2	18	20	6,108	348	8,358	Water production volume is estimated by water meter. Not work due to electrical problem on oct 21 and 22.
Total								10,679			

(5) Result of Chemicals used

- Result of Alum and Chlorine Dosage in each WTP
- (From oct.01 to oct.14)

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced
S.V WTP	14	6	0	8	14.29	3.88	93.20	12.94	1.81	22.43	6.09	146	0.02
Tokor WTP	14	12	0	2	150.00	21.63	519.14	40.75	5.71	43.1	4.9	117	9.2
Mai Nefhi WTP	14	13	0	1	557.14	31.11	746.56	80.34	11.25	33.86	1.89	45.37	4.88

- Result of Alum and Chlorine Dosage in each WTP
- (From oct.15 to oct.31)

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	kg/day	g/m3-Water Produced
S.V WTP	17	15	0	2	17.6	2.3	55.2	7.7	1.1	9.24	1.2	55	0.04
Tokor WTP	17	14	0	3	188.2	31.8	764.2	83.0	11.6	9.3	1.6	37.7	4.1
Mai Nefhi WTP	17	15	0	2	529.4	30.2	724.4	69.8	9.8	37.2	2.1	50.9	4.9

(6) Water Distribution of Service Reservoirs

Result of Water Distribution in Each Pump Station/Reservoir (From oct.01 to oct.14)
-Toker WTP Distribution Area-

Name of Pump Station/Reservoir		Operation Planned	Result of Operation: Number of Data Recorded: Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Days: Not Scheduled	Not Working Days: as Scheduled	Averaged Flowrate per Day: In the Period of Data Recorded	Averaged Flowrate per Day: Excluding Not Working Day	Note.
			Days	Days	Days	Days	Days	m³/day	m³/day	
Denden PS	To Algene Camp	・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to Algene camp for 3 days and to Denden camp for 3 days for 1 week.	14	2	0	0	0	27	192	・Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr) ・There are no much recorded data of the transmision volume becouse the operator does not master how to record the operation yet.
	To Denden Camp		14	0	0	0	0	0	0	
Mai Chehot PS		・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to higher area for 1 day for 1 week.	14	0	0	0	14	0	NO SUPPLY	Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Testserat Res.		・Receiving water from Tokor WTP approxymate once every 3 months ・Transporting water to higher area for 2〜3 days for 1 week.	NO	SUPPLY	OF	WATER	FROM	TOKER		Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Monopolio Res.		・Receiving water from Tokor WTP approxymate 3 days every 2 weeks. ・Transporting water to lower area by gravity everyday.	14	5	0	0	9	157	5.06	Water production volume is estimated by water level decreased for one day. Water received and supplied on the first 5 days of october .
Algena Camp		・Receiving water from Denden PS for 3 days for 1 week. ・Transporting water to the residence in the camp once a week.	14	2	0	0	12	10	68	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)

Result of Water Distribution in Each Pump Station/Reservoir (From oct.15 to oct.31)
-Tokor WTP Distribution Area-

Name of Pump Station/Reservoir		Operation Planned	Result of Operation: Number of Data Recorded: Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Days: Not Scheduled	Not Working Days: as Scheduled	Averaged Flowrate per Day: In the Period of Data Recorded	Averaged Flowrate per Day: Excluding Not Working Day	Note.
			Days	Days	Days	Days	Days	m³/day	m³/day	
Denden PS	To Algene Camp	・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to Algene camp for 3 days and to Denden camp for 3 days for 1 week.	17	2	0	8	5	115	975	・Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr)
	To Denden Camp		17	2	0	8	5	141	1,200	
Mai Chehot PS		・Receiving water from Tokor WTP for 3 days every 2 weeks. ・Transporting water to higher area for 1 day for 1 week.	17	2	0	0	0	78	663	Water production volume is estimated by by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Testserat Res.		・Receiving water from Tokor WTP approxymate once every 3 months ・Transporting water to higher area for 2〜3 days for 1 week.	17	5	0	0	12	19	65	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)
Monopolio Res.		・Receiving water from Tokor WTP approxymate 3 days every 2 weeks. ・Transporting water to lower area by gravity everyday.	NO	SUPPLY	OF	WATER				Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from oct. 15 to oct 31.
Algena Camp		・Receiving water from Denden PS for 3 days for 1 week. ・Transporting water to the residence in the camp once a week.	17	0	0	0	17	18	150	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)

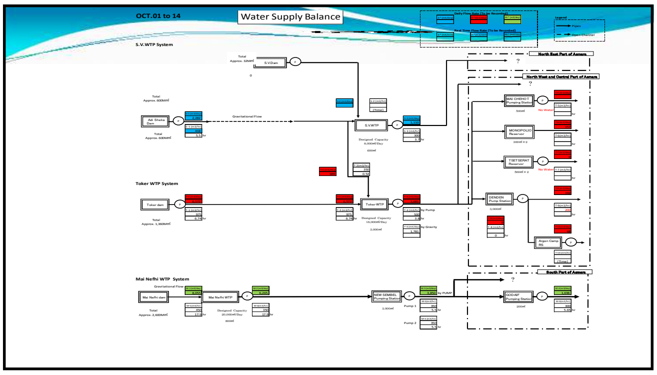
(6) Water Distribution of Service Reservoirs

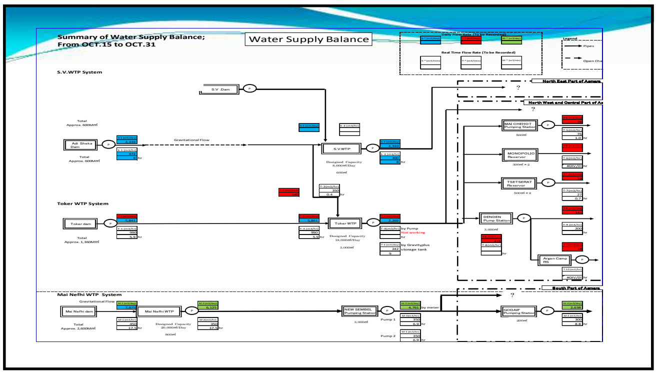
- Result of Water Distribution in Each Pump Station/Reservoir (From oct.01 to oct.14)
- -Mai Nefhi WTP Distribution Area-

Name of Pump Station/Reservoir	Operation Planned	Number of Data Recorded: Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Days: Not Scheduled	Not Working Days: as Scheduled	Averaged Flowrate per Day: In the Period of Data Recorded	Averaged Flowrate per Day: Excluding Not Working Day	Note.
		Days	Days	Days	Days	Days	m³/day	m³/day	
Sembel PS	・Receiving water from Mai Nefhi WTP for 24 hours everyday. ・Transporting water to the Godafi PS and the other area for 24 hours everyday .	14	12	0	2	0	3,850	4,492	Water production volume is estimated by pump operating hours*rated flow rate of pump(m3/hr) N.B. there is no big difference between the water production obtained by meter reading and by pump operating hours.
Godaif PS	・Receiving water from Sember PS for 24 hours everyday. ・Transporting water to the Godaif area etc. for 24 hours everyday .depending on power supply availability.	14	13	0	1	0	1,696	1,827	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)

Result of Water Distribution in Each Pump Station/Reservoir (From oct.15 to oct.31)
-Mai Nefhi WTP Distribution Area-

Name of Pump Station/Reservoir	Operation Planned	Number of Data Recorded: Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Days: Not Scheduled	Not Working Days: as Scheduled	Averaged Flowrate per Day: In the Period of Data Recorded	Averaged Flowrate per Day: Excluding Not Working Day	Note.
		Days	Days	Days	Days	Days	m³/day	m³/day	
Sembel PS	・Receiving water from Mai Nefhi WTP for 24 hours everyday. ・Transporting water to the Godafi PS and the other area for 24 hours everyday .	17	16	0	1	0	4,761	5,059	Water production volume is estimated by pump operation hours multiplied by pump capacity (m3/hr)/.No work on october 22.
Godaif PS	・Receiving water from Sember PS for 24 hours everyday. ・Transporting water to the Godaif area etc. for 24 hours everyday .	17	17	0	0	0	2,638	2,638	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m3/hr)





FACILITY TEAM ACTIVITIES

- A training on the use of GPS for the purpose of taking data from the field which helps for the creation of data base using the GIS softwares is under way.
- this training will enable us :
  - To locate the water supply or sewerage utilities like pipe lines, sewer lines..etc and collect useful data with more precision
  - To process the data in a faster and accurate way
  - So we will be able to draw the major pipe lines from dams to wtp's and the to the distribution in the near future

(7) Findings and Issues for Water Flow

1. Late submittal of and Incorrectness of recorded data ⇒ Difficult for summarizing works
2.Large gap between inlet and outlet flows of Toker WTP ⇒ Incorrectness of flow rate assumption, especially Toker WTP outlet (difficult to estimate due to several operation modes) ⇒ More verification works for flow rate ⇒ More precise record for operation condition (especially discharging modes and in-taken water storage at regulation pond)

3. Large gap between water received and production of water in WTPs. i.e. there is more loss in the treatment plants??

4. Pump capacity /performance in Toker dam should be re-defined according to the values obtained from the UFM measurements taken.

ASMARA WATER SUPPLY INFRASTRUCTURE (DATA COLLECTION AND MANAGEMENT) PROJECT.

ASMARA OCTOBER 2016

AWSSD COUNTER PART TEAM

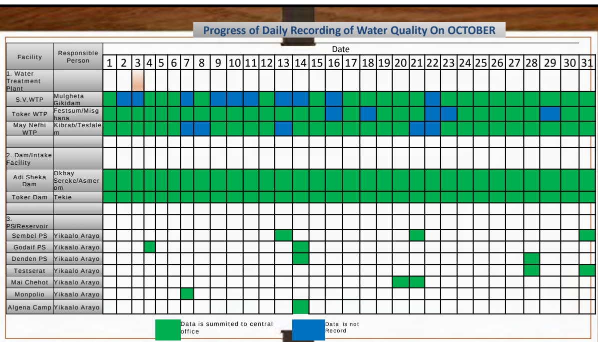
TOKER WTP

Contents

1~Data obtained on October regarding Water Quality

2~Progress of Daily Recording Water Quality

Measuring Pt.	Parameter	Unit	1 OCT	2 OCT	3 OCT	4 OCT	5 OCT	6 OCT	7 OCT	8 OCT	9 OCT	10 OCT	11 OCT	12 OCT	13 OCT
Time			9:30	9:30	9:00	9:00	9:00	10:30	9:30	10:00	8:00	9:30	9:30	10:00	9:00
Weather			Cloudy	Cloudy	Sunny/Rainy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—
RAW WATER	Temperature	Ċ	19.5	19.2	19.1	19.5	19	20.9	18.9	15.3	19.6	19.8	19.3	19	19.3
	PH	-	7.56	7.63	7.65	7.75	7.72	7.87	7.6	8.07	7.62	7.66	7.61	7.85	7.78
	Electrical conductivity	US/cm	242	241	244	244	246	242	252	250	248	249	250	251	254
	Turbidity	NTU	14.3	21.2	16.3	17.7	14.2	13.5	13.3	23.5	10.3	11	8.81	8.75	7.42
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
TREATED WATER	Temperature	Ċ	18.6	17.4	19.4	19	18.4	19.2	18.5	17.9	18.9	18.9	19	18.3	18.7
	PH	-	7.48	8.04	7.4	7.95	7.61	7.6	7	7.77	7.5	7.6	7.58	7.7	7.68
	Electrical conductivity	US/cm	252	266	241	240	248	249	240	252	249	246	250	257	255
	Turbidity	NTU	10.2	12.7	4.66	5.08	7.92	6.24	7.93	8.69	6.8	6.52	4.94	6.49	3.11
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	0.17	0.62	0.22	0.2	0.06	0.17	0.23	0.2	0.04	0.11	0.16	0.16	0.03
	Residual chlorine(Total)	mg/L	0.32	0.86	0.25	0.22	0.88	0.2	0.28	0.4	0.08	0.12	0.18	0.25	0.05
	Bacteria	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Coliform	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0



Measuring Pt.	Parameter	Unit	14 OCT	15 OCT	17 OCT	19 OCT	20 OCT	21 OCT	22 OCT	24 OCT	25 OCT	26 OCT	27 OCT	28 OCT	31 OCT
Time			9:00	9:00	9:30	9:00	8:30	11:00	9:30	10:30	9:30	8:00	9:30	8:30	8:30
Weather			Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana	Misghana
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—
RAW WATER	Temperature	Ċ	19.2	19.2	17.4	18.4	19.8	15.7	18.9	17.3	14.7	19.6	17	18.1	19.1
	PH	-	7.68	7.63	7.96	7.63	7.64	8.44	7.6	8.11	8.1	7.62	7.92	7.72	7.78
	Electrical conductivity	US/cm	253	251	258	264	253	258	252	270	260	248	259	257	258
	Turbidity	NTU	19.2	20.1	8.15	8	6.49	19.8	13.3	8.25	58.5	10.3	11.3	7.64	5.92
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
TREATED WATER	Temperature	Ċ	18.3	16.1	17.1	17.9	17.7	17.5	18.5	18.1	17.1	18.9	17.3	18.1	20
	PH	-	7.53	7.9	7.93	7.55	7.82	7.75	7	8.09	7.81	7.5	7.61	7.66	7.64
	Electrical conductivity	US/cm	258	254	253	259	256	256	240	276	259	249	262	259	255
	Turbidity	NTU	5.12	6.5	6.1	5.97	14.7	2.64	7.93	2.54	14.22	6.8	2.81	6.02	3.57
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	0.18	0.05	0.15	0.1	0.48	0.06	0.23	0.01	0.21	0.04	0.04	0.14	0.19
	Residual chlorine(Total)	mg/L	0.2	0.2	0.18	0.12	0.53	0.09	0.28	0.02	0.24	0.08	0.05	0.15	1.88
	Bacteria	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Coliform	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0

MAI-NEFHI WTP

S.V WTP

Measuring Pt.	Parameter	Unit	1-Oct	2-Oct	3-Oct	4-Oct	5-Oct	6-Oct	9-Oct	10-Oct	11-Oct	12-Oct	14-Oct	15-Oct	16-Oct
Time			18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
Weather			Sunny	Sunny	Cloudy	Sunny	Sunny	Cloudy	Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI
Person Checked			TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM
			—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	21.2	19.5	19.6	18.7	18.9	18.7	19.6	19.9	19.3	19.2	21.3	21	20.8
	PH	-	8.06	7.92	7.76	7.71	7.93	7.79	6.58	7.1	7.32	7.64	8.18	7.69	8.2
	Electrical conductivity	US/cm	264	353	461	333	274	310	234	270	262	253	226	233	259
RAW WATER	Turbidity	NTU	34.6	42.5	46.8	42.6	33.5	35.6	36.1	21	21.3	16.9	18.8	19.9	16.8
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Temperature	ċ	21.2	19.9	19.3	18.8	19	19.2	19.8	19.5	20.2	19.9	21	21	21
	PH	-	6.99	7.1	6.91	7.57	7.48	7.1	6.69	7.01	7.62	7.46	6.85	7.36	7.2
TREATED WATER	Electrical conductivity	US/cm	226	218	233	219	225	222	227	225	218	218	235	225	227
	Turbidity	NTU	32.2	24.5	17	15	14.5	15.3	12.1	10.1	11.2	25.9	10.1	8.05	11.8
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	0.16	0.28	0.21	0.4	0.17	0.01	0.24	0.15	2.02	0.3	0.2	2	0.1
	Residual chlorine(Total)	mg/L	0.22	0.32	0.38	0.45	0.29	0.05	0.35	0.21	2.25	0.45	0.92	2.2	0.7
	Bacteria	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Coliform	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0

Measuring Pt.	Parameter	Unit	1 OCT	4 OCT	5 OCT	6 OCT	8 OCT	12 OCT	15 OCT	17 OCT	18 OCT	19 OCT
Time			10:30	10:00	10:00	9:30	9:30	2:10	10:30	4:30	10:30	11:00
Weather			Sunny	Cloud	Sunny	Sunny	Sunny	Sunny	Cloud	Sunny	Sunny	Sunny
Water Source			Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka
Person Checked			keshi & habtom	keshi & habtom	Goitom	Solomon	Debasi	Mulught	Mulught	Goitom	Abraham	keshi & habtom
			—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	17.7	16.1	15.6	15.6	18.3	18.6	17.8	18	17	16.8
	PH	-	7.72	7.77	8	7.94	7.51	8.22	7.93	8.02	8.02	7.82
	Electrical conductivity	US/cm	273	286	293	291	294	288	315	298	299	292
RAW WATER	Turbidity	NTU	21.1	20.8	23.3	22.6	43	73.9	17.7	36	36.2	40.9
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Temperature	ċ	18.9	18.1	16.3	18.3	16.7	18.3	19.6	16.2	17	NO
	PH	-	7.03	7.38	7.25	7.06	7.85	7.64	7.42	7.98	7.07	16.5
TREATED WATER	Electrical conductivity	US/cm	252	278	339	306	285	291	319	291	288	290
	Turbidity	NTU	17.5	15.4	18.2	17.2	11.1	11.8	16.6	10.8	12	13.9
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	0.02	0.85	0.05	0.28	0.03	0.19	0.05	0.04	0.04	0.02
	Residual chlorine(Total)	mg/L	0.03	1.55	1.87	1.89	0.05	0.46	0.65	0.06	0.15	0.02
	Bacteria	cells/ml	4	2	4	2	-	4	3	9	6	0.05
	Total Coliform	cells/ml	7	3	6	4	-	9	5	12	7	6

Measuring Pt.	Parameter	Unit	17-Oct	18-Oct	19-Oct	20-Oct	23-Oct	24-Oct	25-Oct	26-Oct	27-Oct	28-Oct	29-Oct	30-Oct	31-Oct
Time			18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00	18:00
Weather			Sunny	Sunny	Cloudy	Sunny	Sunny	Cloudy	Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI	MAI NEFHI
Person Checked			TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM	TESAALEM
			—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	18.5	18.9	20.2	20.3	18.9	19.1	20.3	20.7	21.5	19	19.4	19.02	19.5
	PH	—	7.92	7.89	7.97	8.32	7.95	8.39	8.49	7.98	8.12	8.14	8.38	8.29	8.37
	Electrical conductivity	US/cm	311	225	250	257	297	305	253	268	341	284	273	270	238
RAW WATER	Turbidity	NTU	24.4	15.6	11.2	17.9	14.6	14.7	18.2	12.6	15.2	15.8	14	12	12
	Color	—	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	—	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Temperature	ċ	19.8	19.9	20.1	20.1	18.7	19.5	20.4	20	21.2	19.9	19.4	19.3	19
	PH	—	7.65	6.85	7.12	7.25	8.29	8.41	6.85	7.26	6.96	7.87	8.31	8.3	8.3
TREATED WATER	Electrical conductivity	US/cm	221	229	232	230	221	222	256	236	252	229	224	223	228
	Turbidity	NTU	11.3	6.29	9.06	18.9	11.3	13.5	6	7.41	5.89	7.98	10.6	10.2	9
	Color	—	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	—	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	2.02	0.1	0.1	0.13	0.6	0.7	0.13	8.8	4.9	4.1	0.9	0.8	8.9
	Residual chlorine(Total)	mg/L	2.2	2.02	0.85	0.17	0.9	0.9	0.15	8.89	6.6	4.6	1.5	1.1	11.3
	Bacteria	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total Coliform	cells/ml	0	0	0	0	0	0	0	0	0	0	0	0	0

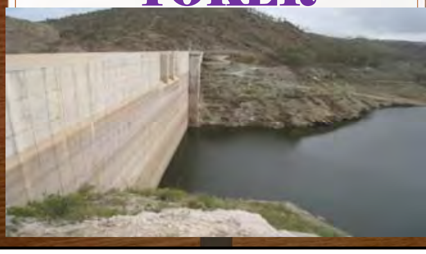
Measuring Pt.	Parameter	Unit	20 OCT	21 OCT	23 OCT	24 OCT	25 OCT	26 OCT	27 OCT	28 OCT	29 OCT	31 OCT
Time			22:00	9:30	10:55	11:00	12:15	10:40	11:05	11:00	12:00	10:30
Weather			Sunny	Rainy	Sunny	Sunny	Sunny	Cloud	Cloud	Sunny	Sunny	Sunny
Water Source			Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka
Person Checked			keshi & habtom	keshi & habtom	Solomon	Debasi	Mulught	Mulught	Goitom	Abraham	keshi & habtom	keshi & habtom
			—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	19.3	19.1	19.2	19.1	20.5	14.2	15	15	16.9	14.8
	PH	-	7.4	7.02	6.92	7.8	7.27	7.83	7.4	7.89	7.76	7.99
	Electrical conductivity	US/cm	366	366	351	342	352	302	303	300	316	300
RAW WATER	Turbidity	NTU	9.17	9.27	7.39	12.4	10.2	15.2	10.5	19.6	12	10.7
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell		NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Temperature	ċ	17.8	17	19	18	19.2	17.3	15.5	17.5	16.5	16.9
	PH	-	7.34	7.14	7.33	6.99	7.34	7.38	7.54	7.87	7.71	7.27
TREATED WATER	Electrical conductivity	US/cm	342	322	369	299	243	312	310	328	299	308
	Turbidity	NTU	19.1	24.6	11.1	7.2	10.6	12	13	11.5	11.8	11.1
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Residual chlorine(Free)	mg/L	0.05	0.04	0.14	0.42	0.58	0.03	0.26	0.75	0.02	0.04
	Residual chlorine(Total)	mg/L	0.65	0.16	1.17	0.65	1.19	0.51	1.2	1.97	0.04	0.07
	Bacteria	cells/ml	-	-	-	-	-	-	-	-	-	-
	Total Coliform	cells/ml	-	-	-	-	-	-	-	-	-	-

DAMS

Date			17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
			OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT
Time			20:00	1:00	5:00	2:29	11:00	12:00	11:00	12:00	3:00	3:30	12:15	9:30	10:00	11:30	12:30
Weather			Cloud	Sunny	Cloud	Sunny	Cloud	Cloud	Cloud	Cloud	Sunny	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud
Water Source			Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka
Person Checked			okubai	okubai	okubai	Asmerom	Asmerom	Asmerom	Asmerom	okubai	okubai	okubai	okubai	okubai	okubai	okubai	okubai
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	30.2	19.6	19.3	19.2	19.5	18.3	16.8	20.4	21	20.5	18.7	22.5	20.5	22.4	24.02
	PH	-	7.4	7.8	7.75	7.7	7.6	7.1	7.4	7.8	7.2	7.4	7.25	7.29	7.21	7.23	7.25
	Electrical conductivity	US/cm	500	425	425	336	335	338	419	480	417	555	557	580	525	522	552
RAW WATER	Turbidity	NTU	16.1	35.2	33.3	15.5	15.8	17.4	12.7	35.2	13.2	32.4	31.8	30.7	32.5	30.15	32.4
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

ADI - SHEKA

TOKER



Date			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT
Time			11:30	7:00	8:00	8:10	10:00	11:30	12:30	7:00	8:00	7:00	9:20	10:00	9:00	8:00	12:00
Weather			Sunny	Cloud	Cloud	Cloud	Sunny	Sunny	Sunny	Cloud	Cloud	Cloud	Sunny	Sunny	Sunny	Cloud	Sunny
Water Source			Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka	Adi Sheka
Person Checked			Asmerom	Asmerom	okubai	okubai	okubai	okubai	okubai	okubai	Okubai	Okubai	okubai	okubai	okubai	okubai	okubai
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	20.4	18.9	20.9	19.2	22.5	20.2	20.6	18.9	22.8	20.5	21.2	18.1	19.3	19.5	24.7
	PH	-	6.87	7.56	7.57	7.85	7.2	6.83	6.82	7.52	7.44	8.91	7.53	7.64	7.98	7.96	7.15
	Electrical conductivity	US/cm	312	428	430	310	428	313	318	416	233	382	380	303	375	380	320
RAW WATER	Turbidity	NTU	27.6	24.9	26.8	29.6	25.6	28.5	25.9	24.8	28.1	51	45.21	37.3	52.2	52.3	19.9
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

Date			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
			OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT	OCT
Time			20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00
Weather			Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	18.3	18.7	18.3	19.1	18.8	19.3	19.5	18.9	20.3	19.6	19.2	21.3	20.8	19.1	20.4	18.5
	PH	-	6.53	6.49	6.34	6.31	6.42	6.51	6.35	6.43	6.73	7.03	7.27	7.15	7.43	7.2	6.49	6.87
	Electrical conductivity	US/cm	205	199	206	213	216	194	324	229	319	288	269	307	334	313	331	297
RAW WATER	Turbidity	NTU	18	18.2	18.3	17.9	17.5	17.3	15.3	14.7	14.2	12.5	11.7	12.3	11.9	11.5	11.8	10.8
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

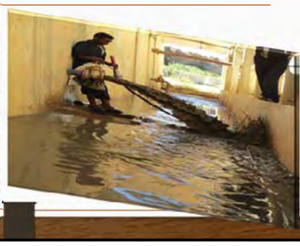
Measuring Pt.	Parameter	Unit	17 OCT	18 OCT	19 OCT	20 OCT	21 OCT	22 OCT	23 OCT	24 OCT	25 OCT	26 OCT	27 OCT	28 OCT	29 OCT	30 OCT	31 OCT
Time			20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00	20:00
Weather			Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud	Cloud
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie	Tekie
Measuring Pt.	Parameter	Unit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	Temperature	ċ	19.3	20.3	17.8	20.9	20.6	19.4	19	19.5	18.9	18.3	19	19.4	19.8	18.9	18.6
	PH	-	6.54	6.37	6.79	6.58	7.09	7.21	6.89	6.83	6.39	6.69	6.83	6.73	7.03	6.82	6.93
	Electrical conductivity	US/cm	215	303	321	288	307	316	305	309	279	339	318	325	288	312	341
RAW WATER	Turbidity	NTU	10.1	10.2	10.4	10.6	9.7	9.3	9	9.2	9	9.5	9	9.4	9	9.7	9.3
	Color	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
	Smell	-	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

CLEANING OF MAI-NEFHI WTP

PUMPING STATION

OF ASMARA

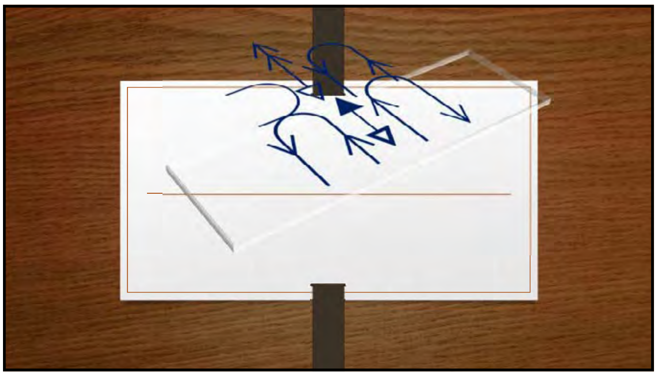
BEFORE



Parameter	Person Checked	Date	Time	Weather	Temperature	PH	Electrical Conductivity	Turbidity	Color	Smell
Unit	-	-	Hr/Sec	-	℃	-	US/cm	NTU	-	-
PUMPING STATION	-	-	-	-	-	-	-	-	-	-
SEMBEL	Yikaalo	13-Oct	2:26	Sunny	23.7	7.75	249	12	NO	NO
	Yikaalo	21-Oct	9:00	Sunny	20.4	6.95	247	9.65	NO	NO
	Yikaalo	31-Oct	9:09	Sunny	15.6	7.06	241	8.11	NO	NO
MAI CHEHOT	Tadese	20-Oct	11:15	Sunny	21.1	7.89	432	3.46	NO	NO
	Tadese	21-Oct	10:26	Sunny	20.7	7.24	333	4.32	NO	NO
DENDEN	Yikaalo	14-Oct	1:08	Sunny	24.1	7.3	277	5.09	NO	NO
	Tadese	28-Oct	4:00	Sunny	23.7	7.6	385	5.8	NO	NO
TESTSERAT	Tadese	7-Oct	10:00	Sunny	17.9	7.61	325	6.61	NO	NO
	Yikaalo	28-Oct	10:00	Sunny	23.8	7.5	305	1.89	NO	NO
	Yikaalo	31-Oct	10:56	Sunny	25.4	7.55	292	12.7	NO	NO
GODAIF	Tadese	4-Oct	3:00	Sunny	25.1	7.49	258	17.9	NO	NO
	Yikaalo	14-Oct	1:02	Sunny	23.4	6.98	230	11	NO	NO
ALGENA	Yikaalo	14-Oct	1:09	Sunny	23.6	7.4	218	1.02	NO	NO
MONOPOLIO	Yikaalo	7-Oct	10:31	Sunny	18.2	7.88	333	3.4	NO	NO

BEFORE

Sampling Pt.	Turbidity Before		Turbidity After
Date	16 NOV	17 NOV	23 NOV
RAW WATER	31.4	65.1	21
LINE-1 AFTER SEDIMENTATION	21.1	52	19.5
LINE-2 AFTER SEDIMENTATION	20.2	54.3	16.4
CLEAR WATER BASIN	9.86	30	5.77



Flow rate measurement

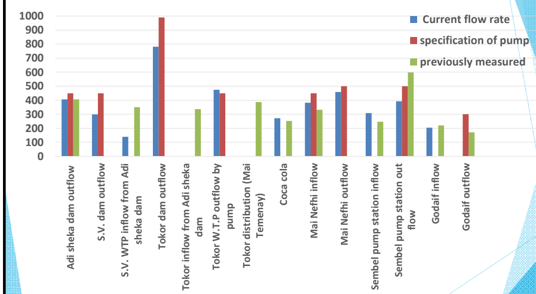
Purpose

- To determine the actual flow rate
- To determine the actual water volume
- To compare the results with the daily recording values of flow rate and volume of water.

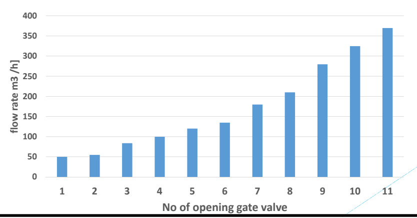
Monthly periodical measuring Every month Measurement and record		Measuring date	Average flow rate during 24hours metering [m3/h]	Total water volume for 24 hours metering [m3]	Pump (or valve) wokring hours	Pump specrification [m3/h]	Estimated Total water volume from pump wokring hours [m3]
S.V. system	Adi sheka dam outflow	3rd. Oct	406.112	700.543	1:45h	450	600
	S.V. dam outflow	21th. Oct	299.041	807.412	3:30	450	1575
	S.V. WTP inflow from Adi sheka dar	8th. Oct	139.867	1185.048	8:30	*450(dam)	
	S.V. WTP ouflow	7th. Oct					
Tokor system	Tokor dam outflow	10th. Oct	781.36877	5658.4122	7:15	991	7184.75
	Tokor inflow from Tokor dam	11th. Oct	not recorded			*991(dam)	
	Tokor inflow from Adi sheka dam	12th. Oct				*450(dam)	
	Tokor outflow	13th. Oct	296.4534	3970.0047	14:35	450	6562.5
			474.7by pu	255.7by gravity		by pump	
	Tokor distribution (Mai Temenay)	17th. Oct	not recorded			*450(WTP)	
	Coca cola	13th. Oct	271.3194	764.21628	2:50		
Mai Nefhi system	Mai Nefhi inflow	18th. Oct	382.4601	6438.0789	16:40		
	Mai Nefhi outflow	19th. Oct	458.93	1170.26	2:30	500	1250
	Sembel pump station inflow	21st. Oct	308.3147	5593.343	9:40	*500(WTP)	
	Sembel pump station out flow	24th. Oct	393.0811	4664.5626	12:00	500	6000
	Sembel distributin area	25th. Oct	198.6856	1054.6896	2:00		
	Godaif inflow	28-30th. Oct	204.2097	4729.1552	19:40	500(Sembel)	
	Godaif outflow (distribution)	28th. Oct	water leakage			300	

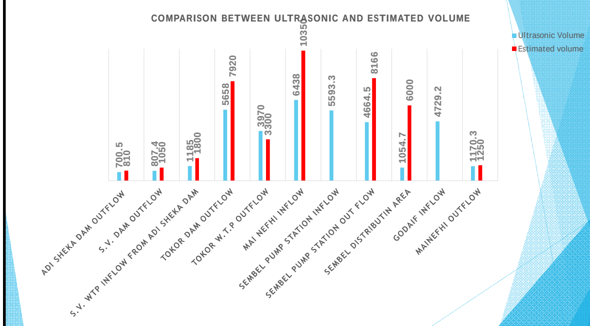
OUR OBSERVATION

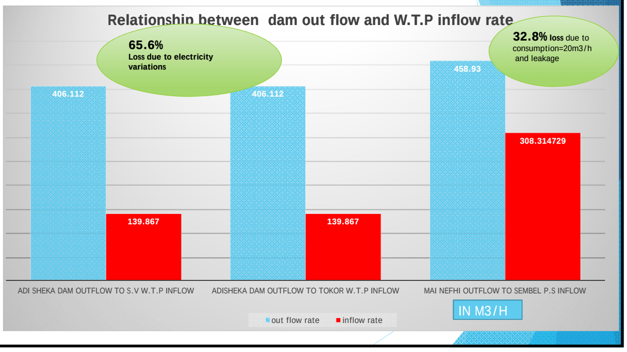
Comparison between flow rates

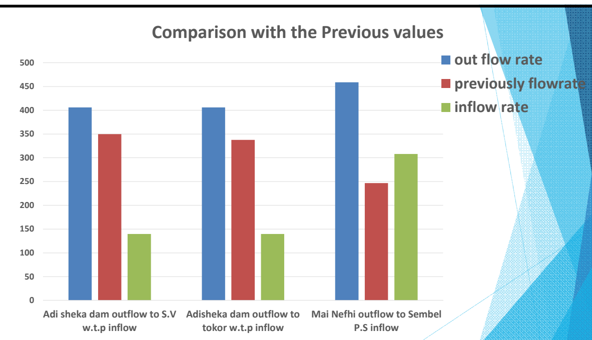


- Investigation between no of opening valve no2 and flow rate with the ultrasonic for inflow rate for Mainefhi Dam
 -There are two Gate valves in Mainefhi inflow by gravity and they use the first one if dam height is grater than 6m
 -And the second one if Dam height is less than 6m and the following graph is when Dam height is less than 6m. The persons control the flow rate by increasing and decreasing the gate valve.









Demand and production calculations for this month in m3 per day

no	villages from mainefhi dam to sembel		no of meters	Volume of water/year	Volume of waterin m3/day	no of family	Population served
1	Hmbrti	90	187	48,860	133.86	2,446	10,126
	Abardae					743	2,904
	Adiraesi						679
2	collage of mainefhi			27,600	109.5		5000
3	collage of sceince			7570	20.74		
4	Ktmeawlie	by fountain		11,581	31.72	795	3,292
5	Adem neger	by fountain		3199	8.76	313	1,308
6	factory of may leham			4,143	11.35		
7	Eitrean poultry farm	not accurate		217	0.59		
8	Daero paulos			3,467.10/21 months	5.6	2,279	8,465
9	sichuan road and Bridge construction group			1957	5.36		
10	Average water truck hydrant in mainefhi			4497.5/30	149.92		
11	Adi geaudad	from truck				5828	12473
				Total	477.4		44,247

Consumption versus demand calculation

Consumption by the people 289m3 calculation: 31,774*50L/cap.day=1588700L/day=15788.7m3/day

demand by the people 1588.7m3 289/1588.7=0.18*100=18%

population satisfied =18% per day or in other words people are getting 18%50L/cap.day=9L/cap.day

FROM SEMBEL PUMP STATION		no of family	Population served
Sembel		5744	21519
Godaif		10782	40640
Tiravolo		3976	14145
Gejeret		10110	38780
Geza-banda		9459	36410
gejeret abi [kebabi abda nora]		849	2123
	sum		153617
FROM TOKOR W.T.P			
Adiabeyto		179	1083
Maitemenay		6539	23950
Peradizo		780	1983
Edagahamus		3585	12627
Maekel ketema		5643	21858
Adi segdo			
kuteba		491	2085
kebabi university		290	1114
shuk abashawl			
maosker denden[algen seserat]		1671	7449
kebabi inshranus [alfermayo]		1412	5565
Tsetserat		5866	23334
	sum		101048
FROM VALLINEKI W.T.P			
Hazhaz		2238	7385
Abashawl		11080	40880
Akria		10818	43458
Arbaete Asmara		9179	34673
	sum		126396
Total			381061

Sample Data for water trucks distribution

New water tunker of water supply Data				for month 3/2016																
	45	volume of t	truck code	date	date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	Date	total	total
Names				42431	42433	42436	42438	42440	42443	42445	42446	42447	42450	42452	42453	42454	42457	42460		Nkf
Gebrebrhan Russom		16	781						10				5				5		20	14400
G/michael T/mikael		16	786			1			8							4			13	9360
Ebrahim M/nesredin		16	771		4	1	3			9	2				2		6		27	19440
G/zgher Zegeye		16	772	2	4	1		8	1			7			6				29	20880
Kahsay Fshaye		16	783	2			9				11				8				30	21600
Ebrahim M/Brhan		16	775	2			6				9						7		24	17280
Brhane tekle		16	769		7			8				9							24	17280
Yonas kesete Mehari		16	778	3		5		9					10			8			35	25200
Asefaw G/kirstos		16	776	2				14							12				28	20160
A/michael tekle		16	774	1					1										2	1440
Tesfamichel Aradom		16	785	4				10	2			8				9			33	23760
Aron G/michael		16	787				16		5			7			7			8	43	30960
Tsegay Abrha		16	779			6		5				8					9		28	20160
Zemichael Mehari		16	780		8	1	4			8						10			31	22320
G/hiwet Kinfe		16	777														13		13	9360
Misgna T/silase		16	770		7	1	5	3		6		3		6			5		36	25920
no of truck			no of truck	16	30	16	43	57	27	23	22	42	15	6	35	31	45	8		416
volume in m3			volume in	256	480	256	688	912	432	368	352	672	240	96	560	496	720	128		6656
payment(NKF)			payment(N	11520	21600	11520	30960	41040	19440	16560	15840	30240	10800	4320	25200	22320	32400	5760		299520

Calculation

Total volume from ultrasonic=out flow from Tokor W.T.P + Out flow from S.V(Vallineki)+Sembel p.s outflow

= 3970+1185.04+ 4664.5

=9819.54m3

but since getting the Data for the total water trucks doesn't specify the exact stations

the truck station found in Mainefhis total volume is added with the total volume=9819.54+149.92

=9969.46m3/day

And the total population starts from sembel p.s but scince Adiguaedad gets water from the truck hydrant from Mainefhi station the population of Adiguedad is added with the total population from Asmara.

i.e=381,061+(pop for Adiguedad)12473 =393,534

Clear result for the calculations

Average data from A.W.S.D for water truck stations=1984.7m3/day

Population	Standard	Demand(m3)	Production(m3/day)	
393534	50L/cap.day	19,675.70	9,969.53	
by truck			1984.7	
by pipe line			9,969-1984.7=	7984.83
%population served by pipe line			**40%**	
%population served by truck			**10.00%**	

- Calculation
- 393534*50L/cap=19676700lit=19676.7m3

  Demand=19676.7m3
- Production/Demand=7984.61/19676.7=40.05% rounded to 40%
- For truck =total production%-pipeline served area=9969.31/19675.70-40%=10%
- In other words population is getting 25L/cap if the water is directly to distribution.

Appendix-10: Recommended Plan for Operation & Maintenance for Water Supply in Asmara

Japan International Cooperation Agency

Asmara Water Supply and Sewerage Department (AWSSD)

ASMARA WATER SUPPLY INFRASTRUCTURE (DATA COLLECTION AND MANAGEMENT) PROJECT IN THE STATE OF ERITREA

Recommended Plan for Operation & Maintenance for Water Supply in Asmara

NOVEMBER 2016

YACHIYO ENGINEERING CO., LTD.

Recommended Plan for Operation & Maintenance
for Water Supply in Asmara

Contents

Abbreviation

Alum	aluminum sulfate
AWSSD	Asmara Water Supply and Sewerage Department
DMA	District Metering Area
JICA	Japan International Cooperation Agency
LCD	Litter / Capita/ Day
NRW	Non-revenue water
NTU	Nephelometric Turbidity Unit
PDCA	Plan, Do, Check and Act
PI	Performance Indicator
PS	Pump station
RS	Service Reservoir
RW	Revenue water
O&M	Operation and Maintenance
SOP	Standard Operational Procedures
S.V.	Stretta Vaudetto
WHO	World Health Organization
WTP	Water treatment plant

Chapter 1: Background

1.1 Background

Asmara, which has a population of 400 thousand, is the capital of the State of Eritrea. Drinking water is distributed to the city from three water treatment plants. The water distribution, however, is insufficient in volume and quality due to aged and damaged facilities. To overcome the present problems, the Government of Eritrea requested the Japan's Grant Aid in 2013 for rehabilitation and expansion of the existing water treatment facilities.

Japan International Cooperation Agency (hereinafter referred to as "JICA") sent a survey team for the requested Grant Aid Project. The team confirmed the following through its survey:

- Maintenance is not properly provided for the water supply facilities.
- Operation data, which are necessary to grasp the present conditions and issues, are not properly recorded.
- Improvement of operation and maintenance (O&M) system should be more prioritized than the facilities rehabilitation / expansion.

The Eritrean side, accordingly, requested JICA in October 2015 a technical cooperation (dispatching experts) on the improvement of management capacity of water supply information for the following objectives:

To institutionalize collecting precise data and storing information in order to secure proper operation and maintenance of the Asmara water supply.

The technical cooperation, namely, Asmara Water Supply Infrastructure (Data Collection and Management) Project (hereinafter referred to as "the Project") , was conducted by JICA from July to September 2016 at Asmara to develop the O&M capacity of the Asmara Water Supply and Sewerage Department (hereinafter referred to as "AWSSD"). The following are the main activities conducted during the technical cooperation:

- Water flow metering by ultrasonic flowmeters.
- Water quality monitoring at water treatment plants and dams.
- Daily recording and management of data.
- Improvement of daily operation procedures.
- Review and preparation of drawings.

During the technical cooperation activities, several issues were abstracted. According to the abstracted issues, JICA Expert Team prepared this document, titled "Recommended Plan for Operation & Maintenance". The expert team expects that the recommendation made will help AWSSD to improve its water supply activities. And JICA and JICA Expert Team appreciate every efforts of AWSSD for the Project.

1.2 Referred Information and Data

Since the Project period is limited to just two months, JICA Expert Team utilized the exiting information and data to prepare this document. The existing information is basically as follows:

- Report of the Preparatory Survey of Asmara Water Supply Development in the State of Eritrea, July 2015, JICA
- Answers of AWSSD to the Questionnaire for the above preparatory survey and for the Project
- AWSSD Annual Report 2015
- Data on operation of water supply facilities from July to September 2016.

1.3 Contents of Recommended Plan for Operation & Maintenance

The "Recommended Plan for Operation & Maintenance" contains mainly the following:

- Current Situations and Issues
- Urgent Plan for Operation & Maintenance
- Operation & Maintenance Plan in Further Stages

Chapter 2, "Current Situations and Issues", summarizes the existing O&M conditions, which are prepared based on the analysis of the existing information. The findings on the exiting conditions, including issues, were discussed by the Project Team (JICA Expert Team and AWSSD Counterpart Team) during the Project period.

Urgent issues that could be undertaken at lower costs are categorized in Chapter 3, under "Urgent Plan for Operation & Maintenance". The described plan is expected to be undertaken immediately by AWSSD. And most of the planned activities have been commenced in the Project period.

The issues requiring higher costs and / or certain preparation periods are categorized in Chapter 4 under "Operation & Maintenance Plan in Further Stages". The expected undertaking period for this plan is 3–5 years. The described activities / improvements should be further studied for feasibility as well as detail planning and budget preparation.

Since this document aims at improvement of O&M, all descriptions are based on the existing facilities. The recommendations do not include a large scale rehabilitation or a new construction of facilities.

Chapter 2: Current Situations and Issues

2.1 Basic Systems for Water Supply

2.1.1 Basic Systems for Water Supply

AWSSD distributes the water to the Asmara city by three systems, namely Stretta Vaudetto (hereinafter referred to as "S.V."), Toker and Mai Nefhi systems. The flows of water are illustrated in Figure 2.1.1 to Figure 2.1.3. Besides the piped water supply, AWSSD distributes the water through water tank trucks to the population not covered by the piped water supply networks.

2.1.2 Water Supply Situations

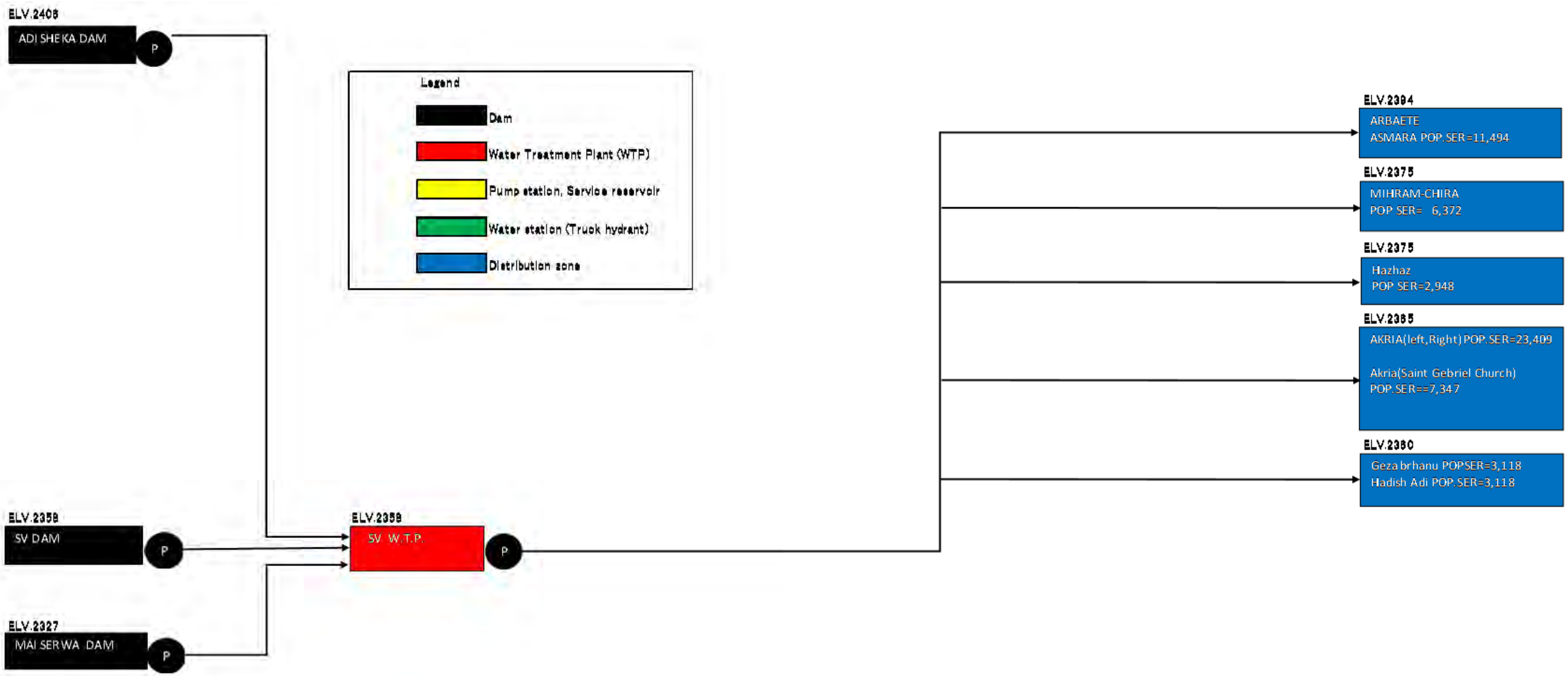
Basic water supply situations in 2015 are summarized in Table 2.1.1.

Table 2.1.1 Basic Water Supply Situation in 2015

No.	Item / Indicator	Value	Remark
1	Water Production in 2015		
1-1	S.V. WTP[1] (m^3/year)	519,100	1,422 m^3/d
1-2	Toker WTP (m^3/year)	2,561,000	7,016 m^3/d
1-3	Mai Nefhi WTP (m^3/year)	3,062,343	8,390 m^3/d
1-4	Total (m^3/year)	6,142,443	16,829 m^3/d
2	Water Distribution by Pipelines (m^3/year)	5,569,634	15,259 m^3/d
3	Water Distribution by Water Tank Trucks (m^3/year)	572,809	1,569 m^3/d
4	Water Consumption of Piped Water (m^3/year)	2,405,402	6,590 m^3/d
5 = 3 + 4	Billed Water Volume (m^3/year)	2,978,211	8,159 m^3/d
6 = 1 - 5	Non-revenue Water Volume (m^3/year)	3,164,232	8,669 m^3/d
7 = 6 / 1	Non-revenue Water Ratio (%)	52%	
8	Service Population (Population in service area)	427,429	39 LCD[2]
9	Number of Connections	34,203	

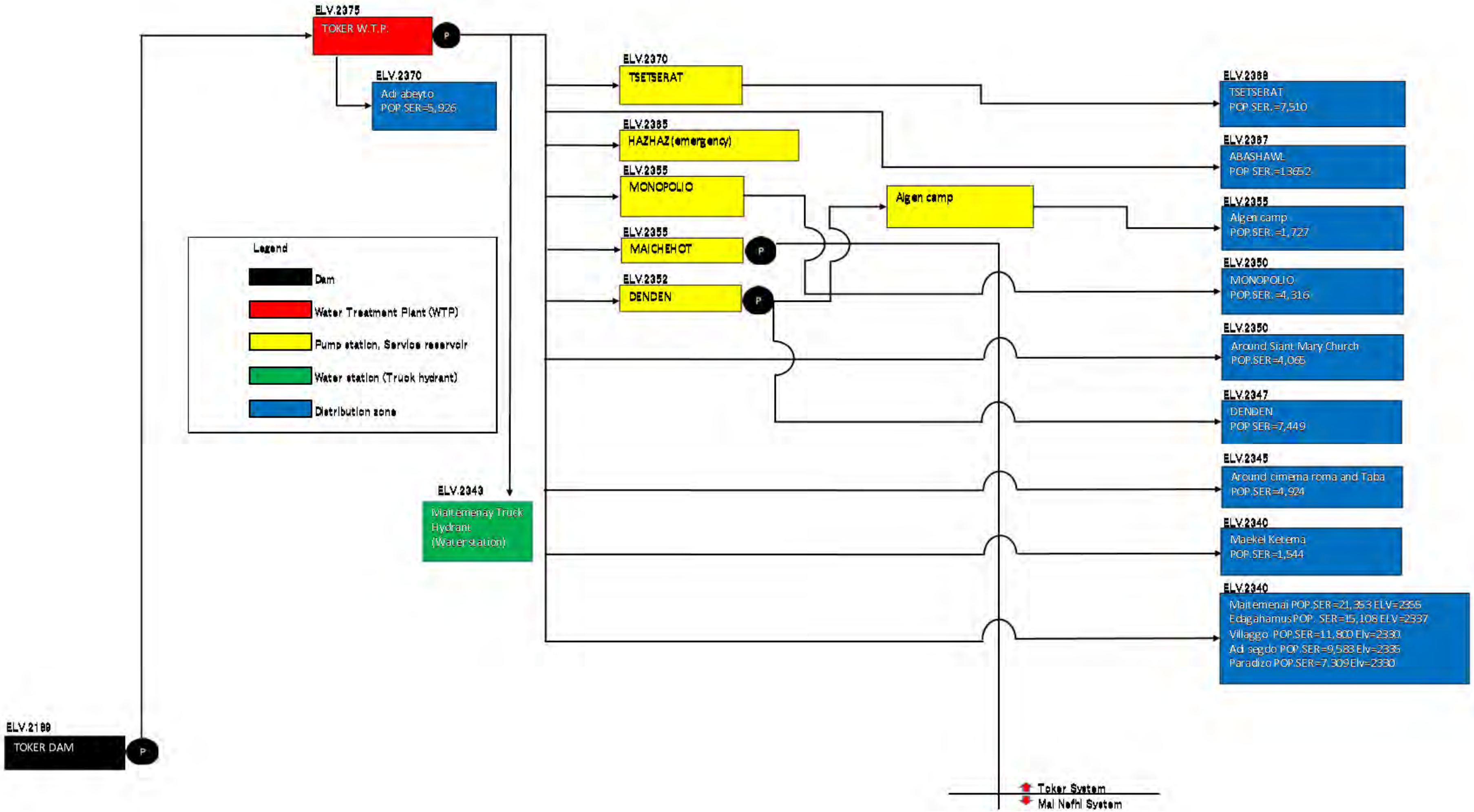
Source: AWSSD

[1] WTP: Water Treatment Plant
[2] LCD: Litter/Capita/Day



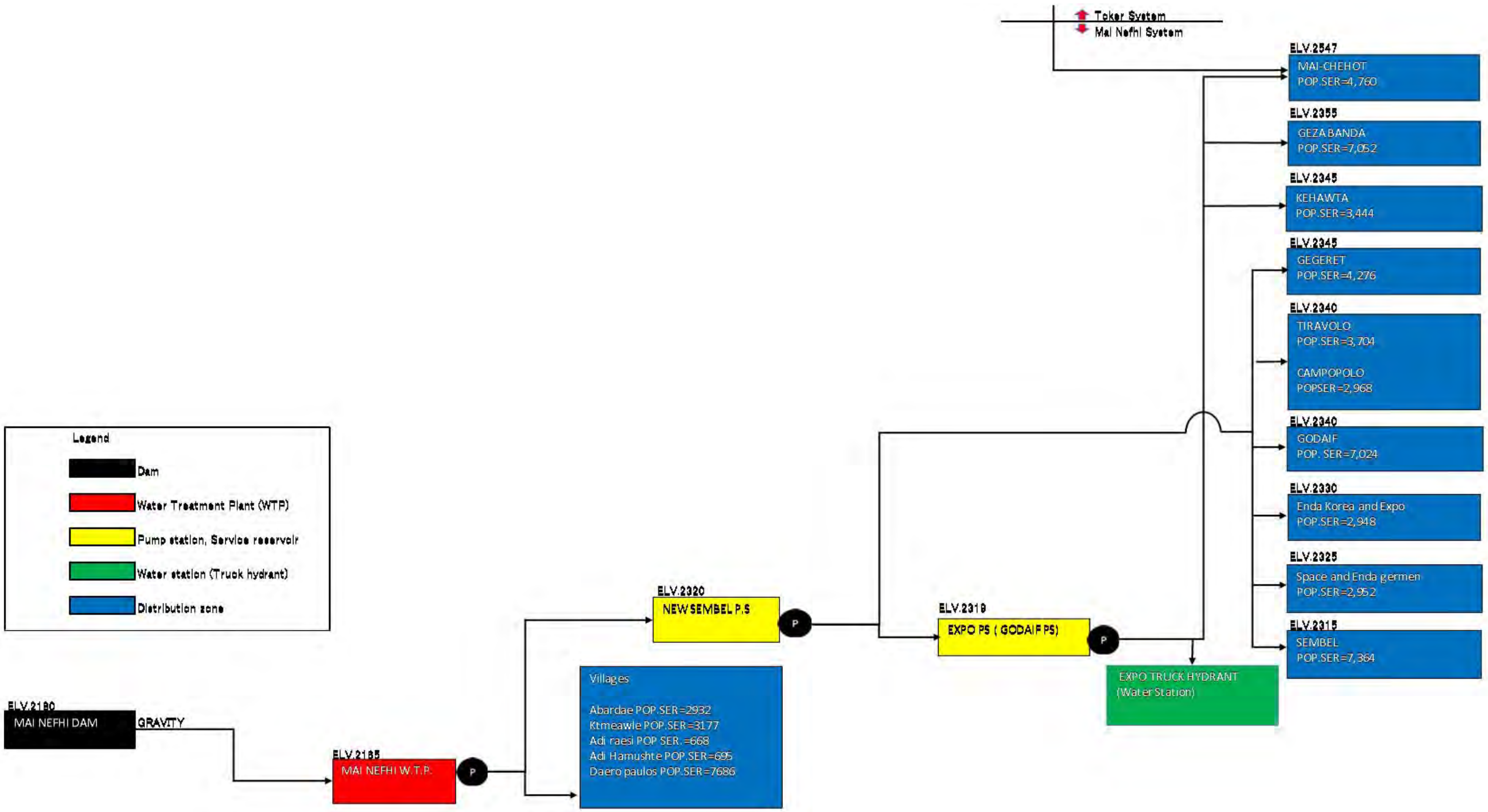
Source: The Project Team

Figure 2.1.1 Water Flow of S.V System



Source: The Project Team

Figure 2.1.2 Water Flow of Toker System



Source: The Project Team

Figure 2.1.3 Water Flow of Mai Nefhi System

2.2 Volumes of Water Production and Distribution

2.2.1 Service Population

No official estimation is available for the actual population of 2016. According to the last census (2015), the population in the water supply service zones was 427,429 (2015). Nevertheless, AWSSD believes that the actual population is a little less than the census estimate. AWSSD roughly estimates the current (2016) population in the water supply zones at 400,000 persons, and most of the population are supposed to be beneficiaries of AWSSD water supply activities.

Besides, the number of registered piped water supply connections is currently (2016) 35,483 as shown in Table 2.2.1. Considering the population and the number of connections, AWSSD estimated the service population as shown in Table 2.2.2.

Table 2.2.1 Number of Piped Supply Connections (2016)

Item	Number of Connection	Remark
1. Connection (Domestic, incl. village, users)	31,304	Observed population: 4 persons / normal connection 20 persons / shared residence
2. Connection (Commercial, incl. industrial and governmental, users)	2,899	
3. Total	35,483	

Source: Subscriber Information of AWSSD

Table 2.2.2 Estimated Service Population (2016)

WTP	Distribution Zone	Service Population		
		Total	By Pipe	By Truck
S.V.	Direct	400,000	50,459	189,588
Toker	Direct		87,955	
	Tsetserat		7,510	
	Monopolio		4,316	
	Denden		7,449	
	Algen Camp		1,727	
Mai Nefhi	Direct (villages)		7,472	
	New Sembel		28,268	
	Godaif		15,256	
Total			210,412	

Source: The Project Team, AWSSD

2.2.2 Water Demand

(1) Annual Report of AWSSD

According to the Annual Report of AWSSD (2015), and water billing data, the billed water in 2015 was 2,978,211 m^3/y (8,159 m^3/d) as shown in Table 2.2.3. The average water consumption simply calculated by the total volume and the census population (427,429 persons) is only 19 litter/capita/day (LCD).

Table 2.2.3 Billed Water Volume (2015)

Item	Volume (m^3/y)	Daily Average (m^3/d)
1. Connection (Domestic, incl. village, users)	1,579,693	4,328
2. Connection (Commercial, incl. industrial and governmental, users)	825,709	2,262
3. Water Tank Truck (AWSSD trucks)	83,266	228
4. Water Tank Truck (other organizations trucks)	489,543	1,341
5. Total	2,978,211	8,159

Source: Based on Annual Report of AWSSD (2015) and billing data for 2015

On the other hand, the water production estimated by AWSSD is much larger than the billed one. The water production estimated by AWSSD is 6,142,443 m^3/y (16,829 m^3/d) as shown in Table 2.2.4, showing unit water supply of 39 LCD. Since the National Water Supply Action Plan (2013-2017) targets a supply rate of 40 LCD for urban area, the present water production achieves nearly the target.

Table 2.2.4 Water Production (2015)

Item	Volume (m^3/y)	Daily Average (m^3/d)
1. S.V. WTP	519,100	1,422
2. Toker WTP	2,561,000	7,016
3. Mai Nefhi WTP	3,062,343	8,390
4. Total	6,142,443	16,829

Source: Based on Annual Report of AWSSD (2015)

(3) Verification of Water Intake, Water Production and Distribution

In parallel with the data collection and management improving activity, the Project team observed the water flow for water intake, production, distribution, etc. in order to verify the present (August 2016) water supply volume. The flow observation was conducted through clocking operation hours and verification of pumping capacity. Based on the acquired data, the water volumes produced and distributed are estimated as follows:

1) Water Level at Each Dam

The summary of water level at each dam is shown in Table 2.2.5, and main findings are summarized below:

- Average water level in Adi Sheka Dam was 11.4 m from the bottom of dam, which is above half of the maximum water depth. The water level was almost stable in August 2016.

- Average water level in Toker Dam was 17.6 m from the bottom of dam, which is 11 m higher than the lowest intake valve. The water level was slightly increasing in August 2016.
- Average water level in Mai Nefhi Dam was 17.1 m from the bottom of dam, which is approximately half of the maximum water depth. The water level was slightly increasing in August 2016.
- Water level in August 2016 is supposed to be the highest in a year because August is the end of rainy season. However, since the dams were not filled with water, water level and intake volume should be carefully monitored at each dam to confirm the capability of continuous water supply.

Table 2.2.5 Summary for Water Level of Dam (from Aug. 11 to Aug. 31)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Ave.	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	21	21	11.4	11.6	11.4	Max.=17.8m
Toker Dam	21	19	17.6	17.8	17.3	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	21	18	17.1	17.8	16.2	Max.=35m

Source: The Project Team

2) Water Intake Volume at Each Dam

The summary of intake volume at each dam is shown in Table 2.2.6, and main findings are summarized below:

- Average operation hours of intake pump were 6.9 hour/day at Adi Sheka Dam. The operation hours were, however, not stable in August 2016. The pump was out of service for 7 of the 21 observation days (in August 2016) due to mechanical problems and electric power outages.
- Intake pump of Toker Dam was operated for 7.7 hours/day on average, throughout the 21 observation days.
- Intake pump of May Nefhi Dam was not operated for 2 of the 21 observation days due to an electrical trouble in Sembel Pump Station. However, the average operation hours of the intake pump were 15 hours/day.
- In the 21-day period, 17,803m^3/day of water was withdrawn for Asmara water supply.

Table 2.2.6 Summary for Intake Volume from Dam (from Aug. 11 to Aug. 31)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day: Recorded	Working Day: Not Recorded	Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	21	13	1	7	6.9	10.4	3,461	500	12,007	Intake volume is estimated by water meter. Not work due to mechanical problem of pump from Aug.20 to Aug.25 and electric power outage in Aug 31.
Toker Dam	21	19	2	0	7.7	7.7	7,607	990	23,760	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not operated due to the problem of electric facility in Sembel PS from Aug.21 to Aug.22
Total							17,803			

Source: The Project Team

3) Water Production of Each Water Treatment Plant

The summary of water production at each WTP is shown in Table 2.2.7 and main findings are summarized below:

- S.V. WTP was out of service for 7 of the 21 observation days due to the stoppage of intake pump in Adi Sheka Dam. Therefore, average operation hours of water transmission pump were quite short, 5.5 hour/day.
- Tokor WTP was also out of service for 5 of 21 observation days due to power outage. Therefore, average operation hours of water transmission pump were quite short, 4.4 hour/day.
- Water transmission pump of Mai Nefhi WTP was out of service for 2 of the 21 observation days due to the distribution facility problem. WTP was operated at a water production rate of approximately 350m^3/hr, which was approximately 40% lower than the design capacity (833 m^3/hr or 20,000 m^3/day). The low production rate is supposed to be caused by inappropriate operation/maintenance of coagulation and sludge blanket.

Table 2.2.7 Summary for Water Production of Each WTP (from Aug. 11 to Aug. 31)

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	14	0	7	5.5	8.2	1,643	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr). Not work due to not receiving water from Aug.20 to Aug.25.
Tokor WTP	Adi Sheka Dam/Tokor Dam	21	14	2	5	4.4	5.6	2,217	500	12,000	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr). Not work due to not receiving water in Aug.18. Trasmission pump was stopped due to electric power outage in Aus.19, 20, 26 and 28.
							(By Gravity)	2,479			
							(Total)	4,696			
Mai Nefhi WTP	Mai Nefhi Dam	21	8	11	2	14.2	17.8	5,037	354	8,499	Water production volume is estimated by water meter. Not work due to electrical problem on New Sembel PS from Aug.21 to Aug.22.
Total								11,376			

Source: The Project Team

4) Water Distribution in Each Pump Station/Reservoir

The treated water of all water treatment plants, except S.V. WTP, is distributed through pump station (hereinafter referred to as “PS”) and / or service reservoir (hereinafter referred to as “RS”). The summary of water distribution volumes of PSs and / or RSs is shown in Table 2.2.8 and 2.2.9 for Toker and Mai Nefhi systems, respectively. The main findings of the analysis of water distribution at PSs and RSs are summarized below:

- PSs and RSs for Toker system were operated at less frequency according to water ration schedule of AWSSD. It is difficult for AWSSD to keep the ration schedule due to water shortage and frequent trouble of water intake pumps. As a result, some of PSs/RSs could distribute the water only once in 3 weeks in August 2016.
- PSs of Mai Nefhi system were basically operated every day, although there were sometimes interruptions due to electrical / mechanical problems of the PSs.

Table 2.2.8 Summary for Water Distribution of Pump Station and Service Reservoir

(Toker System from Aug. 11 to Aug. 31)

Name of Pump Station/Reservoir		Result of Operation							
		Number of Data Recorded					Averaged Flowrate per Day		Note.
		Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
			Recorded	Not Recorded	Not Scheduled	as Scheduled			
		Days	Days	Days	Days	Days	m^3/day	m^3/day	
Denden PS	To Algene Camp	21	0	8	3	10	-	-	・Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) ・Not work due to not receiving water from Tokor WTP from Aug.22 to Aug.24. ・There are no recorded data of the transmission volume for Algena Camp because the operator does not master how to record the operation yet.
	To Denden Camp	21	3	5	3	10	306	1,633	
Mai Chehot PS		21	1	0	2	18	32	675	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.30
Testserat Res.		21	6	4	0	11	20	56	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Monopolio Res.		21	3	0	18	0	15	103	Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.15 and Aug. 20 to Aug. 31.
Algena Camp		21	1	0	3	17	7	145	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Denden PS. From Aug.11 to August 21 and from Aug.23 to Aug.31

Source: The Project Team

Table 2.2.9 Summary for Water Distribution of Pump Station and Service Reservoir

(Mai Nefhi System from Aug. 11 to Aug. 31)

Name of Pump Station/Reservoir	Number of Data Recorded					Averaged Flowrate per Day		Note.
	Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
		Recorded	Not Recorded	Not Scheduled	as Scheduled			
	Days	Days	Days	Days	Days	m^3/day	m^3/day	
Sembel PS	21	17	2	2	0	2,860	3,197	Water production volume is estimated by water meter Not work due to electric facility problem from Aug.21 to Aug.22
Godaif PS	21	19	0	2	0	1,294	1,430	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water by electric facility problem in Sembel PS from Aug.21 to Aug.22

Source: The Project Team

5) Summary of Water Production and Distribution Conditions

The data obtained in August 2016 show that AWSSD produces 11,376m^3/d of water, while the intake volume is 17,803 m^3/d. The reason for the difference between intake and distribution volumes is not confirmed. The following, however, may be possible causes:

- Pumping capacities are not accurately known,

- Clocking and recording operation hours are not appropriately conducted,
- Although the raw water is conveyed to Toker WTP, which has a raw water regulating basin, the conveyed raw water is not immediately treated and reserved in the regulation pond,
- There are water losses between dams and WTPs.

Therefore, AWSSD should continuously monitor and verify water the flow rate.

The daily production volume is around 25% of design capacity as shown in Table 2.2.10, and it is around 30% less than that recorded in 2015. The main reasons, why actual water production was lower than the capacity, are supposed to be as follows:

- Mechanical and electrical problems of water intake pumps occurs frequently happened.
- Water transmission pumps suddenly and often stop because of electric power interruption.
- Water production rate is lower than design capacity in Mai Nefhi WTP due to operational problem of water treatment plant (coagulation and sludge blanket).
- Actual pumping outputs are less than the design capacities.

Table 2.2.10 Summary for Water Distribution of Pump Station and Service Reservoir

WTP	Capacity / Actual Production (m^3/d)		
	Design Capacity (24hrs operation)	Capacity in Scheduled Operation	Actual Output in August 2016
S.V. WTP	8,000	2,664 (8hrs)	1,643
Toker WTP	18,000	6,000 (8hrs)	4,696
Mai Nefhi WTP	20,000	20,000 (24hrs)	5,037
Total	46,000	28,664	11,376

Note: WTP are not able to be operable for 24 hours due to electricity interruption.

Source: The Project Team

(4) Water Allocation in Distribution Zones

Target volume of AWSSD is 50 LCD for piped water supply and 15 LCD for water tank truck distribution. Based on the aforementioned service population in 2016, the water demand and distributed volume are summarized in Table 2.2.11. The table indicates that AWSSD has met 85% of the water demand.

Table 2.2.11 Water Demand and Distributed Volume per Distribution Zone

WTP	Distribute Zone	Population			Water Demand (m^3/d)			Distribution (Aug 2016)	
		Total	By Pipe	By Truck	Pipe 50 LCD	Truck 15LCD	Total	(m^3/d)	% by demand
S.V.	Direct	400,000	50,459	189,588	2,523	2,844	13,365	11,376	85%
Toker	Direct		87,955		4,398				
	Tsetserat		7,510		376				
	Monopolio		4,316		216				
	Denden		7,449		372				
	Algen Camp		1,727		86				
Mai Nefhi	Direct (villages)		7,472		374				
	New Sembel		28,268		1,413				
	Godaif		15,256		763				
Total			210,412		10,521				

Source: The Project Team

(5) Non-revenue Water

As afore described in Table 2.1.1, non-revenue water (hereinafter referred to as "NRW") ratio reached 52% in 2015. Reasons of the high NRW ratio might be as follows:

1) The piped water customers are able to postpone their tariff payment for seven months. Billed data, therefore, does not indicate the precise consumption in a year. Nevertheless, it is a good indicator since the billed water volume ranged between 2.5 and 3.1 million m^3/y for the last 4 years.
2) Accuracy of customers' meters is low due to aging.
3) In low water pressure areas, water meters are insensitive to water flows.
4) Water production / distribution is calculated by pumping hours and not metered.
5) Due to aged pipeline networks, the distributed water may leak in the networks.
6) Although illegal connections are rarely observed (according to the experience of AWSSD), it may be still one of possible reasons for the high NRW ratio.

2.2.3 Water Flow Metering

Water production / distribution is not properly metered in the present. Even though some flowmeters are installed, most of them are out of use. As a result, AWSSD estimates the water flow based on pumping capacity and operation hours, although the pumping capacities have not been verified or calibrated. Table 2.2.12 shows the present metering points.

Table 2.2.12 Present Locations of Water Flow Meters

System	Location	Metering Points	Conditions
S.V.	Adi Sheka Dam	Outlet of raw water pump	Working
	S.V. WTP	Outlet of water transmission pump	Working
Toker	New Sembel PS	Outlet of water distribution pump	Working
	Mai Chehot PS	Outlet of water distribution pump	Working
Mai Nefhi	Mai Nefhi WTP	Outlet of water transmission pump	Working

Source: The Project Team

2.2.4 Issues on Water Distribution Management

The followings are for water distribution management issues.

(1) Gap between the production and the consumption volumes is very large. Reasons of the gap are not clearly confirmed. The verification / calibration of pumping capacities as well as verification of water meters on the costumer sides is necessary. Water flowmeters should be, therefore, installed at all significant points such as outlets of dam, inlet / outlet of WTP, inlet / outlet of pump stations and service reservoirs, and inlets of distribution zones.

(2) Volumes of water transmitted / distributed to the distribution zones are not managed properly. It results from shortage of production capacity against the potential demand and unstable electricity distribution. Nevertheless, AWSSD should clarify the water requirement per distribution zone as well as transmission / distribution volumes and manage the data to make problems clear. Immediately, AWSSD should make clear the water requirement per distribution zone and manage the pump operation according to the requirement as well as data analysis to clarify water distribution per capita. And in later stages, the production / distribution capacities should be improved (to satisfy the potential demand), along with electricity and metering instrument conditions.

(3) Leakage may be one of reasons for the gap between the production and the consumption volumes, since aged pipelines (over 40 years) have been still composed water supply networks. At first, water losses should be confirmed through the verification of the water production / distribution. In later stages, AWSSD should introduce a leakage management system according to district metering areas (hereinafter referred to as “DMAs”) as well as leak detection organizations.

(4) Due to aged pumping equipment, frequent repairs of pumps are observed. Since no spare pumping system is available, scheduled water distribution becomes difficult in case of pumps break-downs. Replacement of pumping equipment and / or installation of spare pumps is necessary to secure stable water distribution.

2.3 Water Quality

2.3.1 Present System for Water Quality Management

(1) Monitoring Equipment and Laboratory

AWSSD has no laboratory in its headquarters. The water quality should be, accordingly, monitored / managed at WTPs. However, the existing equipment in WTPs has not operable for many years, besides being not sufficient. The water quality has not been monitored on daily basis. The Project, therefore, procured the equipment for monitoring basic water quality parameters. The current condition of the equipment at WTPs and dams is as shown in Table 2.3.1.

Table 2.3.1 Current Condition of the Equipment for Water Quality

Location	Exiting Equipment (Not operable)		Procured by the Project (Operable)
	Item	Condition	
S.V. WTP	No equipment	N/A	1 set of turbidity meter 1 set of residual chlorine meter 1 set of pH / EC meter 1 set of coliform / bacteria detector
Toker WTP	1 set of jar tester 1 set of titration device for alkalinity analysis 1 set of turbidity meter 1 set of residual chlorine meter 1 set of pH meter	The equipment has not been utilized for a long time. The equipment does not function well.	1 set of turbidity meter 1 set of residual chlorine meter 1 set of pH / EC meter 1 set of coliform / bacteria detector
Mai Nefhi WTP	1 set of jar tester	The equipment has not been utilized for a long time. The equipment does not function well.	1 set of turbidity meter 1 set of residual chlorine meter 1 set of pH / EC meter 1 set of coliform / bacteria detector
Mai Serwa Dam	No equipment	N/A	1 set of turbidity meter 1 set of pH / EC meter
Toker Dam	No equipment	N/A	1 set of turbidity meter 1 set of pH / EC meter

Source: The Project Team

(2) Laboratory in Water Resources Department of Ministry of Land, Water and Environment

Water Resources Department of Ministry of Land, Water and Environment has a laboratory for basic water quality parameters. It has been used as a reference laboratory to check the water quality periodically, about once per year.

(3) Water Quality Monitoring at Service Reservoirs and Distribution Networks

There is no system for periodical monitoring of the water quality at service reservoirs and distribution networks.

2.3.2 Confirmed Water Quality at Dams and WTPs

The Project team checked the water quality in August 2016, and the result is shown in Table 2.3.2. Since turbidity of the treated water is more than 5 NTU, it does not satisfy the drinking water standards.

Table 2.3.2 Summary of Water Quality in August 2016

Sample	Parameter		S.V. WTP				Toker WTP				Mai Nefhi WTP			
			No. of Data	Ave.	Max.	Min.	No. of Data	Ave.	Max.	Min.	No. of Data	Ave.	Max.	Min.
Raw Water	Temperature	℃	7	20.3	24.6	18.5	19	18.1	20.4	17.0	5	21.6	23.5	20.1
	pH	-	5	8.0	8.5	6.3	19	7.4	8.0	7.0	17	6.8	8.1	4.3
	Electrical Conductivity	uS/cm	6	246	270	225	19	186	245	167	17	233	504	149
	Turbidity	NTU	7	57.4	78.2	28.9	19	>172	>1000	12.6	17	>375	>1000	81
	Color	-	7	-	-	-	19	-	-	-	17	-	-	-
	Smell	-	7	-	-	-	19	-	-	-	17	-	-	-
Treated Water	Temperature	℃	7	20.3	22.2	19.1	18	18.7	21.3	17.1	5	21.5	23.5	20.3
	pH	-	7	7.7	8.2	6.7	18	7.2	7.4	6.8	17	6.8	7.7	5.7
	Electrical Conductivity	uS/cm	7	228	249	187	18	187	244	167	17	183	213	150
	Turbidity	NTU	7	18.7	28.6	11.7	18	55.8	86.3	17.3	17	>221	>1000	40
	Color	-	6	-	-	-	18	-	-	-	17	-	-	-
	Smell	-	7	-	-	-	18	-	-	-	17	-	-	-
	Residual Chlorine (Free)	mg/L	0	-	0.0	0.0	18	0.6	2.2	0.0	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	0	-	0.0	0.0	18	0.6	2.2	0.0	17	1.7	8.8	0.0

Source: The Project Team

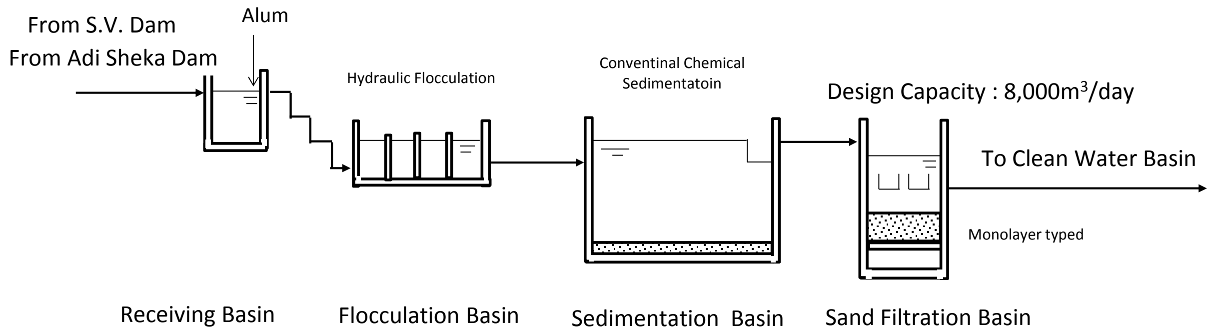
Major findings on water quality are as follows:

- Turbidity of raw water in S.V WTP, Toker WTP and Mai Nefhi WTP was more than 50 NTU. Appropriate water treatment management as well as chemical sedimentation is necessary. It is remarkable that a turbidity of more than 1,000 NTU was recorded for raw water of Toker WTP and Mai Nefhi WTP.
- When turbidity as high as 1,000 NTU is detected at water source, water intake should be suspended.
- Main reason of high turbidity of treated water is inappropriate management of chemical coagulation and sedimentation.
- Residual chlorine in treated water fluctuates in Toker WTP and Mai Nefhi WTP since the chlorine gas is directly injected into the clear water basin without gas flow controller. Regarding S.V. WTP, the operators do not dose the chlorine gas.

2.3.3 Operation of WTPs

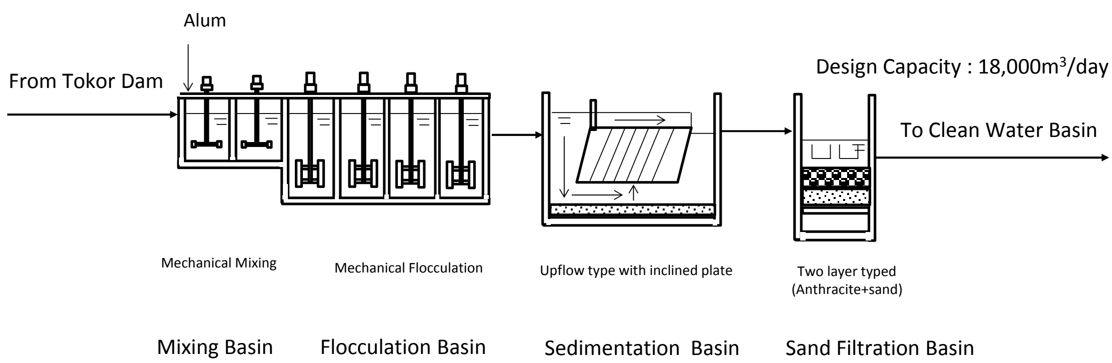
(1) Treatment Process

Treatment process of water at S.V., Toker and Mai Nefhi WTPs is illustrated in Figure 2.3.1, 2.3.2 and 2.3.3, respectively.



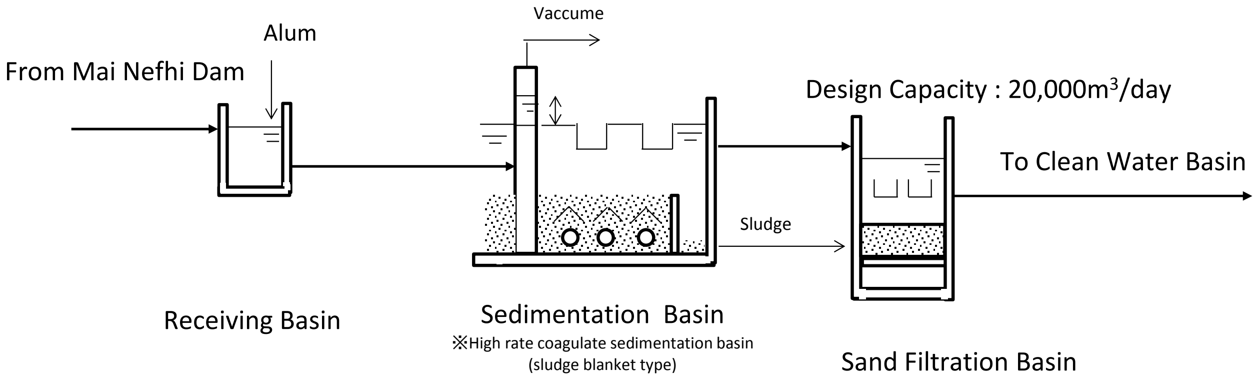
Source: The Project Team

Figure 2.3.1 Treatment Process at S.V. WTP



Source: The Project Team

Figure 2.3.2 Treatment Process at Toker WTP



Source: The Project Team

Figure 2.3.3 Treatment Process at Mai Nefhi WTP

(2) Chemical Dosing

The facilities for chemical dosing have broken down. Coagulant (aluminum sulfate, hereinafter referred to as “alum”) and chlorine, therefore, have been dosed as shown in Table 2.3.3.

Table 2.3.3 Present Methods for Chemical Dosing

Chemical	S.V. WTP	Toker WTP	Mai Nefhi WTP
Coagulant (alum)	Solid alum is thrown into the receiving basin twice per day. Dosing volume is not determined by raw water quality / volume.		
Chlorine	Chlorine gas is injected directly in the clear water basin by a hose. Dosing volume is not controlled.		Chlorine gas is injected directly in the receiving basin by a hose. It is considered as pre chlorination. Post chlorination is not conducted. Dosing volume is not controlled.

Source: The Project Team

(3) Flocculation

Since the coagulant is not dosed and mixed appropriately, flocs are not grown in the flocculation basin. Moreover, the following conditions of facilities are also causes of inappropriate flocculation:

- In Toker WTP, flash mixers and flocculaters are not properly working. Therefore, appropriate flocculation is not expected.
- In Mai Nefhi WTP, pulsator is out of use. As a result, appropriate flocculation is not expected.

(4) Sedimentation

Since the flocculation is not sufficient, little effect of sedimentation is observed. The water after sedimentation is almost same as raw water in turbidity. Moreover, cleaning and sludge removal are not done properly.

In Mai Nefhi WTP, the recycled water from loss-water drainage is fed to the sedimentation basin directly. Since the water contains no coagulant, appropriate flocculation is not expected.

(5) Sand Filtering

Since the effect of sedimentation is little, large loads on sand filters are observed. The filters, however, are not cleaned frequently.

(6) Clear Water Basin

No frequent cleaning is provided for clear water basins. Sludge is accumulated in the basins. Since the chlorine gas is injected in the basins, the accumulated sludge swirls up. Accordingly, the treated water may be more turbid in the clear water basins.

2.3.4 Issues on Water Quality Management

The water distribution management issues are as follows:

(1) Although financial preparation is necessary, the WTPs should be repaired / rehabilitated, especially the chemical dosing system and flocculation system in a long term. When a complete repair of the chemical dosing system is difficult, simple / manual systems should be installed for chemical dosing. However, it is urgently required to control the chemical volumes along with frequent monitoring of treated water quality.

(2) Daily monitoring of water quality should be conducted urgently at not only WTPs but also dams. And water quality at service reservoirs and distribution networks should be monitored periodically by AWSSD to ensure the distributed water quality. In parallel, such monitoring data should be recorded daily and confirmed by management staffs at headquarters.

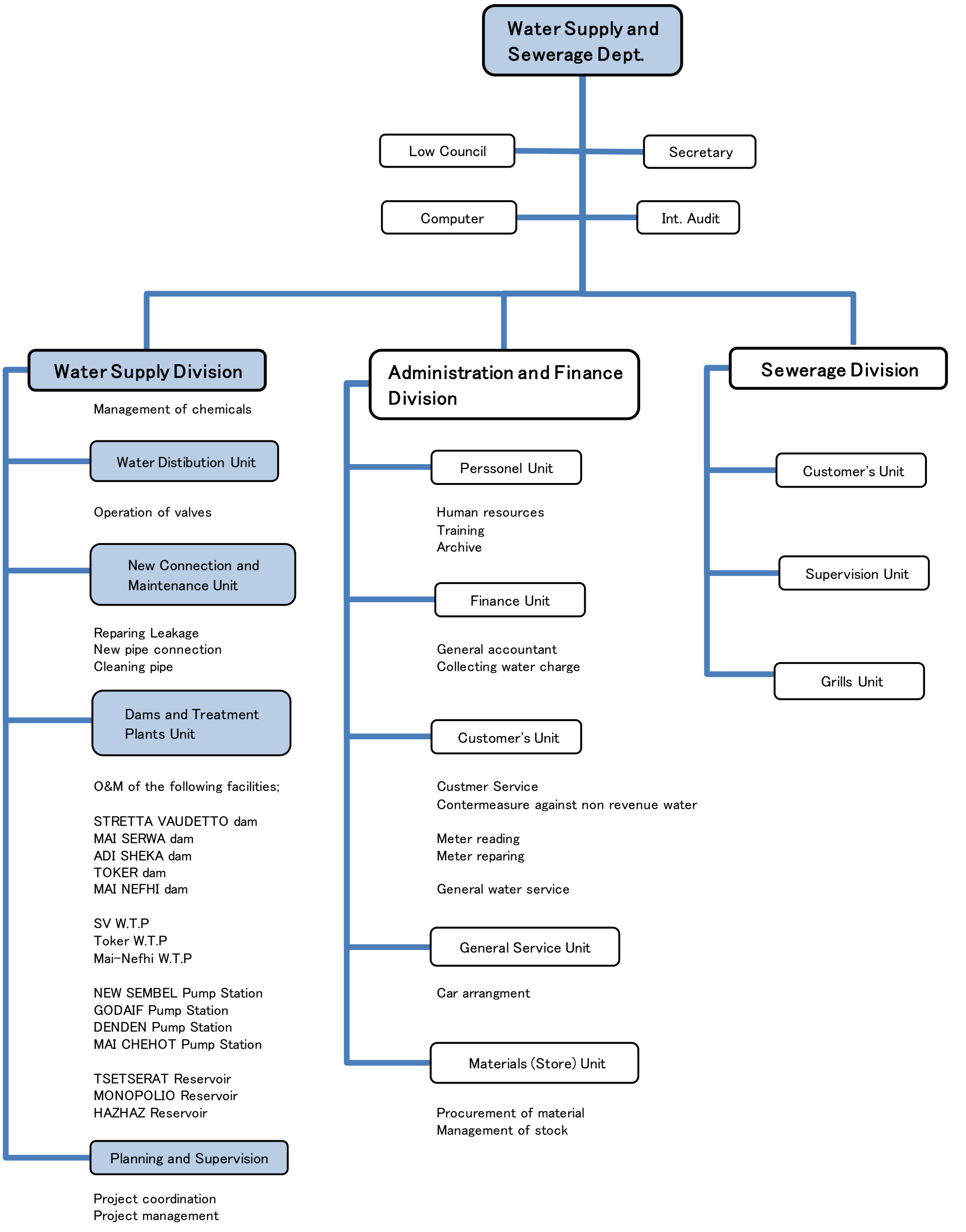
2.4 Organization and Finance

2.4.1 Organization

(1) Organization Chart and Number of Staff Members

AWSSD consists of three divisions as shown in Figure 2.4.1. Operation of water supply is mainly conducted by “Water Distribution Unit” and “Dams and Treatment Plants Unit”. Number of staff members for water supply is shown in Table 2.4.1 and Table 2.4.2.

AWSSD Organizational Chart



Source: JICA Preparatory Survey on the Project for Asmara Water Supply Development and Confirmed by AWSSD

Figure 2.4.1 Organization Chart of AWSSD

Table 2.4.1 Number of Staff Members in AWSSD

	Permanent Staff	Contract Staff	National Service	Total
Water Supply and Sewerage Dept	**1**	**-**	**1**	**2**
Dept Head	1	-	1	2
Water Supply Division	**39**	**162**	**64**	**265**
Division head	1	-	7	8
Water Distribution Unit	2	1	2	5
New Connection and Maintenance Unit	13	34	18	65
Dams and Treatment Plants Unit	23	127	25	175
Planning and Supervision Unit	-	-	12	12
Administration and Finance Division	**29**	**38**	**55**	**122**
Division Head	1	-	-	1
Finance Unit	3	3	6	12
Customer's Unit	15	14	25	54
General Service Unit	4	13	3	20
Materials (Store) Unit	2	8	5	15
Personal Unit	4	-	16	20
Sewerage Division	**7**	**9**	**19**	**35**
Division Head	1	-	3	4
Customer's Unit	3	-	9	12
Supervision Unit	-	-	6	6
Grills Unit	3	9	1	13
Total	**76**	**209**	**139**	**424**

Source: AWSSD

Table 2.4.2 Number of Staff Members working in Water Supply Facilities

Facility	Member	Number of Staff
Dam		
S. V. Dam	Operated by staff of S.V WTP	
Mai Serwa Dam	Including operation of intake pump (Worker: 3, Security: 1)	4
Adi Sheka Dam	Including operation of intake pump (Worker: 3, Security: 1, Gardening: 1, Channel Cleaning: 29)	34
Toker Dam	Including operation of intake pump (Operator: 8 (4×2 shifts), Security: 12)	20
Mai Nefhi Dam	Operated by staff of Mai Nefhi WTP	
WTP		
Toker WTP	Chief Engineer: 1, Worker: 12, Chemical: 6, Security: 4, Cleaning: 3, Others: 7	33
S. V. WTP	Chief Engineer: 1, Worker: 14, Security: 2, Cleaning: 4, Others: 7	28
Mai Nefhi WTP	Chief Engineer: 1, Worker: 8 (4×2 shifts) , Security: 9, Water station: 1	19
Pump Station		
New Sembel Pump Station		12
Godaif Pump Station		6
Denden Pump Station		6
Mai Chehot Pump Station		7
Reservoir		
TsetseraT Reservoir		3
Monopolio Reservoir		-
Hazhaz Reservoir		1
Water Station		
EXPO Water Station		3
Maitemenai Water station		3
Sembel Water Station	For emergency	
Mai Nefhi Water Station	Operated by staff of Mai Nefhi WTP	1

Source: AWSSD

(2) Organization Issues

1) Daily data management system is not available, and there is no unit/section for water flow and water quality management. Therefore, daily performance of water treatment and distribution is not recorded and evaluated properly. Although WTPs and pump stations record the operation hours and water production, the data are not verified and integrated properly. Data management system should be established urgently.

2) "Dams and Treatment Plants Unit" and "Planning and Supervision Unit" are not officially organized in AWSSD. Nevertheless, they function practically as unit. To make responsibilities clear, the units should be officialized urgently.

3) There is no laboratory in the headquarters to verify the water quality analyzed in WTPs as well as a system to supervise the water quality management of WTPs. Water quality management unit should be established urgently and it should be equipped with a central laboratory and additional equipment in later stages.

2.4.2 Finance

(1) Revenue and Expenditure

Operation and maintenance should be sustained by tariff revenues, connection fees, etc. No subsidy is expected from the Central Government / Zoba administration. As shown in Table 2.4.3, the expenditure sometimes exceeds the revenue. In such cases, AWSSD covers the shortage by the savings generated in previous years. Since only little amount is saved, it is difficult to secure enough budgets for major rehabilitation or construction of new facilities. Therefore, major rehabilitation or construction of new facilities is conducted by the Central Government.

Table 2.4.3 Revenue and Expenditure of AWSSD

Items		Amount (thousand Nakfa)			
		2012	2013	2014	2015 tentative
Revenue	Billed water (domestic & governmental)	23,323	23,155	20,693	21,116
	Billed water (commercial)	13,304	12,678	11,665	14,459
	Billed water (water tank truck)	2,785	2,499	2,208	5,553
	Water / sewer connection, penalty, etc.	9,959	33,609	44,745	22,282
	Adjustment for over expenditure, etc.	43	37	4,450	
	Others	2,231	2,615	3,003	999
	Total	**51,645**	**74,593**	**86,764**	**64,409**
Expenditure	Personnel	6,769	6,892	6,113	6,623
	Electricity	13,028	8,070	7,286	15,609
	Fuel for Toker Dam pump	24,941	17,288	16,978	34,982
	Fuel for water tank truck	861	1,159	1,039	2,863
	Chemicals	266	1,244	1,253	
	Connection works	1,639	3,585	13,266	9,145
	Maintenance / repair	2,773	2,462	3,889	1,599
	Others	1,731	2,304	3,835	2,491
	Total	**52,008**	**43,004**	**53,659**	**73,312**

Source: AWSSD and Answers to Questionnaire submitted in Preparatory Survey on the Project for Asmara Water Supply Development

(2) Water Tariff

The present water tariff is shown in Table 2.4.4. The present tariff has not been modified since 2003. Considering the present price increase trend, a tariff improvement may be necessary. Nevertheless, AWSSD cannot revise the tariff by its own decision since the revision has to be approved by the Central Government.

Table 2.4.4 Water Tariff (Nakfa / month)

Tariff		Zone 1 (High income area)	Zone 2 (Middle income area)	Zone 3 (Low income area)	Commercial, Industrial & Governmental Areas
Meter rent		50	40	30	50
Unit price per m^3	1–10 m^3	5	4	3	15
	10–20 m^3	7.5	5	4	20
	20–30 m^3	10	7.5	5	20
	30–50 m^3	15	10	7.5	20
	> 50m^3	20	15	10	20

Source: AWSSD

(3) Unit Cost of Water and Non-revenue Water

According to the estimation by AWSSD for water production and billed water, unit cost of water and NRW ratio are calculated as shown in Table 2.4.5. The following issues, which are related to the high NRW ratio, are observed:

1) Cost recovery by the tariff income is difficult. Additional incomes, such as new house connection works, cover the shortage.
2) Although the water production as high as 40 LCD, the unit water consumption is estimated at 20 LCD or less. Efficiency of water and production cost is very low.
3) Water volume produced is not metered. Verification/improvement of the water volume estimation methods are necessary.

Table 2.4.5 Unit Cost of Water and NRW Ratio

Items	2012	2013	2014	2015
Annual Expenditure (thousand Nakfa)	52,008	43,004	53,659	73,312
Water Production (thousand m^3)	7,461	8,710	6,660	6,142
Cost of water production (Nakfa/m^3)	6.97	4.94	8.06	11.94
Billed Water (thousand m^3)	2,797	3,157	2,454	2,978
Cost of billed water (Nakfa/m^3)	18.59	13.62	21.87	24.62
NRW ratio	63%	64%	63%	52%

Note: NRW ratio = (Water Production - Billed water) / Water Production (%)

Source: AWSSD and Answers to Questionnaire submitted in Preparatory Survey on the Project for Asmara Water Supply Development

(4) Finance Issues

1) AWSSD should urgently improve the system for estimating the water production/distribution/ consumption volumes to grasp properly water supply conditions. According to the data, re-evaluation on unit cost as well as tariff rate should be conducted for further financial improvement.
2) NRW reduction activities as well as leakage management should be conducted. To conduct these activities, arrangement of water flowmeters, proper distribution zoning, leak detection equipment, an exclusive team are necessary.
3) Along with the unit production cost analysis, the water tariff table should be improved to recover the operation and maintenance cost appropriately. Ideally, the water tariff should be improved so that it covers the rehabilitation/construction costs of facilities.

2.5 Maintenance of Facilities and Procurement of Consumables, Spare Parts and Repairs

2.5.1 Maintenance Conditions for Facilities

In general preventive maintenance is not conducted. Maintenance and repair are conducted after break-downs of facilities/devices. It is rare to replace devices and critical parts before the break-down. The following are observed in the maintenance activities:

1) Leakage from pumps and valves are not repaired.
2) Daily inspections and repairs of pumps are not conducted for noise, temperature, leakage, etc.
3) Electricity meters such as voltmeter and ammeter are broken and not repaired.
4) Flowmeters and pressure gauges are broken and not repaired.
5) Chemical injection devices are broken and not repaired.

2.5.2 Procurement Procedures and Present Conditions

(1) Repairs

Small scale repairs are conducted directly by AWSSD staff members. Repairs are outsourced to contractors when they are beyond the capacity of AWSSD staff members. The contractors are selected through bidding process. In general, the contractors are not permitted to import material from foreign countries. The contractors, therefore, request AWSSD to import materials when necessary.

(2) Material Procurement Procedure

Site staff members request the Head of the Water Supply Division to provide all necessary materials, including consumables at working sites. When the necessary materials are not stocked in the stores of AWSSD, procurement procedures are taken by the Head of the Water Supply Division. The materials are procured from material suppliers/factories through bidding process. In case the materials are not available in the local market, AWSSD orders them from foreign agents/manufacturers. The procurement from foreign agents/manufacturers takes several months, and this makes the repair period longer.

(3) Stock in Stores

Major piping materials, alum and chlorine are stocked in stores of AWSSD, and they are replenished as required. However, electrical/mechanical parts are not stored, and they are procured for each repair.

(4) Consumables for Water Quality Analysis

Since no water quality analysis is currently conducted, no method for procurement of related consumables has been established in AWSSD.

2.5.3 Issues on Maintenance and Procurement of Materials and Spare Parts

(1) Along with financial preparation, AWSSD should establish a system to stock mechanical/electrical spare parts, as well as stand-by devices, in the stores for major and critical equipment for continuous water supply, especially materials that have to be ordered from foreign agents/manufacturers. This is important to reduce the repairing period of water production/distribution systems.

(2) Daily monitoring of water quality is urgently required. To continue the monitoring activities started by the Project, AWSSD should establish regular procurement system of consumables for water quality analysis. The system establishment should be completed urgently.

(3) The preventive maintenance system should be introduced in AWSSD. To achieve this, AWSSD should have a periodical inspection and maintenance (including parts replacement) schedule as well as enough stocks of spare parts.

Chapter 3: Urgent Plan for Operation & Maintenance

3.1 Basis of Urgent Plan

The plans described in this Chapter 3 are recommended based on the following:

- To utilize the existing facilities.
- To be undertaken immediately.

3.2 Water Production and Distribution Management

3.2.1 Water Demand Calculation

Water demand should be annually calculated and determined as a target for water production and distribution. The calculated demands should be based on the water volumes to be delivered to water distribution zones. The calculation procedures should be as follows:

(1) Service Population in Water Distribution Zones

The service population of the piped water supply systems should be estimated in the following steps:

1) Make the distribution zones clear.
2) Check the registered population at Zoba administration.
3) Check the number of subscribers (number of meters) by distribution zone.
4) Determine the estimated population per distribution zone for the piped water supply, using the registered population and number of subscribers.
5) Determine the estimated population per distribution zone for the non-piped water supply (supply by water tank trucks), using the service population of piped water supply.

(2) Water Demand in Water Distribution Zones

According to the service populations, the demand (requirement of the citizens) should be calculated by the following formula:

Demand = “Service population” x “Planned Unit Water Distribution per Capita per Day”

Since the citizens utilize groundwater/rainwater in addition to bottled water, it is difficult to precisely estimate the potential water demand. Therefore, the planned unit water distribution per capita per day is provisionally provided by AWSSD as shown in Table 3.2.1. Nevertheless, the units should be upgraded and revised along with improvements of water production/distribution capacities and the requirement of citizens.

Table 3.2.1 Planned Unit Water Distribution

Category	Target
For piped water supply	50 LCD
For water tank truck supply	15 LCD

Source: AWSSD

3.2.2 Flow Metering and Recording

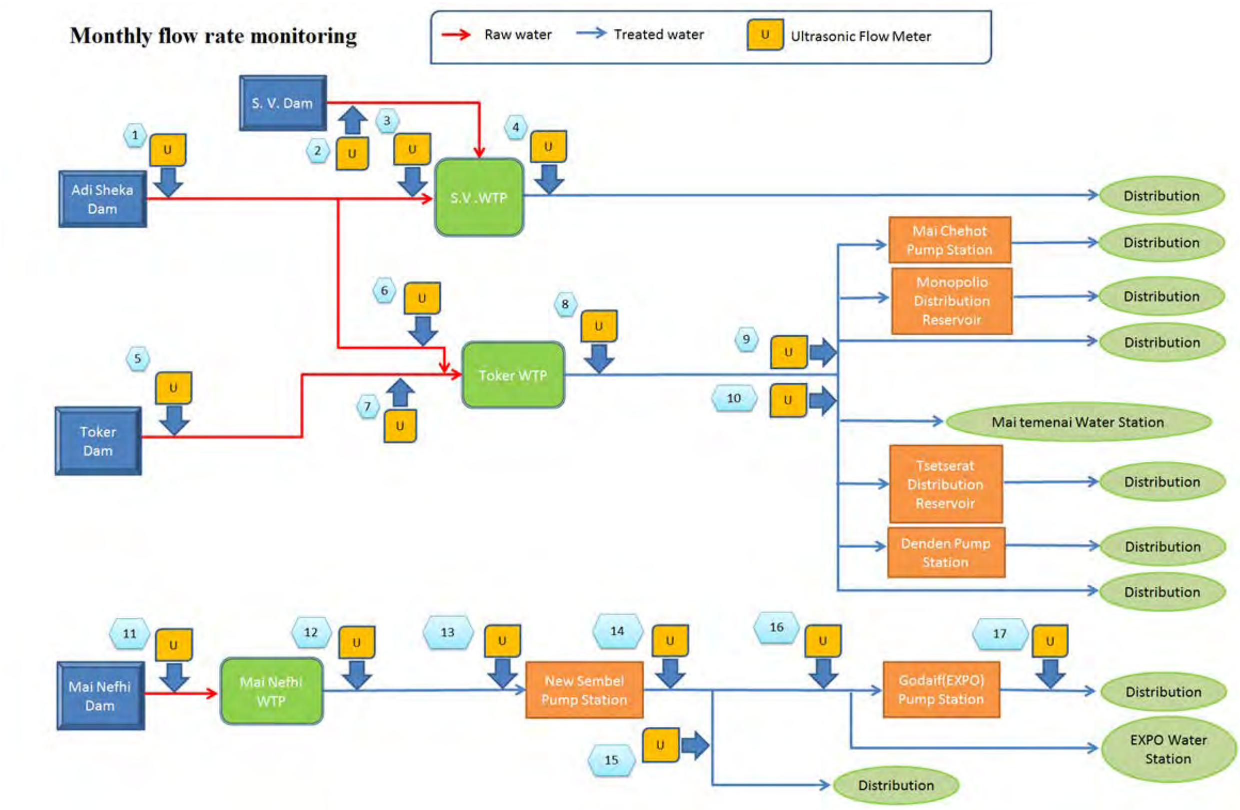
(1) Daily Recording of Water Flow

Water flow should be recorded daily at major facilities such as dams, WTPs, pump stations and service reservoirs. The recording activities should be conducted by the staff members of each facility. Since water flowmeters are not appropriately and permanently installed at the facilities, the operation conditions or estimated water flows should be recorded in the forms (Annex A-4). The estimation methods are basically as follows:

1) Reading the exiting meters.
2) Calculating based on the pumping capacity and operation hours.
3) Calculating based on the overflowing depth of weir.
4) Calculating based on water level decrease (or increase) of water reservoir.

(2) Verification of Estimated Water Flows

As aforementioned, water flows should be estimated and recorded daily. To verify the estimated flow, AWSSD should examine the estimation periodically with ultrasonic water flowmeters. The locations to be metered with ultrasonic water flowmeters are shown in Figure 3.2.1.



Source: The Project Team

Figure 3.2.1 Water Flow Metering Locations

The estimated flow rates until the beginning of September 2016, which have been verified, are shown in Annex A-6.

3.2.3 Water Level Monitoring at Service Reservoir

As well as the operation conditions to estimate the water flow, the water level should be metered at the service reservoir to facilitate the estimation of water flow rate. The metering should be conducted daily according to Annex A-4.

3.2.4 Water Volume Recording for Water Tank Trucks

The water volumes distributed to water stations for the water tank trucks are not metered at WTPs, pump stations and service reservoirs. Therefore, they should be recorded daily at each water station through the number of trucks. As for daily recordings, the present form is enough for the water volume estimation.

3.2.5 Daily Data Management for Water Production/Distribution Flow

(1) Management of Recorded Data

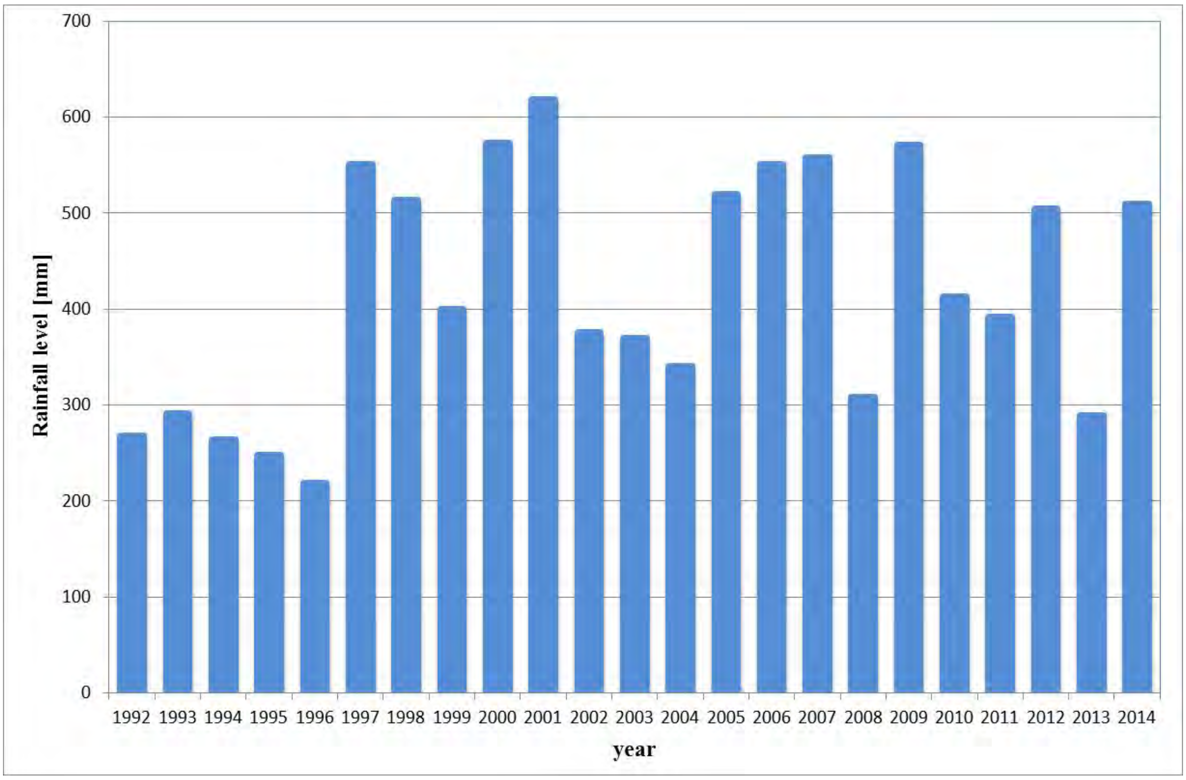
The recorded water flow/volume should be collected by the Planning & Supervision Unit of each dam, WTP, pump station, service reservoir and water station. The record should be collected at least once per week. The Planning & Supervision Unit, then, analyzes and summarizes the daily data according to Annex A-2, so that the basic water flow/volume is confirmed by the top management of AWSSD. The data should be further summarized by month and by year according to Annex A-2. The data, as well as summary sheets and recording form at each facility, should be stored in the Planning & Supervision Unit and should be ready always for information disclosure to related persons and organizations.

When summarizing daily data, the following tasks should be undertaken to get more practical figures:

1) Confirming appropriateness of recorded operation hours.
2) Checking irregularities of water flow rate/volume and their causes.
3) Checking contradictions in pumping capacity, operation hours, water level of service reservoir, electricity distribution hours, etc.

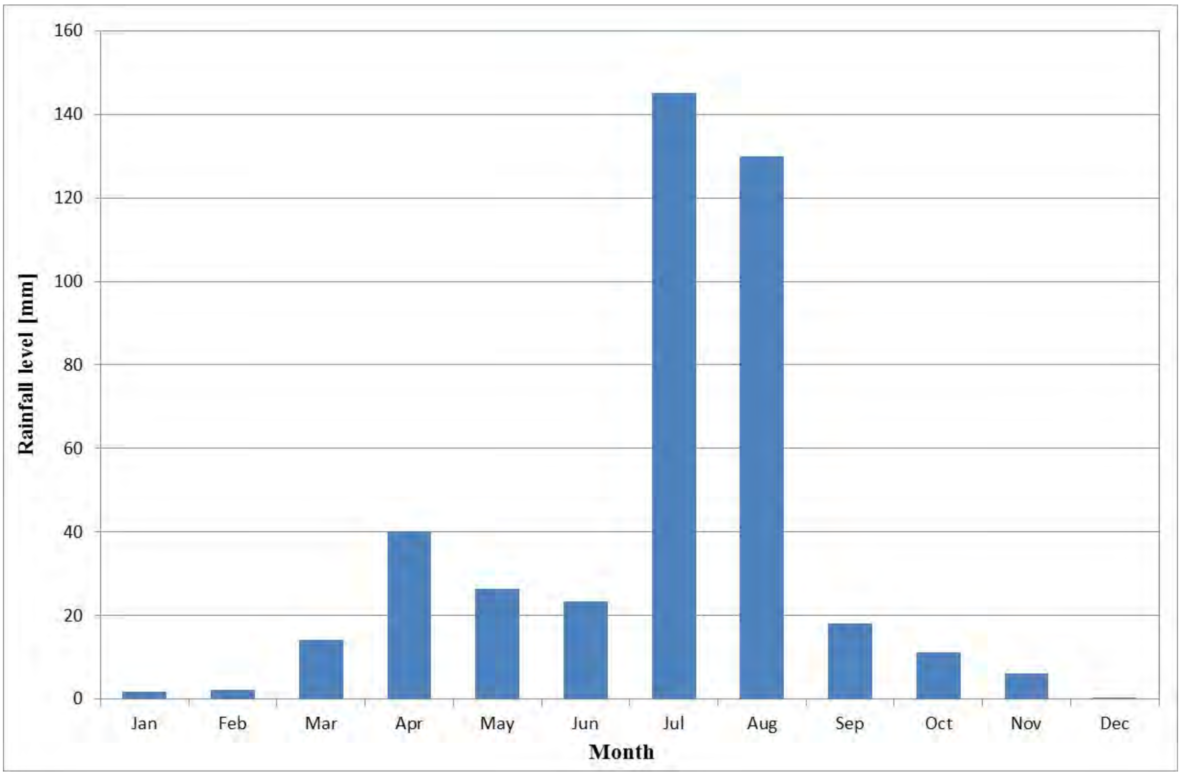
(3) Management for Rainfall Data

In 2016, the water distribution conditions were affected by the water shortage in dams' reservoirs. To forecast the water availability and capability of water intake volume, the rainfall data should be also managed by AWSSD. The data for the last 30 years should be obtained and summarized as shown in Figure 3.2.2 and 3.2.3 to facilitate the forecasting activity.



Source: The Project Team based on JICA Preparatory Survey on the Project for Asmara Water Supply Development

Figure 3.2.2 Summary of Annual Rainfall Trend (1992–2014 in Asmara)



Source: The Project Team based on JICA Preparatory Survey on the Project for Asmara Water Supply Development

Figure 3.2.3 Summary of Monthly Average Rainfall (1992–2014 in Asmara)

(4) Record of Repairs

The Planning & Supervision Unit should summarize the records of the repairs annually as shown in Table 3.2.2. It will be helpful to make a plan for replacement and for periodical maintenance.

Table 3.2.2 Example of Record of Repairs.

Facility	Damaged Device	Damaged Date	Repaired Date	Repairing Factory	Cost	Remark
S.V dam	Intake pump	DD/MM/YY	DD/MM/YY	XXX company	100,000 Nkf	Shaft replacement
S.V WTP	Transmission pump	DD/MM/YY	DD/MM/YY	AWSSD workshop	10,000 Nkf	Gasket replacement

Source: The Project Team

(5) Management as Performance Indicators

The data should be further and annually analyzed as performance indicator (hereinafter referred to as "PI"). It is recommendable to disclose PIs in the annual AWSSD report. The PIs related to water flow/volume and distribution efficiency should be as follows and as shown in Annex A-10:

Unit water production volume (L/person/day) =

Average water production volume/Service population x 1000

Average water production volume (m^3/day): Annual water production volume/365.

Service population: Estimated population served by a water supply system (excluding the population commuting to water distribution zones, tourist, etc.)

It should be calculated for both piped supply and truck supply.

<u>Service coverage of water supply (%) =</u>

<u>Service population / Population living in water distribution zones x 100</u>

Service population: Estimated population served by water supply system (excluding the population commuting to water distribution zones, tourist, etc.)

Population living in water distribution zones: Population living in water distribution zones (statistically estimated one)

It should be calculated for both piped supply and truck supply.

<u>Capacity of water reservoir (hours) =</u>

<u>Total capacity of water reservoir / Daily average water distribution volume x 24</u>

Total capacity of water reservoir (m^3): Total capacity of water reservoirs, clear water tanks, elevated tanks, etc.

Average daily water distribution volume (m^3/day): Annual water distribution volume/365.

Note: The capacity is calculated based on the daily maximum water distribution in general. The average daily distribution, however, is recommended for the present system of AWSSD water supply since the distribution volume is observed to be less than the potential demand and electricity/water resources conditions fluctuate significantly.

<u>Effective utilization ratio of raw water (%) =</u>

<u>Water production volume / In-taken water volume x 100</u>

Water production volume (m^3/year): Water volume at outlets of water treatment plants.

In-taken water volume (m^3/year): Water volume at outlets of dams.

<u>Revenue water ratio (%) =</u>

<u>Billed water volume / Water production volume x 100</u>, or

<u>Non-revenue water ratio (%) =</u>

<u>(Water production volume - Billed water volume) / Water production volume x 100</u>

Billed water volume (m^3): Total volume of billed water

Water production volume (m^3): Total volume of water production, volume at outlets of water treatment plants

3.2.6 Comparison of Distribution Volume with Demand

To confirm the performance and achievement of AWSSD in water supply, the volume of water distributed by both pipelines and trucks should be compared monthly and yearly by water distribution zone.

3.3 Water Quality Management

3.3.1 Standards for Drinking Water

At present, Eritrea does not have its own drinking water quality standards. Therefore, AWSSD is conducting the water quality management in accordance with the World Health Organization (Hereinafter referred to as WHO) guideline for drinking water. The effective guideline for drinking water is shown in Table 3.3.1.

Table 3.3.1 Water Quality Standards of WHO Guideline (4th Edition)

Parameter	Maximum unit	Unit
1.Microbe		
For drinking at Water Tap		
E.Coli or Fecal Coliform	Not Detected in the 100ml	
For Treated Water for Supplying to Distribution System		
E.Coli or Fecal Coliform	Not Detected in the 100ml	
Totatl Coliform	Not Detected in the 100ml	
For Treated Water in the Distribution System		
E.Coli or Fecal Coliform	Not Detected in the 100ml	
Total Coliform	Not Detected in the 100ml	
2. Inorganics		
Color	15	TCU
pH	- (C)	-
TDS	1000 (C)	mg/ L
Turbidity	1 NTU (On the Average) 5 NTU (for one Sample)	NTU
Total Hardness	- (C)	mg/ L
Chloride	250 (C)	mg/ L
Nitrates	50 (Acute)	mg/ L
Nitrites	3 (Acute), 0.2 (P) (Chronic)	mg/ L
Sulfate	250 (C)	mg/ L
Iron	0.3 (C)	mg/ L
Manganese	0.5 (P) , 0.1 (C)	mg/ L
Zinc	3 (C)	mg/ L
Cupper	2 (P), 1 (C)	mg/ L
Ammonia	1.5 (C)	mg/ L
Aluminum	0.2 (C)	mg/ L
Arsenic	0.01 (C)	mg/ L
Cadmium	0.003	mg/ L
Chromium	0.05 (P)	mg/ L
Cyanide	0.07	mg/ L
Lead	0.01	mg/ L
Mercury	0.001	mg/ L
Sodium	200 (C)	mg/ L
Fluordie	1.5	mg/ L
Beryllium	NAD	mg/ L
Boron	0.5 (P)	mg/ L
Molyddenum	0.07	mg/ L
Nikkel	0.02 (P)	mg/ L
Selenium	0.01	mg/ L
Antimony	0.005 (P)	mg/ L
Hydrogen Sulfide	0.05 (C)	mg/ L

Parameter	Maximum unit	Unit
3. Organics		
Carbon Tetrachloride	0.002	mg/ L
Dicloromethane	0.02	mg/ L
1,2-Dichloroethane	0.03	mg/ L
1,1,1-Trichloroethane	2 (P)	mg/ L
Vinyl Chloride	0.005	mg/ L
1,1-Dichloroethylene	0.03	mg/ L
1,2-Dichloroethylene	0.05	mg/ L
Trichloroethylene	0.07 (P)	mg/ L
Tetrachloroethylene	0.04	mg/ L
Benzene	0.01	mg/L
Toluene	0.7, 0.024-0.17 (C)	mg/ L
Xylenes	0.5, 0.02-1.8 (C)	mg/ L
Ethlbenzene	0.3, 0.002-0.2 (C)	mg/ L
Styrene	0.02, 0.004-2.6 (C)	mg/ L
Benzo(a) pyrene	0.0007	mg/ L
Monochlorobenzene	0.3, 0.01-0.12 (C)	mg/ L
1,2-Dichlorobenzene	1, 0.001-0.01 (C)	mg/ L
1,4-Dichlorobenzene	0.3, 0.0003-0.03 (C)	mg/ L
Di(2-ethylhexyl) adipate	0.08	mg/ L
Di(2-ethylhexyl) phthalate	0.008	mg/ L
Acrylamide	0.0005	mg/ L
Epichlorohydrin	0.0004 (P)	mg/ L
Hexachlorobutadien	0.0006	mg/ L
EDTA	0.6	mg/ L
Nitrilotriacetic Acid	0.2	mg/ L

Parameter	Maximum unit	Unit
4. Pesticides		
Alachlor	0.02	mg/ L
Adicarb	0.01	mg/ L
Aldrin	0.00003	mg/ L
Atrazine	0.002	mg/ L
Bentazone	0.3	mg/ L
Carbofuran	0.007	mg/ L
Chlordance	0.0002	mg/ L
Chlorotoluron	0.003	mg/ L
Cyanazine	0.0006	mg/ L
DDT	0.002	mg/ L
1,2-Dibromo-3-Chloropropane(DBCP)	0.001	mg/ L
2,4-Dichlorophenoxy acectic acid (2.4-D)	0.03	mg/ L
1,2- Dichloropropane	0.04 (P)	mg/ L
1,3- Dichloropropane	NAD	mg/ L
1,3- Dichloropropene	0.02	mg/ L
Diquat	0.01	mg/ L
Etylene dibromide (EDB), 1,2-Dibromoethane	0.0004- 0.015 (P)	mg/ L
Glyphosate	U	mg/ L
Heptachlor	0.00003	mg/ L
Hexachlorobenzene	0.001	mg/ L
Isoproturon	0.009	mg/ L
Lindane	0.002	mg/ L
MCPA	0.002	mg/ L
Methoxychlor	0.02	mg/ L
Metolachlor	0.01	mg/ L
Molinate	0.006	mg/ L
Pendimenthalin	0.02	mg/ L
Pentachlorophenol	0.009 (P)	mg/ L
Permethrin	0.02	mg/ L
Propanil	0.02	mg/ L
Pyridate	0.1	mg/ L
Simazine (CAT)	0.002	mg/ L
Terbuthylazine	0.007	mg/ L
Trifluralin	0.02	mg/ L
2,4-DB	0.09	mg/ L
Dichlorpop (2,4 -DP)	0.1	mg/ L
Fenoprop	0.009	mg/ L
MCPB	NAD	mg/ L
2,4,5-T	0.009	mg/ L
Mecoprop (MCPP)	0.01	mg/ L

Parameter	Maximum unit	Unit
5. Disinfectants and Disinfectant by-Product		
Monochloramine	3	mg/ L
Di- and Trichloramines	NAD	
Chlorine	5, 0.6-1.0 (C)	mg/ L
Iodine	NAD	mg/ L
Bromate	0.025 (P)	mg/ L
Chlorate	NAD	mg/ L
Chlorite	0.2 (P)	mg/ L
2-Chlorophenol	NAD, 0.0001-0.01 (C)	
2,4-Dichlorophenol	NAD, 0.0003-0.04 (C)	
2,4,6-Trichlorophenol	0.2, 0.002-0.3 (C)	mg/ L
Formaldehyde	0.9	mg/ L
MX	NAD	
Bromoform	0.1	mg/ L
Dibromochloromethane	0.1	mg/ L
Bromodichloremethane	0.06	mg/ L
Chloroform	0.2	mg/ L
Total Triharlometanes (TTHMs)	Total amount of all the ratio between the concentration of each pesticide and against the guideline value of each pesticide must not exceed 1.0.	mg/ L
Monochloroacetic acid	NAD	mg/ L
Dichloroacetic acid	0.05 (P)	mg/ L
Trichloroacetic acid	0.1 (P)	mg/ L
Chloral Hydrate (Trichloroacetalhehyde)	0.01 (P)	mg/ L
Dichloroacetonitirile	0.09 (P)	mg/ L
Dibromoacetonitrile	0.1 (P)	mg/ L
Bromochloroacetonitrile	NAD	mg/ L
Trichloroacetonitrile	0.001 (P)	mg/ L
Cyanogen Chloride	0.07 (P)	mg/ L
Chloropicrin	NAD	mg/ L

Source: WHO

Considering the present conditions of the equipment and staff members, the following parameters are recommended, especially for urgent water quality management works.

(1) E-coli and Fecal bacteria

- E-coli and Fecal bacteria are not to be detected in the clean water basin at WTPs.
- E-coli and Fecal bacteria are not to be detected at the inspection point of distribution networks and service reservoir.

(2) Turbidity

- Turbidity should be 1 NTU or less on average and 5 NTU at maximum in the clean water basin of WTPs.
- Turbidity should be 1 NTU or less on average and 5 NTU at maximum in the inspection point of distribution networks and service reservoirs.

3.3.2 Water Quality Parameters to be Managed

The following parameters of both raw and treated waters are to be managed as an urgent plan due to insufficiency of monitoring equipment:

(1) Temperature (of raw water and treated/distributed water)
(2) pH (of raw water and treated/distributed water)
(3) Electrical Conductivity (of raw water and treated/distributed water)
(4) Turbidity (of raw water and treated/distributed water)
(5) Color (of raw water and treated/distributed water)
(6) Smell (of raw water and treated/distributed water)
(7) Residual Chlorine (of treated/distributed water)
(8) Bacteria (of treated/distributed water)
(9) Total Coliform (of treated/distributed water)

3.3.3 Daily Data Management for Water Quality

(1) Roles of Related Organizations

Water quality should be managed basically at each WTP to ensure the quality according to the standards. In addition, the headquarters should monitor and supervise the activities of WTP. As described later in Section 3.5, "Water Quality Management Unit" should monitor and supervise the activities of WTP. The roles of organizations related to the water quality are shown in Table 3.3.2.

Table 3.3.2 Roles of Organizations Related to Water Quality

No.	Organization	Basic Role
1.	Water Quality Management Unit	- To check all data reported by WTPs and dams. - To train the staff members of WTPs and dams on water quality analysis and daily records. - To check periodically/randomly the appropriateness of water quality management/monitoring at WTPs and dams. - To check periodically the water quality in water distribution networks. - To inventory the consumables for water quality analysis and to procure the necessary consumables.
2.	WTPs	- To analyze daily the quality of raw and treated waters at WTPs. - To record the data daily and report them to the Water Quality Management Unit. - To inform the water quality condition to the manager of WTP, so that measures to improve it may be taken, if necessary. - To monitor the raw water quality at S.V. dam (by S.V. WTP). - To monitor the raw water quality at Mai Nefhi dam (by Mai Nefhi WTP).

No.	Organization	Basic Role
3.	Dams (Mai Serwa and Toker)	- To monitor the raw water quality at the dam. - To record the data daily and report them to the Water Quality Management Unit.

Source: The Project Team

(2) Daily Analysis and Data Recording

Water quality should be analyzed and recorded at dams and WTPs according to the forms shown in Annex A-4. The obtained data should be promptly reported to the managers of WTPs. The managers of WTPs should take necessary actions to improve the water quality.

The obtained data should be transferred at least once per week to the Planning & Supervision Unit. The Planning & Supervision Unit should confirm/summarize the data with the Water Quality Management Unit according to the forms shown Annex A-3. When irregularity is found, the Water Quality Management Unit should instruct the managers of WTPs to modify/improve the treatment process. When summarizing daily data, the following tasks should be undertaken to get more practical figures:

1) Checking irregularities in water quality and their causes.
2) Checking contradiction among water qualities in treatment process and dozing amount of chemicals.

(3) Management as Performance Indicators

The data should be further and annually analyzed as PI. It is recommendable to disclose the PIs in the annual AWSSD report. The PIs related to water quality and treatment efficiency should be as follows and as shown in Annex A-10:

Frequency of inappropriate water quality (%) =

Number of inappropriate water quality detected / Total number of water quality analysis x 100

Number of inappropriate water quality detected (times/year): Number of times at least one of the water quality parameters is found inappropriate.

Total number of water quality analysis (times/year): Number of times the water quality is analyzed according to schedule.

Chlorine consumption per water production (g/m^3) =

Total chlorine consumption / Total water production

Total chlorine consumption (g/year): Total chlorine consumption, including loss

Total water production (m^3/year): Annual water production volume

Alum consumption per water production (g / m^3) =

Total alum consumption / Total water production

Total alum consumption (g/year): Total alum consumption, including loss

Total water production (m^3/year): Annual water production volume

3.3.4 Improvement of Facilities/Operation for Water Quality

(1) Coagulant Dosing System of Water Treatment Plants

1) Toker WTP

As for Toker WTP, mechanical dosing system is operable for activated carbon although the system for coagulant does not function. It is applicable immediately to dose the coagulant solution into the water receiving basin. To treat 750 m^3/h of raw water, the following dosing operation may be efficient:

- Preparing alum solution by using 60 kg of alum per 1 m^3 of water.
- Storing the solution in the feeding tank of activated carbon.
- Dosing the solution at 6.25 L/min. by activated carbon dosing pump.
- Modifying dosing flow rate in accordance with raw water turbidity and water flow rate into flocculation basin as well as treated water quality.

2) Manual Dosing

At present, one bag (50 kg) of solid alum is added into the water receiving basin as coagulant. The added alum flows out of the receiving basin into the flocculation/sedimentation basin immediately before dissolving. Accordingly, the effectiveness of the coagulant becomes quite low and flocs are not grown appropriately. To avoid this, it is recommended to add it at 30 min. interval and in smaller volume throughout the operation hours. An experiment at Toker WTP in September 2016 confirmed that adding 8 kg of solid alum dosing at 30 min. interval is effective in treating 500 m^3/h. Since no extra budget is necessary, the following dosing method is recommended to be undertaken urgently:

- Add 8 kg of alum into the water receiving basin at 30 min. interval, instead of one bag of alum at the dosing time.
- Modify dosing volume of alum in accordance with raw water turbidity and water flow rate into flocculation basin as well as treated water quality.

(2) Cleaning Frequency of Sedimentation and Filtering Basins

To maintain the treatment efficiency of water, periodical cleaning of basins is necessary. Flocculation, sedimentation and clear water basins are required to be cleaned once a year after draining all the water in the basin. As for the sedimentation basins, removal of sludge accumulated at the bottom of basin is also required as a quotidian work. In respect of rapid sand filiter basins, back-wash is required quotidianly according to water level in the basins (note *) as well as annual cleaning of basin after drying up. According to observation and size of basins, recommended frequency of cleaning is shown in Table 3.3.3.

(note *: Pressure loss of filtered water is commonly utilized for indicator. Since pressure gauges are not available at WTPs, the water level is recommended instead.)

Table 3.3.3 Cleaning Frequency of Basins

Basin	Activity	S.V. WTP	Toker WTP	Mai Nefhi WTP
Flocculation	Cleaning of dried up basin	Once a year	Once a year	
Sedimentation	Sludge discharging	Once a Week in Case-1: Normal turbidity of raw water (no more than 50NTU) Once for a couple of days in Case-2: High turbidity of raw water (more than 50NTU)	Once a Day in Case-1: Normal turbidity of raw water (no more than 50NTU) 2 - 3 times per Day in Case-2: High turbidity of raw water (more than 50NTU)	Once a Day in Case-1: Normal turbidity of raw water (no more than 50NTU) 2 - 3 times per Day in Case-2: High turbidity of raw water (more than 50NTU)
	Cleaning of dried up basin	Once for a couple of months	Once for a couple of months (including inclined plates)	Once for a couple of months
Rapid sand filter	Back-washing	Once for a couple of days	Once for a couple of days	Once for a couple of days
	Cleaning of dried up basin including sand inspection, sand cleaning and re-sanding	Once a Year	Once a Year	Once a Year
Clear water	Cleaning of dried up basin including disinfection	Once for a couple of years	Once for a couple of years	Once for a couple of years

Source: The Project Team

(3) Cleaning Equipment

To clean the flocculation, sedimentation and clear water basins efficiently, a mobile type water jet is recommended to be procured by AWSSD.

3.4 Daily Inspection and Data Management

Daily inspection and data management are to be conducted by the staff members at each dam, WTP, pump station and water station. The activities are to be supervised by the Planning & Supervision Unit. Nevertheless, the following are to be remarked in the daily activities:

3.4.1 Appropriateness of Data to be Recorded

To ensure the appropriateness of data and to facilitate the analysis works in Planning & Supervision Unit, the following points should be taken into account while recording activities at facilities sites:

(1) Recording the facts, and not estimates/supposition (the estimates/suppositions should be recorded under a “note” / “remark” or a blank space).

(2) Recording irregularities such as electricity suspension, troubles of equipment, repairs, etc.

(3) To secure the tractability, name of person in charge should be written down.

(4) To train continuously the site staff members for appropriate recording.

3.4.2 Record of Inspection Result or Irregularity

The following should be inspected and recorded daily as notes/remarks to deepen the understandings of the Planning & Supervision Unit and to facilitate the preparation of the maintenance plan:

(1) Irregularity of leakage.

(2) Irregularity of temperature on equipment.

(3) Irregularity of noise from equipment.

(4) Any damages and troubles of facilities, including building and structural construction.

3.5 Urgent Improvement of Organization

3.5.1 Water Quality Management Unit

At present, AWSSD does not have an official unit and a system for water quality management. As a result, WTPs could get only limited instruction and advice on water quality management and improvement. Therefore, “Water Quality Management Unit” should be established to improve this condition through the following activities:

(1) Checking all data reported by WTPs and dams.

(2) Training the staff members of WTPs and dams on water quality analysis and daily records.

(3) Checking periodically/randomly the appropriateness of water quality management at WTPs and dams.

(4) Checking periodically the water quality in water distribution networks.

(5) Inventorying consumables for water quality analysis and procuring the necessary consumables.

To assure the water quality appropriately, the “Water Quality Management Unit” should be independent from other units. Recommended number of staff members of the unit is shown in Table 3.5.1.

Table 3.5.1 Staff Members for Water Quality Management Unit

Position	Number	Role
Unit Leader / Supervisor of WTP water quality management	1	Management of all works for the unit, including management of consumables for water quality analysis.
Field Analyst of water quality	2	Periodical sampling and analysis of water at dams, at WTPs, and in networks
Total	3	

Note: Laboratory Analyst should be added in a long term along with preparation of laboratory mentioned in Chapter 4.3, if necessary.

Source: The Project Team

3.5.2 Officialization of Units belonging to Water Supply Division

“Dam & Treatment Plant Unit” and “Planning & Supervision Unit”, which are not officialized by the Government, should be promptly approved for following purposes:

(1) Proper and prompt budgeting for activities.

(2) Clear responsibility for activities.

(3) Awareness improvement of staff members belonging to the two units.

3.6 Stock of Materials

3.6.1 Mechanical/Electrical Parts

Basic materials for pipelines’ repairs as well as alum and chlorine are available in AWSSD’s stores. Mechanical and electrical spare parts, however, are not stored by AWSSD. Fast moving parts should be stored always in AWSSD. The items shown below are at least recommended to be stored always:

Table 3.6.1 Recommended Spare Parts to be Stored by AWSSD

Category	Items	Quantity
Pipeline	Straight pipe	10 sets for each kind of diameter and material
	Fittings	10 sets for each kind of type, diameter and material
	Water meter for subscribers	100 sets for each kind of diameter
Pump / Mechanical	Bushings	3 sets for each device
	Gaskets	3 sets for each device
	Packings	3 sets for each device
	Pressure gauge	3 sets
Electrical	Fuses	3 sets for each device
	Lumps	3 sets for each device

Source: The Project Team

3.6.2 Chemicals and Consumables for Water Quality Analysis

Chemicals necessary for water treatment should be stored at least as shown in Table 3.6.2. Consumables for water quality analysis should be stored as well, according to Table 3.6.3.

Table 3.6.2 Recommended Chemicals to be Stored by AWSSD

Items	Quantity
Aluminum Sulfate (Alum)	For 3 months
Chlorine Gas	For 3 months

Source: The Project Team

Table 3.6.3 Recommended Consumables to be Stored by AWSSD for Water Quality Analysis

Equipment	Chemicals	Qty.	Unit
pH/EC meter	pH 4.01standard buffer solution 500 ml	18	Bottles
	pH 6.86 standard buffer solution 500 ml	18	Bottles
	Inner solution for pH meter, KCl (3.33 mol/L) 500 ml	18	Bottles
Residual Chlorine Meter	DPD reagent (powder) for free chlorine for 100 times (Manufactured by HACH, P/# 2105569)	6	Packs
	DPD reagent (powder) for total chlorine for 100 times (Manufactured by HACH, P/# 2105669)	6	Packs
Bacterial Detection Paper	Coliforms detection paper (Manufactured by Sun Chemical Co., Ltd.), 100 pieces	6	Boxes
	Bacterial detection paper (Manufactured by Sun Chemical Co., Ltd.), 100 pieces	6	Boxes

Note: Stocks for 3 months

Source: The Project Team

Chapter 4: Operation & Maintenance Plan in Further Stages

4.1 Basis of Plan for Further Stages

The plans described in this Chapter 4 are recommended based on the following:

- To utilize the existing facilities.
- To be necessary for certain preparations such as finance and further detail plan.
- To be undertaken within 3–5 years.

4.2 Installation of New Flowmeters

4.2.1 Background

Flowmeters are not presently installed at most of the important points where flow metering is necessary. Since the flowmeters are basic tools to measure efficiency as well as volume of water produced/ distributed, AWSSD should install/replace the flowmeters at all key points.

4.2.2 Type of New Flowmeters

There are different types of water flow meter such as impeller, electromagnetic, and ultrasonic types. Considering cost and easiness of maintenance, the impeller type, which requires no electrical devices, is proposed. If it is difficult to provide the impeller types due to limitation of applicable diameter, then electromagnetic type working by lithium battery should be installed.

4.2.3 Location of New Flowmeters

AWSSD should install/replace the flowmeters at the locations listed in Table 4.2.1.

Table 4.2.1 Location to Install / Replace Flowmeters

System	Location	Metering Points
S.V.	Adi Sheka Dam	Outlet of water intake pump
	Mai Serwa Dam	Outlet of water intake pump
	S.V. Dam	Outlet of water intake pump
	S.V. WTP	Inlet of receiving basin from Adi sheka Dam
	S.V. WTP	Outlet of water transmission pump
Toker	Toker dam	Outlet of water intake pump
	Toker WTP	Inlet of receiving basin from Toker Dam
		Inlet of receiving basin from Adi sheka Dam
		Outlet of water transmission pump
		Distribution branching point (2 points)
	Mai Temenai Water Station	Inlet of Water Station
	Mai Chehot PS	Inlet of distribution reservoir
		Outlet of water distribution pump

System	Location	Metering Points
	Denden PS	Inlet of distribution reservoir
		Outlet of water distribution pump
	Monopolio Distribution Reservoir	Inlet of distribution reservoir
		Outlet of service reservoir
	Tsetserat Distribution Reservoir	Inlet of distribution reservoir
		Outlet of service reservoir
Mai Nefhi	Mai Nefhi WTP	Inlet of receiving basin
		Outlet of water transmission pump
	New Sembel PS	Inlet of distribution reservoir
		Outlet of water distribution pump
	EXPO (Godaif) PS	Inlet of distribution reservoir
		Outlet of water distribution pump
	EXPO Water Station	Inlet of water station

Source: The Project Team

4.3 Water Quality Laboratory and Equipment

4.3.1 Background

Equipment for basic water quality parameters is procured by the Project. It is, however, insufficient for following water quality analysis:

(1) To verify periodically the water quality analyzed by dams and WTPs.

(2) To enable a prompt water quality analysis of the distributed water in networks as well as tap water in Asmara.

(3) To confirm periodically other chemical water quality parameters.

Along with the establishment of Water Quality Management Unit, AWSSD should prepare a detail plan to enhance the capacity of water quality monitoring such as installation of laboratory and procurement of additional equipment.

4.3.2 Laboratory to be Installed and Equipment to be Procured

A laboratory should be installed in the headquarters of AWSSD to realize verification activities of water quality. Equipment to be procured are recommended as shown in Table 4.3.1.

Table 4.3.1 Water Parameters to be Analyzed and Equipment to be Installed in the Laboratory

Water Quality Parameter	Category	Required Main Equipment
Water Temperature	General Item	Thermometer
pH		Desk Typed pH meter
Electro Conductivity		Desk Typed EC meter
Turbidity		Turbidity Meter
Color		Colorimeter
Total Dissolved Solid (TDS), Total Suspended Solids (TSS), Suspended Solids (SS)		Filtration Device Set, Drying Oven (For 105℃)
Potassium, Calcium (Hardness)		Titration Device
Alkalinity		
COD_{Cr}	Organic Pollutant	COD Reflux Device
Ammonia, Nitrates, Nitrites		Spectrophotometer, Water Bath
Fecal Coliform	Pathogenic Microbe	Simple Test Paper for Coliform Simple Test Paper for Bacteria Incubator (For 35℃)
Residual Chlorine	Disinfectant	Residual Chlorine Meter
Others		Electric Balance, Magnetic Stirrer, Pure Water Production Device, Draft Chamber, Jar Tester.

Source: The Project Team

4.3.3 Enhancement of Analysis Capacity at Water Treatment Plants

Although basic equipment is procured in the Project for the three WTPs, additional enhancement is recommended as shown in Table 4.3.2 for following purposes:

- Dosing volume of coagulant is determined by daily jar test to promote efficiency of alum consumption as well as to secure appropriate water quality.
- Water sampling is easier, safer and more quickly than the present means by water sampling taps in laboratory space.

Table 4.3.2 Enhancement of Analysis Capacity at Water Treatment Plants

Item	Enhancement Contents
Jar tester	Three jar testers to install at each of WTPs.
Water sampling taps including necessary pipelines	Following taps are installed at each of WTPs: Raw water, after sedimentation, after filtering, clear water

Source: The Project Team

4.4 Vehicles for Patrolling and Monitoring the O&M Activities

AWSSD should urgently prepare vehicles/motorcycles as shown in Table 4.4.1 for stable operation and maintenance activities However, it is categorized into plan in further stages since budget preparation is necessary.

Table 4.4.1 Necessary Vehicles for Operation and Maintenance Activities

Activity	Type of Vehicle	Quantity
Supervision and monitoring of all O&M activities	4WD	1
Continuous metering of water flow by an ultrasonic flowmeter	4WD	1
Supervision of water quality management of dams and WTPs, and sampling water from distribution networks	Motor cycle	2

Source: The Project Team

4.5 Improvement of Facilities

4.5.1 Replacement of Pumps

(1) Background

In present, water production is frequently suspended due to repairs and maintenance of pumping system. To secure stable operation of water production and distribution, replacement of pumps and preparation of spare equipment are necessary.

(2) Required Pumps for Replacement

According to the existing AWSSD plan, pumps shown in Table 4.5.1 are to be replaced together with auxiliary devices such as valves and pressure gauges. It is, however, a subject to be verified in detail planning stage for capacities, quantities and detail contents of auxiliary devices.

Table 4.5.1 List of Recommended Pumps to be Replaced

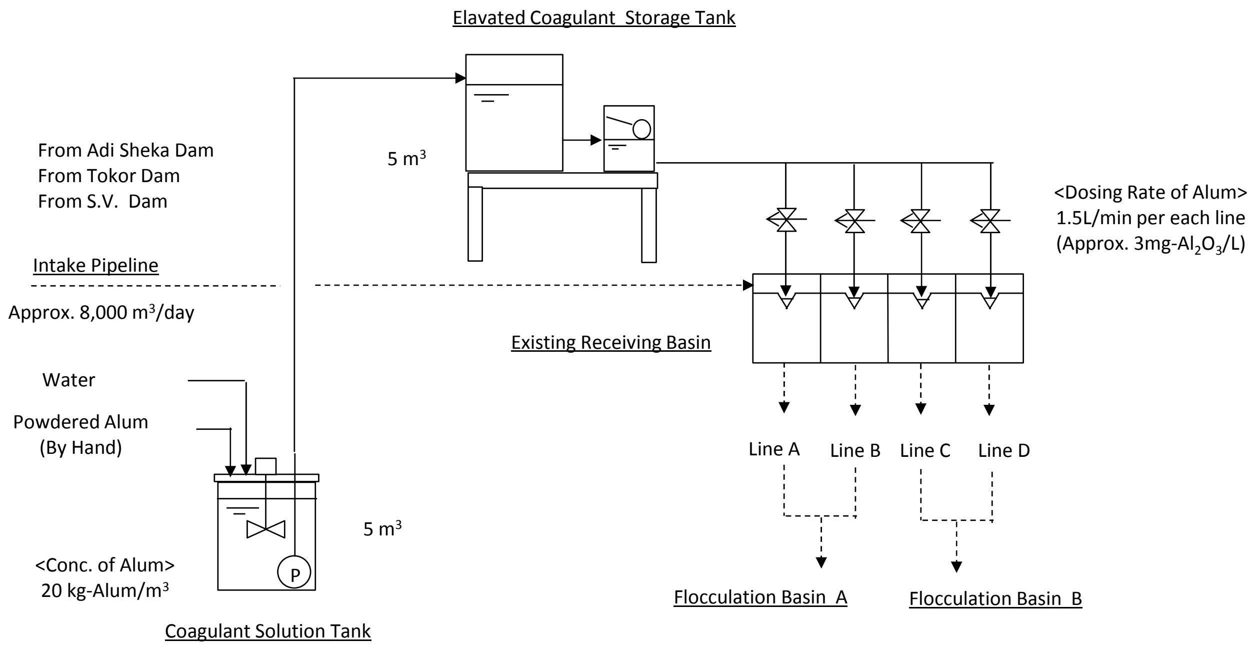
Location		Specifications	Quantity	Remarks
Adi Sheka dam	Intake water pump	Horizontal centrifugal pump ($Q=450m^3/h$, $H=40m$)	3	Incl. spare pump
Mai Serwa dam	Intake water pump	Vertical centrifugal pump ($Q=200m^3/h$, $H=61m$)	3	Incl. spare pump
S.V. dam	Intake water pump	Submersible pump ($Q=180m^3/h$, $H=23m$)	1	
S.V. WTP	Distribution pump	Vertical centrifugal pump ($Q=167m^3/h$, $H=93m$)	4	
Toker WTP	Transmission / Distribution pump	Vertical centrifugal pump ($Q=450m^3/h$, $H=65m$)	4	Incl. spare pump
Mai Nefhi WTP	Transmission pump	Horizontal centrifugal pump ($Q=500m^3/h$, $H=215m$)	4	Incl. spare pump
New Sembel pump station	Transmission / Distribution pump	Horizontal centrifugal pump ($Q=500m^3/h$, $H=90m$)	4	Incl. spare pump
Godaif pump station	Distribution pump	Vertical centrifugal pump ($Q=300m^3/h$, $H=75m$)	2	
Denden pump station	Distribution pump	Vertical centrifugal pump ($Q=170m^3/h$, $H=50m$)	3	Incl. spare pump
Tsetserat pump station	Distribution pump	Vertical centrifugal pump ($Q=10m^3/h$, $H=50m$)	2	Incl. spare pump
Mai Chohot pump station	Distribution pump	Vertical centrifugal pump ($Q=200m^3/h$, $H=61m$)	3	Incl. spare pump

Source: AWSSD

4.5.2 Chemical Dosing Facilities

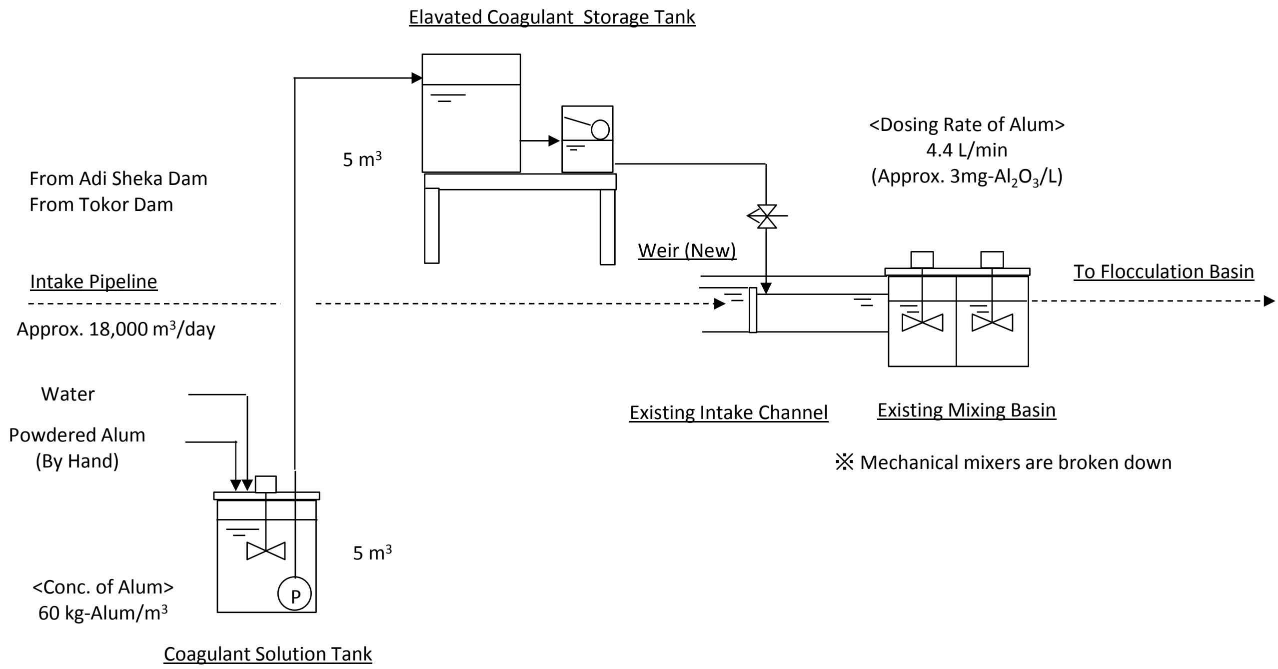
(1) Coagulant Dosing System of Water Treatment Plants

Simple improvement illustrated in Figure 4.5.1, 4.5.2 and 4.5.3 are recommended for coagulant dosing systems of S.V WTP, Toker WTP and Mai Nefhi WTP, respectively. As a dosing system which is operable during electricity interruption, a system storing the coagulant solution in an elevated tank and dosing it by gravity is recommended.



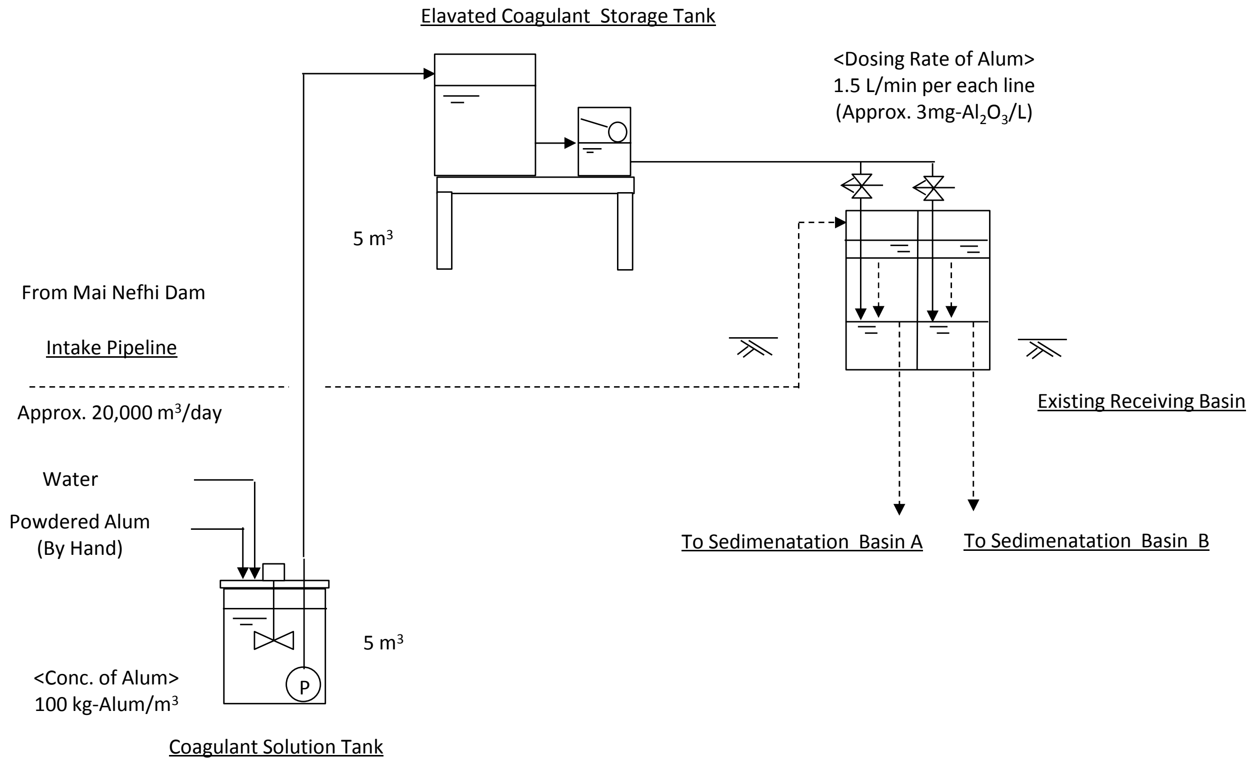
Source: The Project Team

Figure 4.5.1 Schematic Flow Sheet of Coagulant Dosing System Recommended for S.V. WTP



Source: The Project Team

Figure 4.5.2 Schematic Flow Sheet of Coagulant Dosing System Recommended for Toker WTP



Source: The Project Team

Figure 4.5.3 Schematic Flow Sheet of Coagulant Dosing System Recommended for Mai Nefhi WTP

(2) Chlorine Dosing System of Water Treatment Plants

At present, the chlorine gas is directly injected from cylinder to clear water basin. It is difficult to control the dosing flow rate with the present method. Therefore, the concentration of residual chlorine fluctuates significantly, and it is inappropriate for water distribution. Moreover, it is not suitable for maintaining the safety condition against chlorine leakage. To make the injection of chlorine gas into the treated water stable, a mechanical system (chlorinator) should be introduced or the existing system should be rehabilitated. Furthermore, installation of chlorine gas neutralization system is recommended.

4.6 Standard Operational Procedures

4.6.1 Background

In Toker WTP, the operation manuals, which were provided by the constructed company of the plant, are available. However, they are not effectively utilized by the staff members of WTP for the following Reasons:

- Many of the installed systems/devices are broken-down and out of use.
- The staff members of WTP are not able to operate the plant according to the manuals.

In other facilities, no manuals for water treatment, pumping system, etc. are available. Therefore, all facilities are operated by experiences of senior workers and according to the conditions of water distribution.

The current problems of the operation methods are as follows:

(1) All the skills developed through experiences are not written out. Therefore, it is difficult to transfer the skills of the senior workers to the younger generation. It is also difficult to keep the usual operation without the senior workers.

(2) No optimal operation mode is examined in water pressure, flow rate, operation hours, dosing volume of chemicals, etc. No standard operation mode is written out and no one can operate the facilities at the optimal mode.

(3) No manual is available for daily/periodical inspections. Accordingly, neither periodical inspection and nor preventive maintenance of facilities is conducted.

Since it can be commenced without large scale rehabilitations, activities for standard operational procedures (hereinafter referred to as "SOP") should be undertaken along with preparation of finance and expertise.

4.6.2 Preparation of Standard Operational Procedures

It is necessary to introduce activities for SOP as well as preparation of written documents for SOP. Purposes are summarized as follows:

(1) To operate the facilities according to metered data; not to operate by experiences.
(2) To examine optimal operation modes in efficiency and to have trials according to them.
(3) To arrange operation records according to the optimal operation modes.
(4) To write down the optimal operation procedures to facilitate the operation works for all related workers.
(5) To have a system for preventive maintenance as well as written manuals.

4.6.3 Continuous Activities for Standard Operational Procedures

According to demand increase of water, conditions of water sources, replacement/repair of equipment, etc., SOP should be modified and improved continuously under "Plan, Do, Check and Act" (hereinafter referred to as "PDCA") cycle. Examination of optimal operation modes and its trial are very effective to promote skills and awareness of staff members.

4.7 Reduction of Non-Revenue Water

4.7.1 Background

According to the data of 2015, NRW ratio reached 52%. More than half of the water production volume is not delivered properly to the citizens. To improve efficiency in finance and water volume, NRW should be reduced. Since it can be commenced without large scale rehabilitations, NRW reduction activities should be undertaken in parallel with the flowmeters' installation.

4.7.2 NRW metering

According to the flowmeters' installation mentioned in Chapter 4.2, the water flows have to be metered at all significant points in the water transmission / distribution networks. Since the water consumption (billed water) is basically metered, NRW can be calculated according to the Table 4.7.1.

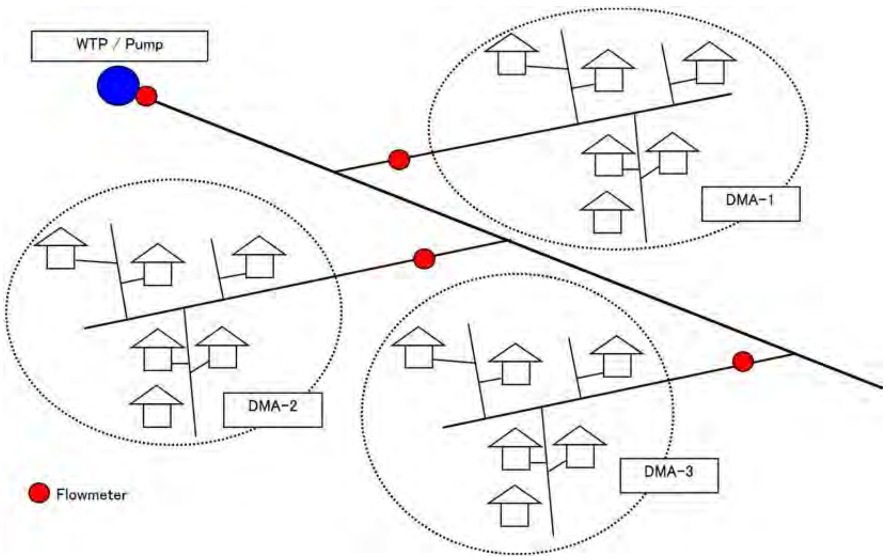
Table 4.7.1 Classification of Water Volume and Definition of NRW

<table>
<tr><td rowspan="11">Raw Water</td><td rowspan="10">Water Distribution Volume</td><td rowspan="5">Authorized Consumption</td><td rowspan="3">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="3">Sold Water (Billed Water)</td><td rowspan="3">Revenue Water (RW)</td></tr>
<tr><td>(Subtract over-registration volume)</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="4">Commercial Loss</td><td rowspan="7">Non Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Metering Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and/or Distribution Lines</td><td rowspan="3">Physical Loss</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
<tr><td colspan="4">Treatment Losses (Backwash, etc.)
Evaporation</td><td colspan="2">Categorized as NRW</td></tr>
</table>

Source: The Project Team

4.7.3 District Metering Area

To identify the critical NRW areas, a system of district metering area (hereinafter referred to as "DMA") should be introduced as much as possible. The concept of the DMA is illustrated in Figure 4.7.1. The balance between the inflow into a DMA and the consumption in the same DMA is NRW if no "unbilled and authorized consumption" considered.



Source: The Project Team

Figure 4.7.1 Concept of District Metering Area

4.7.4 NRW Reduction Activities

In general, reducing the apparent and real losses is a main activity for NRW reduction. The following should be undertaken in parallel. To carry out the works efficienetly, an exclusive team should be established in the Water Distribution Unit for survey works.

Table 4.7.2 Major Activities to Reduce NRW

Subject to be Reduced		Activities
Apparent Losses	Unauthorized Consumption	To check illegal connections along transmission / distribution lines. And to put meters or to disconnect them. Finding illegal connection is not easy. It is found often during leak detection works.
	Metering Inaccuracies	To check meter accuracies and / or to replace old meters with new ones. Meter accuracies should be verified through sampling survey and through consumption data.
Real Losses	Leakage on Transmission and/or Distribution Lines	To find irregular route and / or DMA in water flow from the water flow metering data. After narrowing route / area, leaks should be detected by special tools.
	Leakage and Overflows at Utility's Storage Tanks	To inspect all service reservoirs for leakage and / or overflow as well as leakage from pumps and / or valves.
	Leakage on Service Connections up to point of Customer metering	To have scheduled survey along all distribution lines by special tools. In general, leakage is often found on house connection pipes including branching points.

Source: The Project Team

4.8 Organization and Finance

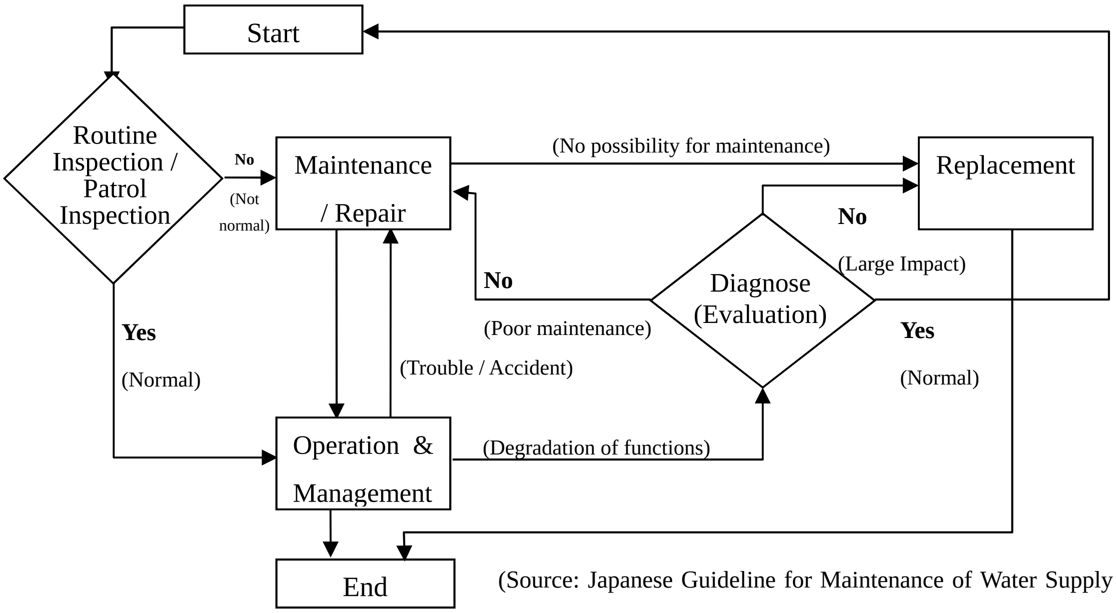
Water tariff should be reviewed and improved so that it covers the necessary expenditures. To make AWSSD independent financially, the tariff rate should be improved to cover the investment cost of major rehabilitations / new facility constructions. It should be noted that the tariff modification is a subject to be approved by the Central Government.

4.9 Maintenance of Facilities and Stocks of Materials

4.9.1 Preventive Maintenance

(1) Concept

For long-time and effective uses of the facilities, periodical and programed maintenances are necessary. The concept of the preventive maintenance is illustrated in Figure 4.9.1 and Table 4.9.1. It is a provision of inspection, repair and replacement works before significant troubles.



(Source: Japanese Guideline for Maintenance of Water Supply Facilities, Japan Water Works Association)

Figure 4.9.1 Conceptual Flow of Preventive Maintenance

Table 4.9.1 Conceptual Activities for Preventive Maintenance

Classification	Main Management Item
Operation Management	1) Water volume control: Controlling equipment and devices whether conforming to the design water volume 2) Water quality control: Measuring raw water and check whether treated water meets the design water quality standard (pH, Electrical conductivity, Turbidity, Color and Odor: daily). Measuring residual chlorine after disinfection and confirming whether it becomes lower than the value at the reservoir. After the measurement, resetting injection rate of disinfection reagent, if required.
Maintenance Management	1) Inspection: Inspecting and checking facilities, equipment and devices by meters and naked eyes. Repairing and maintaining faults or breakdowns. Additionally securing safety of chemicals (chlorine) needed for disinfection. 2) Prevention: Renewing facilities, equipment and devices periodically depending on the importance and characteristics even if no break-down. This leads to safe and stable operation since reliability on facilities, equipment and devices may be promoted.

Source: The Project Team

(2) Regular Inspection Items

Table 4.9.2 and 4.9.3 indicate the standard inspecting items of pumps and power receiving equipment, which are the main equipment of water supply facilities.

Table 4.9.2 Standard Check List for Pumping Equipment

Pump	Daily (during operation)	Record of operation condition; diary (distribution volume, check with naked eyes, abnormal noise, shaft temperature, leakage, pressure of inflow and outflow)
	Monthly	Check of shaft oil and grease Check of gland packing
	Every 6 months	Replacement or refilling of shaft oil and grease Precision of the shaft center Measurement of vibration and noise Tightening each part of the equipment
	Every year	Dismantling check (vibration of rotating parts, aperture of gliding parts, corrosion of inside, choking with substances, paint) Check of accessories and spares
Motor	Daily (during operation)	Record of operation condition; diary (electrical currency, check with naked eyes, abnormal noise, shaft temperature, leakage)
	Every 6 months	Refilling of shaft grease Measurement of vibration and noise Check of temperature of shaft
	Every year	Check of shaft holder Measurement of non-conductance resistance value

Source: The Project Team

Table 4.9.3 Standard Check List for Power Receiving Equipment

Item	Content (Method)	Daily Inspection	1-6 months Inspection	Yearly Precise Inspection
Appearance	Open/Close display device, Indicator condition	X	X	
	Abnormal Noise and odor	X	X	
	Coloring at end points due to temperature	X	X	
	Cracks and stains of bushing and pipes	X	X	
	Rust on case, base, etc.	X	X	
	Abnormal Temperature	X	X	
	Tightness of bushing end (mechanical check)	X	X	
Operation and control devices	Indicator condition of each equipment	X	X	X
	Rotation indicator		X	X
	Rust and stains of controlling box and its inside		X	X
	Oil change and cleanness		X	X
	Tightness of electricity wiring connection	X	X	X

Item	Content (Method)	Daily Inspection	1-6 months Inspection	Yearly Precise Inspection
	Open/close display		X	X
	Air and oil leakage (with air pressure, etc.)		X	X
	Pressure before and after operation (with air pressure, etc.)		X	X
	Operation meter condition		X	X
	Rust, deformation, damage on spring (repair)	X	X	X
	Conditions for connection		X	X
	Conditions of electricity circuited breaker and relay		X	X
Measure-ment and test	Non conductance resistance		X	X
	Condition of earth			X
	Cables		X	X
	Function of relay		X	X

Source: The Project Team

4.9.2 Stock of Materials

Considering that long period is necessary for spare parts procurement from foreign countries, critical equipment should be stocked in AWSSD stores. Although it is costly, it is categorized into investment for stable water supply. Items shown in Table 4.9.4 are recommended to be stored by AWSSD for stand-by equipment.

Table 4.9.4 Items to be Stored as Stand-by Equipment

Category	Items	Quantity
Pipeline	Valve	2 sets for diameter more than D200 5 sets for diameter D100 - D200 20 sets for diameter less than D100
Pump / Mechanical	Transmission / distribution pump	1 set for each kind of pump if no stand-by pump is installed at site
	Chemical injection pump	1 set for each kind of pump
	Chlorinator	1 set

Source: The Project Team

Chapter 5: Recommendation

This “Recommended Plan for Operation and Maintenance” is prepared under following conditions:

(1) To utilize the existing facilities and equipment.

(2) Not to consider large scale rehabilitation and / or new construction of facilities.

If AWSSD improves the operation and maintenance activities according to this plan, the conditions on water distribution and water quality will be clearer than the current ones. Moreover, distribution volumes and water quality will be improved even if the improvement is limited.

To satisfy the target water demand and drinking water quality standards, more actions should be required, especially rehabilitation of facilities. This Chapter recommends such additional actions to have more effective operation of water supply.

5.1 Coagulant Dosing System

Coagulant dozing systems have been broken-down and out of use for all the three WTPs. Although small scale improvement are shown in this document, it is insufficient to assure the water quality due to following reasons:

(1) The recommend systems in this document are temporary ones. To assure the water quality for long years, permanent systems are required.

(2) Coagulant dozing rate should be modified according to raw water quality and intake water volume promptly. It is, however, difficult for the recommend systems to modify / control the coagulant dozing rate quickly.

Accordingly, rehabilitations of the coagulant dozing system should be necessary for the three WTPs, including dozing pump, storage tank of coagulant solution and agitate tank for coagulant solution.

5.2 Flocculation and Sedimentation System

For S.V. system, there is no mechanical mixer and flocculator. However, there are baffling type flocculation basins instead. Although verifications by trial activities are not provided, some effects for flocculation are expected if coagulant dosed appropriately. Since the introduction of mechanical mixers and flocculators is costly, utilizing the existing system is recommended. Sedimentation basin, however, should be cleaned up in parallel as well as pipelines between sedimentation basins and rapid sand filters.

Toker system is equipped with mechanical mixers and flocculators. Appropriate flocculation management, however, is not possible presently due to break-down of the system. The mechanical system, therefore, should be rehabilitated. If rehabilitated in parallel of coagulant dozing system, sedimentation effect will be much improved.

In respect of Mai Nefhi system, it is designed for the pulsator system. To expect the appropriate water treatment and water quality management, the facilities should be rehabilitated for the original design.

5.3 Electric Power Back-up System

Due to unstable electricity distribution, operations of pumps are frequently interrupted. AWSSD is recommended to prepare power back-up system for all dams and WTPs. Power back-up system is exampled as follows:

(1) To rehabilitate the existing emergency generator and / or to install new ones.

(2) To have double sources of electricity distribution (to have a distribution cable from different sub-stations).

5.4 Sludge Management

Presently, WTPs have no appropriate system for sludge management and they dispose it as shown in Table 5.4.1.

Table 5.4.1 Present Disposal Ways of Sludge

WTP	Disposal Ways
S.V. WTP	WTP discharges the sludge into a river
Toker WTP	WTP equipped with sludge accumulation ponds. However, no discharging destination nor treatment system is provided. The sludge is accumulate and nearly full of the accumulation ponds.
Mai Nefhi WTP	The sludge is returned to the dam reservoir.

Source: The Project Team

AWSSD is recommended to manage the sludge as follows:

(1) To secure a land near WTP for sludge drying yard.

(2) To transport the sludge to the drying yard by pump. It is better to have a sludge thickener before the pumping system.

(3) To dry the sludge in the sun.

(4) To dispose the dried sludge into solid waste landfill sites. Dump trucks are recommended for transportation.

5.5 Awareness on Water Quality

Daily water quality analysis was introduced in the Project. It is effective to promote the awareness of AWSSD staff members on water quality. Nevertheless, it should not end at the analysis activity. Higher awareness and further improvement activity for water quality should be required, so that AWSSD distribute the sufficient quality of water in the drinking water quality standards. AWSSD should allocate more budget for water quality improvement as well as improvement of chemical dosing system, frequent cleaning of basins, replacement of filtering sand, etc.

Annex-1

Key Member of the Project

Key Member of the Project

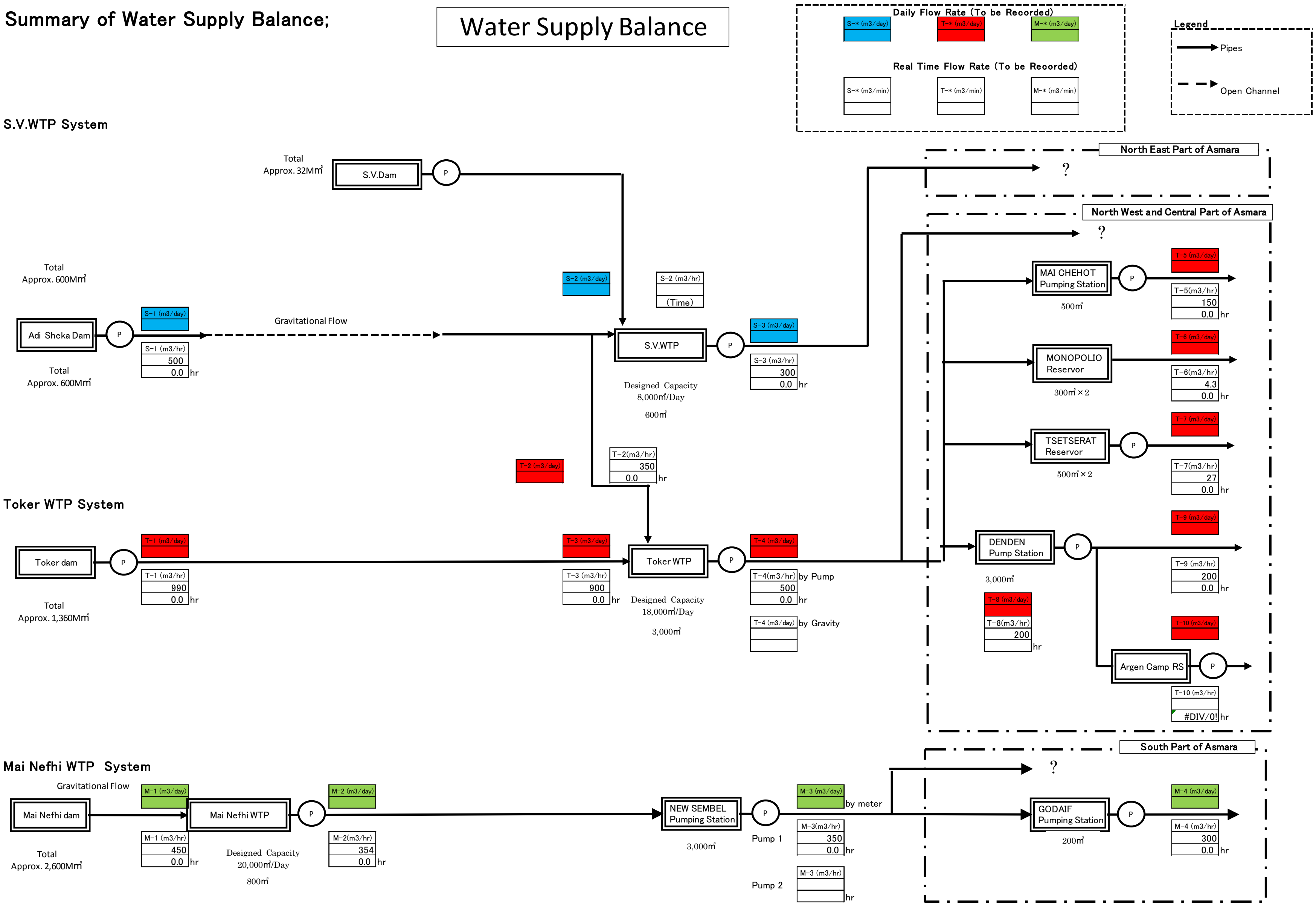
Name	Position	Section
AWSSD		
Mr. Gherekidan Ghirmazion	Director General	-----
Mr. Kidane Kiflemariam	Head of Water Supply Division	Water supply Division
Mr. Tesehaye Woldeab	Head of Adm. Fin	Administration and Finance Division
Mr. Mulgheta G/kidan	Treatment Head of S.V. WTP	S.V. WTP
Mr. Fetsum Araia	Treatment Head of Toker WTP	Toker WTP
Mr. Yohannes (John) Mulu	Geometry/Advisor	Planning and Supervision Unit
Mr. Abiel Kiflai	Civil engineering	Planning and Supervision Unit
Ms. Adiam Yohannes	Civil engineering	Planning and Supervision Unit
Mr. Michiel Temesghen	Technician	Water Distribution Unit
Mr. Biniam Ghebre	Survey	Water Distribution Unit
Mr. Efrem Menghesteab	Drafting	Water Distribution Unit
Mr. Tadesse Berhe	Chemist	Water Laboratory Unit(WRD)
Ms. Feruz Tekle	Survey	Water Laboratory Unit(WRD)
Mr. Yikealo Araia	Chemical technology	Water Laboratory Unit(WRD)
Mr. Awelkier Hiyabu	Drafting	Planning and Supervision Unit
Mr. Abraham Dawit	Drafting	Planning and Supervision Unit
Mr. Samuel Beyene	Survey	Planning and Supervision Unit
JICA Expert Team		
Mr. Katsumi Fujii	JICA Expert	Yachiyo Engineering Co., Ltd.
Mr. Tsuyoshi Onozato	JICA Expert	Yachiyo Engineering Co., Ltd.
Mr. Shinji Miwa	JICA Expert	Yachiyo Engineering Co., Ltd.

Annex-2

Form of Daily Summary Sheet for Water Flow in Asmara (Water Balance)

Summary of Water Supply Balance;

Water Supply Balance



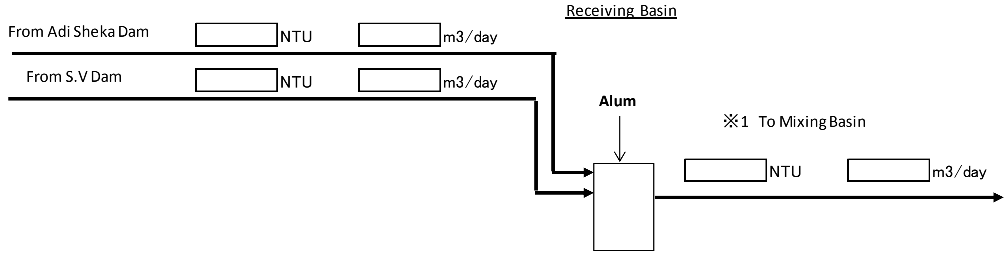
Annex-3

Form of Daily Summary Sheet per Water Treatment Plant

S.V WTP (Designed Capacity 8,000m^3/day= 333m^3/hr)

Daily Water Balance and Performance Data (Date)

As of August 2

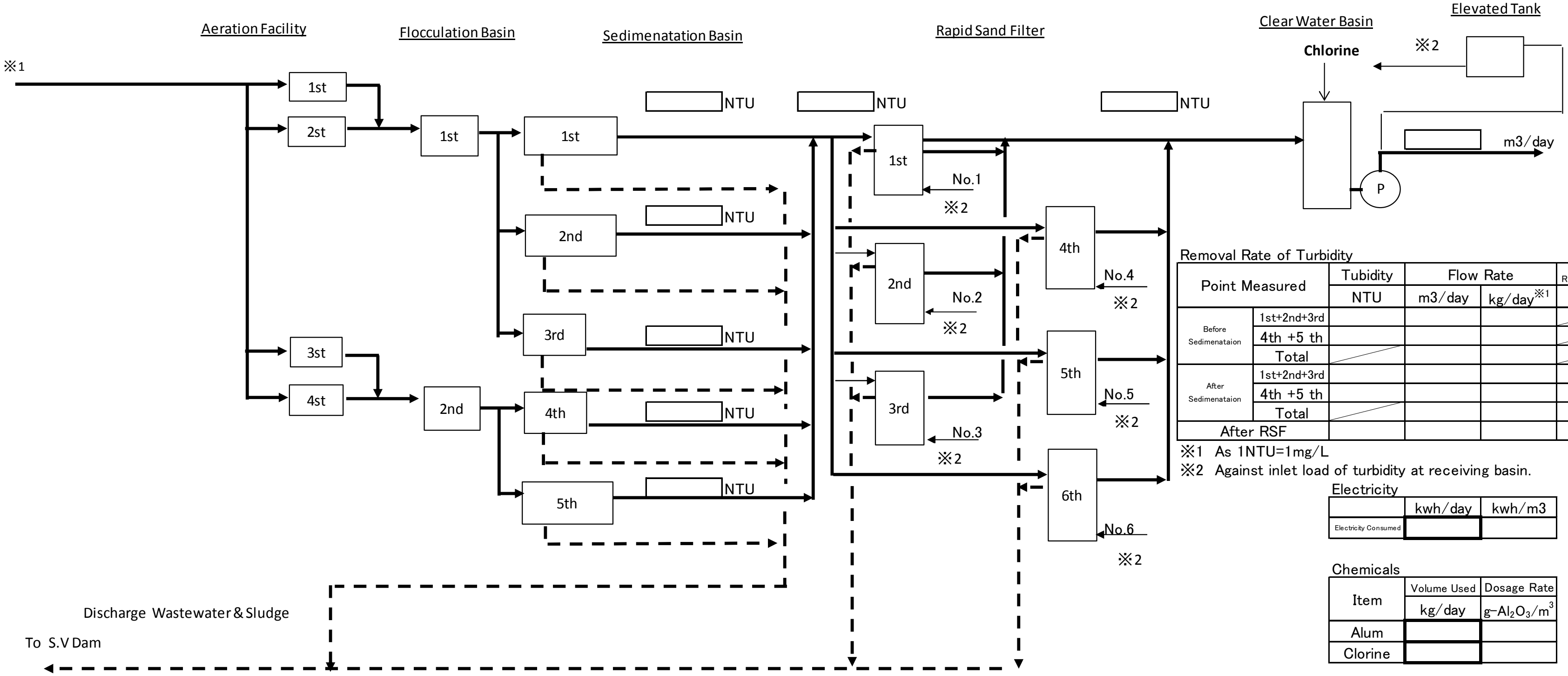


Flow Rate

Point Measured		m3/hr	Operation Time (hr)	m3/day	Recovery Rate (%)
Intake	From Adi Sheka Dam				
	From S.V Dam				
Flocculation Basin	1st				
	2nd				
	3rd				
	4th				
Water Production					

Water Quality

Point Measured		NTU
Intake	From Adi Sheka Dam	
	From S.V Dam	
After Sedimentation	1st	
	2nd	
	3rd	
	4th	
	5th	
Treated Water		



Removal Rate of Turbidity

Point Measured		Tubidity NTU	Flow Rate m3/day	Flow Rate kg/day※1	Removal Rate※2 %
Before Sedimentataion	1st+2nd+3rd				
	4th +5 th				
	Total				
After Sedimentataion	1st+2nd+3rd				
	4th +5 th				
	Total				
After RSF					

※1 As 1NTU=1mg/L

※2 Against inlet load of turbidity at receiving basin.

Electricity

	kwh/day	kwh/m3
Electricity Consumed		

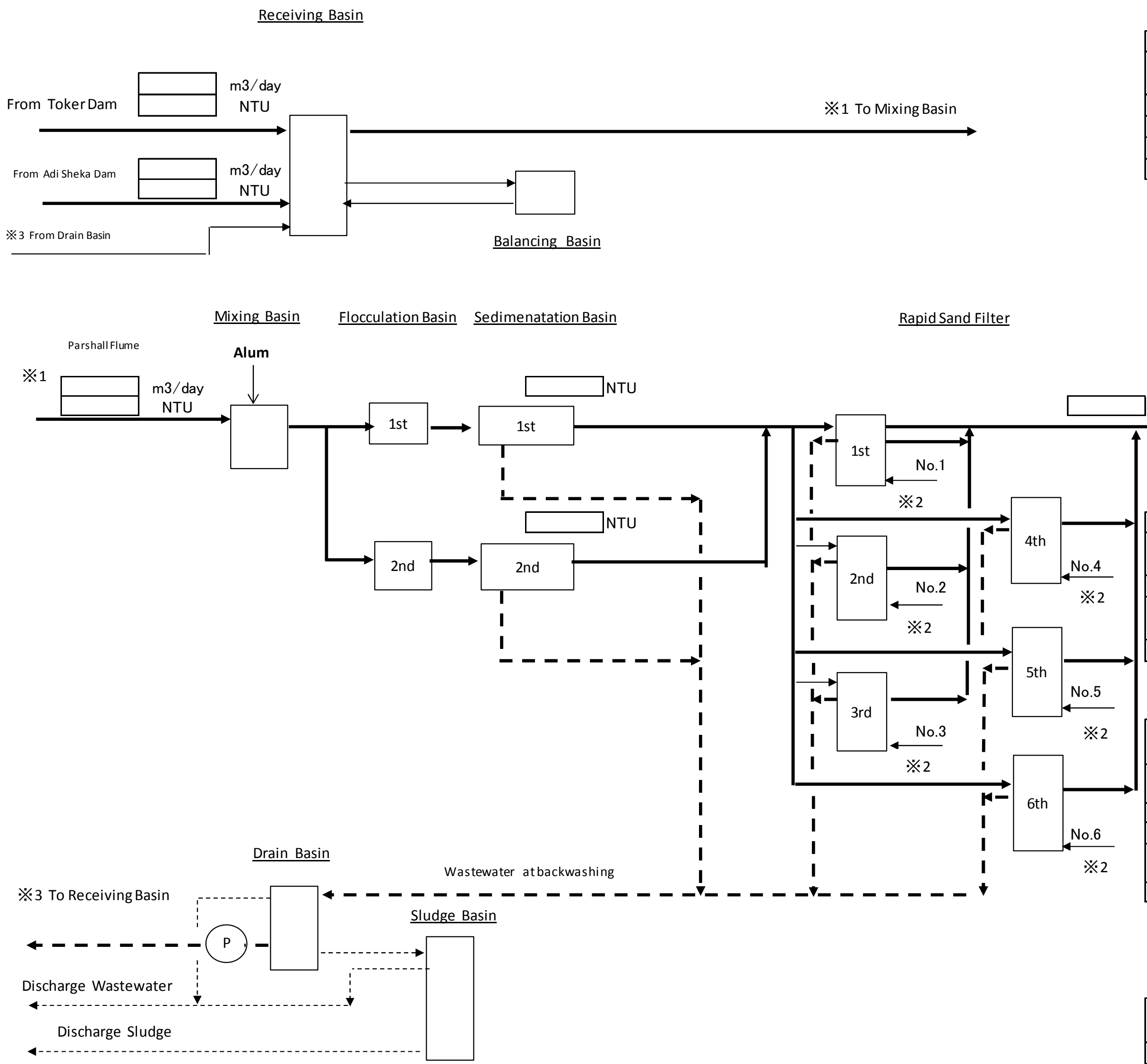
Chemicals

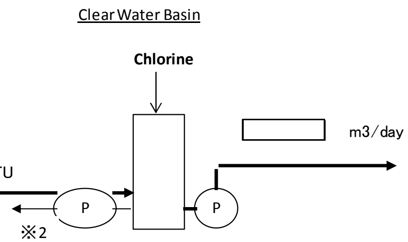
Item	Volume Used kg/day	Dosage Rate g-Al_2O_3/m^3
Alum		
Clorine		

Appendix 10-82

A3-2

Toker WTP (Designed Capacity 18,000m^3/day)   Daily Water Balance and Performance Data   (Date)





Flow Rate

Point Measured		m3/hr	Operation Time (hr)	m3/day	Recovery Rate (%)
Intake	From Adi Sheka Dam				
	From Toker Dam				
Inlet of WTP					
Water Production by Pump					
Water Production by gravity					
Total Water Production					

Water Quality

Point Measured		NTU
Intake	From Adi Sheka Dam	
	From Toker Dam	
Inlet of WTP		
After Sedimentataion	1st	
	2nd	
After RSF		

Removal Rate of Turbidity

Point Measured		Tubidity	Flow Rate		Removal Rate※2
		NTU	m3/day	kg/day※1	%
Intake	From Adi Sheka Dam				
	From Toker Dam				
Total					
Inlet of WTP					
After Sedimentataion	1st				
	2nd				
After RSF					

※1 As 1NTU=1mg/L

※2 Against inlet load of turbidity at inlet of WTP

Chemicals

Item	Volume Used	Dosage Rate
	kg/day	g-Al_2O_3/m^3
Alum		
Chlorine		

Mai Nefhi WTP (Designed Capacity 20,000m^3/day)

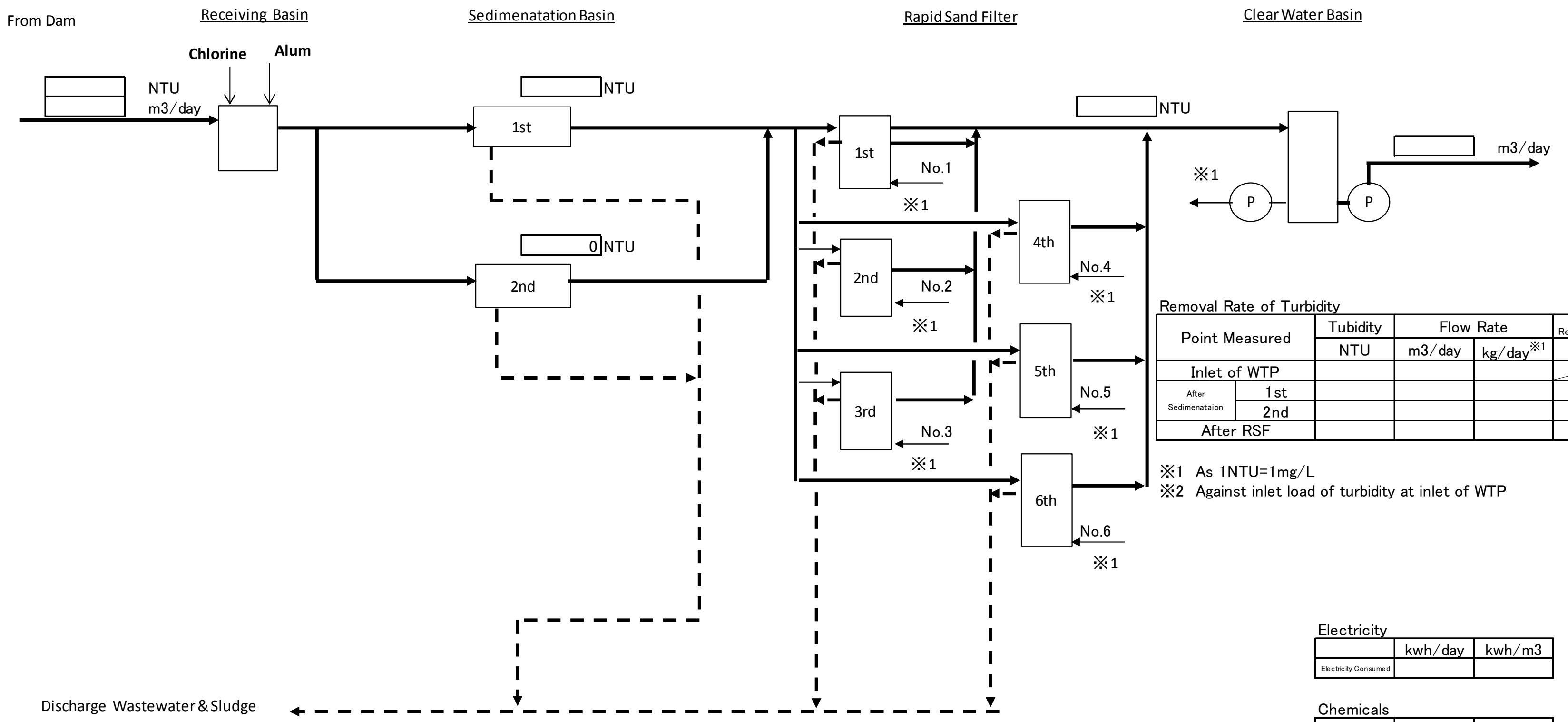
Daily Water Balance and Performance Data (Date)

Flow Rate

Point Measured	m3/hr	Operation Time (hr)	m3/day	Recovery Rate (%)
Inlet at Receiving Basin				
Water Production (by pump)				

Water Quality

Point Measured		NTU
Inlet	From Mai Nefhi Dam	
After Sedimenataion	1st	
	2nd	
After RSF		



Removal Rate of Turbidity

Point Measured		Tubidity	Flow Rate		Removal Rate※2
		NTU	m3/day	kg/day※1	%
Inlet of WTP					
After Sedimenataion	1st				
	2nd				
After RSF					

※1 As 1NTU=1mg/L

※2 Against inlet load of turbidity at inlet of WTP

Electricity

	kwh/day	kwh/m3
Electricity Consumed		

Chemicals

Item	Volume Used	Dosage Rate
	kg/day	g-Al_2O_3/m3
Alum		
Clorine		

Annex-4

Form of Daily Operation Record per Facility

(Water Flow, Water Quality, etc.)

Daily Operation Check Sheet　　Adi Sheka Intake Facility

Date. ____________

1.Adi Sheka Dam　Person Checked __________　Time Checked ____________

Full water level 17.8m　Height of one step 0.2m

Items	①Number of step from the top	②From the bottom		Note.
Water Level			m	②=17.8(Full level)−①×0.2

2.Transmission Pump

Pump 1

Designed Capacity　450m3/hr×40.5mH

	Time (**: **)	Operaing Time (　hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

Pump 2

Designed Capacity　450m3/hr×40.5mH

	Time (**: **)	Operaing Time (　hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

3.Water Production Volume　Person Checked __________　Time Checked ____________

※Check just after transmission pump is stopped.

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Production	Impeller Typed Flow Meter		m3		

Daily Operation Check Sheet　Toker Intake Facility

Date.＿＿＿＿＿＿＿

1.Toker Dam　　Person Checked＿＿＿　　Time Checked＿＿＿＿＿＿＿

Facility Name	Items	Value/Condition		Note.
Toker Dam	Water Level		m	①　Max.46m

2.Transmission Pump (Diezel Engine Pump)

Pump 1

Designed Capacity　990m3/hr×239mH

	Time (**: **)	Operaing Time (　hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				990m3/hr × Total Operating Time (hr)

Pump 2

Designed Capacity　990m3/hr×239mH

	Time (**: **)	Operaing Time (　hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				990m3/hr × Total Operating Time (hr)

3. Fuel Consumec Person Checked＿＿＿　　Time Checked＿＿＿＿＿＿＿

Name of Chemicals	Height of Fuel		Volume		Note/Person Checked
Diesel		m		m3	②= 28.26× ①

Daily Operation Check Sheet S.V. WTP

Date. ____________

1.S.V.Dam Person Checked ________ Time Checked ____________

Facility Name	Items	Value/Condition		Value Designed	Note.
S.V Dam	Water Level		m		

2.Intake Pump of S.V.Dam

Designed Capacity 180m3/hr×20mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				180m3/hr × Total Operating Time (hr)

3.Water Source and Flow Rate Person Checked ________ Time Checked ____________

Designed Capacity 8,000m3/day

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Source	From Adi Sheka Dam				レ or ×
	From S.V Dam				レ or ×
1st Receiving Basin	Flow at Inlet				レ or ×
	Water Level against weir		cm		
	Flow Rate		m^3/hr	83 m^3/hr	①
2nd Receiving Basin	Flow at Inlet				レ or ×
	Water Level against weir		cm		
	Flow Rate		m^3/hr	83 m^3/hr	②
3rd Receiving Basin	Flow at Inlet				レ or ×
	Water Level against weir		cm		
	Flow Rate		m^3/hr	83 m^3/hr	③
4th Receiving Basin	Flow at Inlet				レ or ×
	Water Level against weir		cm		
	Flow Rate		m^3/hr	83 m^3/hr	④

4. Intake Volume

	Time (**: **)	Operaing Hour (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				(①+②+③+④)×Operating Hour (hr)

5.Transmission Pump

Pump 4 Designed Capacity 500m3/hr×80mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

6. Flow Rate for Water Transmission (Read Flow Indicator)

※ Check every 1 hour while pump is operating

Time	Flow Rate (m3/hr)	Person Checked	Note
0:00			
1:00			
2:00			
3:00			
4:00			
5:00			
6:00			
7:00			
8:00			
9:00			
10:00			
11:00			
12:00			
13:00			
14:00			
15:00			
16:00			
17:00			
18:00			
19:00			
20:00			
21:00			
22:00			
23:00			

7. Chemicals Person Checked ____________ Time Checked ____________

Name of Chemicals	Volume Used		Note
Alum		kg	
Gas Chlorine		−	Please check レ when cylinder of gas chlorine is replaced
			1 cylinder of gas chlorine is 157kg

8. Electricity Person Checked ____________ Time Checked ____________

※Check once a day after transmission pump is stopped.

Facility Name	Items	Value/Condition		Value Designed	Note.
Receiving Electric Power Facility	Watt-Hour meter		kwh		

Daily Operation Check Sheet Toker WTP

Date. ____________________

1.Water Source and Flow Rate Person Checked ____________ Time Checked ____________________

Designed Capacity 18,000m3/day

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Source	From Adi Sheka Dam				レ or ×
	From Tokar Dam				レ or ×
	Water Level against weir		cm		
	Flow Rate		m^3/hr	750 m^3/hr	

2. Intake Volume

From Adisheka Dam

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				250m3/hr × Operating Hour (hr)

From Toker Dam

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				990m3/hr × Operating Hour (hr)

3.Inlet Flow Rate of WTP

Parshall Flume	Flow at Inlet				レ or ×
	Flow Rate		m^3/hr	750 m^3/hr	①

4.Inlet Volume of WTP

	Time (**: **)	Operaing Time (hr)	Intake Volume (m3)	Note/Person Checked
Time Started Water Received				
Time Stopped Water Received				
Total				① × Operating Hour (hr)

5.Transmission Pump
Pump 2
Designed Capacity 450m3/hr×65mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

※A

Pump 3
Designed Capacity 450m3/hr×65mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				450m3/hr × Total Operating Time (hr)

※B

6. Water Volume of Clean Water Tank (After transmission pump is finally stopped at the day)

	Time (**: **)	Water Level (%)	Volume (m3)	Note/Person Checked
At the time of pump stopped				② ※Total Capaciy is 3,000m3
At the time of valve closed				③ '= Water level at the time of valve opened next day
②-③				

※C

7. Water Production Volume
Water production volume= A+B+C ______ m3

8. Chemicals Person Checked ______ Time Checked ______

Name of Chemicals	Volume Used		Note
Alum		kg	
Gas Chlorine		−	Please check ﾚ when cylinder of gas chlorine is replaced
			1 cylinder of gas chlorine is 157kg

Daily Operation Check Sheet Mai Nephi WTP

Date. ______________

1.Mai Nephi Dam Person Checked ____________ Time Checked ______________

Maximum water level is 35m

Facility Name	Items	Value/Condition		Value Designed	Note.
Mai Nephi Dam	Water Level		m		①
	Sludge Level		m		② 9m as of 30 July, 2016
	Actural Water Level		m		①−②

2. Intake Volume Designed Flow Rate 20,000 m3/day = 833m3/day

Rotating Number of Intake Valve (0～7)	③Flow Rate (m3/hr)	Time (**: **)	④Oprating Time (hr)	Intake Volume (m3)	Note/Person Checked
					③×④
Total					

3.Transmission Pump

Pump 1

Designed Capacity 500m3/hr×215mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

Pump 2

Designed Capacity 500m3/hr×215mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

Pump 3

Designed Capacity 500m3/hr×215mH

	Time (**: **)	Operaing Time (hr)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

4.Water Production Volume Person Checked ____________ Time Checked ______________

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Production	Impeller Typed Flow Meter		m3		

5. Chemicals Person Checked ____________ Time Checked ______________

Name of Chemicals	Volume Used		Note
Alum		kg	
Gas Chlorine		−	Please check ✓ when cylinder of gas chlorine is replaced
			1 cylinder of gas chlorine is 157kg

6. Electricity Person Checked ____________ Time Checked ______________

Facility Name	Items	Value/Condition		Value Designed	Note.
Receiving Electric Power Facility	Watt−Hour meter		kwh		

Daily Operation Check Sheet Denden PS

Date. ____________________

1.Water Level of Tank Person Checked ____________ Time Checked ____________________

Designed Capacity 3,000m3 Full water level 5m.

Check before water transmission is started. Time Checked ____________________

Facility	Item	①Value (m)	②Volume(m3)	Note.
Reservoir	Water Level			②=3,000×①/5

Check after water transmission is finishied. Time Checked ____________________

Facility	Item	①Value (m)	②Volume(m3)	Note.
Reservoir	Water Level			②=3,000×①/5

2.Water Transmission (To Algena Camp and Denden Camp)

	Name of Place	Check			Note.
Trasmitted to:	Algena Camp				レ or ×
	Denden Camp				レ or ×

Pump 1

Designed Capacity ?m3/hr×?mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				?m3/hr × Total Operating Time (hr)

3.Transmisson to Denden Camp (by Pump and by Gravity)

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Valve Opened				
Time Valve Closed				
Time Valve Opened				
Time Valve Closed				
Total				?m3/hr × Total Operating Time (hr)

Daily Operation Check Sheet   Algena Camp Tank

Date.____________________

1.Water Level of Tank   Person Checked __________   Time Checked ____________________

Designed Capacity 348m3(7.6mL×10.9mW×4.2mH) Full water level 4.2m.

Check before pump is started.

Facility	Item	①Height (m)	②Volume(m3)	Note.
Reservoir	Water Level			②=①×83m3

Check after pump is stopped.

Facility	Item	①Height (m)	②Volume(m3)	Note.
Reservoir	Water Level			②=①×83m3

2.Water Transmission

Pump 1

Designed Capacity ?m3/hr×?mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				?m3/hr × Total Operating Time (hr)

3. Electricity   Person Checked __________   Time Checked ____________________

※Check after pump is stopped.

Facility Name	Items	Value/Condition		Value Designed	Note.
Receiving Electric Power Facility	Watt-Hour meter		kwh		

Daily Operation Check Sheet Monopolio Reservoir

Year 2016
Month August

Design Capacity: 300m^3 × 2 Tank Max water level : 3.5m

Date	Time Checked	Water Level (cm)	Person Checked	Note
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				

If you have any question please condtact Mr. Michael Temesgen, Asmara Water Supply & Sewerage Department (AWSSD
Mobile Number of Mr.Michael Temesgen: 07173851

Daily Operation Check Sheet　　Testserat Reservoir

Date. ____________________

1.Water Level of Tank

Designed Capacity 500m3×2

Check after water transmission is finished.

Facility Name	Items	Condition	Note.
Reservoir	Water Level		Select High/Midium/Low
			When water is received from distribution line, check レ

2.Transmission Pump （To High Area）

Pump 1

Designed Capacity 27m3/hr×40mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				?m3/hr × Total Operating Time (hr)

3. Electricity　　Person Checked ____________　　Time Checked ____________________

※Check once a day at the end of the day

Facility Name	Items	Value/Condition		Value Designed	Note.
Receiving Electric Power Facility	Watt-Hour meter		kwh		

Daily Operation Check Sheet　Mai Chehot PS

Date.____________________

1.Water Level of Tank

Designed Capacity 500m3×1

Item	Time (**: **)	Volume (m3)	Person Checked	Note
Before transmission pump is operated				※1
After transmission pump is operated				

※1 In case transmission pump is not operated at the day, describe the water level in the morning of the day.

2.Transmission Pump

Pump 1 (To high area 1)

Designed Capacity 150m3/hr×30mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				?m3/hr × Total Operating Time (hr)

Pump 2 (To high area 2)

Designed Capacity 200m3/hr×80mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				?m3/hr × Total Operating Time (hr)

3. Electric Power Consumed

Item	Time (**: **)	kwh	kvarh	Person Checked	Note
Before transmission pump is operated					※2
After transmission pump is operated					

※2 In case transmission pump is not operated at the day, describe the electric power value of watt-hour meter (kwh and kvarh) in the morning of the day.

4. Watar Production Volume　Person Checked __________　Time Checked ____________________

Item	Time (**: **)	Volume (m3)	Person Checked	Note
Before transmission pump is operated				※3
After transmission pump is operated				

※3 In case transmission pump is not operated at the day, describe the water level in the morning of the day.

Daily Operation Check Sheet New Sembel PS

Date. ____________________

1.Transmission Pump

Pump 1

Designed Capacity 500m3/hr×90mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

Pump 2

Designed Capacity 500m3/hr×90mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

Pump 3

Designed Capacity 500m3/hr×90mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

2. Watar Production Volume Person Checked ____________ Time Checked ____________________

※Check once a day at the end of the day

Facility Name	Items	Value/Condition		Value Designed	Note.
Water Transimisson	Water Production Volume				$0.3m^3$/ 1 count

Daily Operation Check Sheet Godaif PS

Date.____________________

※Tank Volume 200m3

1.Transmission Pump

Pump 1

Designed Capacity 300m3/hr×88mH

	Time (**: **)	Operaing Hour (hr min)	Transmission Volume (m3)	Note/Person Checked
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Time Started				
Time Stopped				
Total				500m3/hr × Total Operating Time (hr)

Water Quality Record　　　　Adi Sheka Dam

Weather ____________　　　　Date. ____________

Person Checked ____________　　　　Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
From Adisheka Dam	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				

Water Quality Record　　Toker Dam

Weather ____________　　Date. ___________

Person Checked ____________　　Time. ___________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
From Toker Dam	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				

Water Quality Record S.V WTP

Weather ____________ Date. ____________

Person Checked ____________ Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Receiving Basin					
From Adi Sheka Dam	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				
From S.V Dam	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				

1st Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
2nd Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
3rd Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
4th Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
5th Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
Clean Water	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record Toker WTP

Weather ____________ Date. ___________

Person Checked ____________ Time. ___________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
From Adisheka Dam	Temperature		℃		
	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				
From Toker Dam	Temperature		℃		
	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				
Receiving Basin	Temperature		℃		
	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				
1st Line	Temperature		℃		
After Sedimentation Basin	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
2nd Line	Temperature		℃		
After Sedimentation Basin	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		

Clean Water	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record   Mai Nefhi WTP

Weather ____________   Date. ____________

Person Checked ____________   Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Receiving Basin	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
	Color				
	Smell				
1st Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
2nd Line	Temperature		℃		
After Sedimentation Basin	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU		
Clean Water	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record　　　　Denden PS

Weather ____________　　　　Date. ___________

Person Checked ____________　　　　Time. ___________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Denden PS	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record　　　　　　Algena Camp Reservoir

Weather ____________　　　　　　Date. ___________

Person Checked ____________　　　　　　Time. ___________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Algena Camp Res.	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record　　　　Testserat Reservoir

Weather ____________　　　　Date. ____________

Person Checked ____________　　　　Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Testserat Res.	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record — Monopolio Reservoir

Weather ____________ Date. ____________

Person Checked ____________ Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Monopolio Res.	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record　　　　Mai Chehot PS

Weather ____________　　　　Date. ____________

Person Checked ____________　　　　Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Mai Chehot PS	Temperature		℃		
	pH		－		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record New Sembel PS

Weather ____________ Date. ____________

Person Checked ____________ Time. ____________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
New Sembel PS	Temperature		℃		
	pH		–		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Water Quality Record Godaif PS

Weather ____________ Date. ___________

Person Checked ____________ Time. ___________

Sampling Point	Items	Value	Unit	Value Desinged	Note.
Godaif PS	Temperature		℃		
	pH		−		
	Electrical Conducitivity		uS/cm		
	Turbidity		NTU	5 NTU or less	
	Color				
	Smell				
	Residual Chlorine (Free)		mg/L	0.1mg/L or more	
	Residual Chlorine (Total)		mg/L		
	Bacteria		cells/ml		
	Total Coliform		cells/ml	ND	

Annex-5

Calculation of Water Demand per Distribution Zone

Water Demand per Distribution Zone

<table>
<tr><th rowspan="2">WTP</th><th rowspan="2">Distribute Zone</th><th colspan="3">Population</th><th colspan="3">Water Demand (m^3/d)</th><th colspan="2">Distribution (Aug 2016)</th></tr>
<tr><th>Total</th><th>By Pipe</th><th>By Truck</th><th>Pipe 50LCD</th><th>Truck 15LCD</th><th>Total</th><th>(m^3/d)</th><th>% by demand</th></tr>
<tr><td>S.V.</td><td>Direct</td><td rowspan="10">400,000</td><td>50,459</td><td rowspan="10">189,588</td><td>2,523</td><td rowspan="10">2,844</td><td rowspan="10">13,365</td><td rowspan="10">11,376</td><td rowspan="10">85%</td></tr>
<tr><td rowspan="5">Toker</td><td>Direct</td><td>87,955</td><td>4,398</td></tr>
<tr><td>Tsetserat</td><td>7,510</td><td>376</td></tr>
<tr><td>Monopolio</td><td>4,316</td><td>216</td></tr>
<tr><td>Denden</td><td>7,449</td><td>372</td></tr>
<tr><td>Algen Camp</td><td>1,727</td><td>86</td></tr>
<tr><td rowspan="3">Mai Nefhi</td><td>Direct (villages)</td><td>7,472</td><td>374</td></tr>
<tr><td>New Sembel</td><td>28,268</td><td>1,413</td></tr>
<tr><td>Godaif</td><td>15,256</td><td>763</td></tr>
<tr><td>Total</td><td></td><td>210,412</td><td>10,521</td></tr>
</table>

Note

1) Population is calculated based on the last census (2015) and number of piped water customers (connections).

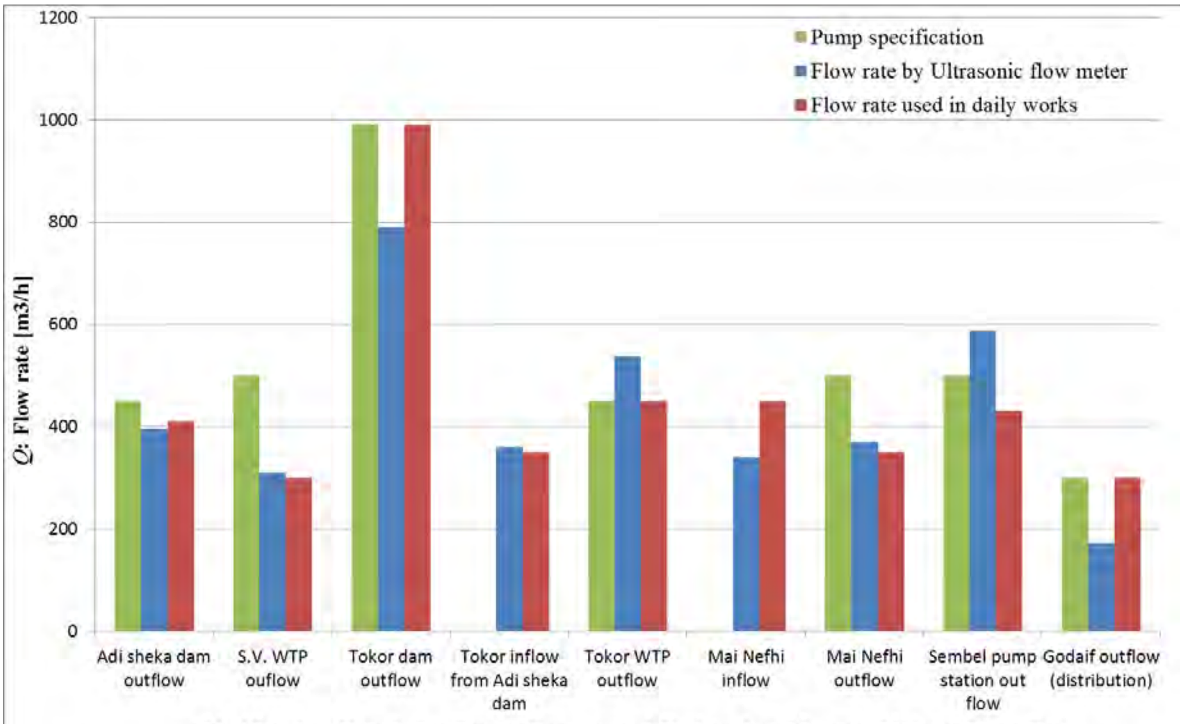
2) Unit water demand is based on the present target of AWSSD which is 50LCD for piped water and 15LCD for water tank truck delivery.

Annex-6

Verification Result for Pump Output and Estimating Means of Water Flow Rate

Verification Result for Pump Output and Estimating Means of Water Flow Rate

	Pump specification [m³/h]	Flow rate by Ultrasonic flow meter [m³/h]	Flow rate used in daily works [m³/h]
Adi sheka dam outflow	450	397	411
S.V. WTP ouflow	500	310	300
Toker dam outflow	991	790	990
Toker WTP inflow from Adi Sheka dam	-	360	350
Toker WTP outflow	450	537	450
Mai Nefhi inflow	-	340	450
Mai Nefhi outflow	500	370	350
Sembel pump station outflow	500	588	432
Godaif outflow (distribution)	300	172	300
Remarks Data collected till the beginning of September 2016			



Verification Result for Pump Output and Estimating Means of Water Flow Rate

Annex-7

Summary of Data Obtained in August 2016

Summary for Intake Volume from Dam From Aug.11 to Aug.31

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded							
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	21	13	1	7	6.9	10.4	3,461	500	12,007	Intake volume is estimated by water meter. Not work due to mechanical problem of pump from Aug.20 to Aug.25 and electric power outage in Aug 31.
Tokor Dam	21	19	2	0	7.7	7.7	7,607	990	23,760	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not operated due to the problem of electric facility in Sembel PS from Aug.21 to Aug.22
Total							17,803			

Summary for Water Level of Dam From Aug.11 to Aug.31

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Ave.	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	21	21	11.4	11.6	11.4	Max.=17.8m
Tokor Dam	21	19	17.6	17.8	17.3	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	21	18	17.1	17.8	16.2	Max.=35m

Summary of Water Treatment Plant From Aug.11 to Aug.31

Water Received

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(=m^3/day)	
S.V WTP	Adi Sheka Dam	21	0	14	7	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Not Recorded	Inlet volume is not recorded. Water is not received from Adi Sheka dam due to mechanical problem of pump in Adi Sheka dam from Aug.20 to Aug.25
Tokor WTP	Adi sheka Dam	21	1	1	19	0.2	4.3	76	350	8,400	Intake volume is estimvated by operating time of pump (hr) × rated flow rate of pump (m3/hr). Water is received from Adisheka dam from Aug.9 to Aug.10 and Aug.30. Water is received from Tokor dam from Aug.9 to Aug.30. But water is not received from Tokor dam in Aug.18 due to mechanical problem of pump in Tokor dam.
	Tokor Dam	21	18	2	1	6.9	7.3	6,225	900	21,600	
Mai Nefhi WTP	Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimvated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not work due to electrical problem on New Sembel PS from Aug.21 to Aug.22
Total								-			

Summary of Water Treatment Plant From Aug.11 to Aug.31

Water Produced

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(= m^3/day)	
S.V WTP	Adi Sheka Dam	21	14	0	7	5.5	8.2	1,643	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr). Not work due to not receiving water from Aug.20 to Aug.25.
Tokor WTP	Adi Sheka Dam/Tokor Dam	21	14	2	5	4.4	5.6	2,217	500	12,000	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr). Not work due to not receiving water in Aug.18. Trasmission pump was stopped due to electric power outage in Aus.19, 20, 26 and 28.
							(By Gravity)	2,479			
							(Total)	4,696			
Mai Nefhi WTP	Mai Nefhi Dam	21	8	11	2	14.2	17.8	5,037	354	8,499	Water production volume is estimated by water meter. Not work due to electrical problem on New Sembel PS from Aug.21 to Aug.22.
Total								11,376			

Summary of Water Treatment Plant From Aug.11 to Aug.31

Chemical Used

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded										
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced
S.V WTP	21	7	7	7	21.4	5.4	128.6	17.9	2.5	0	0	0	0
Tokor WTP	21	18	2	1	284.2	43.3	1,038.6	60.5	8.5	24.9	3.8	91.2	5.3
Mai Nefhi WTP	21	18	1	2	420.0	33.5	804.3	95.3	13.3	31.6	2.1	50.5	6.3

Summary of Water Transmissoin Volume From August 11 to August 31

1. Tokor WTP Water Distribution Area

Name of Pump Station/Reservoir		Result of Operation							
		Number of Data Recorded					Averaged Flowrate per Day		Note.
		Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
			Recorded	Not Recorded	Not Scheduled	as Scheduled			
		Days	Days	Days	Days	Days	m^3/day	m^3/day	
Denden PS	To Algene Camp	21	0	8	3	10	-	-	・Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) ・Not work due to not receiving water from Tokor WTP from Aug.22 to Aug.24. ・There are no recorded data of the transmission volume for Algena Camp because the operator does not master how to record the operation yet.
	To Denden Camp	21	3	5	3	10	306	1,633	
Mai Chehot PS		21	1	0	2	18	32	675	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.30
Testserat Res.		21	6	4	0	11	20	56	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Monopolio Res.		21	3	0	18	0	15	103	Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.15 and Aug. 20 to Aug. 31.
Algena Camp		21	1	0	3	17	7	145	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Denden PS. From Aug.11 to August 21 and from Aug.23 to Aug.31

2. Mai Nefhi WTP Water Distribution Area

Name of Pump Station/Reservoir	Number of Data Recorded					Averaged Flowrate per Day		Note.
	Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
		Recorded	Not Recorded	Not Scheduled	as Scheduled			
	Days	Days	Days	Days	Days	m^3/day	m^3/day	
Sembel PS	21	17	2	2	0	2,860	3,197	Water production volume is estimated by water meter Not work due to electric facility problem from Aug.21 to Aug.22
Godaif PS	21	19	0	2	0	1,294	1,430	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water by electric facility problem in Sembel PS from Aug.21 to Aug.22

Result of Watar Quality Analysis at Facility :Dam Period: From Aug.11 to Aug.31, 2016

Adisheka Dam

Date		11-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	No. of Data	Ave.	Max.	Min.
Time		10:00	8:00	6:30	9:00	10:00	11:30				
Weather		Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy				
Water Source		Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam				
Person Checked		Asmerom	Okbay	Okbay	Okbay	Okbay	Okbay				
Parameter	Unit										
Temperature	℃	18.7	18.1	18.2	18.6	18.5	18.1	6	18.4	18.7	18.1
pH	-	8.0	8.0	8.0	7.9	8.0	8.0	6	8.0	8.0	7.9
Electrical Conducitivity	uS/cm	255	371	374	370	365	365	6	350	374	255
Turbidity	NTU	36.1	36.1	36.1	36.2	36.2	36.0	6	36.1	36.2	36.0
Color	-	No	No	No	No	No	No	6	-	-	-
Smell	-	No	No	No	No	No	No	6	-	-	-

Tokor Dam

Date		10-Aug	30-Aug	31-Aug				No. of Data	Ave.	Max.	Min.
Time		10:33	20:00	20:00							
Weather		Rainy	Cloudy	Cloudy							
Water Source		Tokor Dam	Tokor Dam	Tokor Dam							
Person Checked		Tekie	Tekie	Tekie							
Parameter	Unit										
Temperature	℃	17.3	19.7	18.9				3	18.6	19.7	17.3
pH	-	7.5	4.5	4.4				3	5.5	7.5	4.4
Electrical Conducitivity	uS/cm	204	202	195				3	200	204	195
Turbidity	NTU	127.0	34.3	32.2				3	64.5	127.0	32.2
Color	-	No	No	No				3	-	-	-
Smell	-	No	No	No				3	-	-	-

Result of Watar Quality Analysis Facility :S.V WTP Period: From Aug.11 to Aug.31, 2016

S.V WTP

Date			17-Aug	18-Aug	19-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			15:16	16:30	20:00	11:30	10:45	18:00	7:00					
Weather			Cloudy	Rainy	Cloudy	Sunny	Sunny	Cloudy	Sunny					
Water Source			Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam					
Person Checked			Yikaalo	Mulugheta	Mulugheta	Mulugheta	Mulugheta	Abraham	Mulugata					
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	24.6	19.2	22.4	18.5	18.9	18.6	19.8		7	20.3	24.6	18.5
	pH	-	8.46	6.32	8.24		8.34		8.42		5	8.0	8.5	6.3
	Electrical Conducitivity	uS/cm	243	225	248		247	270	244		6	246	270	225
	Turbidity	NTU	78.2	71.5	74.6	64.2	42.7	28.9	41.4		7	57.4	78.2	28.9
	Color	-	No	No	No	No	No	No	No		7	-	-	-
	Smell	-	No	No	No	No	No	No	No		7	-	-	-
Treated Water	Temperature	℃	21.1	22.2	19.8	19.7	19.1	20.1	20.1		7	20.3	22.2	19.1
	pH	-	7.99	7.08	6.68	7.81	8.10	8.15	8.15		7	7.7	8.2	6.7
	Electrical Conducitivity	uS/cm	249	219	240	187	231	237	234		7	228	249	187
	Turbidity	NTU	19.4	20.2	28.6	11.7	19.5	15.2	16.6	5 NTU or less	7	18.7	28.6	11.7
	Color	-	No	No	No	No		No	No		6	-	-	-
	Smell	-	No	No	No	No	No	No	No		7	-	-	-
	Residual Chlorine (Free)	mg/L	-	-	-	-	-	-	-	(0.1mg/L or more)	0	-	-	-
	Residual Chlorine (Total)	mg/L	-	-	-	-	-	-	-		0	-	-	-
	Bacteria	cells/ml				9	7				2	-	-	-
	Total Coliform	cells/ml				3	2			ND	2	-	-	-

Result of Watar Quality Analysis Facility :Tokor WTP Period: From Aug.11 to Aug.31, 2016

Toker WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	20-Aug	21-Aug	24-Aug	25-Aug
Time			8:00	8:00	11:20	8:00	9:00	8:00	8:30	9:30	8:00	8:30	8:30	8:15
Weather			Cloudy/ Sunny	Sunny	Sunny	Sunny	Sunny	Sunny /Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	17.0	18.1	18.6	17.8	18.1	20.4	18.9	17.6	17.1	17.8	17.5	17.4
	pH	-	7.85	7.35	7.37	7.16	7.04	7.51	7.15	7.3	7.0	7.1	7.17	7.51
	Electrical Conducitivity	uS/cm	178	168	189	219	192	170	168	167	192	186	181	179
	Turbidity	NTU	90.7	98.3	87.7	142	85.5	12.6	122	97.6	>1000	>1000	73	76
	Color	-	High	No	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown
	Smell	-	No	No	No	No	No	No	No	No	No	No	No	No
Treated Water	Temperature	℃	19.4	17.3	18.9	17.7	19.9	20.5	18.7	17.5	17.7	17.7	17.1	17.5
	pH	-	7.36	7.27	7.24	7.22	7.23	7.35	7.42	7.21	6.79	6.92	7.07	7.15
	Electrical Conducitivity	uS/cm	244	167	225	179	168	178	172	176	176	176	179	196
	Turbidity	NTU	17.3	86.3	39.8	77.2	74.9	73.9	65	62.4	76.0	85.1	76.3	57.5
	Color	-	No	High	No	Brown	Brown	No	No	No	No	No	No	No
	Smell	-	Chlorine Smell	No	No	No	No	No	No	No	No	No	No	No
	Residual Chlorine (Free)	mg/L	0.97	0.28	0.11	0.07	0.24	0.08	0.01	0.1	1.98	1.94	0.37	0.01
	Residual Chlorine (Total)	mg/L	1.39	1.19	0.53	0.12	0.32	0.21	0.18	0.18	0.07	0.03	0.55	0.03
	Bacteria	cells/ml	0	0	0	0	0		0				Detect	Detect
	Total Coliform	cells/ml	0	0	0	0	0		Detect				Detect	ND

Date			26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	30-Aug	31-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			8:45	9:00	10:00	9:30	9:00	9:00	9:00					
Weather			Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Adi Sheka Dam	Toker Dam	Toker Dam					
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana					
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	17.1	18.9	19.8	18.2	17.0	17.7	18.1		19	18.1	20.4	17.0
	pH	-	7.28	7.5	7.5	7.2	8.0	7.9	7.4		19	7.4	8.0	7.0
	Electrical Conducitivity	uS/cm	175	180	181	206	245	182	184		19	186	245	167
	Turbidity	NTU	48	67.9	74.4	54.8	62.6	29.9	50		19	>172	>1000	12.6
	Color	-	Brown	No	No	No	Brown	No	No		19	-	-	-
	Smell	-	No	No	No	No	Grass	No	No		19	-	-	-
Treated Water	Temperature	℃	17.7	20.4	21.3	19.2	19.5		18.1		18	18.7	21.3	17.1
	pH	-	6.95	7.2	7.4	7.1	7.2		7.3		18	7.2	7.4	6.8
	Electrical Conducitivity	uS/cm	183	191	183	187	188		192		18	187	244	167
	Turbidity	NTU	42.4	37.5	33.8	37	33.3		29.4	5 NTU or less	18	55.8	86.3	17.3
	Color	-	No	No	No	No	No		No		18	-	-	-
	Smell	-	No	No	No	No	chlorine		chlorine		18	-	-	-
	Residual Chlorine (Free)	mg/L	1.02	0.15	0.07	2.15	0.58		0.43	(0.1mg/L or more)	18	0.6	2.2	0.0
	Residual Chlorine (Total)	mg/L	1.06	0.28	0.19	2.2	0.82		0.83		18	0.6	2.2	0.0
	Bacteria	cells/ml	1	ND	ND	ND	ND				13	-	-	-
	Total Coliform	cells/ml	3	ND	ND	ND	ND			ND	13	-	-	-

Result of Watar Quality Analysis Facility :Mai Nefhi WTP Period: From Aug.11 to Aug.31, 2016

Mai Nefhi
WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	23-Aug	24-Aug
Time			20:00	18:00	18:00	18:00	18:00	15:30	18:00	18:00	18:00	18:00	18:00
Weather				Sunny		Sunny	Sunny	Sunny	Sunny	Sunny	Rain	Sunny	Sunny
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam
Person Checked			Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem
Measuring Point	Parameter	Unit											
Raw Water	Temperature	℃											
	pH	-	7.29	7.68	5.24	8.11	7.81	6.95	6.91	5.72	4.31	6.53	7.01
	Electrical Conducitivity	uS/cm	203	153	392	161	166	228	250	203	163	149	284
	Turbidity	NTU	524	354	361	245	272	369	286	>1000	>1000	530	109
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	Smell	-	No	No	No	No	No	No	No	No	No	No	No
Treated Water	Temperature	℃											
	pH	-	6.94	6.99	7.68	7.58	7.71	6.15	6.42	6.58	6.00	5.71	6.89
	Electrical Conducitivity	uS/cm	166	161	159	178	168	199	183	162	150	187	177
	Turbidity	NTU	268	448	309	101	230	49.8	133	677	>1000	67.4	86.1
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	No	Yellow	Yellow	Yellow	Yellow	Yellow
	Smell	-	No	No	No	No	No	No	No	No	No	No	No
	Residual Chlorine (Free)	mg/L	6.4	7.0	0	0	0	8.3	5.3	1.0	0	0.9	0
	Residual Chlorine (Total)	mg/L	5.0	0	0	0	0	8.8	2.6	1.0	0	1.1	0
	Bacteria	cells/ml	0	5					ND	ND	6	ND	
	Total Coliform	cells/ml	0	2					ND	ND	4	ND	

Measuring Point	Parameter	Unit	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline value	No. of Data	Ave.	Max.	Min.
Time			18:00	7:00	18:00	14:00	18:00	18:00					
Weather			Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam					
Person Checked			Tesfalem	Tesfaalem	Tesfaalem	Tedros	Tesfaalem	Tesfaalem					
Raw Water	Temperature	℃		20.5	23.5	22.7	20.1	21.2		5	21.6	23.5	20.1
	pH	-	7.32	4.26	7.57	7.01	7.83	7.89		17	6.8	8.1	4.3
	Electrical Conducitivity	uS/cm	183	504	265	216	202	245		17	233	504	149
	Turbidity	NTU	104	148	90.1	80.6	807	101		17	>375	>1000	81
	Color	-	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No		17	-	-	-
Treated Water	Temperature	℃		20.4	23.5	21.9	20.3	21.6		5	21.5	23.5	20.3
	pH	-	6.98	6.13	6.61	6.93	7.46	6.65		17	6.8	7.7	5.7
	Electrical Conducitivity	uS/cm	178	213	209	211	208	210		17	183	213	150
	Turbidity	NTU	86.5	40.2	49.1	56.4	81.7	66.5	5 NTU or less	17	>221	>1000	40
	Color	-	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No		17	-	-	-
	Residual Chlorine (Free)	mg/L	0	0.0	0.0	6.8	0.0	0.0	(0.1mg/L or more)	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	0	3.0	0.0	0.0	7.0	0.0		17	1.7	8.8	0.0
	Bacteria	cells/ml					10			7	-	-	-
	Total Coliform	cells/ml					0		ND	7	-	-	-

Result of Watar Quality Analysis Facility :Pump Station and Reservoir Period: From Aug.11 to Aug.31, 2016

Sembel PS

Date		11-Aug	17-Aug	31-Aug			No. of Data	Ave.	Max.	Min.
Time		15:25	9:13	9:30		WHO Guideline valume				
Weather		Rainy	Sunny	Sunny						
Coming From		Mai Nefhi WTP	Mai Nefhi WTP	Mai Nefhi WTP						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.4	20	22.3			3	20.6	22.3	19.4
pH	-	7.68	6.95	6.79			3	7.1	7.7	6.8
Electrical Conducitivity	uS/cm	367	201	110			3	226	367	110
Turbidity	NTU	144	163	43.3		5NTU or less	3	117	163	43
Color	-	No	No	No			3	-	-	-
Smell	-	No	No	No			3	-	-	-

Godaif PS

Date		10-Aug	17-Aug	31-Aug		WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		16:28	9:50	10:00						
Weather		Rainy	Cloudy	Sunny						
Coming From		Sembep PS	Sembel PS	Sembel PS						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.3	22	23.6			3	21.6	23.6	19.3
pH	-	8.4	7.1	7.19			3	7.6	8.4	7.1
Electrical Conducitivity	uS/cm	326	192	233			3	250	326	192
Turbidity	NTU	66.2	185	50.4		5NTU or less	3	101	185	50
Color	-	No	No	No			3	-	-	-
Smell	-	No	No	No			3	-	-	-

Denden PS

Date		15-Aug	26-Aug	30-Aug		WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		9:17	9:30	2:40						
Weather		Sunny	Sunny	Sunny						
Coming From		Tokor WTP	Tokor WTP	Tokor WTP						
Person Checked		Yikaalo	Yikaalo	Yikaalo						
Parameter	Unit									
Temperature	℃	19.5	19.9	24.1			3	21.2	24.1	19.5
pH	-	7.96	7.06	6.87			3	7.3	8.0	6.9
Electrical Conducitivity	uS/cm	278	251	259			3	263	278	251
Turbidity	NTU	46.6	19.5	17.1			3	28	47	17
Color	-	No	No	No			3	-	-	-
Smell	-	No	No	No			3	-	-	-

Testserat RS

Date		15-Aug	31-Aug			WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		10:31	9:00							
Weather		Sunny	Sunny							
Coming From		Tokor WTP	Tokor WTP							
Person Checked		Yikaalo	Yikaalo							
Parameter	Unit									
Temperature	℃	19.7	19.8				2	19.8	19.8	19.7
pH	-	8.04	7.13				2	7.6	8.0	7.1
Electrical Conducitivity	uS/cm	344	283				2	314	344	283
Turbidity	NTU	0.99	0.94			5NTU or less	2	1	1	1
Color	-	No	No				2	-	-	-
Smell	-	No	No				2	-	-	-

Mai Chehot RS

Date		15-Aug				WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		10:45								
Weather		Sunny								
Coming From		Tokor WTP								
Person Checked		Yikaalo								
Parameter	Unit									
Temperature	℃	19.9					1	19.9	19.9	19.9
pH	-	8.09					1	8.1	8.1	8.1
Electrical Conducitivity	uS/cm	284					1	284	284	284
Turbidity	NTU	3				5NTU or less	1	3	3	3
Color	-	No					1	-	-	-
Smell	-	No					1	-	-	-

Monopolio RS

Date		15-Aug				WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		16:00								
Weather		Sunny								
Coming From		Tokor WTP								
Person Checked		Yikaalo								
Parameter	Unit									
Temperature	℃	20					1	20.0	20.0	20.0
pH	-	8.35					1	8.4	8.4	8.4
Electrical Conducitivity	uS/cm	181					1	181	181	181
Turbidity	NTU	66.6				5NTU or less	1	67	67	67
Color	-	No					1	-	-	-
Smell	-	No					1	-	-	-

Algena Camp PS

Date		24-Aug	31-Aug			WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time		16:16	10:30							
Weather		Cloudy	Cloudy							
Coming From		Tokor WTP	Tokor WTP							
Person Checked		Yikaalo	Yikaalo							
Parameter	Unit									
Temperature	℃	23.3	21.1				2	22.2	23.3	21.1
pH	-	8.15	7.55				2	7.9	8.2	7.6
Electrical Conducitivity	uS/cm	198	270				2	234	270	198
Turbidity	NTU	5.5	9.95			5NTU or less	2	8	10	6
Color	-	No	No				2	-	-	-
Smell	-	No	No				2	-	-	-

Annex-8

Findings and Analysis Result from Obtained Data in August 2016 (Water Flow)

Findings and Analysis Result of from Obtained Data in August 2016

(Water Flow)

1. Water Level and Intake Volume on Each Dam

   Summary for water level of intake volume on each dam is shown in Table 1.

   Findings obtained from the result of water level in each dam are shown below;

- Averaged water level in Adi Sheka was 11.4m from the bottom of dam, which was located above the half of maximum water depth. In addition, the water level was almost stable through the period.
- Averaged water level in Tokor dam was 17.6m from the bottom of dam, which was located in 11m higher than lowest intake valve. In addition, the water level was a little increased through the period.
- Averaged water level in Mai Nefhi Dam was 17.1m from the bottom of dam, which was located in approximate half of maximum water depth. In addition, the water level was a little increased through the period.
- Water level in this period of each dam is supposed to be the highest because this period is the end of rainy season in general year. Therefore by taking the data regarding water level and intake volume of each dam through the year, we need to confirm that each dam can supply required water continuously keeping the water above the minimum level in each dam.

Summary for intake volume from dam is shown in Table 2.

Findings obtained from the result of intake volume from each dam are shown below;

- Intake pump of the Adi Sheka dam was stopped for total 7 days through the period of 21 days due to mechanical problem of pump and electric power outage. Therefore averaged operating time of intake pump was down up to 6.9 hour/day, which was approximate 30% lower than original plan.
- Intake pump of Tokor dam was operated for 7.7 hours/day on the average every day through the period
- Intake pump of May Nefhi dam was not operated for total 2 days through the period of 21 days due to the problem of electric facility in Sembel PS. Therefore averaged operating time of intake pump was down up to 15 hours/day, which was 10% lower than original plan.

Table 1　Summary for Water Level of Dam (From Aug. 11 to Aug. 31)

Name of Dam	Number of Data Recorded		Water Level from Bottom (m)			Note.
	Total Days	Data Recorded	Ave.	Max.	Min.	
	Days	Days	m	m	m	
Adi Sheka Dam	21	21	11.4	11.6	11.4	Max.=17.8m
Tokor Dam	21	19	17.6	17.8	17.3	Max.=49m, Lowest intake valve = 11m
Mai Nefhi Dam	21	18	17.1	17.8	16.2	Max.=35m

Table 2　Summary for Intake Volume from Dam (From Aug. 11 to Aug. 31)

Name of Dam	Number of Data Recorded				Averaged Operating Time per Day		Average Intake Volume			Note.
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded							
	Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	m^3/day	
Adi Sheka Dam	21	13	1	7	6.9	10.4	3,461	500	12,007	Intake volume is estimated by water meter. Not work due to mechanical problem of pump from Aug.20 to Aug.25 and electric power outage in Aug 31.
Tokor Dam	21	19	2	0	7.7	7.7	7,607	990	23,760	Intake volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Mai Nefhi Dam	21	18	1	2	15.0	16.6	6,735	450	10,800	Intake volume is estimated by opening time of intake valve(hr) × rated flow rate against opening ratio of intake valve(m^3/hr) Not operated due to the problem of electric facility in Sembel PS from Aug.21 to Aug.22
Total							17,803			

2. Water Production from Each Water Treatment Plant

Summary for water production from each water treatment plant (WTP) is shown in Table 3. Findings obtained from the result of water production from each WTP are shown below;

- Operation of S.V. WTP was stopped for total 7 days thought the period of 21 days due to the stoppage of intake pump in Adi Sheka Dam. Therefore averaged operating time of water transmission pump was down up to 5.5 hour/day, which was approximate30% lower than original plan.
- Operation of Tokor WTP was stopped for total 5 days through the period of total 21 days mainly due to power outage in Tokor WTP. Therefore averaged operating time of water transmission pump was down up to 4.4 hour/day, which was approximate 20% lower than original plan.
- Transmission pump of Mai Nefhi WTP was not operated for total 2 days through the period of 21 days due to the problem of electric facility in Sembel PS. In addition, WTP was operated at the water production rate of approximate 350m^3/hr, which was approximate 40% lower than maximum capacity, 833m^3/hr (= 20,000m3/day). It is thought that the situation was caused by coagulation and sludge blanket operation not being conducted appropriately.
- By the degradation of operating time and production rate, total water production in Mai Nefhi WTP through the period was down up to approximate 25 % against the design capacity.

Table 3 Summary for Water Production from Each WTP (From Aug. 11 to Aug. 31)

Water Produced

Name of WTP	Water Source	Number of Data Recorded				Averaged Operating Time per Day		Averaged Flowrate per Day			Note.
		Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day	In the Period of Data Recorded	Excluding Not Working Day		
			Recorded	Not Recorded							
		Days	Days	Days	Days	hr/day	hr/day	m^3/day	m^3/hr	(= m^3/day)	
S.V WTP	Adi Sheka Dam	21	14	0	7	5.5	8.2	1,643	300	7,200	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Aug.20 to Aug.25
Tokor WTP	Adi Sheka Dam/Tokor Dam	21	14	2	5	4.4	5.6	2,217	500	12,000	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water in Aug.18. Trasmission pump was stopped due to electric power outage in Aus.19, 20, 26 and 28 .
							(By Gravity)	2,479			
							(Total)	4,696			
Mai Nefhi WTP	Mai Nefhi Dam	21	8	11	2	14.2	17.8	5,037	354	8,499	Water production volume is estimated by water meter. Not work due to electrical problem on Sembel PS from Aug.21 to Aug.22
Total								11,376			

1) Water Distribution in Each Pump Station/Reservoir

Summary for water distribution in Tokor WTP water distribution area is shown in Table 4 and summary for water distribution in Mai Nefhi WTP water distribution area is shown in Table 5

Findings obtained from the result of water distribution in each pump station and reservoir is shown below;

- Regarding Mai Chehot PS, water was supplied to the target area only once for 3 weeks because water was not transported from Tokor WTP while water was planned to be supplied to the target area once a week.
- Regarding Testserat RS, water was supplied to the target area 10 days for 3 weeks as almost original schedule.
- Regarding Monopolio RS, water was supplied to the target area only once for 3 weeks and was supplied at 103 m^3/day on the average for the successive 3 days by gravity until the reservoir became empty. Because the valve was not installed in the outlet line of the reservoir, the reservoir became empty in only 3 days after water was received from Tokor WTP.
- Regarding Algena Camp, water was supplied to the target area only once for 3 weeks because water was not supplied from Denden PS while water was supplied to the target area once a week.
- Regarding Denden PS, we cannot get the reliable operation data through the period due to the problem on data recording of the operator.
- Regarding Sembel PS, transmission pump was not operated for total 2 days through the period of 21 days due to the problem of electric facility in Sembel PS. Therefore averaged operating time of transmission pump was down to 8.2 hours /day, which was 10% lower than original plan.
- Regarding Godaif PS, transmission pump was not operated for total 2 days through the period of 21 days due to the problem of electric facility in Sembel PS. Therefore averaged operating time of transmission pump was down to 4.3 hours / day, which was 10% lower than original plan.

Table 4 Summary for Water Distribution in Tokor WTP Water Distribution Area (From Aug. 11 to Aug. 31)

1. Tokor WTP Water Distribution Area

Name of Pump Station/Reservoir		Result of Operation							
		Number of Data Recorded					Averaged Flowrate per Day		Note.
		Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
			Recorded	Not Recorded	Not Scheduled	as Scheduled			
		Days	Days	Days	Days	Days	m^3/day	m^3/day	
Denden PS	To Algene Camp	21	0	8	3	10	-	-	・Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) ・Not work due to not receiving water from Tokor WTP from Aug.22 to Aug.24. ・There are no recorded data of the transmission volume for Algena Camp because the operator does not master how to record the operation yet.
Denden PS	To Denden Camp	21	3	5	3	10	306	1,633	
Mai Chehot PS		21	1	0	2	18	32	675	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.30
Testserat Res.		21	6	4	0	11	20	56	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr)
Monopolio Res.		21	3	0	18	0	15	103	Water production volume is estimated by water level decreased for one day. Not work due to not receiving water from Tokor WTP from Aug.11 to Aug.15 and Aug. 20 to Aug. 31.
Algena Camp		21	1	0	3	17	7	145	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water from Denden PS. From Aug.11 to August 21 and from Aug.23 to Aug.31

Table 5 Summary for Water Distribution in Mai Nephi WTP Water Distribution Area (From Aug. 11 to Aug. 31)

2. Mai Nefhi WTP Water Distribution Area

Name of Pump Station/Reservoir	Number of Data Recorded					Averaged Flowrate per Day		Note.
	Total Days	Working Day		Not Working Days		In the Period of Data Recorded	Excluding Not Working Day	
		Recorded	Not Recorded	Not Scheduled	as Scheduled			
	Days	Days	Days	Days	Days	m^3/day	m^3/day	
Sembel PS	21	17	2	2	0	2,860	3,197	Water production volume is estimated by water meter Not work due to electric facility problem from Aug.21 to Aug.22
Godaif PS	21	19	0	2	0	1,294	1,430	Water production volume is estimated by operating time of pump (hr) × rated flow rate of pump (m^3/hr) Not work due to not receiving water by electric facility problem in Sembel PS from Aug.21 to Aug.22

2) Water Supply Balance of Water Facilities in Asmara City

Summary for water supply balance of all the water facility is shown in Figure 1. Comparison between designed capacity and operational result of flow rate in each water treatment plant is shown in Table 6.

Comparison between designed capacity and operational result of flow rate in each pump station and reservoir is shown in Table 7 .

Findings obtained from water supply balance of all the water facility is shown below;

- Water production volume from 3 WTPs for the period was approximate 11,000m^3/day on the average, which was equivalent to approximate 40% of designed capacity of 3 WTP[※1] and approximate 69% of target water supply[※2] according to National Water Supply Action Plan (2013-2017)

  ※1 Designed capacity of 3 WTPs is as follows;
  S.V. WTP is 2,664 m^3/day (In case of 8 hours operation per day)
  Tokor WTP is 6,000m^3/day (In case of 8 hours operation per day)
  Mai Nefhi WTP is 20,000m^3/day (In case of 24 hours operation per day)
  Total capacity of 3 WTPs is 28,664m^3/day

  ※2 Target water supply according to National Water Supply Action Plan (2013-2017) , which means the water production volume from 3 WTPs required for supplying 40 LCD to the target served population, is 16,000 m^3/day,

- The main reasons why water production was less than the original plan are as follows;
  1. Mechanical & electrical problem such as the stoppage of intake pump in Adisheka dam (From Aug 20 - 26) and Sembel PS (From Aug 21 and 22) was happened.
  2. Transmission pump was stopped by electric power outage in Adisheka dam (Aug 31) and in Tokor WTP (Aug 19, 20, 26 and 28).
  3. Water production rate was decreaed in Mai Nefhi WTP due to operational problem of water treatment plant

- We suppose that the difference of the flow rate between water intake facility and WTP was due to water being supplied to the other area, water leakage, problem of data recording etc.
- To grasp the water balance more exactly, operational data in each water facility should be taken for a long period and moreover the flow rate measurement with the equipment should be conducted at the required point.
- The recovery rate of Tokor WTP, which is the percentage of water production volume against water receiving volume, was approximate 75%. It is thought that the main reason of

such low recovery rate is due to water having been supplied from Tokor dam and having been overflown from the WTP in spite that transmission pump in Tokor WTP was stopped due to the power outage. Such the situation happened for total 4 days through the period according to the operation record.

- Especially regarding Tokor WTP water distribution area, the total flow rate of water transmission to the PS / reservoir was equivalent only to 10～20% of water transmission from Tokor WTP. Therefore it is supposed that most of water was supplied through the direct connection from Tokor WTP. The flow rate of direct connection also needs to be investigated at the required point from now on.

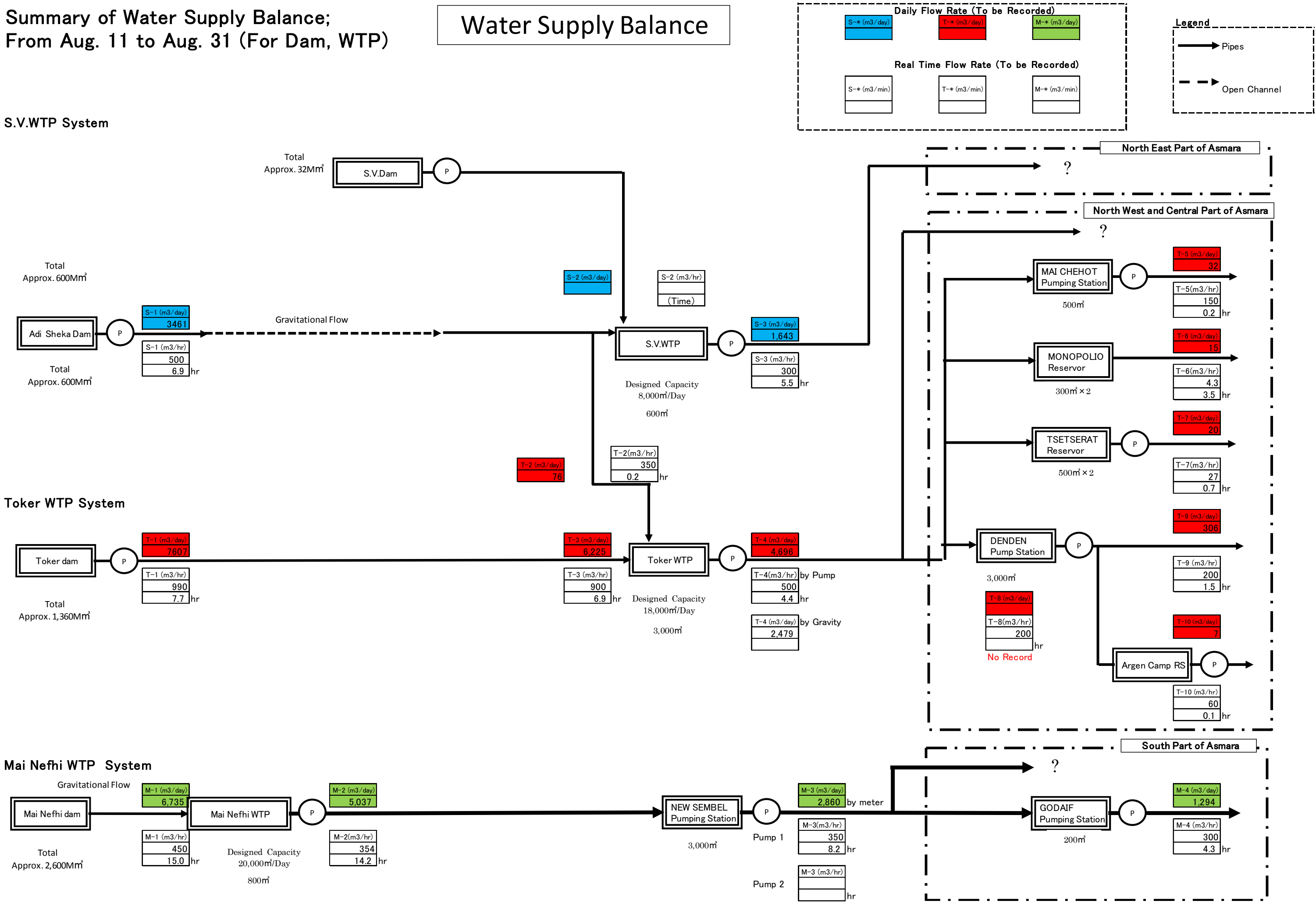


Figure 1 Water Supply Balance of Water Facility in Asmara City (From Aug. 11 to Aug. 31)

Table 6 Comparison between Designed Capacity and Operational Result of Flow Rate in Each Water Treatment Plant

(Based on the Operational Result from Aug 11 to Aug 31)

Facility	Designed Capacity※1 of Existing Facility	Result of Flow Rate	Reason of Difference between Capacity and Result
1.Intake Facility			
Adi Sheka	500m^3/hr×10hr※2×1pump = 5,000m^3/day	500m^3/hr×Approx.7hr×1pump = 3,500m^3/day	・Malfunction of intake Pump ・Not working due to electrical power outage not intentionally happened
Tokor	Engine Pump 990m^3/hr×20hr×1pump =Approx. 20,000m^3/day	990m^3/hr×Approx.8hr×1pump = Approx.7,900m^3/day	(・Operated in accrodance with the opration of Tokor WTP)
Mai Nefhi	※Intake water can be taken by gravity. (In case the recovery rate of WTP is 80%, designed intake volume is equivalent to 25,000m^3/day)	450m^3/hr×Approx. 15hr = 6,800m^3/day	(・Operated in accrodance with the opration of Mai Nefhi WTP)
Total	Approx. 50,000 m^3/day	Approx.18,000 m^3/day	
2.WTP			
S.V.	333m^3/hr(=8,000m^3/day)×8hr※2=2,664 m^3/day	300m^3/hr(=8,000m^3/day)×Approx.5.5hr=1,600 m^3/day	・Due to the stoppage of intake pump in Adi Sheka
Tokor	750m^3/hr(=18,000m^3/day)×8hr※2=6,000 m^3/day	500m^3/hr×Approx.4.4hr=Approx. 2,200m^3/day (By Pump) 200m^3/hr×Approx.12.5hr=Approx.2,500m^3/day (By Gravity) Total Approx.4,700m^3/day	・Due to the stoppage of transmission pump by electric power outage not intentionally happened.
Mai Nefhi	833m^3/hr(=20,000m3/day)×24hr※2=20,000 m^3/day	350m^3/hr×Approx.14hr= Approx.4,900m^3/day	・Flow rate could not be increased because coagulation could not be conducted appropriately and sludge blanket opration could not be conducted. ・Due to the stoppage of Sembel PS by electric facility problem of Sembel PS.
Total	28,664 m^3/day	Approx. 11,000 m^3/day	

※1 Design capacity excludes the loss of flow rate due to the stoppage by electrical power outage intentionally conducded by electric power company

※2 Designed operation time means the time operated only with commercial electric power supply.

Table 7 Comparison between Designed Capacity and Operational Result of Flow Rate in Each Pump Station and Reservoir

(Based on the Operational Result from Aug 11 to Aug 31)

1. Tokor WTP Distribution Area

Name of Pump Station/Reservoir		Original Operational Methods and Capacity※1 of Water Transmission: Operational Methods	Original Operational Methods and Capacity※1 of Water Transmission: Water Transmission Volume	Water Transmission Volume (Operational Result)	Reason of Difference between the Original Plan and Result
Denden PS	To Algene Camp	･Receiving water from Tokor WTP for 3 days every 2 weeks. ･Transporting water to Algene camp for 3 days and to Denden camp for 3 days for 1 week.	Approx. 200m^3/hr×Approx.3.6hr×3day/1week×1pump=Approx.310m^3/day (Ave.)	(No Recorded Data in Current)	
	To Denden Camp		Approx.200m^3/hr×Approx.3.6hr×3day/1week×1pump=Approx.310m^3/day (Ave.)	Approx.200m^3/hr×Approx.3.6hr×3day/1week×1pump=Approx.310m^3/day (Ave.)	
Mai Chehot PS		･Receiving water from Tokor WTP for 3 days every 2 weeks. ･Transporting water to higher area for 1 day per 1 week.	Approx.150m^3/hr×Approx.4.5hr×1day/week×1pump=Approx.100m^3/day (Ave.)	Approx.150m^3/hr×Approx.4.5hr×1day/3weeks×1pump=Approx.30m^3/day (Ave.)	Shortage of water transported from Tokor WTP
Testserat Res.		･Receiving water from Tokor WTP approxymate once every 3 months ･Transporting water to higher area for 2～3 days per 1 week.	Approx.30m^3/hr×Approx.1.6hr×3day/1week×1pump=Approx.20m^3/day (Ave.)	Approx.30m^3/hr×Approx.1.6hr×3day/1week×1pump=Approx.20m^3/day (Ave.)	
Monopolio Res.		･Receiving water from Tokor WTP approxymate 3 days every 2 weeks. ･Transporting water to lower area by gravity everyday.	Approx.4.3m^3/hr×24hr×7day/1week=100m^3/day (Ave.)	Approx.4.3m^3/hr×24hr×1day/1week=15m^3/day (Ave.)	Shortage of water transported from Tokor WTP A lot of water is leaked.(According to the informaiton from the operator)
Algena Camp		･Receiving water from Denden PS for 3 days per 1 week. ･Transporting water to the residence in the camp once a week.	Approx.60m^3/hr×2.5hr×3day/1week=Approx.60m^3/day (Ave.)	Approx.60m^3/hr×2.5hr×1day/3week=Approx.7m^3/day (Ave.)	Shortage of water transported from Tokor WTP

2. Mai Nefhi WTP Distrirbution Area

Name of Pump Station/Reservoir	Original Operational Methods and Capacity of Water Transmission: Operational Methods	Original Operational Methods and Capacity of Water Transmission: Water Transmission Volume	Water Transmission Volume(Result)	Reason between the Original Plan and Result
Sembel PS	･Receiving water from Mai Nefhi WTP for 24 hours everyday. ･Transporting water to the Godafi PS and the other area for 24 hours everyday .	Approx. 350m^3/hr×Approx.24hr×7day/1week×2pumps=Approx.16,800m^3/day (Ave.)	Approx.350m^3/hr×Approx.8hr×7day/1week×1pump=Approx.2800m^3/day (Ave.)	Shortage of water trasported from Mai Nefhi WTP Operational stoppage of Sembel PS due to malfunction of electric facility in Sembel PS
Godaif PS	･Receiving water from Sember PS for 24 hours everyday. ･Transporting water to the Godaif area etc. for 24 hours everyday .	Approx.300m^3/hr×Approx.24hr×7day/1week×1pump=Approx.7,200m^3/day (Ave.)	Approx.300m^3/hr×Approx.4.3hr×7day/1week×1pump=Approx.1,300m^3/day (Ave.)	Shortage of water volum trasported from Sembel PS

Annex-9

Findings and Analysis Result from Obtained Data in August 2016 (Water Quality)

Findings and Analysis Result of from Obtained Data in August 2016

(Water Quality)

1. Result of Water Quality of Dams

   Result of water quality in Adi Sheka Dam is shown in Table 1 and result of water quality in Tokor Dam is shown in Table 2.

   Findings obtained from result of water quality in Dams are shown below;

- Regarding Water Quality in Adi Sheka Dam, turbidity was approximate 36NTU and stable from Aug. 11 to Aug.17. While regarding the data of raw water in S.V dam from Aug.17 to Aug.30, when raw water was sent from Adi Sheka Dam, the turbidity of raw water in S.V WTP was fluctuating. In addition, the turbidity in Aug.17 was 78.2 NTU, which was more than 2 times of that in Adi Sheka Dam. By comparing water quality data of between dam and raw water of WTP in S.V. WTP, it is thought the turbidity may have put into the uncovered intake channel between Adi Sheka dam and WTP after heavy rain. Turbidity in Adi Sheka dam and in raw water of WTP should be measured and the relation between 2 data should be studied from now on.

Table 1　Result of Water Quality in Adisheka Dam (From Aug. 11 to Aug. 31)

Adisheka Dam

Date		11-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	No. of Data	Ave.	Max.	Min.
Time		10:00	8:00	6:30	9:00	10:00	11:30				
Weather		Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy				
Water Source		Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam				
Person Checked		Asmerom	Okbay	Okbay	Okbay	Okbay	Okbay				
Parameter	Unit										
Temperature	℃	18.7	18.1	18.2	18.6	18.5	18.1	6	18.4	18.7	18.1
pH	-	8.0	8.0	8.0	7.9	8.0	8.0	6	8.0	8.0	7.9
Electrical Conducitivity	uS/cm	255	371	374	370	365	365	6	350	374	255
Turbidity	NTU	36.1	36.1	36.1	36.2	36.2	36.0	6	36.1	36.2	36.0
Color	-	No	No	No	No	No	No	6	-	-	-
Smell	-	No	No	No	No	No	No	6	-	-	-

Table 2　Result of Water Quality in Tokor Dam (From Aug. 11 to Aug. 31)

Tokor Dam

Date		10-Aug	30-Aug	31-Aug				No. of Data	Ave.	Max.	Min.
Time		10:33	20:00	20:00							
Weather		Rainy	Cloudy	Cloudy							
Water Source		Tokor Dam	Tokor Dam	Tokor Dam							
Person Checked		Tekie	Tekie	Tekie							
Parameter	Unit										
Temperature	℃	17.3	19.7	18.9				3	18.6	19.7	17.3
pH	-	7.5	4.5	4.4				3	5.5	7.5	4.4
Electrical Conducitivity	uS/cm	204	202	195				3	200	204	195
Turbidity	NTU	127.0	34.3	32.2				3	64.5	127.0	32.2
Color	-	No	No	No				3	-	-	-
Smell	-	No	No	No				3	-	-	-

2. Result of Water Quality of WTPs

(1) Basic Design of WTP

1) S.V. WTP

Schematic flowsheet of S.V. WTP is shown in Figure 1.

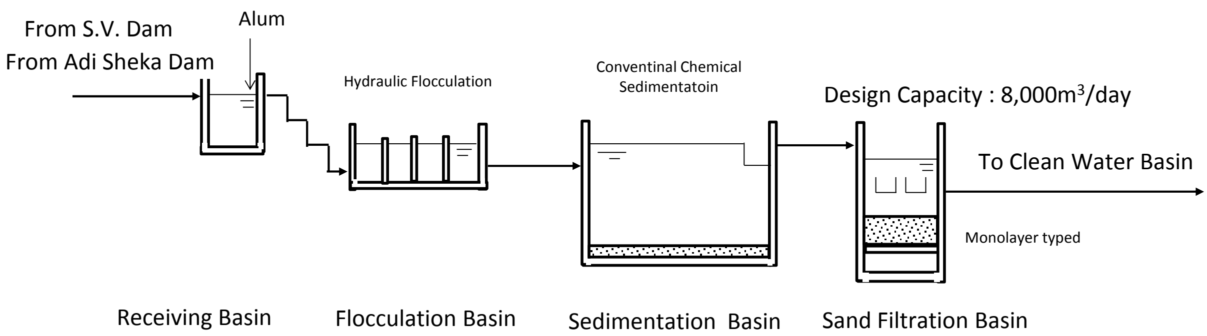


Figure 1 Schematic Flowsheet of S.V. WTP (Water Purification Process only)

Basic design of S.V. WTP is shown in Table 3.

Table 3 Basic Design of S.V. WTP (Designed Capacity 8,000m^3/day)

Facility	Existing WTP		Design Criteria of Japanese Water Treatment Plant for Drinking Water
	Specification	Design Condition	
Mixing Basin	None ※There are 4 receiving basins and 4 aeration basin (step typed)	–	Retension Time: 1～5min G value※1: 100 1/sec or more
Flocculation Basin	0.45mW×20mL×0.4mH×19channels/line×2 lines (Total volume 137 m^3) Hydraulic flocculation typed ※There are no baffle plates.	HRT※3: 137m^3÷8,000m^3/day×1440=25min ※GT value is very low.(because there are no mixing devices.)	Retension Time: 20～40min G value: 10～75 1/sec or more GT value※2: 23,000～210,000(-)
Sedimentation Basin ※3	<1st Sedimentation> 1st: 9.0mW×19.6mL×5mH 2nd: 9.0mW×19.6mL×5mH 3rd: 5.9mW×18.0mL×5mH 4th: 5.9mW×18.0mL×5mH 5th: 9.0mW×19.6mL×5mH (Total surface area 742m^2, Total volume 3,706m^3) Conventional chemical sedimentation typed <2nd Sedimentation> 4mW×7.5mW×2.9m×6basins	Surface load: 8,000m^3/day÷742m^2÷1440×1000=7.5mm/min HRT: 3,706m^3÷8,000m^3/day×24hr =11.1hr	In case of conventional chemical sedimentation using aluminum sulfate (sedimentation without inclined plate) Surface load: 15～30mm/min
Sand Filter Basin	Monolayer typed 2.2mW×2.5mL×2 ponds/basin×6 basins (Total surface area 66m^2)	Linear velocity: 8,000m^3/day÷66m^2=121m/day	In case monolayer typed filtration is applied. Linear velocity: 120m/day or less

※1, ※2 G value and GT value means the indicator for degee of mixing.
※3 HRT means hydraulic retension time.
※4 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000mg/L
<Sludge generation per day >
8,000m^3/day×(100mg/L+5mg-Al2O3/L×1.53)÷10,000(g/m^3)=86m^3-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
3,706m^3×1/3÷86m^3-sludge/day = 14.4days

Water purification process in S.V. WTP is consisted of receiving basin, flocculation basin (hydraulic type), sedimentation basin (conventional chemical sedimentation type) and sand filtration basin (monolayer type).

The characteristic regarding the design in S.V.WTP is shown below;

- The designed volume of sedimentation basin is relatively big comparing with that of the other 2 WTPs (Designed HRT is 11.1 hr and designed sludge storage time is 14.4 days in case the turbidity of raw water is 100 NTU)
- Therefore S.V. WTP can treat the turbidity easily comparing with than 2 WTPs.

2) Tokor WTP

Schematic flowsheet of Tokor WTP is shown in Figure 2.

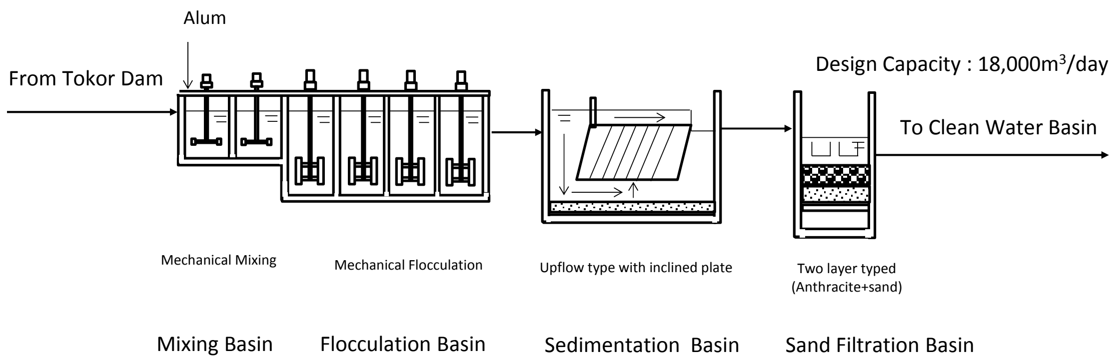


Figure 2 Schematic Flowsheet of Tokor WTP (Water Purification Facility only)

Basic design of Tokor WTP is shown in Table 4.

Table 4 Basic Design of Design in Tokor WTP (Designed Capacity 18,000m^3/day)

Facility	Existing WTP: Specification	Existing WTP: Design Condition	Design Criteria of Japanese Water Treatment Plant for Drinking Water
Mixing Basin	1.6mW×1.6mL×1.6mH×2 basins (Total volume 8.2m3) Mechanical mixer installed for each basin ※Mixers are not currenlty working.	HRT※4: 8.2m^3÷18,000m^3/day×1440=0.65min ※Design condition for mixing is unknown.	Retension Time: 1～5min G value※1: 100 1/sec or more
Flocculation Basin	4mW×4mL×3.5mH×4 basins /line×2 lines (Total volume 448m^3) Mechanical flocculators are installed for each basin ※Some of flocculators are not currenlty working.	HRT: 448m^3÷18,000m^3/day×1440=35min ※Design condition for mixing is unknown.	Retension Time: 20～40min G value: 10～75 1/sec or more GT value※2: 23,000～210,000(-)
Sedimentation Basin※4	11.6mL×6.4mW×3.5mH /line×2 lines (Total surface area 148 m^2, Total volume 519m^3) Upflow type with inclined plate	Surface load: 18,000m^3/day÷461m^2※3÷1440×1000=27mm/min Upflow velocity: 18,000m^3/day ÷148 m^2÷1440×1000 = 84mm/min HRT: 519m^3÷18,000m^3/day×24hr = 0.7hr (=41min)	In case of upflow typed sedimentation with inclined plate (In case only aluminum sulfate is applied) Surface load: 7～14mm/min Upflow velocity: 80mm/min or less ※Distance between the bottom of tank and the bottom of inclined plate should be 1.5m or more.
Sand Filter Basin	2.4mW×3.0mL×2 ponds/basin×6 basins (Total surface area 86.4 m^2) Two layer typed (anthracite+sand)	Linear velocity: 18,000m^3/day÷86.4m^2=208m/day	In case of two layer typed filtration (anthracte + sand) is applied. Linear velocity: 240m/day or less

※1, ※2 G value and GT value means the indicator for degee of mixing.
※3 We assumed that inclined plate of 8mL×6.4mW×0.9mH/basin ×2 basins are installed.
※4 HRT means hydraulic retension time.
※5 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000mg/L
<Sludge generation per day>
18,000m3/day×(100mg/L+5mg-Al2O3/L×1.53)÷10,000(g/m3)=194m3-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
519m3×1/3÷194m3-sludge/day = 0.9 days

Water purification process in Tokor WTP is consisted of mixing basin, flocculation basin (mechanical mixer type), sedimentation basin (upflow type with inclined plate) and sand filtration basin (two layer type).

The characteristic regarding the design in Tokor WTP is shown below;

- By inclined plats are installed in the sedimentation basin, upflow velocity become high (Surface load= 84mm/hr) and the surface area of sedimentation basin is saved. As a result, the volume of sedimentation basin becomes relatively small comparing conventional chemical sedimentation basin (Designed HRT is 0.7 hr).
- But due to the reduction of the volume of sedimentation tank, the sludge needs to be discharged from sedimentation basin at a short interval. In case the turbidity of raw water is 100 NTU, it is estimated that the sludge has to be discharged once a day at least.
- Because upflow typed inclined plate is installed vertically angle against the flow, the flow is apt to drift and the turbidity is apt to leak from the sedimentation basin with the effluent in case the sludge is accumulated on the bottom of sedimentation basin.

3) Mai Nefhi WTP

Schematic flowsheet of Mai Nefhi WTP is shown in Figure 3.

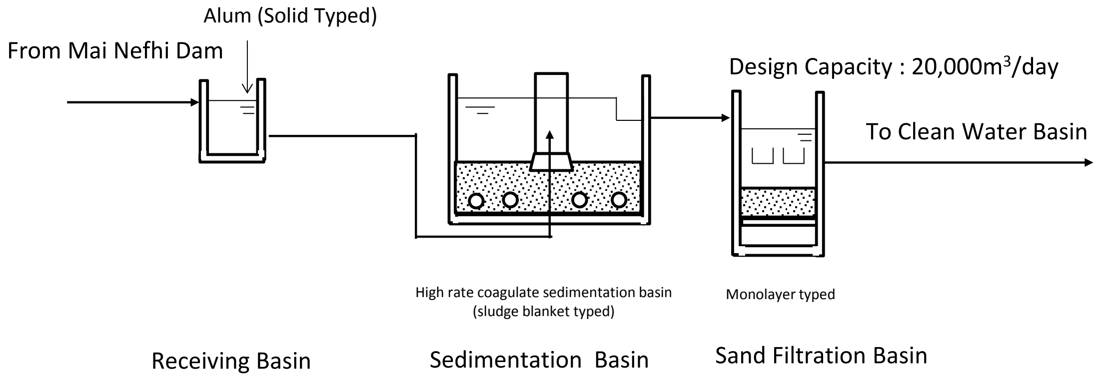


Figure 3 Schematic Flowsheet of Mai Nefhi WTP (Water Purification Facility Only)

Basic design of Main Nefhi WTP is shown in Table 5.

Table 5 Basic Design of Mai Nefhi WTP (Designed Capacity 20,000m^3/day)

Facility	Existing WTP		Design Criteria of Japanse Water Treatment Plant for Drinking Water
	Specification	Design Condition	
Mixing Basin	None ※Function of mixing is included in sedimentation basin (or inlet pipe of sedimentation basin).	–	Retension Time: 1～5min G value※1: 100 1/sec or more
Flocculation Basin	None ※Function of flocculation is included in sedimentation basin.	–	Retension Time: 20～40min G value: 10～75 1/sec or more GT value※2: 23,000～210,000(-)
Sedimentation Basin ※3	13.6mW×12.4mL×3.8mH×2basins (Total surface area 337m^2, Total volume 1282m^3) High rate coagulate sedimentation basin (sludge blanket typed)	Surface load: 20,000m^3/day÷337m^2÷1440×1000=41mm/min HRT※3: 1,282m^3÷20,000m^3/day×24hr =1.5hr	In case of high rate coagulate sedimentation basin with sludge blanket type (In case only aluminum sulfate is applied) Surface load: 40～60mm/min
Sand Filter Basin	7.6mW×3.7mL×6 basins (Total surface area 168m^2) Monolayer typed	Linear velocity: 20,000m^3/day÷168m^2=119m/day	In case monolayer typed filtration is applied. Linear velocity: 120m/day or less

※1, ※2 G value and GT value means the indicator for degee of mixing.
※3 HRT means hydraulic retension time.
※4 Sludge generation per day is as follows;
<Pre-condition>
・Turbidity of raw water: 100 NTU, 1 NTU=1mg/L as Suspended Solids(SS), Sludge Concentration is 10,000mg/L
<Sludge generation per day >
20,000m3/day×(100mg/L+5mg-Al_2O_3/L×1.53)÷10,000(g/m^3)=215m^3-sludge/day
<Days when generated sludge reaches 1/3 of sedimentation volume>
1,282m^3×1/3÷215m^3-sludge/day = 2.0days

- This process introduce high rete coagulation sedimentation basin, what is called “Pulsator”. Pulsator has the 3 functions, that is, mixing with coagulant and flocculation in addition to sedimentation (According to the manufacture's manual).
- By introducing Pulsator, upflow velocity become high (Surface load= 41mm/hr) and the surface area of sedimentation basin is saved. As a result, the volume of sedimentation basin becomes relatively small comparing conventional chemical sedimentation basin (Designed HRT is 1.5 hr).
- Pulsator is operated with “Sludge blanket operation” that inlet water is put from the bottom of

the sedimentation basin and the turbidity in the inlet water is contacted with accumulated sludge on the bottom of basin.

- Characteristics of sludge blanket operation is ;
- In case turbidity in raw water is high, the accumulated sludge on the bottom of sedimentation tank often overflows with the effluent.
- In case turbidity in raw water is low, the sludge is not accumulated on the bottom of sedimentation basin and the turbidity in raw water often overflows with the effluent.
- Discharging rate of the sludge has to be controlled so that some accumulated sludge can be kept on the bottom of sedimentation tank. Therefore this process needs skilled technique for the management of discharging sludge.

(2) Water Quality of WTP

Water quality in S.V. Water Treatment Plant, in Tokor Water Treatment Plant and in Mai Nefhi Water Treatment Plant are shown in Table 6, Table 7 and Table 8, respectively.

Findings obtained from water quality in WTPs are shown below;

- Turbidity of raw water in S.V WTP, Tokor WTP and Mai Nefhi WTP were 57.4 NTU, more than 170NTU and more than 370 NTU on the average, respectively. In addition, turbidity of more than 1000 NTU was recorded twice in the raw water of Tokor WTP and twice in the raw water of Mai Nefhi WTP.
- When high turbidity was detected in water source, it is considered that water intake should have been stopped because they can’t be treated in WTP.
- Turbidity of treated water in S.V WTP, Tokor WTP and Mai Nefhi WTP were 18.7 NTU, 55.8 NTU and more than 220 NTU on the average, respectively, which were much higher than 5 NTU recommended by WHO water quality standard. As one of the reason such the situation happed in 3 WTPs, it is thought that coagulation was not conducted appropriately.
- Residual chlorine in treated water was fluctuating in Tokor WTP and Mai Nefhi WTP through the period and bacteria was sometimes detected because gas chlorine was directly put into the clear water basin without flow controller equipment. Regarding S.V WTP, the operators completely stopped dosing gas chlorine through the period because they could not work in the water supply pump room of S.V. WTP due to the leakage of toxic gas chlorine if it was operated.

Table 6 Result of Water Quality in S.V. Water Treatment Plant (From Aug. 11 to Aug. 31)

S.V WTP

Date			17-Aug	18-Aug	19-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			15:16	16:30	20:00	11:30	10:45	18:00	7:00					
Weather			Cloudy	Rainy	Cloudy	Sunny	Sunny	Cloudy	Sunny					
Water Source			Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam	Adi Sheka Dam					
Person Checked			Yikaalo	Mulugheta	Mulugheta	Mulugheta	Mulugheta	Abraham	Mulugata					
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	24.6	19.2	22.4	18.5	18.9	18.6	19.8		7	20.3	24.6	18.5
	pH	-	8.46	6.32	8.24		8.34		8.42		5	8.0	8.5	6.3
	Electrical Conducitivity	uS/cm	243	225	248		247	270	244		6	246	270	225
	Turbidity	NTU	78.2	71.5	74.6	64.2	42.7	28.9	41.4		7	57.4	78.2	28.9
	Color	-	No	No	No	No	No	No	No		7	-	-	-
	Smell	-	No	No	No	No	No	No	No		7	-	-	-
Treated Water	Temperature	℃	21.1	22.2	19.8	19.7	19.1	20.1	20.1		7	20.3	22.2	19.1
	pH	-	7.99	7.08	6.68	7.81	8.10	8.15	8.15		7	7.7	8.2	6.7
	Electrical Conducitivity	uS/cm	249	219	240	187	231	237	234		7	228	249	187
	Turbidity	NTU	19.4	20.2	28.6	11.7	19.5	15.2	16.6	5 NTU or less	7	18.7	28.6	11.7
	Color	-	No	No	No	No		No	No		6	-	-	-
	Smell	-	No	No	No	No	No	No	No		7	-	-	-
	Residual Chlorine (Free)	mg/L	-	-	-	-	-	-	-	(0.1mg/L or more)	0	-	-	-
	Residual Chlorine (Total)	mg/L	-	-	-	-	-	-	-		0	-	-	-
	Bacteria	cells/ml				9	7				2	-	-	-
	Total Coliform	cells/ml				3	2			ND	2	-	-	-

Table 7 Result of Water Quality in Tokor Water Treatment Plant (From Aug. 11 to Aug. 31)

Toker WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	20-Aug	21-Aug	24-Aug	25-Aug
Time			8:00	8:00	11:20	8:00	9:00	8:00	8:30	9:30	8:00	8:30	8:30	8:15
Weather			Cloudy/ Sunny	Sunny	Sunny	Sunny	Sunny	Sunny /Cloudy	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam	Toker Dam
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana
Measuring Point	Parameter	Unit												
Raw Water	Temperature	℃	17.0	18.1	18.6	17.8	18.1	20.4	18.9	17.6	17.1	17.8	17.5	17.4
	pH	-	7.85	7.35	7.37	7.16	7.04	7.51	7.15	7.3	7.0	7.1	7.17	7.51
	Electrical Conducitivity	uS/cm	178	168	189	219	192	170	168	167	192	186	181	179
	Turbidity	NTU	90.7	98.3	87.7	142	85.5	12.6	122	97.6	>1000	>1000	73	76
	Color	-	High	No	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown
	Smell	-	No	No	No	No	No	No	No	No	No	No	No	No
Treated Water	Temperature	℃	19.4	17.3	18.9	17.7	19.9	20.5	18.7	17.5	17.7	17.7	17.1	17.5
	pH	-	7.36	7.27	7.24	7.22	7.23	7.35	7.42	7.21	6.79	6.92	7.07	7.15
	Electrical Conducitivity	uS/cm	244	167	225	179	168	178	172	176	176	176	179	196
	Turbidity	NTU	17.3	86.3	39.8	77.2	74.9	73.9	65	62.4	76.0	85.1	76.3	57.5
	Color	-	No	High	No	Brown	Brown	No	No	No	No	No	No	No
	Smell	-	Chlorine Smell	No	No	No	No	No	No	No	No	No	No	No
	Residual Chlorine (Free)	mg/L	0.97	0.28	0.11	0.07	0.24	0.08	0.01	0.1	1.98	1.94	0.37	0.01
	Residual Chlorine (Total)	mg/L	1.39	1.19	0.53	0.12	0.32	0.21	0.18	0.18	0.07	0.03	0.55	0.03
	Bacteria	cells/ml	0	0	0	0	0		0				Detect	Detect
	Total Coliform	cells/ml	0	0	0	0	0		Detect				Detect	ND

Table 7 Result of Water Quality in Tokor Water Treatment Plant (From Aug. 11 to Aug. 31)

Measuring Point	Parameter	Unit	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	30-Aug	31-Aug	WHO Guideline value	No. of Data	Ave.	Max.	Min.
Time			8:45	9:00	10:00	9:30	9:00	9:00	9:00					
Weather			Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Toker Dam	Toker Dam	Toker Dam	Toker Dam	Adi Sheka Dam	Toker Dam	Toker Dam					
Person Checked			Misgana	Misgana	Misgana	Misgana	Misgana	Misgana	Misgana					
Raw Water	Temperature	℃	17.1	18.9	19.8	18.2	17.0	17.7	18.1		19	18.1	20.4	17.0
	pH	-	7.28	7.5	7.5	7.2	8.0	7.9	7.4		19	7.4	8.0	7.0
	Electrical Conducitivity	uS/cm	175	180	181	206	245	182	184		19	186	245	167
	Turbidity	NTU	48	67.9	74.4	54.8	62.6	29.9	50		19	>172	>1000	12.6
	Color	-	Brown	No	No	No	Brown	No	No		19	-	-	-
	Smell	-	No	No	No	No	Grass	No	No		19	-	-	-
Treated Water	Temperature	℃	17.7	20.4	21.3	19.2	19.5		18.1		18	18.7	21.3	17.1
	pH	-	6.95	7.2	7.4	7.1	7.2		7.3		18	7.2	7.4	6.8
	Electrical Conducitivity	uS/cm	183	191	183	187	188		192		18	187	244	167
	Turbidity	NTU	42.4	37.5	33.8	37	33.3		29.4	5 NTU or less	18	55.8	86.3	17.3
	Color	-	No	No	No	No	No		No		18	-	-	-
	Smell	-	No	No	No	No	chlorine		chlorine		18	-	-	-
	Residual Chlorine (Free)	mg/L	1.02	0.15	0.07	2.15	0.58		0.43	(0.1mg/L or more)	18	0.6	2.2	0.0
	Residual Chlorine (Total)	mg/L	1.06	0.28	0.19	2.2	0.82		0.83		18	0.6	2.2	0.0
	Bacteria	cells/ml	1	ND	ND	ND	ND				13	-	-	-
	Total Coliform	cells/ml	3	ND	ND	ND	ND			ND	13	-	-	-

Table 8 Result of Water Quality in Mai Nefhi Water Treatment Plant (From Aug. 11 to Aug. 31)

Mai Nefhi
WTP

Date			11-Aug	12-Aug	13-Aug	14-Aug	15-Aug	16-Aug	17-Aug	18-Aug	19-Aug	23-Aug	24-Aug
Time			20:00	18:00	18:00	18:00	18:00	15:30	18:00	18:00	18:00	18:00	18:00
Weather				Sunny		Sunny	Sunny	Sunny	Sunny	Sunny	Rain	Sunny	Sunny
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam
Person Checked			Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem	Tesfalem
Measuring Point	Parameter	Unit											
Raw Water	Temperature	℃											
	pH	-	7.29	7.68	5.24	8.11	7.81	6.95	6.91	5.72	4.31	6.53	7.01
	Electrical Conducitivity	uS/cm	203	153	392	161	166	228	250	203	163	149	284
	Turbidity	NTU	524	354	361	245	272	369	286	>1000	>1000	530	109
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	Smell	-	No	No	No	No	No	No	No	No	No	No	No
Treated Water	Temperature	℃											
	pH	-	6.94	6.99	7.68	7.58	7.71	6.15	6.42	6.58	6.00	5.71	6.89
	Electrical Conducitivity	uS/cm	166	161	159	178	168	199	183	162	150	187	177
	Turbidity	NTU	268	448	309	101	230	49.8	133	677	>1000	67.4	86.1
	Color	-	Yellow	Yellow	Yellow	Yellow	Yellow	No	Yellow	Yellow	Yellow	Yellow	Yellow
	Smell	-	No	No	No	No	No	No	No	No	No	No	No
	Residual Chlorine (Free)	mg/L	6.4	7.0	0	0	0	8.3	5.3	1.0	0	0.9	0
	Residual Chlorine (Total)	mg/L	5.0	0	0	0	0	8.8	2.6	1.0	0	1.1	0
	Bacteria	cells/ml	0	5					ND	ND	6	ND	
	Total Coliform	cells/ml	0	2					ND	ND	4	ND	

Table 8 Result of Water Quality in Mai Nefhi Water Treatment Plant (From Aug. 11 to Aug. 31)

Measuring Point	Parameter	Unit	25-Aug	26-Aug	27-Aug	28-Aug	29-Aug	30-Aug	WHO Guideline valume	No. of Data	Ave.	Max.	Min.
Time			18:00	7:00	18:00	14:00	18:00	18:00					
Weather			Sunny	Sunny	Sunny	Sunny	Sunny	Sunny					
Water Source			Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam	Mai Nefhi Dam					
Person Checked			Tesfalem	Tesfaalem	Tesfaalem	Tedros	Tesfaalem	Tesfaalem					
Raw Water	Temperature	℃		20.5	23.5	22.7	20.1	21.2		5	21.6	23.5	20.1
	pH	-	7.32	4.26	7.57	7.01	7.83	7.89		17	6.8	8.1	4.3
	Electrical Conducitivity	uS/cm	183	504	265	216	202	245		17	233	504	149
	Turbidity	NTU	104	148	90.1	80.6	807	101		17	>375	>1000	81
	Color	-	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No		17	-	-	-
Treated Water	Temperature	℃		20.4	23.5	21.9	20.3	21.6		5	21.5	23.5	20.3
	pH	-	6.98	6.13	6.61	6.93	7.46	6.65		17	6.8	7.7	5.7
	Electrical Conducitivity	uS/cm	178	213	209	211	208	210		17	183	213	150
	Turbidity	NTU	86.5	40.2	49.1	56.4	81.7	66.5	5 NTU or less	17	>221	>1000	40
	Color	-	Yellow	Brown	Brown	Brown	Brown	Brown		17	-	-	-
	Smell	-	No	No	No	No	No	No		17	-	-	-
	Residual Chlorine (Free)	mg/L	0	0.0	0.0	6.8	0.0	0.0	(0.1mg/L or more)	17	2.1	8.3	0.0
	Residual Chlorine (Total)	mg/L	0	3.0	0.0	0.0	7.0	0.0		17	1.7	8.8	0.0
	Bacteria	cells/ml					10			7	-	-	-
	Total Coliform	cells/ml					0		ND	7	-	-	-

(3) Result of Used Chemical

Summary of used chemical in each water treatment plant is shown in Table 9.

Findings obtained from the result of used chemical in each WTP are shown below;

- Averaged dosing rate of Alum in S.V WTP, Tokor WTP and Mai Nefhi WTP were approximate 18 g/m^3-Produced water (=2.5g-Al_2O_3/m^3-Produced water), 61 g/m^3-Produced water (= 8.5g-Al_2O_3/m^3 -Produced water) and 95 g/m^3-Produced water (= 13.3g-Al_2O_3/m^3 -Produced water), respectively.
- But through the period, turbidity could not be treated to 5 NTU or less in 3 WTPs, which is recommended by WHO guideline. Therefore the operation for treating turbidity to 5 NTU or less continuously should be established at first. After that operational data regarding the dosing rate of alum should be recorded in 3 WTPs.
- Averaged dosing rate of gas chlorine in S.V WTP, Tokor WTP and Mai Nefhi WTP ware 0 g/m^3-Produced water, 5 g/m^3-Produced water and 6 g/m^3-Produced water, respectively.
- Because flow controller of gas chlorine is not installed in 3 WTPs, gas chlorine cannot be dosed at constant flow and residual chlorine cannot be kept in the treated water of 3 WTPs though the period. Therefore, appropriate equipment for controlling the flow of gas chlorine should be installed at first. After that operational data regarding the dosing rate of gas chlorine should be recorded in 3 WTPs.

Table 9　Summary of Used Chemical in Each WTP (From Aug. 11 to Aug. 31)

Chemical Used

Name of WTP	Number of Data Recorded				Averaged Dosing Rate of Alum					Averaged Dosing Rate of Chlorine			
	Total Days	Working Day		Not Working Day	In the Period of Data Recorded	Excluding Not Working Day				In the Period of Data Recorded	Excluding Not Working Day		
		Recorded	Not Recorded										
	Days	Days	Days	Days	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced	g-Al2O3/m3-Water Produced	kg/day	kg/hr	(=kg/day)	g/m3-Water Produced
S.V WTP	21	7	7	7	21.4	5.4	128.6	17.9	2.5	0	0	0	0
Tokor WTP	21	18	2	1	284.2	43.3	1,038.6	60.5	8.5	24.9	3.8	91.2	5.3
Mai Nefhi WTP	21	18	1	2	420.0	33.5	804.3	95.3	13.3	31.6	2.1	50.5	6.3

Annex-10

Performance Indicators Calculated in August 2016

Performance Indicators Calculated by Data of August 2016

Unit water production volume (L/person/day) =

Average water production volume/Service population x 1000

Average water production volume (m^3/day): Annual water production volume/365.

Service population: Estimated population served by a water supply system (excluding the population commuting to water distribution zones, tourist, etc.)

It should be calculated for both piped supply and truck supply.

Data in August 2016
Average water production volume (m^3/day): 11,376 m^3/d
Service population (piped supply + truck delivery): 400,000 persons
Unit water production volume (L/person/day) = 11,376,000 / 400,000
28.44 L/capita/day

Service coverage of water supply (%) =

Service population / Population living in water distribution zones x 100

Service population: Estimated population served by water supply system (excluding the population commuting to water distribution zones, tourist, etc.)

Population living in water distribution zones: Population living in water distribution zones (statistically estimated one)

It should be calculated for both piped supply and truck supply.

Data in August 2016
Service population (piped supply + truck delivery): 400,000 persons
Service population (piped supply): 210,412 persons
Service population (truck delivery): 189,588 persons
Population living in water distribution zones: 400,000 persons
Service coverage of water supply (piped water) = 210,412 / 400,000 = 52.6%
Service coverage of water supply (truck delivery) = 189,588 / 400,000 = 47.4%
Service coverage of water supply (piped water + truck delivery) = 400,000 / 400,000 = 100%

Capacity of water reservoir (hours) =

Total capacity of water reservoir / Daily average water distribution volume x 24

Total capacity of water reservoir (m^3): Total capacity of water reservoirs, clear water tanks, elevated tanks, etc.

Average daily water distribution volume (m^3/day): Annual water distribution volume/365.

Note: The capacity is calculated based on the daily maximum water distribution in general. The average daily distribution, however, is recommended for the present system of AWSSD water supply since the distribution volume is observed to be less than the potential demand and electricity/water resources conditions fluctuate significantly.

Data in August 2016

1. Storage Capacity

System	Tank	Capa (m^3)
S.V.	Clear Water Basin, WTP	600
Toker	Clear Water Basin, WTP	3,000
	Monopolio Res.	600
	Hazhaz Res.	1,000
	Tsetserat Res.	1,000
	Maichohot Res.	500
	Denden Res.	3,000
Mai Nefhi	Clear Water Basin, WTP	800
	New Sembel Res.	3,000
	Godaif	200
Total		13,700

2. Average daily water distribution volume (m^3/day) = Average water production volume (m^3/day): 11,376 m^3/d

3. Capacity of water reservoir (hours) = 13,700 / 11,376 x 24 = 29 hours

Effective utilization ratio of raw water (%) =

Water production volume / In-taken water volume x 100

Water production volume (m^3/year): Water volume at outlets of water treatment plants.
In-taken water volume (m^3/year): Water volume at outlets of dams.

in August 2016	
Water production volume (m^3/day):	11,376 m^3/d
In-taken water (m^3/day):	17,803 m^3/d
Effective utilization ratio of raw water (%) =	11,376 / 17,803
	63.9%

Revenue water ratio (%) =

Billed water volume / Water production volume x 100, or

Non-revenue water ratio (%) =

(Water production volume - Billed water volume) / Water production volume x 100

Billed water volume (m^3): Total volume of billed water
Water production volume (m^3): Total volume of water production, volume at outlets of water treatment plants

in 2015	
Billed water volume (m^3/year):	2,978,211 m^3/y
Water production volume (m^3/year):	6,142,443 m^3/y
Non-revenue water ratio =	(6,142,443 - 2,978,211) / 6,142,443 x 100
	51.5%

Frequency of inappropriate water quality (%) =

Number of inappropriate water quality detected / Total number of water quality analysis x 100

Number of inappropriate water quality detected (times/year): Number of times at least one of the water quality parameters is found inappropriate.
Total number of water quality analysis (times/year): Number of times the water quality is analyzed according to schedule.

in August 2016

Number of water quality analysis (treated water): 7 samples (S.V. WTP)

Number of water quality analysis (treated water): 18 samples (Toker WTP)

Number of water quality analysis (treated water): 17 samples (Mai Nefhi WTP)

Number of water quality analysis (treated water): 42 samples (total)

Number of inappropriate water quality detected: 42 samples
(no sample verified as appropriate quality)

Frequency of inappropriate water quality (%) = 42 / 42 x 100
100 %

Chlorine consumption per water production (g/m^3) =
Total chlorine consumption / Total water production

Total chlorine consumption (g/year): Total chlorine consumption, including loss

Total water production (m^3/year): Annual water production volume

Alum consumption per water production (g / m^3) =
Total alum consumption / Total water production

Total alum consumption (g/year): Total alum consumption, including loss

Total water production (m^3/year): Annual water production volume

in August 2016

WTP	Water Production (m^3/d)	Alum		Chlorine	
		kg/d	g/m^3	kg/d	g/m^3
S.V.	1,643	21.4	13.0	0.0	0.0
Toker	4,696	284.2	60.5	24.9	5.3
Mai Nefhi	5,037	420.0	83.4	31.6	6.3
Total	11,376	725.6	63.8	56.5	5.0

Attachment-11: The List of Existing Drawings

Appendix 11-1

LIST OF DRAWINGS

Item		Scale	Year
Pipeline			
Water bridge for pipeline	Raw-Water transmission between Mai Nefhi-Asmara	1:50	
Net Work			
Asmara supply Network		1:0000	2006
Pump station			
Pump-station with reservoir	New Sembel		1968
Map			
Topographic map	Asmara City area	1:25000	1970
Topographic map	Asmara City area	1:50000	
S.V dam			
Plan		1:500	
Section of dam		1:100	1939
Mai-Seraw dam			
Section of dam		1:200	1973
Mai-Nefhi dam			
Plan		1:1250	1973
Plan		1:1250	1973
ABARDA dam			
Plan		1:2000	
Old Asmara W.T.P			
Filtration & Reservoir	Acria	1:50	
S.V W.T.P			
Flocculation & sedimentation		1:50	
Mai-Nefhi(ABARDA)W.T.P			
Office		1:100	1969
Pumping Station		1:50	1969
Pumping Station		1:50	1969

Item		Scale	Year	DWG No
Mai-Nefhi Project			**1969**	
Plan	W.T.P(General layout)	1:250		GC-01
Plan	Flocculation & Sedimentation & Filtration	See DWG		1B
Plan	Office	See DWG		2A
Plan & section	Filtration	1:50		GC-03
Plan & section	Filtration	1:50		GC-04
Plan & section	Filtration	1:20		GC-05
section	Reinforcement of Filtration	1:50		GC-06B
section	Reinforcement of Filtration	1:50		GC-07
section	Reinforcement of Filtration	1:50		GC-08
section	Reinforcement of Filtration	1:50		GC-09B
Plan &section	Receiving well	1:20		GC-10B
section	Reinforcement of receiving well	1:20		GC-11
Section (valve sump)	Reinforcement	1:20		GC-12
Section(Venturimeter)	Reinforcement			GC-13
Plan & section	Office & Back-wash pump station	1:50		GC-14
Section	Reinforcement of Office & Back-wash pump station	1:20		GC-15
Plan & section	Office & Back-wash pump station	See DWG		GC-16
Section	Office & Back-wash pump station	See DWG		GC-17
Section	Reinforcement of Office & Back-wash pump station	See DWG		GC-18
Section	Reinforcement of Office & Back-wash pump station	See DWG		GC-19
Section	Reinforcement of Office & Back-wash pump station	See DWG		GC-20
Plan & section	Drainage	1:100		GC-20B
Plan & section	Flocculation & Sedimentation	See DWG		GC-22B
Section	Reinforcement of Flocculation & sedimentation	See DWG		GC-23
Section	Reinforcement of Flocculation & sedimentation	See DWG		GC-24B
Section	Reinforcement of Flocculation & sedimentation	See DWG		GC-25B
Plan & section	Drainage	See DWG		GC-26B
Plan & section	Office & Back-wash pump station	See DWG		GC-51A
Plan & section	Office & Back-wash pump station	See DWG		GC-52A
PULSATOR (Sedimentation)				
Detail Drawing		See DWG		6A
Detail Drawing		See DWG		9A
Detail Drawing		See DWG		10A
Detail Drawing		See DWG		11A

Item		Scale	Year	DWG No
Detail Drawing		See DWG		12A
Detail Drawing		See DWG		13A
Detail Drawing		See DWG		14A
Detail Drawing		See DWG		15A
Detail Drawing		See DWG		16A
Detail Drawing		See DWG		18A
Detail Drawing	Pump & Piping	See DWG		21A
Detail Drawing	Sedimentation	See DWG		53A
Raw-Water Gate(receiving)				
Detail Drawing	plan	See DWG		24A
Detail Drawing		See DWG		56B
Detail Drawing		See DWG		57B
Filtration				
Detail Drawing		See DWG		7B
Detail Drawing		See DWG		8A
Detail Drawing	Air-Brow	See DWG		19A
Detail Drawing		See DWG		23B
Detail Drawing		See DWG		25A
Detail Drawing		See DWG		26A
Detail Drawing		See DWG		27A
Detail Drawing		See DWG		28A
Detail Drawing		See DWG		29A
Detail Drawing		See DWG		30A
Detail Drawing		See DWG		31A
Detail Drawing		See DWG		32A
Detail Drawing		See DWG		33A
Detail Drawing		See DWG		39A
Detail Drawing		See DWG		50A
Detail Drawing	Filtration	1:50, 1:100		54A
Detail Drawing		See DWG		58A
Siphon		1:2		
Mai-Nefhi(ABARDE) Dam				
Plan		1:5000		
Belesa dam				
Plan		1:2000	1964	
Plan	Channel system	1:10000	1957	
Plan	Open channel between Adi-sheka Beleza	1:1000	1901	
Asmara supply Pipe Network plan				
TOKOR WATER TREATMENT PLAN (ADI NFAS W.T.P)				
Raw water pipeline	Longitudinal section and Details	1:50		013-101c

Item		Scale	Year	DWG No
Mai ubel	Longitudinal section and Details			013-102D
Sludge waste and wash water Recovery pipe net work	Plan and longitudinal section			013-013c
Cathodic protection	orails			013-104b
Treated water pipe line	Over longitudinal section			014-100c
Treated water pipe line	Longitudinal section CH0-1140			014-101c
Treated water pipe line	Longitudinal section CH 1120-2250			014-102c
Treated water pipe line	Longitudinal section CH 2220-3366			014-103c
Treated water pipe line	Longitudinal section CH3340-4480			014-104c
Treated water pipe line	Longitudinal section CH4460-5600			014-105E
Treated water pipe line	Longitudinal section CH 5580-6700			014-106E
Treated water pipe line	Longitudinal section CH 6680-END			014-0107c
Treated water pipe line	Longitudinal section 3CH 0-1140			014-108c
Treated water pipe line	Longitudinal section 3CH 1120-End			014-109D
Treated and raw water pipe line	Air and scour valve details			014-115H
Treated water pipe line	Details of flow meter chamber			014-116G
Treated water pipe line	Details of branch connection			014-117G
Treated water pipe line	Details of connection 168			014-118G
Treated water pipe line	Details of connection 7			014-119G
Treated water pipe line	Details of connection 2.24			014-120G
Treated water pipe line	Details of connections 3and 5			014-121H
Treated water pipe line	Details of connection 6and 9			014-122H
Treated water pipe line	Pipe chambers- miscellaneous details			014-123B
Treated water pipe line	Air valve (nor /traffic)Reinforcement details	1:25		014-501A
Treated water pipeline	Air valve (traffic)Rain details	1:25		014-502A
Treated water	Air valve (traffic) rain details	1:25		014-502B

Appendix 11-3

Item		Scale	Year	DWG No
pipeline				
Treated water pipeline	Scour valve (non/traffic)rain details	1:25		014-503A
Treated water pipeline	Scour valve (traffic) rain details	1:25		014-504A
Treated water pipeline	Reinforcement details to pipe chamber floor slabs	1:25		014-505A
Treated water pipeline	Rein. details to pipe chamber walls	1;25		014-506A
Treated water pipeline	Pipe chambers-Root slabs rein.	1:25		014-507A
Treated water pipeline	Pipe chamber in traffic –floor slabs rain	1:25		014-508A
Treated water pipeline	Connection 4 and flow meter chamber rain	1:25		014-509A
General layout		1:1000		000-101B
Proportional Site l layout	Site utilities	1:250		000-101E
Site pipe work: Connection pipe work	B/n filters and Clear water reservoir	1:100		000-105D
Site pipe work connecting Pipe work b/n row water	Water storage reservoir and inlet works	1:200		000-106D
Site pipe work	Filter Waste	1:100		000-107B
Site pipe work	Treated Water Scour Pipe line	1:100		000-108A
Site pipe work	Back Wash Cannel Construction details	As Shown		000-109
Topographic Map Drawings	Tokor Plan (Top view)			000-M
Tokor Plan	(Top view			000-B
Raw Water Storage Reservoir	Joint Details	1:00		001-104C
Inlet structure	Construction details sheet 1of2	1:50		001-111e
Inlet structure	Construction details sheet 2of2	As Shown		001-112e
Inlet structure	Typical box-out details	As Shown		001-113
Par shall flame and rapid mixers	Construction details sheet1of3	1:50		002-101E
Par shall flame and rapid mixers	Construction details sheet2of3	1:25		002-102e
Par shall flame and rapid mixers	Construction details sheet30+3	1:25		002-103c
Par shall flame and rapid mixers	Reinforcement lay out	1:50		002-501d
Par shall flame and rapid mixers	Bending schedules	As Shown		002-502D

Item		Scale	Year	DWG No
Parshall flame and rapid mixers	Bending schedules	As Shown		002-503
Flocculation channels	Construction details sheet 1of2	1:50		003-101H
Flocculation channels	Construction details sheet 2to2	1:50		003-102G
Flocculation channels	Foundation on reinforcement lay out	1:50		003-501A
Flocculation channels	Foundation on reinforcement lay out	1:50		003-502A
Flocculation channels	Foundation bending schedules	As Shown		003-503A
Flocculation channels	Reinforcement ley out for wells	As Shown		003-504A
Flocculation channels	Reinforcement ley out for wells	1:50		003-505A
Flocculation channels	Reinforcement ley out for wells	1:50		003-506A
Flocculation channels	Bending schedules for walls	As Shown		003-507A
Flocculation channels	Reinforcement lay out for walk ways	As Shown		003-508A
Flocculation channels	Reinforcement lay out for walk ways and beam	1:25		003-509A
Flocculation channels	Bending schedules for walk ways and beam	As Shown		003-510A
Flocculation channels	Reinforcement ley out for Channels	1:25,1:50		003-511A
Flocculation channels	Reinforcement ley out for Channels	1:25,1:50		003-512A
Flocculation channels	Bending schedules for Channels	As Shown		003-513A
Sedimentation basin	Construction details sheet 1to 4	1:50		004-101A
Sedimentation basin	Section A&B sheet 2to4	1:50		004-102F
Sedimentation basin	Section C&D sheet3to 4	1:50,1:5		004-103F
Sedimentation basin	Section D sheet4to4	1:50		004-104F
Sedimentation basin	Elevation	1:75		004-105
Sedimentation basin	Root plan & Elevation	1:75		004-106
Sedimentation basin	Root details	1:50		004-107
Sedimentation basin	Connection details	1:5 and 1:10		004-108
Sedimentation basin	Foundation layout reinforcement layout	1:50		004-501A
Sedimentation basin	Foundation layout reinforcement layout	1:25,1:50		004-502A
Sedimentation basin	Foundation bending schedules	As Shown		004-503A
Sedimentation basin	Wall 1 reinforcement lay out	1:50		004-504
Sedimentation basin	Wall 1bending schedules	As Shown		004-505
Sedimentation basin	Wall 2 reinforcement layout	1:50		004-506
Sedimentation basin	Wall 2 bending schedules	As Shown		004-507
Sedimentation basin	Wall 3 reinforcement layout	1:50		004-508
Sedimentation basin	Wall 3 reinforcement layout	1:50		004-509

Item		Scale	Year	DWG No
Sedimentation basin	Wall 3 bending schedules	As Shown		004-510
Sedimentation basin	Wall 4 bending schedules	As Shown		004-511
Sedimentation basin	Wall 4 bending schedules	As Shown		004-512
Sedimentation basin	Wall 5 reinforcement layout	1:50		004-513
Sedimentation basin	Wall 5 bending schedules	As Shown		004-514
Sedimentation basin	Wall 6 reinforcement layout	As Shown		004-515
Sedimentation basin	Wall 6 bending schedules	As Shown		004-516
FILTERRS	CONSTRUCTION details(sheet 1 of 4)	1:50		004-101F
FILTERRS	CONSTRUCTION details(sheet 2 of 4)	1:50		004-102F
FILTERRS	CONSTRUCTION details(sheet 3 0+4)	1:50		004-103F
Sedimentation basin	Section D and details (sheet 4 0+4)	1:50		004-104F
Sedimentation basin	Elevations	1:75		004-105
Sedimentation basin	Roof plan and elevations	1:75		004-106
Sedimentation basin	Roof details	1:50,1:10		004-107
Sedimentation basin	Connection details	1:5		004-108
Sedimentation basin	Foundation reinforcement layout	1:50		004-501A
Sedimentation basin	Foundation reinforcement layout	1:50,1:25		004-502A
Sedimentation basin	Foundation bending schedules	As Shown		004-502B
Sedimentation basin	Wall 1 reinforcement layout	1:50		004-503A
Sedimentation basin	Wall 1 bending schedules	As Shown		004-504A
Sedimentation basin	Wall 2 reinforcement layout	1:50		004-505A
Sedimentation basin	Wall 2 bending schedules	As shown		004-506A
Sedimentation basin	Wall 3 reinforcement layout	1:50		004-507A
Sedimentation basin	Wall 3 reinforcement layout	As shown		004-508A
Sedimentation basin	Wall 3 bending schedules	As Shown		004-509A
Sedimentation basin	Wall 4 reinforcement layout	As shown		004-510
Sedimentation basin	Wall 4 bending schedules	As shown		004-511
Sedimentation basin	Wall 5 reinforcement layout	1:50		004-512
Sedimentation basin	Wall 5 bending schedule	As shown		004-513
Sedimentation basin	Wall 5 reinforcement layout	As shown		004-514
Sedimentation basin	Wall 6 reinforcement layout	As shown		004-515
Sedimentation basin	Wall 6 bending Schedules	As shown		004-516
Filters	Construction details (sheet 1 of 4)	1:50		004-101f
Filters	Construction details (sheet 2 of 4)	1:50		004-102f
Filters	Construction details (sheet 3 of 4)	1:5		004-103f
Sedimentation basin	Section d and details(sheet 4 of 4)	1:50		004-104f
Sedimentation basin	Elevation	1:75		004-105
Sedimentation basin	Roof plan and elevations	1:75		004-106

Item		Scale	Year	DWG No
Sedimentation basin	Roof details	1:50,1:10		004-107
Sedimentation basin	Connection details	1:5		004-108
Sedimentation basin	Foundation and reinforcement layout	1:50		004-501A
Sedimentation basin	Foundation and reinforcement layout	1:50,1:25		004-502A
Sedimentation basin	Foundation bending schedule	As shown		004-503A
Sedimentation basin	Wal11 reinforcement layout	1:50		004-504
Sedimentation basin	Wal11 bending schedule	As shown		004-505
Sedimentation basin	Wal12 reinforcement layout	1:50		004-506
Sedimentation basin	Wal12 bending schedule	As shown		004-507
Sedimentation basin	Wal1 3 reinforcement layout	1:50		004-508
Sedimentation basin	Wal1 3 reinforcement layout	1:50		004-509
Sedimentation basin	Wal1 3 bending schedule	As shown		004-510
Sedimentation basin	Wal14 reinforcement layout	1:50		004-511
Sedimentation basin	Wal14 bending schedule	As shown		004-512
Sedimentation basin	Wal15 reinforcement layout	1:50		004-513
Sedimentation basin	Wal15 bending schedule	As shown		004-514
Sedimentation basin	Wal15 reinforcement layout	1:50		004-515
Sedimentation basin	Wal1 6 bending schedule	As shown		004-516
Filters	Wal17 reinforcement layout	1:50		004-517
Filters	Wal1 7 bending schedule	1:1		004-518
Filters	Wal18 reinforcement layout	1:50		004-519
Filters	Wal18 bending schedule	1:1		004-520
Filters	Over flow reinforcement detail	1:50		004-521
Filters	Over flow bending schedule	1:1		004-522
Filters	Filter inlet reinforcement detail	1:25		004-523
Filters	Filter inlet bending schedule	1:1		004-524
Filters	Roof reinforcement detail	1:50		004-525
Filters	Roof bending schedule	1:25		004-526
Filters	Back wash inlet reinforcement detail	1:25		005-527
Filters	Back wash inlet reinforcement detail	1:1		005-528
Filters	Filer sub reinforcement detail	1:25		005-529
Filters	Filer sub bending schedule	1:1		005-530
Filters	Stair rein. detail	1:50		005-531
Filters	Stair bending schedule	1:1		005-532
Disinfection and treated water storage layout and setting out details				006-101h
Disinfection and treated water storage	Layout and construction sheet 1 of 4	As shown		006-102h
Disinfection and	Layout and construction sheet 2 of	1:50		006-103g

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Item		Scale	Year	DWG No
treated water storage	4			
Disinfection and treated water storage	Layout and construction sheet 3 of 4	1:25		006-104h
Disinfection and treated water storage	Layout and construction sheet 4 of 4	1:50		006-105g
treated water storage	Typical box-out details	1:20		006-106A
Disinfection and treated water storage	Pipe plinth layout	1:50		006-107
Disinfection and treated water storage	Blower building layout and details	1:50, 1:25		006-108
Treated water reservoir	Reinforcement layout floor slab plan	1:100		006-501b
Treated water reservoir	Reinforcement layout floor slabs sections	1:100		006-502b
Treated water reservoir	Bending schedules – floor slab	As shown		006-503A
Treated water reservoir	Bending schedules	As shown		006-504
Treated water reservoir	Channel A Reinforcement layout	As shown		006-505A
Treated water reservoir	Reinforcement layout floor walls	1:50, 1:200		006-506A
Treated water reservoir	Bending schedules for wall A	As shown		006-507A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-508A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-509A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-510A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-511A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-512A
Treated water reservoir	Reinforcement layout floor wall	1:50		006-513A
Treated water reservoir	Bending schedules for walls	As shown		006-514A
Treated water reservoir	Roof slab reinforcement layout	1:50,1:100		006-515A
Treated water reservoir	Column reinforcement detail	1:20		006-516A
Treated water reservoir	reinforcement detail	1:20		006-517
Bulk earth work	details	1:200		009-104b
Wash water recovery basins	Joint detail	1:100,1:75		010-104c

Item		Scale	Year	DWG No
Wash water recovery basins	Pump station layout	1:150		010-110c
Wash water recovery basins	Pump station construction details	1:25		010-111d
Wash water recovery basins	Pump station reinforcement layout	1:50		010-501
Wash water recovery basins	Pump station bending schedule	1:50		010-502
Wash water recovery basins	Splitter Box 1: reinforcement detail	1:25		010-503
Wash water recovery basins	Splitter Box 2: reinforcement detail	1:25		010-504
Wash water recovery basins	Reinforcement detail	1:75		010-505
Wash water recovery basins	Bending schedule			010-506
Administration buildings	Plan and roof truss layout	1:50		012- 101d
Administration buildings	Sections	1:100, 1:50		012-102d
Administration buildings	elevation	1:50		012- 103d
Administration buildings	Finish schedule	1:50		012-104c
Administration buildings	Truss fixing details	As shown		012-105
Sun screen	Plan section and details	1:25		012-106b
Typical details	Hand railing	1:5		015-102
Septic tank	Construction details	1:20		015-103
Typical details	Security fencing details	As shown		015-104
Typical details	Sewer manhole details sheet 1of 2	N.T.S		015-105
Typical details	Sewer manhole details sheet 2of 2			015-106
Typical details	Joint details	1:5		015-107b
Tokor pump station Asmara Eritrea				
Ventilation gallery and adits	Ventilation details	1:1000		HvacAB
Dam	General plan of dam	1:1000		Tok-d01AB
Profile of gallery				Tok-d02AB
Dam	General profile of dam section and details sheet 1 of 3			Tok-d03AB

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Item		Scale	Year	DWG No
Dam	General profile of dam section and details sheet 2 of 3			Tok-d04AB
Dam	General profile of dam section and details sheet 3 of 3			Tok-d05AB
Dam	Drain holes plan and profile			Tok-d06AB
Dam	Drain holes schedule detail and sections			Tok-d07AB
Dam	Crack control and construction Joint profile Details and schedule			Tok-d08AB
Dam	Profile of gallery			Tok-d09AB-AB
Dam	Gallery and adits sheet 1 of 3 Steel stair case profiles			Tok-d09AB
Dam	Gallery and adits sheet 2 of 3			Tok-d09B-AB
Plan	Of lower north adit and lower south adit			Tok-d10AB
Dam	Gallery and adits sheet 3 of 3			Tok-d11A-ab
foundation	Plan and elevation			Tok-f01AB
foundation	Excavation section and details			Tok-f02AB
Plan	Of curtain grout holes line B main Row			Tok-f03A-AB
Grout Cartesian profile	B-line			Tok-f04-A-AB
Foundation	Profile of grout holes			Tok-f04AB
	Grout take holes over fifty Foot intervals			Tok-f04B-AB
	Permeability of primary and secondary holes			Tok-f04c-AB
	Permeability of verification holes			Tok-f04D-AB
Plan of foundation	Drain holes(revised)			Tok-f05A-AB
foundation	Plan of foundation drain holes, details and schedules			Tok-f05AB
Profile of foundation	Drain holes			Tok-f06-A-AB
Foundation	Profile			Tok-f06AB
Foundation	Cross section			Tok-f07AB
Title sheet, location map, vicinity map and site map				Tok-G01AB
List of drawings				Tok-G02AB
ABBREVATIONS				Tok-

Item		Scale	Year	DWG No
				G03AB
General structural notes				Tok-G04AB
General plan of dam site and Reservoir				Tok-G05AB
Plan of Dam site	Existing conditions			Tok-G06AB
Subsurface Data				Tok-G07AB
Instrumentation	Plan and schedules			Tok-j01AB
Instrumentation	Conduit layout			Tok-j01B-AB
Instrumentation	Sections revised			Tok-j02A
Instrumentation	Sections revised			Tok-j02AB
Instrumentation	Sections and Details			Tok-j03AB
Miscellaneous details				Tok-m01AB
Spillway-	General plan and profile			Tok-s01AB
Spillway-	Stilling basin Plan and section			Tok-s02AB
Spillway-	Stilling basin Plan and section sheet 2 of 2			Tok-s03AB
Retaining wall details				Tok-s04AB-AB
Spillway-	Stilling basin section sheet 1 of 2			Tok-s04AB
Spillway-	Training walls			Tok-s05AAB
Spillway-	Stilling basin section sheet 2 of 2			Tok-s05AB
Downstream concrete placement for spillway crest Above Elv.2202				Tok-s06A-AB
Spillway	Crest plan Elv. detail			Tok-s06AB
Spillway	Crest sections and details sheet 1 of 2			Tok-s07AB
Spillway	Crest sections and details sheet 2 of 2			Tok-s08AB
Spillway	General plan and elv of road Bridge			Tok-s09AB
Spillway	Substructure detail			Tok-s10AB
Spillway	Substructure plan, section and details of road bridge			Tok-s11AB
Temporary Diversion	General plan and sequence			Tok-T01AB

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Item		Scale	Year	DWG No
Temporary Diversion	Details			Tok-T02AB
Outlet works	General plan and profile			Tok-W01AB
Outlet works	Gate tower plan and sections			Tok-W02AB
Trash rack assembly details				Tok-W03AB-AB
Outlet works	Gate tower details			Tok-W03AB
Outlet works	Trash rack structural openings			Tok-W04AB
Outlet works	Grating details			Tok-W05AB
Outlet works	Trash Rack			Tok-W06AB
Outlet works	Gate tower Reinforcement sheet 1 of 3			Tok-W07AB
Outlet works	Gate tower Reinforcement sheet 2 of 3			Tok-W08AB
Outlet works	Gate tower Reinforcement sheet 3of 3			Tok-W09AB
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P1-a_1
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a2
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a3
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a4
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a5
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a6
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a7
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a8
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a9
Pumping station	Discharge pipe line	H,1cm=20m V, 1cm=2m		P2-a10
Pipe line	Miscellaneous Detail	No scale		P2-a11
Pumping station	Site plan	1:20,1:40		Ps1

Item		Scale	Year	DWG No
Outlet works pipeline	Plan and profile	1:20,1:40		Ps2
Pumping station discharge pipe line	details Plan and profile	1:20,1:40		Ps3
Pumping station	Building elevations	1:100		Ps4
Pumping station	Architectural detail			Ps5
Pumping station	Equipment floor plan			Ps6
Pumping station	Structural floor plan	1:40		Ps7
Pumping station	Roof plan	1:40		Ps8
Pumping station	section	1:40		Ps9
Pumping station	Miscellaneous details	1:40		Ps12
Pumping station	Exterior support details	1:4		Ps14
Pumping station	Fuel schematic and details	No scale		Ps15