REPUBLIC OF FIJI
MINISTRY OF INFRASTRUCTURE, TRANSPORT, DISASTER MANAGEMENT AND METEOROLOGICAL SERVICES (MITDMMS)
WATER AUTHORITY OF FIJI (WAF)

DATA COLLECTION SURVEY FOR WATER SUPPLY AND WASTEWATER SECTOR IN THE REPUBLIC OF FIJI

FINAL REPORT

MARCH 2020

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIHON SUIDO CONSULTANTS CO., LTD.
YACHIYO ENGINEERING CO., LTD.
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1FJD=50.2281JPY
(JICA Monthly exchange rate in JPY 2019, February 2020)

Summary

1. Background

The water supply sector requires development of water resources to keep up with the development of other infrastructure. In diplomatic meetings, the Government of Fiji has expressed desire for Japanese assistance in these matters.

In the wastewater sector, the policy is to develop wastewater treatment infrastructure in major cities with the aim of providing wastewater treatment services to 70% of the population by 2033. However, existing wastewater treatment facilities in the Western Division have not been properly maintained and are overloaded. Negative environmental and social impacts are becoming serious and improvement is urgent.

2. Outline of the Survey

This data collection survey (hereinafter referred to as “the Survey”) is carried out to collect information and survey alternatives for the Project Components required by Japan International Cooperation Agency (hereinafter referred to as “JICA”) to fully consider cooperation in the water supply and wastewater sectors in the Republic of Fiji. The Western Division of Fiji (Nadi/Lautoka Region) is included in this survey. The implementing agency is the Ministry of Infrastructure, Disaster Management and Meteorological Services (hereinafter referred to as “MITDMMS”). The executing agency is the Water Authority of Fiji (hereinafter referred to as “WAF”).

3. Organization and Finance of WAF

WAF was established in 2010 to provide water supply and wastewater services. There are four offices on Viti Levu Island. The water supply sector is operating efficiently due to a clear system of division of labor. However, lack of highly qualified technical staff is an ongoing issue. In the wastewater sector, tasks are not clearly defined and effective management is not achieved.

As of 2017, assets related to the water supply sector accounted for 64% of WAF assets, while assets for the wastewater sector accounted for 13%. Revenues from bill collection are deposited in the national budget, and required operational funds are provided by the central government based on application by WAF. Subsidies from the central government are five times greater than revenue from water and wastewater service charges. Wastewater charges are set at 1/10th of water supply charges, and are not enough to cover Operation and Maintenance (hereinafter referred to as “O&M”) expenses. WAF is currently aiming for financial independence, and requesting permission from the central government to increase service charges. They also expect increased charges will lead to water conservation.

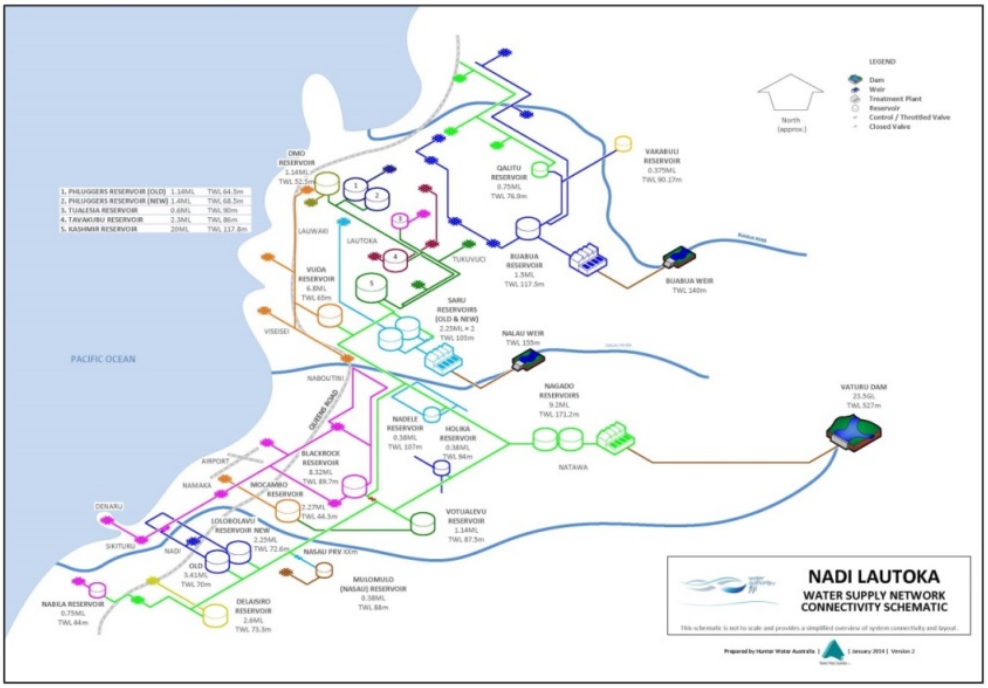
4. Water Supply Sector

The Nadi System and the Lautoka System together make up the Nadi/Lautoka Water Supply System, the main water supply system of the Western Division. Water from Vaturu Dam treated at Nagado Wastewater Treatment Plant (hereinafter referred to as “WTP”) makes up the Nadi System. The Lautoka System consists of water from Nalau Intake and Buabua Intake treated at Buabua WTP, and water from Varaqe Intake treated at Saru WTP, as well as water supplied from Nagado WTP connected to the distribution network.

Major facilities of the system are shown below.

Existing Water Supply Facilities of Nadi/Lautoka

Category	Location/No.	Details
Sources	4	Vaturu Dam supplies water to Nagado WTP Buabua and Nalau Intakes supply water to Buabua WTP Varaqe Intake supplies water to Saru WTP
WTP	Nagado WTP Buabua WTP Saru WTP	90ML/D 10ML/D 5ML/D
Service and Clear Water Reservoirs	20 Reservoirs	3 Clear Water Storage 2 Bulk Reservoirs 15 Service Reservoirs
Pumping Stations	1	Momi Pumping station owned by FNPF development
Distribution/Reticulation	1,059 km	Trunk mains and distribution pipes
Water Meters	37,500	Active meter connections



Outline of Nadi/Lautoka System

The Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033 (hereinafter referred to as “NLWMP33”) was prepared in 2013 and finalized in 2015 for the development of water supply in the region. Water demand until 2033 according to the NLWMP33 is shown below.

Water Demand Projection According to NLWMP33

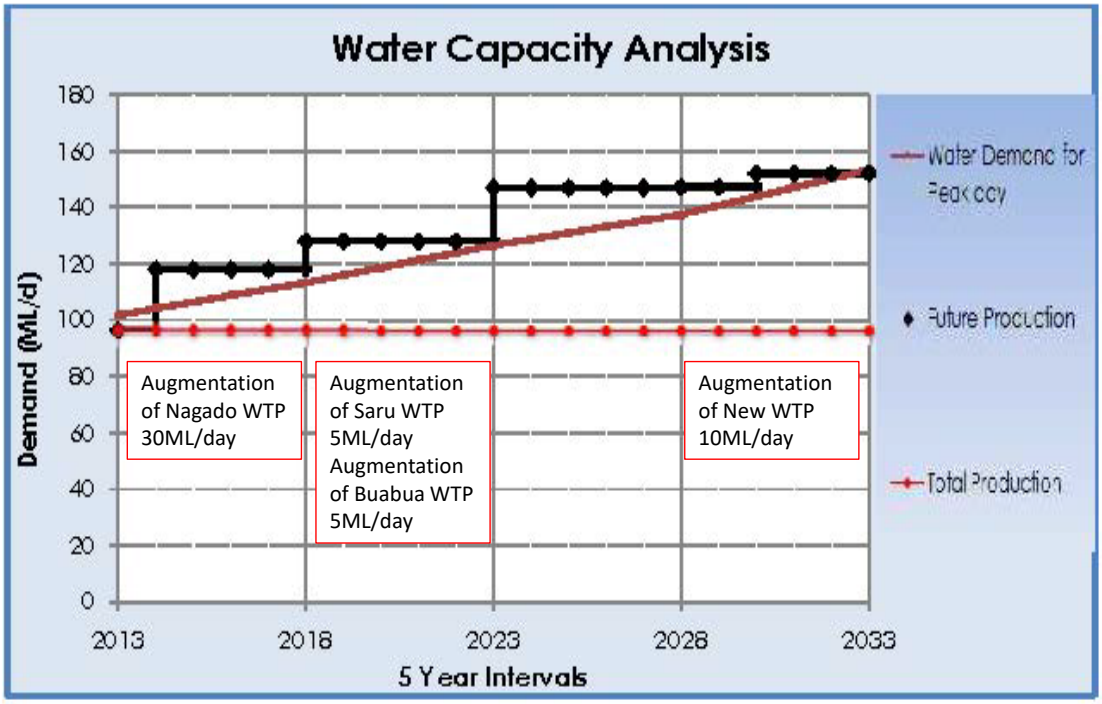
Description	Units	2013	2018	2023	2028	2033
Total Population	No	169,643	194,366	222,776	244,888	269,179
Population Covered	No	152,272	174,459	203,259	223,407	245,550
Non-revenue Water (NRW)	%	39.51	20	20	20	20
Domestic Consumption	ML/d	38.38	49.91	54.79	60.15	66.05
Commercial Consumption	ML/d	17.99	32.13	36.76	39.19	44.64
Government Consumption	ML/d	1.70	1.94	2.23	2.56	2.95
Total Consumption Avg Day	ML/d	58.07	83.98	93.78	101.91	113.64
Total Consumption Peak Day	ML/d	63.88	92.37	103.15	112.10	125.00
Non-revenue Water (NRW)	ML/d	37.93	20.99	23.44	25.48	28.41
Treatment plant Losses	%	5	5	5	5	5
Water demand for Average day	ML/d	96.00	104.97	117.22	127.38	142.05
Raw Water required from sources on Average day	ML/d	100.8	121.8	131.8	151.8	156.8
Water Demand for peak day	ML/d	102	113	127	138	153
Raw Water Required from sources on peak day	ML/d	106.89	133.98	132.93	144.45	161.08
Average Water Production	ML/d	96.00	118.15	127.85	147.25	152.10

Compared to 96.00ML/day in 2013, water demand is expected to be 142.05ML/day in 2033. In order to meet the increased demand, it was concluded that augmentation of water sources and treatment plant capacities are required. However, Non-Revenue Water (hereinafter referred to as "NRW") rates currently stay at 38.3% (as of 2019Q1). This is a significant deviation from the phased development plan, which assumed that the NRW rate would be reduced to 20% by 2018.

On the other hand, expansion of water treatment facilities based on population projections specified in the NLWMP33 are as shown below. In order to supply 153ML/D, total capacity of 155ML/day by 2030 is planned.

- Nagado WTP: augmentation from 90ML/day to 120ML/day
- Saru WTP: augmentation from 5ML/day to 10ML/day
- Buabua WTP: augmentation from 10ML/day to 15ML/day
- New WTP (Vaturu Dam or Namosi Intake): construction 10ML/day

Based on results of surveys conducted by WAF so far, it is judged that the augmentation of Nagado WTP can be achieved by the augmentation of Vaturu Dam and improvements of the trunk mains. The Government of Fiji has requested Japanese assistance in these matters. However, prospects for augmentation of Saru WTP and Buabua WTP, and development of a new WTP are low. Development of these WTPs is expected to be difficult and further surveys and examinations are required.



Augmentation Plan for Nandi/Lautoka WTPS

Due to the difficulty of developing new water resources, this survey considers methods to bridge the gap between the water demand and the NRW rate in the phased development plan. After discussion with the Fiji side, the strategy for Japanese cooperation is suggested as follows:

(a) Raising Vaturu Dam levee and spillway by 5m (Component C1)
(b) Hydraulic improvements of trunk mains to increase transmission volume (Component C2)
(c) Reduction of NRW rate to 20% (Component C8)

Implementation schedule, expected results and benefits are outlined as follows. Implementation of Components C3~C7 are dependent on findings of future surveys that will be conducted by the Fiji side. Component C8 is divided into 3 subcomponents.

C8a: Replace pipes with leakages or pipes with high risks of leakages, focusing on old asbestos cement (AC) and cast iron (CI) pipes
C8b: Repair leakages from distribution reservoirs and repair inlet regulation valves
C8c: Repair standpipes, house connections, and water meters to reduce NRW rates

Implementation Schedule of The Water Supply Sector (Draft)

				2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Water Sector	Water Resources Development	C1	Vaturu Dam Improvement	Under survey by WAF		Preparation				Design	Tender	Construction						
		C2	Vaturu to Nagado Trunk Main Improvement	Under survey by WAF		Preparation		Design		Tender	Construction							
		C3	Water Resouces Development (for Saru & Buabua WTPs)	*Development is not required, in case NRW ratio become below 15%*														
		C4	Water Resouces Development (New WTP in Nadi)	*Under survey by WAF*														
	Water Supply Augmentation	C5	Nagado WTP Expansion Phase I (20ML/d) + Phase II (10ML/d)			Preparation				Design		Tender	Construction					
		C6	Water Supply System Augumentation - Stage I (Saru & Buabua System)	Contract / Design		Construction						Preparation		Design	Tender	Construction		
		C7	Water Supply System Augumentation - Stage II (New WTP in Nadi)	*Development is not required, in case NRW ratio become below 15%*														
	Water Saving	C8-a	NRW Reduction by Replacement of Aged Mains (including Procurement of Equipment and Tools and Introduciton of Monitorign System)			Preparation		Design	Tender	Construction								
		C8-b	NRW Reduction by Repair and Improvement of Service Reservoirs			Preparation		Design	Tender	Construction								
		C8-c	NRW Reduction by Improvement of Service Connections and Billing Collection	Development by WAF				Consulting Service		Construction								
				Implementation by WAF														

Project Benefits (Draft)

Item	Unit	2018 (Baseline Value)	2033 (Target Year)
Production (Day Ave.)	ML/day	105	142.05
NRW Rate	%	37.93	15
Number of connections	no.	34,891	49,110
Supply Area	-	Nadi and Lautoka	Nadi and Lautoka

Benefits of each Project Component (Draft)

	Component	Qualitative Effects
C1	Vaturu Dam Improvement	The water storage capacity of Vaturu Dam will increase from the current 90ML/day to 138ML/day.
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	The transmission capacity of the trunk main between Vaturu Dam and Nagado WTP will increase to 130ML/day. Weaknesses caused by single line sections and old infrastructure will be reduced, and incidence of water shutdown will decrease to less than half of 2018 (5 times).
C8	NRW reduction	The rate of non-revenue water in the Nadi/Lautoka area will be reduced, and water volume shortage and insufficient pressure at the hydrant will be improved.

Operational Effects Indicators (Draft)

	Component	Item	Unit	2018	Target (Target Year)
C1	Vaturu Dam Improvement	Capacity (Day Ave.)	ML/day	90	138 (2033)
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	Capacity (Day Ave.)	ML/day	90	130 (2028)
C8	NRW reduction operations	NRW Rate	%	38.3	20 (2028) 15 (2033)

In order to achieve targets of C1 and C2, in addition to implementing the activities of C1 and C2, the capacity of the Nagado WTP must be increased from 110ML/day to 120ML/day.

5. Wastewater Sector

At present, wastewater works in the Western Division are implemented in Lautoka, Nadi, Ba and Sigatoka. (1) Current status of wastewater Master Plans (hereinafter referred to as “M/P”) and (2) current status and issues of wastewater treatment plants were surveyed, and (3) proposals for the direction of JICA’s Cooperation for the wastewater sector were developed.

(1) Current status of wastewater M/Ps

Wastewater M/Ps of the four city/towns are old. With the exception of Sigatoka, none of them have been updated. The updated Sigatoka M/P is also over 15 years old. Accurate understanding of services areas, population etc. are necessary for effective repair and augmentation of wastewater facilities. Inaccurate information can lead to inappropriate facilities that are too small, or too big. Therefore, updating M/Ps in the four city/towns is urgent and WAF is requesting Japan to assist M/P preparation.

Wastewater Master Plan in the Four City/Towns in the Western Division

City/town	Year	Prepared consultants	Year revised	Revised consultants
Nadi	1987	Fawcett Mouchel Ltd. (UK or Hong Kong, dissolved already)	Not yet	—
Lautoka	1991	PPK Consultants Ltd. (UK)		—
Ba	1986	Harrison & Grierson Consultants (New Zealand)		—
Sigatoka	1987	Fawcett Mouchel Ltd. (UK or Hong Kong, dissolved already)	2005	Erasito Consultants Ltd. (Fiji) Beca International Ltd. (Multinational, originally New Zealand)

(2) Current status and issues of wastewater treatment plants

Current status and issues of four existing wastewater treatment plants were surveyed. Maintenance manuals were not available. Therefore, preventative maintenance was not implemented, leading to equipment failures. In addition, operational and water quality data are hardly used effectively on site. Due to the above-mentioned issues, effluent BOD (40 mg/l) compliance rate is very low for all four Wastewater Treatment Plants (hereinafter referred to as "WWTP").

Compliance Rate of Effluent Standard of BOD

	Navakai (Nadi)	Natabua (Lautoka)	Votua (Ba)	Olosara (Sigatoka)
BOD standard (40mg/L) compliance rate (average of 2014~2018)	30.8%	24.7%	47.8%	38.2%

WAF understands that staff require capacity development for implementing preventative maintenance, establishing maintenance manuals, and analyzing WWTP data, and is requesting Japan for assistance in this matter.

(3) Recommendations for cooperation strategy in the wastewater sector

One of the target of the "20-Year Development Plan 2017-2036" is "Access to central sewerage system is 70% in 2036". In order to achieve this target, a comprehensive M/P of the Western Division and that of each city/town should be prepared. Capacity development for wastewater staff on the following items listed below is also required.

i. Capacity Development on Planning, Design and Construction

① Preparation of wastewater M/P and F/S
② Supervision of design works
③ Project management

ii. Capacity Development on O&M

① Preparation of maintenance manual of sewer networks and implementation of maintenance
② Preparation of O&M manual of WWTP and implementation of O&M
③ Preparation of maintenance plan of mechanical and electrical equipment

④ Preparation of health and safety manual

It is also necessary to develop training programs for capacity development for staff and conduct training according to the programs. WAF is requesting Japan for assistance in this matter.

In consideration of the above, capacity development assistance should be implemented in the following order for the wastewater sector.

① Prepare wastewater M/P for the city/towns of the Western Division (Western Division M/P)
② Prepare M/P for cities with the highest priority (city/towns M/P)
③ Implement Pre-F/S for cities with urgent priority
④ During implementation of ①～③, conduct capacity the M/P development of staff
⑤ Conduct renovation and expansion of wastewater facilities according to the M/P developed
⑥ Implement O&M with staff who have undergone capacity development

The expected outcomes of the cooperation activities are as follows.

- Western Division M/P, city/towns M/P and Pre-F/S are prepared
- Renovation and expansion of wastewater facilities are implemented according to the M/P and Pre-F/S
- Renovation and expansion of wastewater facilities are managed effectively by WAF staff who have undergone capacity development
- Operation and maintenance of wastewater facilities are managed effectively by WAF staff who have undergone capacity development

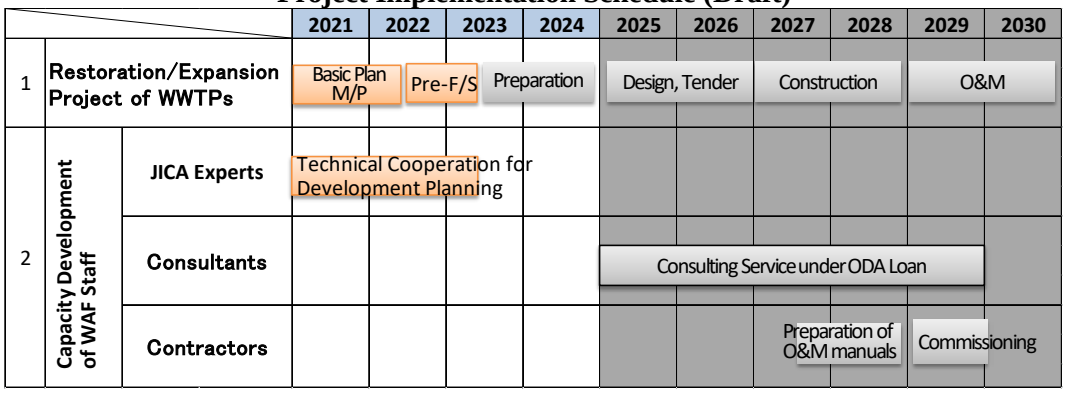
The capacity development program will be conducted in 3 terms, as shown below. The 1st term will be conducted as a Technical Cooperation for Development Planning project. The 2nd and 3rd terms will be conducted as needed as Consulting Services under ODA Loans.

Stages of the Capacity Development (Draft)

Term	Stage		Implementation item
First term	Technical Cooperation for Development Planning	Basic plan, M/P, Pre-F/S preparation stage	- Preparation of Basic plan for wastewater treatment - Instruction for preparation procedure of the basic plan - Preparation of M/P and Pre-F/S - Instruction for preparation procedure of M/P and Pre-F/S - Instruction regarding maintenance of existing sewer networks, O&M procedure of WWTP facilities (including preparation of O&M manuals) and health/safety - Preparation of staff training program and implementation of staff training
Second term	Consulting Service under ODA Loan	Design, construction stage	- Instruction for management of design, tender and construction - Instruction for O&M of treatment facilities to be adopted (Preparation of O&M manuals by contractors)
Third term		O&M stage	- Implementation of OJT regarding O&M of treatment facilities adopted

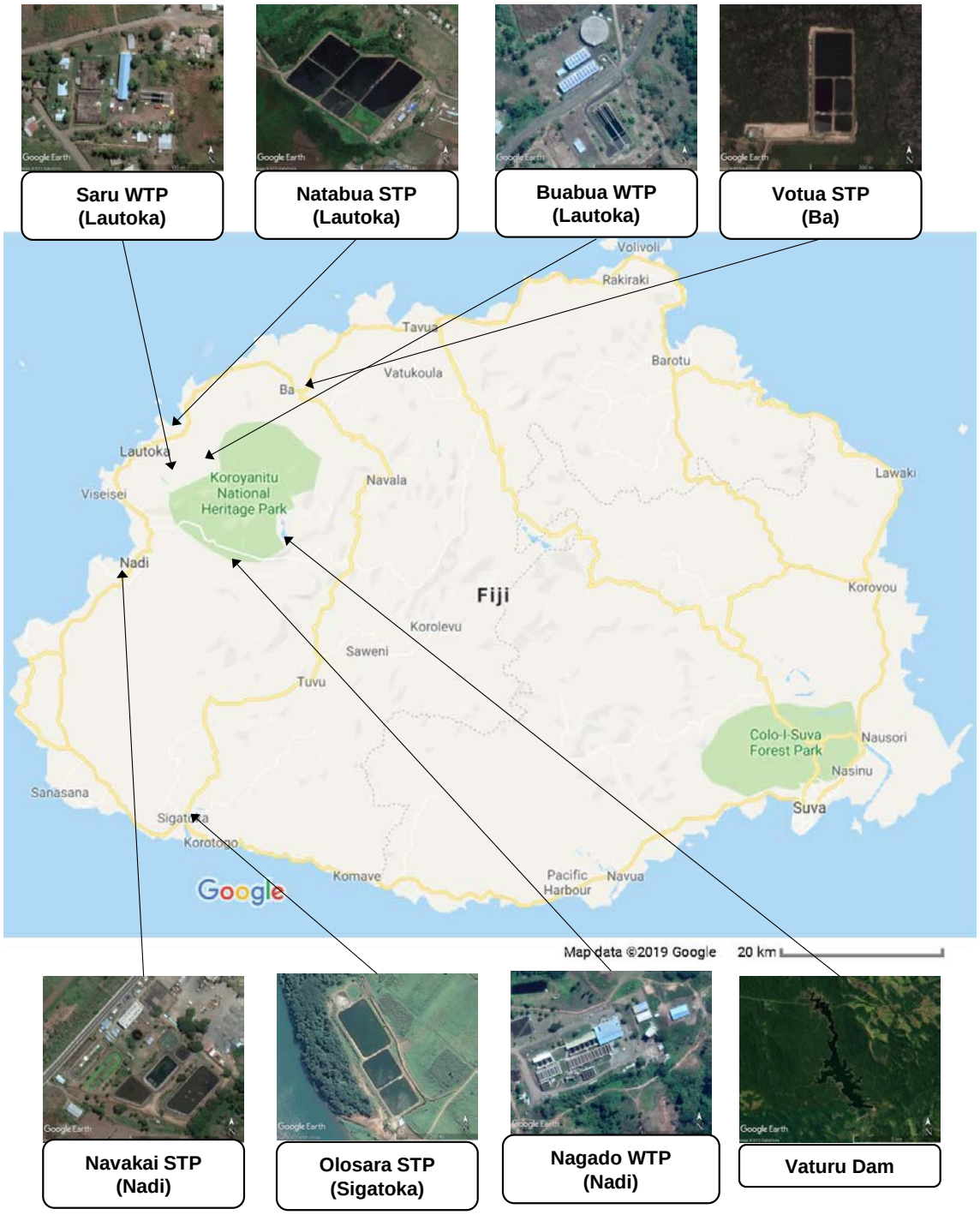
The draft schedule for cooperation is as follows.

Project Implementation Schedule (Draft)



Contents

[Appendix]



Location Map

List of Figures & Tables

Abbreviations

AC	Asbestos-cement
ADB	Asian Development Bank
AIFFP	Australian Infrastructure Financing Facility for the Pacific
CI	Cast Iron
DI	Ductile Cast Iron
EIB	European Investment Bank
FCCC	Fijian Competition & Consumer Commission
FDB	Fiji Development Bank
FJD	Fiji Dollar
GCF	Green Climate Fund
GGGI	Global Green Growth Institute
GOF	Government of Fiji
HDPE	High Density Polyethylene Pipe
IBA	Important Bard Area
IDEA	Intermittent Decanted Extended Aeration
JICA	Japan International Cooperation Agency
KBA	Key Biodiversity Area
LCC	Life Cycle Cost
MITDMMS	Ministry of Infrastructure, Transport, Disaster Management and Meteorological Services
MLMR	Ministry of Lands and Mineral Resources
MOE	Ministry of Economy
MOWE	Ministry of Waterways and Environment
mPVC	multilayered Polyvinyl Chloride
NRW	Non-Revenue Water
NTF	National Trust of Fiji Islands
O&M	Operation and Maintenance
OD	Oxidation Ditch process
ODA	Official Development Assistance
PTF	Pre-treated Trickling Filtration
SBR	Sequencing Batch Reactor
SOP	Standard Operation Process
TLTB	iTaukei Land Trust Board
uPVC	unplasticized Polyvinyl Chloride
WAF	Water Authority of Fiji
WTP	Water Treatment Plant
M/P	Master Plan
WWTP	Wastewater Treatment Plant

Chapter 1 Basic Concept of the Project

1-1 Background of the Survey

The Western Division of Fiji, which includes Lautoka and Nadi (the second and third largest cities of Fiji, respectively) as well as the Nadi International Airport, is an important location for tourism, sugar production and other vital industries. Despite the national significance of Lautoka and Nadi Divisions, the capacity of water supply and wastewater works are not keeping up with the increasing resident and tourist populations. Development of these works corresponding to the increasing demand is needed.

For the water supply sector, the Fiji Government declared in the "National Development Plan (2017-2036)" investment in construction of new water treatment plants (hereinafter referred to as "WTP"), improvement of water distribution networks, development of water sources, and implementation of leakage countermeasures in order to cope with the increasing water demand. As a part of this National Plan, the "Fiji Urban Water Supply and Wastewater Management Project" in Suva Metropolitan Area (in the Central Division), which includes the construction of a new WTP, is now underway as a joint financing project of Asian Development Bank (hereinafter referred to as "ADB"), Green Climate Fund (hereinafter referred to as "GCF") and European Investment Bank (hereinafter referred to as "EIB"). For the Western Division, the necessity of water resources development in Nadi and Lautoka areas is similarly declared in the National Plan.

The Japanese government implemented the "Nadi/Lautoka Area Water Supply Improvement Project" under the official development assistance (hereinafter referred to as "ODA") loan project. Fukuoka City implemented the "Project to Support Reducing Unaccounted Water Through Effective Control on NADI/LAUTOKA Regional Water Supply in the Republic of Fiji (2014-2017)" and is implementing the "Project to Support Strengthening Water Supply Service on NADI/LAUTOKA Regional Supply in the Republic of Fiji (2018-2021)", both through Grassroots Technical Assistance Projects of the Japan International Cooperation Agency (hereinafter referred to as "JICA"). Based on the results of these cooperation projects, the Government of Fiji (hereinafter referred to as "GOF") is looking forward to continued Japanese cooperation for the water supply sector of Fiji.

For the wastewater sector, the National Development Plan (2017-2036) targets access to wastewater systems for 70% of the population of Fiji through the construction and expansion of public wastewater treatment systems in all urban areas by 2033. At present, 11 wastewater treatment plants (hereinafter referred to as "WWTP") are operating in Fiji. In the Western Division, WWTPs are operated in Nadi, Lautoka, Ba, and Sigatoka. Most of the WWTPs are operated in overloaded conditions. This is due mainly to increase in influent volume and decrease in treatment capacity due to the aging of facilities and failure of equipment. Moreover, the WWTPs have not been operated and maintained properly, resulting in insufficiently treated effluent being discharged into the environment. This has caused serious pollution and odor in rivers and sea shores nearby. Urgent measures to improve the situation are necessary.

In the "National Development Plan (2017-2036)", the Government of Fiji planned to implement the renovation of existing and construction of new WWTPs from 2017 to 2022 as a Project implemented by Water Authority of Fiji (hereinafter referred to as "WAF"). However, the plan is not progressing as scheduled and reformulation of the plan is needed.

1-2 Outline of the Survey

This data collection survey (hereinafter referred to as “the Survey”) is carried out to collect information and survey alternatives for the Project Components to consider cooperation by JICA in the water supply and wastewater sector in the Republic of Fiji.

The survey area and related agencies for the survey are shown below.

Table 1-2.1 The Survey Area and Related Agencies for the Survey

Item	Description
Survey Area	Western Division of Viti Levu Island (Nadi and Lautoka Area) in the Republic of Fiji
Related Agencies	Implementing Agency: Ministry of Infrastructure, Transport, Disaster Management and Meteorological Services (MITDMMS) Executing Agency: Water Authority of Fiji (WAF) Related Agency: Ministry of Economy (MOE), Ministry of Waterways and Environment (MOWE), National Trust of Fiji Islands (NTF), Ministry of Lands and Mineral Resources (MLMR), iTaukei Land Trust Board (TLTB)

1-3 Objective and Scope of the Survey

The objective and scope of the survey are summarized as follows.

Table 1-3.1 The Objective and Scope of the Survey

Objective	To understand the present situation of the water supply and wastewater sectors and to define issues in technical and institutional aspects in the Western Division of Viti Levu Island in the Republic of Fiji and to collect information and survey alternatives of the project component for the consideration of draft cooperation policy and concrete cooperation plan (ODA loan, technical cooperation etc.)

1-4 Survey Schedule

The survey schedule is shown below.

Table 1-4.1 The Survey Schedule

Item	2019											2020		
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Preparation in Japan														
Survey in Fiji														
Work and Analysis in Japan														
Submission of Survey Report					△							△		△
Key Meeting with Fiji Side				●	●						●		●	

Chapter 2 Organization and Finance of WAF

2-1 Organization

2-1-1 Current Conditions and Issues in WAF's Organization

(1) Operation and Management of WAF Central

WAF was established in 2010 under the "WAF Promulgation 2007", taking over the duties that belonged to government agencies. It operates under the MITDMMS, receiving national subsidies approved by the MOE. The WAF Head Office decides the operation plans and informs the regional departments responsible for operation and maintenance (hereinafter referred to as O&M) of facilities and customer service in each area. Requests for the operation budget (such as rehabilitation of facilities and increasing number of employees) are sent from each regional department to the head office. The head office prioritizes the requests and allocates budgets for each area. WAF has offices in each region; Central (Suva), Eastern (Nausori), Western (Nadi and Lautoka) and Northern (Labasa). The Suva office shares the building with the head office. WAF office map is shown in **Figure 2-1.1** and organization structure of management system is shown in **Figure 2-1.2**.

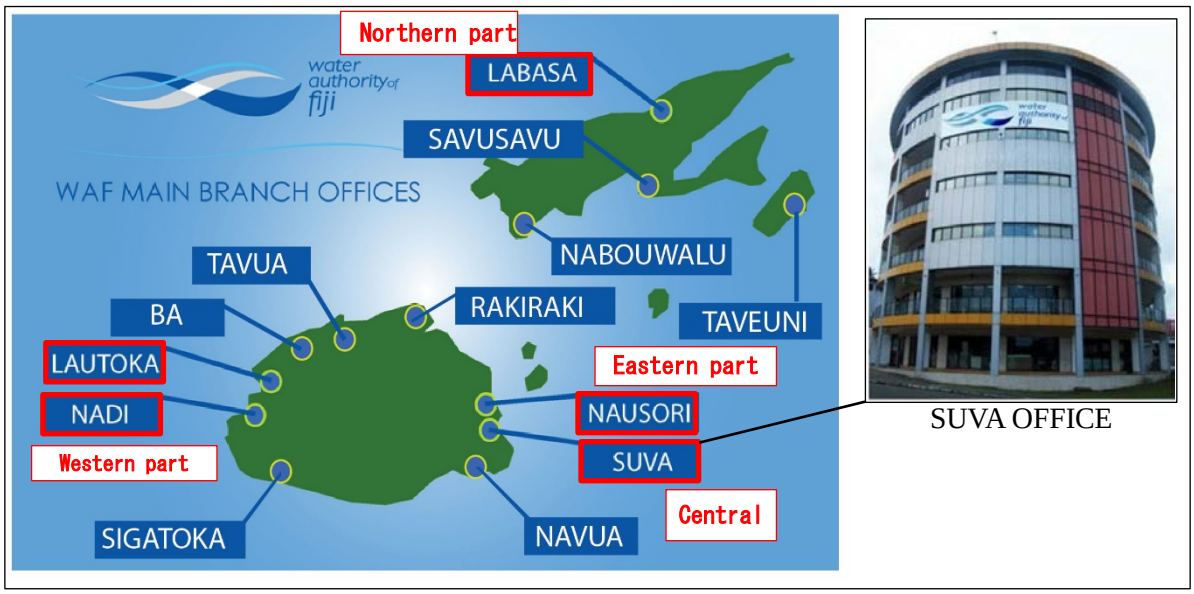


Figure 2-1.1 WAF Offices

Source: Water Authority of Fiji Profile (2015, WAF)

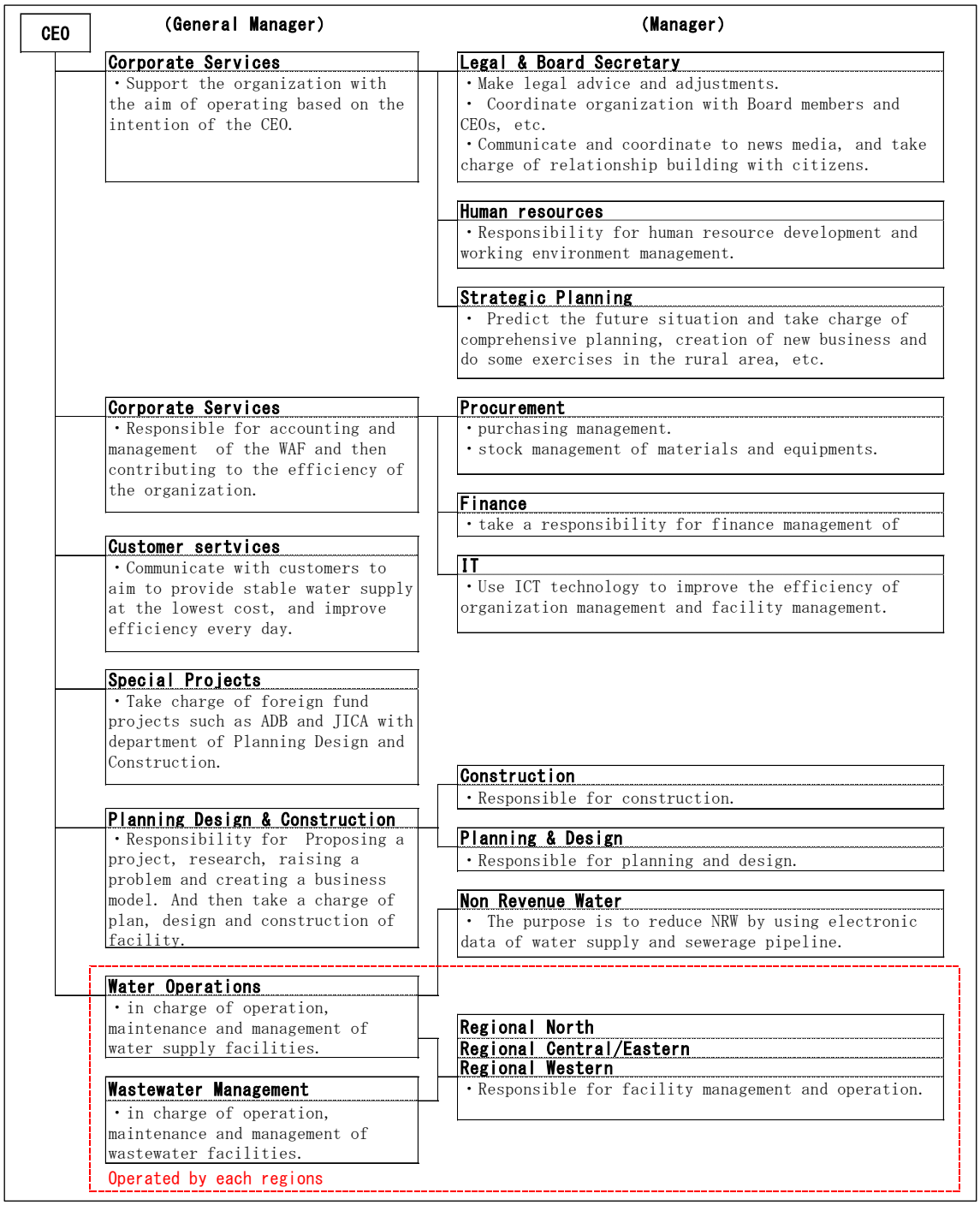


Figure 2-1.2 Organization Structure of WAF (management system)

Source: JICA Survey Team based on Interview of WAF

(2) Water Supply Sector

Organizational structure of the Water Supply Sector for each region is shown in **Figure 2-1.3**.

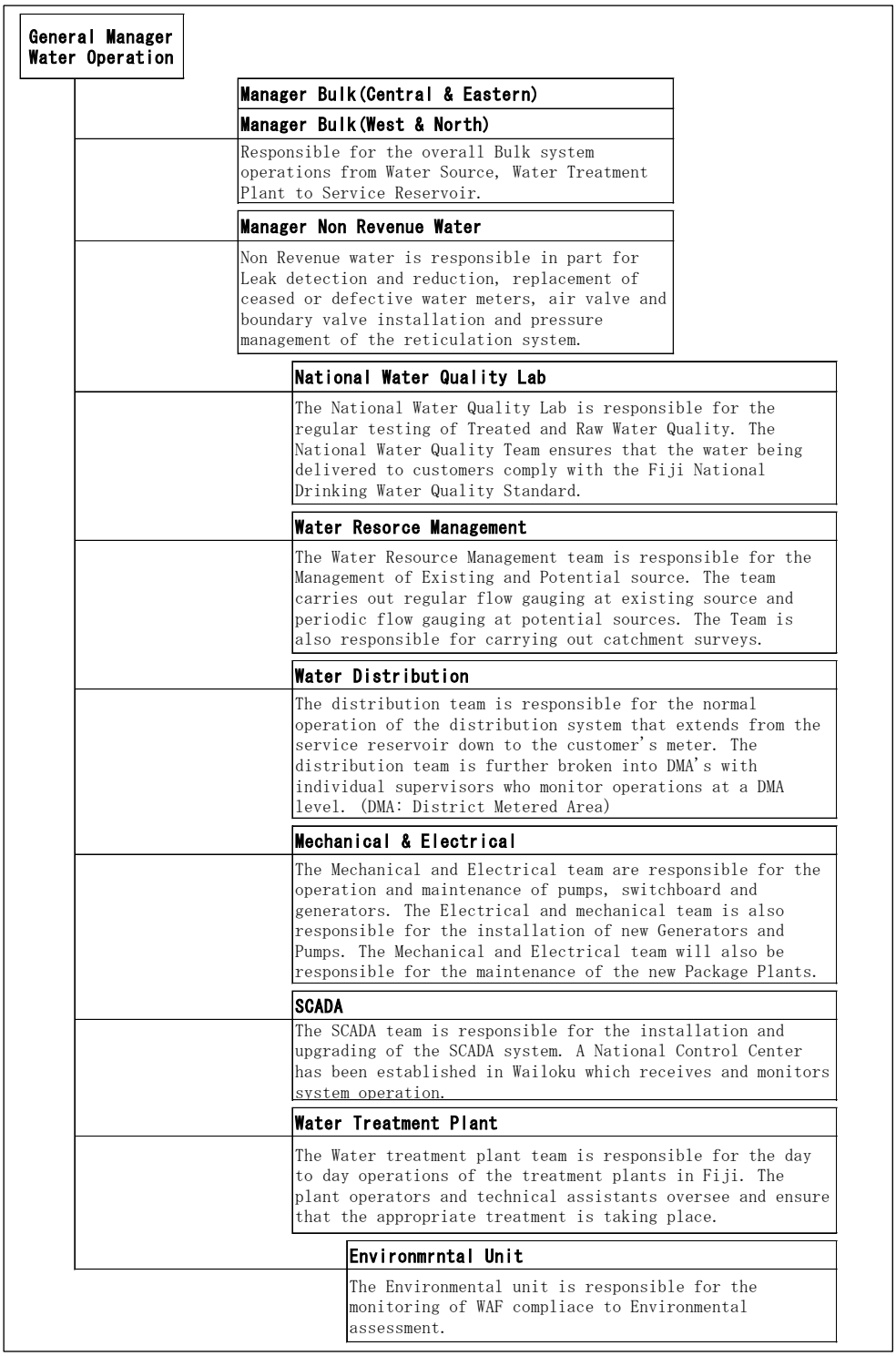


Figure 2-1.3 Organization Structure (Water Operation)

Source: JICA Survey Team based on Interview of WAF

Currently, roles of the workers are clearly defined and operations are carried out efficiently. However, there is a shortage of skilled technical staff.

(3) Wastewater Sector

Organization structure of the wastewater sector for each region is shown in **Figure 2-1.4**.

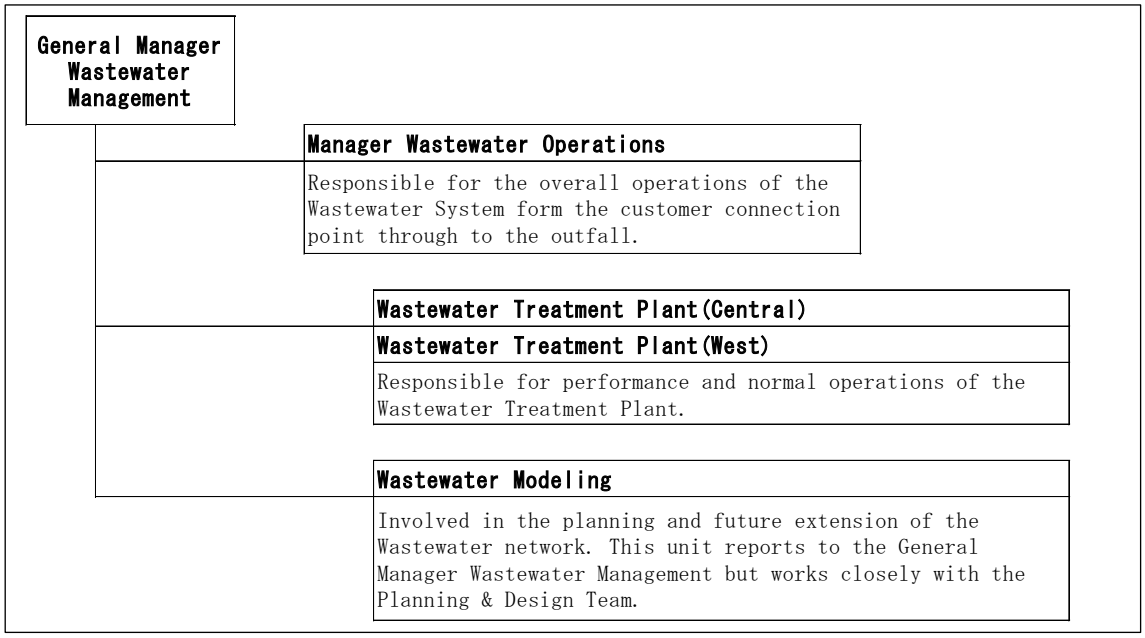


Figure 2-1.4 Organization Structure (Wastewater Management)

Source: JICA Survey Team based on Interview of WAF

The General Manager has the authority to decide operational policies and oversee the results. However, the operational roles of the organization and the business plan are not clearly defined and the intentions of the General Manager are not clearly communicated within the organization. In addition, the major city/towns of the Western Division do have wastewater master plans that represent the current conditions; therefore, operations cannot be implemented systematically.

2-1-2 The Number of Employees

WAF operates the water and wastewater businesses together. Counted together, there are 6 employees per 1,000 water supply and wastewater connections. According to the "ADB&SEAWUN, Data Books of Southeast Asian Water Utilities 2005 (2007.11)", 7.2 employees per 1,000 connections is the average in Asian countries. In this context, the number of employees at WAF is not unreasonably low, and WAF operations could be considered efficient. However, the O&M department of WAF Western has requested additional personnel for O&M in case some workers are ill, etc. Therefore, it is judged that the number of employees is insufficient. It is important to improve the skills of current employees and increase their capacities to perform the required works correctly. For instance, a guideline for maintenance and automated-meter-reading system would be effective.

Table 2-1.1 The Variation in the Number of Employees

YEAR	2015	2016	2017	2018[1]
ⓐFulltime employees	1,191	1,168	1,207	1,128
ⓑConnections [2]	175,988	171,552	174,348	178,785
ⓐ/ⓑ	6.8	6.8	6.9	6.3

Source: Annual Report, Financial Statements (2017, WAF)

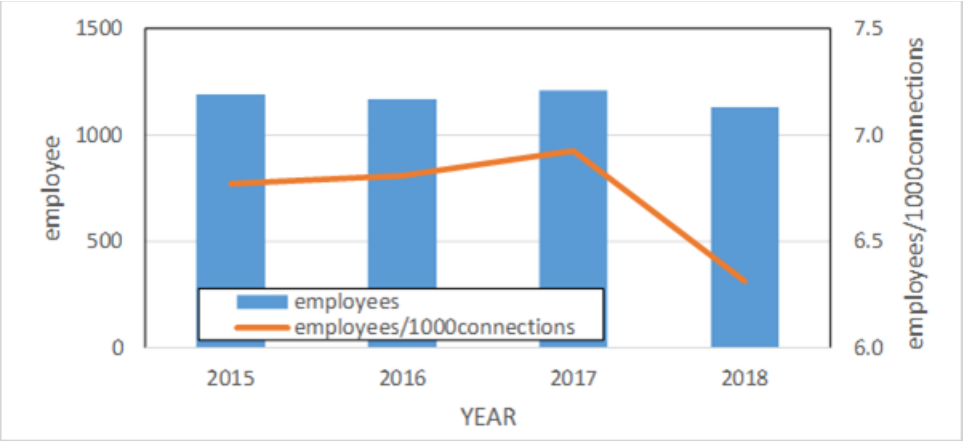


Figure 2-1.5 The Transition of the Number of Employees

Source: Annual Report, Financial Statements (2017, WAF)

The number of water supply and wastewater connections are expected to increase, considering population and tourism growth in the future. Therefore, more employees will be required.

2-1-3 Employee Retention

Table 2-1.2 shows that the number of full-time employees at WAF has not changed much in the last seven years. In interviews, WAF employees revealed that some experienced staff moved to the private sector, which offered better work conditions.

Salary is likely to be a major factor for the retention of experienced employees. Average monthly salary is 1,400 FJD (Rankings by Country of Average Monthly Disposable Salary (Net After Tax) (Salaries and Financing (2017)) and it has been increasing recently (**Figure 2-1.2**). It can be said that WAF salary is an average salary. WAF staff salaries are set based on average national salaries reviewed by the Fijian Competition & Consumer Commission (hereinafter referred to as "FCCC").

Table 2-1.2 Salary of WAF (Full Time Employee)

	2011	2012	2013	2014	2015	2016	2017
Full Time Employees (people)	1,349	1,169	1,156	1,196	1,191	1,168	1,207
Salary Cost (million FJD/month)	14.4	15.2	15.6	16.9	15.9	21.1	21.1
Salary/Person (thousand FJD/month)	10.7	13.0	13.5	14.1	13.4	18.1	17.5

Source: Fiji Bureau of Statistic

[1] Provisional data
[2] Water supply and wastewater systems

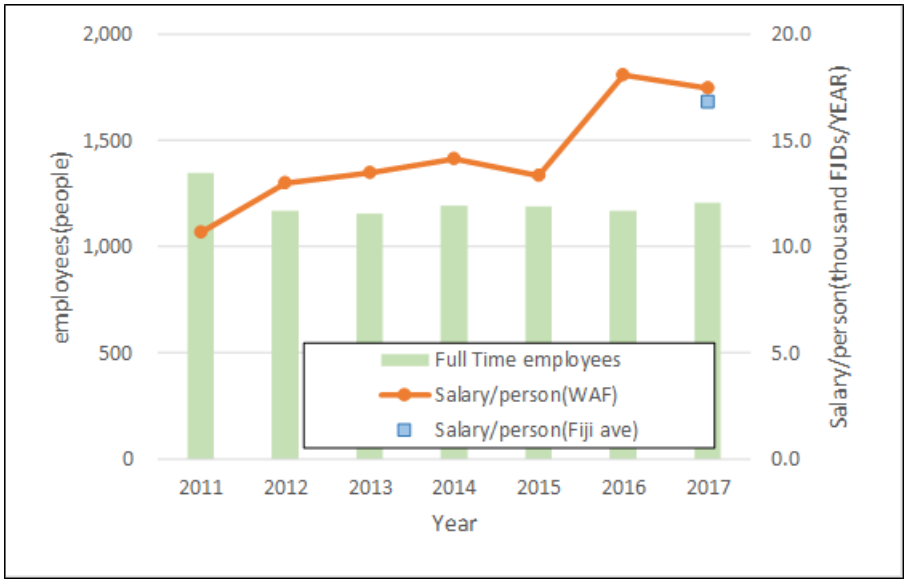


Figure 2-1.6 Salary of WAF (Full Time Employee)

Source: Fiji Bureau of Statistic

Promotion is based on each employee's experiences. Employees get promoted based on years of experience and evaluation from others. This system seems to have the effect of motivating WAF employees. The system of promotion is shown in **Figure 2-1.7.**

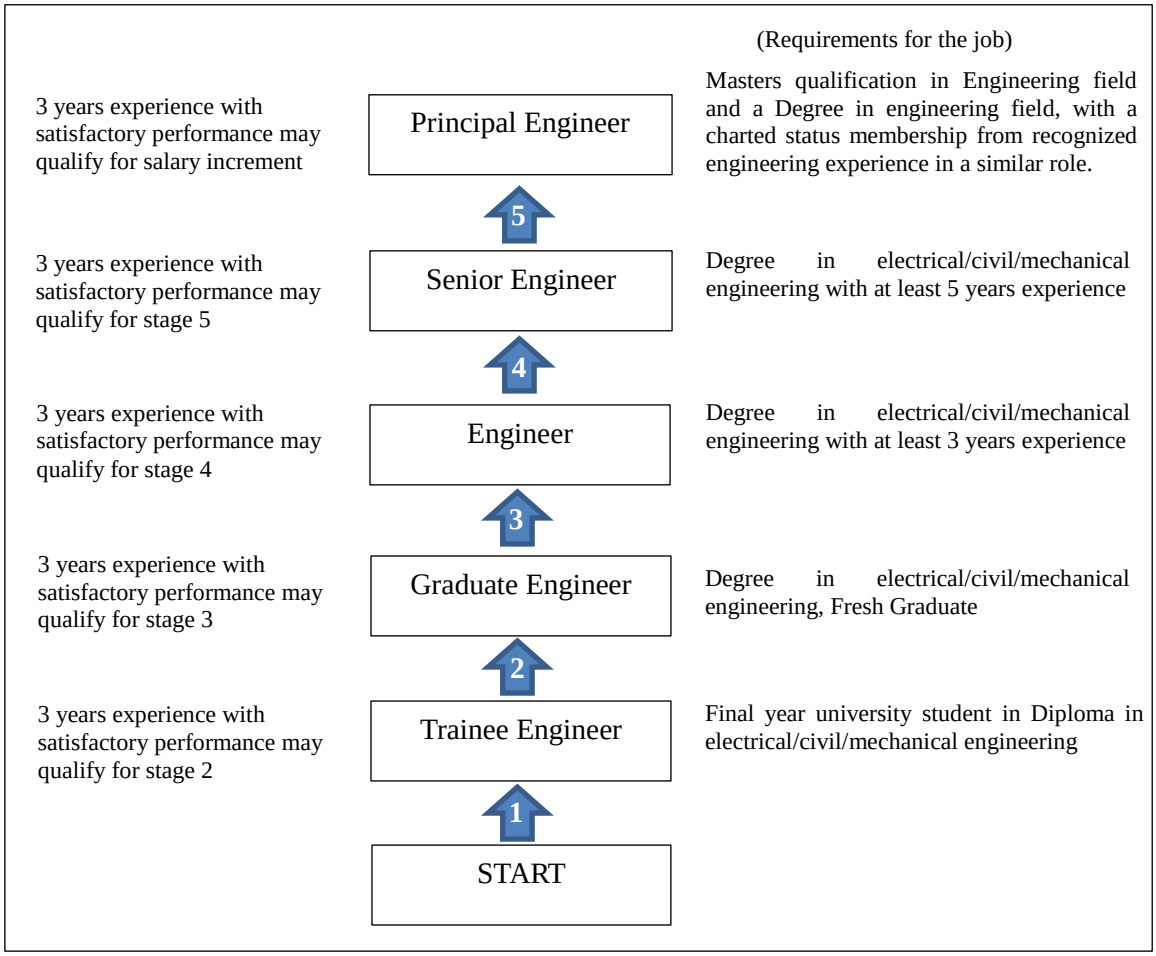


Figure 2-1.7 The System of the Promotion

Source: JICA Survey Team based on Interview of WAF

Retention of employees is desired because experienced technical employees are needed for the following reasons.

- To manage construction of new facilities (water sources, WTPs, raw water transmission pipes, etc.)
- To manage projects as a Project Manager according to established plans and policies
- To implement appropriate O&M and prompt response to trouble of facilities

2-1-4 Human Resource Development

WAF conducts training programs, including on-the-job training, based on each employee's experiences. Employees should take 2 days a year for trainings conducted by WAF. For the water supply sector, Fukuoka City Waterworks Bureau has been conducting the "Project to Support Reducing Unaccounted Water through Effective Control on NADI/LAUTOKA Regional Water Supply in the Republic of Fiji (2014-2017)" for WAF. In addition to unaccounted water, increasing demand and aging facilities will become pressing issues in the future. The following training programs are required for both water supply and wastewater management sectors to deal with these issues in the future.

(Water supply sector)

- Technical engineer in charge of water source development and project management
- Technical engineer in charge of the efficient management of facilities

(Wastewater management sector)

- Manager responsible for operation and management of future projects-based master plans
- Technical engineer responsible for management of existing facilities which are aging

2-1-5 Issues and Measures

The following issues and measures are proposed for organizational improvements.

(1) Issues

- Operation organization: Operate facilities efficiently.
- Number of employees: Secure sufficient number of employees, keeping in mind the future increase in resident population, foreign tourist and connection rate.
- Retention of employees: Secure experienced employees by improving the work environment and employee promotions.
- Human resource development: Conduct training programs to support efficient O&M of facilities.

(2) Measures

- Operation organization: Strengthen the capacity of the divisions in charge of Non-Revenue Water (hereinafter referred to as “NRW”) measures and SCADA system.
- Number of employees: Establish effective organizational structure that can operate services with minimum employees by increasing skills through appropriate training programs.
- Retention of employees: Charge appropriately for water services and reflect it in employee salaries.
- Human resource development: Conduct Grassroots projects, such as NRW training program by JICA, to improve facility operation and maintenance.

2-2 Finance

2-2-1 The Present Situation

2-2-1-1 Assets

Assets and their breakdown in 2017 are shown in **Table 2-2.1** and **Figure 2-2.1**, respectively. **Figure 2-2.1** shows that Water and Distribution Equipment account for a majority (64%) of the assets.

Table 2-2.1 Details of Assets (2017)

	ASSETS (million FJD)	Percentage of total
Water and Distribution Equipment	1,139	64%
Land and Buildings	240	14%
Wastewater Equipment	235	13%
Work in Progress-Capex	148	1%
Vehicles Office	14	1%
TOTAL	1,776	100%

Source: Annual Report, Financial Statements (2017, WAF)

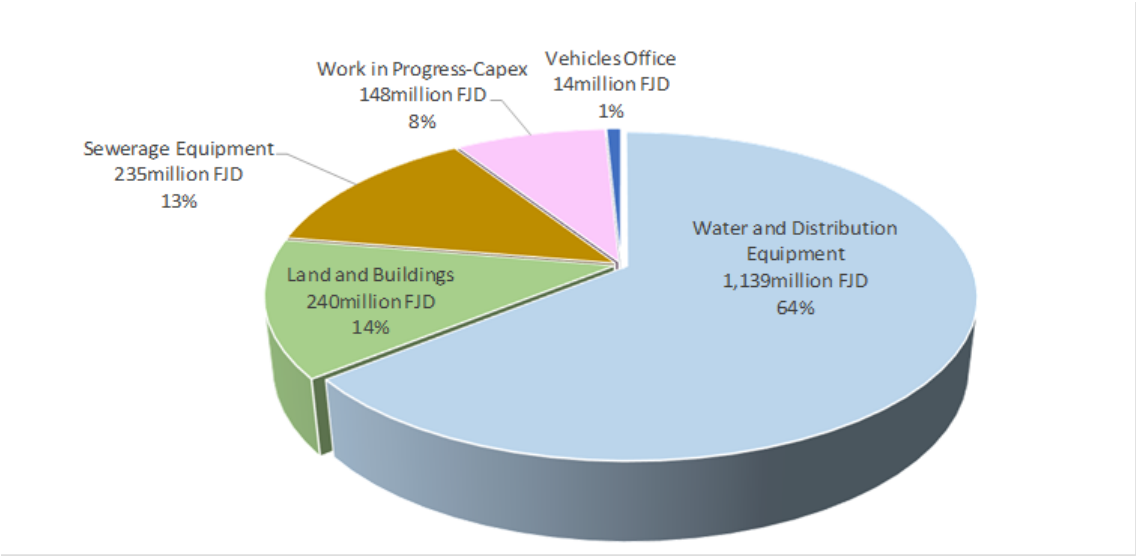


Figure 2-2.1 Breakdown of Assets (2017)

Source: Annual Report, Financial Statements (2017, WAF)

Table 2-2.2 Summary of Assets

		Central	Eastern	Western	Northern
Water	Intakes	12	13	17	22
	Treatment plants	8	6	11	19
	Reservoirs	32	24	34	31
	Distribution network	7	7	7	4
	Pumps / Pump stations	72/17	-	39/17	23/14
	Length of distribution pipes	4,313km			
Wastewater	Pumps / Pump stations	210/96	-	135/58	16/32
	Treatment plants	6	-	4	1
Office	Base	Suva	Nausori	Lautoka Nadi	Labasa
	Branch	1	0	4	3

Source: Water Authority of Fiji Profile (WAF)

Table 2-2.3 Summary of Assets (More-than-3MLD-Capacity WTP, WWTP)

Category	Central	Eastern	Western	Northern
WTP	Waila Tamavua Nayagi Deuba	-	Nagado Waiwai Matovo Buabua Saru Vatukoura Rakiraki	Benau
WWTP	Kinoya Nadali ACS, Wailada Naboro Pacific Harbor	-	Navakai Natabua Votua Olosara	Namara

Source: JICA Survey Team based on Water Authority of Fiji Profile (WAF)

2-2-1-2 Finance

Financial statements are shown below. According to **Table 2-2.4** and **Table 2-2.5** government subsidy is about 5 times the amount of water and wastewater feed collected. Cash flow is positive unless depreciation is considered. In the 3-year business plan (Strategic Plan 2017 – 2019) service efficiencies will be improved to reduce the deficits by using SCADA system in the water supply sector and appropriate operation and management in the wastewater sector.

Table 2-2.4 Statement of Cash Flow

YEAR	2011	2012	2013	2014	2015	2016	2017
Operating activities	**(35,671,555)**	**4,552,341**	**23,934,605**	**(5,685,715)**	**(17,924,309)**	**(20,556,891)**	**(65,333,736)**
Receipts from customers	20,178,637	24,910,619	27,306,660	28,836,806	31,257,761	36,753,022	45,673,261
Receipt from Government -operating grant	38,324,384	45,565,910	50,083,311	47,935,848	54,918,804	72,071,657	68,265,897
Payment to suppliers and employees	(73,995,939)	(41,013,569)	(26,148,706)	(53,621,563)	(72,843,113)	(92,628,548)	(133,599,633)
Payment to Government -Consolidated Fund Account	(20,178,637)	(24,910,619)	(27,306,660)	(28,836,806)	(31,257,761)	(36,753,022)	(45,673,261)
Investing activities	**41,016,455**	**379,375**	**(13,338,017)**	**(1,321,833)**	**37,659,209**	**19,973,721**	**93,611,135**
Recipient from Government -capital grant	59,062,357	31,185,971	31,143,381	64,845,220	116,500,872	104,576,413	169,576,635
Recipient from rural entities -rural projects		303,488	346,078	243,749	441,560	3,738	
Payments for property, plant and equipment	(18,045,902)	(29,004,047)	(44,827,476)	(66,410,802)	(79,283,223)	(84,606,430)	(75,965,500)
Payments for term deposits		(2,106,037)					
Financing activities	**3,673**	**55,128**	**(305,314)**	**(309,383)**	**(327,395)**	**(315,989)**	**62,952**
Payment to finance lease			(312,306)	(354,883)	(377,710)	(419,443)	(91,458)
Proceeds from interest income	3,673	55,128	6,992	45,500	50,315	103,454	154,410
Cash and cash equivalents							
at 1 January	2,747,168	8,095,741	13,082,585	23,373,859	16,056,928	35,464,433	34,565,274
at 31 December	**8,095,741**	**13,082,585**	**23,373,859**	**16,056,928**	**35,464,433**	**34,565,274**	**62,905,625**

Unit: FJD

Source: Annual Report, Financial Statements (2017, WAF)

Table 2-2.5 Statement of Comprehensive Income

YEAR	2011	2012	2013	2014	2015	2016	2017
Revenue	**67,149,540**	**85,606,216**	**96,588,616**	**98,126,764**	**109,827,237**	**153,148,199**	**173,894,553**
Government grant	38,324,384	45,565,910	50,083,311	50,935,848	54,918,804	72,071,657	78,899,685
Water charges	25,694,458	25,824,079	25,951,147	26,963,549	29,125,910	37,762,502	42,596,094
Waste Water charges	2,496,604	2,622,687	2,902,649	3,016,293	3,284,743	4,291,343	4,086,956
Transfer from deferred revenue	564,404	8,232,827	17,418,779	17,026,878	20,955,924	38,821,696	47,855,900
ADB Grant Flood 1&2 in 2013	-	3,099,221	-	-	-	-	-
Other income	69,690	261,492	232,730	184,196	1,541,856	201,001	455,918
Personal expenses	**(17,166,364)**	**(17,453,269)**	**(17,589,710)**	**(18,896,220)**	**(19,515,199)**	**(26,026,267)**	**(29,899,448)**
Salaries and wages	(15,126,362)	(15,039,492)	(15,531,311)	(15,924,345)	(15,822,443)	(21,390,775)	(25,125,428)
Annual leave	(311,471)	(903,472)	(551,772)	(1,450,267)	(1,263,472)	(1,636,110)	(1,337,097)
Fiji National Provident Fund	(1,414,991)	(1,405,344)	(1,237,061)	(1,133,628)	(1,570,034)	(1,813,482)	(2,592,501)
Staff welfare	(313,540)	(104,961)	(269,566)	(387,980)	(859,250)	(1,185,900)	(844,422)
Operating expenses	**(39,958,918)**	**(60,713,614)**	**(52,536,054)**	**(53,045,001)**	**(62,452,610)**	**(89,319,186)**	**(104,374,838)**
Chemical usage	(1,789,047)	(2,855,121)	(1,721,232)	(1,948,305)	(1,983,194)	(2,223,771)	(2,129,806)
Doubtful debts	(10,219,510)	(6,112,036)	4,017,415	1,922,500	(1,676,832)	(4,134,836)	(1,667,627)
Directors fees	(6,123)	(8,696)	(33,292)	(3,163)	(36,034)	(28,536)	(34,025)
Water and electricity	(18,113,443)	(17,859,578)	(19,930,328)	(18,407,078)	(18,261,523)	(18,152,881)	(22,492,995)
Fuel and oil	(1,549,843)	(1,340,567)	(1,106,415)	(2,236,275)	(1,427,210)	(1,669,869)	(1,891,881)
Plant and equipment	(1,465,472)	(4,917,965)	(4,122,666)	(6,968,895)	(7,755,509)	(9,872,304)	(13,457,634)
Loss on disposal of fixed assets	(337,282)	-	-	(11,726)	-	(22,876)	-
Professional fees	(127,809)	(467,620)	(3,285,183)	(215,522)	(140,252)	(2,180,284)	(586,877)
Repairs and maintenance	(4,611,041)	(9,987,432)	(12,385,001)	(17,051,327)	(24,531,346)	(43,178,729)	(52,792,773)
Telephone and communication	(641,435)	(665,334)	(672,643)	(1,114,188)	(1,282,992)	(1,952,818)	(2,100,783)
Others	(1,097,913)	(16,499,265)	(13,296,709)	(7,011,022)	(5,357,718)	(5,902,282)	(7,220,437)
Depreciation	**(54,070,661)**	**(54,626,099)**	**(55,449,068)**	**(57,177,979)**	**(58,300,576)**	**(59,288,328)**	**(56,892,377)**
Finance income	**3,673**	**55,128**	**27,425**	**58,212**	**50,315**	**103,454**	**154,410**
Income tax expense	**(1,818,199)**	**-**	**-**	**-**	**-**	**-**	**-**
Total comprihensive(loss) for the year	**(45,860,929)**	**(47,131,638)**	**(28,958,791)**	**(30,934,224)**	**(30,390,833)**	**(21,382,128)**	**(17,117,700)**

Unit: FJD

Source: Annual Report, Financial Statements (2017, WAF)

If the service life of mechanical and electrical equipment can be extended from 15 year to 25 years, and that of civil engineering and construction equipment from 50 years to 75 years through appropriate maintenance, depreciation costs for water and wastewater facilities will decrease by 63%.

①Present depreciation rate	②Depreciation rate after improvement	①÷②
$\frac{0.5}{50}+\frac{0.5}{15}=0.0433\fallingdotseq 4.3\%$	$\frac{0.5}{75}+\frac{0.5}{25}=00266\fallingdotseq 2.7\%$	$\frac{2.7}{4.3}=0.627\fallingdotseq 63\%$

The percentage of depreciation rate of all facilities should be down to 82%, and the amount of depreciation should be down from 46.7 million FJD to 56.9 million FJD in 2017.

The percentage of reduced depreciation rate to all facilities

$$=\frac{\text{the percentage of the reduced depreciation rate}}{\text{the percentage of water and wastewater facilities to all facilities}}=\frac{63\%}{77\%}=0.812\fallingdotseq 82\%$$

According to “Statement of changes in equity” and “Statement of financial position” shown below, WAF’s assets are increasing. This suggests that the scales of WAF operations are expanding.

Table 2-2.6 Statement of Changes in Equity

YEAR	2011	2012	2013	2014	2015	2016	2017
Loss	**(66,039,566)**	**(72,042,257)**	**(56,265,451)**	**(59,771,030)**	**(61,648,594)**	**(58,135,150)**	**(62,790,961)**
Loss for the period	(45,860,929)	(47,131,638)	(28,958,791)	(30,934,224)	(30,390,833)	(21,382,128)	(17,117,700)
Transfer of water and sewerage bills collected to Government of Fiji Consolidated Fund Account	(20,178,637)	(24,910,619)	(27,306,660)	(28,836,806)	(31,257,761)	(36,753,022)	(45,673,261)
Equity							
at 1 January	1,793,498,965	1,761,544,239	1,689,501,982	1,636,266,862	1,576,495,832	1,514,847,238	1,456,712,088
at 31 December	**1,727,459,399**	**1,689,501,982**	**1,633,236,531**	**1,576,495,832**	**1,514,847,238**	**1,456,712,088**	**1,393,921,127**

Unit: FJD

Source: Annual Report, Financial Statements (2017, WAF)

Table 2-2.7 Statement of Financial Position

YEAR	2011	2012	2013	2014	2015	2016	2017
Total assets	**1,811,279,154**	**1,843,933,461**	**1,826,112,864**	**1,818,564,558**	**1,833,314,108**	**1,838,428,857**	**1,903,353,440**
Non-current assets	**1,763,139,003**	**1,806,654,091**	**1,783,142,387**	**1,766,973,142**	**1,762,534,613**	**1,757,340,790**	**1,776,448,638**
property, plant and equipment	1,763,139,003	1,806,570,757	1,783,049,975	1,765,768,276	1,761,711,340	1,756,373,289	1,775,623,199
Intangible asset		83,334	92,412	1,204,866	823,273	967,501	825,439
Current assets	**48,140,151**	**37,279,370**	**42,970,477**	**51,591,416**	**70,779,495**	**81,088,067**	**126,904,802**
Cash and cash equivalents	8,095,741	13,082,585	23,373,859	16,056,928	35,464,433	34,565,274	62,905,625
Trade and other receivables	16,454,521	11,015,425	6,872,247	10,874,281	12,235,959	15,694,970	29,791,851
Inventories	22,299,412	9,887,955	9,368,250	20,100,003	16,565,503	28,939,985	32,284,896
Held-to-maturity investments	1,000,000	3,106,037	3,118,692	3,131,404	5,000,193	1,000,000	1,000,000
Other assets and prepayments	290,477	187,368	237,429	1,428,800	1,513,407	887,838	922,430
Total equity and liabilities	**1,811,279,154**	**1,843,933,461**	**1,826,112,864**	**1,818,564,558**	**1,833,314,108**	**1,838,428,857**	**1,903,353,440**
Equity	**1,694,449,782**	**1,689,501,982**	**1,633,236,531**	**1,576,495,832**	**1,514,847,238**	**1,456,712,088**	**1,393,921,127**
Contributed equity	1,860,011,694	1,835,101,075	1,807,794,415	1,778,957,609	1,747,699,848	1,710,946,826	1,665,273,565
Accumulated losses	(165,561,912)	(145,599,093)	(174,557,884)	(202,461,777)	(232,852,610)	(254,234,738)	(271,352,438)
Total liabilities	**116,829,372**	**154,431,479**	**192,876,333**	**242,068,726**	**318,466,870**	**381,716,769**	**509,432,313**
Current liabilities	**1,611,889**	**9,243,476**	**21,602,369**	**27,362,756**	**16,374,230**	**16,476,799**	**25,266,742**
Obligation under finance lease			422,551	422,551	422,551	91,458	
Trade and other payables	1,300,418	8,609,956	20,589,721	26,156,115	15,268,669	15,610,201	24,861,664
Provision for employee entitlements	311,471	633,520	590,097	784,090	683,010	775,140	405,078
Non-current liabilities	**115,217,483**	**145,188,003**	**171,273,964**	**214,705,970**	**302,092,640**	**365,239,970**	**484,165,571**
Obligation under finance lease			820,943	466,060	88,350		
Deferred revenue-capex grant	77,825,814	79,926,705	102,907,216	142,622,716	231,992,329	296,841,158	416,938,952
ADB funded grant	34,361,338	62,230,967	64,515,474	71,617,194	70,011,961	68,398,812	67,226,619
Deferred tax liabilities	3,030,331	3,030,331	3,030,331				

Unit: FJD

Source: Annual Report, Financial Statements (2017, WAF)

Table 2-2.8 shows that total assets were almost constant between 2011-2017, while liabilities increased. This is probably because the government's priority on water and wastewater projects is high and is expanding operations by investing in equity. The capital-to-asset ratio is 73% as of 2017. Thist does not threaten the survival of the WAF, but considering the cost of measures for the aging facilities, it is not a good situation and it is necessary to secure a source of income.

Table 2-2.8 Variation of Assets and Liabilities

YEAR	2011	2012	2013	2014	2015	2016	2017
①Total liabilities	117	154	193	242	318	382	509
②Equity[3]	1,694	1,690	1,633	1,577	1,515	1,456	1,394
③Total assets(①＋②)	1,811	1,844	1,826	1,819	1,833	1,838	1,903
Gearing ratio(①÷③)	6.5%	8.4%	10.6%	13.3%	17.3%	20.8%	26.7%
Capital-to-asset ratio(②÷③)	93.5%	91.6%	89.4%	86.7%	82.7%	79.2%	73.3%

Unit: million FJD

Source: Annual report, Financial statements (WAF)

[3] capital assets

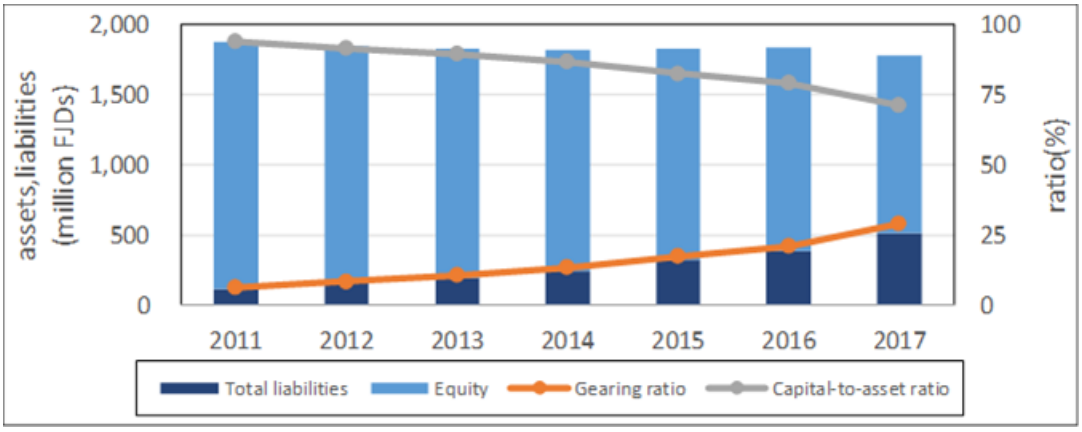


Figure 2-2.2 Variation of Assets and Liabilities

Source: Financial statements (2017)

2-2-1-3 The Budget for Construction and Budget Details

The cost of project rose between 2013 and 2016. Although there are some fluctuations, costs have mostly stabilized since 2016.

Table 2-2.9 Variation of CAPEX Budget

YEAR	2013	2014	2015	2016	2017	2018
Capital Budget	35.3	71.0	176.1	229.3	195.7	246.5

Unit: million FJD

Source: How the budget allocation for WAF will be spent (2018, WAF)

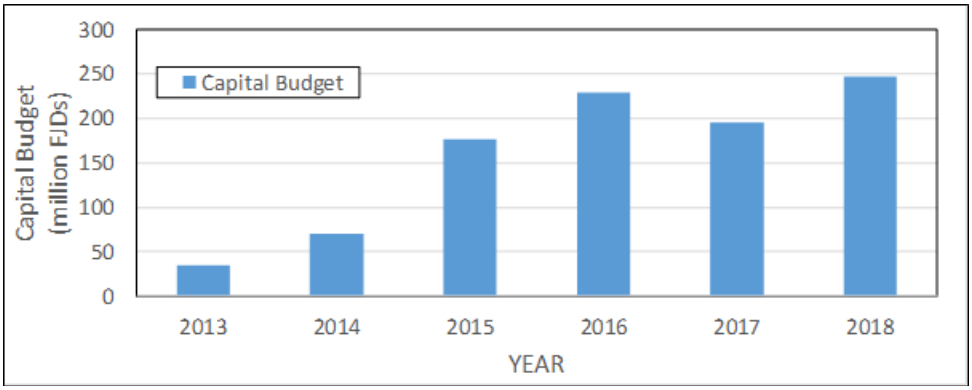


Figure 2-2.3 Variation of CAPEX Budget

Source: How the budget allocation for WAF will be spent (2018, WAF)

Water supply projects account for 70% of all costs, and wastewater only 30%. The total budget of the Western Region is similar to the budgets of other regions. But in the Western Division, the ratio of the construction cost for wastewater facilities is smaller than the construction cost for water supply facilities, and it can be found that the water supply facility maintenance is required. Typically, maintenance of water supply facilities precedes maintenance of wastewater facilities. High spending on wastewater facilities suggests that investment has been carried out mainly in the central area where the capital Suva is located. Additionally, of the 89.2 million FJD water supply budget of the Western Region, 8.3 million FJD were allocated to the Nagado WTP upgrading from total budget (89.2 million FJD).

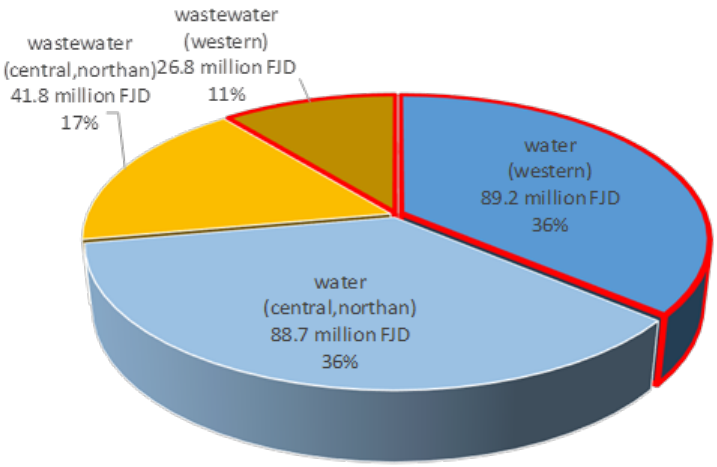


Figure 2-2.4 Budget Details (2018)

Source: How the budget allocation for WAF will be spent (2018, WAF)

2-2-1-4 The Number of Connections for Water and Wastewater System

The number of connections for water supply and wastewater system has been increasing slightly. However, in 2015, the number of connections decreased, while water and wastewater revenues increased dramatically. One way to explain the increase in revenue is the implementation of programs such as water meter management and bill collection system of JICA's Grassroots Technical Assistance Project (non-revenue water measures). In addition, WAF tried to count the number of connections more accurately. This may explain the observed decrease in connections.

Table 2-2.10 Number of Connections by Area (Water Supply)

Year	2011	2012	2013	2014	2015	2016	2017	2018
Northern	14,629	14,694	14,773	14,919	14,954	13,817	13,938	13,884
Central	73,557	74,032	74,306	75,937	76,112	74,111	76,645	78,520
Western	52,256	52,963	53,483	55,006	55,389	53,657	53,545	55,529
Total	140,442	141,689	142,562	145,862	146,455	141,585	144,128	147,933

Unit: connections

Source: JICA Survey Team based on Interview of WAF

Table 2-2.11 Billing Revenues (Water Supply)

Year	2011	2012	2013	2014	2015	2016	2017	2018
Revenue	25,694	25,824	25,951	26,964	29,126	37,763	42,596	-

Unit: thousand FJD

Source: Annual Report, Financial Statements (2017, WAF)

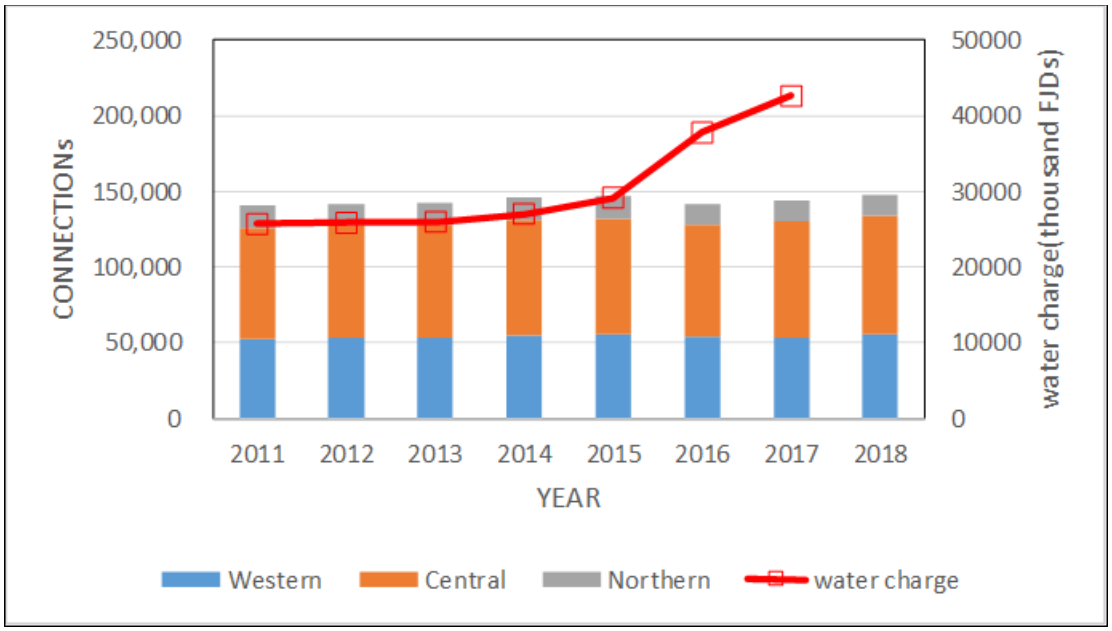


Figure 2-2.5 Number of Connections by Area and Billing Revenues (Water Supply)

Source: Annual Report, Financial Statements (2017, WAF)

Table 2-2.12 Number of Connections by Area (Wastewater)

Year	2015	2016	2017	2018
Northern	1,698	1,659	1,702	1,733
Central	14,958	16,067	16,323	16,676
Western	12,887	12,211	12,195	12,443
Total	29,543	29,937	30,220	30,852

Unit: connections

Source: JICA Survey Team based on Interview of WAF

Table 2-2.13 Billing Revenues (Wastewater)

Year	2015	2016	2017	2018
Charge	3,285	4,291	4,087	-

Unit: thousand FJD

Source: Annual Report, Financial Statements (2017, WAF)

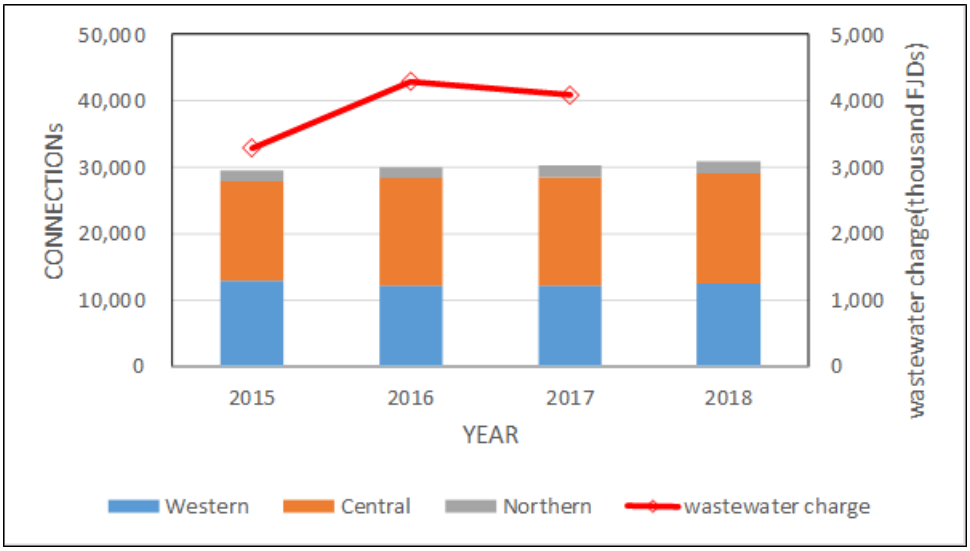


Figure 2-2.6 Number of Connections by Area and Billing Revenues (Wastewater)

Source: Annual Report, Financial Statements (2017, WAF)

2-2-1-5 Operation, Personnel Expenses and Charges

Operation expense, personnel expense and service charges are shown in **Table 2-2.14**. Collected charges are not enough to cover operation and personnel expenses. Also, wastewater charge remains at 1/10 of the water charge. In order to cover operation and personnel expenses by service charges, it is estimated that service charge must be tripled. Personnel expenses and operation cost are not divided between water supply sector and wastewater service sector.

Table 2-2.14 Operating Expenses, Personnel Expenses and Service Charge

YEAR		2011	2012	2013	2014	2015	2016	2017
①charges	water	25,694	25,824	25,951	26,964	29,126	37,763	42,596
	wastewater	2,497	2,623	2,903	3,016	3,285	4,291	4,087
	total	28,191	28,447	28,854	29,980	32,411	42,054	46,683
②operating expenses		39,959	60,714	52,536	53,045	62,453	89,319	104,375
③personnel expenses		17,166	17,453	17,590	18,896	19,515	26,026	29,899
②+③		57,125	78,167	70,126	71,941	81,968	115,345	134,274
①-(②+③)		-28,934	-49,720	-41,272	-41,961	-49,557	-73,291	-87,591
(②+③)/①		2.03	2.75	2.43	2.40	2.53	2.74	2.88

Unit: thousand FJD

Source: Annual report, Financial statements (WAF)

In **Figure 2-2.7**. operating expenses and personnel expenses were divided by income. “Repairs and maintenance” and “Plant and equipment cost” are increasing. This suggests facilities are aging.

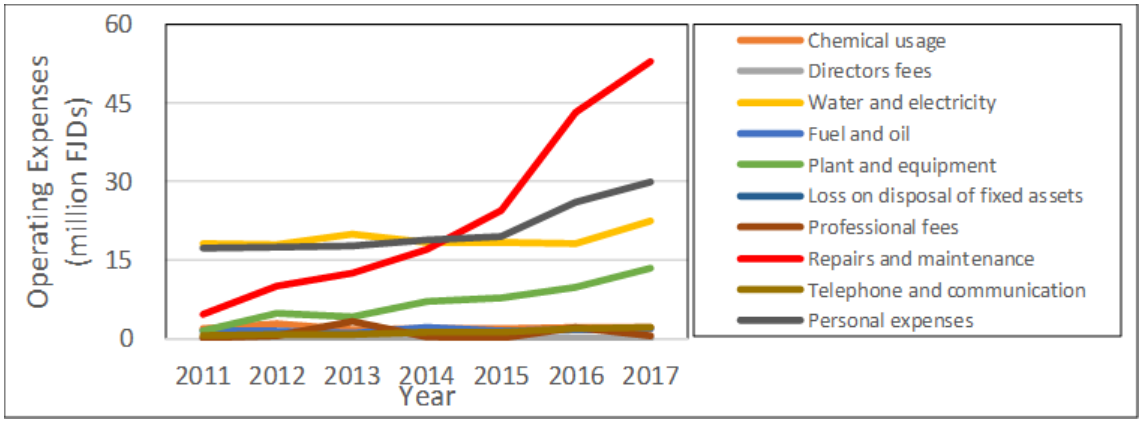


Figure 2-2.7 Changes of Operating and Personnel Expenses

Source: Annual report, Financial statements (WAF)

2-2-1-5-1 Water and Wastewater Charges

GDP per capita has increased 1.6 times over the past 30 years. However, water and wastewater charges have not been changed for 30 years due to political influences (**Figure 2-2.8**). This is considered to lead to a situation where the operating expenses and the personnel expense cannot be covered by the service charges.

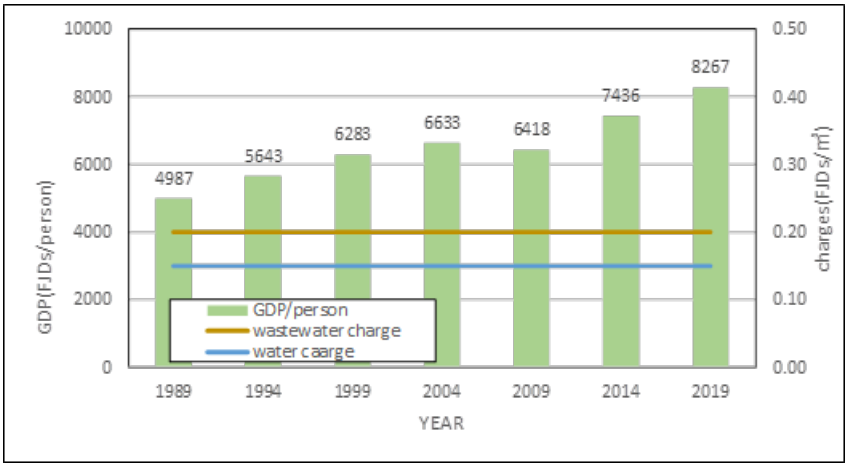


Figure 2-2.8 Water and Wastewater Charges and GDP per Capita

Source: IMF (2017)

WAF cannot cover operational cost and personnel expenses from income, so they depend heavily on government subsidies. Residents of Fiji have learned about this from the “Strategic Plan 2017 - 2019”. On the other hand, a WAF leaflet announced that they provide water at very low costs. This makes it difficult for people to understand the actual financial situation of WAF.

Table 2-2.15 Water Charge

	Charge (FJD/m^3)
Domestic	0.153
～50 m^3/3months	0.439
50～100 m^3/3months	0.838
101 m^3/3months～	
Commercial	1.060
Government	0.530

Source: WAF Save Water Brochure

Table 2-2.16 Wastewater Charge

	Charge (FJD/ m^3)
All	0.200

Source: WAF Save Water Brochure

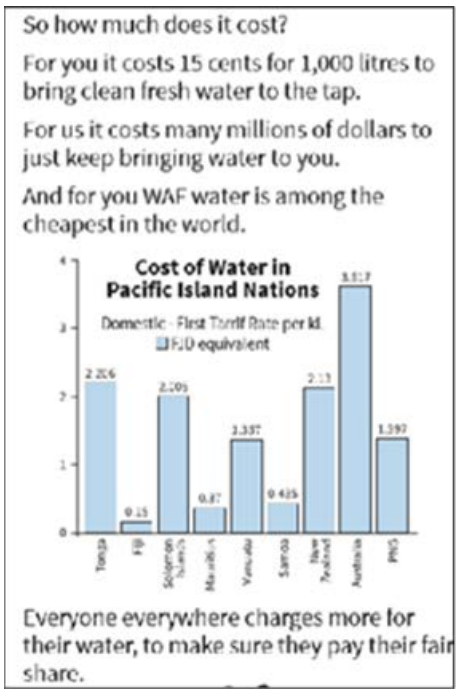


Figure 2-2.9 Comparison of the Water Charge Among Pacific Countries

Source: WAF Save Water Brochure

2-2-2 Improvement of Financial Condition

Improvements to the financial condition are proposed as follows.

- Investment cash flow

The total liabilities have been increasing, so suppressing the liabilities should be considered.

- Business activity cash flow

Water and wastewater charges are not enough to cover personnel expenses and operating expenses. If facilities are constructed, the deficit will grow larger. Increasing the fees and efficiencies of operating facilities should be considered.

2-3 WAF's Financial Analysis and Project Implementation Capabilities

2-3-1 Estimation of Construction Investment Allowance

The construction investment has increased in the last six years, and the average investment amount is around 220 million FJD for 2 years from 2016. An estimate was made of the WAF's financial condition and construction investment allowance if this investment is continued.

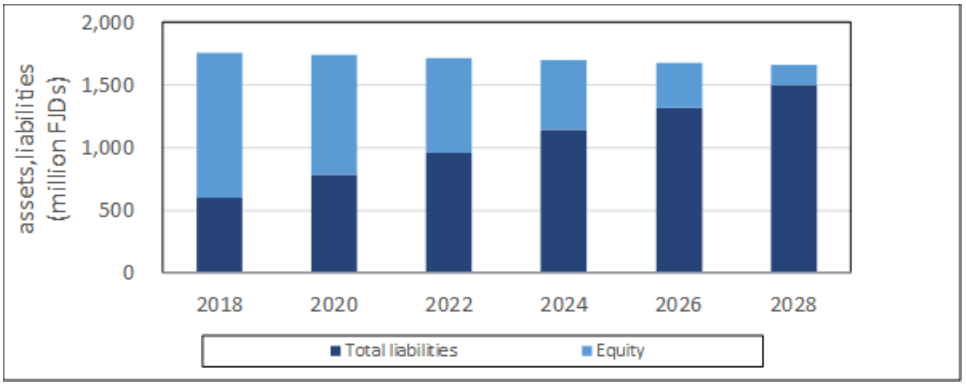
【Condition of Estimation】

- Total annual construction investment remains at 220 million FJD as stated in the "Strategic Plan from 2020 to 2022".
- Liabilities are increasing in proportion to annual investment.
- Calculation of the relation between liabilities amount and annual investment is based on the actual value of 2016 to 2018.
- Total assets will be decreasing as usual.

(1) In the case of investing with 220 million FJD from 2023 to 2028

YEAR	2018	2020	2022	2024	2026	2028
①Total liabilities	602	782	962	1,142	1,322	1,502
②Equity	1,157	957	757	557	357	157
③Total assets(①＋②)	1,759	1,739	1,719	1,699	1,679	1,659
Capital-to-asset ratio(②÷③)	65.8%	55.0%	44.0%	32.8%	21.3%	9.5%

Source: JICA Survey Team

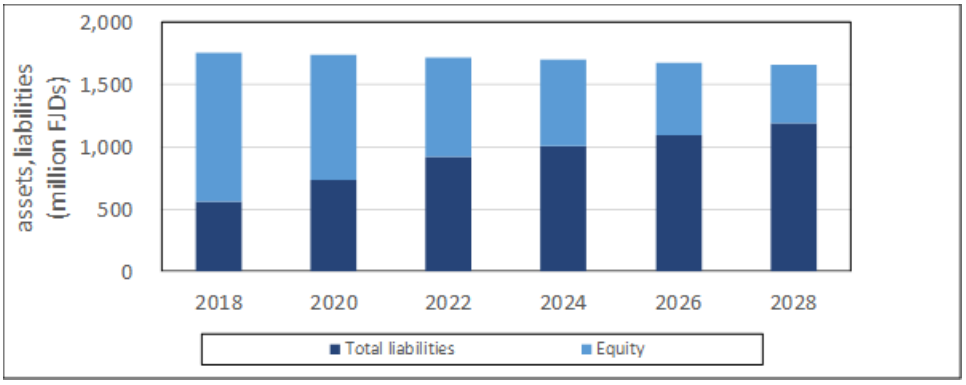


Source: JICA Survey Team

(2) In the case of investing with 110 million FJD from 2023 to 2028

YEAR	2018	2020	2022	2024	2026	2028
①Total liabilities	602	782	962	1,052	1,142	1,232
②Equity	1,157	957	757	647	537	427
③Total assets(①＋②)	1,759	1,739	1,719	1,699	1,679	1,659
Capital-to-asset ratio(②÷③)	65.8%	55.0%	44.0%	38.1%	32.0%	25.7%

Source: JICA Survey Team

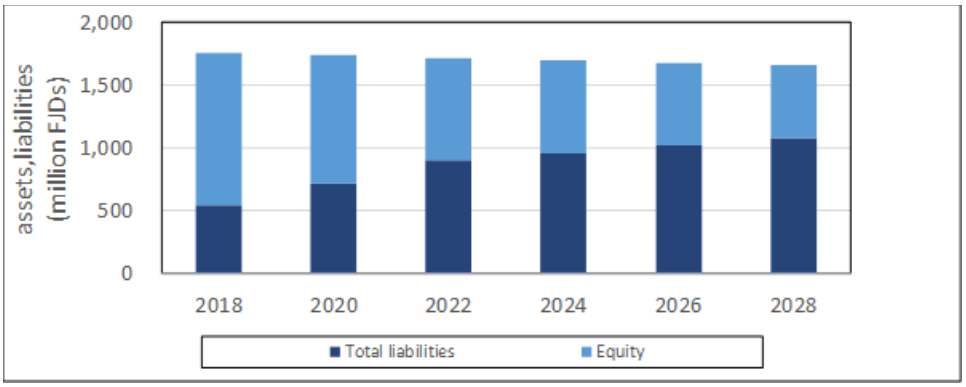


Source: JICA Survey Team

(3) In the case of investing with 70 million FJD from 2023 to 2028

YEAR	2018	2020	2022	2024	2026	2028
①Total liabilities	602	782	962	1,022	1,082	1,142
②Equity	1,157	957	757	677	597	517
③Total assets(①＋②)	1,759	1,739	1,719	1,699	1,679	1,659
Capital-to-asset ratio(②÷③)	65.8%	55.0%	44.0%	39.8%	35.5%	31.2%

Source: JICA Survey Team

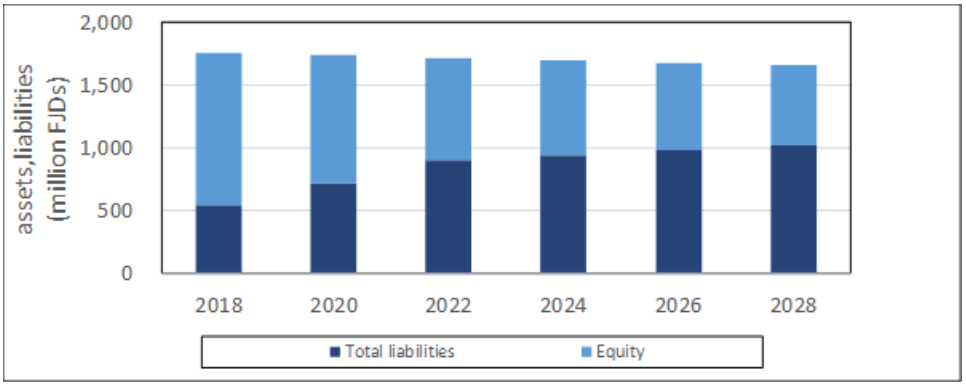


Source: JICA Survey Team

(4) In the case of investing with 55 million FJD from 2023 to 2028

YEAR	2018	2020	2022	2024	2026	2028
①Total liabilities	602	782	962	1,002	1,042	1,082
②Equity	1,157	957	757	697	637	577
③Total assets(①＋②)	1,759	1,739	1,719	1,699	1,679	1,659
Capital-to-asset ratio(②÷③)	65.8%	55.0%	44.0%	41.0%	37.9%	34.8%

Source: JICA Survey Team



Source: JICA Survey Team

2-3-2 Result of Estimation

If WAF continues similar amounts of investment until 2022 and beyond, the capital to asset ratio will be about 10% in 2028. If the investment is reduced to 55 million FJD, the capital to asset ratio will be 34.8%, which is more appropriate.

If current investment levels are to be covered by service charges, the current charges must be increased by a factor of 9.

Allocation required by 2028

= Investment is 220 million FJD case – Investment is 55 million FJD case

= 1,502 – 1,082 = 420 million FJD

Additional fees to be collected yearly = 420 million FJD ÷ 10 years = 42 million FJD/year

420 million FJD ÷ 47 million FJD = 9 (factor for service fee increase)

2-3-3 Investment Amount for Western Region

If the facility construction spending in the Western Region is similar to 2018 (water supply projects: 15%, Wastewater service project: 5%), spending for each sector is calculated as follows.

Water Supply Projects: 55 million FJD×15% = 8.25 million FJD/year

Wastewater Service Projects: 55 million FJD×5% =2.75 million FJD/year

2-3-4 Other Supports

Since current revenues do not cover operation and personnel costs, expansion of operations will only increase the deficit. It is necessary to increase operational efficiency and services charges to improve this deficit.

From the above, the following supports for WAF are deemed necessary.

(Water supply sector)

- Support WAF to set appropriate service charges
- Support WAF to reduce life cycle cost (hereinafter: LCC) by extending life of the facilities

(Wastewater service sector)

- Support WAF to set appropriate service charges
- Support WAF to increase the number of house connections to the wastewater system
- Support WAF to reduce LCC by extending life of the facilities

2-4 Project Procedure

2-4-1 Procedure of Budget Decision

The decision-making procedure for annual operating expenses in WAF is shown in **Figure 2-4.1**. First, WAF decides the necessary budget and submits it to MITDMMS. Then MITDMMS and MOE decide on the budget.

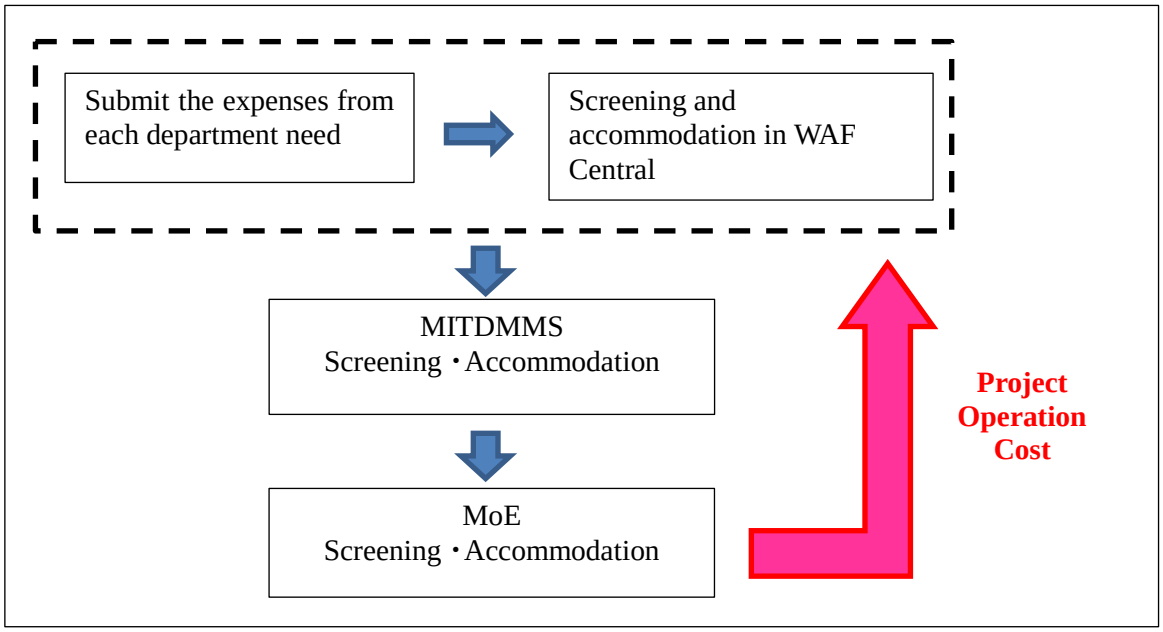


Figure 2-4.1 Procedure for Annual Operation Budget Decision

Source: JICA Survey Team based on Interview of WAF

2-4-2 Decision Making Procedure of Water Charge

It is necessary to obtain the approval of the FCCC when setting water and wastewater service charges. The charges have not changed for 30 years.

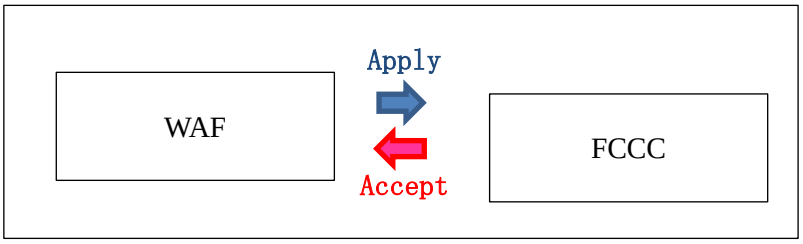


Figure 2-4.2 Decision Procedure of Water and Wastewater Charges

Source: JICA Survey Team based on Interview of WAF

2-4-3 Decision Making Procedure for Donor Support

At WAF, the General Manager Planning Design & Construction is the focal point from foreign developing partners. After discussion with other General Managers in WAF and endorsed by CEO, the proposal is approved by Board Members (Board Members: 5 people, Chairman: 1 person) composed of government agencies and lawyers.

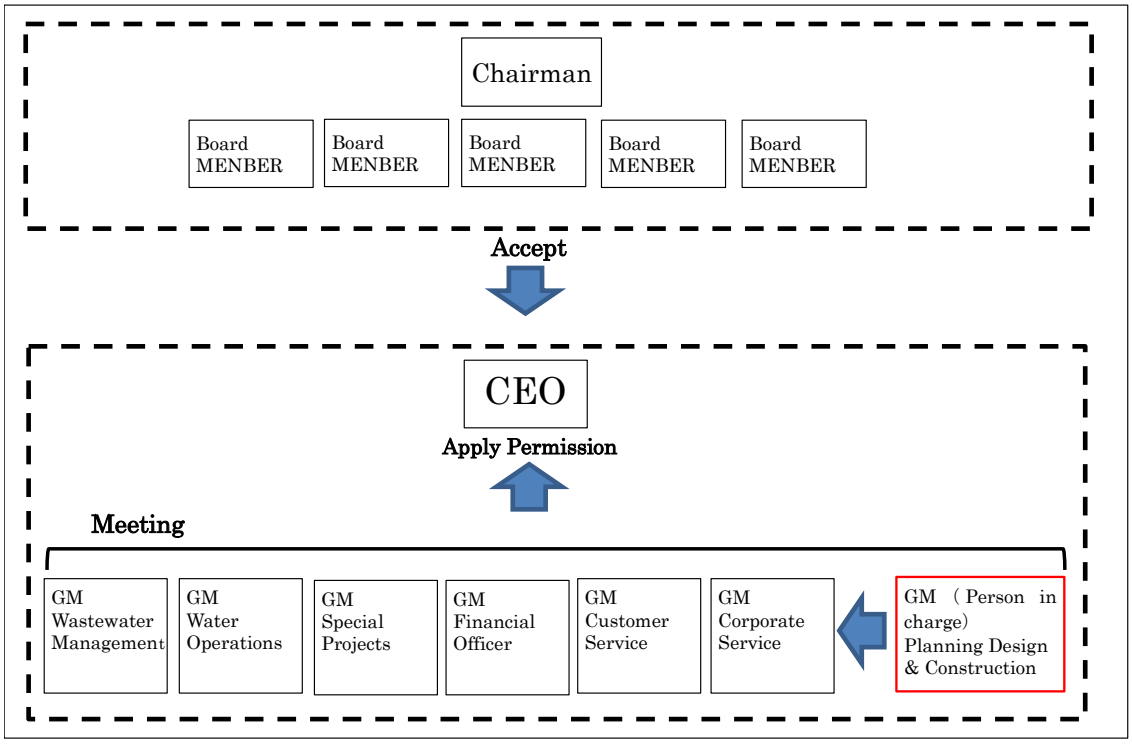


Figure 2-4.3 Decision Making Procedure for Donor Support

Source: JICA Survey Team based on Interview of WAF

After the decision is made within WAF, discussions are conducted with MITDMSS and the MOE, and an official request is made to the donor (for example JICA).

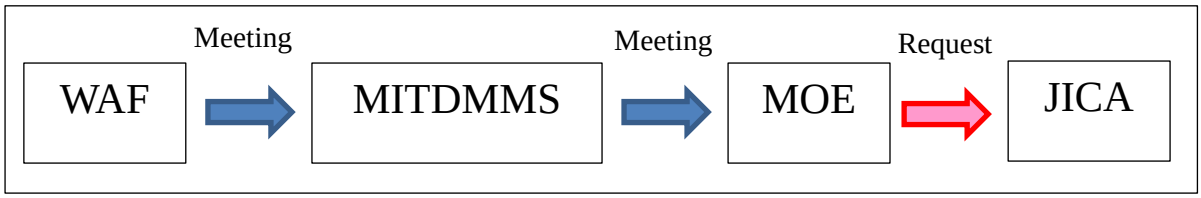


Figure 2-4.4 Meetings Required after Decision-Making

Source: JICA Survey Team based on Interview of WAF

Chapter 3 Current Conditions and Issues in the Water Supply Sector

3-1 Current Condition of the Water Supply System

The Nadi/Lautoka Water Supply System consists of the following systems connected together to supply water to the entire Nadi/Lautoka area.

- Nadi System: Water from Vaturu Dam treated at Nagado WTP
- Lautoka System: Water from Nalau Intake and Buabua Intake treated at Buabua WTP and water from Varaqe Intake treated at Saru WTP

Major facilities of the system are shown in **Table 3-1.1**.

Table 3-1.1 Major Water Supply Facilities of Nadi/Lautoka

Category	Location/No.	Details
Sources	4	Vaturu Dam supplies water to Nagado WTP Buabua and Nalau Intakes supply water to Buabua WTP Varaqe Intake supplies water to Saru WTP
WTP	Nagado WTP Buabua WTP Saru WTP	90ML/D 10ML/D 5ML/D
Service and Clear Water Reservoirs	20 Reservoirs	3 Clear Water Storage 2 Bulk Reservoirs 15 Service Reservoirs
Pumping Stations	1	Momi Pumping station owned by FNPF development
Distribution/Reticulation	1,059 km	Trunk mains and distribution pipes
Water Meters	37,500	Active meter connections

Source: Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033

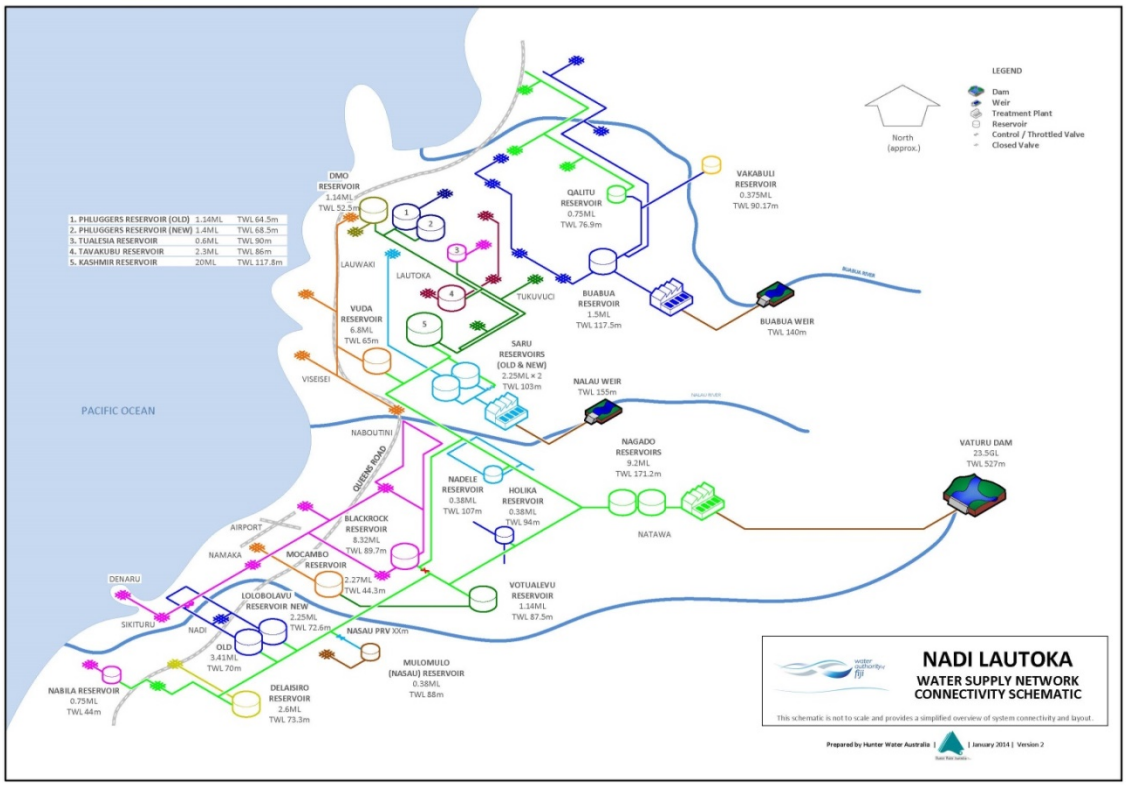


Figure 3-1.1 Outline of Nadi/Lautoka System

Source: Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033

Intake volume, treatment volume, and loss for the Nadi/Lautoka System are shown in the tables below.

Table 3-1.2 Inflow Volumes of Nadi/Lautoka WTPs

WTP	Unit	2014	2015	2016	2017	2018
Nagado WTP	ML/year	33,142	33,826	34,909	35,334	35,018
	ML/day (ave.)	90.8	92.7	95.6	96.8	95.9
Buabua WTP	ML/year	3,349	3,417	3,398	3,581	3,378
	ML/day (ave.)	9.2	9.4	9.3	9.8	9.3
Saru WTP	ML/year	1,872	1,873	1,630	1,538	1,765
	ML/day (ave.)	5.1	5.1	4.5	4.2	4.8

Amount of inflow to the receiving well at the WTP

Source: JICA Survey Team based on Interview of WAF

Table 3-1.3 Treatment Volumes of Nadi/Lautoka WTPs

WTP	Unit	2014	2015	2016	2017	2018
Nagado WTP	ML/year	32,154	32,472	34,324	34,486	33,874
	ML/day (ave.)	88.1	89.0	94.0	94.5	92.8
Buabua WTP	ML/year	3,182	3,196	3,233	3,401	3,261
	ML/day (ave.)	8.7	8.8	8.9	9.3	8.9
Saru WTP	ML/year	1,781	1,744	1,536	1,453	1,669
	ML/day (ave.)	4.9	4.8	4.2	4.0	4.6

Source: JICA Survey Team based on Interview of WAF

Table 3-1.4 Treated Water Loss at Nadi/Lautoka WTPs

WTP	Item	2014	2015	2016	2017	2018	Average
Nagado WTP	ML/year	3%	4%	2%	2%	3%	3%
	ML/day (ave.)	3%	4%	2%	2%	3%	3%
Buabua WTP	ML/year	5%	7%	5%	5%	4%	5%
	ML/day (ave.)	6%	7%	4%	5%	4%	5%
Saru WTP	ML/year	5%	7%	6%	6%	6%	6%
	ML/day (ave.)	4%	6%	7%	5%	4%	5%

Source: JICA Survey Team based on Interview of WAF

3-2 Development Plans for the Water Supply Sector

3-2-1 Outline of Master Plan

3-2-1-1 Water Demand Forecast According to the Master Plan

The Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033 (hereinafter: NLWMP33) was prepared by WAF in 2013 and finalized in 2015. Water demand until 2033 according to the NLWMP33 is shown in **Table 3-2.1**.

Table 3-2.1 Water Demand Projection According to NLWMP33

Description	Units	2013	2018	2023	2028	2033
Total Population	No	169,643	194,366	222,776	244,888	269,179
Population Covered	No	152,272	174,459	203,259	223,407	245,550
Non-revenue Water (NRW)	%	39.51	20	20	20	20
Domestic Consumption	ML/d	38.38	49.91	54.79	60.15	66.05
Commercial Consumption	ML/d	17.99	32.13	36.76	39.19	44.64
Government Consumption	ML/d	1.70	1.94	2.23	2.56	2.95
Total Consumption Avg Day	ML/d	58.07	83.98	93.78	101.91	113.64
Total Consumption Peak Day	ML/d	63.88	92.37	103.15	112.10	125.00
Non-revenue Water (NRW)	ML/d	37.93	20.99	23.44	25.48	28.41
Treatment plant Losses	%	5	5	5	5	5
Water demand for Average day	ML/d	96.00	104.97	117.22	127.38	142.05
Raw Water required from sources on Average day	ML/d	100.8	121.8	131.8	151.8	156.8
Water Demand for peak day	ML/d	102	113	127	138	153
Raw Water Required from sources on peak day	ML/d	106.89	133.98	132.93	144.45	161.08
Average Water Production	ML/d	96.00	118.15	127.85	147.25	152.10

Source: NLWMP33（Scenario 5 NRW 20% by 2018）

Compared to 96.00ML/day in 2013, water demand is expected to be 142.05ML/day in 2033. In order to meet the increased demand, augmentation of water sources and treatment plant capacities are required.

In order to meet the demand, the NLWMP33 outlines projects to be implemented by 2033, in two

packages. Package 1 consists of improvement and optimization of existing facilities. Package 2 consists of augmentation of WTPs and transmission facilities. (**Table 3-2.2**)

Table 3-2.2 Activities of the Water Supply Master Plan

Package 1 Consolidation & Optimization Programme (the improvement and enhancement of the existing system)	①	Replacement & Augmentation of Structurally weak and undersized mains (Replacement of AC pipe)
	②	Air valve Replacement Programme
	③	Installation of Pressure Reducing valves
	④	Water Meter Replacement Programme
	⑤	Water Catchment Management and Conservation
	⑥	Upgrading of Access Roads to Water Intakes
	⑦	De-siltation and Aerator replacement works at Vaturu Dam
	⑧	PPM on Raw water trunk main and fixtures
	⑨	Recommissioning of Mini Hydro-turbine at Vaturu
	⑩	Repair, Maintenance and Replacement of Instrumentation at Vaturu Dam
	⑪	Institutional Development of WAF
	⑫	Conditional Assessment of Water mains in Nadi/Lautoka Region
Package 2 Augmentation Programme (increase the treatment, storage capacity, bulk trunk mains and distribution reticulation to meet the customer demands for the next 20 years)	⑬	Vaturu to Nagado Raw Water trunk main augmentations
	⑭	Augmentations on Potential Water Sources
	⑮	Lautoka Gravity Source Trunk mains
	⑯	Nadi/Lautoka Water Treatment Plant Augmentations
	⑰	Reservoir Augmentations
	⑱	Trunk Main Augmentations
	⑲	Distribution Mains
	⑳	Augmentations for Rehabilitation of SCADA System in Nadi/Lautoka Region

Source: NLWMP33

3-2-1-2 Consolidation and Optimization of Existing Facilities (Package1)

Facilities improvements mentioned in the NLWMP33 include improvements for Vaturu Dam, trunk mains, and existing transmission facilities.

The following improvements are planned for Vaturu Dam and raw water trunk mains:

- Package1-⑥: Repair access road to Vaturu Dam
- Package1-⑦: Dam de-siltation and aerator repair

Repair of access roads, de-siltation, replacement of aerators, re-commissioning of the small hydro-turbines (Package 1-③), and maintenance and repair Vaturu Dam facilities (Package 1-⑩) are mentioned. However, increasing the elevation of the spillways of the dam is not mentioned.

Trunk main improvements are described in Package 1-⑧.

Water treatment and distribution facilities, renewal of existing pipes, air valves, pressure regulators, flowmeters are mentioned in Packages 1-① to 1-④ and 1-⑩.

3-2-1-3 Augmentation of Water Sources, Raw Water Trunk Mains, Water Treatment Plants and Distribution Facilities (Package 2)

Augmentation of water sources, trunk mains, WTPs and transmission/distribution facilities are

planned in the NLWMP33 under Package2-⑬ through 2-⑳.

⑬ Vaturu to Nagado and Lautoka raw water trunk main augmentation works
The transmission capacity of the raw water trunk main will be increased to 130ML/day by eliminating three "critical sections" in the network.

⑭ Augmentations on potential water sources
The possibility of the development of the new water sources listed in **Table 3-2.3** are under consideration for increasing the water sources.

Table 3-2.3 Development of New Water Sources

Potential Water Sources	− Sabeto River − Nawaka River − Namosi River − Vitogo River near Vakabuli − Saru water source- Vuda creek − Teidamu River

Source: NLWMP33

Up to 10ML/day can be taken from Sabeto River. However, difficulties in supplying high-voltage power for pumping water to the Nagado WTP, and water pollution and turbidity caused by mining activities and gravel extraction upstream make development of this source unlikely.

The capacities of the Nawaka River and the Namosi River during the dry season are low, at 3ML/day and 2.5ML/day, respectively. Therefore, construction of dams would be required. As described later in this report, the Namosi River is currently being considered as an alternative to Vaturu Dam in the Votualevu Intake.

The dry season capacity of the Vitogo River and Saru Intake is less than 2.0ML/day. Therefore, development is unlikely.

No specific plans to develop Teidamu River as a water source exist.

⑮ Lautoka Gravity Source Trunk Mains
The transmission line from the Varaqe Intake to the Saru WTP is a single 300mm DI pipe. In case of damage or other emergency situation, repairs would take a long time and significantly impact water supply services. Therefore, installation of duplicate 450mm pipes are planned.

⑯ Nadi/Lautoka Water Treatment Plant Augmentations
Augmentation of the WTP is planned as shown in **Table 3-2.1** and **Table 3-2.2**.

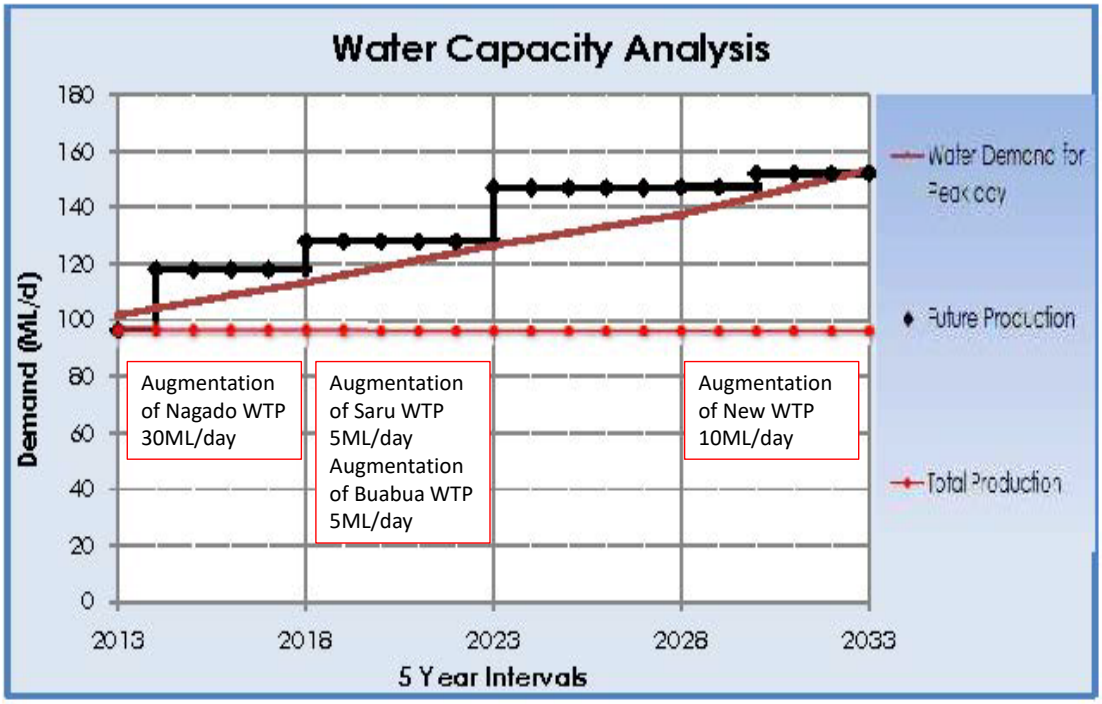


Figure 3-2.1 Augmentation Plan for Nadi/Lautoka WTPs

Source: NLWMP33

The WTP augmentation plan in the M/P is based on the population forecast. In order to meet the day maximum water demand of 153ML/day in 2030, 155ML/day total capacity is planned, as outlined below.

- Nagado WTP: augmentation from 90ML/day to 120ML/day
- Saru WTP: augmentation from 5ML/day to 10ML/day
- Buabua WTP: augmentation from 10ML/day to 15ML/day
- New WTP (Vaturu Dam or Namosi Intake): construction 10ML/day

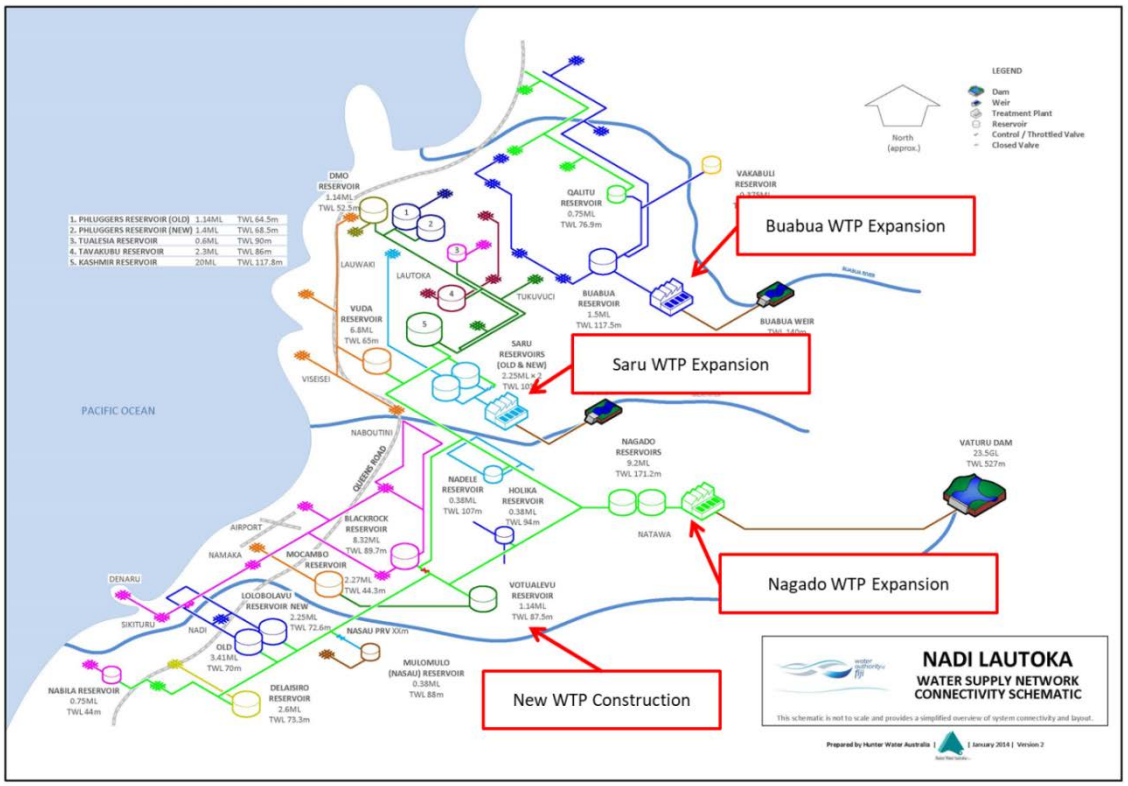
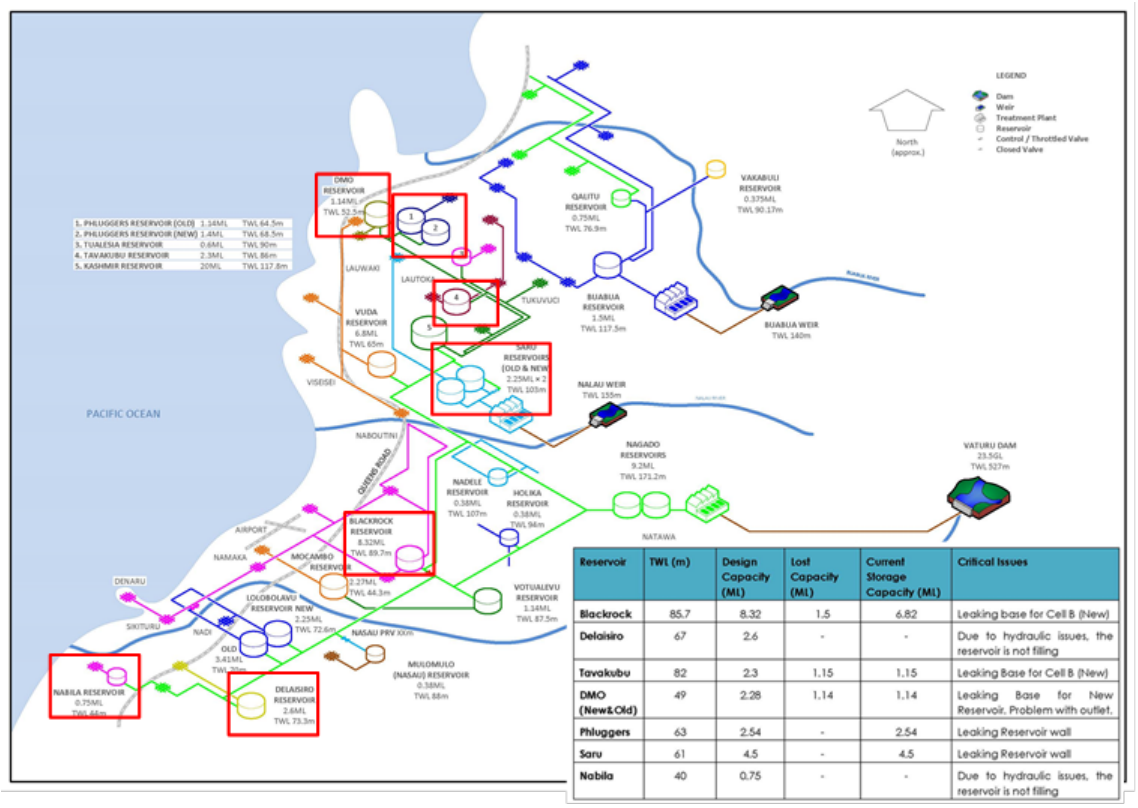


Figure 3-2.2 Augmentation Plan for Nadi/Lautoka WTPs

Source: NLWMP33

⑰ Reservoir Augmentations

For reservoirs, repair of existing reservoirs and construction of new reservoirs are planned. The repair plan is shown in **Figure 3-2.3**, and the construction plan of new reservoir is shown in **Table 3-2.4**.



Reservoir	TWL (m)	Design Capacity (ML)	Lost Capacity (ML)	Current Storage Capacity (ML)	Critical Issues
Blackrock	85.7	8.32	1.5	6.82	Leaking base for Cell B (New)
Delaisiro	67	2.6	-	-	Due to hydraulic issues, the reservoir is not filling
Tavakubu	82	2.3	1.15	1.15	Leaking Base for Cell B (New)
DMO (New&Old)	49	2.28	1.14	1.14	Leaking Base for New Reservoir. Problem with outlet.
Phluggers	63	2.54	-	2.54	Leaking Reservoir wall
Saru	61	4.5	-	4.5	Leaking Reservoir wall
Nabila	40	0.75	-	-	Due to hydraulic issues, the reservoir is not filling

Figure 3-2.3 Repair Plan for Distribution Reservoirs

Source: NLWMP33

Table 3-2.4 Development of New Water Sources

	Contents
Blackrock reservoir	Additional 16.68ML of storage capacity required by the year 2033.
Lolobalavu reservoir	Upgrading of two inlets from 150mm to 200mm and additional 5.2ML storage capacity.
Phluggers reservoir	Upgrading of inlet mains from 150mm to 200mm and additional 3ML of storage capacity for each.
Vakabuli reservoir	Construction of 4.2km of inlet mains and outlet mains to be converted to outlet mains.
Nawaicoba reservoir	Construction of 2 x 6ML reservoirs, pumping station with 3 pumps, 250mm inlet riser main from existing 375mm mPVC at Nawaicoba junction and construction of 300mm outlet mains cross connecting 375mm mPVC along Queens's highway.
Momi reservoir	FNPF needs to recommission

Source: NLWMP33

⑱ Trunk Main Augmentations

Construction of major trunk mains are planned along with the construction of new reservoirs. The maintenance plan of the trunk mains is shown in **Table 3-2.5**. AC indicates asbestos cement pipe, DI indicates ductile iron pipe, CI indicates cast iron pipe, mPVC indicates multi-layer PVC pipe, uPCV indicates unplasticized PVC pipe.

Table 3-2.5 Maintenance Plan for Major Trunk Mains

	Contents
Bulk Supply trunk mains to Nadi reservoirs	Duplication of the existing 7.3km of 500mm DI trunk mains down Holika to Votualevu with 500 mm DICL cross connecting from the existing new 600mm DI trunk mains supplying water from Nagado to Lautoka.
Blackrock Reservoir inlet trunk main	Duplication of existing 3.5km of DN 375 DICL inlet trunk main with DN 375mm DICL mains to Blackrock reservoir from new 600mm DI mains.
Blackrock to Denarau trunk mains	Upgrade existing 12.5km of 375mm mPVC from Blackrock reservoir to Denarau Island with 450mm mPVC mains.
Blackrock to Wailoaloa junction trunk mains	Upgrade existing 300mm 7.1km of AC mains from Blackrock reservoir with 375mm mPVC up to Wailoaloa junction.
Lolobalavu to Wailoaloa junction trunk mains	Upgrade existing 5.34km of Lolobalavu DI outlet mains from 300mm to 450mm mPVC up to Wailoaloa junction.
500mm Bulk Supply trunk mains to Lolobalavu reservoir	Upgrade existing 2.4km of duplicate DI DN 375 trunk mains with DN 500mm DICL mains from Solovi to Lolobalavu reservoir.

Source: NLWMP33

⑲ Distribution Mains

The plan for replacement of major distribution mains with larger diameter pipes is based on the water demand projected in NLWMP33. The replacement plan for major distribution mains is shown in **Table 3-2.6**.

Table 3-2.6 Maintenance Plan for Major Distribution Mains

	Contents
Lautoka Area	1. Upgrade existing 2890.17m of 50mm and 75mm PVC mains to 100mm mPVC mains from King's Road junction to Naviyago Village in Lautoka.
	2. Replace existing 2521.07m of 200mm AC outlet mains from Buabua reservoir to Qalitu reservoir with 250 mm mPVC mains.
	3. Replace existing 2221.7m of 200mm AC outlet mains from Qalitu reservoir to Qalitu Road junction with 250mm mPVC mains.
	4. Upgrade existing 864.07m of 80mm PVC mains to 100mm mPVC mains to Vitogo village.
	5. Upgrade existing 456.8m of 25mm POLY mains branching from 150mm PVC mains to 100mm mPVC at Lovu seaside.
	6. Upgrade existing 1508.43m of 50 and 75mm uPVC to 100mm mPVC at Lovu seaside.
	7. Replace existing 2899.54m of 200mm AC mains with 250mm mPVC along the King's Road from Buabua Road junction past Qalitu road junction.
	8. Upgrade existing 3118.51m of 25mm POLY and 50&75mm PVC to 100mm mPVC mains in Lomolomo after Naisoro subdivision.
	9. Upgrade existing 1575.19m of 50mm and 75mm PVC mains to 100mm mPVC mains in Viseisei village.
	10. Remove throttle control valve from Vuda reservoir and change the 300mm DI outlet to 375mm. Replace existing 2990.7m of 250mm AC main with 375mm mPVC main along Vuda Road up to Vuda Terminal.
	11. Upgrade existing 699.85m of 50mm PVC main to 200mm mPVC at Saphire Bay Resort.
	12. Upgrade existing 2755.33m of undersized 25, 50 and 75mm off takes to 100mm mPVC mains for Vuda Terminal, Anchorage Fiji Resort, First Landing Resort and future tourism development areas in Vuda.
	13. Change existing 200mm cross connection from Vuda outlet main to the existing 250mm AC main to 300mm mPVC. Replace the existing 3097.58m of AC main going towards Saweni with 300mm

	Contents
	mPVC main. Change the throttle control valve to 300mm and setting to 50% open.
	14. Upgrade existing 3798.26m of 100mm uPVC and 200mm PVC to 250mm mPVC from Saweni Road junction to Saweni point.
	15. Replace approx. 10 km of existing 250mm AC main with 300 mPVC from Vuda junction to Lautoka City.
	16. Upgrade existing 2936.13m of 75mm PVC cross connected to existing 250mm AC to 150mm mPVC from Saweni access road junction.
	17. Upgrade existing 2774.76m of 50 and 75mm off takes connected from existing 75mm PVC mains to 100mm mPVC mains in Saweni.
	18. Upgrade existing 480m of 25mm POLY mains to 100mm mPVC main in Saweni tourism development area.
	19. Upgrade existing 8447m of 50mm uPVC mains cross connected to existing 250mm AC main at Lawaki village junction to 100mm mPVC.
Nadi Area	1. Duplicating Delaisiro 200mm outlet mains with the 375mm mains near the Malakua junction along Mate Road and cross connecting it to the existing 375mm mains at the Nawaicoba Road junction near the Denny's shop.
	2. Upgrade existing 4485m of 100mm uPVC main to 200mm mPVC main from the Nawaicoba junction along King's Road to Nacobi road up to Sonaisali Resort.
	3. Upgrade existing 1505.74m of 80mm uPVC mains to 150mm mPVC main along Waireba Road.
	4. Upgrade all 25 and 50mm off takes from 150mm to 100mm mPVC mains along Waireba and Nacobi Road. This would require 7195.48m of 100 mm mPVC mains.
	5. Upgrade existing 2690.83m of 80mm uPVC mains to 150mm mPVC mains in Waireba area.
	6. Upgrade existing 2048.85m of 100mm uPVC mains to 250mm mPVC mains at Hilton and The Cove-Denarau.
	7. Upgrade existing 1473.97m of 200mm uPVC main to 300mm mPVC mains for Radisson, Sheraton and Sunset Resorts.
	8. Upgrade existing 843.7m of 100mm uPVC off takes to 150mm mPVC from 200mm trunk mains for Denarau Residential. Similarly, all the off takes from existing 200mm uPVC mains shall be upgraded to suit the pressure requirements.
	9. Upgrade existing 3500m of 100mm uPVC off takes to 150mm mPVC at Sikituru village, 50&80mm to 100mm mPVC and 80mm uPVC to 150mm mPVC from the 375mm trunk mains to Maqalevu Road.
	10. Upgrade existing 2575.92m of 100mm PVC to 200mm mPVC to Fantasy Island road. Approximately1000m of major 50mm&100mm off takes from existing main shall be upgraded to 150mm mPVC mains.
	11. Upgrade existing 2791.74m of 25mm POLY, 50&80mm uPVC mains to 100mm mPVC at Togo Nawaka and Qaleloa in Lolobalavu supply zone.
	12. Upgrade existing 3430.44m of 25mm POLY and 80mm uPVC to 100mm mPVC from the existing 100mm uPVC along Nasau access road.
	13. Upgrade existing 2200m of 150mm PVC to 200mm mPVC along Wailoaloa road to Golf course. Upgrade all undersized GALV, POLY, uPVC off takes from the existing 150mm PVC to 100mm mPVC and connect it with the new 200mm mPVC main. This would require 1182m of 100mm mPVC main.
	14. Upgrade existing Naisoso 200mm mPVC main to 250mm mPVC by 2028.
	15. Upgrade existing 1000m of 50mm PVC to 100mm mPVC off takes from 150mm PVC mains at Balabala Crescent to Waqadra commercial area.
	16. Upgrade existing 8283m of 25mm POLY, 50mm AC and 80mm uPVC to 100mm mPVC in Votualevu Voivoi area. (intermittent supply area)
	17. Replace existing 2356m of 80mm AC main connected to 100mm PVC at Nasoso junction with 100mm mPVC mains. Similarly, the 25mm POLY, 50mm PVC and Ac off takes from existing 80mm AC should be upgraded to 100mm mPVC mains. This would require 3104m of 100mm mPVC mains.
	18. Upgrade 400m of two 25mm POLY off takes from 150mm PVC main from Nadele reservoir to 100mm mPVC- Sabeto Quarry area.
	19. Upgrade approx. 1000m of existing 25mm POLY and 50mm PVC to 100mm mPVC from 100mm PVC running along Barara flats to Wailoku Settlements.

Source: NLWMP33

⑳ Augmentations for Rehabilitation of SCADA System in Nadi/Lautoka Region
Augmentations for Rehabilitation of SCADA System is shown in **Table 3-2.7**.

Table 3-2.7 Renewal of SCADA System

	Contents
Rehabilitation of SCADA System in Nadi/Lautoka Region	− Rehabilitation of Existing System − Changeover of existing Reservoir instrumentations − Increase SCADA coverage to additional Reservoirs − Setting up Master Stations − Nagado, Buabua and Saru Water Treatment Plant Automation works − Installation of flow Control Valves with Actuators for Reservoirs in Nadi/Lautoka Region (total of 20 Reservoirs in the region)

Source: NLWMP33

3-2-1-4 Progress of the Master Plan

Progress of the NLWMP33 implementation is shown in **Table 3-2.8**.

Table 3-2.8 Current Implementation of the Master Plan

	Description	Progress
Package 1 Consolidation & Optimization Programme	① Replacement & Augmentation of Structurally weak and undersized mains (Replacement of AC pipe)	Ongoing 5% Completed
	② Air valve Replacement Programme	Ongoing 40% Completed
	③ Installation of Pressure Reducing valves	Planning
	④ Water Meter Replacement Programme	Ongoing
	⑤ Water Catchment Management and Conservation	Planning
	⑥ Upgrading of Access Roads to Water Intakes	Not yet
	⑦ De-siltation and Aerator replacement works at Vaturu Dam	Tender Called and Awarded
	⑧ PPM on Raw water trunk main and fixtures	Ongoing
	⑨ Recommissioning of Mini Hydro-turbine at Vaturu	Not yet
	⑩ Repair, Maintenance and Replacement of Instrumentation at Vaturu Dam	Planned for 2019/2020 PSIP
	⑪ Institutional Development of WAF	Not yet
	⑫ Conditional Assessment of Water mains in Nadi/Lautoka Region	Not yet
Package 2 Augmentation Programme	⑬ Vaturu to Nagado Raw Water trunk main Augmentations	Ongoing
	⑭ Lautoka Gravity Source Trunk mains	Ongoing
	⑮ Augmentations on Potential Water Sources	Ongoing
	⑯ Nadi/Lautoka Water Treatment Plant Augmentations	Ongoing
	⑰ Reservoir Augmentations	Ongoing
	⑱ Trunk Main Augmentations	Ongoing
	⑲ Distribution Mains	Ongoing
	⑳ Augmentations for Rehabilitation of SCADA System in Nadi/Lautoka Region	Not yet

Source: JICA Survey Team based on Interview of WAF

Package 1 is implemented in line with the overall budget of WAF. According to hearing survey of WAF staff, about 75% of the renewal of AC pipes, air valve, regulators, flowmeters planned in the NLWMP33 have not been implemented.

Regarding Package 2-⑬ (Improvement of raw water trunk mains), according to the NWMP33,

"carrying capacity will be increased by 20ML/day not later than 2028 through bypassing the critical sections." However, detailed feasibility studies are required. In addition, implementation of the following items is recommended in the "Vaturu to Nagado Trunk main Hydraulic Capacity Assessment" by WAF in 2014 (HunterH2O Ltd. Australia).

- Utilization of idle scour pipes in existing dams
- Reduction of roughness of transmission pipe by washing or lining pipe surfaces (including installation of valve at #1 tunnel)
- Bypass and duplicate piping of the critical sections
- Installation of pumping facilities

Detailed survey for the raw water trunk main improvement started in August 2019 but survey results have not yet been published (to be completed in May, 2020). The survey results will be used to improve the capacity of the mains from 89~92ML/day (dry season) up to 130ML/day. Japanese assistance is being requested for these works.

Regarding Package2: Expansion of WTP and distribution mains, Pre-Feasibility Studies for Package2-⑭～⑮ were subcontracted to HunterH2O Ltd. of Australia. The draft final report is expected to be available in July 2019.

Package2-⑯ Detailed design study for the augmentation of Nagado WTP has been started by Suez Corporation. Contractors for augmentation of Saru WTP and Buabua WTP, and construction of new WTPs are not yet selected.

Package2-⑰ Improvement of distribution reservoirs, construction works for Nawaicoba Reservoir and Lolobalavu Reservoir have been implemented. Improvement works for other reservoirs are currently being planned.

Package2-⑱～⑳ Replacement of distribution pipes and SCADA system are planned to be implemented by WAF.

3-2-2 Three-year Operation Plan (Strategic Plan 2017 – 2019)

WAF made significant progress towards the goals set forth in the Strategic Plan 2014 – 2016, having achieved 91% of them. Still, many challenges remain. To achieve further improvements, WAF has formulated another three-year plan, the Strategic Plan 2017 – 2019. The current conditions of WAF according to the Strategic Plan 2017 – 2019 are shown below.

Issues that need improvements in the Strategic Plan 2017-2019

- Service charges are set with government assistance. Revenues cover only 50% of O&M costs.
- OPEX and CAPEX both rely heavily on government subsidies.
- Residents strongly demand water and wastewater services.
- Customers are spread out over approximately 200 villages on 108 islands.
- High NRW rate (approximately 31.5%)
- There are eight intermittent water supply areas, affecting approximately 1,635 people.
- Frequent natural disasters damage facilities and hinder water supply.
- Electricity costs are as high as 20 million FJD/year.
- Fuel costs for operation of electric generators and pumps are high.
- Highly qualified water supply and wastewater technical staff are lacking.
- Difficulty in meeting environmental and regulation requirements.
- Evaluation in exchange rates when procuring equipment.

- Social cost of adapting to fast-paced cultural and social changes.
- Lack of technical and managerial information.
- SOPs are being prepared.
- Lack of automated equipment.
- Limited funds for dealing with aging facilities.
- High energy cost due to reliance on pumping from rivers.
- Customers are households, businesses, and government agencies.

Source: Strategic Plan 2017 - 2019

The following strategic goals are specified.

Strategic objectives of Strategic Plan 2017-2019

1. Provide stable water to all customers 24/7
2. Efficient planning and project management
3. Provide safe drinking water
4. Provide adequate wastewater system
5. Improve services to non-urban areas
6. Provide efficient and sustainable services
7. Conduct staff training
8. Expand service area
9. Management information system
10. Cooperate with customers and other stakeholders

Source: Strategic Plan 2017 - 2019

A new three-year plan (Strategic Plan 2020 – 2022) was scheduled to be formulated after 2019. However, due to delayed budget allocation by GOF, it was decided to extend the activities of the Strategic Plan 2017 – 2019 until 2020 making it the Strategic Plan 2017 – 2020. Policies of the strategic plan and hearing survey results of the progress, effect indicators, and achievement are shown in **Table 3-2.9**.

Table 3-2.9 Policies, Progress, Effect Indicators and Achievement of Strategic Plan 2017 ~ 2020

Strategic objective 1: Provide consistent water supply 24/7 to all customers			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Continue with pressure management programs.	Ongoing	− Positive customer surveys. (90% of satisfied customers)	Approx. 90%
− Increased automation of key network components.	Ongoing	− Number of intermittent supply areas. (Reduced to zero)	Approx. 41 areas
− Continue implementation of water conservation programs.	Ongoing	− Non-Revenue Water (Reduced to 20%)	Approx. 40 %
− Implement infrastructure development and maintenance works.	Ongoing	− Reduction in demand per capita by 5%	Increased
− Implement SCADA network for Nadi - Lautoka	Not implemented	− TP to be operating above 95% of capacity	Approx. 95 %
− Implement Disaster Risk Preparedness Plan	Completed		
− Implement customer charter	Completed		

Source: Strategic Plan 2017‐2019 and JICA Survey Team based on Interview of WAF

Strategic objective 2: Effective Planning and Project Management			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Strengthen capacity of the Planning and Design unit.	− Ongoing	− Project deliverables of Cost, Schedule and Quality (95% success rate)	− N/A
− Effective management of contracts.	− Completed		
− Construct Master Plans for all major urban centres.	− Ongoing	− Completion of Master Plans for all major urban centres	− N/A
− Review and develop revised project management manual	− Completed	− Capex implementation rate of at least 20% per quarter, reaching to at least 85% by June.	− N/A
− Monitor and control budgets monthly	− Completed	− 100% completion of closure report for all completed projects within 60 days of completion of projects	− Approx. 20%
		− 100% contractual compliance of all projects	− N/A

Source: Strategic Plan 2017‐2019 and JICA Survey Team based on Interview of WAF

Strategic objective 3: Safe Drinking Water Systems			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Improve treatment quality to comply with national and international water standards (WHO).	− Completed	− Test results across all WAF systems samples. (100% compliant)	− Approx. 90%
− Ensure safe storage and transportation of treated water	− Not implemented	− ISO certification by 31st December,2017	− Certified
− Continue ISO certification process application of the National Laboratory by 31st December 2017	− Completed		
− Review of Water Safety Plan	− Completed		
− All urban water treatment plants to be upgraded to proper treatment levels	− Ongoing		

Source: Strategic Plan 2017 – 2019 and JICA Survey Team based on Interview of WAF

Strategic objective 4: Adequate Sanitation Systems			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Implement Trade waste policy.	− Completed	− Customer complaints on wastewater overflows and odours. (20% reduction)	− Not achieved
− Construct wastewater models for all major urban centres	− Not implemented		
− Upgrade all major wastewater TP	− Planning	− Completion of wastewater models for all major wastewater systems	− Almost completed
− Continue desludge and odour control program	− Ongoing	− Compliance to service permit conditions	− Not achieved
		− Reduce Biological Oxygen Demand (BOD) affluent level by 10mg/l on all major WWTP	− Not achieved
		− Reduction of sludge by 50%	− N/A

Source: Strategic Plan 2017 – 2019 and JICA Survey Team based on Interview of WAF

Strategic objective 5: Improve Rural Services			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Implementation and completion of schemes as per budget as per financial year.	− Completed	− Positive Customer Surveys. (90% of satisfied customers)	− Not achieved
− Progressively implement cost effective water treatment systems.	− Completed (EPS)	− Complaints referrals from government. (20% reduction)	− Not achieved
− Complete survey requests	− Completed	− Survey requests and estimates completed within 30 days of receiving application	− Achieved
− Full implementation of awareness on Rural Water and Sanitation Policy	− Completed	− Completion of all scheme projects by June 30	− N/A
		− 30% increase in registration of Water Committees	− Not achieved
		− 100% completion of closure reports after 60 days of completion of projects	− N/A
		− 100% attendance in all tikina council meetings	− 100%

Source: Strategic Plan 2017 – 2019 and JICA Survey Team based on Interview of WAF

Strategic objective 6: Sustainable and Efficient Service Delivery			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Enhance Customer Service through implementation of customer charter.	− Completed	− Collection rate of 95% = Collection / Net Invoices	− Not achieved
− Implement customer awareness programs annually	− Completed	− Manage monthly cash flow to ensure all statutory payments are made on due dates with no late penalties.	− 100%
− Maintain Statutory Compliance.	− Completed		
− Tariff Review.	− Completed		
− Develop Business Continuity Plan (BCP)	− Not implemented	− Service level at call centre achieved (80/20) (80% of calls answered in 20 seconds)	− Not achieved
− Implement Enterprise Risk Management (ERM)	− Completed	− Complaints resolution (100% within 72 hours)	− Not achieved
− OHS Review	− Ongoing	− 100% Hazard rectification	− Not achieved
		− OHS compliance (Zero Accidents)	− Not achieved
− Develop and Implement outsourcing plan	− Completed −	− Operate within budget	− N/A
− Driving a positive cultural change	− Completed	− Business Continuity Plan (BCP) to be endorsed by Board by December,2017	− N/A
− Implement Asset Management	− Ongoing		
− Complete Reorganization	− Ongoing	− Workforce plan completed by Quarter 1,2018	− N/A
		− Employee Evaluation on Organization Culture	− N/A

Source: Strategic Plan 2017‐2019 and JICA Survey Team based on Interview of WAF

Strategic objective 7: Building Personnel Capacity			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Implement Capacity Building programs.	− Completed	− Positive Employee job satisfaction surveys. (90% of satisfied employees)	− Not achieved
− Implement Performance Management Systems (PMS)	− Ongoing	− Staff Training Days ratio (5 Training days /per staff per year)	− Not achieved
− Measure competency gaps	− Ongoing		
− Implement staff succession planning	− Ongoing	− 0.75 TRD	− N/A
− Implementation of apprenticeship scheme	− Not implemented	− Minimal staff turnover. (7% or less)	− N/A
− Implement Staff Job Rotation	− Ongoing	− Implement PMS by Quarter 2,2017	− N/A
− Implement staff retention strategy	− Ongoing	− 95% grant claimed	− N/A

Source: Strategic Plan 2017‐2019 and JICA Survey Team based on Interview of WAF

Strategic objective 8: Increase Services Coverage			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Implement Infrastructure development as per master plan recommendations to increase reticulation network coverage.	− Ongoing	− Increase connection to reticulated water and wastewater systems	− Achieved
		− Urban Water by 2%	− Achieved
− Continued collaboration between WAF and other stakeholders	− Completed	− Urban Wastewater by 6%	− Achieved
− Continue with augmentation work	− Ongoing		
− Service Coverage extension criteria sample is detailed in Appendix 15	− Ongoing		

Source: Strategic Plan 2017 - 2019 and JICA Survey Team based on Interview of WAF

Strategic objective 9: Management Information Systems			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Establish Information Centre (IC)	− Not implemented	− Information Centre (IC) up and running by Quarter 3,2017	− N/A
− Data warehousing	− Not implemented		
− Establish data governance framework	− Not implemented		
− Conduct customer satisfaction survey on ease of access	− Ongoing		

Strategic objective 10: Establish Effective Communication with Customers and Stakeholders			
Key Action items	Key Action items (Progress)	Key Result indicator	Present Status (Progress)
− Develop communication strategy	− Completed	− Positive Customer Surveys. (90% of satisfied customers)	− Approx. 90%
− Conduct customer satisfaction survey	− Ongoing	− Complaints referrals from government. (20% reduction)	− N/A

Source: Strategic Plan 2017 - 2019 and JICA Survey Team based on Interview of WAF

The results above show that with the exception of increasing the number of connections, most of the goals have not been achieved. This is because facility and response capacity of WAF have not been able to keep up with the rapidly increasing number of users and billing work, perhaps due to lack of budget allocation.

Major projects implemented in the last five years in the Nadi/Lautoka area, including items from the water sector three year plan 2017-2019, are shown in **Table 3-2.10**.

Table 3-2.10 Major Projects Implemented in the Last 5 years

Item	Project Description	Project Benefit	Year Completed	Project Budget (FJD)	Consultant /Contractor
1.	Duplication of existing DN 700 raw water trunk mains at Vaturu Dam with 1200mm MSCL interconnection to scour Pipe	Improvement in trunk mains hydraulic capacity	2014	$900,000.00	HunterH2O Australia
2	Augmentation and Refurbishment of Nagado WTP	Improvement in treatment plant capacity	2013-2014	$6,700,000.00	Fletcher Construction Fiji Ltd
3	Air valve installation works to overcome air lock issues and improve hydraulic capacity of the trunk and distribution mains	Improvement in pipeline hydraulic capacity and overcome air lock issues	2015-2016	$500,000.00	In-house project
4	Upgrading of existing DN 200 mPVC mains from Malakua junction to Denny's Shop with DN 375 mPVC trunk mains	Improvement in hydraulic capacity and supply towards Southern end of Nadi	2016-2016	$2,931,393.70	China Railway First Group [Fiji] Ltd - CRFG
5	Upgrading of duplicate DN 375 DI trunk mains from Solovi chamber to Lolobalavu reservoir with DN 500 DICL trunk mains	Improvement in hydraulic capacity and supply towards Southern end of Nadi	2016-2017	$996,587.91	China Railway First Group [Fiji] Ltd - CRFG
6	Upgrading of existing DN 500 DI line to line with DN 600 DICL trunk mains from Nadele to Votualevu Rice mill junction	Improvement in hydraulic capacity and supply towards Southern end of Nadi	2017-2018	$9,127,775.84	China Railway First Group [Fiji] Ltd - CRFG
7	Duplication of existing DN 700 DI outlet trunk mains into the Vaturu Dam 1st tunnel with 1200mm MSCL	Improvement in raw water trunk mains hydraulic capacity and supply to Nagado WTP	2017-2018	$205,727.84	HunterH2O Australia
8	Upgrading of existing 300mm trunk mains in Vatulaulau with 450mm mPVC trunk mains	Improvement in hydraulic capacity and supply to the customers in Ba area	2017-2018	$385,218.44	China Railway First Group [Fiji] Ltd - CRFG

Source: JICA Survey Team based on Interview of WAF

Of the major projects implemented in the last five years, those with the highest priorities in the NLWMP33 were improvement of a section of the raw water trunk main from Vaturu Dam to Nagado WTP (2017 – 2018), replacement of major distribution lines, and renewal of air valves.

In the three-year business plan, NLWMP33 plans to improve the existing facilities of Package 1 and augment the WTP and transmission/distribution facilities of Package 2. However, projects of highest priority are selected and those with lower priorities are postponed to the next plan. At present, sufficient budget has not been allocated and projects have not been implemented sufficiently.

3-2-3 Three-year Operation Plan (Strategic Plan 2021 - 2023)

The newest three-year plan (Strategic Plan 2021-2023) underwent budget deliberation in June

2020 and is expected to be published by July 2020. Tentative plans for the water sector are shown in **Table 3-2.11**, **Table 3-2.12** and **Table 3-2.13**.

Table 3-2.11 Plans for Intake Facilities

Implementation of New Water Source				
Item No.	Project Description	Project Benefit	Completion Year	Project Costs (FJD)
1	Implementation of Teidamu/Vitogo Water Source with pump station	Not listed	Not listed	$8,000,000.00
2	Rehabilitation of Vaturu Pumping station	Not listed	Not listed	$4,000,000.00

Source: JICA Survey Team based on Interview of WAF

Table 3-2.12 Plans for Water Treatment Facilities

Water Treatment Plant Upgrades				
Item No.	Project Description	Project Benefit	Completion Year	Project Costs (FJD)
1	Upgrading of Nagado WTP capacity by additional 20ML/D treatment	Improvement in current treatment capacity and meet the water demand for the next 10-15 years	2018-2022	$20,000,000.00
2	Upgrading of Matovo WTP plant capacity from 16ML/D to 30ML/D	Improvement in treatment plant capacity and cater demands for the next 10-15 years	2018-2022	$15,000,000.00
3	Upgrading of Vatukoula treatment from 5.5ML/D to 10ML/D	Improvement in treatment plant capacity and cater demands for the next 10-15 years	2019-2022	$7,000,000.00
4	Upgrading of Waiwai WTP capacity	Improvement in treatment plant capacity and cater demands for the next 10-15 years	2018-2020	$10,000,000.00
5	Upgrading of Bitutaralagi WTP capacity from 5ML/D to 10ML/D	Improvement in treatment plant capacity and cater demands for the next 10-15 years	2019-2021	$7,000,000.00

Source: JICA Survey Team based on Interview of WAF

Table 3-2.13 Plans for Transmission/Distribution Facilities

Pipeline Upgrades				
Item No.	Project Description	Project Benefit	Completion Year	Project Costs (FJD)
1	Upgrading of existing DN 500 and DN 375 trunk mains from Votualevu to Malawai-Nadi River	Improvement in hydraulic capacity and supply towards Southern end of Nadi	2018-2019	$2,400,00
2	Replacement and upgrading of existing fragile DN 375 mPVC outlet from Lawai reservoir to Sigatoka town	Overcome frequent bursts mains issues on the trunk mains and improvement in hydraulic capacity	2018-2019	$2,112,000.00
3	Replacement and upgrading of DN 300 outlet trunk mains from Varaqe dam	Improvement in hydraulic capacity and overcome frequent collapsing of trunk mains	2018-2020	$3,920,000.00
4	Upgrading of Varaciva dam outlet trunk mains	Overcome trunk mains failure during heavy flooding	2018-2019	$500,000.00
5	Repair of leaking 711mm tee along	Overcome risks of failure of	2018-2019	$450,000.00

Pipeline Upgrades				
Item No.	Project Description	Project Benefit	Completion Year	Project Costs (FJD)
	Vaturu Nagado raw water trunk mains	existing 711mm MSCL trunk mains and disruption in water supply to Nadi/Lautoka Region		
6	Procurement of DN 450 Polyjet valves for Nagado WTP	Overcome risks of failure existing 2 x Polyjet valves and disruption in water supply to Nadi/Lautoka Region	2018	$1,800,000.00
7	Procurement of DN 500 Vanessa valves for Nagado WTP	To replace the existing defective Vanessa valve and for standby purposes	2018	$180,000.00
8	Augmentations for recommissioning of Lawai new reservoir	To replace the existing new reservoir with collapsed roof and utilized the old concrete reservoir	2018-2019	$250,000.00
9	Feasibility Studies and De-silting of Vaturu Dam	To remove excessive silt build-up from dam bed, improve dam water quality and build additional storage capacity	2018-2021	$8,000,000.00
10	Replacement of Vaturu Dam Aerator	For de-stratification and improve dam water quality	2018-2019	$1,000,000.00
11	Implementation of Nawaicoba system-Booster pumps	For improvement in storage capacity and improvement in water supply to southern end of Nadi	2018-2020	$1,500,000.00
12	Duplicate DN 375 DI inlet trunk main to Blackrock reservoir from new 600mm DI mains	Improvement in hydraulic capacity and flow to Blackrock reservoir	2019-2021	$2,485,305.52
13	Upgrade 300mm mains from Blackrock reservoir to Wailoaloa Junction with 375mm mPVC mains	Improvement in hydraulic capacity and pressures to customers in Namaka & Martintar areas	20219-2021	$5,000,000.00
14	Upgrade existing 375mm to 450mm from Blackrock to Denarau	Improvement in Hydraulic capacity and supply to Denarau and other customers	2018-2020	$4,112,435.13
15	Replace 250 AC mains and 300mm Vuda reservoir outlet to 375mm mPVC up to Vuda terminal	Improvement in hydraulic capacity and supply to the customers	2019-2021	$1,220,205.60
16	Replace 250mm AC mains to 300mm mPVC from Vuda junction to Saweni junction	Improvement in hydraulic capacity and supply to the customers	2019-2021	$1,022,201.40
17	Replace existing 250 AC mains with 300 MPVC from Vuda junction to Lautoka City	Improvement in hydraulic capacity and supply to the customers	2019-2021	$3,300,000.00
18	Construction new 2ML reservoir at Naikabula	Improvement in storage capacity and ensure 24/7 supply to customers	2018-2019	$2,000,000.00
19	Construction of new 6ML reservoir at Nawaicoba	Improvement in storage capacity and supply towards southern end of Nadi	2018-2019	$6,400,000.00
20	Implementation of 1ML reservoir at Nadi Hospital	Have contingency and dedicated supply to hospitals in terms of any disruption	2019-2020	$1,000,000.00
21	Implementation of 1ML reservoir at	Have contingency and	2019-2020	$1,000,000.00

Pipeline Upgrades				
Item No.	Project Description	Project Benefit	Completion Year	Project Costs (FJD)
	Lautoka Hospital	dedicated supply to hospitals in terms of any disruption		
22	Upgrading of Phlugger reservoir capacity by additional 6ML	Improvement in storage capacity and ensure 24/7 supply to customers	2019-2021	$3,200,000.00
23	Upgrading of Lolobalavu reservoir capacity by 5.2ML	Improvement in storage capacity and ensure 24/7 supply to customers	2019-2021	$5,000,000.00
24	Upgrading of Blackrock reservoir capacity by 17ML	Improvement in storage capacity and ensure 24/7 supply to customers	2019-2021	$8,000,000.00
25	Renovation of leaking reservoirs	Improvement in storage capacity and ensure 24/7 supply to customers	2018-2022	$7,500,000.00

Source: JICA Survey Team based on Interview of WAF

3-2-4 Issues with Operational Plan

3-2-4-1 Financial Issues

Collected revenues are deposited into the national treasury. WAF applies for the necessary operational funds, and funds are provided as subsidies from the national treasury. Therefore, the financial framework is limited by government restrictions. Service charges are set at low levels and are insufficient to cover O&M costs.

3-2-4-2 Water Source Development

The new operational plan, water source development plan, and WTP augmentation plan proposed in NLWMP33 are slightly delayed. It is true that development of new water resources is difficult, but another significant reason for the delay is the lack of sufficient budget for implementation.

3-2-4-3 Deviation between the Water Demand Plan and the Current Situation

Reducing NRW rate to 20% by 2018 was one of the targets of the Water Demand Plan (**Table 3-2.1**). This has not been achieved. If NRW conditions are not improved, water demand will significantly exceed production, and measures such as water curtailment will be required. Therefore, reduction of NRW is an important issue with high urgency.

3-3 Water Supply Facilities Current Conditions and Issues

3-3-1 Water Source, Intake, and Transmission Facilities

3-3-1-1 Vaturu Dam and Trunk Mains

3-3-1-1-1 Water Resources (the Vaturu Dam)

The purpose of the Vaturu Dam is only to supply water, and the existing dam body and spillway do not have flood control function. Specifications of the Vaturu Dam are as shown in **Table 3-3.1**.

Table 3-3.1 Specification of the Current Vaturu Dam

Dam body	
Type of dam	Clay core rock fill dam
Elevation of dam crest	532 m
Full Supply Level	527 m
Storage capacity	23.5 million m^3
Design capacity for water supply	98ML/D
Dam height	54 m
Width of dam crest	10 m
Length of dam crest	297 m
Slope gradient	Upstream side 3H:1V, Downstream side 2H:1V
Dam core	5m thickness, gradient 0.25H:1V
Filter	1.5 m in thickness for both fine and coarse filters
Spillway	
Type of spillway	Mass concrete, free fall weir
Elevation of the crest	527 m
Length	130 m
Other facilities	
Intakes	Three intakes @ 513m, 506 m, 500 m and scour pipe @ 493 m

Source: JICA Survey Team

WAF had implemented studies on the Vaturu Dam, particularly on raising the spillway, by outsourcing. Maunsell Ltd., a New Zealand company, implemented hydrological study, run-off analysis, yield analysis and reservoir optimization assessment, including examination of spillway raising and rough estimation of construction cost from 2004 to 2005. GHD, an Australian company, implemented the Vaturu Dam safety study and feasibility study from 2014 to 2016 based on reviewing of the study report by Maunsell Ltd.

The previous master plan projected the water demand in 2016 to be 86ML/day, and it was considered that the capacities of the water supply facilities would be sufficient for the water demand in Lautoka and Nadi area. Therefore, no project execution plan has been developed. Also, there was concern about opposition against the dam raising by the community located just downstream of the Vaturu Dam.

Vaturu dam has three intakes at elevations of 500.00 m, 506.25 m, and 513.00 m. However, water pressure is very low and only two intakes are used due to concerns about pipe rupture and leakage due to the aging facilities, which were constructed 36 years ago. There is no electricity at the dam site. There are three staffs / technicians on duty, but one of the staff positions was vacant as of 2019. Mini-hydro turbines have been installed at the Vaturu/Nagado raw water trunk mains and the Nagado WTP. Utilization of mini-hydro turbines is planned in NLWMP33 as one of the programs in Package 1, “Consolidation and Optimization Programme”. However, the turbine sections are bypassed in order to secure an adequate amount of raw water for the Nagado WTP because the energy loss at the turbine sections is high. As mentioned above, no operation and maintenance of the dam and the spillway are needed since its structure is designed as a free fall weir.

Overflow of the surplus water from the spill way　　2nd tunnel of the trunk main

Figure 3-3.1　Present Conditions of the Spillway and the Raw Water Trunk Main

Source: JICA Survey Team

3-3-1-1-2 Precipitation and Storage Water Level

Past precipitation at the Vaturu Dam is as shown in **Figure 3-3.2**. Slight increase in rainfall is observed from 1977 to 2018. Since 2012, rainfall data and water storage level data at the Vaturu Dam have been managed by WAF. Rainfall data of 2010 are not shown since the data from October to December are missing and the resulting yearly rainfall is very small. Also, the data from May to December 2012 are missing. However, monthly rainfall of January to April in 2012 was high, between 800 to 1200 mm, and therefore shown in the graph.

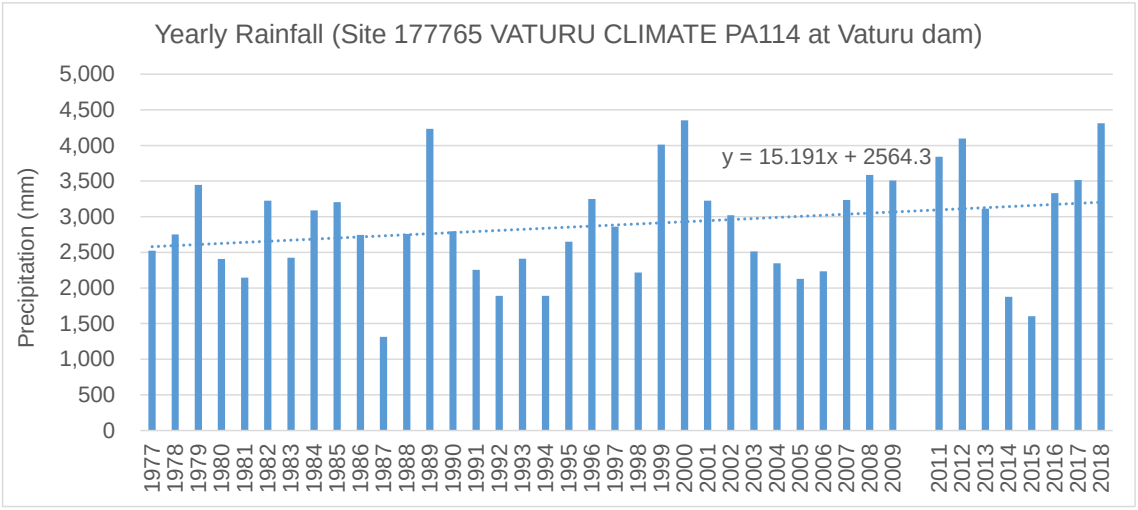


Figure 3-3.2　Past Precipitation at The Vaturu Dam

Source: JICA Survey Team made the graph using the daily rainfall data obtained from the FMS and WAF

As mentioned in the JICA Climate Finance Impact Tool (JICA Climate-FIT (adaptation)) changes in frequency of drought need to be checked in order to show the linkage between climate change and the climate trends in Fiji. Moreover, changes in meteorological data, such as frequency and intensity of cyclone, temperature, evapotranspiration and so on, must be checked in the future detailed survey. On the other hand, it is considered that the sea level rise due to the climate change will not have a strong impact on the spillway raising of the Vaturu Dam, which is located in the mountains (elevation of the spillway crest is 527 m above mean sea level), and the Nagado WTP is located approximately 171m above sea level.

3-3-1-1-3 Vaturu Dam Water Level

Figure 3-3.3 shows the Vaturu Dam water level from 1986 to July 2019. The water level drops almost 6 to 10 meters from the full supply level (527m) until the rainy season starts, even though it remains above the intakes (513m, 506m and 500m). Every year the water level recovers to the full supply level rapidly once the rainy season starts and it is basically filled up during the rainy season.

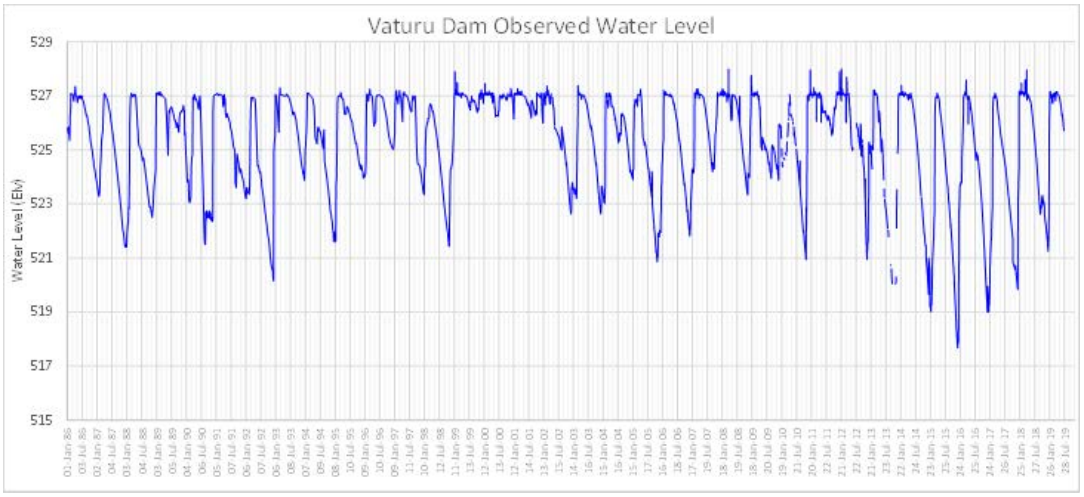


Figure 3-3.3 Observed Water Level at the Vaturu Dam

Source: JICA Survey Team made the graph using the obtained data from WAF

3-3-1-1-4 Sedimentation and De-Siltation of the Vaturu Dam Lake

There are four aerators (one aerator will be installed in July 2019) in the Vaturu dam lake. High concentration of iron and manganese, which are considered to be absorbed in the sedimentation/silt, and clogging of the intake filter due to high algae growth are the major issues at the lake. De-siltation of the lake and replacement of the aerators are some of the contents of "Package 1 - Consolidation and Optimization Programme". As of August, 2019, WAF has been examining options for de-siltation and plans to outsource feasibility study on available measures.

WAF is considering De-siltation of the dam and outsourcing of a feasibility study including de-siltation method was planned for August 2019. As of January 2020, they are waiting to finalize the contract.

3-3-1-2 Other Water Resources

WAF has been examining the possibility of new development of the water resources shown in the **Table 3-3.2**.

Table 3-3.2 Development of New Water Resource

Potential Water Sources [Estimated cost for the development]	Sabeto River [FJD 10,194,262] Nawaka River [No detailed plan] Namosi River [FJD 39,930,000] Vitogo River near Vakabuli [FJD 4,669,500] Saru water source- Vuda creek [FJD 1,285,900] Teidamu River [No detailed plan]

Source: NLWMP33

It is estimated that approximately 10ML/day of water can be taken from the Sabeto River. However, major concerns are; securing a high-voltage power supply for pumping facility in order to supply the water to the Nagado WTP; and the contamination of raw water due to the mining industry and river gravel extraction in upstream of the planned intake. Therefore, the possibility of water resources development is low. Available intakes during dry season are estimated at approximately 3ML/day for Nawaka River and 2.5ML/day for the Namosi River. Due to the low flow, dams/reservoirs upstream of the planned intake would be required. A survey on water resource development, especially for Votualevu, along the Namosi River, was implemented by WAF, as discussed below. This water resource might be one of the alternatives to the Vaturu Dam raising. The possibilities of new water resources development at the Vitogo River and the Saru water source, which are located downstream of Buabua and Nalau, are also low since the available intake during the dry season is estimated to be less than 2.0ML/day, same as that of the Nawaka and Namosi Rivers.

As for the Teidamu River, no detailed survey / examination has been conducted, as mentioned in **Figure 3-3.4**. Teidamu is located approximately 4 km from Kings Road and 9.6 km from Buabua WTP. It is the observation site for flow measurement, and its elevation is 42.5 m. The plan is to pump the river water from the proposed location of Teidamu to the Buabua WTP. Drasa and another site located upstream of Teidamu, are also considered as candidate sites. Available intake is estimated approximately 10ML/day based on past (from 1978 to 2006) flow measurement, but no development plans have been made.

Candidate sites of water resources

Candidate site of pumping from the river (Teidamu)

Candidate site of pumping from the river (Drasa)

Candidate site of pumping from the river (Upstream of Drasa)

Figure 3-3.4 Present Situation of Teidamu (Candidate Site of New Water Resource)

A new water resource in Votualevu is located at the confluence of the Nadi River and the Namosi River, approximately 25 km from the river mouth of the Nadi River. Water will be taken from the

river and new WTP will be constructed nearby. The available intake is estimated to be 40ML/day (3ML/day in the dry season).

During the dry season, water from Vaturu Dam will need to be manually discharged to Nadi River. Water availability in Nadi River will depend heavily on the amount of water released from Vaturu Dam. Further hydrological and hydraulic investigations need to be assessed whether this is a viable alternative.

If a WTP is constructed at Votualevu, the distribution pipes will be connected to the distribution pipes of Nagado WTP.

Confluence point of the Nadi River and the Namosi River

Candidate site of pumping from the river (Downstream of the confluence point)

Figure 3-3.5 Present Situation of Votualevu (Candidate Site of New Water Resource)

3-3-2 Water treatment facilities

3-3-2-1 Nagado WTP (Nadi)

The Nagado WTP is located in the western region of Nadi. It started operation in 1982 with a capacity of 45ML/day. It was expanded to 90ML/day in 2003 to meet the demand in Nadi/Lautoka.

Raw water is carried through gravity mains from Vaturu Dam to the WTP. Treatment is accomplished through inclined plate settler and rapid gravity filtration. A flocculation basin was added in 2014 to deal with high turbidity during the rainy season and prevent floc overflow into the filter.

Treated water from Nagado WTP is supplied to reservoirs of Nadi WTP and Sar WTP, and distributed to the Nadi/Lautoka area.

In 2014, a flocculation basin was added, and capacity of the sedimentation basin was increased to 104ML/day. However, intake capacity remains at 90ML/day, so production capacity has not increased. However, the installation of the flocculation basin has reduced treatment loads of the sedimentation basin and filter, leading to water quality improvement.

Major facilities, hydraulic profile, and facility conditions of the WTP are shown below.

Table 3-3.3 Projects in the Water Supply Master Plan Major Facilities of Nagado WTP

Item	Description
Commissioned	1982, 2003
Capacity	45ML/day (1982), 90ML/day (2003), 104ML/day (2014: Flocculation tank only)
Major facilities	Receiving well/Mixing tank: RC (1 tank, (1982)) Flocculation Tank: RC (2 tanks, horizontal flow) (2014) Cross-flow settling basin: RC (6 basins, (1982)), (6 basins (2003)) Rapid gravity filter: RC (6 filters, (1982)), (6 filters (2003)) Chemical dosing facility: dosing pumps Coagulant: Alum, polymer (imported from China) pH regulator: caustic soda, lime (imported from China) Chlorine: Chlorine gas (imported from Australia) Clear water tank: RC (6.2ML (1982)), (3ML (2003)) Backwash water tank: RC (1 tank, (1982)), (1 tank (2003)) Lagoon: (2 lagoons)
Treatment process	Incline plane sedimentation＋Rapid gravity filer ＋Chlorine treatment
Water source	Vaturu Dam
Raw water quality	Turbidity(3NTU), Alkalinity(9.9mg/L), pH (6.95), Manganese(0.11mg/L)
Treated water quality	Turbidity(0.8NTU), Alkalinity(18.7mg/L), pH (7.2), Manganese(<0.02mg/L)

Source: JICA Survey Team based on Interview of WAF

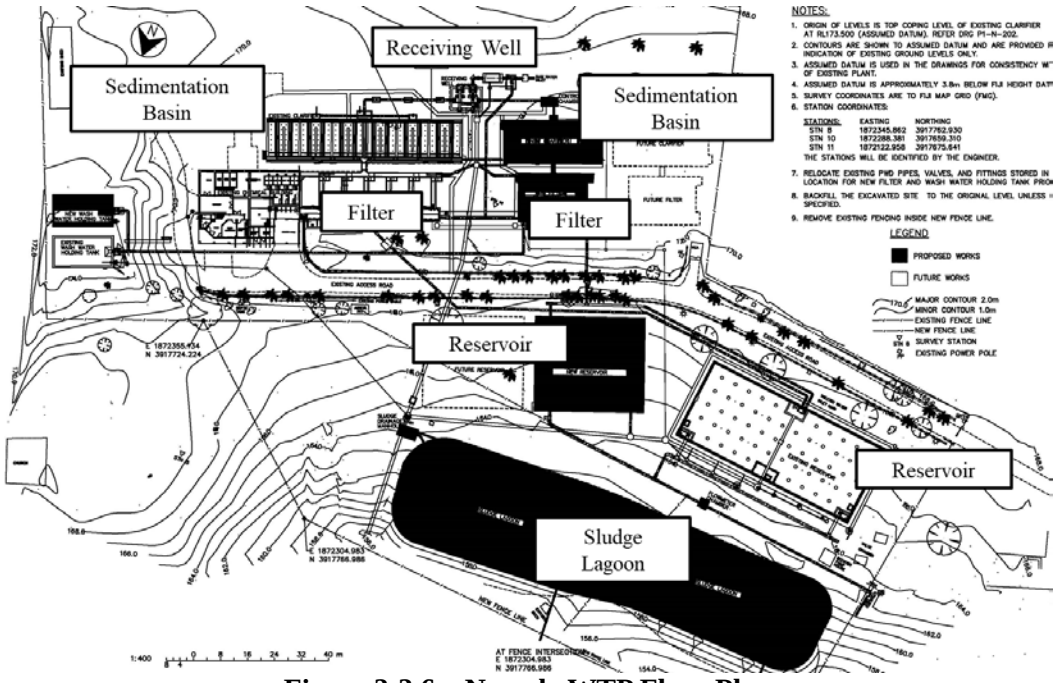


Figure 3-3.6 Nagado WTP Floor Plan

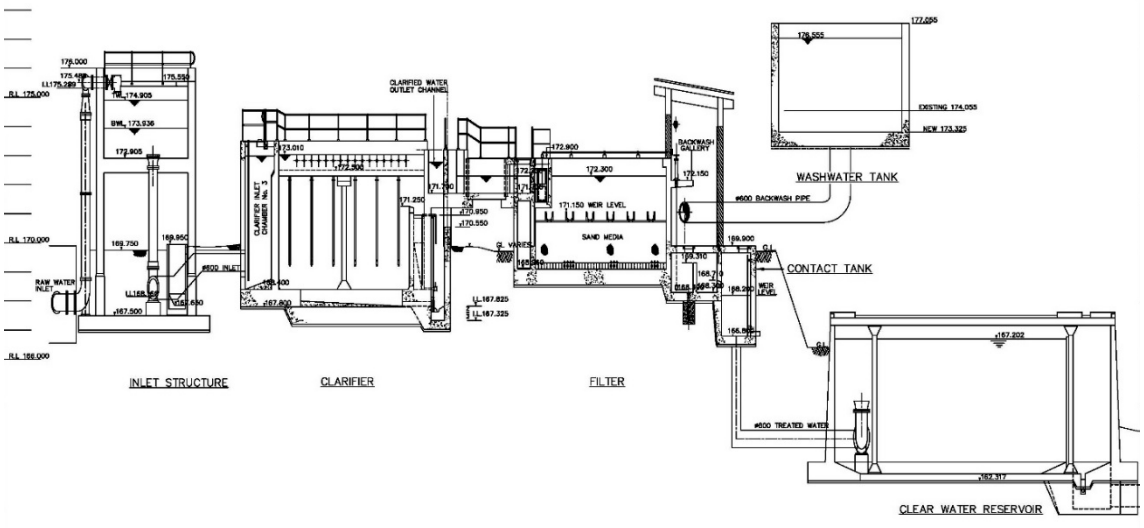


Figure 3-3.7 Nagado WTP Hydraulic Profile

Condition of receiving well

Condition of inclined plane sedimentation basin

Condition of filter

Condition of lagoon

Figure 3-3.8 Condition of Nagado WTP

Staff arrangement in Nagado WTP is shown below.

Table 3-3.4 Staff Arrangement of Nagado WTP

Staff	Count
Supervisor	1
Operator	4
Assistant Engineer	6

Source: JICA Survey Team based on Interview of WAF

Nagado WTP is operated by 11 employees working in 3 shifts of 8:00~16:00, 16:00~24:00, 24:00~8:00. In addition to operators, a supervisor and assistant engineers may be present during the day, for a total of 4 to 5 employees onsite. Night time operations are performed by 2 employees. Major electrical and mechanical systems are inspected and maintained by technicians from the head office every six months.

Operators measure and record water quality, flow, and water levels, and report to WAF Western Offices in Lautoka by telephone. Water level of the transmission reservoir and flow in the transmission main are monitored by transmission management SCADA system of WAF Head Office and transmitted to WAF Central Management Center in Suva. The SCADA system for water treatment at the WTP and the SCADA of the Central Management Center are not directly connected.

The sedimentation basin is cleaned every 6 months, and filter sand is replaced every 3 months. The filtration basin is backwashed every 24 hours. Backwash water is discharged into a nearby river after treatment in a lagoon. Sludge is landfilled. Staff carry out maintenance using standard operating procedure (SOP) manuals.

In recent years, overall treatment volume has decreased due to renovation works of transmission lines (2019) and replacement of regulator valves (2018). Each work took less than one week but Nagado treatment volume fell to 60ML/day. During these repair works, the Nagado WTP supplied water to Nadi only, while Lautoka received water from Saru WTP and Buabua WTP. The Nagado WTP is a major water source for the Nadi/Lautoka area and interruptions to the Nagado system can have significant impacts on services. Care must be taken to ensure minimal service interruption during the construction works related to the planned augmentation works. The services may temporarily be shut due to the planned augmentation works (20ML/day) at Nagado WTP by Suez.

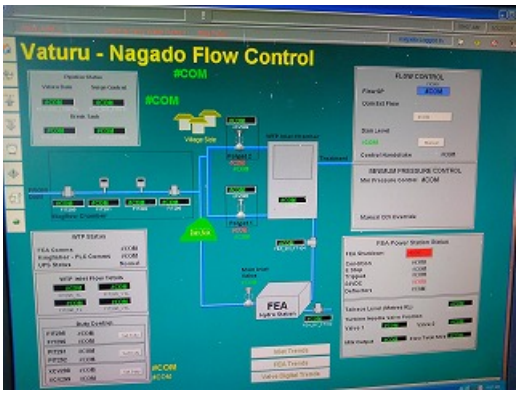
The following issues were found for the major facilities of Nagado WTP

- Algae grows in Vaturu Dam every year between June and October and is carried to Nagado WTP via the raw water trunk main. A sun-blocking sheet was installed over the sedimentation basin to prevent growth of algae. However, it was damaged by a cyclone and has not been repaired.
- In 2018, water levels in the dam became very low and dam sediment was carried to the WTP. Similar events are likely to occur again in the future.
- The SCADA system of Nagado WTP was installed in 2003. However, software maintenance has not been performed and is currently not functioning. Therefore, the SCADA team at WAF Head Office is considering software updates and system improvements so that the SCADA system can be used effectively. In addition, the WTP SCADA and the WAF Head Office water distribution management SCADA system are not linked.
- The spare chemical feed pump is malfunctioning.

Renewal of inlet regulator (2018)

Renewal of inlet regulator (2019)

Flow of algae into sedimentation basin



Unused WTP SCADA system

Figure 3-3.9 Malfunctions at Nagado WTP

3-3-2-2 Saru WTP (Lautoka)

Saru WTP is located in the western region of Lautoka. It started operation in 1959 with a capacity of 19.5ML/day. Initially, water was sourced from Buabua Intake and Varaqe Intake. The treatment process was pressure rapid filtration (24 units). With construction of Buabua WTP in 2002, Buabua Intake was switched to Buabua WTP, and 16 of the 24 filters were relocated to Buabua WTP. However, flocculation and sedimentation basins were augmented and chemical injection equipment, etc. were installed at Saru WTP.

Saru WTP receives water from Varaqe Intake. Water is conveyed to the plant via 300mm gravity flow raw water trunk main. The treatment process is trans-flow coagulation with pressure rapid filtration. Current capacity is 5ML/day. In order to meet demand of Lautoka area, an additional 3ML/day of treated water is received from Nagado WTP and a total of 8ML/day is supplied from the service reservoir of Saru WTP.

Major facilities, hydraulic profile, facility conditions of the WTP are shown below.

Table 3-3.5 Major Facilities of Saru WTP

Item	Description
Commissioned	1959, 2002
Capacity	19.5ML/day (1959), 5ML/day (2002)
Major facilities	Receiving well: RC (1 tank), Mixing tank: RC (1 tank) Flocculation tank: RC (2 tanks, horizontal flow) Cross-flow sedimentation basin: RC (2 tanks) Steel pressure rapid filter: (8 filters) Chemical dosing facilities: dosing pumps Coagulant: Alum (Imported from China) pH regulator: Caustic soda (Imported from China) Chlorine: Chlorine gas (imported from Australia) Clear water well: RC(2.25ML) Backwash water tank: RC (1 tank)
Treatment process	Crossflow flocculation and sedimentation + Pressure rapid filtration + Chlorine treatment
Water source	Varaqe Intake
Raw water quality	Turbidity (1.5-700NTU), pH (7.2)
Treated water quality	Turbidity(＜1.0NTU), pH(7.2-7.6)

Source: JICA Survey Team based on Interview of WAF

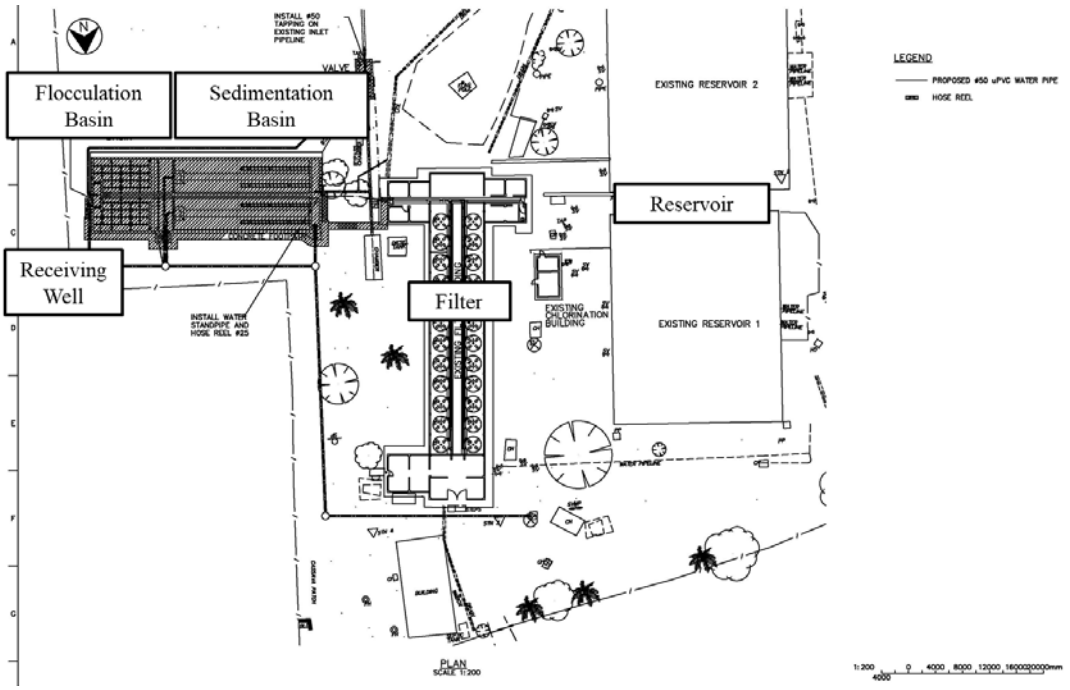


Figure 3-3.10 Saru WTP Floor Plan

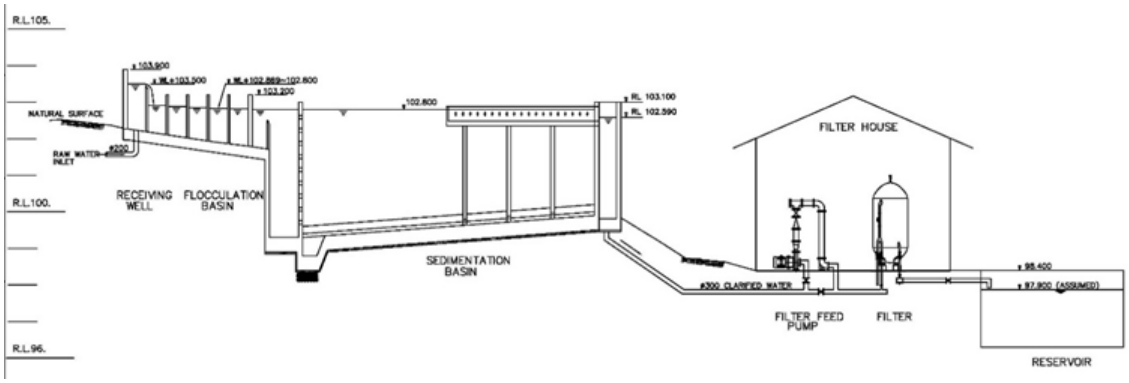


Figure 3-3.11 Saru WTP Hydraulic Profile

WAF purchased a mobile water treatment station in 2015 for emergency water supply (Float-type intake pump with membrane filtration units and power generator, made in New Zealand). Capacity is 300 m^3/day. It is used three to four times during the dry season. Membrane filters are cleaned and maintained regularly.

A power generator was purchased in 2018. It provides power to pressure filters, chemical injection facilities, and backwash pumps during power outages. In 2018, there were three major power outages, each approximately one hour in duration.

Condition of flocculation tank and sedimentation basin

Condition of filters

Intake pump of mobile station

Interior of mobile station

Figure 3-3.12 Condition of Saru WTP

Staff arrangement of Saru WTP is shown below.

Table 3-3.6 Staff Arrangement of Saru WTP

Staff	count
Supervisor	1
Operator	5
Assistant Engineer	2

Source: JICA Survey Team based on Interview of WAF

Saru WTP is operated by 8 employees working in 3 shifts 8:00~16:00, 16:00~24:00, 24:00~8:00. In addition to operators, a supervisor and assistant engineers may be present during the day, for a total of 4 to 5 employees onsite. Night time operations are performed by 1 employee. Major electrical and mechanical systems are inspected and maintained by technicians from the head office every 6 months.

Operators measure and record water quality, flow, and water levels, and report to WAF Western Offices in Lautoka by telephone. A "master meter" is installed on the outlet line of the reservoir and measurement data is sent to the Central Management Center via SCADA system of WAF Headquarters. Originally, one "master meter" was installed. It was replaced in 2007 due to malfunction.

The sedimentation basin is cleaned every 3 months. The filters are backwashed every 24 hours. Wastewater and sludge from the sedimentation basin are discharged to a nearby river. Employees carry out maintenance works using standard operational procedure (SOP) manuals.

The following issues were found for the major facilities of Saru WTP. Damage and malfunction of facilities were not found.

- Water supply from Nagado WTP was suspended three times in 2018 and twice in 2019 to renew valves, and repair leaks at Nagado WTP and only water from Saru WTP and Buabua WTP were available for Lautoka.
- Relatively large leaks from cracks in the side walls and bottom plates of the reservoir were confirmed. Although the leaks have been reported to WAF headquarters, no repair measures have been implemented.

Leakage from crack on floor of distribution reservoir

Leakage from crack on walls of distribution reservoir

Figure 3-3.13 Malfunctions at Saru WTP

3-3-2-3 Buabua WTP (Lautoka)

Buabua WTP is located in the western region of Lautoka. The WTP started operation in 2002 with a capacity of 9ML/day. The Buabua WTP receives water from the Buabua Intake and the Nalau Intake. Flocculation ponds, sedimentation basins, chemical injection facilities, etc. were constructed and 16 pressure filters were moved from the Saru WTP. The treatment process is trans-flow coagulation sedimentation with pressure rapid filtration.

Water is supplied from the reservoir at Buabua WTP to Qalitu distribution reservoir and Vakabuli distribution reservoir. The Lautoka distribution system receives water from these sources 24 hours a day.

Major facilities, diagram of the WTP, water level diagram, facility conditions are shown below.

Table 3-3.7 Major Facilities of Buabua WTP

Item	Description
Commissioned	2002
Capacity	9ML/day
Major facilities	Receiving well: RC (1 tank), Mixing tank: RC (1 tank) Flocculation tank: RC (2 tanks, horizontal flow) Cross-flow sedimentation tank: RC (2 tanks) Pressure rapid filter (16 filters) Chemical dosing facility: Dosing pumps Coagulant: Alum (Imported from China) pH regulator: Caustic soda (Imported from China) Chlorine: Chlorine gas (imported from Australia) Clear water well: RC (1.5ML (1 tank) Backwash water tank: RC (1 tank)
Treatment process	Cross-flow flocculation and sedimentation＋Pressure rapid filtration＋Chlorine treatment
Water source	Buabua intake, Nalau intake
Raw water quality	Turbidity(1-200NTU), pH (7.2)
Treated water quality	Turbidity(<1NTU), pH (7.2-7.6)

Source: JICA Survey Team based on Interview of WAF

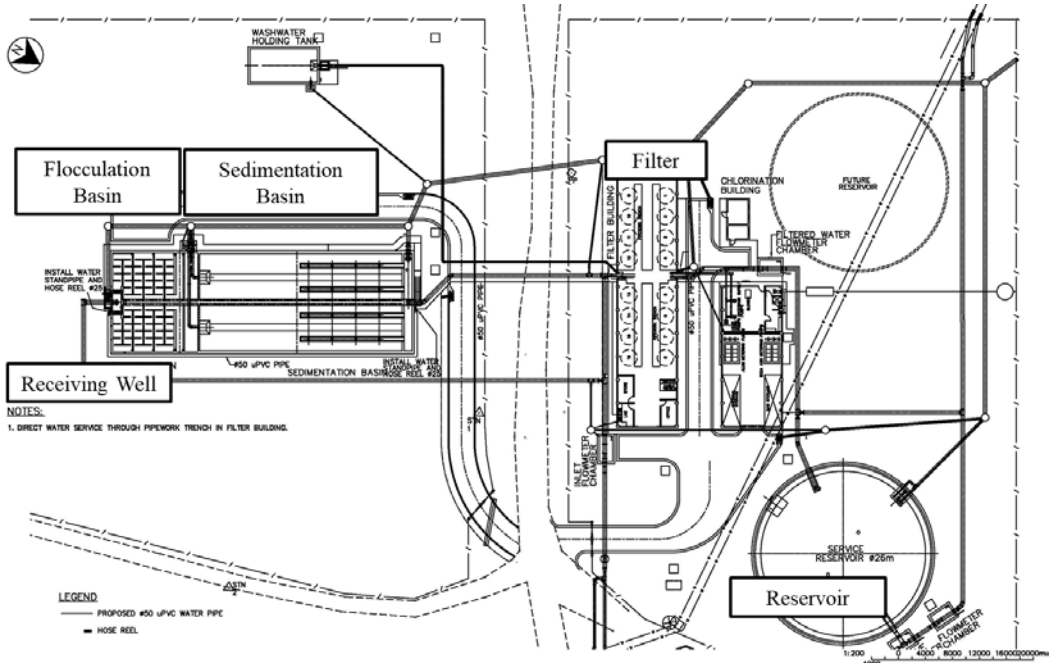


Figure 3-3.14 Buabua WTP Floor Plan

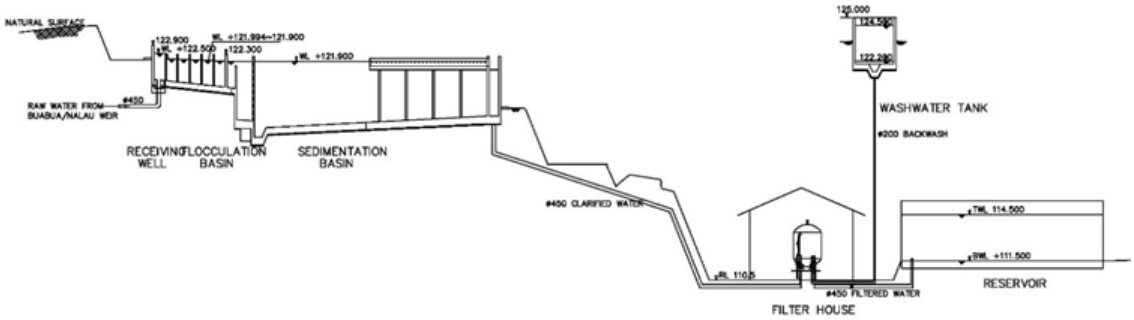


Figure 3-3.15 Buabua WTP Water Level Diagram

In 2019, a pump was installed in the Nalau Intake as a countermeasure to decreased water level during the dry season. During the dry season when water levels are low, water is pumped with pressure to the WTP to ensure water supply.

A power generator was purchased in 2017. It provides power to pressure filters, chemical injection facilities, and backwash pumps during power outages. In 2018, there were three major power outages, each approximately one1 hour in duration.

Condition of flocculation tank and sedimentation basin

Condition of pressure filters

Condition of distribution reservoir

Pressurized main from Nalau Intake (2019)

Figure 3-3.16 Condition of Buabua WTP

Staff arrangement of Buabua WTP is shown below.

Table 3-3.8 Staff Arrangement of Buabua WTP

Staff	Count
Supervisor	1
Operator	4
Assistant Engineer	2

Source: JICA Survey Team based on Interview of WAF

Buabua WTP is operated by 7 employees working in 3 shifts 8:00~16:00, 16:00~24:00, 24:00~8:00. In addition to operators, a supervisor and assistant engineers may be present during the day, for a total of 4 to 5 employees onsite. Night time operations are performed by 1 employee. Major electrical and mechanical systems are inspected and maintained by technicians from the head office every 6 months.

Operators measure and record water quality, flow, and water levels, and report to WAF Western Offices in Lautoka by telephone. A "master meter" is installed on the outlet line of the reservoir and measured data is sent to the Central Management Center via SCADA system of WAF Headquarters.

The sedimentation basin is cleaned every 3 months. The filters are backwashed every 24 hours. Wastewater and sludge from the sedimentation basin are discharged to a nearby river. Staff carry out maintenance works using standard operational procedure (SOP) manuals.

The following issues were found for the major facilities of Buabua WTP.

- Pressure filter No. 14 failed in 2014, and five pressure gauges of the filter also failed. Although the failure has been reported to the WAF headquarters, no repairs have been made.
- The WTP inlet flowmeter (electromagnetic flowmeter) was broken. No repairs have been carried out. Inlet flow measurements are taken regularly with an ultrasonic flowmeter.
- In 2009, the WTP SCADA system was damaged due to lightning. No repairs have been made. On-site measurements are recorded manually by the operator.
- One of the two Alum injection pumps is out of order. The remaining pump is in operation, and there is no spare.

Pressure filter No. 14 malfunctioning


WTP SCADA system not operational

Figure 3-3.17 Malfunctions at Buabua WTP

3-3-3 Distribution Facilities

3-3-3-1 Reservoirs

The capacities of existing reservoirs are shown in **Table 3-3.9**. Conditions and issues related to the reservoirs are shown in **Figure 3-3.18** and **Figure 3-3.19**.

Table 3-3.9 Capacities of Existing Distribution Reservoirs

Water Systems	Sources	Treatment	Reservoir name	Reservoir capacity
NADI	Vaturu Gravity Dam	Nagado WTP	Nadele Reservoir	0.38ML
			Holika Reservoir	0.38ML
			Blackrock Reservoir	8.32ML
			Votualevu Reservoir	1.14ML
			Mocambo Reservoir	2.27ML
			Lolobalavu New	2.25ML
			Lolobalavu Old	3.41ML
			Mulomulo Reservoir	0.38ML
			Delaisiro Reservoir	2.6ML
			Nabila Reservoir	0.75ML
LAUTOKA	Vaturu Gravity Dam	Nagado WTP	Kashmir Reservoir	20ML
			Vuda Reservoir	6.8ML
	Varaqe Gravity Dam	Saru WTP	Saru Reservoir Old	2.25ML
			Saru Reservoir New	2.25ML
			Phluggers New	1.40ML
			Phluggers Old	1.14ML
			Tavakubu Reservoir	1.4ML
			DMO Old	1.14ML
			DMO new	1.40ML
			Tualesia Reservoir	0.6ML
	Buabua Gravity Dam	Buabua WTP	Qalitu Reservoir	0.75ML
	Nalau Gravity Dam		Vakabuli Reservoir	0.375ML

Source: NLWMP33

Blackrock Reservoir

Leak in base plate. Inlet flow control is not possible due to malfunctioning inlet float valve.

Delasiro Reservoir

Reservoir is not filled due to hydraulic issues and is not used. The reservoir inlet and outlet are connected by a bypass line.

Holika Reservoir

Inlet flow control is not possible due to malfunctioning inlet float valve. Water is constantly overflowing from the overflow pipe.

Lolobalavu Reservoir

Although located far away from Nagado Reservoir, depending on the time of day, inlet is more difficult than other reservoirs due to its high elevation.

Mocambo Reservoir

Insufficient capacity.

Mulomulo Reservoir

Although located far away from Nagado Reservoir, depending on the time of day, inlet is more difficult than other reservoirs due to its high elevation.

Nabila Reservoir

Reservoir is located on a hill. It is not filled due to hydraulic issues and is not used. The reservoir inlet and outlet are connected by a bypass line.

Nadele Reservoir

Inlet flow control is not possible due to malfunctioning inlet float valve. Water is constantly overflowing from the overflow pipe.

Votualeve Reservoir

Leakage on side wall. Inlet flow control is not possible due to malfunctioning inlet float valve. Water is constantly overflowing from the overflow pipe.

Figure 3-3.18 Current Conditions and Issues of Capacities of Existing Distribution Reservoirs (Nadi)

DMO Old / DMO New Reservoir

Due to floor leak, the reservoir has not been used since installation. The reservoir inlet and outlet are connected by a bypass line.

Kashimir Reservoir

Electric facilities are faulty and not repaired.

Phluggers Old Phluggers New Reservoir

Cracks and efflorescence on side wall. Water does not flow in if the water level of the Kashimir Reservoir is low.

Qalitu Reservoir

Buabua reservoir supplies water to Qalitu and Vakabuli reservoirs. However, only one reservoir can be supplied at one time due to hydraulic reasons.

Tavakubu Reservoir

Not used due to floor leak. The reservoir inlet and outlet are connected by a bypass line.

Tulesia Reservoir

Water does not flow in if the water level of the Kashimir Reservoir is low.

Vakabuli Reservoir

Buabua reservoir supplies water to Qalitu and Vakabuli reservoirs. However, only one reservoir can be supplied at one time due to hydraulic reasons.

Vuda Reservoir

Normal operating condition.

Figure 3-3.19 Current Conditions and Issues of Existing Distribution Reservoirs (Lautoka)

WAF is implementing "A Treated Water Storage Reservoirs Condition & Performance Assessments" and evaluation the current conditions of the major reservoirs. A summary of the evaluation is shown in **Table 3-3.10**.

Table 3-3.10 Evaluation of Current Condition of Major Reservoirs

		Blackrock	Delasiro	DMO Old	DMO New	Holika
Reservoir Structure (the foundations, walls and roof structures)	Condition	5	5	4	5	4
	Performance	4	5	4	5	4
Hydraulic Structure (the associated inlet, outlet and other chambers and their associated pipework and fittings)	Condition	4	5	4	4	5
	Performance	4	TBC	4	5	5
Geotechnical (the site subsoil conditions and stability)	Condition	5	4	4		3
	Performance	4	3	4		3
Electrical & Instrumentation (the site power, control and monitoring systems)	Condition	5	4	-		3
	Performance	5	5	-		TBC
Other Features (the site access, security, drainage and vegetation)	Condition	5	4	5		5
	Performance	5	4	4		5

		Mocambo	Nadele	Votualeve	Phluggers	Tavakubu
Reservoir Structure (the foundations, walls and roof structures)	Condition	5	5	5	5	5
	Performance	4	5	4	5	5
Hydraulic Structure (the associated inlet, outlet and other chambers and their associated pipework and fittings)	Condition	4	5	4	5	5
	Performance	4	5	4	4	5
Geotechnical (the site subsoil conditions and stability)	Condition	2	3	5	5	5
	Performance	2	3	5	4	4
Electrical & Instrumentation (the site power, control and monitoring systems)	Condition	3	5	-	4	-
	Performance	4	TBC	-	4	-
Other Features (the site access, security, drainage and vegetation)	Condition	5	5	5	5	5
	Performance	5	5	5	5	5

Rating: 5 Very poor, issues require urgent attention, 4 Poor, issues require attention, 3 Average, issues need to be monitored, 2 Good, no issues to be addressed, 1 Very good, near new condition
TBC: to be confirmed
Source: TREATED WATER STORAGE RESERVOIRS CONDITION & PERFORMANCE ASSESSMENTS

The distribution reservoirs are evaluated on a 5-level scale based on aging condition and functionality. All reservoirs were rated 5 – Severely Weakened, or 4 – Weakened. Specifically, cracks and deterioration of water sealing has started to cause leaks. In addition, malfunctioning valves and other equipment caused the facilities to be evaluated as needing repairs.

Various issues such as structural issues that cause leakage, equipment replacement, and hydraulic problems afflict the existing reservoirs.

3-3-3-2 Transmission and Distribution Pipeline

The total length of the transmission/distribution network is about 1,000km (including raw water trunk mains, transmission pipes, distribution pipes, and supply lines). Approximately 37,500 water meters are installed. The extent of existing transmission/distribution pipe is shown below.

Table 3-3.11 Quantity of Existing Water Transmission/Distribution Mains

	AC	AS	BS	CI	DI	DICL	GALV	MSCL	POLY	PVC	mPVC	uPVC	STEEL	Sub total
Raw water transmission	**0.00**	**0.00**	**0.00**	**0.00**	**16.29**	**0.00**	**0.00**	**16.44**	**0.00**	**0.00**	**0.00**	**0.00**	**8.91**	**41.65**
300	0.00	0.00	0.00	0.00	5.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.90	14.56
600	0.00	0.00	0.00	0.00	9.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.63
700	0.00	0.00	0.00	0.00	1.00	0.00	0.00	9.97	0.00	0.00	0.00	0.00	0.01	10.99
900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.47	0.00	0.00	0.00	0.00	0.00	6.47
Transmission	**55.77**	**3.40**	**1.70**	**39.56**	**78.60**	**7.39**	**0.02**	**8.02**	**0.00**	**151.02**	**41.60**	**111.06**	**0.02**	**498.16**
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.00	0.00	0.00	0.74
100	1.08	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	26.44	0.00	9.89	0.00	37.60
150	10.12	3.40	1.70	13.57	2.06	0.00	0.02	0.00	0.00	76.21	6.02	35.04	0.00	148.15
200	18.85	0.00	0.00	1.38	0.00	0.00	0.00	0.00	0.00	26.22	18.58	23.67	0.00	88.70
225	0.39	0.00	0.00	1.78	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	2.71
250	8.49	0.00	0.00	2.89	0.00	0.00	0.00	0.00	0.00	6.41	4.39	11.53	0.00	33.71
300	13.89	0.00	0.00	14.64	24.24	0.00	0.00	0.00	0.00	8.78	0.39	19.78	0.00	81.72
375	1.44	0.00	0.00	3.91	14.61	0.00	0.00	0.00	0.00	1.15	9.80	10.52	0.00	41.43
400	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
450	1.51	0.00	0.00	1.21	1.48	0.00	0.00	0.00	0.00	0.10	0.21	0.00	0.00	4.51
500	0.00	0.00	0.00	0.00	5.84	0.00	0.00	0.00	0.00	4.96	2.21	0.08	0.00	13.09
600	0.00	0.00	0.00	0.00	30.15	7.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	37.54
750	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
800	0.00	0.00	0.00	0.00	0.13	0.00	0.00	7.77	0.00	0.00	0.00	0.00	0.00	7.89
900	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.30
Distribution	**40.47**	**0.00**	**0.48**	**7.92**	**0.04**	**0.01**	**2.88**	**0.00**	**36.99**	**292.68**	**22.43**	**188.16**	**0.00**	**592.05**
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.54
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.83	1.93	0.00	0.04	0.00	37.80
50	12.74	0.00	0.39	1.56	0.00	0.00	2.56	0.00	0.62	80.66	0.00	49.30	0.00	147.84
75	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	17.23	0.00	0.28	0.00	18.11
80	6.90	0.00	0.00	0.89	0.02	0.01	0.12	0.00	0.00	100.07	5.68	93.94	0.00	207.63
100	17.87	0.00	0.09	4.87	0.02	0.00	0.19	0.00	0.00	81.67	15.42	42.50	0.00	162.64
110	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.47
150	2.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.15	1.33	2.09	0.00	15.52
200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00	1.50
Ground total	**96.23**	**3.40**	**2.17**	**47.48**	**94.93**	**7.40**	**2.90**	**24.46**	**36.99**	**443.70**	**64.03**	**299.22**	**8.94**	**1131.86**

Unit: km
Source: JICA Survey Team based on WAF GIS Data

The replacement of aging AC pipes with larger diameter pipes (approximately 100km) is an important topic. Installation condition of the AC pipes is shown in **Figure 3-3.20**. In addition, approximately 50km of CI pipes have been installed. Aging and clogging of these pipes are expected to have negative effects on water capacity and quality. Survey of the current CI pipe

condition as well as measures for improvement are needed.

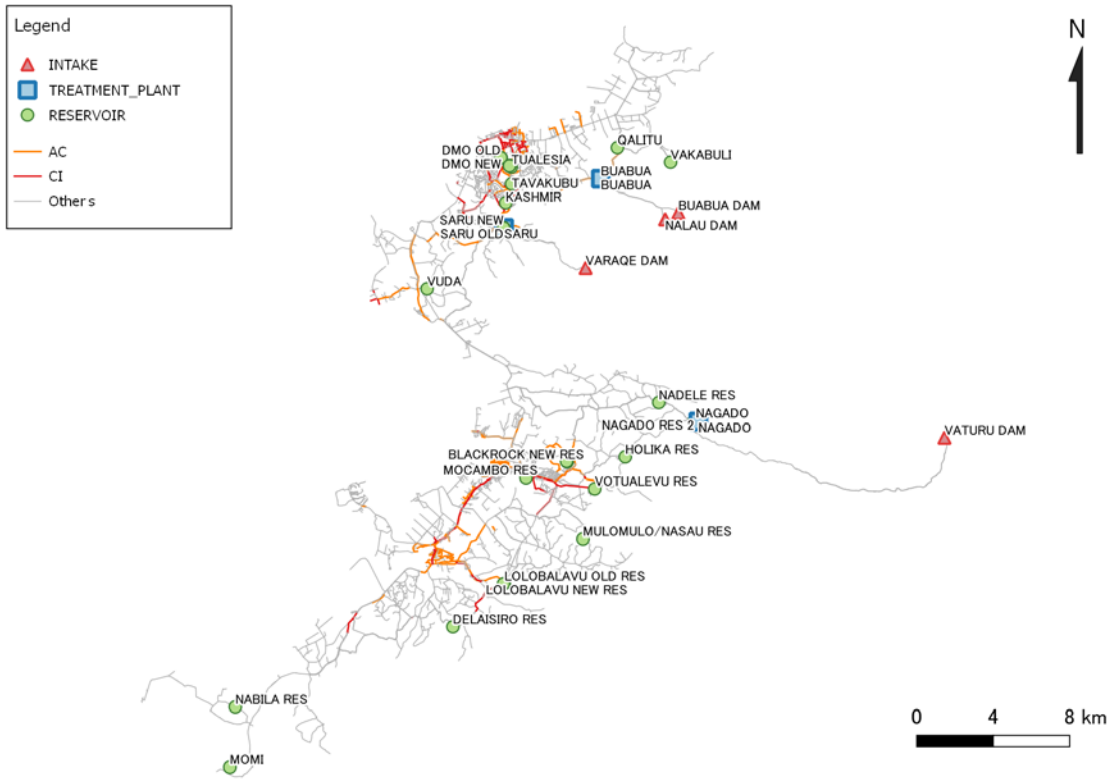


Figure 3-3.20 Installed AC and CI Pipes

Source: JICA Survey Team based on WAF GIS Data

Leakage condition of pipelines surveyed in the city are shown in **Figure 3-3.21**.

Many leaks were confirmed in the survey. Particularly, leakage from main pipes were confirmed in Nadi Town. Some leaks were big enough to cause puddles. WAF was aware of these leaks but was not able to take sufficient action due to lack of funds.

Figure 3-3.21 Leakage Conditions Verified in Nadi Town

3-3-4 SCADA System

In 2014, WAF installed a SCADA system for water distribution management in Fiji nationwide to measure the water levels of reservoirs and the inflow and outflow volumes. It is monitored by WAF headquarters.

The outline of the water supply management SCADA system is shown below. In the western region, 25 reservoirs are monitored.

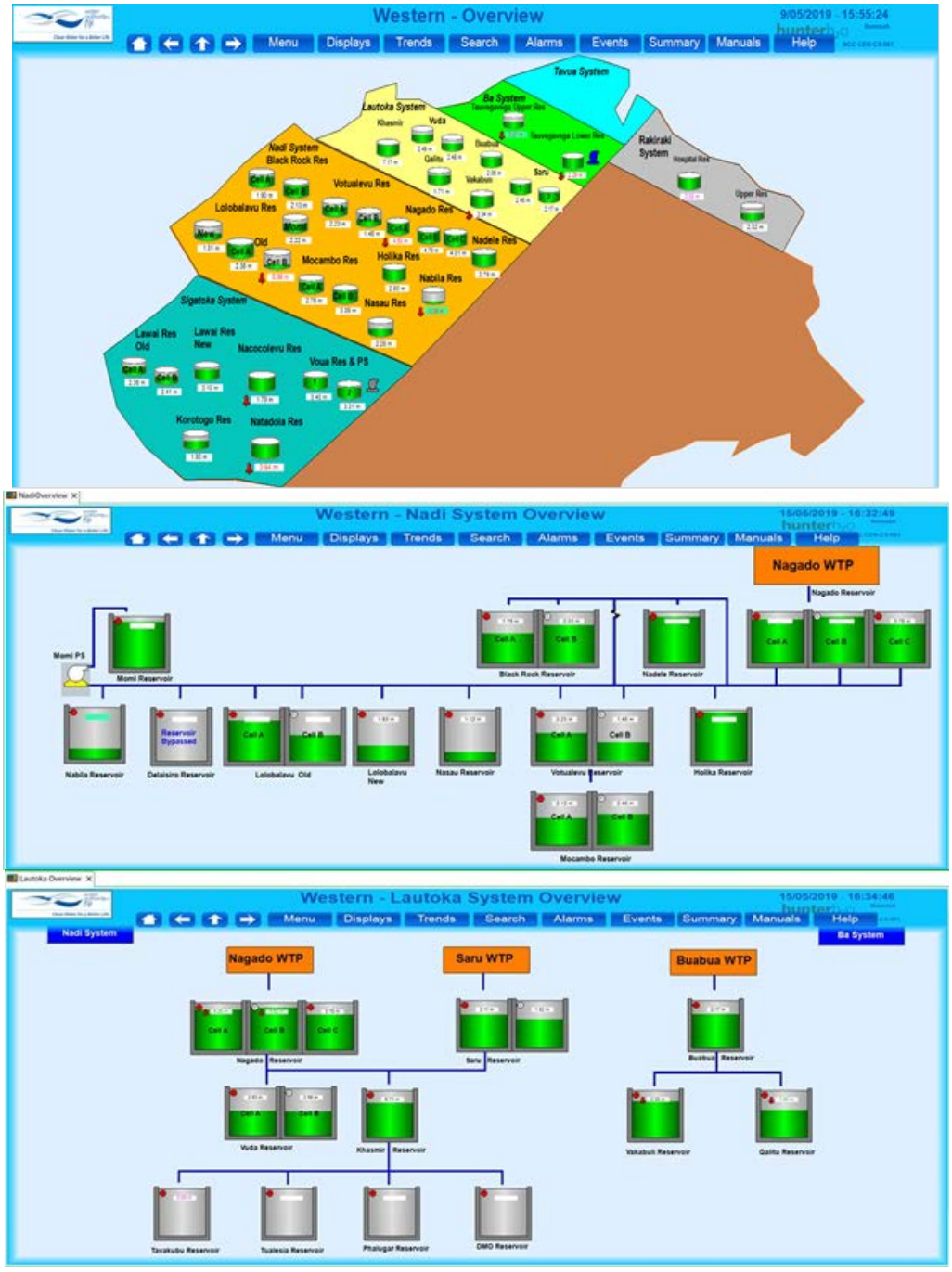


Figure 3-3.22 WAF headquarters Supply Management SCADA

Source: WAF SCADA System

3-3-5 Other Considerations

3-3-5-1 Drinking Water Quality Standards and Wastewater Standards

Regarding drinking water in Fiji, "Treated water is to comply with the Fiji National Drinking Water Quality Standard." WAF is compliant with this standard. pH, chlorine concentration, and turbidity are analyzed daily at each WTP. Other water quality analysis items are performed at the Water Quality Center in Suva. The analysis of algae at the Nagado WTP is performed by external

analysis in New Zealand.

Wastewater discharged from water treatment processes have been granted a drainage permit in accordance with the “Environmental Management Act 2005”, which is the wastewater standard of the country.

3-3-5-2 Technical Competence and Procurement of Contractors

Major local contractors for waterworks construction are shown below:

- Flame Tree Development Ltd.
- Fairdale Earthmoving Contractor Ltd.
- General Machinery and Civil Development Ltd.
- Nand Civil Contractor Ltd.
- China Railway First Group (Fiji) Ltd.

Small-scale repair and renewal of small-diameter pipes are carried out by the WAF construction department. Large-scale works such as main pipes are outsourced to overseas and national contractors. Technical competence of these contractors seems sufficient. Production plants for PVC and small-diameter High Density Polyethylene Pipe (hereinafter referred to as “HDPE”) are available domestically. However, ductile iron pipes used for main pipes are imported. Contractors also have heavy machinery needed for construction works.

3-4 Countermeasures for Issues in the Water Supply Facilities

3-4-1 Water Source, Intake and Raw Water Transmission

3-4-1-1 Vaturu Dam Raising

As mentioned in **Table** 3-4.1, both Maunsell and GHD recommend a free fall weir with mass concrete as an optimal structure for enhancement of storage / water supply capacity. The report of Maunsell Ltd. recommends raising of the spillway by 2m to enhance the capacity up to 106ML/day, and the GHD report recommends raising the spillway by 5m to increase the capacity up to 138ML/day. The free fall weir with mass concrete is recommended in the both reports because it is “a simple structure compared with movable weirs, and it requires no operation and maintenance cost”. Several movable weirs are examined in the both reports. The report of Maunsell Ltd. mentioned that movable weir might be applied to raise the spillway by more than 2m, and the GHD report mentioned that movable weir might be applied to reduce the height of dam body raising. The reports concluded that the dam/spillway raising would have small social and environmental impacts.

Table 3-4.1 Assumed Specification of the Vaturu Dam Raising

	Only water supply purpose	Multi-purpose (water supply and flood control)
Elevation of dam crest	537m above mean sea level (5m-raising)	Same as on the left of more
Full supply level / Elevation of spillway	532m above mean sea level (5m-raising)	
Capacity (corresponding target year)	138ML/D (2040)	138ML/D (2040)
Type of spillway	Free fall weir with mass concrete	Movable flood gate
Roughly estimated construction cost *Assuming 1FJD = 50YEN	< 2m-rasing (Assumption by Fiji) > 7 million FJD *According to WAF concept note < 2m-raising (Estimated by the JICA Survey Team) > Approximately 35 million FJD (refer to **Figure 3-4.2**) < 5m-raising (Estimated by the JICA Survey Team) > Approximately 76 million FJD (refer to **Figure 3-4.3**) * It is based on the unit price of dam construction cost in Japan. It does not include the expenses of temporary construction, administrative, survey, and compensation)	In addition to the dam-raising described in the left column, cost for installation of a movable flood gate, which is mentioned below, is required. <Reference example of flood gate in Japan> Approximately 10 million FJD if the scale of gate is 23.45m in width, 3.98m in height with 2 movable gates.
Maintenance cost of spillway	0% * According to the existing report in 2005 by Maunsell	1.5 – 6.0 % and more * According to the existing report in 2005 by Maunsell
Work safety, workability	Work safety and workability by a local constructor are high because it is simple structure.	Examination on work safety is required since it has an intricate structure. Workability by a local constructor is not high.
Requisite time (Survey, design and construction)	Survey and design: More than 2 years Construction: More than 5 years * According to the existing report in 2016 by GHD	In addition to the requisite time for dam-raising described in the left column, the requisite time for movable flood gate shall be considered, which is mentioned below. Survey and design: Around 2 years Construction: Around 2 years * In the case of the above flood gate in Japan

Raising the dam body by 5m with a free fall weir with mass concrete has an advantage in the case the dam is only for water supply purpose, since the structure of the spillway will remain the same. In this case, work safety and workability by a local constructor are higher compared with the movable flood gate because its structure is simple. Moreover, no operation and maintenance are required for the free fall weir.

Flood gate operation, development of gate operation manual, personnel capacity development for operation and maintenance, and proper operation and maintenance are necessary in case the dam is transformed to a multi-purpose dam.

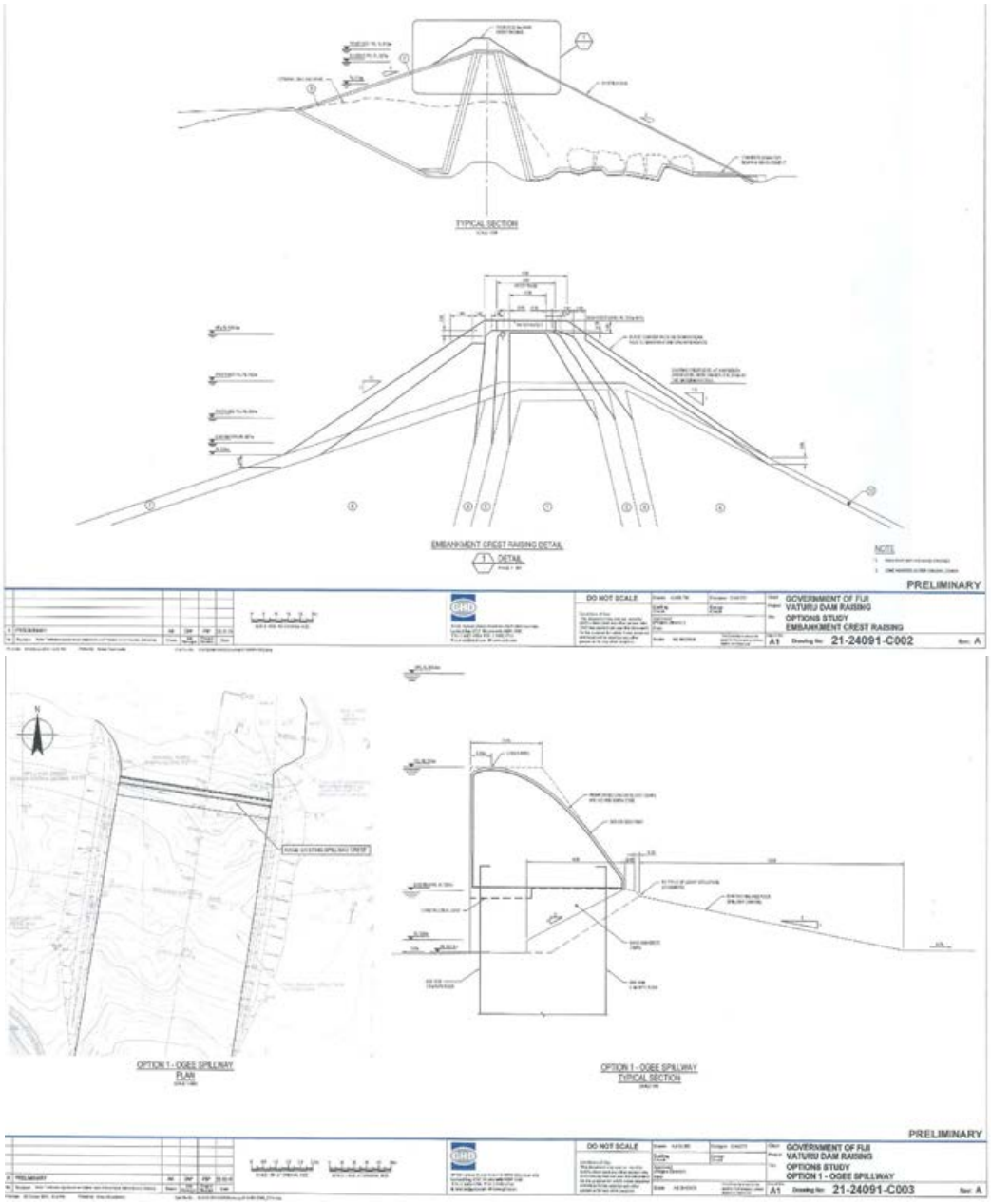


Figure 3-4.1 Assumed Cross-Sections (in the Case of 5m Raising)

Source: Vaturu dam safety study / Feasibility study report, 2016, GHD

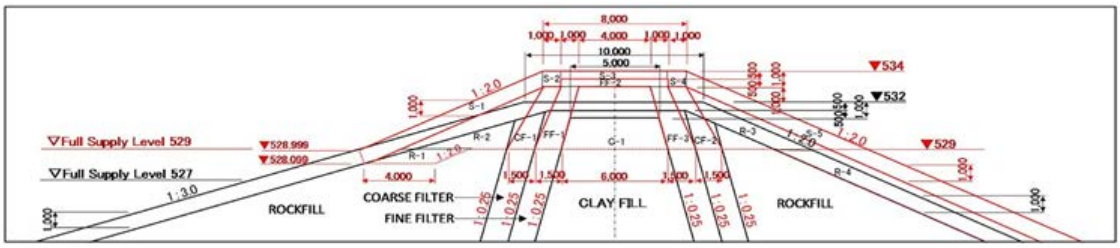


Figure 3-4.2 Outline Drawing in the case of 2m-Raising the Dam Body

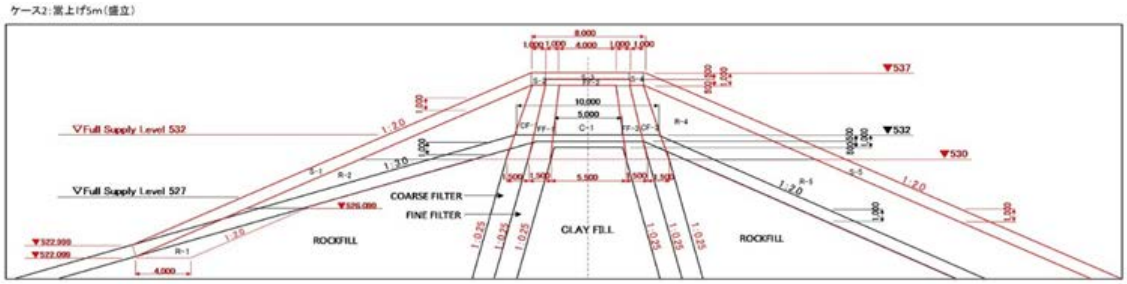


Figure 3-4.3 Outline Drawing in the case of 5m-Raising the Dam Body

The rough construction costs estimated by GHD survey and by the JICA Survey Team are different because there is a difference in the configuration of the dam-raising, such as the dam-raising from the dam base, as **Figure 3-4.1** to **Figure 3-4.3** show. Further investigation is required for the detailed configuration of the dam raising.

3-4-1-2 Vaturu / Nagado Raw Water Trunk Mains

The Vaturu / Nagado raw water trunk mains system is based on gravity flow. There are 3 major critical sections, including no-duplicated section / single trunk main with narrow tunnel and elevated section (refer to **Figure 3-4.4**). The first critical section, which is a single section, is located at Tunnel 2. The capacity of the existing raw water trunk main is limited to 100ML/day with full supply level of 527m, and the capacity of the pipeline decreases to approximately 89 to 92ML/day during the dry season, when dam levels decrease. It can be increased to up to 108ML/day by duplication of 385m of trunk main at the Tunnel 2 and bypassing with a pipe line of 700mm in diameter. Moreover, it can be further enhanced up to 130ML/day if the second critical section is solved. However, there is a site availability issue due to topographical constraints. The second critical section is an elevated section with elevation of 448m, approximately 10,000m from the Vaturu Dam. It is also a single section. Head loss / energy loss needs to be improved by bypassing this elevated section. The third critical section is the aging pipe line, 9.4km in length, near the Nagado WTP. Improving the redundancy of the trunk mains by the duplication of the pipe line is required.

Figure 3-4.4 Measures to be taken for Enhancement of The Vaturu / Nagado Raw Water Trunk Mains

Source: WAF Concept Note (red line: vulnerable section where requires duplication)

Several sizes and types of the pipes, such as 600mm-diameter ductile iron pipe, 711mm, 914mm, and 1,200mm diameter MSCL (Mild Steel Cement Lined) pipe, are used for the Vaturu / Nagado raw water trunk mains. It is buried 1.0 to 1.5m below the ground surface. According to the concept note provided by WAF, the trunk mains have several issues, such as limited supply capacity due to the hydraulic, topographic and structural restrictions, vulnerability due to lack of backup system, and approximately 40-year-old aging section. There were 5 major water supply shutdowns in 2018 due to several leakages, and they cost approximately 4 million FJD (1FJD=50.2281JPY (JICA Monthly exchange rate in JPY 2019, February 2020)) in total. Therefore, immediate improvement of the trunk main is required.

3-4-2 Water Treatment Facilities

3-4-2-1 Nagado WTP

Countermeasures for issues uncovered at the Nagado WTP are as follows:

- Augmentation of WTP

Augmentation of the Nagado WTP is needed to meet the growing Nadi/Lautoka water demand.

The augmentation of the Nagado WTP was requested by the Fiji side. But it was learned that WAF is already planning to introduce a flotation pond and a pressure filter in a project with Suez with a capacity of 20ML/day from August 2019. This installation is planned within the existing boundary.

In NLWMP33, the Nagado WTP needs to be expanded to 120ML/day. An additional 10ML/day capacity increase is needed in the future.

The 20ML/day expansion planned by Suez is shown in **Figure 3-4.5**.

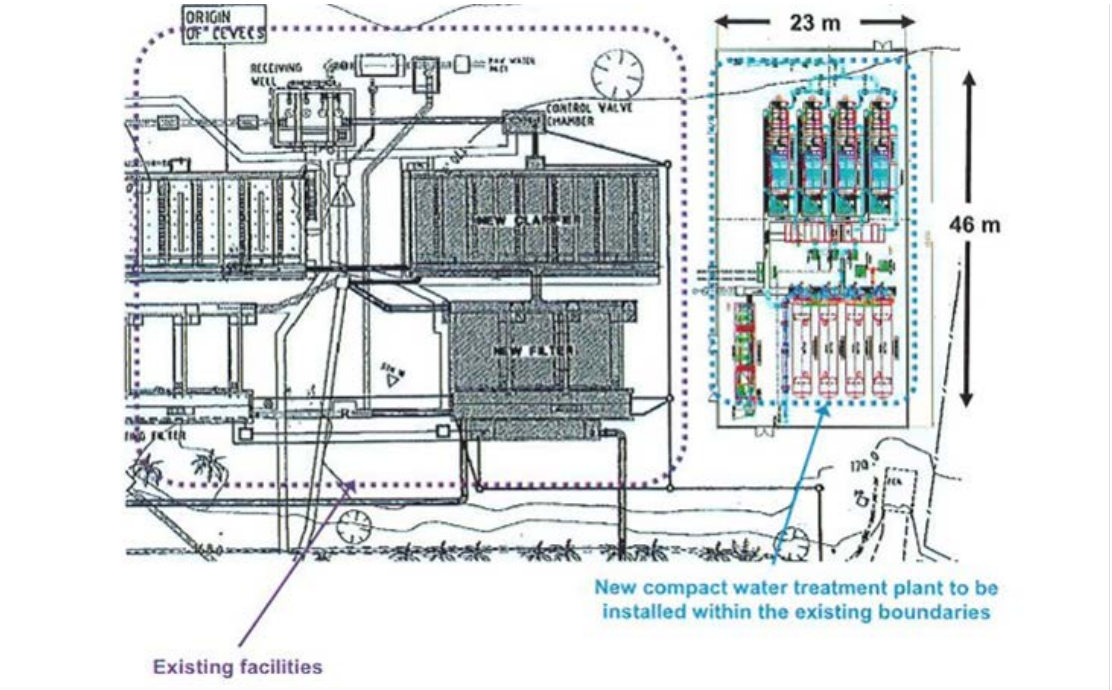


Figure 3-4.5 Nagado WTP Augmentation Plan by Suez Corporation

Source: Design report-WTP NAGADO-21,000m^3/day

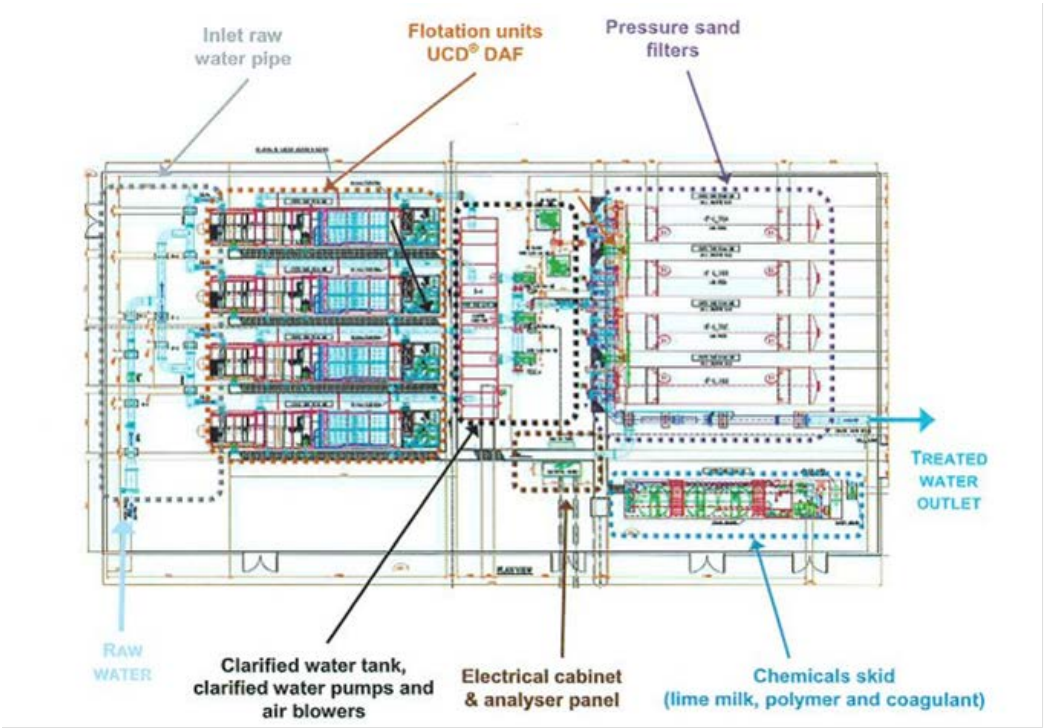


Figure 3-4.6 Treatment Augmentation Plan according to Suez Corporation

Source: Design report-WTP NAGADO-21,000m^3/day

Flotation ponds planned to be introduced are called Dissolved Air Flotation (DAF) ponds, which use microbubbles to float aggregated floc and remove them as supernatant. The growth of algae has become a persistent problem in Nagado WTP, and this method is considered effective in

removing algae formed as floc. This method has been employed by Suez at other locations; France (8,000m^3/day and 40,000m^3/day), USA (New York 80,000m^3/day), Macau (31,500 m^3/day).

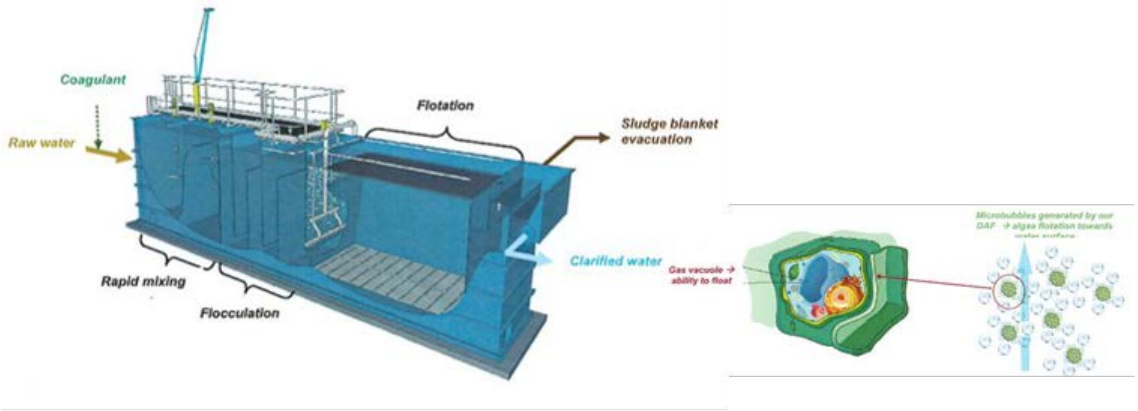


Figure 3-4.7 Floc Flotation Tank

Source: Design report-WTP NAGADO-21,000m^3/day

Since augmentation of the water purification pond is not included in this plan, the existing 9.2ML/day pond will be used. To accommodate the required 110ML/day capacity, new distribution reservoirs (Nawaicoba Reservoir and Lolobalavu Reservoir) will be constructed in the city to manage fluctuations in demand. In addition, there is no need for a temporary road for construction because the existing access road is being developed for the expansion of the water treatment plant.

- Countermeasures for algae at the WTP

From June to October, algae generated at the Vaturu Dam flow to Nagado WTP. Since the WTP is operating at overcapacity, some algae get carried over to the filters, increasing treatment burden, causing clogging and requiring more frequent backwashing.

Countermeasure against algae such as pre-chlorination, increasing coagulant dose, and using PAC instead of alum are under consideration by WAF.

Increased maintenance costs due to increased chemical doses, more frequent washings, and generation of moldy odors from algae are some concerns. Due to these limitations, it is also desirable to take measures against the generation of algae in Vaturu Dam.

- Renewal of SCADA at Nagado WTP

Since the WTP SCADA system at Nagado WTP is not functioning, it is desirable to update software or otherwise restore functionality.

3-4-2-2 Saru WTP

Countermeasures for issues uncovered at the Saru WTP are as follows:

- Augmentation of WTP

As outlined in the NLWMP33, augmentation of Saru WTP is required to meet future water demand. As shown in **Figure 3-4.8**, land for augmentation has been secured within the facility grounds. However, there is no further planning such as processing methods and implementation schedules for the augmentation facilities. Therefore, it is necessary to prepare a future augmentation plan for the WTP based on F/S and other surveys. In addition, there is no need for a temporary road for construction because the existing access road is being developed for the augmentation of the WTP.

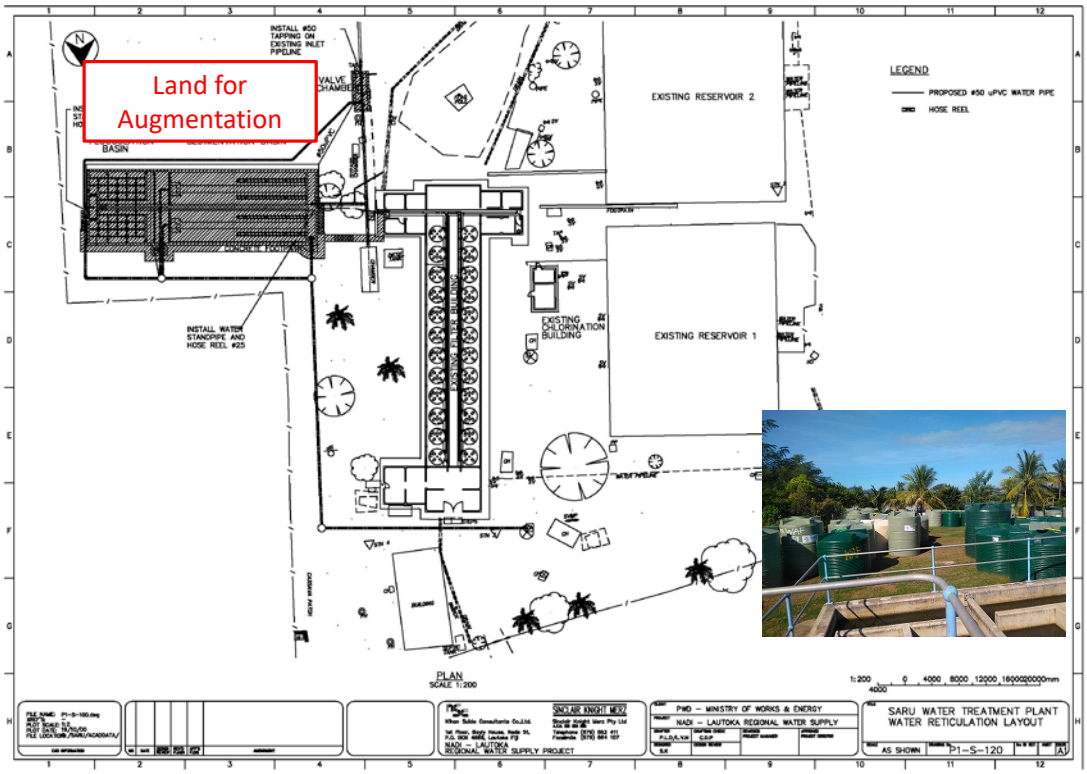


Figure 3-4.8 Proposed Land for Saru WTP Augmentation

- Improvement plan repair plan, renovation plan

Cracks are forming due to the advanced age of the reservoirs and causing leaks. WAF is planning repair works.

3-4-2-3 Buabua WTP

Countermeasures for issues uncovered at the Buabua WTP are as follows:

- Augmentation of WTP

According to the NLWMP33, augmentation of Buabua WTP is needed to meet future water demand, assuming that the water source can meet the demand. As shown in **Figure 3-4.9**, land for augmentation is available within the facility grounds. However, there is no further planning, such as processing methods and implementation schedules. Therefore, it is necessary to prepare a future augmentation plan for the WTP based on F/S and other surveys. In addition, there is no need for a temporary road for construction because the existing access road is being developed for the augmentation of the WTP.

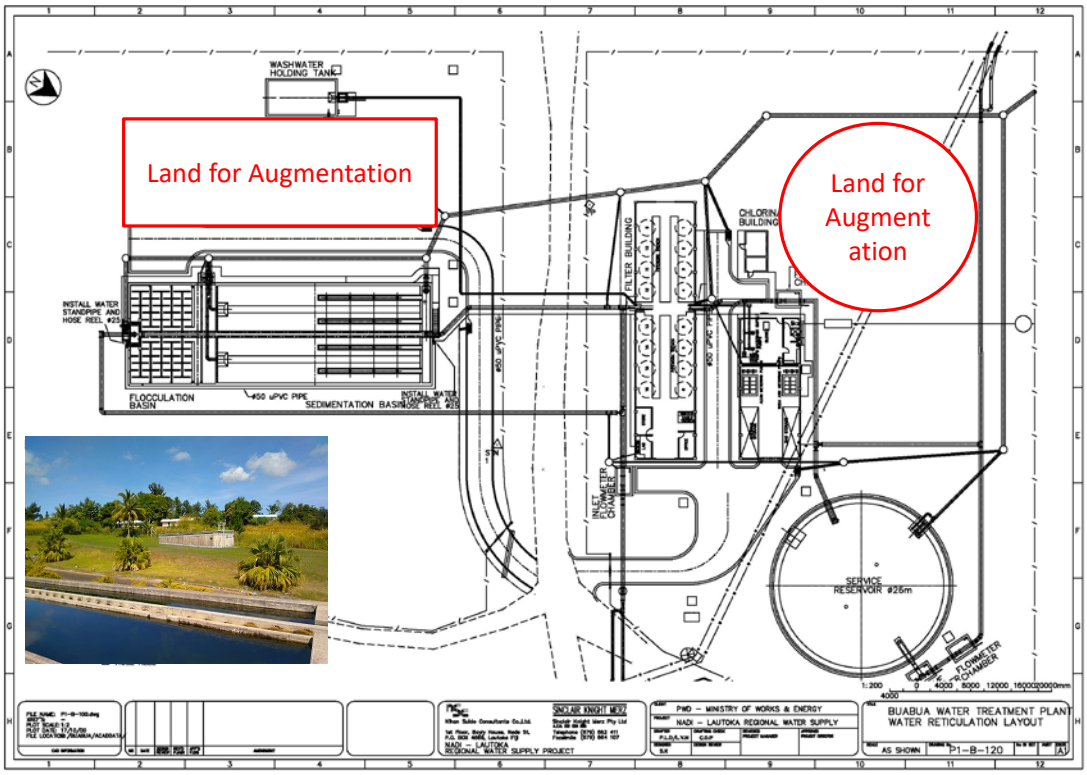


Figure 3-4.9 Proposed Land for Buabua WTP Augmentation

- Repair and renovation plan

Repair and renewal of equipment is necessary. Although WAF is aware of the situation, there are no serious impacts to water treatment function and repairs are not implemented due to budget constraints and other priorities.

3-4-3 Water Transmission and Distribution Facilities

Countermeasures for issues uncovered regarding water transmission and distribution facilities are as follows.

3-4-3-1 Distribution Reservoirs

- Rehabilitation of reservoirs by repairing cracks

Cracks due to the aging of reservoirs have resulted in leaks. Repair of the cracks is necessary. Repair plans are included in WAF annual plan, but are not implemented due to budget shortages.

- Rehabilitation/replacement of auxiliary equipment

Inlet valves and electrical equipment are malfunctioning and rehabilitation/replacement are required. Improvements are included in WAF annual plan, but are not implemented due to budget shortages.

- Improvement of hydraulic issues

Water supply from distribution reservoirs has become difficult due to increased water demand in the water supply areas; especially faraway areas. In these cases, reservoirs are bypassed and water is supplied directly from the source. Water supply areas need to be restructured taking into consideration reservoir capacities, water demand, topography and hydraulic factors so the distribution reservoirs can be effectively used to supply water.

3-4-3-2 Transmission/Distribution Mains

- Repair leaks in transmission/distribution mains and replacement of AC pipes

Water leakage in aging AC pipes is especially an issue. Although the renewal plans are being promoted in WAF, progress has been slow due to budget limitations.

- Survey and replacement of CI pipes

Clogging and leakage from joints is possible in the aging CI pipes. The conditions of CI pipes need to be surveyed. The pipes should be renewed if needed.

Chapter 4 Contents of Request on Augmentation between Vaturu Dam and Nagado WTP

4-1 Contents of Vaturu Dam Raising

Contents of the Vaturu Dam raising requested by GOF are as follows according to the concept note provided by the WAF:

Constructed in 1982, Vaturu Dam is the main source of water supply in the area with a capacity of 90ML/day. The location of the Dam in relation to treatment works, pipeline and storage areas allows for total gravity supply as the water flows from the Dam through the four Break-Pressure Tanks to Nagado WTP. Being the main supply for the Nadi/Lautoka Region, the existing storage capacity at the dam is heavily stressed to meet the current water demand requirements for the region, operating between 98ML/d to 110ML/d. The design capacity is 98ML/d.

To overcome the issues of inadequate water storage capacities at the dam, pipeline hydraulic issues and eradicate potential threats of water crisis in relation to the upcoming developments in the Nadi/Lautoka Region, WAF had engaged qualified external dam specialists to conduct dam safety studies and feasibility studies regarding plans for raising the Vaturu Dam spillway to store additional water to accommodate the demand during drought and as well as meet the demands for the upcoming developments. The recent dam studies show that the Vaturu Dam can accommodate extra storage capacity by raising the spillway. The additional storage capacity would ensure continuous delivery of 130ML/d to the Nadi/Lautoka Region and also eliminate the risks of water crisis during droughts.

GOF requests support from Japan to implement the above Vaturu Dam raising.

Contents of the requested dam raising was confirmed with MITDMMS, MOE and WAF through the study. It was confirmed that the Vaturu Dam raising (including the dam body and spillway raising) and improvement of the raw water trunk mains are among the urgent issues to be solved, like the Nadi River flood alleviation project. However, it was also confirmed that the dam raising will not be necessary if feasible water resources with capacities equivalent to the dam raising are found.

4-2 Contents of Vaturu / Nagado Raw Water Trunk Mains

Contents of the of the Vaturu/Nagado raw water trunk mains requested by GOF are as follows, according to the concept note provided by the WAF:

The system of the Vaturu/Nagado raw water trunk mains is gravity flow. There are 3 major critical sections, such as no-duplicated section/single trunk main with narrow tunnel and an elevated section (refer to **Figure 3-4.4**). The first critical section is a single-pipe section at “Tunnel 2”. This section has a transmission capacity of 100ML/day when the Dam is at full water level (527m). The capacity reduces to 89~92ML/day as water levels fall during the dry season. Capacity can be increased to 108ML/day by duplication of 385m of trunk main at Tunnel 2 and bypassing with a pipe line of 700mm diameter. Capacity can be further increased to 130ML/day if the second critical section is solved. However, land for pipe duplication is limited due to the topographical features of the area. The second critical section is located approximately 10,000 m from the Vaturu Dam. It is also a single-pipe section that reaches a high elevation of 448 m. Head loss/energy loss needs to be reduced by bypassing this section. The third critical section is the

aging pipe line which is also a vulnerable single-pipe section and 9.4km in length, near the Nagado WTP. Improving the redundancy of the trunk mains by the duplication of the pipe line is required.

The trunk main capacity can be increased to 130ML/day by eliminating these critical points to meet the increasing water demand of the Nadi/Lautoka area. The GOF requests assistance from GOJ for the implementation of these works.

Similar to the raising of Vaturu Dam, the current Project verified the contents of the requests with GOF (MITDMMS, MoE, and WAF). It was confirmed that the improvement of the trunk mains is required and highly urgent for meeting the demand of the Nadi/Lautoka area because demand is expected to continue to increase due to population growth and tourism development.

4-3 Contents of Augmentation at Nagado WTP

The contents of Nagado WTP augmentation works requested by GOF are described below.

“The Nagado Water Treatment Plant was constructed in the year 1982 with a treatment capacity of 45ML/day. The Nagado WTP is strategically important in supplying most of the bulk water to the tourist centres of Nadi Town and Lautoka City and the many hotels and resorts scattered along the Western coast as far south as Momi.”

To meet the demands of increasing population and development of hotels and resorts in the area, the treatment plant was upgraded with Japanese ODA loan in 2003 to achieve a treatment capacity of 90ML/day. The treatment plant was further upgraded and augmented in 2014 with two flocculation & coagulation basins to treat high turbidity water during the rainy season and also avoid frequent clogging of the filters resulting from the carryover of the flocs due to the over stretched treatment capacity.

With the addition of the flocculation basin, sedimentation capacity increased to 98-110ML/day. However, the treatment plant capacity of the WTP itself is currently 90ML/day. During high water demand, high turbidity, or during algae outbreaks, major issues with the treatment and water quality are experienced.

Suez Company started detailed design for construction of a package plant (20ML/day) in August 2019, commissioned by WAF for the augmentation of Nagado WTP.

This will increase total capacity to 110ML/day. In addition, installing duplicate trunk mains will increase transmission capacity to 130ML/day, and after the dam is raised, the planned facility capacity will be 120ML/day. From these improvements, an additional 10ML/day capacity development becomes possible.

In the future, further augmentation of the Nagado WTP or construction of a new WTP can be considered, but no concrete plans have been studied at this time.

Chapter 5 Non-Revenue Water Reduction

5-1 Current NRW Rate

NRW rates in Nadi/Lautoka are shown in **Table 5-1.1**.

Table 5-1.1 Changes in NRW Rates in Nadi/Lautoka

	1Q-2017	2Q-2017	3Q-2017	4Q-2017	1Q-2018	2Q-2018	3Q-2018	4Q-2018	1Q-2019
Nadi/ Lautoka	37.0%	33.7%	40.5%	34.3%	34.6%	34.4%	37.3%	40.8%	38.3%

Source: JICA Survey Team based on Interview of WAF

According to **Table 5-1.1** and a hearing survey of WAF staff, NRW rates in the Nadi/Lautoka area exceeded 50% until 2014. NRW rates were decreased to between 30% ~ 40% in 2015 after NRW reduction activities by WAF, Grassroots Technical Assistance projects by Fukuoka City, and replacement of old pipes were implemented. As of 2019Q1, NRW rate is 38.3%.

However, the NLWMP33 target of reduction of NRW rate to 20% by 2018 has not been achieved. Depending on the season, water supply does not meet demand due to the limited production capacities of the existing facilities.

5-2 Necessity of Reviewing Planned Scenarios

In the NLWMP33, development of new water resources for the expansion of Saru and Buabua WTPs (2016), development of water sources for a new WTP (2018 ~ 2023), and augmentation of Nagado WTP (2016 ~ 2017) and augmentation of Saru and Buabua WTP (2015 ~ 2016) were planned. With the exception of Nagado WTP (2016 ~ 2017), the project plan has been delayed. Particularly, reduction of NRW rate to 20% by 2018 has not been achieved, and it is presumed that actual water demand greatly exceeds predicted demand.

Requirement for NRW reduction in terms of water demand forecast is shown in **Figure 5-2.1**.

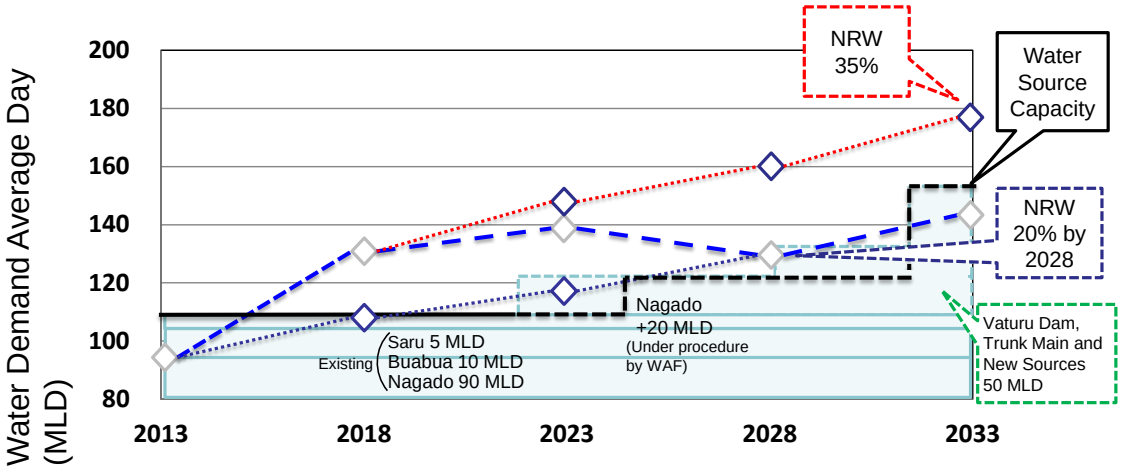


Figure 5-2.1 Requirement for NRW Reduction in terms of Water Demand

NRW reduction in the water demand plan (**Table 3-2.1**) finalized in the NLWMP33 has been

delayed. If NRW rates are not improved by 2033 (**Table 5-2.1**), water demand will greatly exceed planned supply capacity by 2023 (Scenario X, created by JICA Survey Team). If the planned development of water sources and augmentation of WTPs are not implemented, it is expected that measures such as water supply restrictions will be required.

Table 5-2.1 Water Demand Forecast of NLWMP33 (Scenario X NRW 35% by 2033)

Description	Unit	2013	2018	2023	2028	2033
Total Population	No	169,643	194,366	222,776	244,888	269,179
Population Covered	No	152,272	174,459	203,259	223,407	245,550
Non-revenuew Water (NRW)	%	39.51	35	35	35	35
Domestic Comsumption	ML/D	38.38	49.91	54.79	60.15	66.05
Commercial Consumption	ML/D	17.99	32.13	36.76	39.19	44.64
Government Consupmtion	ML/D	1.70	1.94	2.23	2.56	2.95
Total Consumption Avg Day	ML/D	58.07	83.98	93.78	101.90	113.64
Total Consumption Peak Day	ML/D	63.88	92.38	103.16	112.09	125.00
Non-revenuew Water (NRW)	ML/D	37.93	45.22	50.50	54.87	61.19
Treatment Plant Losses	%	5	5	5	5	5
Water Demand for Average Day	ML/D	96.00	129.20	144.28	156.77	174.83
Raw Water required from sources on Average Day	ML/D	100.80	135.66	151.49	164.61	183.57
Water Demand for Peak Day	ML/D	102.00	138.00	158.70	172.45	192.31
Raw Water required from sources on Peak Day	ML/D	106.89	144.47	132.93	144.45	161.08
Average Water Production	ML/D	96.00	96.00	96.00	96.00	96.00

Source: JICA Survey Team based on NLWMP33

Therefore, reduction of NRW is an urgent task of the highest priority. As of now, the immediate objective is to implement NRW countermeasures to reduce NRW rate to 20% by 2028 as shown in Scenario 4 of the Water Demand Plan (**Figure 5-2.1**). NRW reduction from 35% to 20% will save 30ML/day in 2028.

Table 5-2.2 Water Demand Forecast of NLWMP33 (Scenario 4)

Description	Unit	2013	2018	2023	2028	2033
Total Population	No	169,643	194,366	222,776	244,888	269,179
Population Covered	No	152,272	174,459	203,259	223,407	245,550
Non-revenuew Water (NRW)	%	39.51	35	30	20	20
Domestic Comsumption	ML/D	38.38	49.91	54.79	60.15	66.05
Commercial Consumption	ML/D	17.99	32.13	36.76	39.19	44.64
Government Consupmtion	ML/D	1.70	1.94	2.23	2.56	2.95
Total Consumption Avg Day	ML/D	58.07	83.98	93.78	101.90	113.64
Total Consumption Peak Day	ML/D	63.88	92.38	103.16	112.09	125.00
Non-revenuew Water (NRW)	ML/D	37.93	45.22	40.19	25.48	28.41
Treatment Plant Losses	%	5	5	5	5	5
Water Demand for Average Day	ML/D	96.00	129.20	133.97	127.38	142.05
Raw Water required from sources on Average Day	ML/D	100.80	135.66	140.67	133.74	149.15
Water Demand for Peak Day	ML/D	102.00	138.00	143.00	140.11	156.26
Raw Water required from sources on Peak Day	ML/D	106.89	144.47	150.51	144.45	161.08
Average Water Production	ML/D	96.00	96.00	96.00	96.00	96.00

Source: NLWMP33 (Scenario 4 NRW 20% by 2018)

5-3 Proposal for Target NRW Rates

The above sections discussed the importance of reducing NRW rate to 20% by 2028. At the same time, although the feasibility of development of new water sources planned in NLWMP33 was examined (**Section 3-3-1-2**), the development of these sources is currently deemed difficult.

If NRW rates can be reduced to 15% by 2033, water demand can be met with raising of the Vaturu Dam, duplication of trunk mains, and water source development (10ML/day).

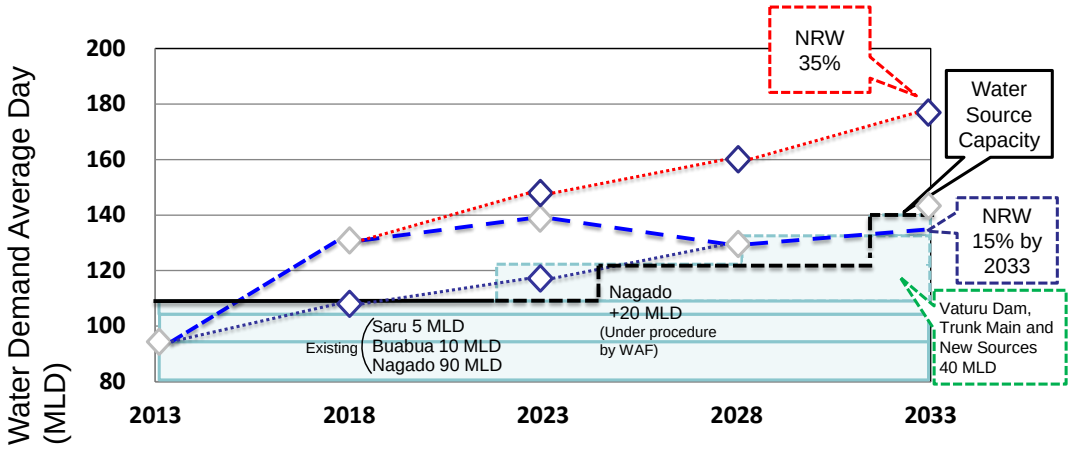


Figure 5-3.1 Requirement for NRW Reduction in Terms of Water Demand

Table 5-3.1 Water Demand Forecast of NLWMP33 (NRW 15% by 2033)

Description	Unit	2013	2018	2023	2028	2033
Total Population	No	169,643	194,366	222,776	244,888	269,179
Population Covered	No	152,272	174,459	203,259	223,407	245,550
Non-revenuew Water (NRW)	%	39.51	35	30	20	15
Domestic Comsumption	ML/D	38.38	49.91	54.79	60.15	66.05
Commercial Consumption	ML/D	17.99	32.13	36.76	39.19	44.64
Government Consupmtion	ML/D	1.70	1.94	2.23	2.56	2.95
Total Consumption Avg Day	ML/D	58.07	83.98	93.78	101.90	113.64
Total Consumption Peak Day	ML/D	63.88	92.38	103.16	112.09	125.00
Non-revenuew Water (NRW)	ML/D	37.93	45.22	40.19	25.48	20.05
Treatment Plant Losses	%	5	5	5	5	5
Water Demand for Average Day	ML/D	96.00	129.20	133.97	127.38	133.69
Raw Water required from sources on Average Day	ML/D	100.80	135.66	140.67	133.74	140.38
Water Demand for Peak Day	ML/D	102.00	138.00	143.00	140.11	147.06
Raw Water required from sources on Peak Day	ML/D	106.89	144.47	150.51	144.45	161.08
Average Water Production	ML/D	96.00	96.00	96.00	125.00	135.00

Source: JICA Survey Team based on NLWMP33

5-4 Future WAF Policies for NRW Countermeasures

WAF will continue to implement integrated meter management, leak reduction program, replacement of supply lines and valves, pressure management, GIS and water modelling in order achieve the 20% leakage rate targeted in the three-year plan.

Recent NRW reduction activities WAF has implemented nationally is shown in **Table 5-4.1**. According to the hearing surveys of the WAF, the Western Regions allocated about one-third of the whole budgetary support from GOF.

Table 5-4.1 Budget Allocation of NRW Reduction Activities Implemented by WAF Nationally

Activity	2017-2018	2018-2019	2019-2020
Integrated Meter Management	6,000,000	5,200,000	2,000,000
Leak Reduction Program	5,900,000	2,500,000	1,000,000
Service Pipe Replacement	1,000,000	2,300,000	500,000
Boundary Valve Replacement	250,000	100,000	375,000
Air Valve Replacement/ Installation	500,000	100,000	375,000
Data Loggers	450,000	-	-
Pressure Management	700,000	500,000	500,000
Project Management Cost & Other Cost	-	500,000	-
GIS Program	1,215,000	1,300,000	500,000
Water Modelling	304,200	700,000	900,000
Total	8,119,200	8,190,200	4,150,000

Unit: FJD

Source: JICA Survey Team based on Interview of WAF

Although NRW has been reduced by WAF's NRW reduction measures, further reductions are required to achieve the 20% targeted in the three-year plan and the NLWMP33.

According to hearing surveys of WAF staff, the plan for next year includes an NRW reduction program that aims reduce NRW to 30% at national average. As an NRW countermeasure, complaints and reports about leakage and pressure will be examined, NRW countermeasure zones will be prioritized, and countermeasures will be implemented from the highest priority areas.

Priorities in the Western Region are (1) Saru-Vuda (2) Narewa (3) Nawaka (4) Sabeto (5) Korovuto (refer to **Figure 5-4.1**)

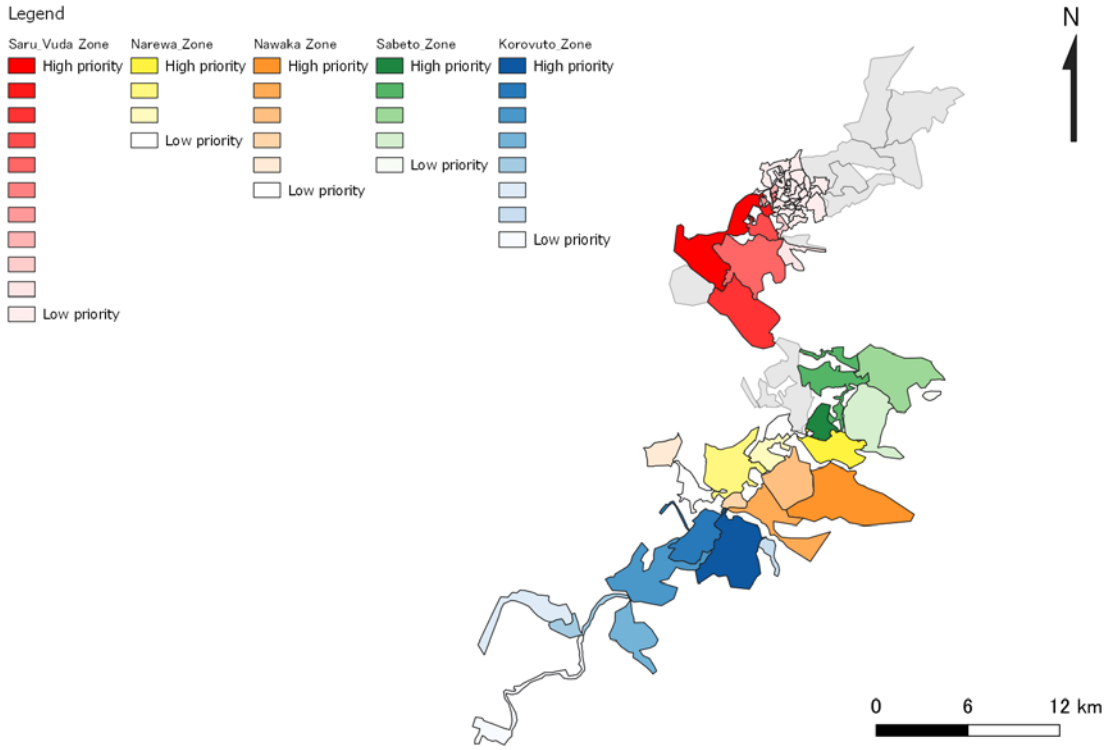


Figure 5-4.1 Priorities in the Western Region

Source: JICA Survey Team based on Interview of WAF

The survey contents include visual inspection of the leakage conditions, confirmation of operational conditions of meters and valves, renewal of old meters, and identification of pipe leak location and renewal. Flow and pressure surveys by hydraulic separation of survey areas are planned. About 200m/day, or 2 weeks for each DMA are expected to be surveyed. The 34 DMAs of the Western Region are expected to take 15 months.

For NRW countermeasures, analysis of water distribution volumes is also important and installation of meters in the network to measure distribution flow and pressure are needed. DMA meter location is shown in **Figure 5-4.2**.

In the Western Region, about 70% of DMA meters and 10% of data loggers have been installed. Further development is needed to conduct water distribution analysis.

Figure 5-4.2 Location of DMA Meter

Source: JICA Survey Team based on Interview of WAF

In addition to leakage reduction, improvements other than facility aspect such as meter reading and bill collection system are also necessary for NRW reduction.

Furthermore, until water supply facilities, including water sources and WTPs, are fully developed, activities are required to encourage users to save water, reduce consumption, and carefully share limited water resources.

The current NRW rate is approximately 38%. Assuming that 33% is due to water leakage, and the remaining 5% is due to other reasons such as meter reading and bill collection, in order to achieve an NRW rate of 20%, it is necessary to enhance meter reading and bill collection, to improve existing transmission and distribution mains and reservoirs, and to improve about 13,000 house connections. In order to achieve the 15% NRW rate by 2033, an additional 12,000 connections must be improved.

A majority of the existing house connections are concentrated in the densely populated areas shown in **Figure 5-4.3**. It is estimated that the 2028 targets can be met with prioritized improvement works in this area.

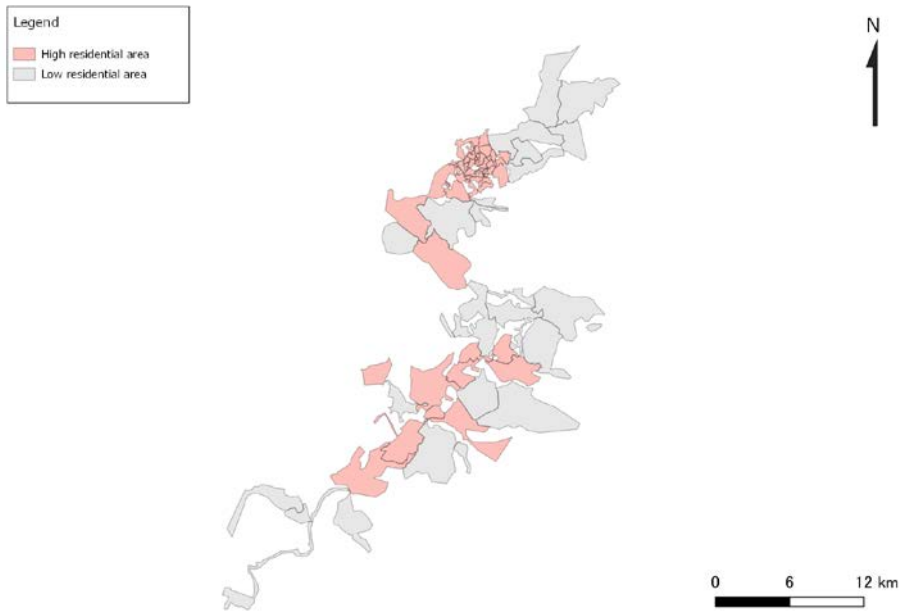


Figure 5-4.3 High Population Density Areas in the Western Region

As shown in **Figure 5-4.4**, WAF aims to achieve 20% NRW rate by updating and improving the existing transmission and distribution pipes and supply pipes for house connection in priority areas.

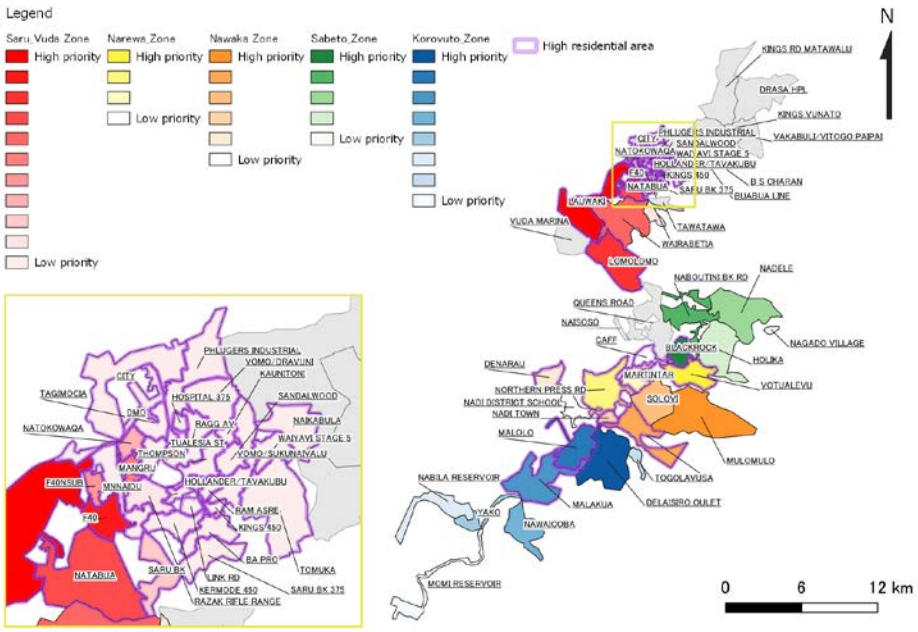


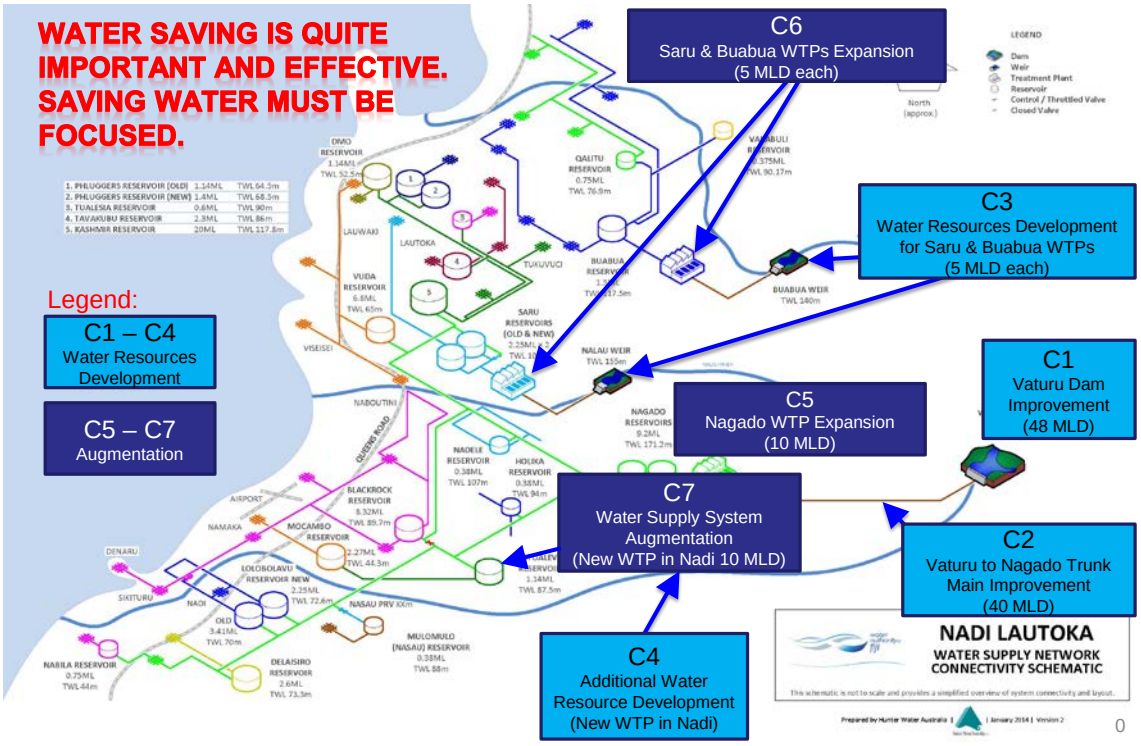
Figure 5-4.4 Priority Areas of NRW Reduction in the Western Region

Chapter 6 Recommendation for Cooperation Strategy in the Water Supply Sector

Based on conditions of existing facilities, whether or not master plans and business plans were implemented, and results of water source surveys and water pipe surveys, possible projects were extracted, and strategies for cooperation were considered.

6-1 Augmentation Program

Figure 6-1.1 shows a summary of the projects that the water supply sector in the Nadi/Lautoka area should implement in the future.



	Component	Description	Possible Additional Capacity MLD
Water Resources Development Water Resources Development	C1	Vaturu Dam Improvement	48MLD
	C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	40MLD
	C3	Water Resources Development for Saru & Buabua WTPs	10MLD
	C4	Additional Water Resources Development for New WTP in Nadi	10MLD
Augmentation	C5	Nagado WTP Expansion	10MLD
	C6	Saru & Buabua WTPs Expansion	10MLD
	C7	Water Supply Augmentation by New WTP in Nadi	10MLD

Figure 6-1.1 Required Operations of the Future Water Supply Sector

(1) C1：Raising the Spillway at Vaturu Dam

Any discussion related to raising the spillway at Vaturu Dam must also consider the Nadi River Flood Control Project, the highest priority project in Fiji, and include the possibility of creating

a “multi-purpose facility by raising the spillways (addition of flood control function)”. Specifications of the assumed elevation increase of the Vaturu Dam are shown in **Table 3-4.1**.

(2) C2：Duplication of Trunk Mains

For the trunk mains, WAF has been conducting the detailed survey, started in 2019 and planned to be completed by the end of May 2020, that includes preliminary design and preparation of tender documents by outsourcing, and seek funding based on the results. However, the urgency and importance associated with the raising of the Vaturu Dam is quite high. Implementing one component without the other will not produce effective results.

(3) C3：Water Source Development for Saru WTP and Buabua WTP Augmentation

In order to respond to the increase in Lautoka water demand, WAF is considering Teidamu as a new water source for the augmentation of Buabua WTP. However, field surveys have raised concerns about water shortages during the dry season. It is necessary to develop new water sources to augment Saru WTP and Buabua WTP.

(4) C4：Water Source Development for Augmentation of New WTP

Although WAF has requested raising the spillway for Vaturu Dam, there is a long lead time in its implementation. In order to meet water demand during this time, the survey on the development of Votualevu water source was implemented by outsourcing to HunterH2O Ltd. (Australian consulting company). According to the survey result, further hydrology studies are required. It is not considered that the alternative water resource is feasible at the moment.

(5) C5：Augmentation of Nagado WTP

The augmentation of the Nagado WTP was also requested by GOF, but WAF is already planning to introduce the Suez designed flotation-coagulation pond and pressure filter in August 2019. After raising the Vaturu Dam and duplicating trunk mains, the facility capacity will be improved, and capacity can be increased by an additional 10ML/day, up to the 120ML/day outlined in the NLWMP33.

(6) C6：Improvement of Lautoka Water Supply Capacity through Augmentation of Buabua WTP and Saru WTP

The Nadi/Lautoka water supply system is interconnected. Therefore, the augmentation of Buabua WTP will also be a measure to reduce the amount of water sent from Nagado WTP to Saru WTP. Both Buabua WTP and Saru WTP have ample space for augmentation works. Addition of water treatment facilities in keeping with development of new water sources is possible.

(7) C7：Improvement of Nadi Water Supply Capacity through Development of New WTP

Construction of a new WTP (**Figure 6-1.2**) based on the development of the Votualevu water source, which was surveyed/examined by HunterH2O Ltd, an Australian firm, is currently under consideration. According to the survey, water must be released from the Vaturu Dam during the dry season for the development of Votualeve water resource. The development also requires future hydrological studies for optimal operation.

Location of Votualevu intake and New Votualevu WTP

Proposed site for the New Votualevu WTP

Figure 6-1.2 Summary of Votualevu Intake and WTP

6-2 NRW Reduction Operations

As mentioned in **Chapter 5**, reduction of NRW and secure revenues are essential to deal with future water shortages. The following operations are given for NRW reduction.

Table 6-2.1 NRW Reduction Operations (Including Increasing Billing and Collection Rate)

	Component	Description
NRW Reduction	C8	NRW Reduction to 20%
	a	Rehabilitation of Old AC and CI pipes
	b	Rehabilitation of Reservoirs and Pipeline
	c	Improvement of Service Connection and Billing Collection
	d	Public Awareness and Education

(1) C8-a：Rehabilitation of Old AC and CI pipes

The NRW rate of Nadi/Lautoka in 2019 is approximately 38%. AC pipes are used in the existing water distribution system, and water leakages have developed due to aging of the pipes and load on the joints. For existing AC pipes, renewal is planned in the NLWMP33 and the three-year plan. However, progress is made in accordance with the overall budget of WAF, and more than 75% of renewals planned in NLWMP33 have not been implemented so far. As the development of new water sources is currently difficult, reducing NRW is an effective approach to meet the ever-increasing water demand.

In addition, in order to implement measures efficiently within the limited budget, procurement of equipment and tools for the identification of leak points and weaknesses in the supply network, as well as establishment of a monitoring system are important.

(2) C8-b：Rehabilitation of Reservoirs and Pipeline

Leaks are occurring due to aging of reservoirs and reservoir facilities. Repairs of reservoirs and replacement of equipment are necessary. In addition, by updating the transmission/distribution network, restoration of the water supply system and reduction of NRW become possible.

(3) C8-c: Improvement of Service Connection, Billing, and Collection

In addition to updating house connections (water meters and supply line), improvements of soft components such as meter reading and bill collection system are needed to reduce NRW.

(4) C8-d: Public Awareness and Education

Activities to encourage users to save water, reduce water consumption, and carefully share limited water resources should also be carried out.

6-3 Considerations

(1) Necessity of simultaneous implementation of water source development and WTP Augmentation

Implementation of components C3 to C7 is considered to be difficult without progress in water source development.

(2) NRW Reduction

In order to formulate an overall plan for NRW reduction, it is necessary to first analyze the factors causing NRW in each area. In addition, it is necessary to systematically implement the renewal of distribution pipes and water supply pipes, countermeasures against water theft, replacement of defective meters, and improvement of meter reading accuracy. In order to collect basic data, it is necessary to install flowmeter and pressure sensor for measurement.

(3) NRW Reduction Activity by WAF

In order to achieve the target of reducing NRW, continuous implementation of components of C8-c and C8-d by WAF is also necessary.

Chapter 7 Japanese ODA loan Projects in the Water Supply Sector

7-1 Overview of Fundamental Information Required for Japanese ODA Loan Projects

In order to be considered for a Japanese ODA loan, the project needs to contribute to economic and social development and economic stability. Therefore, the following items need to be examined in this study and subsequent preparatory survey.

① Confirm consistency, priority and urgency with high level planning
② Soundness of contents: contents are sound and sufficient to achievement project objectives
③ Maturity of the project plan
④ Capacity of the implementing agency to achieve objectives, possibility of achieving project objectives
⑤ Consensus between residents and other stakeholders
⑥ Consideration of vulnerable populations in planning

7-2 Examining the Need for the Project

7-2-1 Scope

The potential scope expected in Japanese ODA loan Project is shown in **Table 7-2.1**.

Implementation of components C3~C7 given in Chapter 6 is considered to be difficult without progress in water source development. In order to achieve the target of reducing NRW, continuous implementation of components of C8-c and C8-d by WAF is also necessary.

Table 7-2.1 Scope of Japanese ODA Loan Project

Component		Contents	Consulting Service
C1	Vaturu Dam Improvement	Raising spillway of the Vaturu Dam by 5m including the dam body and related facilities	Detailed design, support of tendering, construction supervision
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	Duplication of 3 single pipe sections Section 1: Duplication and bypassing Length 385m (tunnel section) Diameter 700mm Section 2: Bypassing of high elevation (448m) section, 10,000 meters from observation point of Vaturu Dam. Section 3: Aged pipes around Nagado WTP. Duplication with large diameter pipes.	Detailed design, support of tendering, construction supervision
C8	NRW Reduction to 20%	a) Renewal of old pipes b) Renewal of reservoirs, transmission/distribution lines c)Renewal of house connections	a, b, c) Preparatory survey, detailed design, tendering, construction supervision c) Water distribution analysis, NRW reduction plan, improvement of meter reading, improvement of bill collection system.

7-2-2 Development Indicators and Benefits

The improvements to development indicators and benefits expected from the implementation of the water supply sector improvements are shown in **Table 7-2.2**.

Table 7-2.2 Project Benefits (Draft)

Item	Unit	2018 (Baseline Value)	2033 (Target Year)
Production (Day Ave.)	ML/day	105	142.05
NRW Rate	%	37.93	15
Number of connections	no.	34,891	49,110
Supply Area	-	Nadi and Lautoka	Nadi and Lautoka

Qualitative and quantitative effects of each component of the Project is shown in **Table 7-2.3**. Operational effects indicators are shown in **Table 7-2.4**.

Table 7-2.3 Benefits of each Project Component (Draft)

	Component	Benefits
C1	Vaturu Dam Improvement	The transmission capacity of the trunk main between Vaturu Dam and Nagado WTP will increase from the current 90ML/day to 130ML/day.
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	The transmission capacity of the trunk main between Vaturu Dam and Nagado WTP will increase to 130ML/day. Weaknesses caused by old infrastructure and critical sections will be reduced, and incidence of water shutdown will decrease to less than half of 2018 (5 times).
C8	NRW reduction	NRW will be reduced to 20% in the Nadi/Lautoka area. NRW will remain at 20% after completion of the project.

Table 7-2.4 Operational Effects Indicators (Draft)

	Component	Item	Unit	2018	Target (Target Year)
C1	Vaturu Dam Improvement	Capacity (Day Ave.)	ML/day	90	138 (2033)
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	Capacity (Day Ave.)	ML/day	90	130 (2028)
C8	NRW reduction operations	NRW Rate	%	38.3	20 (2028) 15 (2033)

In addition to implementing the activities of C1 and C2, the capacity of the Nagado WTP must be increased from 110ML/day to 120ML/day in order to achieve targets of C1 and C2.

7-2-3 Estimated Project Cost

Estimated cost of the project scope is given in **Table 7-2.5**. The project cost is estimated based on the scope given in the NLWMP33. Thorough evaluations through future F/S and Preparatory Surveys are needed.

Table 7-2.5 Estimated Project Cost

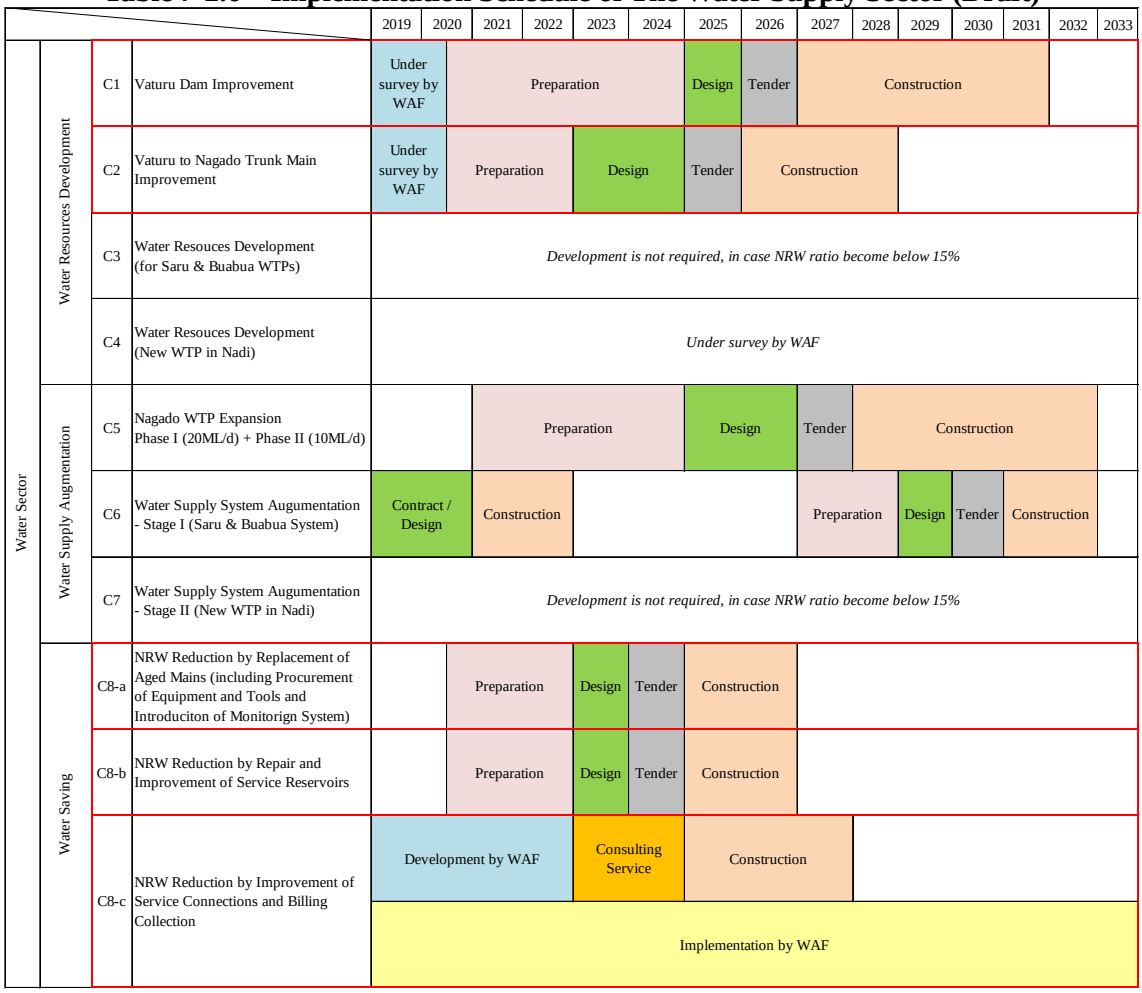
	Scope	Estimated Cost (thousand FJD) [converted thousand JPY]	
		Project Cost	Consultant Service
C1	Vaturu Dam Improvement	146,000 [7,300,000]	18,000 [900,000]
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	67,100 [3,355,000]	9,000 [450,000]
C8	NRW Reduction to 20%		
a	Rehabilitation of Old AC and CI pipes	53,200 [2,660,000]	5,200 [260,000]
b	Rehabilitation of Reservoirs and Pipeline	34,400 [1,720,000]	3,440 [172,000]
c	Improvement of Service Connection and Billing Collection	24,700 [1,235,000]	2,470 [123,500]

1FJD=50.2281JPY (JICA Monthly exchange rate in JPY 2019, February 2020)

7-2-4 Project Implementation Schedule (Draft)

Table 7-2.6 shows the projects that should be implemented in and the implementation schedule (draft).

Table 7-2.6 Implementation Schedule of The Water Supply Sector (Draft)



7-3 Related Technologies

7-3-1 Technical Options for ODA Loan Projects

Related technologies which Japanese private firms have technical advantages are summarized in **Table 7-3.1**. However, ODA loan project is in accordance with the Guidelines for Procurement under ODA loans.

Table 7-3.1 Technical Options Water Supply Sector

Name	Specific Features	Overall Advantage	Japanese Advantage	Category
Pump	Intake pump Transmission and Distribution pump	Pump	High reliability based on a lot of experience High quality facility by suitable operation and maintenance High durability more than other country's one Saving energy by high efficiency	Intake, Transmission & Distribution
PC tank	1) Top board assembling by dome method 2) Fixed sidewall base method	1) Maintenance for internal corrosion is not required 2) Decrease of leakage risk at sidewall base	1) High reliability based on a lot of experience 2) Prevention of construction delays by detail process management 3) High safety through meticulous safety control 4) High quality construction work and products through attentive quality control	Distribution
Curved and long-distance jacking method (Middle - Large diameter)	Pipe jacking method (1 span > 500 m, Include multiple curve and/or sharp curve in 1 span)	Pipe can be installed where open cut method can't be applied. Pipe can be installed under heavy traffic road. Decrease number of pipe jacking shafts by applied to long distance and curve.	1) High reliability based on a lot of experience 2) Prevention of construction delays by detail process management 3) High safety through meticulous safety control 4) High quality construction work and products through attentive quality control 5) Construction accuracy control for long distance / curved pipe jacking method 6) Construction accuracy control under soft ground condition.	Water supply system Wastewater system
Underground object survey (combine used pipe jacking method)	Search for underground obstacles	Can avoid underground metal obstacles (e.g. Unexploded ordnance etc.) while conducting pipe jacking method	Foreign companies haven't had experience as used the technology that search device was installed pipe jacking machine.	Water supply system Sewerage system
Non-suspension water supply method	Can conduct construction work without water suspension	New pipe can be connected or replaced to existing pipe without water suspension	1) High reliability based on a lot of experience about large pipe diameter 2) Prevention of construction delays cause of construction company 3) High safety through meticulous safety control	Distribution pipeline

Name	Specific Features	Overall Advantage	Japanese Advantage	Category
			4) High quality construction work and products through attentive quality control	
Ducktail Iron pipe	Earthquake resistant joint	Prevention of leakage due to pipe escape by resistance escape of earthquake resistant joint.	1) High reliability based on a lot of experience 2) High quality products through attentive quality control	Pipeline
Sludge scraper at WTP	Sludge scraper for sedimentation pond	Can be collected sludge in sedimentation pond automatically.	1) High ability of sludge scrape 2) Small space for driving mechanism 3) Decrease of exchange frequency for consumable parts	Water treatment system
Sludge disposal at WTP	Filter press for long-term dewatering	1) Suppression of carcinogenesis risk due to no chemical injection 2) Decrease of sludge disposal cost through efficiency dewatering	1) Dewatering machine and system have saving energy and high efficiency are developed 2) High reliability based on a lot of experience 3) Preventive measure for construction delays due to bring low spec machine 4) High safety through meticulous safety control 5) High quality products through attentive quality control and high reliability service after installation	Water treatment
Control valve	Two-stage closing valve	Saving space through no need to install a secondary valve including a bypass pipe.	1) High reliability based on a lot of experience 2) High quality products through attentive quality control 3) Foreign suppliers' valves don't have this mechanism	Distribution pipeline
Free surface auto-reducer tank unit for pressure absorbing	Can be released water pressure maximum 1.6 MPa automatically without battery	Can be released water pressure without battery, maintenance through unitized. Suppression of cavitation.	1) Unitized product 2) A lot of experience	Distribution and water supply system
SCADA system	1) Treatment monitoring and control system at WTP 2) Water supply monitoring and control system for wide area 3) Monitoring and control system for Water distribution	Can be monitored and remote-controlled water treatment, transmission and distribution systems. Some control system can be automated.	1) Can be considered to detailed request to build a system through sufficient experience and accumulated research. 2) Can be possible to predict accidents in advance by using a prediction system that uses big data in the future. 3) Can be applied to prevent construction delays through precise process control in the future. 4) High quality products	Whole system of water supply

Name	Specific Features	Overall Advantage	Japanese Advantage	Category
	system		through attentive quality control and high reliability service after installation	

7-3-2 Advantages of Japanese Technologies

Advantages of Japanese technology to each Project component are summarized in **Table 7-3.2**.

Table 7-3.2 Advantages of Japanese Technologies to Each Component

	Project Scope	Applicable Japanese Tech
C1	Vaturu Dam Improvement	-
C2	Vaturu Dam to Nagado WTP Trunk Main Improvement	Ductile pipe Hot tapping Control valves Pipe jacking
C8	NRW Reduction to 20%	Ductile iron pipe Double-layer HDPE pipe, Saddle for house connection Branch valve Non-suspension water supply method

Trenchless/tunneling methods have advantages for the construction of trunk mains in the mountainous areas. Compared with construction methods that are affected by the surrounding terrain, trenchless/tunneling methods can achieve optimal gradients for water transmission while decreasing construction difficulty and risk of accidents. Non-suspension water supply methods are essential when working on trunk lines that have large impacts when interrupted. For distribution lines, replacement of PVC pipes with ductile iron or HDPE pipes is effective for implementing NRW countermeasures.

7-4 Eligibility for the GCF

The JICA Survey Team examined the applicability of the GCF for the current project by comparing it with past GCF projects of similar scale and scope. The “Fiji Urban Water Supply and Wastewater Management Project” is one of the GCF financed projects in Fiji. The project was for building and renovating infrastructure to improve access to safe water and sewerage systems in the greater Suva area of Fiji. Scope of the project was creating a new river water intake station on the River Rewa and improving the Kinoya wastewater treatment plant and associated sewer coverage. Establishment of the water supply system was implemented by an ADB loan, and creating river water intake etc. was implemented by GCF. In other words, conventional development projects were implemented as a loan project and climate change adaptation measures were financed through GCF funding. Therefore, the JICA Survey Team interviewed ADB and MOE to collect information on the current situation of the projects, requirements of the project formulation, investment criteria and so on in order to examine the eligibility Vaturu Dam raising project for GCF.

FDB (Fiji Development Bank) is the only Direct Access Accredited Entity in Fiji. The size of project handling is set as “Micro”, which indicates the project scale is less than 10 million USD. The concept notes of the “Fiji Climate Friendly House Loan Programme”, which was developed

by FDB in 2016, and the "Strengthened Weather and Climate Services for Resilient Development for Pacific Islands", which is the regional project for the pacific islands, were submitted. However, the funding proposals of these projects are not approved. Moreover, the project of "Urban traffic by the bus company" is one of the recent GCF candidate projects in Fiji, even though it is at the stage of preparation of the GCF concept note supported by the GGGI (Global Green Growth Institute). The GOF tried to apply for the GCF for the Nadi Flood Alleviation Project, but it did not choose GCF eventually and formulate.

As for the project formulation, congressional authorization for the GCF will take less time compared with Japanese ODA loan according to the MoE. Although some risks for the Vaturu dam and the trunk main, such as overgrowth of algae in the dam lake and increase of disaster risk to the vulnerable pipeline, can be associated with climate change, clear demonstration of the direct relationship between those phenomena and climate change on scientific grounds is a challenge.

In order to show the relevance to climate change, it is necessary to confirm changes and others in past drought frequency. In addition, changes in meteorological data, such as cyclone frequency and intensity, temperature, and evapotranspiration, will be required in future detailed surveys. On the other hand, sea level rise due to climate change is not considered to have a significant effect on the spillway (at an altitude of 527m) at Vaturu Dam in the mountains and the Nagado WTP (at an altitude of about 171m).

Although there is no investment threshold, the above-mentioned program for the Kinoya WWTP mentioned above, out of the total investment of 222.00 million USD, ADB burden is 67.70 million USD (30.5%), EIB burden is 38.00 million USD (17.1%), GCF funding is 31.04 million USD (14.0%), and the Government of Finland is 85.26 million USD (38.4%)[4].

7-5 Assistance by Other Donors

7-5-1 Assistance by Development Agencies

7-5-1-1 USA, Australia, New Zealand

According to WAF, there are no assistance projects by US, Australia, or New Zealand in the water or wastewater sectors in Fiji. However, survey and design projects, and construction through international competitive bidding are being outsourced to Australian consultant companies through WAF funding. They are summarized in **Table 7-5.1**.

[4] Approved funding proposal, https://www.greenclimate.fund/projects/fp008

Table 7-5.1 Survey and Design Works Outsourced to Foreign Companies

Item	Project Description	Project Benefit	Year Completed	Project Budget (FJD)	Consultant /Contractor
1	F/S on Nagado Trunk main	Improvement of Trunk main	Ongoing, To be completed in May, 2020	1.1M	HunterH2O Australia
2	Hydraulic capacity assessment of Vaturu to Nagado Trunk main	Understanding of issues and examining of countermeasures			
3	F/S on Votualevu new water resource	Finding the new water resource	2019	867,607.00	HunterH2O Australia
4	F/S on Vaturu Dam safety study	Improvement of water supply capacity	2016		GHD Australia
5	Yield analysis and reservoir optimization assessment	Improvement of water supply capacity	2005		Maunsell Australia
6	F/S on de-siltation of Vaturu dam		2019 – ongoing (waiting for a contract signing as of January 2020)		GHD Australia
7	Procurement of aerator of Vaturu dam		Ongoing To be completed in 2021		GHD Australia

Source: JICA Survey Team based on Interview of WAF

7-5-1-2 ADB, EIB, GCF

"The Fiji Urban Water Supply and Wastewater Management Project" is being implemented with ADB, EIB, and GCF support. The project will construct a new 40ML/day WTP to enhance the Suva-Nausori water supply system. Augmentation, repairs, and expansion of the service area for the Kinoya WWTP are also planned to support the wastewater sector.

For the Suba/Nausori Water Supply System, a contract was signed with Sinohydro Co. (China) in 2019 and construction is planned from 2020 until 2021. After construction, Sinohydro will operate and maintain the system for 7 years before handing over to WAF. In addition, detailed design for the Kinoya WWTP will be completed in 2020 (SMEC Co, Australia), and contract finalization is scheduled in 2021.

"The Fiji Urban Water Supply and Wastewater Management Project" is outlined in **Table 7-5.2**.

Table 7-5.2 The Fiji Urban Water Supply and Wastewater Management Project

Project title	Rewa River Water Supply Scheme (Construction Phase)
Outline of the project	Construction of a new 40MLD Water Treatment Plant, rising main, reservoir and gravity main that will increase the volume of safely treated drinking water in the Greater Suva Area. The plant in a second stand will further be expanded to an 80MLD Plant
	Tranche1: Construction: 1) Rewa River WSS Water Intake and WTP Design and Construction Operation, 2) Transmission Main & Reservoir, 3) Water Supply Improvement (NRW Reduction), Consultant service: 1) Project Preparatory Work and Capacity Building, Design, 2) Documentation & Tendering of Rewa River Water Supply Scheme & Kinoya Wastewater Treatment Plant Upgrade
	Tranche2: Construction: 1) Kinoya WWTP Upgrade, 2) Kinoya WWTP Operation & Maintenance Support, 3) Ex Pumping Station Upgrade, 4) Ex Wastewater Main Upgrade Consultant service: 1) Survey, Investigation, Detailed & Tendering of Wastewater System Upgrade & Extension, 2) Super vision for Kinoya WWTP Upgrade
Name of donor	ADB, GCF, EIB and Government of Fiji
Project period	2019 – 2021 (Expected Completion for Construction only)
Project cost in USD with breakdown	Tranche 1 (Construction) USD 66,659,731.13 – Design and Build Works (Water Treatment Plant, Rising Main) USD 86,581,165.07 – Construction of Gravity Pipeline USD 40,739,152.70 – Operation Service for a period of 7 Years USD 1,401,518.53 – Asset Replacement Fund
Type of assistance	ODA Loan
Design condition and specification	As a part of the 2013 GSA master plan, the recommendation for a new 40MLD water treatment plant was made as currently the Waila (90MLD) and Tamavua (60MLD) are unable to meet Peak day water demand. The Water treatment plant is to be a conventional type treatment plant due to the familiarity and capability of local operators. The Plant is to be design using relevant AS/NZ and WSA standards where applicable.

Source: JICA Survey Team based on Interview of WAF

7-5-2 Possibility of Cooperation with Other Donors

Australian companies have experience in implementing WAF projects (**Table 7-5.1**). If Japanese ODA loans in the water supply or wastewater sectors are implemented in the future, cooperation with Australian and local companies will be effective for implementing survey, design, and construction works. Involvement of Australian donors may also be explored. Also, the contents / lessons learned from the technical cooperation in the water supply and wastewater sectors in Suva by ADB can be applied to the operation of facilities in the Western Division.

Chapter 8 Points to be considered for Future Proposals and Surveys (Preparatory Surveys, etc.)

8-1 Basic Information for Formulation of Japanese ODA Loan Projects

In this survey, basic information for project formulation using Japanese ODA loan was collected. Items that need to be confirmed through further study in order to formulate Japanese ODA loan projects are described below. The items need to be confirmed in more detail during a subsequent Preparatory Survey.

(1) Project Priority and Urgency

Each component is considered as an important project of the NLWMP33, and essential to improve water supply conditions into the future. Therefore, priority and urgency are high.

(2) Project Outcome and Effectiveness

In the NLWMP33, Package 1: Consolidation & Optimization Programme (repairing and updating existing facilities) and Package 2: Augmentation Programme (augmentation of water sources, WTPs, and transmission/distribution facilities) are planned in order to meet water demand in 2033. Components envisaged for the Japanese ODA loan project are important for enhancing the water supply capacity of Nadi/Lautoka and essential for the successful development of water supply services by 2033 (treatment capacity: 142ML/day, NRW: 20%, connections: 49,110).

(3) Maturity of the Project

Feasibility studies for raising the Vaturu Dam spillways (GHD and Maunsell) have been conducted and detailed survey of the duplication of trunk mains is under way (2019 until end of May 2020, HunterH2O Ltd. Australia). Items to be surveyed need to be verified in the Preparatory Survey, which is the next step of the process.

(4) Capability of the Implementing Agency

WAF, the implementing agency for this Project has recently implemented “The Fiji Urban Water Supply and Wastewater Management Project” through joint financing by ADB, EIB and GCF. In that project, the water supply sector was improved with the construction of a new 40ML/day WTP and augmentation of the Suva-Nausori water supply system. For the wastewater sector, augmentation and repair of the Kinoya WWTP and expansion of the service area were achieved. From these and other accomplishments, it is judged that WAF is presumed to have the capacity to carry out the current Project without issue.

(5) Agreements among Stakeholders

For the environmental and social considerations, consensus among residents and other stakeholders must be reached. In particular, matters concerning raising of the Vaturu Dam spillway and duplication of trunk mains needs to be verified in the Preparatory Survey, which is the next step of the project.

(6) Consideration for Low-income Households

The Preparatory Survey will confirm whether the plan makes sufficient considerations for low-income households.

8-2 Other Remarks

Table 8-2.1 lists the items required for formulation of Japanese loan aid.

Table 8-2.1 Items to be Considered for Preparation of Loan Project

Category	Requirements	Specific Actions
1) Adequacy of Basic Planning	Identify served population in service area, and service ratio	· Set service area and target year · Confirm that supply capacity will meet the projected demand · Review of F/S prepared by the Third Master Plan
	Estimate demand for each category, non-revenue water ratio and peak factor	
2) Facility Requirements	Determine facility size, intake facility, water treatment plant, transmission facility, elevated tank	· Study available water sources (possible intake amount) based on hydrogeological data, flow quantity survey, seek consensus among concerned parties. · Determine water rights and agreement on intake point · Assure safe water quality · Prepare facility drawings, water supply system flow diagrams, system diagram of transmission facility. · Recommend NRW reduction measures · Prepare implementation schedule and determine cost reduction measures
	Determine if existing facilities can be effectively utilized	
	Review land requirement & availability	· Determine whether land acquisition is required for intake facility and elevated tank etc.
3) Project Scope	Determine scope, including technical, financial and institutional capability of executing agency	・Confirm project implementation strategy and schedule; operation & maintenance plan, financial plan, disbursement schedule, water tariff structure. ・Possibility for applying Japanese technologies to Bakheng WTP project. ・Possibility for applying "Japanese Loan Project with Condition of Operation and Maintenance by SPC Scheme" and "Design-Build Scheme"
4) Project Schedule	Estimate time required for implementation	
5) Project Cost	Construction and operation & maintenance costs	
6) Project Organization	Establish specific project organization, operation & maintenance structure, responsibilities and assignments	
7) Operation & Maintenance Structure		
8) Water Tariff	Determine tariff structure	· Set appropriate water tariff
9) Environmental Issues and Mitigation Measures	Noise, vibration, water pollution, disposal of sludge from treatment process (soil contamination) during construction stage and after the start of operation	· Conduct environmental assessment and recommend mitigation measures
10) Economic Evaluation and Financial Analysis	Analyze Internal Rate of Return (IRR)	· Calculate IRR with consideration of operation & maintenance costs (running costs)

8-3 Contents of Consulting Service under ODA Loan

Long-term efforts by WAF are required for NRW reduction. However, if it is difficult for WAF to achieve this alone, Consulting Services under ODA Loan projects can be considered to realize the full potential of the assistance projects.

Consulting Service under ODA Loan Project schemes (drafts) envisaged are as follows.

In the Consulting Service under ODA Loan, WAF's 20% NRW rate will be targeted by continuation and expansion of outcome from grassroots technical assistance projects implemented by Fukuoka City. Pilot activities for NRW reduction will be expanded. Multiple

pilot areas will be established and problematic areas will be selected and analyzed to improve pressure management and countermeasures for pipe breakages, and countermeasures will be established. Comprehensive improvement of NRW reduction capabilities will be targeted through training for improving meter-reading, underground leak detection, and the billing and collection system.

In order to achieve NRW rate of 20%, a comprehensive NRW reduction plan is needed (a master plan for NRW reduction is needed). To formulate the plan, distribution volume and water pressure data need to be collected and analyzed to gain deep understanding of the current situation. From the results, problem areas can be identified and prioritized for countermeasures. In addition, water pressure management, pipeline maintenance, capacity development of meter readers and leak detection workers, and improvement of bill collection system can be implemented to achieve comprehensive development of WAF NRW capabilities.

In the demand forecast in the NLWMP33, NRW rate for 2018 is set at 20%. However, it is currently closer to 40%. In addition, renewal and augmentation of aging facilities are planned, but have been greatly delayed due to budget shortages. Therefore, a mid-term review of the master plan and optimization for the current conditions is appropriate.

Improving WAF capabilities to achieve NRW reduction targets and proposing a feasible water supply development plans through implementation of Consulting Service under ODA Loan are important first-steps.

8-4 Recommendations on the Water Supply Sector (Preparatory Survey, etc.)

8-4-1 Recommendations on Preparatory Survey

The following components are expected for cooperation projects in the future. However, whether the project is to be implemented with ODA Loan funds or WAF funds will be considered in a future feasibility study.

1) Raising the dam spillway: Raising the dam will allow augmentation of the Nagado system, which is the only water supply source in the area.

2) Improvement of trunk mains: Accompanying the dam raising, trunk main augmentation will transmit more raw water to the Nagado WTP.

3) Distribution reservoirs: Repairs of leaks from the body, and overflows etc. caused by malfunctioning equipment will prevent real water losses.

4) Transmission and distribution lines: Replacement of aging pipes and repair of joint leaks will prevent real water losses.

5) Supply lines: Reducing leaks between the saddle and customer meter will prevent real water losses.

6) Personnel training: Training for meter reading and better monitoring will prevent apparent water losses. In addition, by implementing O&M that includes preventative maintenance, facilities can be operated in optimal conditions and lifespans will be increased.

Each of the above components will be evaluated in the feasibility study. Components that can be financed by Fiji and also have immediate and significant impacts can be selected.

8-4-2 Recommendations on the Three-Year Plan (Strategic Plan 2021 – 2023)

Recommendations for the Three-Year Plan (Strategic Plan 2021 – 2023) that WAF is currently preparing are described below.

1) Increase efforts for NRW reduction: Implement projects founded on sufficient surveys and planning to take pro-active measures to reduce water leakage, not just taking action after leaks occur.

2) Establish water conserving society: Water shortages will not be resolved until the project is completed, and water source shortages are expected beyond 2033. Water conservation must be promoted to consumers.

3) Human resource development and organizational improvements, including establishment of guidelines: Development of personnel and improvement of organization capable of formulating water management plans, selecting and procuring proper equipment and materials, installing appropriate pipes, based on proper hydraulic analysis is necessary.

4) Establishment and improvement of O&M system that includes preventative maintenance: Incorporate preventative maintenance and implement performance management of facilities and equipment to extend the life of facilities and equipment, reduce the risk of accidents, and reduce unexpected repair costs.

5) Continue securing water sources: Efforts to secure water sources should continue, keeping in mind demands beyond 2033.

Chapter 9 Current Status and Issues in Wastewater Sector

9-1 Current Status of Wastewater System

In the Western Division, wastewater works are implemented in Lautoka City as well as Nadi, Ba and Sigatoka towns.

Figure 9-1.1 City and Towns in the Western Division Implementing Wastewater Works

Wastewater works in these city/towns are outlined in **Table 9-1.1**.

Table 9-1.1 Outlines of Wastewater Works in City/Towns in the Western Division

		Nadi	Lautoka	Ba	Sigatoka
Wastewater networks	Total length (km)	129	80.5	26	16
	Length of conveying pipe (km)	38.48	34	9	10.02
	Pipe material	Concrete PVC, AC, Clay	DI, AC, Concrete, PVC	AC, PVC	DI, AC, PVC
	Diameter (mm)	100~550	150~750	150~375	100~300
Pump station	Number	40	12	8	5 (1 under construction)
	No. of pump (/station)	2~3	2~3	2	2~3
	Pump capacity (kW)	3~45	1.3~54	4.4~30	1.3~13.5
WWTP	Name	Navakai	Natabua	Botua	Olosara
	Start operation	1974	1983	1996	1986
	Capacity (estimation)	35,000EP (7,000m^3/day)	43,000EP (8,600m^3/day)	10,000EP (2,000m^3/day)	4,000EP (800m^3/day)
	Treatment process	IDEA	Stabilization pond	Stabilization pond	Stabilization pond
	Discharge to	Nadi River	Ocean outfall	Water channel	Sigatoka River

Source: JICA Survey Team based on Interview of WAF

9-2 Centralized and Decentralized Wastewater Treatment

9-2-1 Centralized Treatment

According to WAF, service areas of sewer systems are generally within jurisdiction under city or town. However, in order to accommodate land development such as housing and hotel construction outside these borders, WAF negotiates with the Department of Town and Country Planning, the iTaukei Land Trust Board, the provincial councils, the Housing Authority of Fiji, the Hotel Licensing Board etc. and expands services to areas outside of the borders.

All areas inside the borders are considered to be the centralized treatment area. No decentralized treatment areas are defined. Therefore, areas inside the border which currently do not have sewer systems can be considered future sewer service areas.

"National Liquid Trade waste policy for Discharge to Wastewater System Owned and Operated by Water Authority of Fiji" (WAF, The Department of Water and Wastewater) indicates that WAF is the main service provider for wastewater services in Fiji and has the responsibility of managing the liquid commercial waste. It also requires factories and commercial facilities to connect to the wastewater systems, as expressed below;

6.1 The Water Authority of Fiji Promulgation 2007 requires all commercial and industrial entities situated within 30 metres of WAF wastewater line, to connect to the WAF wastewater network.

The penalties clause in the policy is described as below; however, no details of the penalties are mentioned.

9.0 Penalties shall be applicable when non-compliance is practiced by commercial and industrial companies.

The sewerage service charge for commercial waste is under development and is described as below.

8.1 WAF will develop trade waste charges in consultation with appropriate stakeholders.

Regarding private premises, "Water Authority of Fiji Promulgation 2007" indicates that WAF provides wastewater service as below, but there is no clause to indicate the obligation to connect to the wastewater system.

26. The owner or occupier of premises in an area where the Authority is able to supply water or provide sewerage or other services to such premises may, in writing, apply to the Authority for the supply of water or for the provision of sewerage or other services, subject to conditions.

27.-(1) The Authority may provide service connections to premises within the vicinity of such premises.

(2) No owner or occupier of premises shall connect the premises to the Water System or Sewerage System except with the prior written approval issued by the Authority.

9-2-2 Decentralized Treatment

(1) Private Premises

Article 30 of "Public Health Act 1936 (Amended 1977)" indicates that private premises not connected to wastewater system must install "Sufficient Privy"[5] as below;

30. Every building intended for human occupation shall be provided with a sufficient privy and dustbin and with proper drains for the efficient carrying off of storm and slop water to the satisfaction of the local authority:

According to the Act, in the case of non-compliance to regulations, the local authority may, by notice, require the owner of houses to remedy the non-compliance. If the non-compliance is not remedied within 28 days of the notice, it may be prosecuted in a court of competent civil jurisdiction.[6]

As the standard drawing of a "sufficient privy", Public Health Act (Cap.111) Public Health (National Building Code) Regulation 2004 shows two drawings. One is a pit latrine for use in areas without water supply. The other is a domestic septic tank.

This means that pit latrines are generally used in areas that lack water supply and septic tanks are used in areas with water supply but without wastewater connections.

Supervisory authority of the Public Health Act is the Central Board of Health of the Ministry of Health and Medical Service; however, Article 34 of the Act indicates that "It shall be the duty of the local authority to provide to the satisfaction of the Board that all privies and drains within its district are so constructed and maintained as not to be likely to become a nuisance or injurious to health." So, the sufficient privy is supervised by the local authorities and maintained by land owners.

The Fiji National Liquid Waste Management Strategy and Action Plan (2007 Ministry of Environment) states that "the Public Health Act and Local Government Act do not apply to Fijian villages as they are governed by the Fijian Affairs Act. This Act also does not require village households to install septic tanks."

(2) Decentralized Treatment of Commercial Wastewater

According to the "Environment Management (Waste Disposal and Recycling) Regulation 2007", the commercial and industrial facilities must get liquid waste permit to discharge wastewater (except wastewater discharged into septic tanks and wastewater system) as below;

5. – (1) Subject to this regulation, every commercial or industrial facility that discharges liquid waste or pollutant from any of its premises must hold a liquid waste permit in respect of the discharge.

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[5] In the Act, there is no definition regarding the "Sufficient Privy."

[6] It is not confirmed whether the direction for the default of the act is implemented or not.

Article 7 of the Regulation requires facilities to check wastewater quality and comply with the standards.

Table 9-2.1 shows the main discharge standards.

Table 9-2.1 Main Standards in the Regulation

Parameter	Unit	Standard value
BOD	mg/L	40
SS		60
Grease		5
T-P		5
T-N		25
Fecal coliform	/100mL	400

Source: Environment management (Waste Disposal and Recycling) Regulation 2007

Regarding tourism wastewater, "Fiji National Liquid Waste Management Strategy and Action Plan (2007 Ministry of the Environment)" indicates;

[Summary] Most of the large hotels have sewage treatment systems, which provide primary or secondary treatment. Across Fiji there are approximately 15 large (>100 rooms) and 25 medium-sized resorts (30–100 rooms). Smaller resorts and backpackers' accommodations (1–30 rooms) usually have septic tanks; there are an estimated 65 such facilities.

[Summary] Resorts are starting to recognize the importance having "environmentally friendly" reputations. Although installing advanced wastewater treatment systems can be expensive, the long-term costs of degraded environments to a resort could potentially be much higher; consequently, many have opted to upgrade their wastewater treatment plants.

There is no mention regarding hotels connecting to the wastewater system in the above-mentioned reports. According to WAF, six large resorts in Denarau area, Nadi and one large resort near Olosara WWTP, Sigatoka connect to the wastewater system in the Western Division; however, no information was obtained regarding other middle to small scale hotels connecting to the wastewater system.

(3) Adoption of "Johkasou"

One of the technologies for advanced wastewater treatment is the Johkasou[7], a Japanese technology. Johkasous are already used in Fiji. Survey Team interviewed a Japanese Johkasou manufacturer which has experience delivering Johkasou to Fiji. The result of the interview is below;

- Number of Johkasou delivered: 11 (Size of Johkasou is not known)
- Customers: Hotels and restaurants (Details are unknown since an Australian cooperative company manages everything)
- Maintenance: Implemented by Australian cooperative company
- Regulations: No regulations regarding installation and quality of Johkasou
- Relation between public sectors: No relation because all Johkasous were delivered to private sectors by private funding

[7] A Johkasou is a domestic wastewater treatment system that sanitizes impurities contained within household wastewater, using the power of microorganisms that occur naturally within the apparatus.

9-3 Construction Plan of Wastewater Sector

9-3-1 Wastewater Master Plan

9-3-1-1 Preparation of Wastewater Master Plan in Four City/Towns in the Western Division

Table 9-3.1 shows the status of the preparation of the wastewater master plan in the four city/towns in the Western Division.

Table 9-3.1 Wastewater Master Plan in the Four City/Towns in the Western Division

City/town	Date and Author of current M/P	Comments
Nadi	1987 Fawcett Mouchel Ltd. (UK or Hong Kong, dissolved already)	Harrison Grierson Consultants reviewed the M/P and submitted a draft to WAF but it was not authorized. The reason is unknown.
Lautoka	1991 PPK Consultants Ltd. (UK)	
Ba	1986 Harrison & Grierson Consultants (New Zealand)	―
Sigatoka	2005 Erasito Consultants Ltd. (Fiji) Beca International Ltd. (Multinational, originally New Zealand)	Review of M/P prepared by Fawcett Mouchel Ltd.in 1987

Source: JICA Survey Team based on Interview of WAF

As shown in the **Table 9-3.1**, 29 to 34 years have passed since M/Ps were prepared for Nadi, Lautoka and Ba, and 15 years have passed since revision of the Sigatoka M/P in 2005. Thus, all of the M/Ps are out-of-date. WAF recognizes the necessity of updating the M/Ps and a plan to revise the M/Ps was included in the "5-Year Development Plan 2017-2021". Budget for the revision of M/P in Nadi, Lautoka and Ba was integrated into the "2019-2020 Budget Kit".

9-3-1-2 Outlines of M/Ps

Of the M/Ps shown in **Table 9-3.1**, the "Master Plan Sigatoka Regional Wastewater Scheme 2005" was available at WAF.

In 2011 Harrison Grierson (New Zealand) reviewed the M/Ps of Nadi and Lautoka. The draft of the review was obtained from the sewerage planning group in WAF Central. The review was not authorized by WAF (reasons are not known). Therefore, they are not valid.

Contents of the papers obtained in this survey are outlined below.

(1) Nadi

Outline of the revised M/P of Nadi which was made by Harrison Grierson in 2011 but was not authorized by WAF is as follows;

(a) Target Year

Target year of the revised M/P is 2028.

(b) Wastewater Service Area

The paper indicates “The area of service generally covers the town boundary, plus extensive areas of development outside of the current boundary. As new areas are developed, the reticulation system has been extended in a somewhat ad hoc manner. The exact area served by the current scheme is not accurately documented, and throughout our review we have noted there are a few discrepancies.”

(c) Population

From the 1996 and 2007 census, the population growth rate in the Nadi urban area was 2.2% per annum and 3.1% per annum in the Nadi peri-urban area. Assuming the same growth rates, population in the target year (2028) is forecast to be 86,683. Current (2019) population is 56,337.

(d) Design Criteria

The design criteria used in the paper are shown in **Table 9-3.2**. The peak wet weather flow is estimated as four times the dry weather flow.

Table 9-3.2 Design Criteria in Nadi Wastewater Scheme

Flow	Dry weather flow	Peak wet weather flow
Per capita flow	200 L/capita/day	0.093 L/sec (800L/capita/day)
Flow per dwelling	1,200 L/day	0.056 L/sec (4,800L/day)
Commercial	10,800 L/ha/day	0.5 L/sec/ha (43,200L/ha/day)
Industrial	17,700 L/ha/day	0.82 L/sec/ha (70,800L/ha/day)

Source: Nadi Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

(e) Influent Volume into WWTP

The flowmeter in the Navakai WWTP was already out of operation during the preparation of the paper and influent volume was not grasped. Hence, the wastewater volume in 2009 is estimated from the estimated population connected to the wastewater system, as shown in **Table 9-3.3**.

Table 9-3.3 Estimated Population Connected to Wastewater System and Influent Volume into WWTP in 2009

Item	Estimated value in 2009
Population connected to wastewater system	33,000
Influent volume in dry weather	6,600 m^3/day

Source: Nadi Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

By using the estimated value and population growth rate shown in (b), the population connected to the wastewater system and influent volume from 2013 to 2028 is estimated as shown in **Table 9-3.4**.

Table 9-3.4 Estimated Population Connected to Wastewater System and Influent Volume into WWTP in 2013 to 2028[8]

Year	2013	2018	2023	2028
Total population of Nadi	62,316	70,114	78,106	86,683
Population connected to sewer system	41,971	51,986	65,073	79,342
Influent volume(m^3/day)	8,573	10,720	13,517	16,599

Source: Nadi Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

(f) Wastewater Pipe Networks and Pumping Stations

Main proposals in the paper were shown below;

- In order to cope with the increase in population and urban development, new wastewater pipe networks and pumping stations need to be constructed from 2013 to 2027 in stages
- Installation of emergency storage chambers with 4 hours retention time and stand-by electricity generators
- Construction of storage tank for storing pumping station overflow prior to discharge to watercourse

(g) Wastewater Treatment Process

Construction of two treatment lines of sequential batch reactor (SBR) is recommended by 2028.

The construction is implemented in two stages, as below;

- The first stage: Construction of the first sequencing batch reactors (SBR) facility on the area of previous oxidation ditch (OD) facility and smaller intermittently decanted extended aeration (IDEA) facility.
- The second stage: Construction of the second SBR facility by purchasing adjacent land. (Existing WWTP area is too small to construct two SBR facilities.)

(h) Sludge Treatment Process

In order to cope with the increased sludge generation in the future, improvement of the dewatering machine is proposed. (Note by Survey Team: At present, a belt-press dewatering machine is installed, but is not used due to mechanical trouble.)

(i) Construction Cost

The cost of the renovation and expansion of the wastewater facilities is estimated as shown in **Table 9-3.5**.

Table 9-3.5 Cost Estimation for Renovation and Expansion of Wastewater Facilities

Item	First term	Second term	Third term	Total
Year	2013-2017	2018-2022	2023-2027	―
Population connected to wastewater system	41,971	51,986	65,073	79,342
WWTP	$21.59	$25.67	―	$47.26
Pumping station	$13.11	$4.46	$6.68	$24.25
Trunk sewer	$17.11	$3.86	$3.88	$24.63
Total	$51.80	$33.99	$10.56	$96.13

Unit: million FJD

Source: Nadi Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

[8] Although the inflow from commercial and industrial facilities is set in the design criteria, they are not included in the influent volume in **Table 9-3.4**.

(2) Lautoka

Outline of the revised M/P of Lautoka which was made by Harrison Grierson in 2011 but was not authorized by WAF is as follows;

(a) Target Year

Target year of the revised M/P is 2028.

(b) Wastewater Service Area

The M/P indicates the service area as "The area of service generally covers the city boundary, and a few new development areas just outside of the current city boundary. As new areas are developed, the reticulation system has been extended as growth occurs."

(c) Population

From the 1996 and 2007 census, the population growth rate in the Lautoka urban area was 1.8% per annum, and 1.1% per annum in the Lautoka peri-urban area. Assuming the same growth rates, the population in the target year (2028) is forecast to be 73,991. Current (2019) population is 53,639.

(d) Design Criteria

The design criteria used in the paper are shown in **Table 9-3.6**. The peak wet weather flow is estimated as four times the dry weather flow.

Table 9-3.6 Design Criteria in Lautoka Wastewater Scheme

Flow	Dry weather flow	Peak wet weather flow
Per capita flow	200 L/capita/day	0.093 L/sec (800L/capita/day)
Flow per dwelling	1,200 L/day	0.056 L/sec (4,800L/day)
Commercial	10,800 L/ha/day	0.5 L/sec/ha (43,200L/ha/day)
Industrial	17,700 L/ha/day	0.82 L/sec/ha (70,800L/ha/day)

Source: Lautoka Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

(e) Influent Volume into WWTP

No flowmeter is installed in the Natabua WWTP and accurate influent volume into the WWTP is not grasped. Hence, the sewage volume in 2009 is estimated from the estimated population connected to the wastewater system as shown in **Table 9-3.7**.

Table 9-3.7 Population Connected to Wastewater System and Influent Volume into WWTP

Item	Estimated value in 2009
Population connected to wastewater system	41,500
Influent volume in dry weather	8,300 m^3/day

Source: Lautoka Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

By using the estimated value and population growth rate shown in (c), the population connected to wastewater system and influent volume from 2013 to 2028 is estimated as shown in **Table 9-3.8**.

Table 9-3.8 Population Connected to Wastewater System and Influent Volume[9]

Year	2013	2018	2023	2028
Total population of Lautoka	57,190	62,069	67,719	73,991
Population connected to wastewater system	45,995	53,034	60,471	72,431
Influent volume(m^3/day)	9,199	10,607	12,094	14,486

Source: Lautoka Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

(f) Wastewater Pipe Networks and Pumping Stations

Main proposals in the paper were as follows;

- In order to cope with the increase in population and urban development, new wastewater networks and pumping stations need to be constructed from 2013 to 2027 in stages.
- By reviewing the capacity of the existing pumping stations, 2 out of 12 pumping station can be decommissioned.
- Installation of emergency storage chambers with 4 hours retention time and stand-by electricity generators.
- Construction of storage tank for storing pumping station overflow prior to discharge to watercourse.

(g) Wastewater Treatment Process

In consideration of the construction and O&M cost, the paper recommends the construction of a stabilization pond facility similar to the existing process to expand the treatment capacity.

The expansion construction is divided into two stages as follows;

- The first stage (~2013): A facultative and a maturation pond is constructed in the WWTP site adjacent to the existing facility to expand treatment capacity.
- The second stage (2020~2023): A facultative and a maturation pond is constructed in the WWTP site to expand treatment capacity.

The paper also recommends adoption of a nutrients removal process in the future, if necessary.

(h) Outfall Facility

The capacity of the pump facility and pipe for the ocean outfall to 2km offshore is inadequate and the M/P recommends increasing the capacity as follows;

- The first stage (2013): Increase number of pumps (At present two pumps are installed)
- The second stage (2017): Replace land-section (400m) of outfall pipe with 750mm diameter DI and connect to the existing outfall
- The third stage (2018): Replace remainder of the outfall pipeline with 800mm polyethylene pipeline

(i) Construction Cost

The cost of renovation and expansion of the wastewater facilities is estimated as shown in **Table 9-3.9**.

[9] Although the inflow from commercial and industrial facilities is set in the design criteria, they are not included in the influent volume in **Table 9-3.8**.

Table 9-3.9 Cost Estimation for Renovation and Expansion of Wastewater Facilities

Item		First term	Second term	Third term	Total
Year		2013	2018	2023	―
Population connected to wastewater system		53,034	60,471	72,431	72,431
WWTP		$10.16	-	$9.25	$19.41
Outfall facility	Pump	$0.41	-	$0.34	$0.75
	Pipe	-	$17.28	-	$17.28
Pumping station		$6.93	$3.83	$4.51	$15.27
Trunk sewer		$1.80	$1.55	$3.88	$7.23
Total		$19.3	$22.7	$18.0	$60.0

Unit: million FJD

Source: Lautoka Regional Sewerage Scheme Review of Master Plan (Draft) (Harrison Grierson 2011)

(3) Sigatoka

In 2005, Erasito Consultants Ltd. (Fiji) and Beca International Ltd. (multinational, originally New Zealand) reviewed and revised the original M/P of 1987. The revised M/P was obtained from the sewerage planning group of WAF Central. Contents of the M/P are outlined below.

(a) Contents of the Revised M/P

a) Target Year

Target year of the revised wastewater M/P is 2023.

b) Wastewater Service Area

Figure 9-3.1 shows the planned wastewater service area[10] indicated in the original M/P (1987) and **Figure 9-3.2** shows the studied area of the revised M/P. For clarity, the JICA Survey Team created **Figure 9-3.2** based on figures given in the original M/P.

The coastal area to the south of Sigatoka Town is one of the prominent coral reefs in Fiji. According to "Integrated Coastal Management Framework of the Republic of Fiji; 2011 Department of Environment", Fiji's coastal environmental quality is being threatened by ever-increasing urbanization trends. Hence, it is written that the study area of the revised M/P was widened east and west along the coral coast in response to the demand of the Public Works Department of the then Ministry of Public Utilities (currently MITDMMS), as shown in **Figure 9-3.2**.

[10] The M/P indicates the service area as "The general area within points A, B, C and no other detail description. Probably, the inside of lines connecting points A, B, C will be the service area planned.

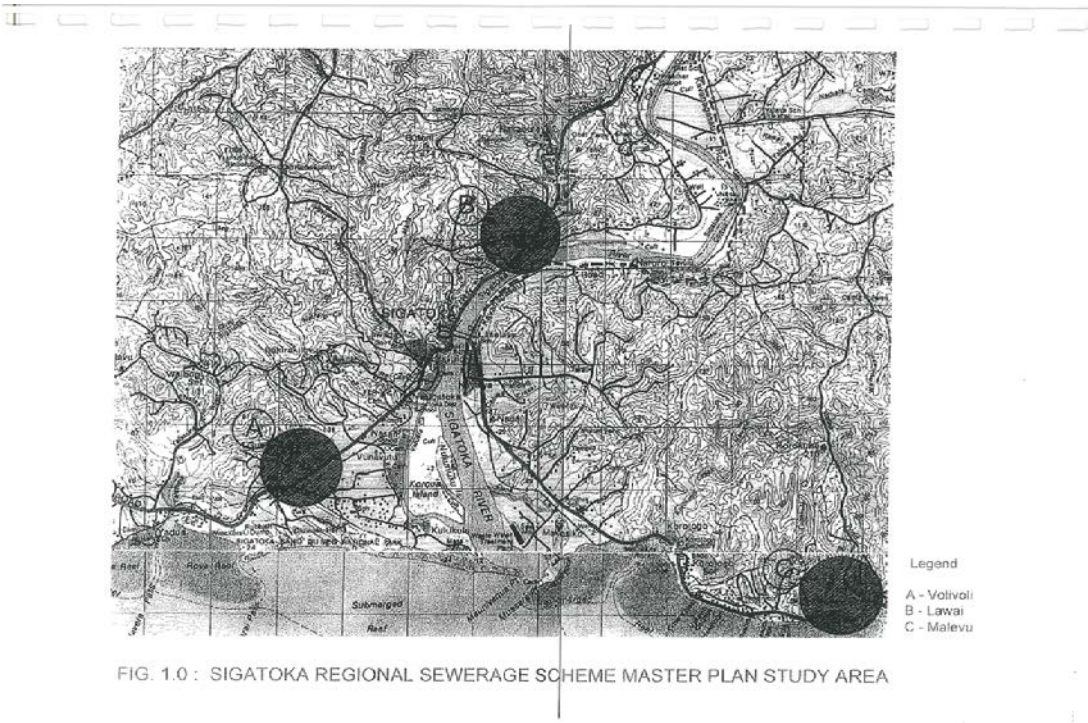


Figure 9-3.1 Service Area Planned in The M/P 1987

Source: Master Plan Sigatoka Regional Wastewater Scheme (Erasito Consultants, Beca International 2005)

Figure 9-3.2 Study Area of the Revised M/P

Source: Survey Team based on the Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

c) Contents of Survey of M/P

The study of revision was implemented as per the 4 scenarios shown in **Table 9-3.10**.

Table 9-3.10 Scenarios of the Revised M/P

Scenario	Contents
1	Strengthening of wastewater networks within the present service area in accordance with the increase of population
2	Construction of wastewater pipes in 6ha of the high priority peri-urban area
3	Construction of wastewater pipes in the planned service area of the 1987 M/P (Approx. 20ha in addition to the scenario 2)
4	Construction of wastewater pipes in all study area of the 2005 M/P

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005

d) Population

Population in the target area of the scenario 1 to 4 is calculated by using the Census 1996 as shown in **Table 9-3.11**.

Table 9-3.11 Population in the Target Area of Scenario 1 to 4 by the Census 1996

	Scenario 1 and 2	Scenario 3	Scenario 4
	Current service area plus high priority area	Planned service area in the 1987 M/P	Study area of 2005 M/P
Population by Census 1996	3,033	8,443	14,421

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005

The populations in 2003 (survey year) and 2023 (target year) are estimated using the estimated population growth rates (1998, Fiji Bureau of Statistics) as shown in **Table 9-3.12**.

Table 9-3.12 Estimation of Population in 2003 and 2023

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Current wastewater service area	Current service area + high priority area	Planned service area in the original M/P 1987	Study area of revised M/P
2003	—	4,500	10,200	16,700
2023	3,550	5,200	12,200	20,100

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

Table 9-3.13 shows the required expansion of treatment capacity of WWTP in each scenario.

Table 9-3.13 Required Treatment Capacity of WWTP in each Scenario

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
A: Population in 2023	3,350	5,200	12,200	20,100
B: Current treatment capacity of WWTP (person equivalent)				4,000
Ratio(A/B)	0.83	1.30	3.05	5.03
Necessity of expansion of WWTP	No	Necessary	Necessary	Necessary
Necessary capacity expansion ratio	—	2 times	3 times	5 times

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

e) Wastewater Volume per Capita

There is no mention regarding the wastewater volume in the M/P.

f) Wastewater Construction Plan

Wastewater construction is proposed to be implemented in two separate stages, as shown in **Table 9-3.14**.

Table 9-3.14 Two Stages of Wastewater Construction Plan

Stage	Content
1	Scenario 1 and 2 will be implemented within 5 years
2	Scenario 1, 2 and 3 will be implemented within 15 years

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

Scenario 4 includes wide area of villages and resorts along the coral coast and the M/P indicates the area as "The whole question of wastewater collection, treatment and disposal from villages and resorts along the Coral Coast should be the subject of a separate dedicated study that considers the economic, environmental and cultural issues of different collection, treatment and disposal options. This study needs to be completed in conjunction with the Integrated Coastal Management (hereinafter referred to as "ICM") committee[11] who are considering trials of onsite village-based treatment and disposal systems."

In the report of the M/P, there is no figure indicating the 1st and 2nd stage area, so the JICA Survey Team prepared the figure as **Figure 9-3.3**.

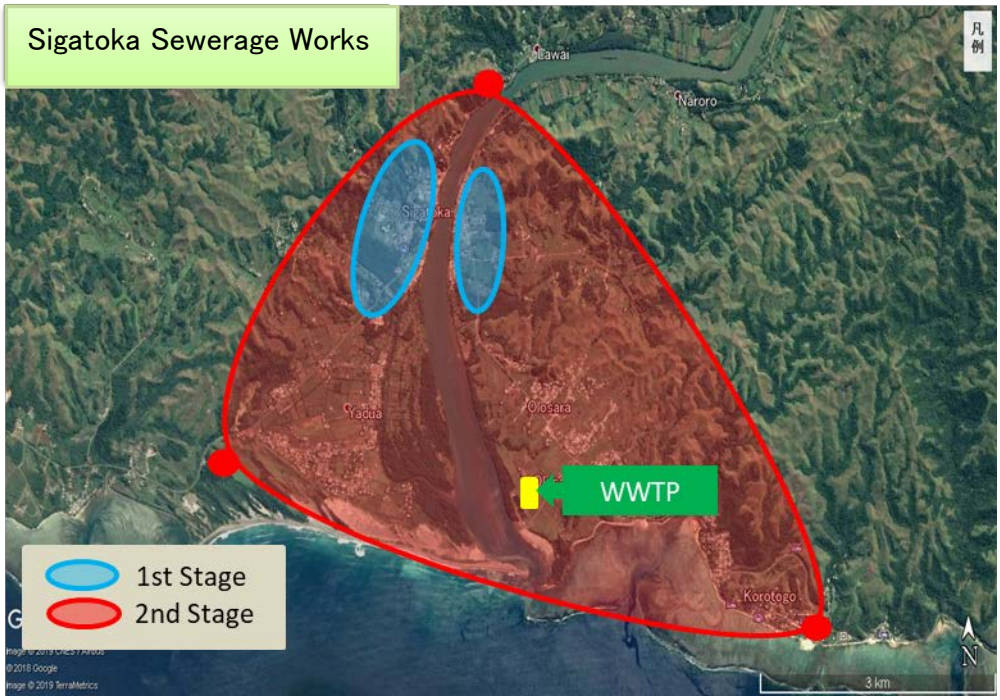


Figure 9-3.3 Sewerage development area in the 1st and 2nd stage

Source: JICA Survey Team based on the Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

[11] Note: ICM committee is the organization established under the National Environment Council as per the Fiji Environment Management Act 2009. Activity of the committee includes the studies such as the composting toilet and septic tanks with downstream reed beds, implemented together with the Institute of Applied Science of the University of South Pacific.

g) Construction Works in Each Stage

Table 9-3.15 shows the construction works in the first stage.

Table 9-3.15 Construction Works in the First Stage

Construction works in the first stage	
Target year	In 5 years
Target area	Existing wastewater service area + high priority area near periphery of town (approx. 6ha)
Sewer networks	Gravity pipe 2.8km(ϕ150mm) Pressure pipe 2.0km(ϕ 100mm) 0.55km(ϕ 150mm)
Pumping station	Newly constructed = 4, Capacity increase = 1
WWTP	Bisection of 2 existing maturation ponds to prevent short circuit. Stabilization pond facility of same scale of the existing one is constructed in parallel and treatment capacity becomes double; 8,000EP (1,600m^3/day)

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

Table 9-3.16 is the construction works in the second stage shown in the M/P.

Table 9-3.16 Construction Works in the Second Stage

Construction works in the second stage	
Target year	In 15 years
Target area	Planned area in the original M/P
Sewer networks	Gravity pipe 3.75km(ϕ 150mm) Pressure pipe 1.8km(ϕ 100mm) 8.2km(ϕ 150mm)
Pumping station	Newly constructed = 8, Capacity increase = 2
WWTP	Stabilization pond facility of same scale of the existing one is constructed in parallel and treatment capacity becomes triple; 12,000EP (2,400m^3/day) (Land acquisition is necessary.)

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

The construction works in pumping stations and WWTP shown in **Table 9-3.17** is mentioned to be necessary besides those in the two stages,

Table 9-3.17 Construction Works Needed in Pumping Station and WWTP

1	Installation of coarse screen in pumping station
2	Dredging of sludge in ponds of WWTP
3	Replacement of rubber sheet on the bottom of ponds of WWTP

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

h) Construction Cost

The construction cost indicated in the M/P is as shown in **Table 9-3.18**.

Table 9-3.18 Construction Cost

Works		Description	Cost (FJD, without TAX)
Maintenance works		Installation of coarse screen in pumping stations	105,000
		Replacement of rubber sheet in WWTP	400,000
Construction works	First stage	Bisection of maturation ponds	240,000
		Sewer pipe construction	3,710,000
		Expansion of WWTP	2,630,000
	Second stage	Sewer pipe construction	8,360,000
		Expansion of WWTP	2,630,000

Source: Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

(b) Issues in the Wastewater Works in Sigatoka

- Although the wastewater M/P was updated in 2005, no renovation/expansion of WWTP or sewer networks was implemented due to shortage of budget; therefore the updated M/P is also now out-of-date. A new M/P needs to be prepared. However, budget to implement the project should be secured before preparing the new M/P.
- As mentioned above, the coastal area south of Sigatoka Town is one of the prominent coral reefs of Fiji, and coastal environmental protection is an important issue throughout Fiji. ICM committee has studied the composting toilet and the septic tank with downstream reed bed together with the Institute of Applied Science of the University of South Pacific. Therefore, adoption of advanced wastewater treatment processes in the Olosara WWTP in place of the existing stabilization pond process in the future is possible.

(c) Figures in the M/P

List of figures in the M/P are as indicated in **Table 9-3.19**.

Table 9-3.19 List of Figures in the M/P

Number	Title of Figure
Figure 1	Master Plan Study Area[12]
Figure 2	Study Area
Figure 3	Areas of Proposed Development – Housing Authority
Figure 4	Sewer Reticulation Priority Areas – Sigatoka Town Council
Figure 5	Development Area
Figure 6	Stage 1 Sewer Expansion
Figure 7	Stage 2 Sewer Expansion
Figure 8	Layout of Olosara Sewage Treatment Plant

Source: JICA Survey Team based on Master Plan Sigatoka Regional Sewerage Scheme (Erasito Consultants, Beca International 2005)

9-3-2 Strategic Plan of WAF

9-3-2-1 Strategic Plan 2017-2019

According to the Strategic Plan 2017-2019, WAF could implement 91% of the main activities set in the Strategic Plan 2014-2016. However, WAF still has many issues to improve, and has formulated the Strategic Plan 2017-2019 to address them. The current status of WAF described in the Plan is shown below (from **Section 3-2-2**).

[12] Study area of the original M/P (1987)

Issues that need improvements in the Strategic Plan 2017-2019

- Service charges are set with government assistance. Revenues cover only 50% of O&M costs.
- OPEX and CAPEX both rely heavily on government subsidies.
- Residents strongly demand water and wastewater services.
- Customers are spread out over approximately 200 villages on 108 islands.
- High NRW rate (approximately 31.5%)
- There are eight intermittent water supply areas, affecting approximately 1,635 people.
- Frequent natural disasters damage facilities and hinder water supply.
- Electricity costs are as high as 20 million FJD/year.
- Fuel costs for operation of electric generators and pumps are high.
- Highly qualified water supply and wastewater technical staff are lacking.
- Difficulty meeting environmental and regulation requirements.
- Effects of changes in exchange rates when procuring equipment.
- Social cost of adapting to fast-paced changes in cultural and social perceptions.
- Lack of technical and managerial information.
- SOPs are being prepared.
- Lack of automated equipment.
- Limited funds for dealing with aging facilities.
- High energy cost due to reliance on pumping from rivers.
- Customers are households, businesses, and government agencies.

Source: Strategic Plan 2017‐2019

The following strategic goals are specified.

Strategic objectives of Strategic Plan 2017-2019

1. Provide stable water to all customers 24/7
2. Efficient planning and project management
3. Provide safe drinking water
4. Provide adequate wastewater system
5. Improve services to non-urban areas
6. Provide efficient and sustainable services
7. Conduct staff training
8. Expand service area
9. Management information system
10. Cooperate with customers and other stakeholders

Source: Strategic Plan 2017‐2019

Originally, the Three-Year Plan (Strategic Plan 2017-2019) was to be completed by the end of 2019; however, the Plan was extended to 2020 due to delay of budget allocation. Achievement status of the strategic objectives of the plan is shown in **Table 3-2.9**. “20% reduction in customer complaints on wastewater overflows and odors” and “Reduce Biological Oxygen Demand (BOD) affluent level by 10mg/l on all major WWTP” indicated in “Strategic Objective 4: Adequate sanitation systems” is not achieved.

The implementation status of the wastewater projects in the Western Division indicated in the Strategic Plan 2017-2019 were obtained from the hearing survey at WAF West as shown in **Table 9-3.20**.

Table 9-3.20 Plan and Implementation Status of the Wastewater Projects in the Western Division

Sort	Project	Area	Budget	Status
WWTP	(1) Consolidation Works	Lautoka (Natabua) Sigatoka (Olosala)	$100,000 $100,000	Completed Completed
	(2) Feasibility studies of new treatment plants	Tavua Rakiraki	$500,000 $500,000	Approved for implementation Shelved
	(3) Desludging	Lautoka (Natabua) Sigatoka (Olosala)	$3,400,000	Approved for implementation
	(4) Navakai design and construction of consolidation works	Nadi (Navakai)	$2,217,000	On-going
Wastewater networks Pumping station	(1) Ba industrial sewer extension	Ba	$5,300,000	On-going
	(2) Upgrading of wastewater pumping stations	Nation wide	$210,000	Completed
	(3) Consultation, Design and Implementation of odour control system	Nationwide	$200,000	Shelved
	(4) Upgrading of wastewater pipe network	Nationwide	$17,300,000	Completed
	(5) Mobile Jetting & CCTV units	Nationwide	$500,000	On-going

Source: WAF Strategic Plan 2017-2019

9-3-2-2 Three-Year Plan (Strategic Plan 2021-2023)

The newest Three-Year Plan (Strategic Plan 2021-2023) will be deliberated in June 2020 and released in July 2020.

9-3-2-3 Issues in the Strategic Plan

As shown in **Table 9-3.20**, two wastewater projects, “Feasibility Studies of New Treatment Plants in Rakiraki” and “Consultation, Design and Implementation of Odor Control System” were shelved. According to WAF, lack of budget was the cause.

9-4 Current Status and Issues of Wastewater Treatment Plants

9-4-1 Navakai WWTP (Nadi)

Wastewater service area of Nadi is as shown in **Figure 9-4.1**.

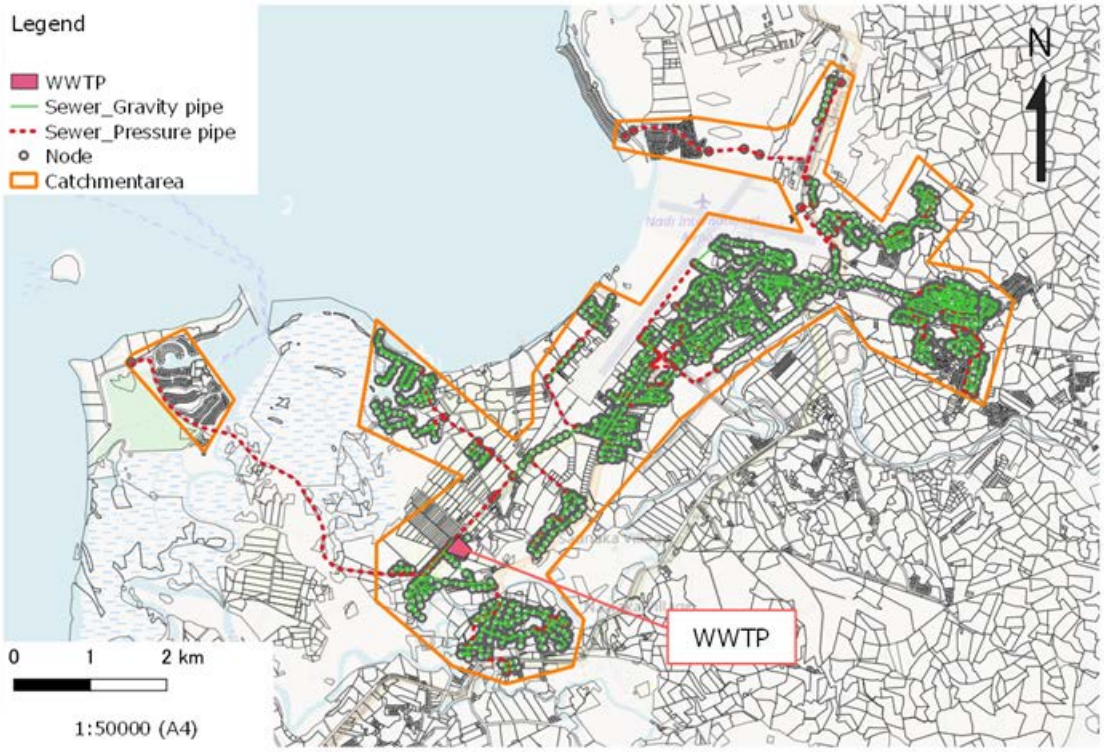


Figure 9-4.1 Wastewater Service Area of Nadi

Source: JICA Survey Team based on the sewer pipe networks figure of WAF

Outline of the WWTP is shown in **Table 9-4.1** and layout of the facilities is shown in **Figure 9-4.2**.

Table 9-4.1 Outline of Navakai WWTP

Name	Navakai WWTP
Commencement of operation	1974
Treatment capacity	35,000EP Based on the unit wastewater volume used in WAF (200L/capita/day), the 35,000EP is 7,000m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	IDEA (Intermittent Decanted Extended Aeration)
Sludge treatment process	Excess sludge removed from the IDEA reaction tank is sent to the aerobic digestion and is digested. Then, it is sent to the mechanical dehydrator and is dewatered. Dewatered sludge is dumped into the dump site in the WWTP. However, the hydrator has stopped operation due to mechanical trouble and the sludge is dewatered in the drying beds (8 beds). WAF has requested to Nadi town to accept the sludge in the solid waste disposal site of the town; however, the town has refused because the sludge may contain high concentration of heavy metals.
Wastewater treatment flow	Inflow → Mechanical screen → IDEA reaction tank → Maturation tank → Discharge to the Nadi River
Sludge treatment flow	Excess sludge form IDEA reaction tank → Aerobic digestion tank → Drying beds → Dumping site in WWTP (Because mechanical dehydrator is now out of order and drying bed is used.)
Discharging point	Nadi River
Outsource	No use

Source: JICA Survey Team based on Interview of WAF

Figure 9-4.2 Layout of Facilities in Navakai Wastewater Treatment Plant

(1) Current Status

When operation started in 1974, the WWTP used the oxidation ditch (OD) process for wastewater treatment; however, treatment capacity became insufficient due to increased influent volume and IDEA treatment (capacity 10,000EP) was started in 1997, and the OD treatment facilities were not used. In 2008, a larger IDEA facility (capacity 25,000EP) was adopted due to further increases in influent volume. Operation of the smaller IDEA has now stopped due to age related deterioration and poor maintenance condition of all four aerators of the reaction tank.

In the new IDEA tank, although 8 aerators are required, only 6 were installed. Furthermore, 2 aerators broke down in 2011 only 4 years after start of operation. Currently, the IDEA plant is operated with only 4 aerators.

Central laboratory of WAF has analyzed the water quality in every wastewater treatment plant once a month. **Table 9-4.2** shows the annual average of influent and effluent quality from 2014 to 2018.

Table 9-4.2 Water Quality of Navakai WWTP

Year	Influent						Effluent					
	T-SS	BOD	COD	T-KN	T-P	FOG	T-SS	BOD	COD	T-KN	T-P	FOG
Stand.							60	40	―	―	5	5
2014	965	503	934	9.2	3.5	257	80.3	54.9	138	5.4	2.8	41.6
2015	926	355	884	9.2	2.8	187	43.5	41.4	90.8	5.6	2.3	55.3
2016	589	451	1310	12.8	2.3	23.8	54.4	49.2	124	10.9	1.6	10.7
2017	513	317	648	57.9	3.3	16.5	155	84.7	233	32.0	1.5	10.3
2018	447	241	586	47.2	3.2	57.2	123	68.2	176	29.4	2.4	22.8
Ave.	679	367	846	31.1	3.0	108	95.2	62.0	156	18.2	2.2	27.8

Unit: mg/L
Stand.: Values shown in “Environment Management (Waste Disposal and Recycling) Regulation 2007 Schedule 2”
Source: JICA Survey Team based on Interview of WAF

Table 9-4.3 shows the compliance rate of effluent standard (BOD=40mg/L).

Table 9-4.3 Compliance Rate of Effluent Standard of BOD

Year	Number of analysis	Number of data under the standard	Compliance rate (%)
2014	11	5	45.5
2015	7	4	57.1
2016	9	2	22.2
2017	11	2	18.2
2018	14	3	21.4
Sum/Ave	52	16	30.8

Source: JICA Survey Team based on Interview of WAF

Average compliance rate to the effluent standard in the five years is only 30.8%. The aerator malfunctions must be fixed as soon as possible in order to improve the effluent quality. If restoration of the aerators is insufficient for improving effluent quality, it may be necessary to consider adoption of more sophisticated wastewater treatment processes.

(2) Restoration/Expansion Project

Typically, restoration and expansion of the WWTP must be based on the wastewater M/P; however, it is not yet prepared. Accordingly, WAF contracted with HunterH2O Ltd., an Australian consultant company in 2018, and started preparation of a restoration/expansion plan. The plan will be completed at the beginning of 2020. The detail of the plan is currently

unknown, but restoration of malfunctioning and new expansion of facilities is expected.

None of the WWTPs measure influent flow rates. Therefore, shortage of treatment capacity is unknown. Restoration/expansion without this knowledge should not be implemented in order to avoid construction of too small or too large facility.

(3) O&M Organization

Organization of the WWTP is as shown in **Table 9-4.4**.

Table 9-4.4 Organization of Navakai WWTP

Position	Number	Main works
Supervisor	1	Not only the supervision of WWTP, wastewater networks and pumping stations in Nadi but also those in Sigatoka
Operator	4	3 shifts
Maintenance	3	Maintenance works such as cleaning of WWTP, sludge removal from drying beds, transportation of dried sludge etc.
Assistant	2	Helping various works in WWTP

Source: JICA Survey Team based on Interview of WAF

Maintenance of mechanical and electrical equipment of all WWTPs and WTPs in the Western Division is carried out by the maintenance group based in Natabua WWTP (Lautoka).

(4) Issues

Issues found in the Navakai WWTP are as follows;

(a) Issue in sewerage works planning

a) Wastewater M/P

The existing wastewater M/P was prepared in 1997 (by Fawcett Mouchel Ltd.) and is no longer appropriate for the restoration/expansion of the current wastewater system. It must be revised and a new, more appropriate M/P should be provided.

(b) Issues in treatment facility

a) Aerators

As shown in (1) Current Status, although 8 aerators are required in the IDEA tank, only 6 were installed. Furthermore, 2 aerators broke down in 2011, only 4 years after start of operation. Hence, the process is currently operated with only 4 aerators and treatment capacity has dropped significantly. (According to the hearing survey at the WWTP, no customer complaints were received when 6 aerators were operational. Complaints increased when the number of operational aerators was reduced to 4.) The required aerators have already been purchased. They must be installed promptly and treatment capacity restored.

b) Machine trouble

It is not natural for 2 aerators to break down in 4 years.

Usually, the causes of machinery issues are deterioration due to aging, low quality product, lack of maintenance capacity of O&M staff and inferior maintenance of machinery due to budget shortages. In the Navakai WWTP, deterioration due to aging is unlikely.

Therefore, the Survey Team conducted hearing surveys to investigate the cause of the trouble for (1) Management level of WAF Central and (2) Maintenance group which is in Natabua WWTP (Lautoka) and implements maintenance of machinery. The results are as follows;

① Management Level of WAF Central

The management level of WAF Central considered aerator issues were caused by shortage of O&M staff, and listed the causes as follows;

- Lack of maintenance capacity of O&M staff
- Lack of preventive maintenance of equipment

② Maintenance Group (in Navakai WWTP)

According to the hearing surveys for the maintenance group in Navakai WWTP, the following were indicated.

- There was no problem in the quality of aerators.
- There was no maintenance manual of the aerator from the beginning, so the maintenance group could not know how to maintain them.
- There was no agent to import spare parts in the country, so they could not procure the parts and could not implement appropriate maintenance.

Regarding the maintenance manual, it should be delivered by the manufacturer. Lack of manual from the beginning indicates mismanagement by the manufacturer. (Possibility is that manuals existed but may have not been not delivered to the maintenance group, or the manuals were delivered but may have been lost.) On the other hand, difficulty of procurement of spare parts is a significant issue. When any wastewater project is implemented in Fiji, securing of import agency for preparing spare parts of all mechanical and electrical equipment is necessary.

(An agency in the country was nominated for importing spare parts for aerators in Navakai WWTP and spare parts became available for purchase in 2017.)

Thus, the management level of WAF Central and the maintenance group in Navakai WWTP have different views regarding the cause of aerator trouble. The issues were most likely caused by a lack of communication between WAF Central and the work sites of WAF West. Therefore, the following points should be noted for the appropriate maintenance of facilities.

- Good communication between WAF Central and the work site by holding periodic meetings and exchanging information
- Capacity development of staff in charge of O&M through implementation of various trainings
- Provision of budget for implementing preventive maintenance of equipment
- Preparation of O&M manuals and standard operation procedures (SOPs) of facilities and equipment
- Establishment of system for easy procurement of spare parts and repair of equipment through agencies

According to WAF West, the required number of aerators have already been purchased; therefore, it is important to install the aerators in the IDEA tank and secure the treatment capacity. At present, WAF contracted with HunterH2O Ltd., and started preparation of a restoration/expansion plan, which will be completed at the beginning of 2020. WAF will install

the aerators based on the plan.

c) Sludge disposal

Sludge generated at the Navakai WTTP is stored on site after drying in the sun. The storage site is not isolated by rubber lining. There is possibility of sludge flowing to the ocean during the rainy season.

WAF as requested permission to dispose of the sludge in the Nadi municipal landfill. However, the city has refused due to concerns about heavy metal contamination of the sludge. WAF is also coordinating with the Ministry of Environment to secure its own sludge disposal site, but no progress has been made. At minimum, the current storage site should be managed with rubber lining.

(c) Issues in management of WWTP

a) Influent volumes

Influent volume to the WWTP is not known because there are no flowmeters in the WWTPs. Since WAF is now preparing the restoration/expansion plan of the WWTPs, WAF should verify whether the WWTPs are operated in overloaded conditions or not. Flowmeters to measure the influent volume is required for this task. WAF understands the necessity of installing the flowmeters and has plans to install them within two years. Until they are installed, the JICA Survey Team has provided a method for estimating the influent volume from the water bills of households.

b) Compliance to effluent standards

Average compliance rate of effluent BOD in 2014-2018 is only 30.8%. According to WAF, this is caused by the failure of 2 aerators. The 2 troubled aerators are now being repaired. In addition, 3 aerators (2 for operation and 1 for stand-by) have been purchased. It is necessary to install the 2 repaired and the 2 purchased aerators and operate the tank with the required 8 aerators (including 4 aerators currently in operation) and confirm whether the effluent quality is improved.

c) O&M manuals

According to the hearing survey at the WWTP, almost no O&M manuals exist in the WWTP and O&M is implemented according to the experience and expertise of the staff. The wastewater treatment process is simple and the only mechanical machines at the WWTP are mechanical screen in the inlet, aerators in IDEA tank, and dehydrator (out of order); however, standard operation procedures (SOP) should be prepared for appropriate operation.

Maintenance of machines and electrical equipment is carried out by the maintenance team in the Natabua WWTP. They report that they have very few maintenance manuals.

Inflow surge tank (Inflow wastewater is pumped from pumping station in the town center.)

IDEA reaction tank (Floating aerators are set on the tank.)

Aerator left unused due to mechanical trouble

Belt-press dehydrator (Stopped operation due to SCADA trouble)

Figure 9-4.3 Present Condition of Navakai WWTP

9-4-2 Natabua WWTP (Lautoka)

Figure 9-4.4 shows the wastewater service area of Lautoka.

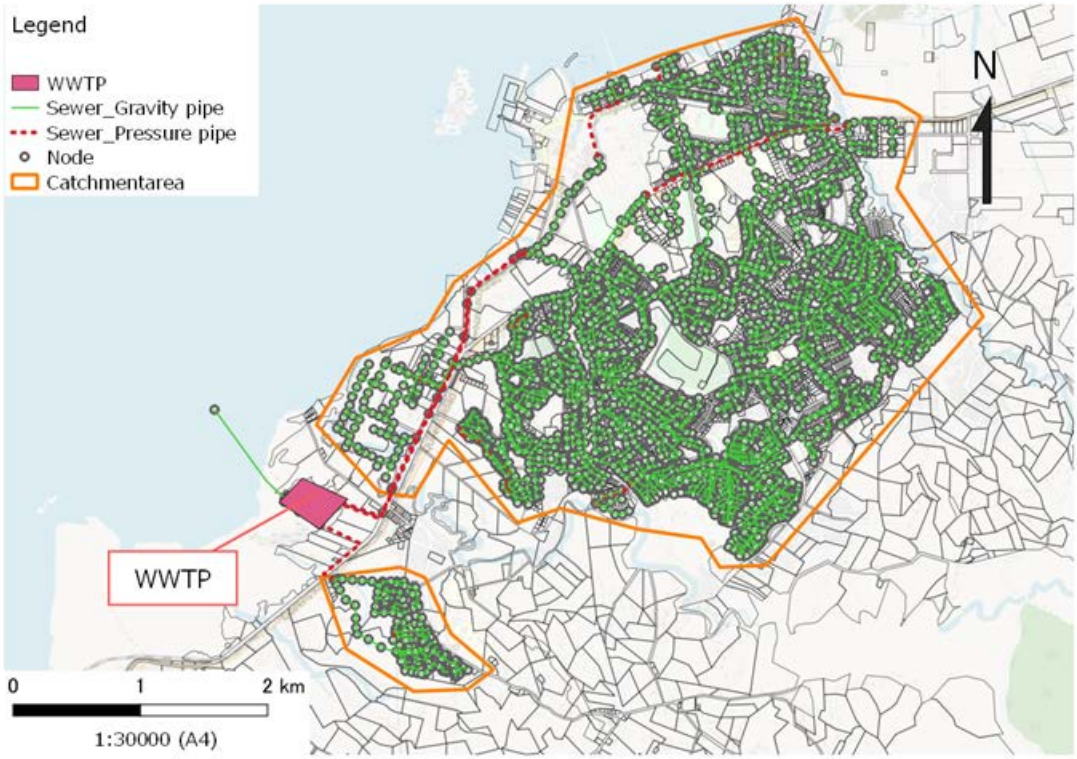


Figure 9-4.4 Wastewater Service Area of Lautoka

Source: JICA Survey Team based on the sewer pipe networks figure of WAF

Outline of the WWTP is shown in **Table 9-4.5** and layout of the facilities is shown in **Figure 9-4.5**.

Table 9-4.5 Outline of Natabua WWTP

Name	Natabua WWTP
Commencement of operation	1983
Treatment capacity	43,000EP Based on the unit wastewater volume used in WAF (200L/capita/day), the 43,000EP is 8,600m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond
Sludge treatment process	Typical anaerobic pond operation requires that sludge is dredged every 1~2 years. At Natabua, sludge has not been removed since start of operation more than 30 years ago. Hence no sludge treatment has been done. However, because bad odor, especially from anaerobic pond, is a big issue in WWTP, sludge dredging from the ponds was decided to be implemented from 2019 and dredging equipment are already delivered to the WWTP by the Australian contractor. According to the dredging program, dredged sludge (which seems to contain a lot of sand) will be dewatered by mechanical dehydrator and will be stored temporarily on land reserved for WWTP expansion. If the sludge composition is found to be suitable for producing compost, it

	will be composted. If not, it will be reclaimed in the WWTP site.
Wastewater treatment flow	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Pump facility → Ocean outfall
Discharging point	Ocean outfall (Pumped to 1.2km offshore)
Outsource	No use

Source: JICA Survey Team based on Interview of WAF

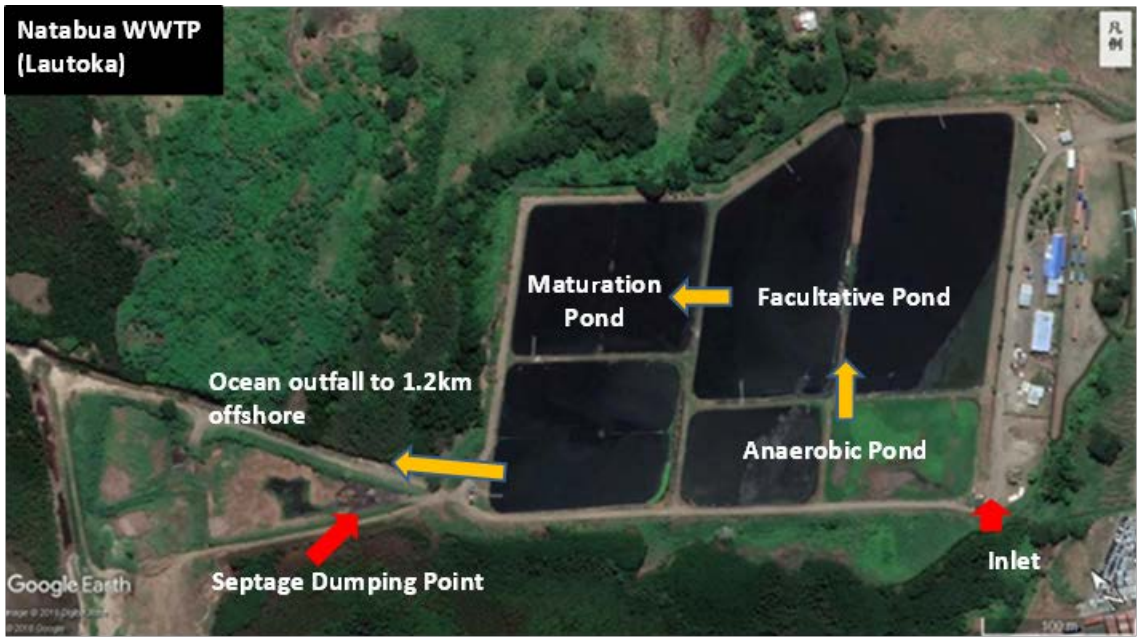


Figure 9-4.5 Layout of Facilities in Natabua Wastewater Treatment Plant

(1) Current Status

The stabilization pond system of Natabua WWTP consists of 2 anaerobic ponds, 2 facultative ponds and 2 maturation ponds. The inflow wastewater pumped from the final pumping station in the city urban area flows into the anaerobic ponds and is anaerobically treated. Then, the wastewater is led to the facultative ponds and treated by algae and microorganisms. It then flows to the maturation ponds for settling of suspended solids and polishing, and is discharged. The bottoms of all ponds are lined by rubber sheet; however, some parts of the sheets have peeled off from the bottom and are floating on the surface. Leakage of wastewater into the soil is a concern.

The plant relies entirely on gravity flow for conveyance of wastewater. There is no machinery in the WWTP except the pumps for ocean outfall. There is a pond for receiving septic tank sludge in the WWTP site and tank trucks come and discharge septic tank sludge into the pond. A big issue of this pond is the peeling of the rubber sheets from the bottom of the pond. Groundwater pollution by septic tank sludge is a concern.

The pond can overflow in the rainy season, causing contamination of the surrounding areas with septic tank sludge. Septic tank sludge should be dumped into the anaerobic pond same as in other WWTP or special treatment facility should be constructed.

Table 9-4.6 shows the influent and effluent quality (annual average) from 2014 to 2018.

Table 9-4.6 Water Quality of Natabua WWTP

Year	Influent						Effluent					
	T-SS	BOD	COD	T-KN	T-P	FOG	T-SS	BOD	COD	T-KN	T-P	FOG
Stand.							60	40	―	―	5	5
2014	533	318	594	8.4	4.6	236	81.6	64.3	170	4.4	3.4	38.2
2015	482	303	575	10.6	3.7	149	44.2	65.3	125	4.9	2.2	32.7
2016	439	394	828	-	0.6	22.4	52.3	43.6	117	-	0.8	4.2
2017	846	329	603	50.7	3.6	24.4	114	68.6	191	26.0	2.3	7.3
2018	295	207	517	41.3	2.3	71.4	54.8	51.1	140	21.6	1.2	32.3
Ave	537	307	606	28.8	3.5	111	71.9	60.7	152	14.6	2.3	24.7

Unit: mg/L
Stand.: Values shown in “Environment Management (Waste Disposal and Recycling) Regulation 2007 Schedule 2”
Source: JICA Survey Team based on Interview of WAF

Table 9-4.7 shows the compliance rate of effluent standard (BOD=40mg/L).

Table 9-4.7 Compliance Rate of Effluent Standard of BOD

Year	Number of analysis	Number of data under the standard	Compliance rate (%)
2014	12	2	16.5
2015	9	0	0.0
2016	5	2	40.0
2017	12	1	8.3
2018	10	4	40.0
Sum/Ave	48	9	18.8

Source: JICA Survey Team based on Interview of WAF

Average compliance rate of the effluent standard in the five years is only 18.8%. It is the lowest of the four WWTPs in the Western Division. Desludging of the anaerobic and facultative ponds is expected to improve effluent quality and is planned to be implemented soon.

If the sludge dredging is insufficient for improving the quality, it may be necessary to consider adoption of more sophisticated wastewater treatment processes.

(2) Restoration/Expansion Project

In order to improve the effluent quality of the Natabua WWTP, WAF contracted with GHD (an Australian consulting company) in 2018 and started preparation of a restoration/expansion plan.

As a result, assessment of wastewater treatment options was completed in October 2019, as outlined in **9-3.2**. However, implementation of the project is not certain because required funds for project implementation are not yet secured.

As mentioned in **9-4-1** Nadi, influent volume is not measured at any of the WWTPs in Fiji and the extent of treatment capacity deficiency is not known. Restoration/expansion projects must be implemented after measuring flowrates to ensure appropriately sized facilities are constructed and avoid misuse of funds.

(3) O&M Organization

Organization of the WWTP is as shown in **Table 9-4.8**.

Table 9-4.8 Organization of Natabua WWTP

Position	Number	Main works
Supervisor	1	Not only the supervision of WWTP, wastewater networks and pumping stations in Nadi but also those in Ba
Operator	2	3 shifts

Source:JICA Survey Team based on Interview of WAF

The office for the maintenance team is located at the Natabua WWTP (Lautoka). They are responsible for the maintenance of mechanical and electrical facilities of all WWTPs in the Western Division. Organization of the maintenance group is as shown in **Table 9-4.9**.

Table 9-4.9 Organization of Maintenance Group

Position	Number	Main works
Supervisor	1	Supervision of maintenance works of mechanical and electrical equipment
Maintenance staff	7	Maintenance and repairing of mechanical and electrical equipment

Source: JICA Survey Team based on Interview of WAF

(4) Issues

Issues found in the Natabua WWTP are as follows;

(a) Issue in planning

a) Wastewater M/P

The existing wastewater M/P was prepared in 1991 (by PPK Consultants Ltd.) and is no longer appropriate for the restoration/expansion of the current wastewater system. M/P must be revised and new, more appropriate M/P should be provided.

(b) Issue in treatment facility

a) Acceptance of septic tank sludge

Although the WWTP accepts septic tank sludge, the bottom of the septic tank sludge dump site is not covered by rubber sheet; therefore, infiltration of pollutant and/or environment pollution by overflow of sludge during rainy season is a concern. When the incoming septic tank sludge volumes are small, treatment in the anaerobic pond will be effective. When volumes are large, it will be better to consider the construction of acceptance facility.

(c) Issues in management of WWTP

a) Influent volumes

Influent volume into the WWTP is unknown because there are no flowmeters in the WWTP. Since WAF is preparing the restoration/expansion plan of the WWTPs, WAF should verify whether the WWTP is operated in overloaded condition or not. Flowmeters to measure the influent volume is required for this task. WAF understands the necessity of setting the flowmeter and has plans to install them by 2021. Until they are installed, the JICA Survey Team has provided a method for estimating influent volume from the water bills of households.

b) Compliance rate to effluent standards

Table 9-4.7 shows that the average compliance rate of effluent BOD in 2014-2018 was only 18.8%. According to WAF, the low compliance rate is caused by lack of desludging of the anaerobic and facultative ponds since the beginning of the operation. Inflow of industrial wastewater with high pollutant load is also a contributing factor.

c) Desludging of ponds

Sludge accumulated in the anaerobic and facultative ponds has never been dredged since start of operation; therefore, accumulated sludge and sand may have significantly reduced the volume of the ponds. Dredging of sludge must be implemented periodically henceforth.

WAF will implement desludging of anaerobic and facultative ponds from 2019 and necessary machines have already been brought into the WWTP.

Inlet into WWTP (Wastewater is pumped from the pumping station in the city center)

Anaerobic pond (A part of rubber sheet is peeled off and floats onto the surface of pond.)

Effluent discharge pumps (Effluent of WWTP is pumped to ocean outfall point of 1.2km offshore.)

Septic tank sludge dump site (Septic tank sludge is dumped into deep pond.)

Figure 9-4.6 Present Condition of Natabua WWTP

9-4-3 Votua WWTP (Ba)

Figure 9-4.7 shows the wastewater service area of Ba.

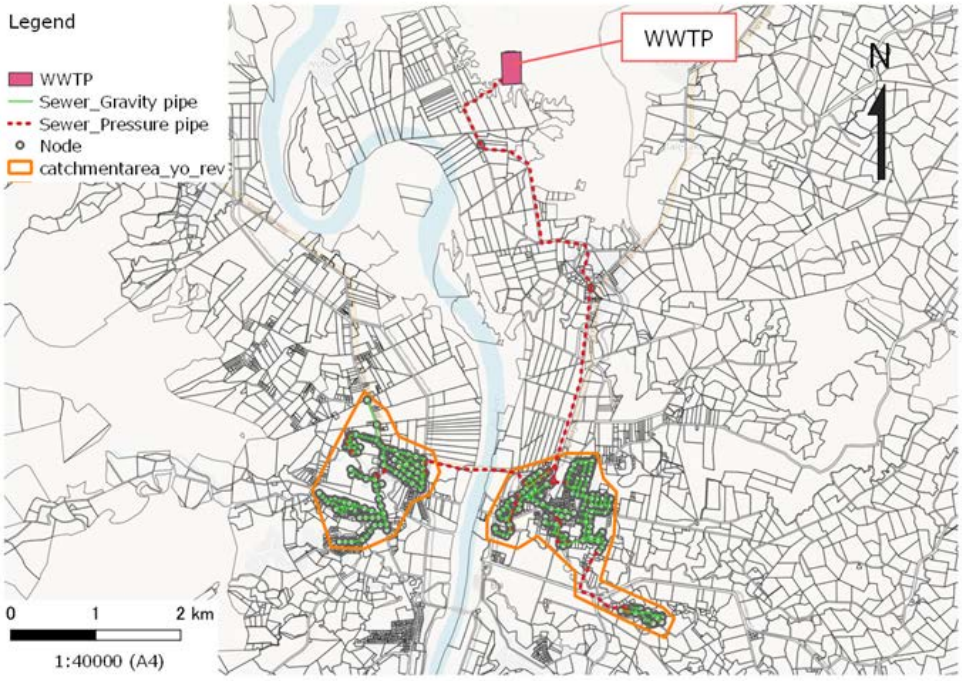


Figure 9-4.7 Wastewater Service Area of Ba

Source: JICA Survey Team based on the sewer pipe networks figure of WAF

Outline of the WWTP is shown in **Table 9-4.10** and layout of the facilities is shown in **Figure 9-4.8**.

Table 9-4.10 Outline of Votua WWTP

Name	Votua WWTP
Commencement of operation	1996
Treatment capacity	10,000EP Based on the unit wastewater volume used in WAF (200L/capita/day), the 10,000EP is 2,000m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond Septic tank sludge is accepted at the inlet of the WWTP
Sludge treatment process	Sludge accumulated in the ponds has never been removed since the start of operation; hence, no sludge treatment has been done. Desludging from anaerobic and facultative ponds will start in 2019 by WAF's budget.
Wastewater treatment flow	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Discharge
Discharging point	A channel in mangrove forests flowing near the WWTP
Outsource	No use

Source: JICA Survey Team based on Interview of WAF

Figure 9-4.8 Layout of Facilities in Votua WWTP

(1) Current Status

The stabilization pond process of Votua WWTP consists of 1 anaerobic, 1 facultative and 1 maturation ponds. The wastewater is pumped into the WWTP through the final pumping station located in the center of the town. There are no houses near the WWTP; hence complaints regarding bad odors are not received.

Table 9-4.11 shows the influent and effluent quality (annual average) from 2014 to 2018.

Table 9-4.11 Water Quality of Votua WWTP

Year	Influent						Effluent					
	T-SS	BOD	COD	T-KN	T-P	FOG	T-SS	BOD	COD	T-KN	T-P	FOG
Stand.							60	40	—	—	5	5
2014	471	290	749	8.5	4.6	172	86.2	40.5	136	5.1	3.4	43.1
2015	543	308	795	7.8	2.5	116	78.1	52.7	156	3.9	1.9	31.8
2016	589	273	909	11.2	2.6	13.7	42.0	49.2	126	9.8	1.7	6.0
2017	2240	285	655	31.7	3.1	22.2	69.9	50.4	138	16.7	2.0	10.5
2018	951	274	667	36.0	2.8	59.2	53.8	52.5	144	14.6	1.9	22.3
Ave	1020	285	739	21.3	3.2	80.0	67.8	48.7	140	10.3	2.3	24.0

Unit: mg/L
Stand.: Values shown in “Environment Management (Waste Disposal and Recycling) Regulation 2007 Schedule 2”
Source: JICA Survey Team based on Interview of WAF

Table 9-4.12 shows the compliance rate to effluent standard (BOD=40mg/L).

Table 9-4.12 Compliance Rate of Effluent Standard of BOD

Year	Number of analysis	Number of data under the standard	Compliance rate (%)
2014	11	7	63.6
2015	6	3	50.0
2016	7	3	42.9
2017	11	6	54.5
2018	11	3	27.3
Sum/Ave	46	22	47.8

Source: JICA Survey Team based on Interview of WAF

Average compliance rate of the effluent standard in the five years is 47.8%. Desludging of the anaerobic and facultative ponds is expected to improve effluent quality and is planned to be implemented soon. If the improvement is insufficient, adoption of other treatment processes should be considered.

(2) Restoration/Expansion Project

Site for expansion of WWTP is available adjacent to the existing treatment facility; however, there is no specific plan for restoration/expansion.

(3) O&M Organization

An officer in charge (usually in WAF office in Ba) implements unscheduled patrol for O&M of Votua WWTP. Because there is no mechanical and electrical equipment in the WWTP; unscheduled patrol is enough for O&M.

(4) Issues

Issues found in the Votua WWTP are as follows;

(a) Issue in sewerage works planning

a) Wastewater M/P

The existing wastewater M/P was prepared in 1986 (by Harrison & Grierson Ltd.) and it has never been revised. If checking the influent volume reveals that the WWTP is operating under overloaded conditions, restoration/expansion project should be considered.

(b) Issues in management of WWTP

a) Influent volumes

Influent volume into the WWTP is unknown because there is no flowmeter installed. WAF already secured budget for installing a flowmeter by 2021.

b) Compliance rate to effluent standards

Table 9-4.12 shows that the average compliance rate of effluent BOD in 2014-2018 is 47.8%. According to WAF, the low compliance rate is caused by lack of desludging of the anaerobic and facultative ponds since the beginning of the operation. Inflow of industrial wastewater with high pollutant load is also a contributing factor.

c) Desludging of ponds

Sludge accumulated in the anaerobic and facultative ponds has never been dredged since start of operation; therefore, accumulated sludge and sand may have significantly reduced the volume

of the ponds. Dredging of sludge must be implemented periodically henceforth.

WAF will implement desludging of anaerobic and facultative ponds of Votua WWTP from 2019.

Inlet (Wastewater is pumped from the center of the town. Septic tank sludge is dumped into the inlet.)

Anaerobic pond (No strong odor)

Facultative pond (Green algae grow vigorously.)

Maturation pond (Buffer piles are set.)

Figure 9-4.9 Present Condition of Votua WWTP

9-4-4 Olosara WWTP (Sigatoka)

Figure 9-4.10 shows the wastewater service area of Sigatoka.

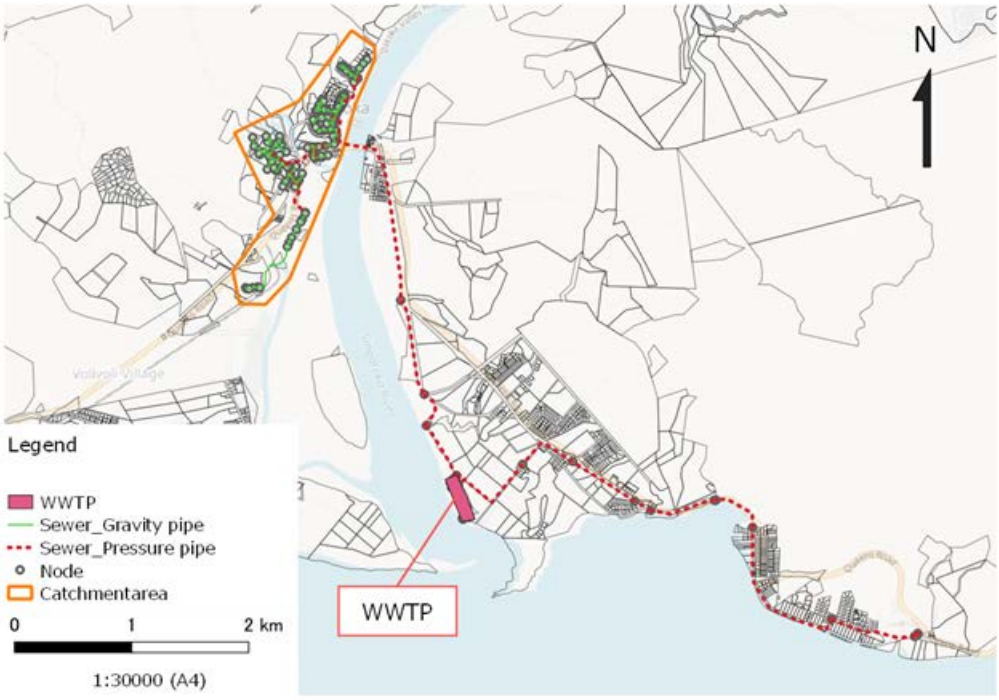


Figure 9-4.10 Wastewater Service Area of Sigatoka

Source: JICA Survey Team based on the sewer pipe networks figure of WAF

Outline of the WWTP is shown in **Table 9-4.13** and layout of the facilities is shown in **Figure 9-4.11**.

Table 9-4.13 Outline of Olosara WWTP

Name	Olosara WWTP
Commencement of operation	1986
Treatment capacity	10,000EP Based on the unit wastewater volume used in WAF (200L/capita/day), the 10,000EP is 2,000m^3/day
Inflow volume at present	Not measured
Wastewater treatment Process	Stabilization pond Septic tank sludge is accepted at the inlet of the WWTP
Sludge treatment process	Sludge accumulated in the ponds has never been removed since the start of operation; hence, no sludge treatment has been done. Desludging from anaerobic and facultative ponds will start in 2019 by WAF's budget.
Wastewater treatment flow	Inflow → Anaerobic pond → Facultative pond → Maturation pond → Pump facility → Ocean outfall
Discharging point	Sigatoka River flowing near the WWTP
Outsource	No use

Source: JICA Survey Team based on Interview of WAF

Figure 9-4.11 Layout of Facilities in Olosara WWTP

(1) Current Status

The stabilization pond process of Olosara WWTP consists of 2 anaerobic, 1 facultative and 2 maturation ponds. The wastewater is pumped into the WWTP through the final pumping station located in the center of the town. Green algae grows vigorously in the facultative and maturation ponds. There are no houses near the WWTP; hence complaints regarding bad odors are not received.

Table 9-4.14 shows the influent and effluent quality (annual average) from 2014 to 2018.

Table 9-4.14 Water Quality of Olosara WWTP

Year	Influent						Effluent					
	T-SS	BOD	COD	T-KN	T-P	FOG	T-SS	BOD	COD	T-KN	T-P	FOG
Stand.									—			
2014	736	414	1220	9.1	3.4	225	78.0	57.2	124	4.3	1.7	39.9
2015	347	242	526	9.1	3.0	68.8	44.8	55.4	157	5.1	2.4	37.3
2016	437	263	550	29.8	2.5	12.4	42.0	41.2	135	23.5	1.0	7.3
2017	409	289	583	47.5	4.2	82.1	59.7	40.2	129	17.5	1.5	37.0
2018	512	374	873	46.4	3.3	71.0	49.2	54.5	142	19.9	1.0	18.8
Ave	495	321	752	27.7	3.3	95.1	57.1	49.4	138	11.8	1.6	29.0

Unit: mg/L
Stand.: Values shown in “Environment Management (Waste Disposal and Recycling) Regulation 2007 Schedule 2”
Source: JICA Survey Team based on Interview of WAF

Table 9-4.15 shows the compliance rate to effluent standard (BOD=40mg/L).

Table 9-4.15 Compliance Rate of Effluent Standard of BOD

Year	Number of analysis	Number of data under the standard	Compliance rate (%)
2014	11	3	27.3
2015	10	3	30.0
2016	11	6	54.5
2017	12	7	58.3
2018	11	2	18.2
Sum/Ave	55	21	38.2

Source: JICA Survey Team based on Interview of WAF

Average compliance rate of the effluent standard in the five years is only 38.2%. Desludging of the anaerobic and facultative ponds is expected to improve effluent quality. If the improvement is insufficient, adoption of other treatment processes should be considered.

(2) Restoration/Expansion Project

The original wastewater M/P prepared in 1987 by Fawcett Mouchel Ltd. was revised in 2005 consigning to Erasito Consultants Ltd and Beca International Ltd.; however, no specific restoration/expansion project has been conducted due to shortage of budget.

(3) O&M Organization

An officer in charge (usually in WAF office in Sigatoka) implements unscheduled patrol for O&M of Votua WWTP. Because there is no mechanical and electrical equipment in the WWTP, unscheduled patrol is enough for O&M.

(4) Issues

Issues found in the Olosara WWTP are as follows;

(a) Issue in sewerage works planning

a) Wastewater M/P

Fourteen years have passed since the revision of the original old M/P in 2005. However, no actions were taken and the revised M/P has become obsolete. WAF is considering updating the revised M/P.

(b) Issues in management of WWTP

a) Influent volume

Influent volume into the WWTP is unknown because there is no flowmeter installed. WAF understands the necessity of installing the flowmeters and has secured budget for installing a flowmeter by 2021.

b) Compliance to effluent standards

Table 9-4.15 shows that the average compliance rate of effluent BOD in 2014-2018 was 38.2%. According to WAF, low compliance rate is caused by lack of desludging of anaerobic and facultative ponds since the beginning of the operation.

c) Desludging of ponds

Sludge accumulated in the anaerobic and facultative ponds has never been dredged since the start of operation; therefore, accumulated sludge and sand may have significantly reduced the

volume of the ponds. Dredging of sludge must be implemented periodically henceforth.

WAF will implement desludging of anaerobic and facultative ponds of Olosara WWTP from 2019.

Anaerobic pond-1

Anaerobic pond-1 (Septic tank sludge is dumped into the pond.)

Anaerobic pond-2 (The surface of the pond is covered by grass. It is better for preventing bad odor.)

Maturation pond (A part of rubber sheet is peeled off and floats onto the surface of pond.)

Figure 9-4.12 Present Condition of Olosara WWTP

9-4-5 Issues in WWTPs and Countermeasures

Issues in WWTPs discovered by this survey in WAF Central, WAF Western and each WWTP are summarized as follows;

9-4-5-1 Issues Found in WAF Central

a) Wastewater M/Ps

The existing wastewater M/Ps of Nadi, Lautoka and Ba were prepared in 1987, 1991 and 1986, respectively, and all of them are still active. In Sigatoka, the original M/P prepared in 1987 was revised in 2005; however, 15 years have passed since the revision without realization of the project and the revised M/P now out of date.

Especially in Nadi and Lautoka, population has increased rapidly in the last 20 years and the active M/Ps are completely obsolete; therefore, revision of the M/P is required.

WAF is preparing restoration/expansion plans of Navakai and Natabua WWTP by contracting with Australian consulting companies. However, the restoration/expansion projects must be based on the M/P to ensure appropriately sized facilities. Therefore, M/P must be provided before the implementation of the projects.

b) General manager in charge of wastewater

Because the post of general manager (GM) in charge of wastewater has been vacant since May 2019, business decisions regarding wastewater works of WAF are made by the council system of other GMs. In order to avoid delay of decision-making, prompt assignment of new GM is required.

9-4-5-2 Issues Found in WAF West

a) Staff training

According WAF staff, there is no official staff training and technical experience and expertise is transferred directly from senior level to younger level. However; staff training for capacity development in introducing wastewater treatment processes, maintenance of machinery, safety management et cetera is essential for the establishment of a safe and secure work place and appropriate wastewater treatment.

b) O&M manual

Among the 4 WWTPs in the Western Division, only the Navakai WWTP (Nadi) is equipped machinery that require daily O&M (in the IDEA and sludge dewatering facility). However, no O&M manuals were found in the WWTP. It is not certain whether the manuals were lost or not prepared from the beginning. The O&M of the WWTP is implemented based on the experience of the staff. Standard operation procedures (SOPs) must be prepared to perform consistent O&M.

9-4-5-3 Issues Found in WWTPs

(1) Issues with facilities

(a) Sludge disposal

Sludge generated at the Navakai WTTP (Nadi) is dried and stored in the WWTP premises. The storage site is not isolated by rubber lining. There is possibility of sludge flowing to the ocean during the rainy season. In fact, a large-scale flooding event occurred in at the Navakai WWTP in 2013.

WAF as requested permission to dispose of the sludge in the Nadi municipal landfill. However, the city has refused due to concerns about heavy metal contamination of the sludge. WAF is also coordinating with the Ministry of Environment to secure its own sludge disposal site, but no progress has been made. At minimum, the current storage site should be managed with rubber lining.

(b) Acceptance of septic tank sludge

At the Votua WWTP in Ba and Olosara WWTP in Sigatoka, septic tank sludge is received in the anaerobic tanks and treated. However, at the Natabua WWTP in Lautoka, septic tank sludge is dumped into a deep pond adjacent to the wastewater treatment facility. The ponds are not lined with rubber sheets and water may overflow into the ocean during the rainy season. Therefore, a fundamental reconsideration of septic tank sludge treatment at Natabua WWTP is required. At minimum, the ponds should be lined with rubber sheets and supernatant conveyed to the facultative pond for treatment.

(2) Issues in management of WWTP

a) Influent volumes

Wastewater inflow volume into WWTPs is the most basic and important piece of information. It is impossible to form rational restoration/expansion plans of facilities without it. Currently, it is not possible to verify whether the WWTPs are operated under overloaded conditions, or not. So, the installation of flowmeters is necessary in every WWTP. Ultrasonic or electromagnetic flowmeters are not needed. Simple, partial flume types will be adequate. According to WAF, they will secure budget and install flowmeters in all 4 WWTPs by 2021.

Until installation, Survey Team introduced to WAF a way to estimate the influent volumes. Wastewater volumes are proportional to water consumption. The wastewater volume can be estimated from the total water consumption of customers connected to the wastewater system.

b) Dumping of dewatered sludge into WWTP site

The dewatered sludge generated in the Navakai WWTP (Nadi) is discarded into a dump site located in the WWTP. Bottom of the dump site is not covered by rubber sheet. During the rainy

season, the sludge might overflow and flow into the sea. For instance, a severe flood occurred in 2013 in Navakai area.

Although WAF has requested Nadi town municipality to accept the sludge at the solid waste disposal site, the town council refused due to possibility of pollution by heavy metals in the sludge. WAF should consider alternatives such as adopting sludge incineration and/or finding individual disposal site. At least, WAF should lay rubber sheet on the bottom of the dump site.

c) Dumping of septic tank sludge

Although septic tank sludge is discharged into anaerobic pond in Votua WWTP (Ba) and Olosara WWTP (Sigatoka), septic tank sludge in Lautoka is discharged into a deep pond adjacent to the WWTP site without any treatment. The bottom of the deep pond is not covered by rubber sheet, so pollutant in sludge could infiltrate the soil, especially in the rainy season. Therefore, treatment and disposal process of septic tank sludge must be considered in Natabua WWTP. At least, the bottom of the pond should be covered by a sheet and the supernatant of the pond be returned into the maturation pond and treated.

d) Compliance rate to effluent standards

The water quality data of four WWTPs in 2014-2018 was obtained in the survey.

The average compliance rate of BOD standard in the Navakai WWTP (Nadi) was found to be 30.8% over a 5-year period. According to WAF Western, the low rate is caused by 4 out of 8 aerators in the IDEA reaction tank being nonoperational. At present, 2 aerators are under repair and 3 new aerators (2 for operation, 1 for stand-by) have been purchased. WAF must install the required number of aerators in the reaction tank soon, and check if the effluent quality is improved.

The compliance rates to BOD standard in the Natabua (Lautoka), Votua (Ba) and Olosara (Sigatoka) WWTP using stabilization pond process were 18.8%, 47.8% and 38.2%, respectively. In the stabilization pond process, algae growing in the pond have an important role for wastewater treatment. However, if algae are not separated in the maturation pond and are discharged together with effluent (it is often observed in the stabilization pond process) apparent BOD will become high. So, WAF should check whether the low compliance rate is caused by the algae, or by insufficient treatment of wastewater. If the low compliance rate is found to be caused by the algae, measures such as control of algae growth in the maturation pond by floating grass to prevent penetration of sun light into the pond should be implemented.

The 5-year average concentration of effluent fat/oil/grease (FOG) in Navakai (Nadi), Natabua (Lautoka), Votua (Ba) and Olosara (Sigatoka) WWTP was 27.8 mg/L, 24.7mg/L, 24.0mg/L and 29.0mg/L, respectively. These are significantly higher than the effluent standard of 5mg/L.

WAF considers the violation is caused mainly by inflow of commercial liquid water of high pollutant load, so WAF initiated the control of it. The discharge standard of trade liquid waste into wastewater system has already been issued. The standard of BOD and SS is set at 600mg/L and that of FOG is set at 200mg/L. Removal of FOG in WWTP is not easy. Therefore, WAF instructs restaurants and food processing factories to install oil-trap before discharging to wastewater system. If the control goes well, violation of effluent standard of FOG in WWTPs is expected to be improved.

Chapter 10 Result of Survey regarding Restoration/Expansion Project of WWTPs

10-1 Restoration/Expansion Plan for Navakai WWTP (Nadi)

In the Navakai WWTP (Nadi), the effluent quality exceeds the standards frequently due to low treatment capacity caused by deterioration and malfunction of equipment. In addition, the stabilization pond process at the Natabua WWTP (Lautoka) does not always function properly, causing the effluent quality to exceed standard values frequently.

Because Nadi and Lautoka are the major towns for tourism and business in the Western Division, WAF is preparing restoration/expansion projects of Navakai WWTP by contracting with HunterH2O Ltd, an Australian consulting company. The plan will be completed in the early 2020.

Planning for the Navakai WWTP is expected to completed in early 2020.

10-2 Restoration/Expansion Plan for Natabua WWTP (Lautoka)

The stabilization pond process at the Natabua WWTP (Lautoka) does not always function properly, causing the effluent quality to exceed standard values frequently.

Because Lautoka is a major city for tourism and business in the Western Division, WAF is preparing restoration/expansion projects of Natabua WWTP by consigning to GHD, an Australian consulting company. In October 2019, the report of “Upgrading of Wastewater Treatment Plant at Natabua, Option Assessment” was completed.

The outline of the option assessment of Natabua WWTP is as follows;

(1) Population

The design sewer-serviced population of Natabua WWTP in 2040 is predicted to be twice as that of 2019 due to population growth and the expansion of wastewater service area, as shown in **Table 10-2.1**.

Table 10-2.1 Design Sewer-Serviced Population of Natabua WWTP

Year	2019	2020	2025	2030	2035	2040	Extreme case
Population	47,757	50,031	61,278	72,530	83,787	95,049	154,745

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(2) Acceptance of Septic Tank Sludge

Natabua WWTP accepts septic-tank sludge from factories and commercial facilities, as well as from domestic houses. On average, seven vacuum tankers ($20m^3$ each) discharge septic-tank sludge into the WWTP daily. Septic-tank sludge concentrations are as shown in **Table 10-2.2**.

Table 10-2.2 Septic-tank Sludge Concentration (Average and Maximum)

Pollutant		Concentration(mg/L)	Average daily EP load (7*20m^3 tankers)
TSS	Average	66,866	156,019
	Maximum	338,730	790,370
COD	Average	42,000	48,951
	Maximum	132,000	154,000
FOG	Average	8,712	121,971
	Maximum	49,690	695,660

Average daily EP load: Obtained by dividing sewerage volume (including liquid trade waste) by capita flow (200L/capita/day)

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(3) Flow Projections

Table 10-2.3 provides a summary of the average dry weather flow (ADWF), peak dry weather flow (PDWF) and peak wet weather flow (PWWF) projections. The projections include the daily hydraulic contribution of 7 x 20kL from the vacuum tankers.

Table 10-2.3 Flow Projections of Natabua WWTP

Year		2019	2020	2025	2030	2035	2040	Max
ADWF	L/sec	112	117	143	170	196	222	368
	L/day	0.0097	0.0101	0.0124	0.0146	0.0169	0.0192	0.0318
PDWF	L/sec	224	235	287	339	391	443	736
PWWF	L/sec	561	587	717	848	978	1,108	1,840

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(4) Load Projections

Table 10-2.4 provides a summary of the pollutant load projections, including the septic tank sludge from tankers.

Table 10-2.4 Pollutant Load Projections of Natabua WWTP to 2040

Pollutant	2019	2020	2025	2030	2035	2040	Max
T-COD	6,236	6,509	7,859	9,209	10,560	11,911	18,601
BOD	3,118	3,254	3,929	4,604	5,280	5,956	9,301
T-P	94	98	118	138	158	179	279
VSS	2,650	2,766	3,340	3,914	4,488	5,062	7,905
TSS	3,118	3,254	3,929	4,604	5,280	5,956	9,301
ISS	468	488	589	691	792	893	1,395
T-KN	624	651	786	921	1,056	1,191	1,860
Ammonia	416	434	524	614	704	794	1,240

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(5) Wastewater Treatment Process Options

The 6 wastewater treatment processes shown in **Table 10-2.5** were evaluated.

Table 10-2.5 Options of Wastewater Treatment Process

Option	Treatment process
1	Intermittently decanted extended aeration (IDEA)
2	Sequential batch reactor (SBR)
3	Plastic media trickling filter plant
4	Modified Ludzack-Ettinger Process
5	Primary sedimentation with anaerobic digestion followed by activated sludge process
6	SBR/IDEA hybrid flexibility plant

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

Among these, Option-3 (Plastic media trickling filter plant) was omitted from the evaluation because this process cannot remove nutrients without installation of advanced treatment facilities, which will make O&M complicated. Option-6 (SBR/IDEA hybrid flexibility plant) is described as basically an SBR plant which can also be operated as an IDEA plant.

Figure 10-2.1 to **Figure 10-2.4** shows the layout plans of Option-1, -2, -4 and -5.

Figure 10-2.1 Layout Plan of Option-1

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

Figure 10-2.2 Layout Plan of Option-2

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

Figure 10-2.3 Layout Plan of Option-4

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

Figure 10-2.4 Layout Plan of Option-5

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(6) Cost Comparison

Table 10-2.6 shows the costs of each option.

Table 10-2.6 Cost Summary of each Option

	Treatment process	Capital Cost(FJD)	Average O&M Cost (FJD/year)
1	Intermittently decanted extended aeration (IDEA)	85,470,000	3,030,000
2	Sequential batch reactor (SBR)	91,730,000	3,130,000
3	Plastic media trickling filter plant	Not evaluated	Not evaluated
4	Modified Ludzack-Ettinger Process	103,580,000	3,480,000
5	Primary sedimentation with anaerobic digestion followed by activated sludge process	128,040,000	3,050,000
6	SBR/IDEA hybrid flexibility plant	91,730,000	3,130,000

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

(7) Multi-Criteria Analysis

According to the report of "Upgrading of Wastewater Treatment Plant at Natabua Options Assessment", a multi-criteria analysis (MCA) workshop was conducted on 1st October 2019, with the WAF staff at WAF Central for evaluating the wastewater treatment processes of Natabua WWTP. The purpose of the workshop was;

- Agree on non-cost criteria to compare the options
- Agree on weighting for the cost and non-cost criteria
- Score the non-cost criteria from 1 (worst9 to 5 (best)
- Generate the preferred upgrade option

Table 10-2.7 provides the results of the MCA.

Table 10-2.7 Results of Multi-Criteria Analysis

Assessment	Weighting (%)	Option-1 (IDEA)		Option-2 (SBR)		Option-3 (MLE)	
		Initial Score	Weighted Score	Initial Score	Weighted Score	Initial Score	Weighted Score
Capital cost		85,470,000		91,730,000		103,580,000	
Cost score	50	3.2	32.3	2.9	29.2	2.3	23.3
Plant flexibility	10	3	6.0	3	6.0	3	6.0
Plant reliability (normal operation)	10	3	6.0	3	6.0	4	8.0
Operational complexity	10	4	8.0	3	6.0	2	4.0
Constructability /interfacing risks	10	4	8.0	4	8.0	3	6.0
Environmental impact/ Approval	10	3	6.0	4	8.0	4	8.0
Total	100	20.2	66.3	19.9	63.2	18.3	55.3

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

As shown in **Table 10-2.7**, the IDEA process scored the highest. The reasons are indicated as follows;

- Low capital cost
- Reduced operational complexity, as WAF has experience in operating IDEA plants
- Compact site footprint, low construction/interface risks

Regardless of which option is select, construction of facilities shown in **Table 10-2.8** is required to treat septic-tank sludge accepted at the WWTP.

Table 10-2.8 Septic-tank Sludge Treatment Facilities Required

1	Drum screen with linear grit separator
2	Concrete storage bays
3	Primary clarifier
4	Cold anaerobic digester with mixer (SRT=60 days)
5	Anaerobic tank (HRT=1 day)
6	Dissolved air flotation tank
7	Transfer pump station

Source: Upgrading of Wastewater Treatment Plant at Natabua Options Assessment (GHD 2019)

10-3 Votua WWTP (Ba), Olosara WWTP (Sigatoka)

There are no restoration/expansion plans for Votua WWTP (Ba) and Olosara WWTP (Sigatoka).

Chapter 11 Proposal for the Direction of Japanese Cooperation for the Wastewater Sector

WAF requests Japanese cooperation for the following two wastewater sector projects in the Western Division.

1	Preparation of wastewater M/P in the cities and towns of the Western Division
2	Technical cooperation for capacity improvement of staff

11-1 Preparation of Wastewater M/P in the City/Towns of the Western Division

As shown in **9-3-1-1**, wastewater M/P were prepared for Nadi in 1987, Lautoka in 1991, and Ba in 1986. The M/P for Sigatoka was updated in 2005, but 15 years have passed and it is also considered obsolete.

Table 11-1.1 shows the result of the census of Fiji. During the twenty-one years from 1996 to 2017, average population growth rate compared to the 1996 population was 6.2% in Nadi, 3.1% in Lautoka, 0.4% in Ba and 1.6% in Sigatoka. Population increase in Nadi and Lautoka were especially high. Therefore, if the restoration/expansion of pumping station and WWTP is implemented based on the old M/P, the design parameters (service population, treatment volume, influent quality etc.) may not match the present situation and the expansion/renovation scale might be insufficient. Therefore, the preparation of a current M/P in Nadi and Lautoka is urgent. The revision of M/P in Ba and Sigatoka is also necessary when any restoration/expansion of WWTP is planned.

Table 11-1.1 Population Change in Four Cities/Towns

City/Town	Population			Annual average increase	Annual average increase rate (%) (against 1996 population)
	1996	2007	2017	1996~2017	
Nadi	30,884	42,284	71,048	1,913	6.2
Lautoka	43,274	52,220	71,573	1,348	3.1
Ba	14,716	18,526	15,846	54	0.4
Sigatoka	7,862	9,622	10,509	126	1.6

Source: JICA Survey Team based in Fiji census

One target of the “20-Year Development Plan 2017-2036” is “Access to central sewerage system (% by population) is 70% in 2036”. On the other hand, in Fiji, there is no guideline or plan indicating how to treat wastewater generated in cities and towns, and centralized and de-centralized wastewater treatment areas are not clearly defined. Furthermore, the development of sewerage systems by WAF is not systematic. Therefore, in order to achieve the target of the “20-Year Development Plan”, preparation of a “Basic plan for sewerage system” that indicates municipalities that require wastewater treatment and prioritizes introduction of treatment is required for the city/towns in the Western Division.

Cooperation for the sewerage sector is recommended to be implemented in the order indicated below.

(1) Preparation of M/P for the Western Division

The following items will be considered for the Western Division M/P.

① Population, development condition of water supply, water quality, environment, and volume of wastewater generated etc. in city/towns in the Western Division.
② In order to achieve the targets of the Development Plan through effective sewerage development, prioritization of sewerage development for city/towns (including 4 city/towns already implementing sewerage works) based on the urgency and feasibility of the sewerage project.

(2) Preparation of City/Towns M/P

M/P of wastewater treatment for the high priority city/towns selected in the Western Division M/P will be implemented.

① Centralized and decentralized treatment areas will be defined. In the 4 city/towns in the Western Division, all city/town areas have been considered as centralized treatment area and all wastewater is transferred to WWTPs by gravity and pump sewers. However, power consumption in the pumping stations is an issue for WAF and its reduction has become an important issue. Hence, it is important to consider which is more economical; to connect to the central wastewater system or introduce decentralized systems in each area.
② Service area, served population, wastewater volume (domestic, industrial, commercial and tourism) and capacity of the existing wastewater networks, pumping stations and WWTPs will be reviewed. Based on the results of the review, required wastewater pipes and pumping stations, and required capacity and processes of wastewater and sludge treatment facilities will be studied. Fiscal plan, organization, and project schedule required for the implementation of the project will also be studied.
③ In the case of new sewerage project and if the budget for the project is certain, it is better to finalize the M/P after holding stakeholder meetings regarding the sewerage service area, site and scale of WWTP, and collecting opinions.

(3) Implementation of Pre-F/S

For the high urgency city/towns identified in the city/towns M/P, feasibility of the sewerage project will be studied by implementing a pre-F/S before starting the actual loan project. The pre-F/S will be carried out based on the stepwise project implementation schedule prepared in the city/towns M/P. Fiscal plan, maintenance plan and project cost as well as renovation and expansion plan of WWTP will be studied.

WAF included funding for the preparation of sewerage M/Ps in Nadi, Lautoka and Ba in the "2019-2020 Budget Kit". However, it is not based on the order of procedures (1) to (3) shown above; therefore, WAF must implement the above items (1) ~ (3) consecutively to implement the sewerage works systematically in the Western Division.

(4) Consideration for preparing Western Division M/P and city/towns M/P

To efficiently prepare the Western Division M/P and the city/Towns M/P, the data and information indicated in **Table 11-1.2** should be collected prior to the start of the works.

Table 11-1.2 List of Data and Information to be collected

All city/towns in the Western Division		
Drawings		Contour map of city/town
		City/town map indicating boundary
Basic Data		City/town area, Population (census data in 1996, 2007 and 2017)
		List of schools and number of students, List of accommodations and hospitals and number of beds
		Development projects of housings, schools, hospitals, accommodations, industrial zones and commercial facilities
		List of water consumption of each school, hospital, accommodation, factory and commercial facility (monthly data of last 5 years)
Environmental Data		Water quality data of rivers and sea area (last 5 years)
		Generation rate of water-borne diseases (last 5 years)
		Location of environmental protection areas and national parks
		Location of water source (if any within the city/town boundary)
City/towns without sewerage system in the Western Division		
Feasibility of sewerage project		Possible site for construction of WWTP
		Residents opinion for sewerage project
City/towns with sewerage system in the Western Division		
Buildings connecting to sewerage system and those water consumption		List of buildings connecting to sewerage system (houses, schools, hospitals, accommodations, factories and commercial facilities etc.) Water consumption of each building (monthly consumption, last 5 years)
Sewerage M/P		Review of sewerage M/P
Facility	Pipe networks	Map of pipe networks, Information of pipe diameter, pipe material, length of pipe of each material and condition of pipes
	Pumping station	Pump capacity, number of pumps and pump condition of every pumping station
		Record of pump operation (every station, last 5 years)
		Power consumption of every pumping station (monthly data of last 5 years)
	WWTP	Inflow sewerage volume (monthly)
		Influent and effluent quality (monthly data of last 5 years)
		Operation record (last 5 years)
		Water quality of effluent discharging river and sea area (monthly data of last 5 years)

11-2 Capacity Development of WAF West Staff for Implementing the Wastewater Project

During data collection from the relevant staff of WAF Western, it was found that they have many challenges in their activities due to shortage of implementation capacity.

- O&M and water quality data are not analyzed in WWTPs
- Almost no technical training is implemented
- O&M manuals are not prepared for WWTPs
- No preventive maintenance of mechanical and electrical equipment is implemented

Appropriate O&M of any new treatment processes or equipment cannot be ensured in the current condition. Capacity development of staff is necessary.

In the implementation of the renovation and expansion project in WWTPs, supervision of design works, tender, construction etc. are quite important for quality assurance of the completed WWTP facilities. Poorly constructed facilities will have negative long-term influences on O&M. So, capacity development of staff in charge of design and project management is also important.

The capacity development of the following items will be effective for the capacity development of staff.

(1) Capacity Development for Planning, Design and Construction

① Preparation of wastewater M/P and F/S
② Supervision of design works
③ Project management

(2) Capacity Development for O&M

① Preparation of maintenance manual of sewer networks and implementation of maintenance
② Preparation of O&M manual of WWTP and implementation of O&M
③ Preparation of maintenance plan of mechanical and electrical equipment
④ Preparation of health and safety manual

(3) Capacity Development for Staff Training

① Programing and implementation of staff training

Table 11-2.1 shows an example of the training program.

Table 11-2.1 Example of Staff Training Program

Program	Main contents	Target
Wastewater works management	Sound management of wastewater works	Management level
Planning of wastewater works	Preparation of wastewater M/P and project implementation as per M/P	Staff in wastewater planning Key engineers
Planning of sewer pipe networks	Planning of sewer networks and pumping stations	Staff in sewer pipe Key technical staff
Maintenance of sewer pipe networks	Appropriate maintenance of sewer networks and pumping stations	Staff in maintenance of sewer pipe
Wastewater treatment technologies	Principles and characteristics of various wastewater treatment process	Key technical staff
Sludge treatment technologies	Principles and characteristics of various sludge treatment process	Key technical staff
Maintenance of mechanical and electrical equipment	Maintenance of mechanical and electrical equipment such as daily check and preventive maintenance	Staff in charge of machinery and electricity
O&M of WWTP	Stable and economical O&M of WWTP	Staff in WWTP
Activities of public awareness	Effective procedure of public awareness regarding wastewater works	Management level Staff in customer service
Health and safety	Health and safety activities in works place	All staff

11-3 Renovation and Expansion Project of Wastewater Treatment Plant

Due to mechanical trouble, inflow of highly polluted wastewater, and inappropriate maintenance of facilities, present effluent quality of WWTPs in the Western Division exceeds the effluent standard often. Moreover, if effluent standards are tightened in the future, compliance will be much more difficult. Hence, consideration of more sophisticated treatment technologies is warranted.

In the selection of new technologies, electrical power stability of Fiji, financial condition of WAF and capacity of staff should be considered. Processes with low energy consumption and

easy O&M should be selected. Oxidation ditch (OD) used widely in Japan due to easy O&M process, sequential batch reactor (SBR) used in Kinoya WWTP (Suva) and pre-treated trickling filter (PTF) and biological anaerobic-aerobic filter are suitable for small scale WWTPs and considered to be applicable in Fiji.

Table 11-3.1 compares pollutant removal rate, required site area and costs etc. of these candidate processes.

However, it should be noted that even these processes include much more mechanical and electrical equipment compared to the IDEA process and require more complicated O&M; therefore, technical capacity of O&M staff must be improved before commencement of operation. The way to obtain spare parts through local agents must also be established to ensure appropriate maintenance of equipment.

At present, sludge generated in the WWTP is dumped into a hole dug in the WWTP site; however, because no rubber sheet is laid in the hole, there is concern for groundwater pollution. Therefore, appropriate sludge treatment and disposal processes, including the beneficial use of sludge must be studied in the M/P.

Table 11-3.1 Adoptable Wastewater Treatment Processes

Comparison item		Conventional activated sludge	Oxidation ditch	Pre-treated trickling filter	Biological anaerobic aerobic filter	Sequential batch reactor
Outline		Standard and basic treatment process Used in many middle to large scale WWTP with stable performance	Extended aeration process with endless channel reactor Primary sludge control is not necessary. Sludge generation is smaller than that in conventional process and O&M cost also is lower. Suitable for small to middle scale WWTP.	New type of trickling filter with using plastic media and without using aeration. Cost necessary for blower can be reduced. Not suitable for high BOD wastewater. Suitable for relatively small scale WWTP.	Recovery of methane gas from anaerobic reaction is possible. Aeration air and sludge generation volume can be reduced. Suitable for relatively small scale WWTP.	One of the extended aeration processes. One tank takes 4 cyclic roles of fill, react, settle, decant. Continuous inflow type SBR is trend. Suitable for small to middle scale WWTP.
Main facilities required		Primary settling tank Reaction tank Final settling tank	Reaction tank Final settling tank	Pre-filtration Trickling filter Final filtration	Anaerobic filter Aerobic filter	Sequential reactor
Removal rate (%)	BOD	90-95	93-96	85-90	84-90	90-95
	TSS	90-95	92-96	85-90	84-90	90-95
	T-N	25-35	85	—	—	25-35
	T-P	40-50	40-70	—	—	40-50

Comparison item		Conventional activated sludge	Oxidation ditch	Pre-treated trickling filter	Biological anaerobic aerobic filter	Sequential batch reactor
Required area for 10,000m3/d WWTP	Area	6,600 m^2	9,400 m^2	5,600 m^2	6,200 m^2	7,400 m^2
	Ratio against conventional process	100%	142%	85%	94%	112%
	Basis (HRT in tanks)	Primary settling tank: 2hr Reaction tank: 8hr Final settling tank: 5hr	Reaction tank: 19hr Final settling tank: 8hr	—	—	Batch reactor: 20hr
O&M (Comparison when conventional process is "Normal".)		Normal	Relatively easy, (Primary sludge control is not necessary).	Easy, (Control of sludge conc. and air volume is not necessary.)	Easy, (Control of sludge conc. is not necessary)	Normal
Sludge generation	Against conventional process	100%	85-95%	80-100%	30-40%	85-95%
Construction cost		100%	100%	90%	100%	100%
O&M cost		100%	90%	70%	70%	90%
Possibility of conversion to advanced treatment process in future		Removal rate, T-N=60-70% & T-P=70-80% by renovation to Anaerobic-Anoxic-Oxic process	Removal rate, T-N=85% & T-P=40-70% by renovation to Dual DO control process, one of the Japanese technologies.	Cannot expect at present, because there is no experience.	Cannot expect at present, because there is no experience.	Removal rate, T-N=70-80% by Anoxic-Oxic operation, T-P=60-80% by setting anaerobic zone in reactor,
Evaluation (Evaluation as for adoption into WWTP of treatment capacity 10,000m^3/d)		Requirement of experience and expertise in O&M, Relatively high sludge generation rate, Necessity of primary sludge control, Possible to convert into advanced treatment, <Slightly inappropriate>	Requirement of experience and expertise in O&M, Relatively easy O&M due to no control of primary sludge, Possible to convert into advanced treatment, <Appropriate>	Low O&M cost and easy O&M, Not easy to adopt into Nadi and Lautoka due to high inflow pollutant load, <Inappropriate>	Low O&M cost and easy O&M Possible to use generated gas effectively, <Appropriate>	Experience and expertise in O&M such as control of sludge conc. and setting of operation cycle Possible to convert into advanced treatment, <Appropriate>

11-4 Direction of JICA's Cooperation

Sections **11-1** to **11-3** above have been presented in sequential order and should be implemented

as below;

① Preparation of Western Region M/P for wastewater treatment in the Western Division
② Preparation of M/P for wastewater treatment in high priority city/towns
③ Preparation of sewerage development plan by implementing Pre-F/S for the high-urgency city/towns
④ In parallel, implementation of staff capacity development by technical cooperation project
⑤ Implementation of restoration/expansion projects of WWTP based on the city/town M/P prepared
⑥ O&M of restored/expanded facilities of WWTP by staff who have undergone capacity development

The stages of the capacity development is shown in **Table 11-4.1**.

Table 11-4.1 Stages of the Capacity Development (Draft)

Term	Stage		Implementation item
First term	Technical Cooperation for Development Planning	Western Division M/P, city/towns M/P, Pre-F/S preparation stage	Preparation of Western Division M/P for wastewater treatment Instruction for preparation procedure of the basic plan Preparation of city/towns M/P and Pre-F/S Instruction for preparation procedure of city/towns M/P and Pre-F/S Instruction regarding maintenance of existing sewer networks, O&M procedure of WWTP facilities (including preparation of O&M manuals) and health/safety Preparation of staff training program and implementation of staff training
Second term	Consulting Service under ODA Loan	Design, construction stage	Instruction for management of design, tender and construction Instruction for O&M of treatment facilities to be adopted (Preparation of O&M manuals by contractors)
Third term		O&M stage	Implementation of OJT regarding O&M of treatment facilities adopted

If request from Government of Fiji is admitted, Western Division M/P, city/towns M/P, and Pre-F/S would be supported. Regarding O&M of wastewater facilities, O&M procedures of existing sewer networks and WWTP (including preparation of O&M manuals) would also be taught. According to WAF, staff trainings are not sufficient; hence, preparation of training programs and implementation of trainings based on the programs would be conducted.

In the second term, if ODA loan will be formulated, project management procedures, such as management of design, tender and construction would be taught for implementing the project smoothly in accordance with the progress of the renovation and expansion project of WWTPs. (Consulting Service under ODA Loan)

In the third term, the use of prepared manuals is disseminated to all O&M staff. Also, preventive maintenance procedures of equipment, measure for troubles of equipment occurring on sites and implementation of economical and stable operation of WWTPs would be taught to O&M staff through OJT. Regular O&M works for stable operation of treatment facilities cannot be taught under emergency conditions, such as during failure of machinery. Training must be conducted under normal operating conditions, after commissioning of the new facilities. Therefore, technical assistance in the third term would be important for implementing O&M of facilities appropriately. (Consulting Service under ODA Loan)

The expected outcomes of the cooperation activities are as follows;

- Western Division M/P, city/towns M/P and Pre-F/S are prepared
- Renovation and expansion of wastewater facilities are implemented according to the M/P and Pre-F/S
- Renovation and expansion of wastewater facilities are managed effectively by WAF staff who have undergone capacity development
- Operation and maintenance of wastewater facilities are management effectively by WAF staff who have undergone capacity development

Table 11-4.2 shows the project implementation schedule (draft). Preparation of Western Division M/P and city/towns M/P would be implemented in 2021 and Pre-F/S in 2022. After two years of preparation period, design and tender works would be implemented in 2025-2026, construction works are in 2027-2028 and O&M would start in 2029.

The first phase of capacity development would be implemented by JICA Experts from 2021 to 2022. From 2025, activities would be implemented by Consulting Services under ODA loan.

The implementation schedule for the period after 2025 would be discussed with WAF, taking into consideration the types of financial resources that are available, including the possibility of ODA loan project.

Table 11-4.2 Project Implementation Schedule (Draft)

			2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1	Restoration/Expansion Project of WWTPs		Basic Plan M/P	Pre-F/S	Preparation		Design, Tender		Construction		O&M	
2	Capacity Development of WAF Staff	JICA Experts	Technical Cooperation for Development Planning									
		Consultants					Consulting Service under ODA Loan					
		Contractors							Preparation of O&M manuals		Commissioning	

Appendix 1 Member List of the Survey Team

Name	Position
JICA HEADQUARTERS	
Mr. Ken OKUMURA	Deputy Director, Pacific and Southeast Asia Division 6, Southeast Asia and Pacific Department, JICA
Mr. Yuta TAKAHASHI	Senior Engineering Officer, Office for Loan Project Technical Examination, Infrastructure Engineering Department / Environmental Management Group, Global Environmental Department, JICA
Mr. Kazunori NAKAI	Senior Engineering Officer, Office for Loan Project Technical Examination, Infrastructure Engineering Department / Water Resource Group, Global Environmental Department, JICA
JICA FIJI OFFICE	
Mr. Shinya TAMIO	Deputy Resident Representative, JICA Fiji Office
Ms. Atsumi KANI	Project Formulation Officer, JICA Fiji Office
Ms. Rina KURUMISAWA	Assistant Resident Representative, JICA Fiji Office
Ms. Nila Prasad	Program Officer, JICA Fiji Office
Mr. Naushad A. Yakub	Program Officer, JICA Fiji Office
CONSULTANT TEAM	
Mr. Koichi OKAZAKI	Chief Consultant / Water Supply Planning Nihon Suido Consultant Co., Ltd.
Mr. Kiyohiko HAYASHI	Sewerage Planning Nihon Suido Consultant Co., Ltd.
Mr. Tomohiro UMEKI	Water Resource Development Yachiyo Engineering Co., Ltd.
Mr. Shigeo HAYAKAWA	Organization & Finance Original Engineering Consultants Co., Ltd.
Mr. Takahiro NAKATA	Water Supply & Sewerage Facility Nihon Suido Consultant Co., Ltd.

Appendix 2 Survey Schedule

Item	2019											2020		
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Preparation in Japan														
Survey in Fiji														
Work and Analysis in Japan														
Submission of Survey Report					△							△		△
Key Meeting with Fiji Side				●	●						●		●	

Appendix 3 List of Parties Concerned in the Recipient Country

WAF

- Nemani Waqanivalu — General Manager Planning Design & Construction
- Manasa Tusulu — Senior Business Analyst(Strategic Plannning)
- Mohammed Flliyoz — Water Engineer
- Leigh Clayton Chan — Engineer Planning and Design unit
- Jone D.B. Vunidaiga — Engineer Planning and Design unit
- Seymour Singh — Manager Strategic Planning
- Thomas Hughes — Team Leader SCADA
- Joana Kaloucava — CAPEX Account
- Romulusi Nataitoga — Regional Manager Western
- Miteshwar Chand — Regional Engineer Bulk Supply (West)
- Mosese Vunisalevu Deku — Team Leader Water (West)
- Jai Sharma — Nagado WTP Superviser
- Ilaisa Latianava — Saru WTP Superviser
- Joeli Batirufu — Buabua WTP Superviser
- Enktesh Permal — Team Leader Wastewater Management Unit (West)
- Ponipate Naigulevu — Team Leader Leak Detection West (NRW)
- Monish Kumar — Team Leader (Wastewater Modelling)
- Shaheed Ali — Supervisor (Wastewater Management) Nadi
- Alipate Maya — Supervisor Mechanical/Electrical Pumps (West)

Ministry of Infrastructure, Transport, Disaster Management & Meteorological Services

- Taitusi Vakadravuyaca — Permanent Secretary
- George Tavo — Acting Deputy Secretary Operation
- Mohammed Nistar Khan — Acting Director Water & Sewerage
- Misaeli Funaki — Director Meteorogical Services

Ministry of Economy

- Kamal Krishnan Gounder — Manager/Coordinator – Infranstructure Sector Budget and Planning Division
- Vinay Singh — Budget Analyst
- Mauvina Simgh — Senior Budget Analyst

Ministry of Lands & Mineral

- Meizyanne Hicks — Director Geospatil Information Management
- Viliame Waqa — Principal Geospatial officer
- Shanael Prakash — Principal Geospatial officer
- Vilimone Raqona — Senior Geospatial officer
- Veniana Wainiqolo — GIS officer

Ministry of waterway & environment

- Mahendra Kumar — Director of Waterway
- Kim Mon Cho — Department of waterway
- Sandeep K. Singh (Ms) — Director of Envrionment

Mineral resources department

- Sakaraia Malodali, Principal — Technical Officer

iTaukei Land Trust Board

- Epeli Ravula — Manager IT

National Trust of Fiji

- Elizabeth Erasito — Director
- Ksaqa Toru — GIS / DRR officer

Asian Development Bank

- David Fay — Unit Head, Project Administration Pacific Subregional Office
- Kristina Katich — Urban Development Specialist Pacific Subregional Office

Appendix 4 Recognition of Organization structure, Finance, Capacity of implementation of project and Technical standard of WAF

4.1 "Check sheet of general information of water supply sector"

Index/Information		Data/Information	Source
Outline of the sector			
1	Population	890,000	2018IMF statistics
	GDP per capita	5,752USD	2018IMF statistics
2	Annual precipitation	Nadi：1,882 mm/Annual Suva：3,023 mm/Annual	Fiji Meterological Service
	Climatic zone	Tropical rainforest climate	
3	Rate of access to improved water	70%	JMP 2017
4	Governance of water supply sector	Under the jurisdiction of MITDMSS, WAF operates a water and sewage business. The collected fee is paid in full to MITDMSS, and the necessary operating costs are secured by applying for a budget and obtaining approval from MITDMSS. This is thought to hinder independent management.	WAF Interview survey
5	Development issues	WAF implements the project based on the master plan. However, it is the issue that to meet the demand for water supply as the tourist population grows in the western region.	Nadi/Lautoka Regional Water Supply Scheme Master Plan 2013-2033
Outline of the water supply sector			
1	Organization structure of WAF	Under the jurisdiction of MITDMSS, WAF operates a water and sewage business. Business projects are submitted to MITDMSS, and MITDMSS determines the budget is acceptable or not	Strategic Plan from 2017 to 2019
2	Planned water supply area of WAF	WAF supplies water for every part of Fiji. The number of water treatment facilities is 8 in central area, 6 in the eastern region, 11 in the western region and 19 in the northern region.	WAF Profile 2015
3	Water source	Dams, rivers and boreholes In the western region, new water sources are demanded as the tourism industry develops.	Water supply plan in western part of Fiji -March 2018-
4	Water source development capacity	Recently, the gap in the water quantity of rivers in the rainy season and the dry season is remarkable. It is the challenge to aim enough water in the dry season.	WAF Interview survey
5	Water supply penetration rate	70%	WAF Interview survey
6	Population served	624,968	WAF Interview survey

Index/Information		Data/Information	Source
7	Amount of water supply (per day)	370,740 m^3/day	WAF Interview survey
8	Amount of water supply (per capita, per day)	216.5 L/person・day	WAF Interview survey
9	Water suppling time	24hours	WAF Interview survey
10	Non-revenue water rate	29.3%	WAF Interview survey
11	Finance/balance of payment	The budget for WAF in 2018 is 246 million FJDs, of which approximately 60% (155 million FJDs) is the cost of water supply project.	WAF Interview survey
12	Standard water usage fee	Depending on the amount of water usage. （house use） The unit price increases as usage increases. ～50 m^3/ 3months ：0.153FJD/ m^3 50～100 m^3/3months：0.439FJD/ m^3、 100～ m^3/3months：0.838FJD/ m^3 （Commercial use） The unit price is higher than house use 1.60FJD/ m^3 （Public use） Same as house use 0.530FJD/ m^3	WAF Save water brochure
13	Rate of collection water usage fee	90%	WAF Interview survey
14	Rate of installment of water meter	Although it is 100%, there are some water meters that have been installed for more than 10 years and some that cannot be measured correctly.	WAF Interview survey
15	The number of employees in every 1000 connection	Employees: 1,226people (including waste water) 6employees / 1,000connections	WAF Interview survey
16	Facility condition and operation and maintenance status	The water source depends on surface water (dams), the surface water quality is good, and chlorination is performed. 24 hours water supply has been achieved, and maintenance is well done. Also to manage and provide the service, WAF implements the water supply which follows water quality regulation and collects appropriate water usage fees to operate the project and publicizes their project to make water supply sustainable.	WAF Interview survey
17	Project goal and challenge of WAF	The future image of 20 years ahead is drawn, and the three-year business plan summarizes matters that need improvement. The following matters are necessary for improvement. ・Improvement of information management system performance ・Improvement of staff ability ・Building a sustainable and efficient water supply system ・Reduction of operation management costs ・Securing other income sources	Strategic Plan from 2017 to 2019

4.2 “Handbook for Capacity Assessment for Urban Water Sector and Water Utilities in Developing Countries”

Index		Category	Evaluation
Capacity	Technical	Knowledge	・Every employee has necessary knowledge in each department
		Technique	・For water treatment plants, an operation manual was made and knowledge is acquired.
		Information sharing system	・Information is centrally managed in Suva (central region). However, the convenience of information access from the western region and the northern region is not good.
	Core	Behavior management	・The central organization is in Suva (central region). This central organization checks the central, western and northern organizational behavior.
		Decision making	・The western and northern region’s site presents some requirements to the central WAF and they make a decision.
		Organization system	・The central policy is firmly communicated to the west and the north. However, it seems that it may take time to make decisions in the central part in response to requests from the site side.
	Environment	Finance	・MITDMSS collects and manages all charge of water usage. Every office proposes the budget to MITDMSS and obtaining approval.
		Human resource	・The number of employees (permanent employment) is matched to the standard. However, some of the well-experienced employees move to the private company so that it lacks the employees for the managerial position. ・The salary is determined by the FCCC based on the average in the country. ・Although it is understood that the income of the water usage fee is low, they don’t understand to what extent the facilities should be made more efficient.
		Asset	・The treatment facilities have enough capacity for now however, they are using AC pipe for distribution and it can be inefficient. ・It is the issue that to meet the demand for water supply as the tourist population grows in the western region.
		Financial base	・it is understood that the income of the water usage fee is low so they are considering to raise the water usage fee.
Performance		Project Plan/ Implement	・They are planning 3-Year Strategy. ・According to the 2014-2016 business plan, about 90% of the items have been improved dramatically.
		improvement of service	・To communicate with users, they provided the customer center.
		Satisfaction of users	・More than 90% of the charges are collected, and it can be said that the users are highly satisfied.
Impact		Penetration rate of water supply service	・70% of population have access to water.
		Constant improvement of quality	・To make constant improvement of quality, they implement the project efficiently(reducing the non-revenue water) and make a PR video for users to understand what they do.

4.3 “Capacity Assessment for Urban Wastewater Sector”

Index	Capacity of organization	Detail information
External influences	WAF can’t operate appropriate and planned maintenance of the sewerage facility.	・Effluent water does not meet the standard of the water quality. ・WAF can not fix the broken materials.
○National policy in terms of sewerage unit		
Policy on sewerage	Although priority areas for sewerage system have been identified, it is based on the master plan than which was made more than 20 years ago.	There is a master plan that matches the situation in recent years in Suva, but the western area is under consideration and the project has not been promoted systematically.
	Separate sewer system is installed.	The ratio of the rainy day to sunny day is 1.2 of the flow. It seems that almost all rainwater flow from the storm overflow chamber.
	Residences, factories, commercials and government facilities are accepted.	Sewage connected households and facilities are managed by data. Only some of the permitted employees working at the central office have access to the data. And it would take some time to collect data from the western region.
Legal obligation of sewage works	・When sewer pipes are installed, houses within 30m must be connected. ・Although not subject to WAF management, there is an obligation to install a septic tank.	・Although there is LIQUID TRADE WASTE POLICY, the sewer connection population is little, and there are some that have insufficient management of the grease trap installed before the sewer connection.
	Although the septic tank is not subject to WAF management, it is necessary to get the approval of WAF to handling (disposal place) the septage.	In terms of septage tends to be filled in or bring to the treatment plant and WAF handles it.
Policy on water pollution	There is a water quality standard for effluent from sewage treatment facility.（NATIONAL LIQUID WASTE STANDARDS）	Effluent water quality is over the water quality standard.
Financial support	Subsidies, low interest loans (loans from other donors)	・OPEX and CAPEX are mostly covered by subsidies from the government because WAF couldn’t collect water usage fees sufficiently. ・The western region doesn’t receive the loan from any donors. However, the Kinoya wastewater treatment plant which is in Suva (the central region) receives a loan from Asia Development Bank for the rehabilitation of the facility.
Related policy	・LIQUID TRADE WASTE POLICY ・GREASE INTERCEPTORS HANDBOOK	・WAF has the authority to teach users about septage. ・WAF has the authority to teach users about grease trap of the commercial facilities.
○Stakeholders in waste water treatment		
Sewerage managed by private firm	There is no private firm to manage the sewerage.	There is no place to dispose the sludge (including septage).
Congress	Regarding the budget for each year, after applying to MITDMSS (Ministry of Infrastructure), discussions will be held between MITDMSS and MOE (Ministry of Economy).	The requested budget is not 100% allowed.
	It is necessary to get permission from FCCC (Fijian Competition & Consumer Commission) to change the fee.	Although it hasn’t been changed fee for 30years, it was written that it needs to change it in “Strategic Plan From 2017 to 2019”.

Index	Capacity of organization	Detail information
Influence of citizens, company and mass media	・It is necessary to handle the complaint from users about pump's spill and odor.	・WAF thinks it important to have a communication with users through the internet, when any trouble happens ・WAF introduces the importance of water through the internet or customer center however, there is any PR about sewage.
○Capacity of waste water treatment（system）		
Power balance with national government	The annual budget is approved by MITDMSS and MOE, so national authority gets deeply involved.	The usage fee is not collected enough for maintenance, and it is necessary to apply not only for construction funds but also for facility operation.
Ordinance	There is a regulation on the quality of inflow water to the sewer, and if the discharge quality over the regulation extra fee will be charged. （ LIQUID TRADE WASTE POLICY）	Many grease traps are not maintained and some are not functioning. Recently, the variety of restaurants have increased, and the function of the grease trap has not been demonstrated, and malicious sewage has increased into the sewer pipes.
Permission of private sewerage facilities	There is no private firm to manage the sewerage facilities.	
Sewerage plan	Factory facilities, commercial facilities, and government facilities are connected to the sewer, but the amount of waste water is not clear and there is no plan. And the capacity of wastewater treatment facility calculated in EP(xx people)	・Master plan for Nadi and Lautoka(the western region) are under consideration. ・there are no environmental regulations for public water bodies such as the ocean and rivers. ・Sewage from factories / commercial facilities and government facilities are not comprehended.
○Capacity of waste water treatment （organization）		
Unit organizational form	They manage water supply and sewerage system at ones.	To supply safe tap water to the people of Fiji, there is a background that the project has been carried out mainly in the water supply sector, and it makes the water supply and sewage sector has become more efficient by unifying it.
Structure of department	It is largely divided into the north, the center, and the west as the regions and water supply and sewerage system as the work.	・The facilities are managed by each of the north, central and western offices. In addition to this, the central office gets in charge of finance as well. ・The number of employees in every 1000 connections meets the average of Asian ones. On the other hand, some of the treatment plant maintenance manager sad that sufficient personnel was not secured in case of emergency.
Decision making	・there is a GM for each department and the matters proposed by each department are discussed by seven GMs and are approved by the CEO. ・The selection of human resources is decided after a discussion with the department manager.	・Since there is currently no CEO, the decision-making mechanism is different from the original, but it is being discussed within GM. ・Although work specialization is in progress, projects from other countries will be carried out with the agreement of all GMs and CEOs.
Range of work	Water, rainwater and water distribution are managed by Ministry of Environment and Waterways.	The scope of work is clearly divided with other institutions and understood by other institutions.
Authority management	The WAF is under the jurisdiction of MITDMSS and has authority over the water supply and sewage systems in the country.	The WAF's annual budget needs to be applied for and approved by MITDMSS along with the project, and clerical tasks are delegated to WAF, but MITDMSS has strong authority.
○Capacity of waste water treatment （Management/service）		
Problem aweless	The issues are following ・The demand for water supply is increasing	・Each of central organization and site side bring up the same issues.

Index	Capacity of organization	Detail information
	as the tourist population grows in the western region. ・There is no master plan. ・Lack of technical capability to perform facility maintenance.	・The projects proposed from the site are prioritized in the central organization so that it is easy to reflect in the budget about the opinion of the site.
Management tools	・There is no maintenance and management manual at the site. ・Regarding human resources, there is a manual called Performance Management System, and staff are evaluated based on this manual, but ultimately the manager decides the evaluation.	・They could not operate the facilities efficiently so some stop the operation. ・Not only the manuals (Performance Management System) but also discussions at multiple departments in the workplace, the qualities of the target staff are appropriately judged and assigned. However, WAF doesn't conduct the test to judge their ability.
Range of service	All of the houses connected to water/sewerage system data are recorded in electronic, however, they don't record the amount of water.	・It is common for sewage to overflow from pumping stations in the rainy season because they don't measure the amount of influent.
○Capacity of waste water treatment（finance）		
Balance of payment	There is a balance sheet but they didn't cover the maintenance/management expenses and personnel expenses by collected water usage fee.	The collected fee is paid to the Ministry of Economy, and WAF requests budget to them through the Ministry of Infrastructure. This avoids price increases.
Expenditure/Details（By cost category）	The amount of expenditure is subdivided and tabulated every year.	WAF collects and consolidates the data and easy to see it for everyone. But only the person who in charge of consolidation of the data knows the data by area.
Contract amount of consignment	Price setting	WAF adopt bit system
Income/Detail	・All budgets are drawn up for each project. ・All collected fees are delivered to the government and so that it is not the financial resources of WAF.	・(Example) How the 2018-2019 Budget Allocation for Water Authority of Fiji Will Be Spent ・Regardless of the amount of collected fee, WAF request the budget to CAPEX and OPEX. This causes uninterested of a few collected fee. The system is considered to be one factor that has led to a situation of indifference for the small amount of collection fee.
Sewerage charge	If it is general waste water from the household, it is a flat fee of 0.200FJD/㎥. However, if it is the poor quality of waste water from the restaurant etc, customers should pay extra fees according to the water quality. (LIQUID TRADE WASTE POLICY)	The total amount of sewerage usage fee is about 30% of the maintenance cost.
Collection of the charge	The fee is collected with the water usage fee at the same time every 3 months. And it hasn't changed for 30 years.	WAF collect the fee every 3 months. They will stop the water supply if user don't pay. (Almost 100% collection)
Client management	The customer information is into the database and managed.	In terms of the number of the collection, WAF surveys the number of connection.
Funding/Liability management	WAF applies for the budget to the Ministry of Infrastructure e and MoI reports to the Ministry of Economy. MoE manages the liability of WAF.	The expenditures are summarized for each fiscal year.
Procurement/Contract	There is no contract on the procurement.	・Appropriate outsourcing can be selected based on the experience.
Accounting	There is a rule about accounting procedures.	Some employees doesn't understand.
○Capacity of waste water treatment（Outsourcing）		

Index	Capacity of organization	Detail information
Contract	Contractor selection procedures are published. And on the contract, it is written about payment and corrections action.	・Contractors are selected by bidding method. ・ Evaluation is based on performance matrix. ・ The results of selecting suppliers are open. ・Contractors that produce good results are undertaking large construction work. ・ Consignment is performed when good results cannot be expected from direct management. ・ If the supplier's performance is poor, set a period and start over, but if it is absolutely impossible, take a fine.
Job description	Required fields are written in the contract in detail. And WAF requires results as described in the contract.	There is no problem with the WAF's business instruction.
Monitoring	WAF evaluates the contractors and rank them.	If the contractors work doesn't match the request, WAF put them on the black list and doesn't allow to work with them.
Director	WAF engineers can supervise directly or consultants can supervise.	There has been no big problem.
Cost	Achieve the best results at the lowest cost.	When it is judged that the results are the same between direct management and outsource, it is decided whether to outsource by comparing costs.
○Capacity of waste water treatment（Human resource/Labor）		
Assign the role	In terms of the personnel changes and promotions, determined through discussions between general managers.	Managers decide the personnel changes and acceptance of the secondment.
Evaluation	・General managers evaluate the works of every employees and decide their promotion. ・The salary is based on the average in the country and their work .	・WAF has a manual for evaluation so every employees can get adequate evaluation.
Number of employee	Set the number of employees based on Workforce planning. Workforce planning	・It is considered that the lack of employees because of the increase of connection. ・In the site (the treatment facility), a minimum number of employees operate the facility so there is no substitute employee if someone absent from work because of sickness.
Administrative position	It is a system that managers must be well experienced and surrounding recommendations.	There is a manual for the promotion.
Job rotation	Normally, employees won't change their department for 3 years.	There is a manual for the job rotation.
Training	Employees have to receive the training twice a year and it counts as regular work.	・By receiving training, there is no system of salary increase or promotion, but employees can promote by managers' evaluation. ・WAF orders "Design, Built and Training" in the consignment work. And even for the new technologies are also trained in the consignment work.
○Capacity of waste water treatment （information）		
Amount of sewage	Amount of Water usage is managed by data, however, in terms of the sewerage system, they don't keep the data of the amount of sewage, only the connected population.	WAF measures water quality not the amount of water. (they don't have the flow meter)
Rainwater	They don't comprehend about rainwater.	There is no analysis of inflow sewage volume, connected population, and maintenance area.

Index	Capacity of organization	Detail information
facility	They don't comprehend about existing facilities exactly.	There is no design guideline and maintenance manual.
○Capacity of waste water treatment （facility）		
Pipe （ separate system）	There is a piping network diagram.	GIS data
Pumping station	・WAF keeps all of the diagrams of pumping station at the central. ・Pump station data captured in SCADA data can be viewed on a compatible PC.	・The drawings of facilities that are not registered in the SCADA system are managed in the central part of the WAF. It takes a few days to see in the western area.

Vaturu/Nagado Water Supply Scheme Capacity and Redundancy Improvement Project

Summary

1. **The Government of Japan in 1998 provided a loan of 2,287 million yen for the Nadi-Lautoka Water Supply Project. Since then the water demand in the Nadi-Lautoka corridor has really grown due to tourism industry.**

2. The Vaturu Dam which is the source of water supply in the area was constructed in the year 1982 with a capacity of 90 ML/day.

3. The location of the Dam in relation to treatment works, pipeline and storage areas allows for a total gravity supply as the water flow from the Dam through the four Break Pressure Tanks to Nagado Water Treatment Plant with the old system and this was later by-passed to achieve high pressures flow to allow hydro turbine operations which was setup adjacent to the Water treatment plant at Nagado. The Dam composition is of clay core with earth and rock fill shoulders. It has a crest level of 532 meters above sea, crest length of 297m and has a catchment area of 40 km^2. The spillway is located on the left abutment in natural rock saddle and the weir level is at 527m above the sea level and provides an overflow in times of flood. The spillway channel has a discharge capacity of 1800 m^3/s. The dam fortunately is in an uninhabited catchment area, ensuring the quality and cleanliness of the supply and to eliminate the water borne diseases

4. The recent development within the region and the growing demand for water immensely requires the following stages of upgrades and improvement to ensure continuous delivery of supply and quality of water for the people of the region.

    (i) Improvement in Vaturu Dam storage capacity (FJ$7.0 million);
    (ii) Duplication and bypassing of critical sections - duplication of existing single section of pipeline into the 2nd tunnel and By-passing of highest point (FJ$32 million);;
    (iii) Improvement in Nagado Water Treatment Plant Capacity - upgrading of Nagado Water Treatment Plant Capacity from 90 ML/d to 130 Ml/d (FJ$20.0 million); and
    (iv) Improving the redundancy of the Vaturu Nagado raw water trunk mains- duplication of the lower section of raw water trunk mains (FJ$15.0 million).

5. Thus, the total cost required for the improvements in the Nadi-Lautoka Water Supply scheme is around FJ$74 million.

Detailed Information
Vaturu/Nagado Water Supply Scheme Capacity and Redundancy Improvement Project

Technical Summary for Improvements

(i) **Improvement in Vaturu Dam storage capacity**
Being the main supply for the Nadi/Lautoka Region, the existing storage capacity at the dam is heavily stressed to meet the current water demand requirements for the Region which is operating between 98 ML/d to 110 ML/d in comparison to the design capacity which is 98 ML/d. The constraints with the storage capacity has become a major concern in continuous water supply to the major population centres during the dry season with depleting dam levels having major implications on the hydraulic performance of the raw water pipelines and as well as inadequate capacity to meet increase in demand from the upcoming developments in the Nadi/Lautoka Region.

To overcome the issues of inadequate water storage capacities at the dam, pipeline hydraulic issues and eradicate potential threats on water crisis in relation to the upcoming developments in the Nadi/Lautoka Region, WAF had engaged a qualified external dam specialists to conduct dam safety studies and feasibility studies on the plans for raising the Vaturu Dam spillway to store additional volume of water to accommodate the demand during the drought and as well as meet the demands for the upcoming developments. The recent dam studies shows that the Vaturu Dam has got a capability to accommodate extra storage capacity of up to 2.0m height achieved by raising the spillway raising. The additional storage capacity at the dam would ensure a provision for continuous delivery of 130 ML/d to the Nadi/Lautoka Region and also eliminate the risks on water crisis during the drought.

(ii) **Duplication and bypassing of critical sections- Duplication of existing single section of pipeline into the 2nd tunnel and By-passing of highest point**
The capacity of the raw water pipeline is limited by the high elevations in the first section of the current pipe alignment. There are three critical sections of localised high points that limit the pipeline operating capacity. Capacity may be increased by reducing the elevation or minimising head losses in these critical sections. This option can be achieved via the several methods describe below.

The first critical section of single trunk main is located in the second tunnel and experiences a theoretical head loss of approximately 8– 10m. With this head loss the capacity of the existing raw water pipeline is limited to 100 ML/d with full supply levels-TWL: 527m amsl while the capacity of the pipeline is reduced to approximately 89-92 ML/d with the deteriorating dam levels during the dry season. The recent Hydraulic analysis shows that the overall pipeline capacity could be further increased to 108 ML/d through by-passing or duplicating the 385m long section of DN 700 pipeline into the 2nd tunnel.

The main impediment to duplicating this section within the existing tunnel is that access is highly restrictive. One potential solution to utilise spare space within the tunnel would be to fabricate a cradle system which enables the duplicate pipe to be located above the existing pipe. This option does however greatly increase the risk that a failure of either pipe within the tunnel would be extremely difficult to access. Provision should be made in any design utilising the existing tunnel to allow easy isolation of one or both mains for maintenance / repairs. In addition to this, there are existing air valves located at the crown of the existing pipe which would have to be modified to accommodate the cradle. Whilst this solution does present significant potential for operational issues, therefore it is recommended for drilling of a second tunnel to duplicate the existing single section of main while maintaining the same alignment and levels.

The second critical section of trunk main is located at the final high point –chainage 0.0 (RL: 448m) in the elevated section of trunk main. To increase capacity to 130ML/d to maintain the demand for the Nadi/Lautoka Region, the required HGL at this high point must be able to be reduced to approximately RL: 413m without creating negative pressures which may lead to air entrainment in the pipeline. Two methods are possible at this location to reduce the elevation of the trunk main.

1. The first method is to re-lay the trunk main around the high point. Based on existing survey & NASA elevation data, this would require approximately 5.3km of new trunk main (this length requires detail survey confirmation).
2. The second method to bypass this section would be to utilise directional drilling techniques which would each be in the order of 4.6km long. This option is considered prohibitively expensive.

It is noted that whilst the existing trunk main follows the well-established access road to Vaturu, any deviation could be designed such that high points (i.e. valves requiring maintenance) are located in currently accessible areas, thus reducing the requirement and cost for well-established access along the new sections.

Therefore, it is highly recommended for duplication of the existing single section of the raw water pipeline into the 2nd tunnel with a 900mm pipe and also by-pass the critical section to achieve the overall pipeline operating capacity of 130 ML/d and also improve the redundancy of the existing pipelines during any Natural disasters.

(iii) **Improvement in Nagado WTP Capacity- upgrading of Nagado WTP capacity from 90 ML/d to 130 Ml/d**

The Nagado Water Treatment Plant was constructed in the year 1982 with a treatment capacity of 45 ML/d. The treatment plant was designed with a full treatment process with conventional water treatment principle which earlier which consists of Six (6) clarifiers/sedimentation unit, Six (6) Rapid sand filters, Two (2) clear water reservoirs and the disinfection units accommodating the full treatment process. The Nagado WTP is strategically important in supplying most of the bulk water to the tourist centres of Nadi

Town and Lautoka City and the many hotels and resorts scattered along the Western coast as far south as the recently developed Momi Resort.

The treatment plant was upgraded in the year 2003 to achieve a treatment capacity of 90 ML/d with inclusion of process improvements works with new up flow lamella plates for the Clarifiers. During the upgrading, additional three (3) numbers of clarifiers & filters were constructed with upgrading works at the inlet chamber to accommodate the 90 ML/d of raw water into the treatment plant. The upgrading was carried out in line with the other pipeline upgrading works at Vaturu to accommodate treatment capacity of 90 MLD to meet the increase in demand requirements due to the surge in water demands resulting from the commercial & residential developments and as well as the population growth due to the rural urban drift.

The treatment plant was further upgraded and augmented in the year 2014 with the Two (2) flocculation & coagulation units to improve the treatment capacity with full conventional water treatment through the plant during deteriorated water quality. This was done to improve the coagulation process to treat high turbid water during the rainy season and also avoid frequent clogging of the filters resulting from the carryover of the flocs due to the over stretched treatment capacity which the plant is currently experiencing which high flow rates ranging from 98-110 ML/d.

With the existing treatment plant capacity, the condition of the treatment infrastructure and high operating flow rates of 98-110 ML/d exceeding the treatment plant design capacity of 90 ML/d, major issues with the treatment and water quality is experienced in the event of high water demand, high turbid water and also during algae outbreaks. The production at the treatment plant is compromised to achieve or maintained the treated water with required water standards, thus having major water supply disruption and implications to the customers in Nadi/Lautoka Region. In addition, the existing treatment plant is also over stretched from its design capacity to meet the overtime demand for Providence of water that has increased recently as our service area has experienced rapid residential housing and business growth in large number in Nadi/Lautoka Region.

In order overcome the treatment issues and to meet the increasing demand for the next 20 years along with the advent of improved water treatment processes and an aging infrastructure at the treatment plant, the 20 year Master Plan recommends in improving the existing water treatment capacity and process at Nagado from 90 ML/d to 130 ML/d. The improved plant capacity will also accommodate the provisions for treating raw water with high algae as WAF has started to experience the effect of the algae issue recently with the change in climatic conditions.

Upon completion of the water treatment plant augmentation works, not only will Providence of Water improves its quality to reliable supply to customers in Nadi/Lautoka Region. The treatment process will also be improved to deliver an even better water quality to consumers.

(iv) **Improving the redundancy of the Vaturu Nagado raw water trunk mains - duplication of the lower section of raw water trunk mains**

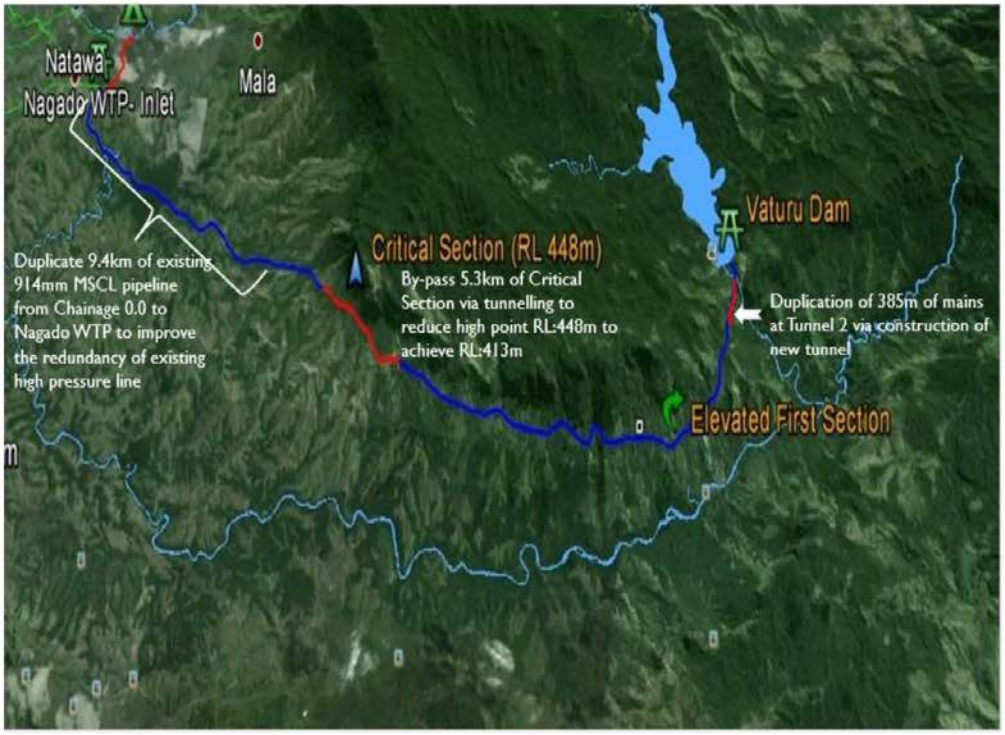
The Nadi - Lautoka region on the west coast of Fiji receives raw water from Vaturu Dam (RL527) via Nagado Water Treatment Plant (WTP) (RL175 to inlet). The Vaturu - Nagado trunk main is the sole means of conveying water from the dam to the WTP. The trunk main consists of several sections, of single DN 600 DI & 1200mm MSCL, 914mm MSCL main and duplicate DN 600 DI & 711mm MSCL, with two sections of mains through tunnels. The existing trunk mains in operation for almost 14 to 36 years.

The entire Vaturu Nagado raw water pipelines are prone to failure from the past 36 years due to the pipeline being subjected to high pressure and topographic conditions possessed on the existing pipeline alignments. There had been a few major issues in the past with pipeline failures resulting from the Natural disasters and also the structural conditions of the pipes. The downtown resulting from the recovery works during any major failures had been catastrophic to WAF in terms on water supply disruptions and the costs on maintenance. To overcome these issues WAF has opted for staged development plans for upgrading & duplicating of the Vaturu Nagado raw water pipelines to improve the downtime and redundancy during any major maintenance and failures resulting daily operations and Natural disasters. With the past experience in the event of any major pipeline failure and maintenance works, WAF has utilized its redundant or duplicated mains to maintain the supply to the customers without much disturbance in supply to the customers in Nadi/Lautoka Region.

A similar strategy is also being planned to manage the operations on Vaturu Nagado raw water infrastructure considering the potential treats on the raw water pipelines and its implications on water supply to the major centre. This is very critical on the lower section of pipeline whereby currently there is only a single 914 mm MSCL line in operation to transport raw water to Nagado WTP under high pressures ranging from 150-380m while the old DN 600 DI line is being considered as structurally weak and have inadequate capacity to meet the existing demand requirements. In the event of any failure or major repairs on this section, the entire Vaturu Nagado pipeline is shutdown to accommodate the required works thus having a major water supply disruption to the entire Nadi/Lautoka Region. A similar issue or a shutdown was carried out during this year for major planned repair works at Nagado WTP inlet pipe which has resulted in major disruptions in Nadi/Lautoka Region and as well costs WAF around $3 million to supplement the supply to customers through water carting and restoration of supply.

Therefore with the recent experience on major water supply disruption and costs implications, WAF is implementing on strategies in augmenting the Vaturu Nagado pipeline to improve the redundancy of the raw water pipeline during any emergencies and also during normal operating conditions though construction of a duplicated section of 9 km of high pressure pipe from the critical point-chainage 0.0 to Nagado WTP. This will essentially benefit WAF in reducing the risks on water supply disruption during any failure

on the existing high pressure pipeline and also minimise the operational expenditure in maintaining the supply to affected customers.



Note: **Red** – Proposed for Duplication (Critical Section) & **Blue** – Existing Pipeline.