REPUBLIC OF FIJI
WATER AUTHORITY OF FIJI (WAF)

REPUBLIC OF FIJI
PROJECT FOR FORMULATION OF WASTEWATER TREATMENT MASTER PLAN IN WESTERN DIVISION

FINAL REPORT
PART 4：PRE-FEASIBILITY STUDY OF PRIORITY PROJECTS

OCTOBER 2024

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NIHON SUIDO CONSULTANTS CO., LTD.
YACHIYO ENGINEERING CO., LTD.

GE
JR
24-076

<u>Preface</u>

The Final Report (F/R) of "the Project for formulation of Wastewater Treatment Master Plan in Western Division" is composed of the following four parts:

Part 1: Executive Summary

Part 2: Regional Wastewater Treatment Master Plan

Part 3: Municipal Sewerage Master Plan

Part 4: Pre-F/S of Priority Projects

This report is <u>Part 4: Pre-F/S of Priority Projects</u> of the F/R.

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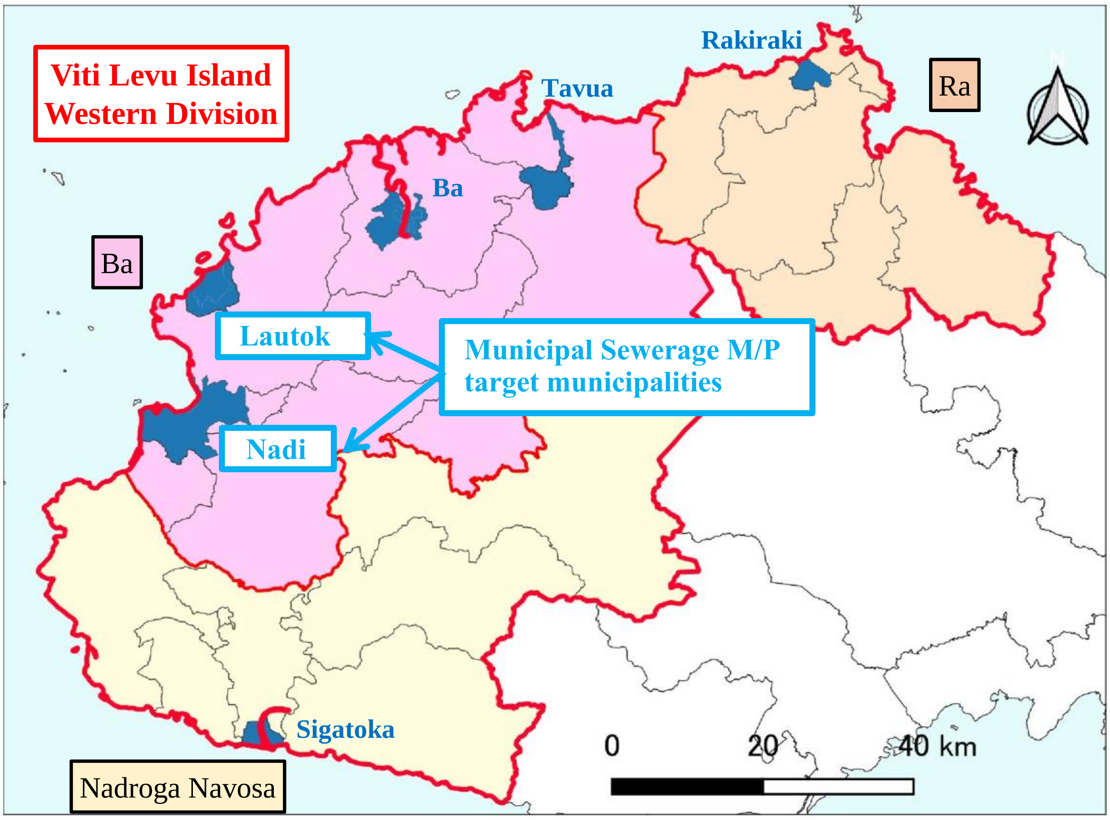
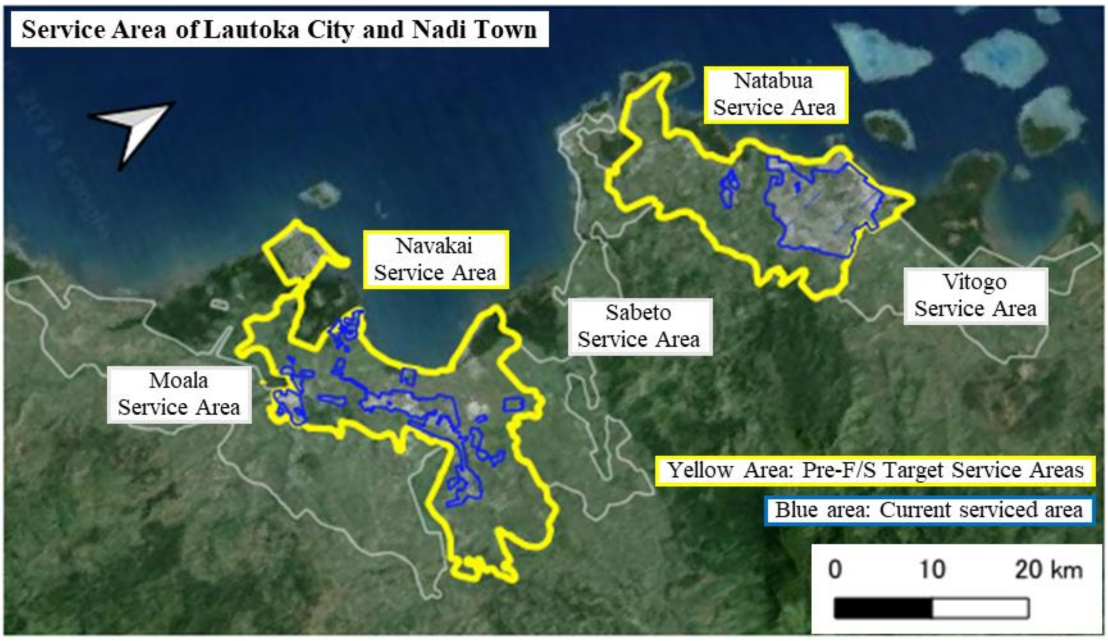




ABBREVIATIONS

ADB	Asian Development Bank
ADWF	Average Dry Weather Flow
AHP	Analytic Hierarch Process
AL	Aerated Lagoon
AS	Australian Standards
ATP	Affordable To Pay
BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
CD	Capacity Development
CBH	Central Bureau of Health
COD	Chemical Oxygen Demand
C/P	Counter Part
CWIS	Citywide Inclusive Sanitation
DBOM	Design Build Operation Maintain
DD	Detailed Design
DF/R	Draft Final Report
DOE	Department of Environment
DOF	Department of Fisheries
DOL	Department of Land
DTCP	Department of Town and Country Planning
DWS	Department of Water and Sewerage
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EIRR	Economic Internal Rate of Return
ESC	Environmental and Social Considerations
FBS	Fiji Bureau of Statistic
FIRR	Financial Internal Rate of Return
FOG	Fats, Oil, Grease
FRA	Fiji Roads Authority
F/R	Final Report
F/S	Feasibility Study
GCF	Green Climate Fund
GHG	Green House Gas
GIS	Geographic Information System
HQ	Headquarters
IC/R	Inception Report
IDEA	Intermittent Decant Extended Aeration
IEE	Initial Environmental Examination
JCC	Joint Coordination Committee
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
JPP	JICA Partnership Programs
KCCP	Knowledge Co-Creation Program (JICA)
LCC	Lautoka City Council
LEDS	Fiji Low Emission Development Strategy 2018-2050

L&D	Lecture & Discussions
LMMA	Locally Managed Marine Area
MBBR	Moving Bed Biofilm Reactor
ME	Mechanical/Electrical
MHCD	Ministry of Housing and Community Development
MHMS	Ministry of Health and Medical Services
MIMS	Ministry of Infrastructure and Meteorological Service (before organizational restructuring: current MPW)
MLIT	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
MLMR	Ministry of Lands and Mineral Resources
MOA	Ministry of Agriculture
MOE	Ministry of Economy (before organizational restructuring: current MOF)
MOF	Ministry of Finance (after organizational restructuring: former MOE)
MoU	Memorandum of Understanding
MOWE	Ministry of Waterways and Environment
M/P	Master Plan
MPW	Ministry of Public Works, Meteorological Services and Transport (after organizational restructuring: former MIMS)
MRMD	Ministry of Rural and Maritime Development and Disaster Management
MWCPA	Ministry of Women, Children and Poverty Alleviation
NFA	National Fire Authority
NPO	Non-Profit Organization
NTC	Nadi Town Council
OD	Oxidation Ditch
ODA	Official Development Assistance
OJT	On the Job Training
O&M	Operation and Maintenance
PDWF	Peak Dry Weather Flow
PG/R	Progress Report
PI/R	Project Implementation Report
Pre-F/S	Pre-Feasibility Studies
R/D	Record of Discussion
SCF	Standard Conversion Factor
SDGs	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEZ	Significant Ecological Zone
SOP	Standard Operation Procedure
SP	Stabilization Pond
SPD	South Pacific Distilleries Ltd.
SS	Suspended Solids
TC	Technical Committee
TF	Trickling Filter
TLFC	iTaukei Land and Fisheries Commission
TLTB	iTaukei Land Trust Board
TN	Total Nitrogen
TOR	Terms of Reference
T-P	Total phosphorus
TSS	Total Suspended Solids
UNDP	United Nation Development Program

WAF	Water Authority of Fiji
WWTP	Wastewater Treatment Plant

CHAPTER 1 INTRODUCTION

1-1 Background

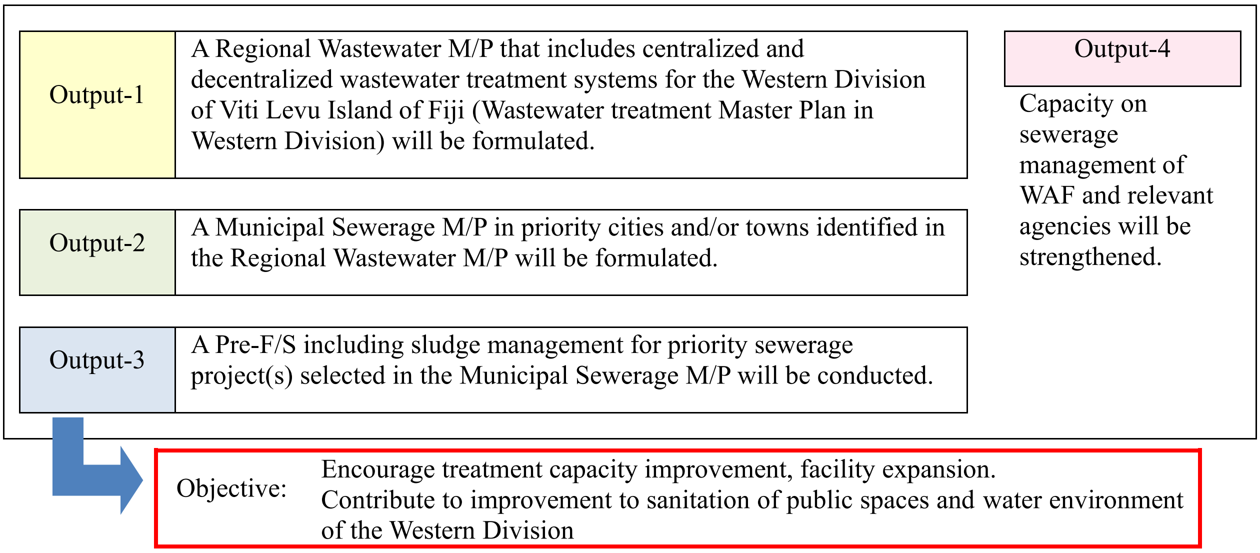
In the Western Division of Viti Levu, Fiji, four cities and towns have wastewater treatment plants, but due to factors such as overloading caused by increasing WWTP inflow, improper operation and maintenance, equipment failure and aging facilities, wastewater is discharged without adequate treatment, raising concerns of water pollution. Against this background, the “Project for Formulation Wastewater Treatment Master Plan in Western Division” has been implemented from October 2021 to develop a Regional Wastewater Master Plan, including decentralized treatment system in the Western Division, and provide training to improve the maintenance and management capacity of sewerage facilities.

In the first year's Output 1: “Formulation of the Regional Wastewater Master Plan,” the sewerage service areas needed to achieve the National Development Plan’s goal of “70% population access to centralized treatment systems” were identified for six cities and towns in the Western Division (Lautoka, Nadi, Ba, Tavua, Rakiraki, and Sigatoka).

In the second year's Output 2: “Municipal Sewerage Master Plan,” the target cities were Lautoka City and Nadi Town, and the Municipal Sewerage Master Plan was formulated. Based on the WAF's request to divide the service areas into multiple service areas, Lautoka City was divided into Vitogo and Natabua service areas, and Nadi Town was divided into Sabeto, Navakai and Moala service areas. Based on discussions with the DOE, it was decided that the Navakai WWTP would use the Oxidation Ditch process, which meets the SEZ discharge standards, and the other four WWTPs would use the Trickling Filter process, which meets the general discharge standards with ocean outfall pipes. As the priority of development is considered high for the already-developed Natabua and Navakai service areas, priority projects will be selected, and Pre-F/S will be carried out.

1-2 Purpose of the Project and Outputs

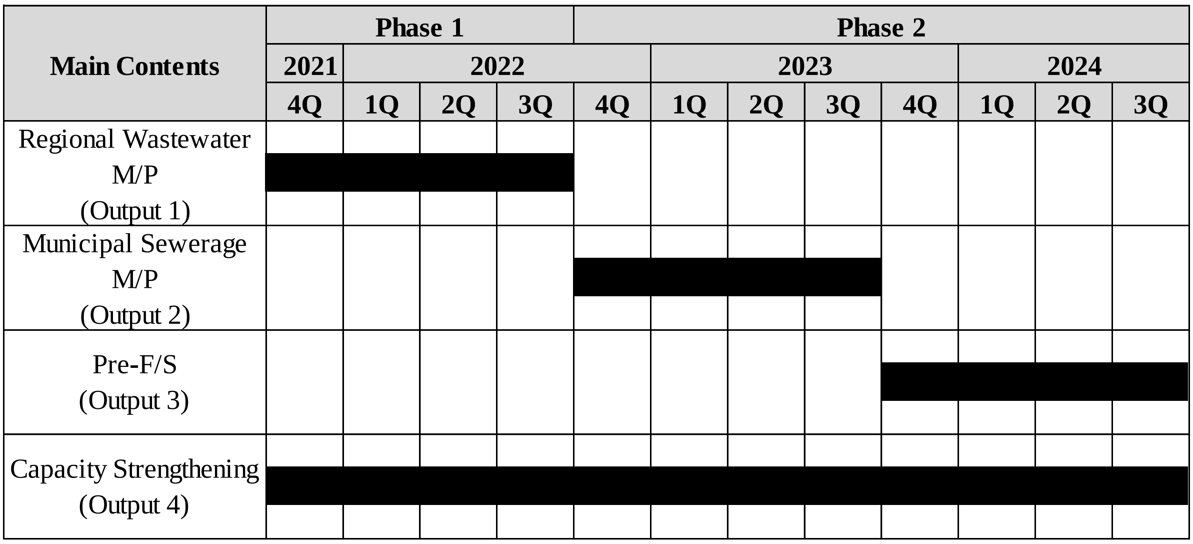
In the third year of the Project, a Pre-F/S for the priority projects will be formulated on the basis of Outputs 1 and 2. The achievement of these outputs will facilitate the implementation of the capacity improvement and expansion project for sewerage facilities in the Western Division and contribute to the improvement of the urban, public hygiene and water environment in the Western Division.



Source: JET based on R/D

Figure 1-2.1 Purpose and Outputs of the Project

This project, which will be implemented over a period of three years, will achieve Output 4, strengthening capacity for sewerage maintenance and management, in parallel with other Outputs 1 to 3. Over the past two years, 1) capacity assessments and needs surveys of relevant organizations were conducted, 2) a capacity development plan was formulated based on the results of the above 1), and 3) capacity development training was systematically implemented in cooperation with Fukuoka City. In the second phase, online training, on-the-job training, and training in Japan will be implemented based on the plan.



Source: JET based on R/D

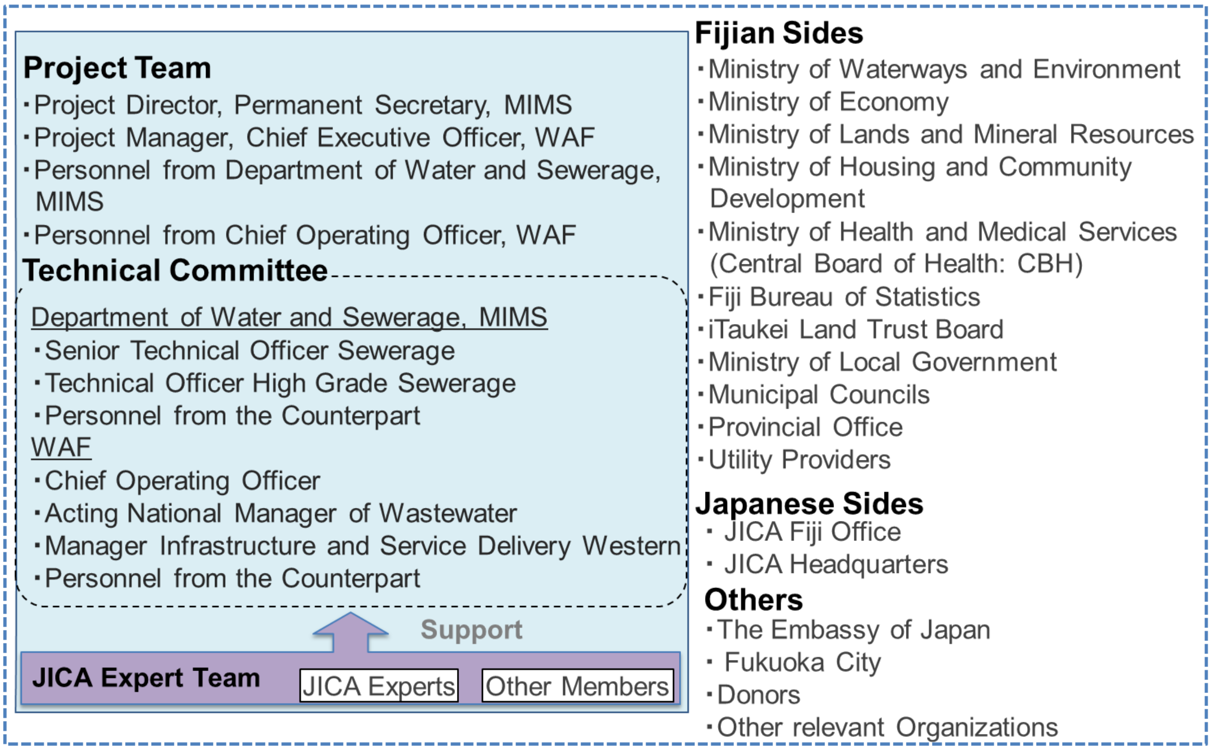
Figure 1-2.2 Contents and Phasing of the Project

1-3 Project Implementation Structure

(1) Joint Coordination Committee

The project implementation structure is shown in **Figure 1-3.1**, with the Joint Coordination Committee (hereinafter referred to as "JCC") at its nucleus. This project will use the JCC to ensure mutual communication between parties throughout the planning process, and to ensure prompt approval of the formulated plans. The main role of the JCC is summarized as follows.

- Confirm and approve progress of Phase 1 Regional Wastewater M/P, Phase 2 Municipal Sewerage M/P and Pre-F/S
- Discuss overall direction of the project and build consensus between relevant authorities



*1: MIMS: before organizational restructuring; current MPW
*2: MOE: before organizational restructuring; current MOF
Source：Created by JET based on R/D

Figure 1-3.1 Project Implementation Structure

(2) Advisor

Upon the formulation of the Master Plans and implementation of the Pre-F/S study in this project, the Road and Sewerage Bureau of Fukuoka City has been participating as an advisor to provide advice from a professional and technical standing point. In addition, Fukuoka City also cooperated as the lecturer/instructor of the training program for WAF. Fukuoka City has a record over the years participating/cooperating with Fiji in its water and sewerage projects, holding connections with WAF and familiar with its institutional system.

(3) Members of the JICA Expert Team

JICA officials and JICA Expert Team (JET) consists of the following members (see **Table 1-3.1**). In addition, JICA has asked the Fukuoka City to participate as an advisor, and the bureau provides advice on project activities and plans as appropriate.

Table 1-3.1 Members of the JICA Expert Team

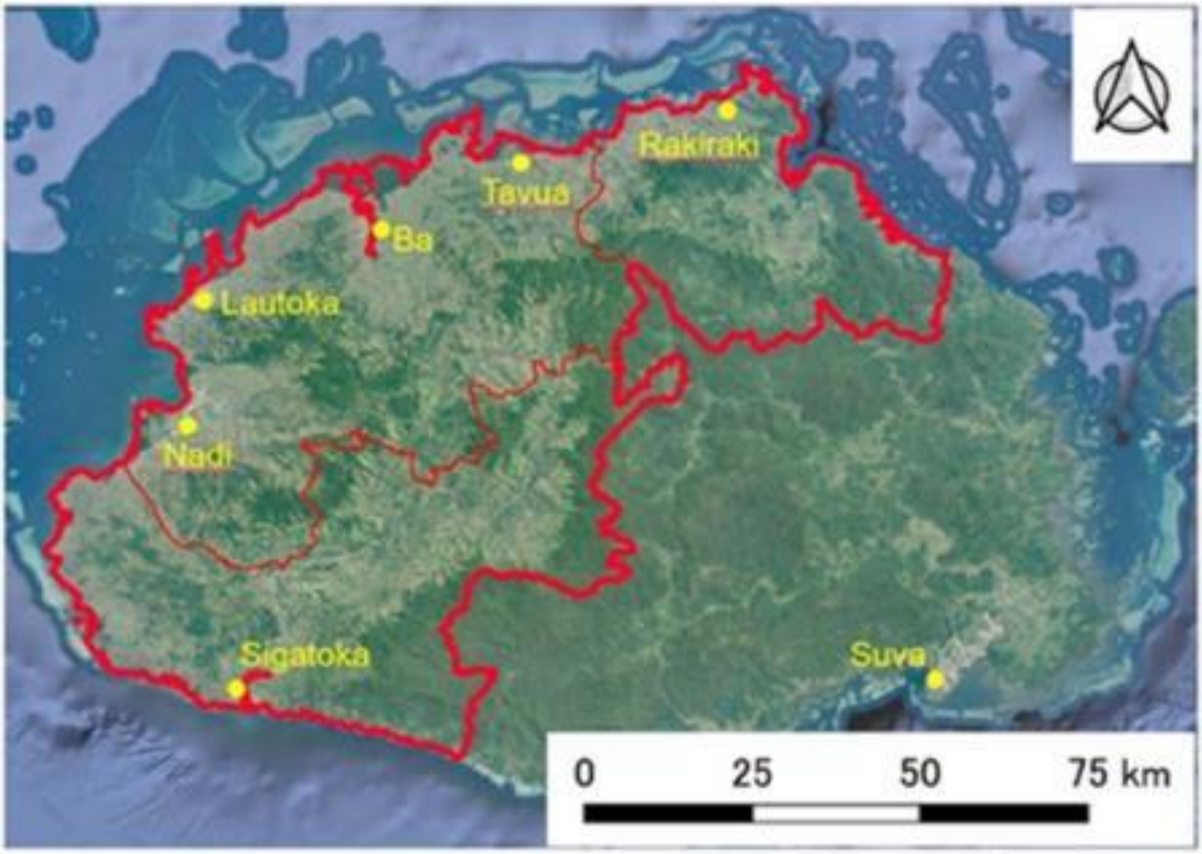
JICA	
NAME	**TITLE**
Hideaki MATSUOKA	Director, Environmental Management Group, Global Environment Department, JICA HQ
Kentaro YOSHIDA	Director, Environmental Management Group, Global Environment Department, JICA HQ
Yukiya HOSAKA	Officer, Environmental Management Group, Global Environment Department, JICA HQ
Shinichi WADA	Officer, Environmental Management Group, Global Environment Department, JICA HQ
Takashi OBA	Assistant Resident Representative, JICA FIJI Office
Shigeki NAMBA	Project Formulation Advisor, JICA FIJI Office
Hideaki IWASE	Project Formulation Advisor (Regional Infrastructure), JICA FIJI Office
Advisor: Fukuoka City	
NAME	**TITLE**
Hironori YASHIMA	Director, Policy Coordination Section, Road and Sewerage Bureau
Shingo MORIKAWA	Assistant Section Chief, Policy Coordination Section, Road and Sewerage Bureau
Shojiro HASHIZUME	Chief, Policy Coordination Section, Road and Sewerage Bureau
Mayumi ONO	Officer, Policy Coordination Section, Road and Sewerage Bureau
Makoto OHTA	Manager, Chubu Sewage Treatment Center, Road and Sewerage Bureau

CONSULTANT TEAM		
NAME	**TITLE**	**OCCUPATION**
Yoshinobu NAKAJIMA	Team Leader/ Sewerage Works management	Nihon Suido Consultants Co., Ltd.
Kiyohiko HAYASHI	Deputy Team Leader/ Organization & Institutions	Nihon Suido Consultants Co., Ltd.
Tetsuo WADA	Sewerage planning	Nihon Suido Consultants Co., Ltd.
Hiroyuki KAWASHIMA	On-site wastewater treatment planning	Nihon Suido Consultants Co., Ltd.
Shinichi SASAKI / Yoko KOTEGAWA	WWTP planning and design	Nihon Suido Consultants Co., Ltd.
Hideyuki IGARASHI	Sewer collection system and existing drainage survey	Yachiyo Engineering Co., Ltd.
Yasuaki MATSUMOTO	Mechanical engineering	Nihon Suido Consultants Co., Ltd.
Jyoji WAKAMOTO	Electrical engineering	Nihon Suido Consultants Co., Ltd.
Yuichiro KONNO	Implementation Plan and Cost estimation	Nihon Suido Consultants Co., Ltd.
Yoshiyuki CHOSO	Economic & Financial Analysis	Nihon Suido Consultants Co., Ltd.
Yuriko KUDO	Environmental & Social considerations/ Public Awareness	Yachiyo Engineering Co., Ltd.
Yasuo IIJIMA	Natural condition survey	Yachiyo Engineering Co., Ltd.
Koichi OKAZAKI	Water Supply Planning Adviser	Nihon Suido Consultants Co., Ltd.
Divesh SAMI	Sewerage Planner	NRW Macallan (Fiji) Ltd
Daiana BOLA	Sewerage Planner	NRW Macallan (Fiji) Ltd
Andrew BANNER	Civil Engineer	NRW Macallan (Fiji) Ltd
Aneshwar AMIT	Economic/Financial Analyst	NRW Macallan (Fiji) Ltd
Ashika SINGH	Secretary	NRW Macallan (Fiji) Ltd

Source: JET

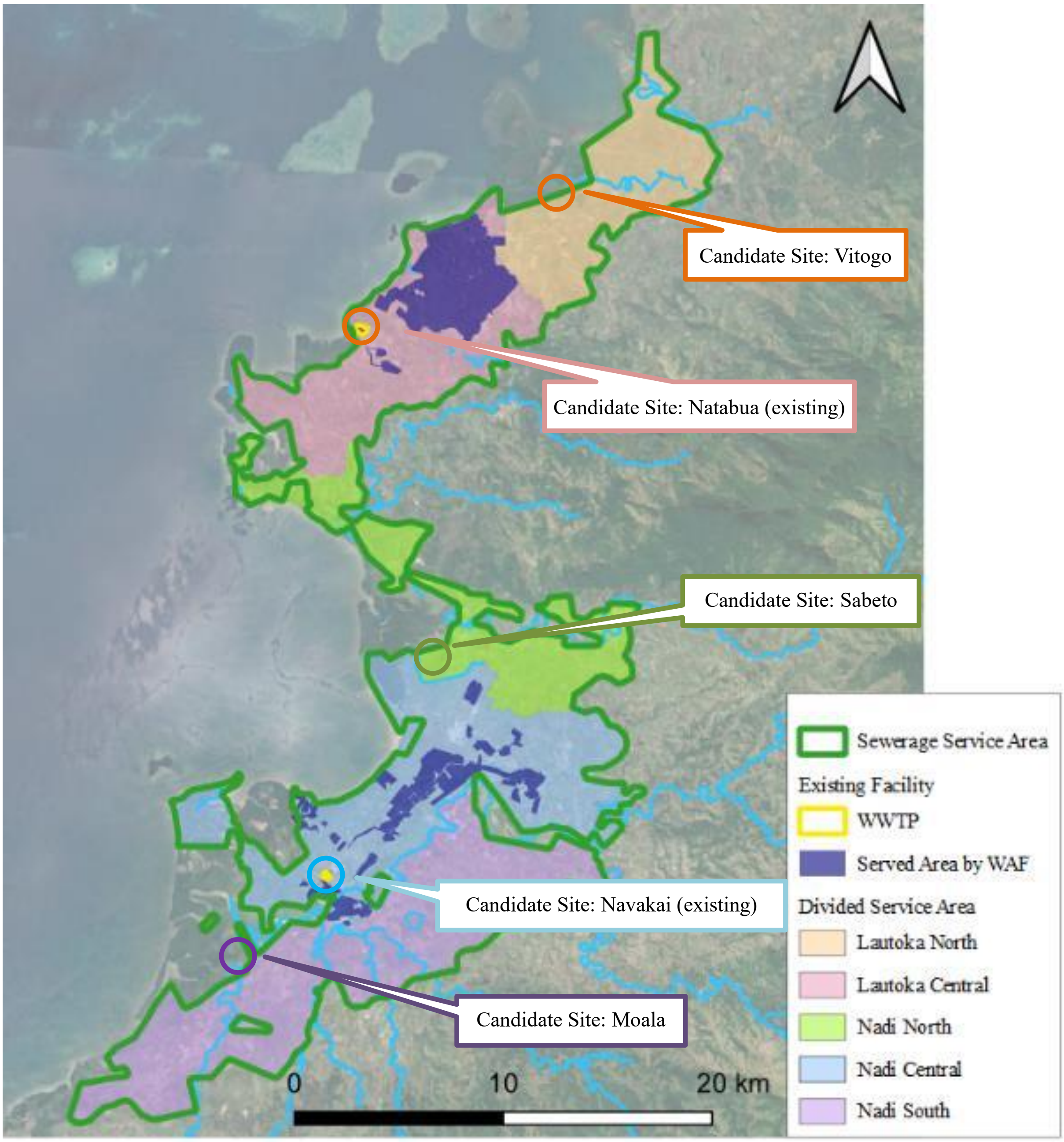
1-4 Target Area

The target area of this project is the Western Division of Viti Levu, as shown in **Figure 1-4.1**, and the proposed service areas of the Lautoka City and the Nadi Town, as identified in the Municipal Sewerage M/P, are shown in **Figure 1-4.2**.



Source: JET

Figure 1-4.1 Target Area of the Project



Source: JET

Figure 1-4.2 Proposed Service Areas in the Lautoka and Nadi Corridor

1-5 Current Challenges

Both Navakai and Natabua WWTPs have been in operation for 40 to 50 years, and although the Navakai WWTP has been upgraded to IDEA process, the current inflow is exceeding the design treatment capacity. In addition, due to factors such as lack of maintenance and long-term failures of mechanical equipment (including aerators), the effluent has not been adequately treated and discharge standards have not been met. Since WAF's effluent quality does not meet discharge standards, it is not possible to actively increase the number of new connections, so the main challenge is to increase the capacity of the treatment plant and comply with discharge standards. In addition, there are several problems such as the lack of proper treatment and final disposal of sludge. **Table 1-5.1** shows the general problems of the two WWTPs.

Table 1-5.1 Current Challenges of Natabua, Navakai WWTP

Category	Natabua WWTP	Navakai WWTP
Wastewater Treatment	• Treated water does not satisfy effluent standards • Lack of treatment capacity • Decreased effective pond volume (in other words, treatment capacity) due to lack of sludge dredging	• Treated water does not satisfy effluent standards • Lack of treatment capacity • Lack of aerators (planned: 8 units, currently working: 4 units) • Unhealthy condition of IDEA pond activated sludge (over aging due to lack of excess sludge withdrawal)
Sludge Treatment	• Lack of sludge dredging (desludging):only implemented once since operation commencement 40 years ago) • Lack of proper final disposal site (dumped at open lot in vicinity of WWTP) →sludge and leachate flowing out to nearby water bodies through rain/wind	• Lack of excess sludge withdrawal • Broken aerobic digestion pond aerator (planned: 2 units, currently working: 1 unit) • Broken sludge dewaterer • Lack of proper final disposal site (dumped onsite) →sludge and leachate flowing out to nearby water bodies through rain/wind
Other	• Lack of proper Operation and Maintenance (O&M) • Septage dumped to unlined pit → no proper treatment, flows out to nearby water bodies	• Lack of proper O&M

Source: JET

Table 1-5.2 shows the effluent quality of Natabua WWTP and **Table 1-5.3** shows the effluent quality of the Navakai WWTP. The treated effluent quality from both WWTPs often does not meet Fiji's discharge standards, with the BOD compliance rate (number of effluent samples that meet the standard / total number of effluent samples) being approximately 50% for Natabua and 60% for Navakai.

Table 1-5.2 Effluent Quality from Natabua WWTP

Year	Influent							Effluent						
	T-SS	BOD	COD	T-N	T-P	FOG	Faecal Coliforms	T-SS	BOD	COD	T-N	T-P	FOG	Faecal Coliforms
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Col./100ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Col./100ml
Gen Std.								60	40	—	25	5	5	400
2014	530	320	590	8.4	4.6	240	—	82	64	170	4.4	3.4	38	—
2015	480	300	580	11	3.7	150	—	44	65	130	4.9	2.2	33	—
2016	440	390	830	—	0.6	22	—	52	44	120	—	0.8	4.2	—
2017	850	330	600	51	3.6	24	54,000,000	110	69	190	26	2.3	7.3	1,200,000
2018	300	210	520	41	2.3	71	260,000,000	55	51	140	22	1.2	32	22,000
2019	370	220	410	28	5.8	86	300,000,000	53	39	110	20	4.0	15	210,000
2020	870	220	530	20	8.1	170	96,000,000	58	36	120	15	5.7	40	98,000
2021	430	170	480	22	7.0	130	360,000,000	57	83	210	1.9	3.9	49	770,000
2022	260	220	390	18	11.0	120	420,000,000	78	84	170	18	7.0	51	46,000
2023	480	260	370	23	15.0	87	9,400,000	27	35	90	14	7.0	23	10,000
平均	520	310	620	28	3.0	100	210,000,000	69	59	150	14	2.0	23	330,000

Table 1-5.3 Effluent Quality from Navakai WWTP

Year	Influent							Effluent						
	T-SS	BOD	COD	T-N	T-P	FOG	Faecal Coliforms	T-SS	BOD	COD	T-N	T-P	FOG	Faecal Coliforms
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Col./100ml	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	Col./100ml
Gen Std.								60	40	—	25	5	5	400
2014	970	500	930	9.2	3.5	260	—	80	55	140	5.4	2.8	52	—
2015	930	360	880	9.2	2.8	190	—	44	41	91	5.6	2.3	55	—
2016	590	450	1300	13.0	2.3	24	—	54	49	120	11	1.6	11	—
2017	510	320	650	58.0	3.3	17	370,000,000	160	85	230	32	1.5	10	7,700,000
2018	450	240	590	47.0	3.2	57	300,000,000	120	68	180	29	2.4	23	8,900,000
2019	250	190	440	33.0	6.5	140	330,000,000	43	29	77	27	5.9	60	560,000
2020	200	140	430	20.0	7.6	130	98,000,000	24	20	100	15	2.8	36	3,200,000
2021	200	130	290	21.0	9.0	150	170,000,000	29	31	54	20	4.3	54	1,900,000
2022	260	220	390	18.0	11.0	120	160,000,000	78	83	190	17	8.0	55	6,400,000
2023	400	210	330	25.0	13.0	150	9,500,000	60	45	77	21	10.0	43	9,000
平均	690	370	870	27.0	3.0	110	210,000,000	91	60	150	17	2.1	30	4,100,000

CHAPTER 2 PLANNING BASIS AND DESIGN CONDITIONS

2-1 Priority Projects for the Pre-F/S

(1) Target Sewerage Service Area

In the Municipal Sewerage M/P, it was concluded that it would be most economically advantageous to partition Lautoka/Nadi into five service areas (Vitogo, Natabua, Sabeto, Navakai, Moala) for its sewerage system development. Out of the five service areas, Natabua and Navakai were determined to have high priority due to their urbanized zones and already-existing WWTPs. Therefore, the Pre-F/S's target project will be selected from the components of Natabua and Navakai service areas.

(2) Project Components Extracted from the Municipal Sewerage M/P

The Municipal Sewerage M/P recommends a staged development, which proposes to divide Natabua and Navakai service areas' development in two phases. The project components for Phase 1 and Phase 2 are shown in **Table 2-1.1**. The Pre-F/S's priority projects will be selected from this list.

Table 2-1.1 Natabua/Navakai Project Components extracted from the Municipal Sewerage M/P

Area	Type	Outline of Facilities	
Natabua	WWTP (Ln-w1)	Half of total capacity (1/2)	TF process: Q=22,000 m^3/day
	WWTP (Ln-w2)	Half of total capacity (2/2)	TF process: Q=22,000 m^3/day
	Septage Treatment Plant (Ln-w3)	Install septage treatment facility at Natabua WWTP	Q=65 m^3/day
	Sewer (Ln-s1)	Trunk lines in urban zone (half of Natabua service area)	Trunk/Sub-trunk lines: Dia.100-750mm L=32 km
	Sewer (Ln-s2)	Trunk lines in remaining half of Natabua service area +branch sewers	Trunk/Sub-trunk lines: Dia.100-750mm L=32 km Branch sewers Dia.100- 600mm L=72 km
	Sewer (Ln-s3)	Branch sewers	Branch sewers: Dia.100- 600mm L=72 km
Navakai	WWTP (Nn-w1)	Half of total capacity (1/2)	OD process: Q=15,000 m^3/day
	WWTP (Nn-w2)	Half of total capacity (2/2)	OD process: Q=15,000 m^3/day
	Sewer (Nn-s1)	Trunk lines in urban zone (half of Navakai service area)	Trunk/Sub-trunk lines: Dia.100-900mm L=29 km
	Sewer (Nn-s2)	Trunk lines in remaining half of Navakai service area +branch sewers	Trunk/Sub-trunk lines: Dia.100-900mm L=29 km Branch sewers: Dia.100-310mm L=102 km
	Sewer (Nn-s3)	Branch sewers	Branch sewers: Dia.100-310mm L=102 km

Source: JET

(3) Selection of the Priority Projects for Pre-F/S

Table 2-1.2 shows the comparative assessment of candidate cases. Upon determining the Pre-F/S priority projects, WAF placed importance in the compliance of legal effluent standards by existing WWTPs. For this reason, the upgrade of Natabua and Navakai WWTP, which have large treatment capacities, were selected.

Table 2-1.2 Candidate Case Comparison of Priority Projects

Item	Case 1: Nadi sewer & WWTP	Case 2: Lautoka sewer & WWTP	Case 3: Nadi & Lautoka & WWTP
Persons connected to sewer system	Lautoka: 29,000 Nadi: 21,100	Lautoka: 40,500 Nadi: 15,800	Lautoka: 29,000 Nadi: 15,800
Effluent BOD (mg/L)	Natabua: 56 Navakai: 20	Natabua: 40 Navakai: 47	Natabua: 40 Navakai: 20
Effluent BOD load (BOD-t/yr)	304	331	237
Removed BOD load (BOD-t/yr)	94	67	161
Construction cost (mil. FJD)	413	356	399
Cost/ Removed BOD load (mil. FJD/t/yr)	4.4	5.3	2.5

Source: JET

- Case 3, which includes both Natabua and Navakai WWTP, has the highest development effectiveness per unit load reduction, which is directly related to compliance with effluent water quality.
- Legal compliance of effluent standards from existing WWTPs has a high priority for WAF.
- The expansion/development of sewer and pumping stations in both service areas can be implemented by WAF, provided that the capacity and treatment quality of WWTPs are improved

2-2 Necessity of the Project

This project aims to contribute to the protection/improvement of water environment and public hygiene in the Natabua (Lautoka City) and Navakai (Nadi Town) area by expanding sewerage and sludge treatment facilities. Since the contents of the project matches with the target areas' needs as well as Fiji's national development policies, the project's validity and necessity to support its implementation is high. Specific points are as follows:

1. Natabua and Navakai are areas with highest population growth in the Western Division of Viti Levu, and are expected to continue its growth in the future. The service population of the two areas are expected to increase to about 1.3 times that of 2023 by year 2043.

2. Although there are currently no immediate plans to expand the water supply facilities in the area, measures to reduce non-revenue water are being taken as part of a Japanese technical cooperation project ("The Project for Capacity Development of Non-Revenue Water Reduction in Nadi and Lautoka Area"). Increase in domestic, commercial and tourist water consumption is expected.

3. In result of the above, the amount of generated sewerage in Natabua and Navakai is expected to steadily increase through 2043.

4. Tourism revenue accounts for approximately 25% of Fiji's gross domestic product (GDP), and approximately 40% of tourists to Fiji stay in the Nadi-Lautoka area, and 10% stay on the islands around Nadi. Since marine and coastal resources form the backbone of resorts, there is a high need to conserve public waters as a tourism resource.

5. However, the compliance rate of effluent quality from both Natabua/Navakai WWTP as of 2023 is only about 60%, suggesting the discharge of insufficiently treated sewerage. The effluent, including untreated sewerage/wastewater, is causing water quality deterioration of public waters.

6. This project will upgrade the sewerage/sludge treatment facilities of Natabua and Navakai WWTP to achieve the proper treatment of inflowing sewerage. By treating sewerage up to levels meeting effluent standards, the assurance of legal compliance, as well as the improvement of downstream water quality are expected, further leading to the preservation of marine environment (tourism resources). Therefore, the implementation of this project is highly significant.

7. The National Development Plan 2036 states that "the development/expansion of sewerage systems will be promoted in all urban areas, to achieve 70% population access to sewerage systems by 2036." In addition, the Water Sector Strategy 2050 (published by MPW[1] and WAF in April 2024) lists the expansion plans for Natabua and Navakai WWTP as projects to be achieved by 2040, based on the Municipal Sewerage M/P. This project is consistent with these policies, and the validity of its implementation is high. In parallel, it is also important to implement restoration projects of existing facilities, as well as improvements in intangible initiatives of facility maintenance/ management.

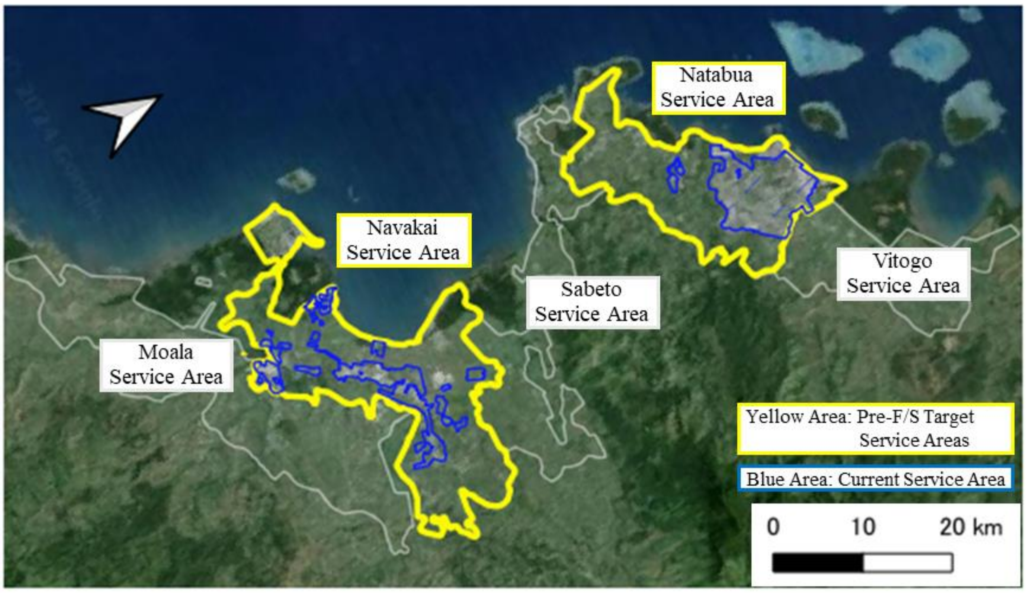
2-3 Target Year

The target year is set at 2043, in accordance with the Municipal Sewerage M/P.

2-4 Sewerage Service Area

The proposed sewerage service area is the same as that of the Municipal Sewerage M/P, shown in **Figure 2-4.1**. There is no change to the sewerage planning area because the area is set to achieve the National Development Plan's goal of "70% population access to centralized treatment systems."

[1] MPW：former Ministry of Infrastructure and Meteorological Service（MIMS）



Source: JET

Figure 2-4.1 Sewerage Service Area (Natabua/Navakai Service Areas)

2-5 Design Flow

(1) Service Population and Planning Frames

Fundamental planning frames such as the planned service population, unit wastewater volume etc. are set in accordance with the Municipal Sewerage M/P.

The planned total wastewater flow in 2043 determined in the Municipal Sewerage M/P is shown in **Table 2-5.1**. As the WWTPs and sewer systems of Natabua/Navakai service areas will be developed in two phases, the Phase 1 development scale was determined, taking into consideration the current wastewater flow and step-wise development.

Table 2-5.1 Wastewater Flow of Each Service Area (2043)

No	Parameter	Units	Lautoka		Nadi			Total
			Vitogo	Natabua	Sabeto	Navakai	Moala	
1	Population	capita	15,130	105,590	13,510	52,740	35,420	222,390
2	Water Consumption	m^3/capita/day	0.220	0.220	0.220	0.220	0.220	
3	Return Ratio	%	90	90	90	90	90	
4	Unit wastewater Flow	m^3/capita/day	0.200	0.200	0.200	0.200	0.200	
5	Domestic Flow	m^3/day	3,026	21,118	2,702	10,548	7,084	44,478
6	Non-Domestic Flow	m^3/day	2,760	15,640	3,110	14,000	8,810	44,320
7	Generated Wastewater	m^3/day	5,786	36,758	5,812	24,548	15,894	88,798
8	Infiltration ratio	%	10	10	10	10	10	
9	Infiltration water	m^3/day	579	3,676	581	2,455	1,589	8,880
10	Total Inflow ADWF	m^3/day	6,365	40,434	6,393	27,003	17,483	97,678
11	Total Inflow PDWF	m^3/day	7,001	44,477	7,033	29,703	19,232	107,446

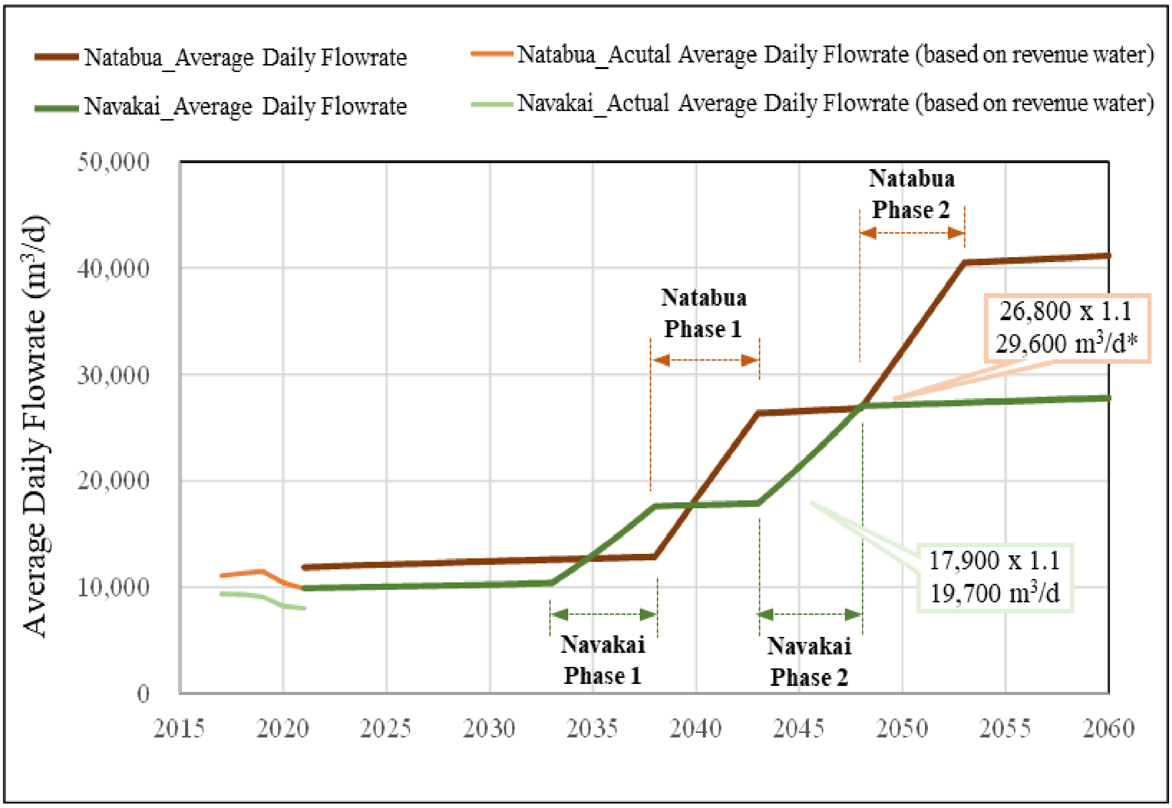
Source: JET

(2) Design Flow of the Pre-F/S

The design flow of Natabua WWTP was set at 29,600 m^3/day (maximum daily flow), and for Navakai WWTP was set at 19,700 m^3/day (maximum daily flow).

The current influent flow, planned wastewater flow, and development steps of both WWTPs are shown in **Figure 2-5.1**. The service areas are also planned to be developed in two phases, and the expected influent flow to Natabua and Navakai WWTP upon completion of Phase 1 sewer system development is approximately 29,600 m^3/day (maximum daily flow of raw sewerage, does not include other accepted wastewater) and 19,700 m^3/day (maximum daily flow), respectively.

The number of treatment lines to be developed as part of the Pre-F/S was determined based on the design flow, as well as the ability to handle overloaded operations when one treatment line is shut down for maintenance, etc. Details will be provided in **CHAPTER 3** and **CHAPTER 4** .



*Raw sewerage from pipelines. Does not include other wastewater accepted at Natabua WWTP (Refer to **2-6**)
Source: JET

Figure 2-5.1 Estimation of Natabua/Navakai WWTP Inflow

2-6 Design Influent Quality

(1) Natabua WWTP

This project will set WWTP-specific influent wastewater qualities and effluent qualities. The treatment targets of Natabua WWTP's wastewater treatment system was set as the following, and its influent water quality was examined

- Raw sewerage (influent from sewer pipelines)
- Dewatered septage leachate
- Pre-treated distillery wastewater

The overall influent water quality of Natabua WWTP is shown in **Table 2-6.1**.

Table 2-6.1 Natabua WWTP Influent Wastewater Quality*

BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)	Water Temperature (℃)
398	500	45	11	20

*Mixture of raw sewerage, dewatered septage leachate, and pre-treated distillery wastewater
Source: JET

1) Raw Sewerage

The water quality of sewerage was determined based on Natabua WWTP's raw influent data from 2014-2019 and 2023, which excludes periods affected by the COVID-19 pandemic. The results are shown in **Table 2-6.2**. Refer to **APPENDIX 3-3** for details.

Table 2-6.2 Natabua WWTP Raw Sewerage Water Quality

Max Daily Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
44,477	373	486	37	9

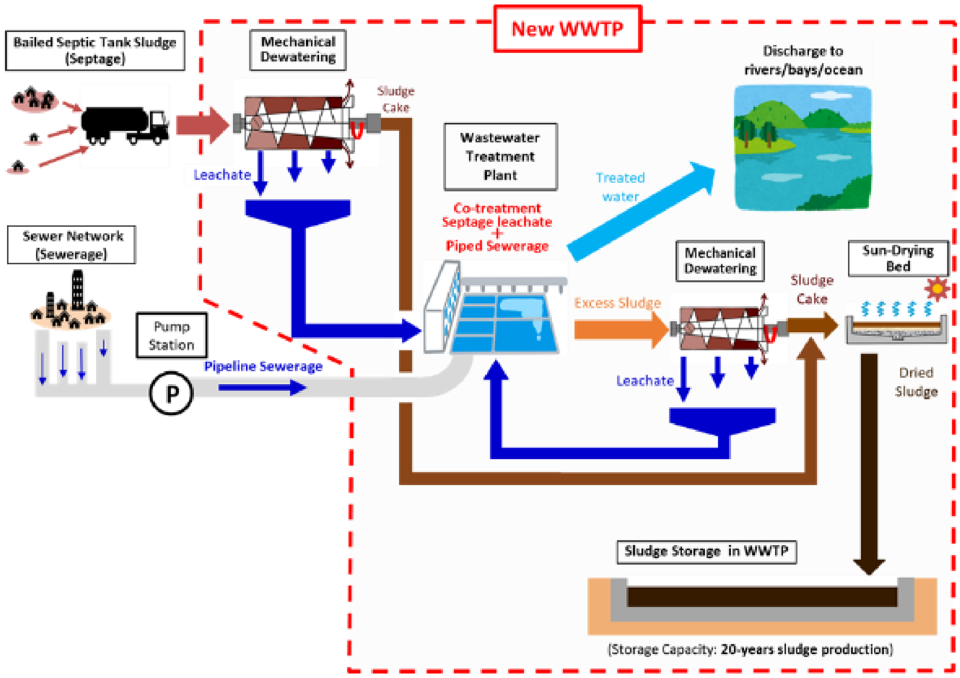
Source: JET

2) Septage and Dewatered Septage Leachate

Currently, Natabua WWTP is the only WWTP in the Lautoka/Nadi area that accepts septage; bailing trucks collect septage from households, commercial facilities etc., and its contents are dumped into an unlined pit. For this reason, it was assumed that Natabua WWTP will continue to accept collected septage for proper treatment.

Bailed septage will be dumped into a septage receiving tank, which is then directly dewatered, sun-dried, and stored onsite. The leachate produced from the dewatering process will be treated by Natabua WWTP's wastewater treatment system (**Figure 2-6.1**).

The water quality of the dewatered septage leachate is shown in **Table 2-6.3**. The daily average volume of bailed septage was forecasted for 2017-2036, resulting in a maximum of 65 m^3/day. 59 m^3/day of leachate will be produced and treated (Refer to **APPENDIX 3-3** for details).



Source: JET

Figure 2-6.1 Septage Treatment Flow Diagram

Table 2-6.3 Dewatered Septage Leachate Water Quality

Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
59	250	620	37	9

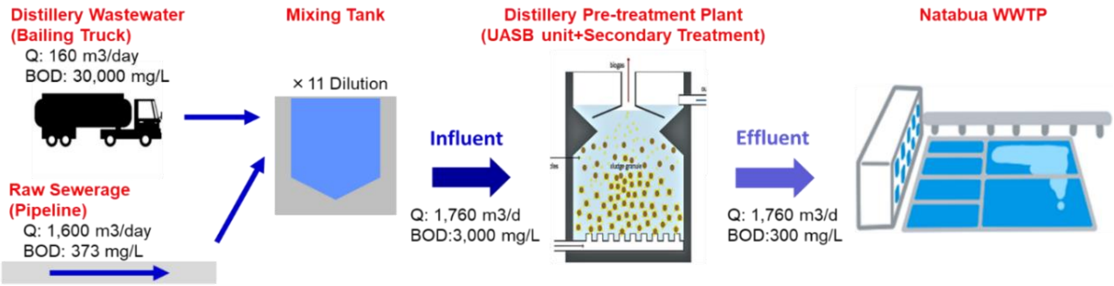
Source: Created by JET based on "Adoption/Demonstration Experiment Project of Johkaso Sludge Dewatering Machines in Cebu City (Philippines)" (AMCON INC.) (2016)

3) Pre-treated Distillery Wastewater

In this project, WAF requested Natabua WWTP to accept pre-treated distillery wastewater (hereinafter referred as "pre-treated wastewater") as one of its treatment targets.

A Distillery Pre-treatment Plant will be constructed in the vicinity of Natabua WWTP, which will accept liquid trade waste produced by South Pacific Distilleries Ltd. (hereinafter referred to as "SPD"), a local distillery. The waste is currently discharged to the ocean without treatment. Bailed-in distillery wastewater will be diluted using a part of the raw sewerage flowing into Natabua WWTP, and treated by UASB units, etc. The pretreated wastewater will be then accepted to Natabua WWTP's wastewater treatment system (**Figure 2-6.2**).

Although the Pre-treatment Plant itself is out of the Pre-F/S's project scope, its pretreated water quality was estimated as shown in **Table 2-6.4**, and considered in determining Natabua WWTP's influent water quality. Refer to **APPENDIX 3-1** for details.



Source: JET

Figure 2-6.2 Treatment Flow Diagram of Distillery Wastewater

Table 2-6.4 Estimated Water Quality of Pre-treated Distillery Wastewater

Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
1,760*	600	600	100	20

*Includes raw sewerage used to dilute distillery wastewater. Refer to **APPENDIX 3-1** for details
Source: Created by JET based on WAF, NSW Department of Planning Industry and Environment

(2) Navakai WWTP

Navakai WWTP is planned to treat only raw sewerage (influent from sewer pipelines). Its water quality was determined based on Navakai WWTP's raw influent data from 2014-2019 and 2023, which excludes periods effected by the COVID-19 pandemic. The results are shown in **Table 2-6.5**. Refer to **APPENDIX 4-1** for details.

Table 2-6.5 Navakai WWTP Influent Water Quality

BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)	Water Temperature (℃)
367	544	37	6	20

Source: JET

2-7 Effluent Quality

As shown in **Table 2-7.1**, two types of effluent quality standards are established in Fiji: General standards and Significant Ecological Zone (hereinafter referred to as "SEZ") standards, which is more stringent.

Table 2-7.1 Effluent Quality Standards

Parameter	Units	Concentration	
		General	Significant Ecological Zone
pH	pH	7-9	7-9
BOD5	mg/L	40	20
SS	mg/L	60	30
Fecal coliforms	CFU/100mL	400	200
TN	mg/L	25	10
Ammonia	mg/L	10	5
TP	mg/L	5	2

Source: Schedule 3 of the Waste Disposal and Recycling Regulations of Fiji (Environment Management (Waste Disposal and Recycling) Regulations, 2007).

According to the DOE, SEZ standards are “applied to coastal areas and river areas with delicate environmental characteristics.” However, there are no set conditions of applications/materials clearly showing areas of SEZ standards application. Meanwhile, WAF is currently working on the expansion/renovation project for Kinoya WWTP in Suva, in which General standards effluent is planned to be discharged 1 km offshore through an ocean outfall pipe. In discussions with the DOE, it was confirmed that the same concept as the Kinoya WWTP could be applied to the Pre-F/S, leaving the option of “General standards + ocean outfall pipe” in the project.

In this project, Natabua WWTP, which will be designed to satisfy the above “General standards + ocean outfall pipe”, will be designed to satisfy General standards. Navakai WWTP, which discharges to Nadi River, will be designed to satisfy SEZ standards.

As a sidenote, DOE commented that when adopting “General standards + ocean outfall pipe”, it is necessary to submit an Environmental Impact Assessment to the DOE and hold discussions at the F/S stage.

- Effluent volume and water quality to be discharged from WWTPs
- Degree of effluent dilution and environmental carrying capacity of the planned discharging area
- Environmental/biological assessment of planned discharging areas, etc.

2-8 Facility Planning and Design Parameters

In accordance with the Municipal Sewerage M/P, Natabua adopted the two-stage Trickling Filter process (hereinafter referred to as “TF process”), and Navakai WWTP adopted the Oxidation Ditch process (hereinafter referred to as “OD process”)

The design parameters for each treatment process are summarized as follows.

(1) TF Process

Table 2-8.1 Design Specification of the TF Process

Facility	Parameter	Range	Noted Reference
Primary Clarifier	Surface Loading Rate	35~70 m^3/m^2・day	JSWA※1, Ed.2019, p.103
	Water Depth	2.5~4.0 m	JSWA※1, Ed.2019, p.103
	Weir Loading Rate	250 m^3/m・day	JSWA※1, Ed.2019, p.103
Trickling Filter: Common Parameters	Filter Media Height	1.5~2.0 m	JSWA※2, Ed.1984, p.377
	Filter Media Diameter	Maximum 45 m	JSWA※2, Ed.1984, p.377
	Media Specific Surface Area	100 m^2/m^3	WEF & ASCE※3, p. 13-146
	IWEM Kinetic Coefficient	0.40 $m^{m-1}d^{n-1}$	WEF & ASCE, p. 13-169
	Temperature Coefficient	1.089 (-)	WEF & ASCE, p. 13-169
	Reduction Factor for Surface Loss with Increasing Area	0.732 (-)	WEF & ASCE, p. 13-169
	Hydraulic Rate Coefficient	1.396 (-)	WEF & ASCE, p. 13-169
	Minimum Sewerage/Air Temperature Difference Requirement for Natural Draft Ventilation	Δ2.8℃	WEF & ASCE, p.13-159
	Air Flow in Filter Media	1 $m^3/min/m^2$	CPHEEO※4, p.250
	N-removal rate of double TF System	33%	Pearce※5, p.47-52
Stage 1 Trickling Filter	BOD loading (BOD Removal)	1.20 kg-BOD/(m^3・day)	JSWA, Ed.1984, p.379
Stage 2 Trickling Filter	BOD loading (Ammonia Nitrification + BOD Removal)	0.16 kg-BOD/(m^3・day)	WEF & ASCE, p.13-173
	Ammonia Nitrification	75 %	WEF & ASCE, p.13-173
Coagulation/ Flocculation Canal	Fe:P Ratio of coagulant	1:1	JWWA※6, p.185-190
	Rapid Mixing Canal HRT	1~5 min	JWWA※6, p.185-190
	Flocculation Canal HRT	20~30 min	JWWA※6, p.185-190
Final Clarifier	Settling Time	6~12 hrs	JSWA, Ed.2019, p.108
	Water Depth	3.0~4.0 m	JSWA, Ed.2019, p.108
	Surface loading rate	8~12 m^3/m^2・day	JSWA, Ed.2019, p.108
	Weir loading rate	25~30 m^3/m・day 125~250 m^3/m・day	JSWA, Ed.2019, p.108 Metcalf & Eddy※7, p.620
Disinfection Tank	Chlorine contact time	15 min	JSWA, Ed.2019, p.238

※1 : " Sewerage Facility Planning and Design Guideline and Commentary: 2019 Edition," Japan Sewerage Works Association, 2019
※2 : " Sewerage Facility Planning and Design Guideline and Commentary: 1984 Edition," Japan Sewerage Works Association, 1984
※3 : "Design of Municipal Wastewater Treatment Plants: WEF Manual of Practice No.8 ASCE Manuals and Reports on Engineering Practice No.76: Fifth Edition," Water Environment Federation & American Society of Civil Engineers, 2010
※4 : "Manual on Sewerage and Sewerage Treatment: Second Edition," Central Public Health and Environmental Engineering Organization, 1993
※5 : "Trickling filters for upgrading low technology wastewater plants for nitrogen removal," P. Pearce, 2004
※6 : "Water Facility Design Guideline," Japan Water Works Association, 2012
※7 : "Wastewater Engineering 4th Edition," MetCalf & Eddy, 2004
Source: JET

(2) OD Process

Table 2-8.2 Design Specifications of the OD Process

Facility	Parameter	Range	Noted Reference
Oxidation Ditch Basin	HRT	24~36 hrs	JSWA※1, Ed.2019, p.103
	Water Depth	1.0~5.0 m	JSWA, Ed.2019, p.103
	Basin Width	2.0~6.0 m	JSWA, Ed.2019, p.103
	MLSS	3,000~4,000 mg/L	JSWA, Ed.2019, p.103
	BOD-SS loading	0.03~0.05 mg-BOD/kg-SS・day	JSWA, Ed.2019, p.103
	Return Sludge Ratio	100~200 %	JSWA, Ed.2019, p.103
Final Clarifier	Settling Time	6~12 hrs	JSWA, Ed.2019, p.108
	Water Depth	3.0~4.0 m	JSWA, Ed.2019, p.108
	Surface loading rate	8~12 m^3/m^2・day	JSWA, Ed.2019, p.108
	Weir loading rate	25~30 m^3/m・day 125~250 m^3/m・day	JSWA, Ed.2019, p.108 Metcalf & Eddy※2, p.620
Disinfection Tank	Chlorine Contact Time	15 min	JSWA, Ed.2019, p.238

※1 : " Sewerage Facility Planning and Design Guideline and Commentary: 2019 Edition," Japan Sewerage Works Association, 2019
※2 : "Wastewater Engineering 4th Edition," MetCalf & Eddy, 2004
Source: JET

CHAPTER 3 NATABUA WASTEWATER TREATMENT PLANT

3-1 Facility Overview

Natabua WWTP will switch its treatment process from the current "stabilization pond" to the "two-stage trickling filter + post-coagulation," increasing its capacity to a daily maximum of 29,800 m^3/day in Phase 1, then up to a daily maximum of 44,800 m^3/day in Phase 2. Responding to WAF requests, facilities were designed with capacity margins to enable proper treatment even when one treatment line is shut down for equipment maintenance, etc. (Phase 1: 5-line operation, Phase 2: 7-line operation) (**Table 3-1.1**).

In addition to its sewerage and sludge treatment facilities, Natabua WWTP will also have the facilities listed in **Table 3-1.3** installed within or in close proximity to the plant. Refer to **APPENDIX 3-1** for details on the Distillery Pretreatment Plant, and **APPENDIX 3-2** for details on the Sludge Digestion Facilities/Biogas Power Generation Plant. Along with the installment of these facilities, Natabua WWTP's treatment flow will change from Phase 2 (**Figure 3-1.1**, **Figure 3-1.2**).

Table 3-1.1 Natabua WWTP Facility Overview

Parameters		Phase 1	Phase 1 +Phase 2
Treatment Target		【Wastewater】 ・Raw Sewerage ・Pretreated distillery wastewater 【Sludge】 ・Septic Sludge ・Pretreatment Plant Sludge	【Wastewater】 ・Raw Sewerage ・Pretreated distillery wastewater 【Sludge】 ・Septic Sludge ・Pretreatment Plant Sludge ・Thickened raw sludge from other WWTPs
Treatment Process		Two-stage Trickling Filter with post-coagulation	
	Composition of one treatment line	1 Primary Clarifier 2 Stage-one Trickling Filter 2 Stage-two Trickling Filter 1 Coagulation/Flocculation Canal 1 Final Clarifier	
Max Daily Flowrate		29,800 m^3/day	44,800 m^3/day
Number of Treatment Lines		6 lines	8 lines total
Intended Treatment Capacity per line		5,600 m^3/day (6,100 m^3/day per line including all return flows)	
Max Treatable Capacity per line*1		6,600 m^3/day per line (including all return flows)	
Footprint	**Total**	24.51 ha*2*3	46.5 ha*2*3
	Wastewater Treatment Facilities	16.36 ha	24.51 ha
	Sludge Drying Bed*4	3.68 ha	4.93 ha
	Sludge Storage Space*4	4.48 ha	13.99 ha
	Sludge Digestion + Biogas Power Plant	0.00 ha	3.05 ha

*1 Max. capacity is based off minimum HRT requirements and maximum loads of basins. To ensure treated water quality, capacity margins must be included in the design
*2 Does not include Distillery Pretreatment Plant (Assumed footprint: 2.88 ha)
*3 Includes parts of current Natabua WWTP boundaries
*4 Including roads, buffer zones, etc. on premises
Source: JET

Table 3-1.2 Natabua WWTP Influent Water Quality and Target Effluent Quality

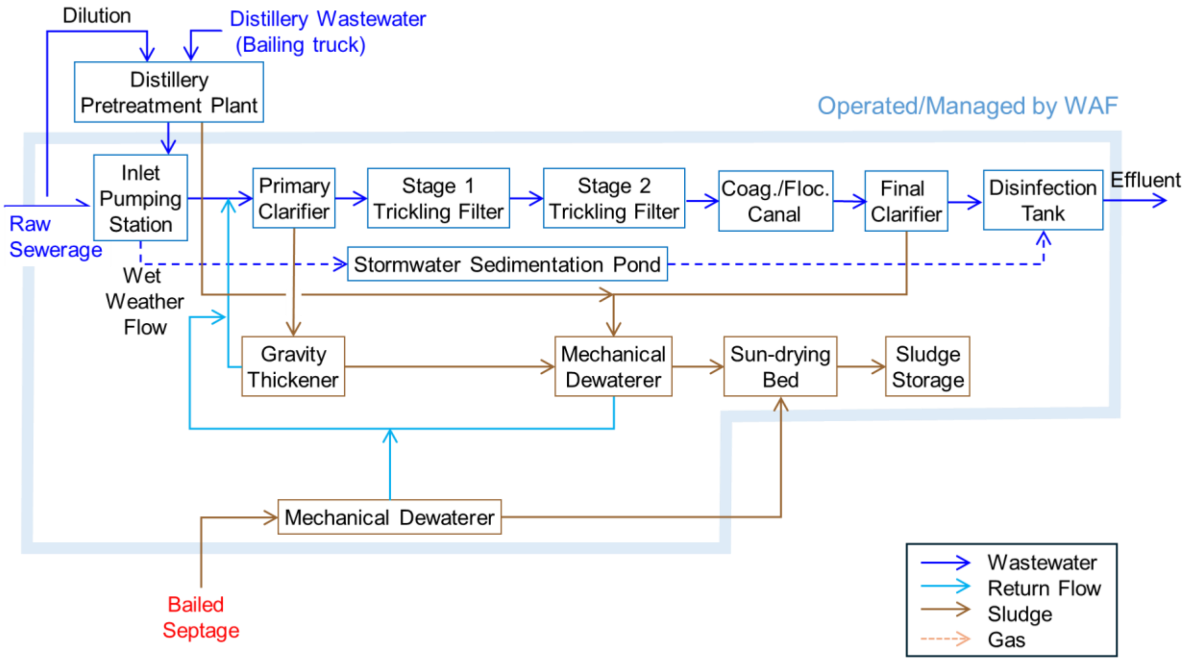
Parameters	Influent Water Quality*	Target Effluent Quality (General Standards)
BOD (mg/L)	398	40
SS (mg/L)	500	60
T-N (mg/L)	45	25
T-P (mg/L)	11	5

*: Including pretreated distillery wastewater and septage leachate,
Source: JET

Table 3-1.3 Facilities Co-related with Natabua WWTP

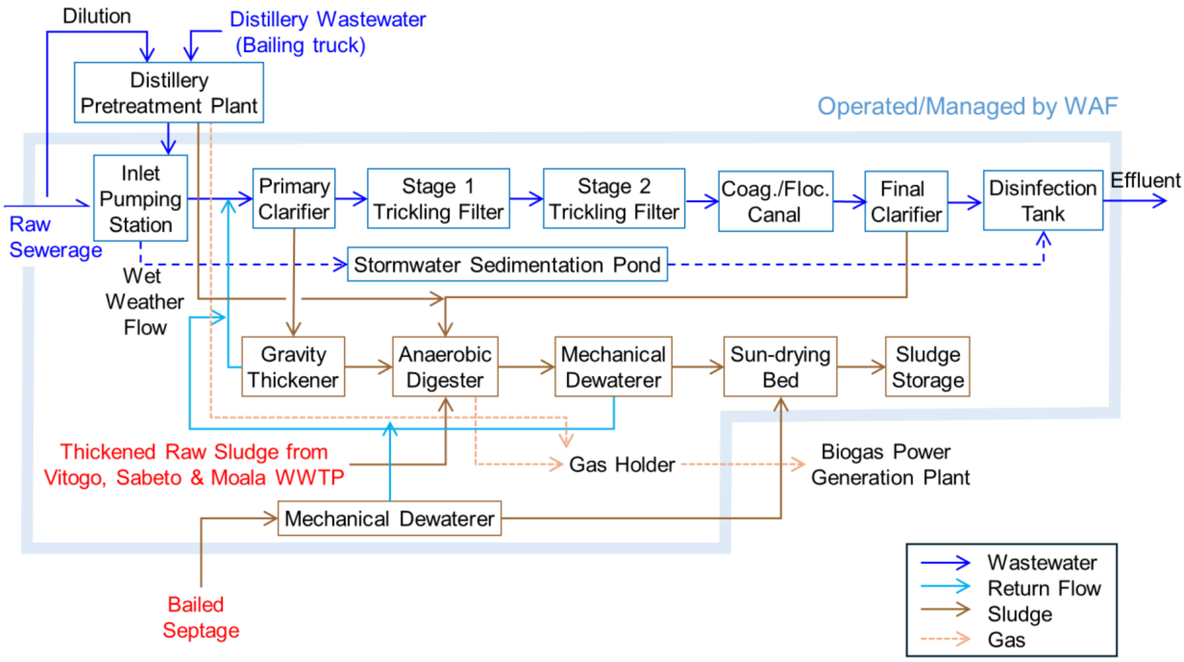
Facility	Description	Co-relation with Natabua WWTP	Planned Time of Construction	Pre-F/S Target
Septage Treatment Facilities	Treats septage bailed in by bailing trucks	・Septage dewatering → Drying → onsite storage ・Dewatered leachate treated by Natabua wastewater treatment system	Phase 1 or before	Included
Distillery Pretreatment Plant	Pretreats distillery wastewater bailed in from South Pacific Distillery Inc.	・Dilute distillery wastewater using part of raw sewerage flowing into Natabua ・Pretreated wastewater treated by Natabua wastewater treatment system ・UASB unit sludge co-treated with Natabua WWTP sewerage sludge in Sludge Digestion Facility	Phase 1	Not Included
Outer Sludge Receival Tank*	Receives thickened raw sludge bailed from planned future WWTPs (Vitogo, Sabeto, Moala)	・Received sludge co-treated with Natabua WWTP sewerage sludge in Sludge Digestion Facility	Phase 2	Included
Sludge Digestion Facility	Anaerobically digests Natabua, Vitogo, Sabeto, Moala WWTP sewerage sludge and Distillery Pretreatment Plant UASB sludge. Produced biogas is collected and sent to Biogas Power Generation Plant	・Anaerobic digestion of Natabua sludge and sludge bailed from other WWTPs ・Digested sludge is dewatered → Drying → onsite storage ・Dewatered leachate treated by Natabua wastewater treatment system	Phase 2 or after	Included
Biogas Power Generation Plant	Refines biogas methane gas, which is utilized for power generation	・Receives biogas produced from Sludge Digestion Facility	Phase 2 or after	Not Included

*: Refer to **APPENDIX 3-1、3-2**
Source: JET



Source: JET

Figure 3-1.1 Natabua WWTP Treatment Flow Diagram (Phase 1)



Source: JET

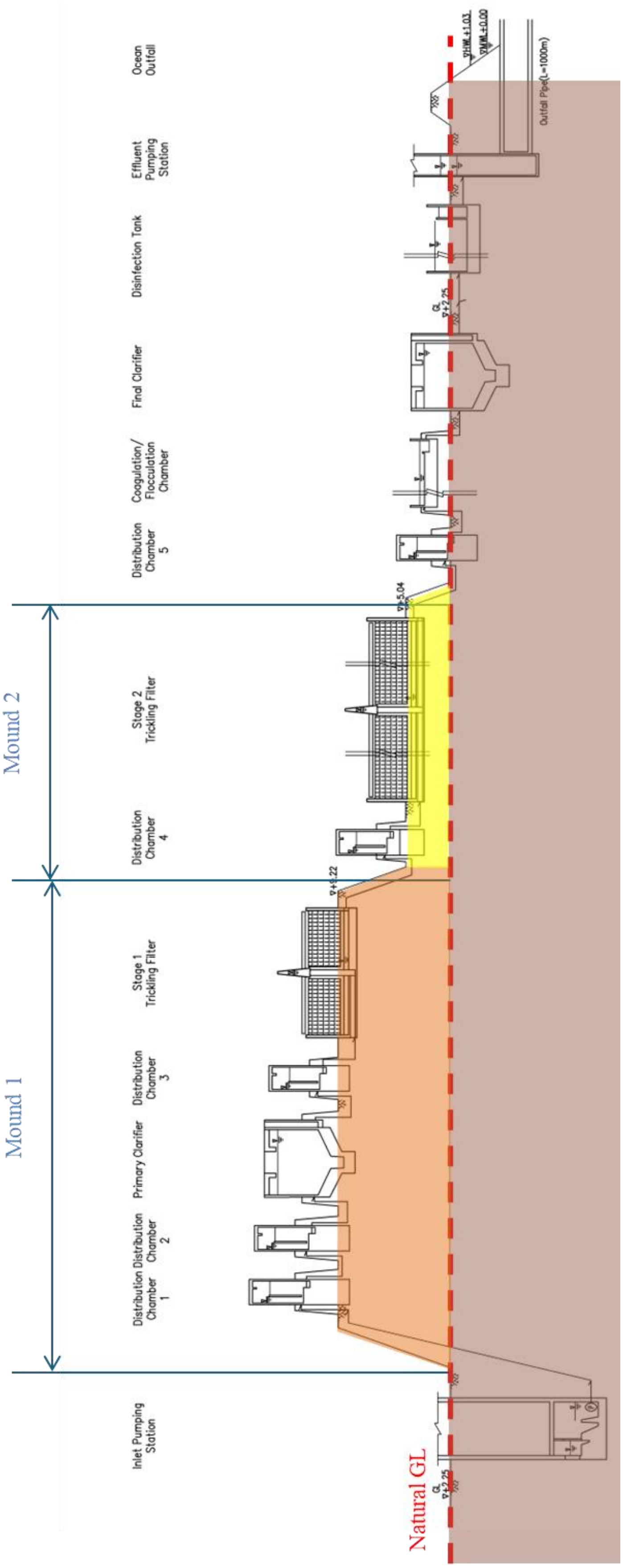
Figure 3-1.2 Natabua WWTP Treatment Flow Diagram (Phase 2)

Source : JET

Source: JET

Figure 3-1.3 Natabua WWTP Facility Layout

In the case of Natabua WWTP, WAF requested to place the TF towers on two artificial mounds so that sewerage will flow by gravitational flow from the inlet pump to the effluent pump (**Figure 3-1.4**).



Source: JET

Figure 3-1.4 Cross sectional image of Natabua WWTP

3-2 Current Land Use Situation around Natabua WWTP

Figure 3-2.1 shows the land use situation around Natabua WWTP as of March 2024.

The adjacent lots located along the northern to eastern side of Natabua WWTP are State Lands under active lease contracts, with some parts going through development (②~⑧). Existing facilities include houses, factories, warehouses, etc. scattered at some distance, and the rest of the land is undeveloped fields. The land southwest of Natabua WWTP is Foreshore Land (⑨), which has no official registration with the Department of Land. The land is mostly covered by mangroves, and a small informal settlement (⑩) is located along the coast, some distance away from the current plant boundaries.

Source: JET

Figure 3-2.1 Land Use Situation around Natabua WWTP (as of March 2024)

3-3 Treatment Process and Civil Facilities

(1) Treatment Process

1) Wastewater Treatment

In accordance with the Municipal Sewerage M/P, the Trickling Filter (TF) process was selected, taking the following into consideration:

- Effluent quality satisfies General effluent standards,
- Similar treatment process is already adopted in Kinoya WWTP, Suva
- Economically efficient and relatively easy to operate and maintain

2) Sludge Treatment

The Phase 1 treatment flow for each sewerage sludge type is listed as below:

- Raw sludge: Gravitational Thickening → Mechanical Dewatering → Sun-drying
- Excess sludge: Mechanical Dewatering → Sun-drying
- Septage: Mechanical Dewatering (separate system) → Sun-drying

Sludge treatment will switch to anaerobic digestion from Phase 2, when sewerage and sludge amounts increase. The Sludge Digestion Facilities and Biogas Power Generation Plant (planned to be operated/maintained outside of WAF's authority) will be planned when raw sludge can be collected from the three WWTPs other than Natabua (Vitogo, Sabeto Moala). (Refer to **APPENDIX 3-2** for details).

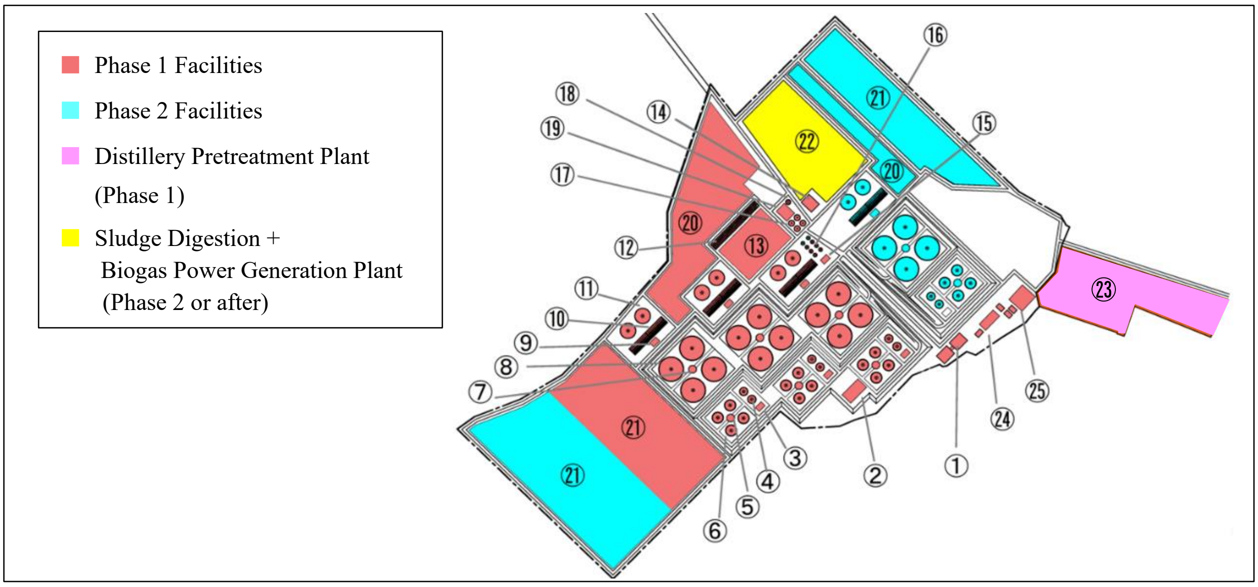
3) Sludge Storage

At the current state, there are no external landfills, etc. that accept sewerage sludge for their final disposal. In this Pre-F/S, sludge storage space is planned onsite in accordance with the Municipal Sewerage M/P.

(2) Layout Plans

Natabua WWTP's layout plan and facilities list are shown in **Figure 3-3.1** and **Table 3-3.1**. Since the current treatment system must continue its operation during the Phase 1 construction period, Phase 1 facilities (colored red in the Figure) are located outside the current WWTP, or placed in areas not interfering with current operating facilities. When Phase 1 facilities are completed and the current system ends its operation, construction of Phase 2 facilities (colored blue in the Figure) will commence within the current site.

The Distillery Pretreatment Plant is not included in this Pre-F/S's project scope, but will be planned to be constructed at the same time as Natabua WWTP Phase 1 facilities, under WAF requests. The Sludge Digestion Facility and Biogas Power Generation Plant are planned for construction in Phase 2 or after. It should also be noted that the site area for sludge drying beds and sludge storage can be reduced or removed in case sludge utilization schemes or sludge final disposal sites are found/formulated offsite.



Source: JET

Figure 3-3.1 Natabua WWTP Layout Plan

Table 3-3.1 Natabua WWTP Facilities

Ref. No.	Facility	Remarks
1	Inlet Pumping Station	Includes Sewerage and Stormwater pumps
2	Distribution Chamber①	Influent from: Inlet Pump Stationing, Distribution to: Distribution Chambers ②, Stormwater Sedimentation Pond
3	Distribution Chamber②	Influent from: Distribution Chamber①, Distribution to: Primary Clarifiers
4	Primary Clarifiers	8 basins, Diameter: 14m
5	Distribution Chamber③	Influent from: Primary Clarifiers, Distribution to: Stage 1 TF
6	Stage 1 Trickling Filters	16 towers, Diameter: 19m (BOD removal)
7	Distribution Chamber④	Influent from: Stage 1 TFs, Distribution to: Stage 2 TFs
8	Stage 2 Trickling Filters	16 towers, Diameter: 43m (BOD + N removal)
9	Distribution Chamber⑤	Influent from: Stage 2 TFs, Distribution to: Coag./Floc. Canals
10	Coagulation/Flocculation Canals	8 canals (P removal)
11	Final Clarifiers	8 basins, Diameter: 27m
12	Disinfection Tank	Minimum contact time: 15 min
13	Stormwater Sedimentation Pond	
14	Effluent Pumping Station	Pump to ocean outfall
15	Sludge Distribution Chamber	
16	Gravitational Sludge Thickeners	8 tanks, Diameter: 6 m
17	Sludge Receival Tank	Phase 1: Thickened raw sludge + excess sludge Phase 2: Thickened raw sludge from other WWTPs 4 tanks, Diameter: 10 m
18	Septage Receival Tank	Diameter: 6 m, Included in project scope
19	Sludge Dewatering Building	Includes dewatering machine for septage treatment
20	Sludge Drying Beds	3.76 ha (Includes space for septage)
21	Sludge Storage Space	11.48 ha (Includes space for septage)
22	Sludge Digestion + Biogas Power Generation Plant	Biogas Power Generation Plant not included in project scope
23	Distillery Pretreatment Plant	Not included in project scope
24	Administration Building	Includes emergency power generator
25	M/E Team Workshop	Currently stationed at Natabua WWTP

Source: JET

(3) Summary of Treatment Facilities

The scale and equipment specifications of major sewerage/sludge treatment facilities (Phase 1) are shown in **Table 3-3.2** and **Table 3-3.3**. Refer to **APPENDIX 3-9** for capacity calculations.

Table 3-3.2 Summary of Major Wastewater Treatment Facilities (Phase 1)

Facility	Load	Shape and Number of Basins
Sewerage Grit Chamber	Hydraulic Load 1,800 m^3/m^2・day	4 chambers Rectangular, 3 m × 4 m
Stormwater Grit Chamber	Hydraulic Load 1,800 m^3/m^2・day	4 chambers Rectangular, 3 m × 6 m
Primary Clarifier	Overflow Rate 35 m^3/m^2・day	6 basins Circular, φ 14 m
Stage 1 Trickling Filter	Hydraulic Load 9.5 m^3/m^2・day	12 towers Circular, φ 19 m
Stage 2 Trickling Filter	Hydraulic Load 2.5 m^3/m^2・day	12 towers Circular, φ 43 m
Coagulation/ Flocculation Channel	Velocity Rapid mixing 1.5 m/s Floc formulation 0.16m/s～0.30m/s	6 channels Rectangular Rapid mixing 0.3m × 193 m × 0.3 m Floc formulation 1.3m/2.0m/2.5m × 80 m × 0.3 m
Final Clarifier	Overflow rate 10 m^3/m^2・day	6 basins Circular φ 27 m
Disinfection Tank	Chlorine contact time 15 min	1 basin Rectangular, 2m × 470 m × 2 m
Stormwater Sedimentation Pond	HRT: 2.5 hrs	1 basin Open cut, 75m × 105 m × 3.0 m

Source: JET

Table 3-3.3 Summary of Major Sludge Treatment Facilities (Phase 1)

Facility	Load	Shape and Number of Basins
Gravitational Sludge Thickeners	SS load 75kg-DS/m^2・day	8 tanks Circular, ϕ 6m
Mechanical Dewatering Machines	Dewatering Capacity 400 kg-DS/hr・unit	2 units Multi-plate screw press dewaterer
Sludge Drying Beds	Drying period: 3 months	2.9 ha
Sludge Storage Space	Storage of 20 years-worth dried sludge	3.9 ha

Source: JET

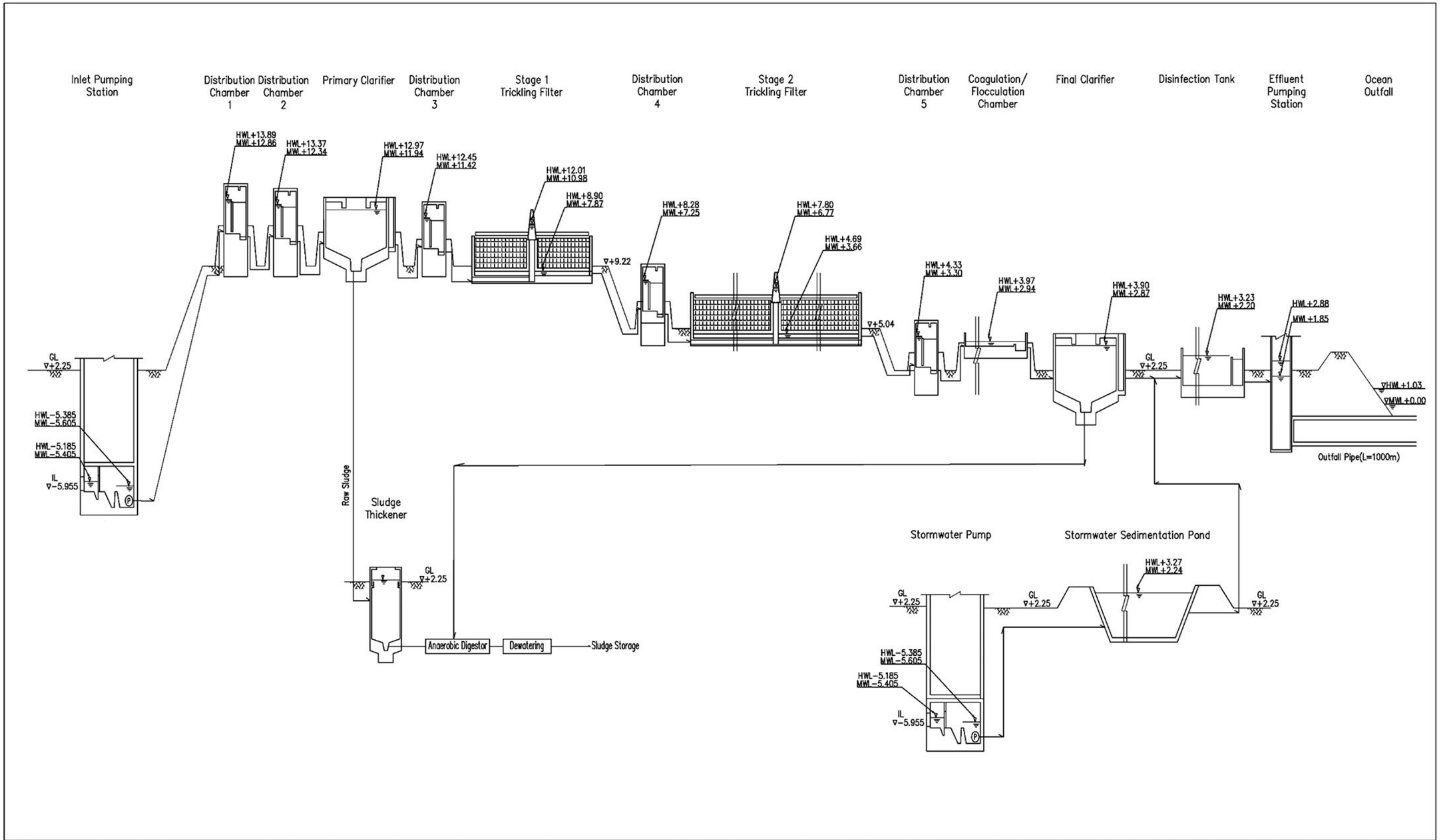
(4) Water Level Conditions

Based on the assumed inlet/outfall water levels, the water levels of each wastewater treatment facility were calculated. The water level conditions are shown in **Table 3-3.4.** The hydraulic profile is shown in **Figure 3-3.2.**

Table 3-3.4 Water Level Conditions

Component	Water Level*	Location
Inlet	-5.19 M	Inflow channel
Water in Ocean outfall	+1.03 M	1km from offshore

*HWL
Source: JET



Source : JET

Figure 3-3.2 Natabua WWTP Hydraulic Profile

(5) Soil Survey Results and Foundation Structures

1) Selecting the Supporting Soil Layer

Results of the soil boring test performed at Natabua WWTP (**APPENDIX 3-6**) was studied to find candidate supporting soil layers for the foundation structures. In general, sand/gravel soils with N≧30, or clay soils with N≧20 can provide enough support for civil structures.

For Natabua WWTP, the sandy silty layer (N=50+) at depth GL-21.5m～24.5 m fulfilled these conditions, and was chosen as the supporting soil layer for Natabua WWTP structures. It should be noted that the soil boring tests were performed within the current Natabua WWTP site, and in future design projects, additional tests located in the construction grounds are recommended to re-examine soil layers and foundation structure options.

2) Determining Foundation Type

Setting aside specialized structures (such as caisson foundations), foundation structures are largely categorized into two types: direct foundations and pile foundations. Direct foundations are applied when the supporting soil layer is found in relatively shallow depths, namely 0-5 m. For any deeper supporting soil layers, pile foundations are adopted.

For the structures of Natabua WWTP, the supporting soil layer is found at GL-21.5 m. Since the supporting layers is found at a depth deeper than 5m, and majority of the structures are to be constructed on top of elevated mounds, direct foundations are non-applicable. Since the minimum pile length (in other words, structures located on the natural GL) would be between 21~22.5m, exceeding the maximum applicable pile length for precast concrete piles, cast-in-place concrete piles were adopted for all structures.

3-4 Mechanical Equipment

Natabua WWTP's mechanical equipment options were examined and determined as follows. Refer to **APPENDIX 3-7** for details. Mechanical equipment drawings are shown in **APPENDIX 3-8**.

(1) Inlet Gate Equipment

The main inlet gate is placed at the at the inlet culverts where sewerage flows into the WWTP. The sewerage and stormwater grit chamber following the inlet culvert are each equipped with separate inlet gates, allowing individual inspection/equipment cleaning. "Cast-iron outside screw-type gate" was selected due to its durability and easy maintenance features.

Table 3-4.1 Inlet Gate Equipment

Equipment	Specifications
Main Inlet Gate (motorized)	Effective opening 1.5m x 1.5m, 1 gate
Sewerage Grit Chamber Inlet Gate (manual)	Effective opening 0.5m x 0.5m, 4 gates
Stormwater Grit Chamber Inlet Gate (manual)	Effective opening 0.6m x 0.6m, 4 gates

Source: JET

(2) Screen Equipment

The grit removal screen is installed to protect the following sewerage/stormwater pumps from damage caused by debris and sediment. Large debris will be removed by manually operated coarse screen (coarse screen, opening size: 50 mm); smaller debris/grit will be removed by the automated grit removal screen (fine screen, opening size: 25 mm).

1) Fine screen opening size

The opening size for the automated grit removal screen was selected based on the pump diameter size ("Grit Removal Equipment Design Guidelines," Watergate and Iron Pipe Association), and set at 25 mm.

2) Automated Grit Removal Screen

The "automatic belt-running grit screen + biaxal screw type" was selected for the automated grit removal screen, due to its high score in overall evaluation and economic efficiency.

Table 3-4.2 Screen Equipment

Number of Grit Chambers	Sewerage: 4 chambers Stormwater: 4 chambers
Screen Equipment	Sewerage: Coarse screen + Automated grit removal screen (4 units) Stormwater: Coarse screen + Automated grit removal screen (4 units)

Source: JET

(3) Grit Chamber Equipment

The sediment mixed in the influent must be removed to prevent wearing of the pump impellers. Sediment settles to the bottom of the sand pit, where it is collected and pumped up along with water. A sand separator separates the sand and removes it from the grit chamber, returning the water back for further treatment. The "sand pump + cyclone-type sand separator" was selected, due to its simple system, economic efficiency, and easy maintenance features.

Table 3-4.3 Grit Chamber Equipment

Number of Grit Chambers	Sewerage: 4 chambers Stormwater: 4 chambers
Screen Equipment	Sand pump: 8 units Cyclone-type sand separator + Grit container: 2 sets

Source: JET

(4) Influent Pump Equipment

Two pump wells with a connecting gate between the wells will be installed to facilitate pump maintenance (cleaning, replacement). The capacity and number of pumps was determined based on the design flow, with at least 2 pumps of equal capacity, along with 1 spare unit. The "submersible sewerage pump" was selected, due to its economic efficiency, easy procurement, and easy maintenance features. **Table 3-4.4** shows the pump units/capacity and **Table 3-4.5** shows the pump specifications.

Table 3-4.4 Number of Pump Units and Capacity

Target Flowrate	Flowrate (m^3/min)	Number of Units	Pump Capacity*2 (m^3/min・unit)	
Average Daily Flowrate	28.26	2 units	14.14	14.5
Maximum Daily Flowrate	31.11		15.56	29.0
Maximum Hourly Flowrate	56.32	2 units (1 standby unit) *1	28.16	29.0
Peak Wet Weather Flowrate	84.24	3units (1 standby unit) *1	42.12	42.5

*1: Standby pump units to be installed in pump well
*2: Red font: rated capacity
Source: JET

Table 3-4.5 Pump Specifications

Pump	Specifications
Phase 1Sewerage Pump	φ400mm × Discharge 14.5 m^3/min × Pump Head 20m × Motor Capacity 75kW × 2 units
Phase 2 Sewerage Pump	φ600mm × Discharge 29.0 m^3/min × Pump Head 20m × Motor Capacity 132kW × 2 units (1 standby unit)
Stormwater Pump	φ700mm × Discharge 42.5 m^3/min × Pump Head 9.5m × Motor Capacity 90kW × 3 units (1 standby unit)

Source: JET

(5) Distribution Chamber Equipment

Distribution chambers were installed to equally distribute sewerage to each treatment line. Each distribution chamber will be equipped with a manually operated movable weir. The "cast-iron outside screw-type movable weir" was selected due to its durability and easy maintenance features.

(6) Primary Clarifier Equipment

1) Sludge Scraper

There are two types of sludge scrapers: central-driven types and peripheral-driven types. Since the primary clarifier has a small diameter and the required rotational torque is low, the "central-drive suspended type," which rotates its arm by a central drive unit, was selected due to its low equipment cost.

Table 3-4.6 Primary Clarifier Sludge Scraper

Sludge Scraper	Specifications
Phase 1 Sludge Scraper	φ14m × Water Depth 2.5m × Motor Capacity 0.4kW × 6 units
Phase 1 Sludge Scraper	φ14m × Water Depth 2.5m × Motor Capacity 0.4kW × 2 units

Source: JET

2) Raw Sludge Pump Equipment

Two raw sludge pumps (1 as a spare unit) will be installed per two treatment lines. Since the pump will withdraw sludge from the primary clarifier's sludge pit, the "dry-installed suction screw pump" was selected, considering its O&M features.

Table 3-4.7 Raw Sludge Pump Specifications

Pump	Specifications
Phase 1 Raw Sludge Pump	φ100mm × Discharge 0.5 m^3/min × Pump Head 8m × Motor Capacity 1.5kW × 6 units (3 standby units)
Phase 2 Raw Sludge Pump	φ100mm × Discharge 0.5 m^3/min × Pump Head 8m × Motor Capacity 1.5kW × 2 units (1 standby unit)

Source: JET

(7) Trickling Filter Equipment

1) Water Distributer

Both Stage 1 and Stage 2 Trickling Filters will be equipped with a non-motorized water distributor, which gains rotational power from the head difference of water. As for the filter media, plastic honey-comb module media was selected, which is lightweight and easy to install, and also low in equipment cost.

2) Blower

A water/air temperature difference of at least 4°C is required for natural ventilation to work in trickling filters. In the case of Fiji, the maximum temperature difference is about 2°C due to its tropical climate, requiring forced air ventilation by blowers.

Three types of blowers were evaluated: steel plate multi-stage turbo blowers, rotary (root-type) blowers, and screw-type blowers. The equipment cost, O&M cost, installment space requirements, machine weight were compared, and the "screw-type blower" was selected. Three units (1 as a spare unit) will be installed per two treatment lines. Blower specifications are shown in the following table.

Table 3-4.8 Trickling Filter Blowers

Phase	Blower	Air Flow (m^3/min)	Discharge Pressure (kPa/m)	Motor Capacity (kW)	Number of Units (units)
Phase 1	Stage 1 TF Screw-type Blower	4.8 ~ 17	35	18.5	9 units (3 standby units)
	Stage 2 TF Screw-type Blower	5.5 ~ 22	35	26	9 units (3 standby units)
Phase 2	Stage 1 TF Screw-type Blower	4.8 ~ 17	35	18.5	3 units (1 standby unit)
	Stage 2 TF Screw-type Blower	5.5 ~ 22	35	26	3 units (1 standby unit)

Source: JET

(8) Final Clarifier Equipment

1) Sludge Scraper

There are two types of sludge scrapers: central-driven types and peripheral-driven types. Since the final clarifier has a large diameter, a type that can generate large torque with less driving force/power is preferred. For the final clarifier the "peripheral drive column-supported type," where a cart running on the clarifier's peripheral wall pulls the collector's arm to make it rotate, was selected.

Table 3-4.9 Final Clarifier Sludge Scraper

Sludge Scraper	Specifications
Phase 1 Sludge Scraper	Φ27m × Water Depth 3m × Motor Capacity 0.75kW × 6 units
Phase 2 Sludge Scraper	Φ27m × Water Depth 3m × Motor Capacity 0.75kW × 2 units

Source: JET

2) Excess Sludge Pump Equipment

Two excess sludge pumps (1 as a spare unit) will be installed per two treatment lines. Since the pump will withdraw sludge from the final clarifier's sludge pit, the "dry-installed suction screw pump" was selected, considering its O&M features.

Table 3-4.10 Excess Sludge Pump Specifications

Pump	Specifications
Phase 1 Excess Sludge Pump	φ150mm × Discharge 1.25 m^3/min × Pump Head 10m × Motor Capacity 3.7kW × 6 units (3 standby units)
Phase 2 Excess Sludge Pump	φ150mm × Discharge 1.25 m^3/min × Pump Head 10m × Motor Capacity 3.7kW × 2 units (1 standby unit)

Source: JET

(9) Disinfection Tank Equipment

1) Sodium Hypochlorite Storage Tank

The decomposition of sodium hypochlorite is accelerated when exposed to sunlight/high temperatures and must be properly stored in a tank. The tank's storage capacity was set as one-weeks' worth of sodium hypochlorite to be used for the Peak Wet Weather Flowrate, at an injection dosage of 3 mg/L.

2) Sodium Hypochlorite Injection Pump

The "diaphragm metering pump," which uses a rotation speed control device to control the injection volume based on a fixed ratio against the disinfection tank flowrate, was selected for the sodium hypochlorite injection pump, due to its low equipment cost and proven track record.

Table 3-4.11 Sodium Hypochlorite Injection Pump Specifications

Pump	Discharge Diameter	Injection Volume Control Range	Max Injection Pressure	Motor Capacity	Units
Sodium Hypochlorite Injection Pump	25 mm	0.704～1.757 L/min	0.7 MPa	0.4 kW	3 units (1 standby unit)

Source: JET

(10) Effluent Pump Equipment

Natabua WWTP's effluent is discharged into an ocean outfall 1000 m offshore. When the tidal level rises above MWL 0.00 M, gravitational flow cannot discharge the treated water, thus needing an effluent pump. The "submersible sewerage pump" was selected due to its low equipment cost and easy maintenance features. **Table 3-4.12** shows the pump units/capacity, and **Table 3-4.13** shows the pump specifications.

Table 3-4.12 Number of Pump Units and Capacity

Pump	Flowrate (m^3/min)	Number of Units	Pump Capacity (m^3/min・unit)	
Effluent Pump	84.24	3 units (1 standby unit)	70.28	71.0

*1: Standby pump units to be installed in pump well
*2:Red font: Rated capacity
Source: JET

Table 3-4.13 Pump Specifications

Pump	Specifications
Effluent Pump	Φ800mm × Discharge 71 m^3/min × Pump Head 5m × Motor Capacity 90kW × 3 units (1 standby unit)

Source: JET

(11) Stormwater Sedimentation Pond

The stormwater sedimentation pond will retain four times the maximum daily flowrate for 2.5 hours to let solids and particles sedimentate. The water will then go through the disinfection tank before being discharged to the ocean.

(12) Reclaimed Water Utilization Equipment

Part of the treated water will be reclaimed and used for equipment washing, dilution of sodium hypochlorite, etc. The "pressurized sand filtration system," which is a packaged system (including the control panel) was selected due to its low equipment cost and easy maintenance features.

(13) Sludge Dewatering Equipment

1) Sludge Storage Tank Mixer

The sludge storage tank will have a capacity to store 2 days-worth of sludge and install 1 tank per two treatment lines (total of 4 tanks). The "submerge mixer" was selected due to its low equipment cost and easy maintenance features. Each tank will be equipped by 3 mixers, placed 4 m apart from each other.

2) Sludge Dewaterer

The sludge feed pump sends sludge to the dewatering machine, which reduces the water content and volume of sludge. The "multi-plate screw press dewaterer" was selected, due to its high dewatering efficiency and low equipment/O&M cost. The dewatering capacity and number of units was based on a daily nine-hour operation time.

Table 3-4.14 Dewatering Machine Specifications

Sludge Solids Content (t/day)	17.81
Input Sludge (kg/day)	1,979
Dewatering Method	Multi-plate screw press dewaterer
Dewatering Capacity	400 kg-DS/h×8.3 kW×5 units
Operation (hr/day)	7 days a week, 9-hour operation per day
Dewatered Sludge (m^3/day)	68

Source: JET

(14) Odor Control Facilities

Odor control facilities will be installed to prevent foul odors (emitted from sewerage/sludge) adversely affecting the surrounding area. The "activated carbon adsorption process" and "packed-column tower bio-deodorization process" were selected, due to their relatively easy maintenance features, high deodorization efficiency, and procurement features. Other candidate odor control processes were not adopted for the following reasons:

- Gas combustion: Both construction and maintenance costs are high; requires relatively high technical skills for facility O&M
- Chemical scrubbing: Chemical scrubbing agents lead to high maintenance costs; requires additional facilities to treat liquid chemical waste produced from deodorization
- Soil bed filters: Construction and maintenance costs are relatively low; however, vast amounts of new media must be imported for replacement, (approximately every five years) unlikely being feasible in terms of procurement

For these reasons, the activated carbon adsorption process was adopted for Natabua WWTP's wastewater treatment system; for the sludge treatment system, which emits stronger odors, the combination of packed-column tower bio-deodorization will be adopted.

Table 3-4.15 Odor Control Facilities

Treatment System	Sewerage Treatment System	Sludge Treatment System
Target Facilities	・Influent Pump Station (Influent chamber, grit removal chamber, pump well)	・Sludge Receival Tank ・Sludge Dewatering Building
Odor Control Process	Activated carbon adsorption	Packed-column tower bio-deodorization ＋Activated carbon adsorption

Source: JET

3-5 Electrical Equipment

Natabua WWTP's electrical equipment options were examined and determined as follows. Refer to **APPENDIX 3-8** for equipment drawings.

(1) Power Receiving Equipment

1) Power Receiving System and Distribution Voltage

Upon selecting the power receiving equipment, meetings with the Energy Fiji Ltd. (hereinafter referred as "EFL") were held to confirm equipment specifications. Fiji's transmission voltages is 3-phase 3-wire 11kV, with a frequency of 50Hz. Under full installment cost coverage by WAF, EFL will install a transformer within the WWTP site, which will step down the voltage from 11kV to 415V.

On the WAF equipment side, this transformer secondary voltage of 3-phase 4-wire 415V is received by the WWTP main distribution panel, which supplies power to each facility equipment' motor control center's power load.

Table 3-5.1 Receiving and Distribution Voltages

Voltage	Specifications
Received Voltage and Power Load Voltage	3 phase 4 line 50Hz, 415V
Building Power and Lighting Load Voltage	Power distribution voltage: 3 phase 4-line 50 Hz, 415V Lighting distribution voltage: single phase 2-line 50 Hz, 240V

Source: JET

2) Load Capacity

The loads for each facility are listed in **Table 3-5.2**.

Table 3-5.2 Equipment Load List

Facility Equipment	Phase 1 Load (kW)	Phase 2 Load (kW)
Grit Chamber	25.2	
Influent Pump	414	
Stormwater Pump	180	
Primary Clarifier	8.1	2.7
Stage 1 Trickling Filter	166.5	55.5
Stage 2 Trickling Filter	234	78
Final Clarifier	38.2	11.5
Disinfection Tank	18.75	
Effluent Pump	183.7	
Sludge Thickener	8.1	2.7
Sludge Dewatering	138.95	73.55
Building Equipment Power	329.00	
Building Lighting Power	165.00	
subtotal (kW)	1,909.5	223.95
	Total (kW)	2,133.45

Source: JET

3) Transformer Capacity and Contract power

In Fiji, the contract power (maximum power demand) of Natabua WWTP is calculated by the construction contractor based on the AS/NZS 3000:2018 ELECTRICAL INSUTALLATIONS STANDARD. Before construction commences, calculation results are submitted along with an application form to EFL for their approval, namely, to confirm the transmission line capacity and construction schedule.

It was confirmed with EFL that for the Natabua WWTP transformer capacity requirement of 2,000 KVA, the EFL side's transformer will be 1,000 KVA x 2 units. It should be taken note that these contents be re-confirmed with EFL in future design stages and before construction.

The transformer capacity and contract power of the Pre-F/S stage are listed as follows:

Table 3-5.3 Transformer Capacity and Contract Power

Phase	Total Load (kW)	Contract Power (kW)	Daily Electricity Demand (kWh/d)	Annual Electricity Demand (kWh/yr)
Phase 1	1907.5	810	13,608	4,966,920
Phase 2	223.9	905	15,204	5,549,460

Source: JET

(2) Emergency Generator Equipment

1) Past Power Outage Records

Past power outage records of Lautoka between 2018-2023 were studied to determine the necessity of emergency power generators. Results are shown in **Table 3-5.4**. Records indicate that an average of 33 power outages occur annually (majority being unplanned), and commercial-level emergency generators are needed as backup.

Table 3-5.4 Past Records of Power Outages

Contents	Unplanned	Planned
Number of cases (2018-2023)	192	1
Maximum outage time (hr)	12	8
Average outage time (hr)	3	—
Minimum outage time (hr)	0.02	—
Annual average of cases	32	1
Monthly average of cases	2.7	
Number of outage cases lasting over 12 hours	—	—
Average length of over-12-hour outages	—	—

Source: JET

2) Emergency Generator Targets

Natabua WWTP will install emergency generators to cope with frequently-occurring power outages of the Lautoka area. Major target loads of the emergency generator are listed below.

Table 3-5.5 Emergency Generator Target Loads

Target Equipment	Target Units
Inlet Gate	1 unit
Sewerage Pump	All units (excluding spares)
Stormwater Pump	All units (excluding spares)
Blowers	1 unit per two treatment lines
Sodium Hypochlorite Injection Pump	All units
Effluent Pump	All units (excluding spares)
Water equipment for daily use	All units
Emergency generator auxiliaries	All units
Building power/lighting needed for O&M	Required minimum

Source: JET

3) Emergency Generator Engine Type

The "diesel engine generator (radiator mounted package, air-cooled)" was selected, due to its low equipment cost and maintainability features. One unit will be installed at Natabua WWTP.

(3) Instrumentation Equipment

The instrumentation equipment necessary for the proper operation/monitoring/control of grit chamber/pump, wastewater treatment, and sludge dewatering facilities are listed in **Table 3-5.6**.

Table 3-5.6 Instrumentation Equipment

Facility	Instrumentation Equipment	Type	Reason of Installment
Grit Chamber/ Pump Facilities	Pump well water level gauge	Submersible water level gauge	To control/adjust number of operating pump units
	Influent sewerage flowmeter	Electromagnetic type	To record actual influent flowrate
Wastewater Treatment Facilities	TF tower airflow meter	Orifice type	To control/adjust blower operation
	Excess sludge flowmeter	Electromagnetic type	To control/adjust excess sludge withdrawal
	Sodium hypochlorite storage tank level gauge	Pressure type	To record consumption/ remaining stock of sodium hypochlorite
	Sodium hypochlorite injection flowmeter	Electromagnetic type	To inject proper amount of sodium hypochlorite proportional to actual effluent flowrate
	Effluent flowmeter	Weir system	To control sodium hypochlorite injection quantity
	Effluent pump well water level gauge	Submersible water level gauge	To control/adjust number of operating pump units
Sludge Dewatering Facilities	Thickening tank sludge withdrawal flowmeter	Electromagnetic type	To control/adjust thickening tank sludge withdrawal pump operation
	Chemical tank level gauge	Pressure type	To record consumption/ remaining stock of chemicals
	Sludge storage tank level gauge	Pressure type	To control/adjust excess sludge withdrawal
	Chemical injection flowmeter	Electromagnetic type	To inject proper amount of chemicals in proportion to actual sludge feed
	Sludge feed flowrate	Electromagnetic type	To control chemical injection quantity
	Sludge feed concentration meter	Microwave type	To control sludge solids feed to dewaterer
	Sludge cake hopper load	Load cell type	To record amount of produced sludge cake

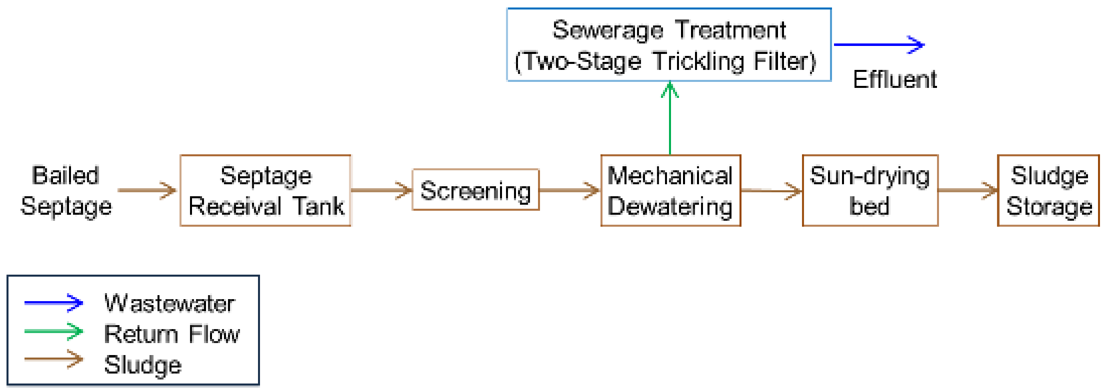
Source: JET

(4) Monitoring and Control Equipment

Monitoring and control equipment allows for the centralized management of all WWTP information, essential for operators to monitor and operate the plant's equipment based on real-time information. It also records the plant's O&M data that can be utilized for future projects such as stock management. For the Pre-F/S, the "SCADA monitoring and control system," a highly versatile system using computer networking technology, was selected.

3-6 Septage Treatment Facility

The treatment flow of the septage treatment facility is shown in **Figure 3-6.1**. The septage produced by household and commercial facilities in the Ba and Ra provinces is periodically collected by private sector bailing companies and bailed to Natabua WWTP. The maximum daily average of collected septage in the future (2017-2036) was forecasted to be 65 m^3/day. As household connections to the WAF sewerage system increases, this value is expected to decrease. The construction period of the septage treatment plant will be set as Natabua Phase 1 construction or earlier.



Source: JET

Figure 3-6.1 Septage Treatment Facility Treatment Flow Diagram

Table 3-6.1 Equipment and Specifications of the Septage Treatment Facility

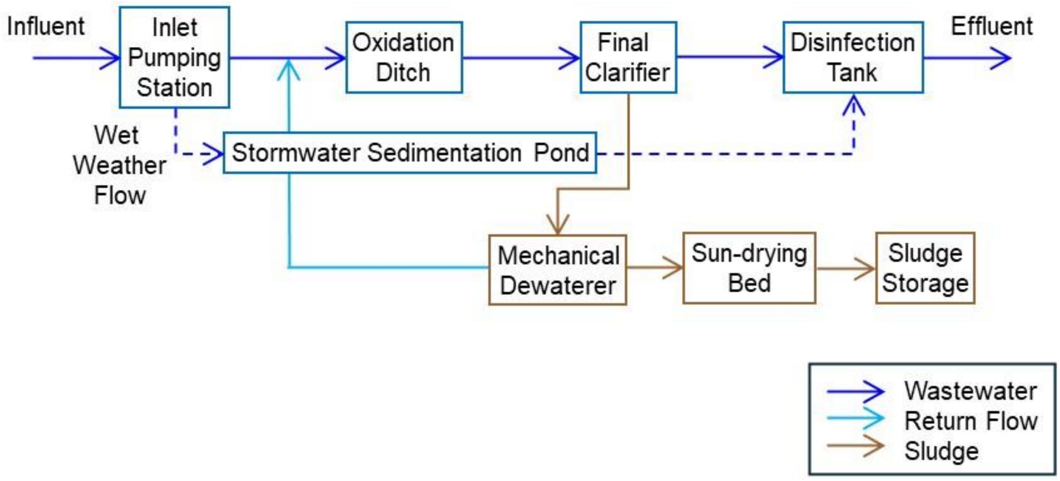
Equipment	Specifications	
Septage Receival Tank	**Tank Diameter (m)**	6
	Tank Capacity	113 m^3 × 1 tank
Screen Equipment	**Type**	Drum screen (equipped with washing unit and control panel)
	Treatment Capacity	32 m^3/hr ×0.kW×1 unit
	Screen Opening Width (mm)	1.0
Septage Dewatering Equipment	**Sludge Solids Content (t/day)**	1.56
	Input Sludge (m^3/day)	65
	Input Sludge (kg/day)	173.3
	Dewatering Method	Multi-plate screw press dewaterer
	Dewatering Capacity	400 kg-DS/h×8.3kW×5 units
	Operation (hr/day)	7 days a week, 9-hour operation per day
	Dewatered Sludge (m^3/day)	6

Source: JET

CHAPTER 4 NAVAKAI WASTEWATER TREATMENT PLANT

4-1 Facility Overview

Navakai WWTP will switch its treatment process from the current "IDEA process" to the "OD process" (**Figure 4-1.1**), increasing its capacity to a daily maximum of 19,700 m^3/day in Phase 1, then up to a daily maximum of 29,900 m^3/day in Phase 2. Responding to WAF requests, the facilities were designed with capacity margins to enable proper treatment even when one treatment line is shut down for equipment maintenance, etc. (Phase 1: 3-line operation, Phase 2: 5-line operation) **(Table 4-1.1**).



Source: JET

Figure 4-1.1 Navakai WWTP Treatment Flow Diagram

Table 4-1.1 Navakai WWTP Facility Overview

Parameters		Phase 1	Phase1 +Phase 2
Treatment Target		Raw Sewerage	
Treatment Process		Oxidation Ditch Method	
Max Daily Flowrate		19,700 m^3/day	29,900 m^3/day
Number of Treatment Lines		4 lines	6 lines (total)
Intended Treatment Capacity per line		4,900 m^3/day per line	4,900 m^3/day per line
Max Treatable Capacity per line*1		6,800 m^3/day per line	6,800 m^3/day per line
Footprint	**Total**	12.16 ha	20.86 ha
	Wastewater Treatment*2	7.08 ha	7.08 ha
	Sludge Drying Bed	1.99 ha	3.02 ha
	Sludge Storage Space	3.10 ha	10.77 ha

*1 Max. capacity is based off minimum HRT requirements and maximum loads of basins. To ensure treated water quality, capacity margins must be included in the design

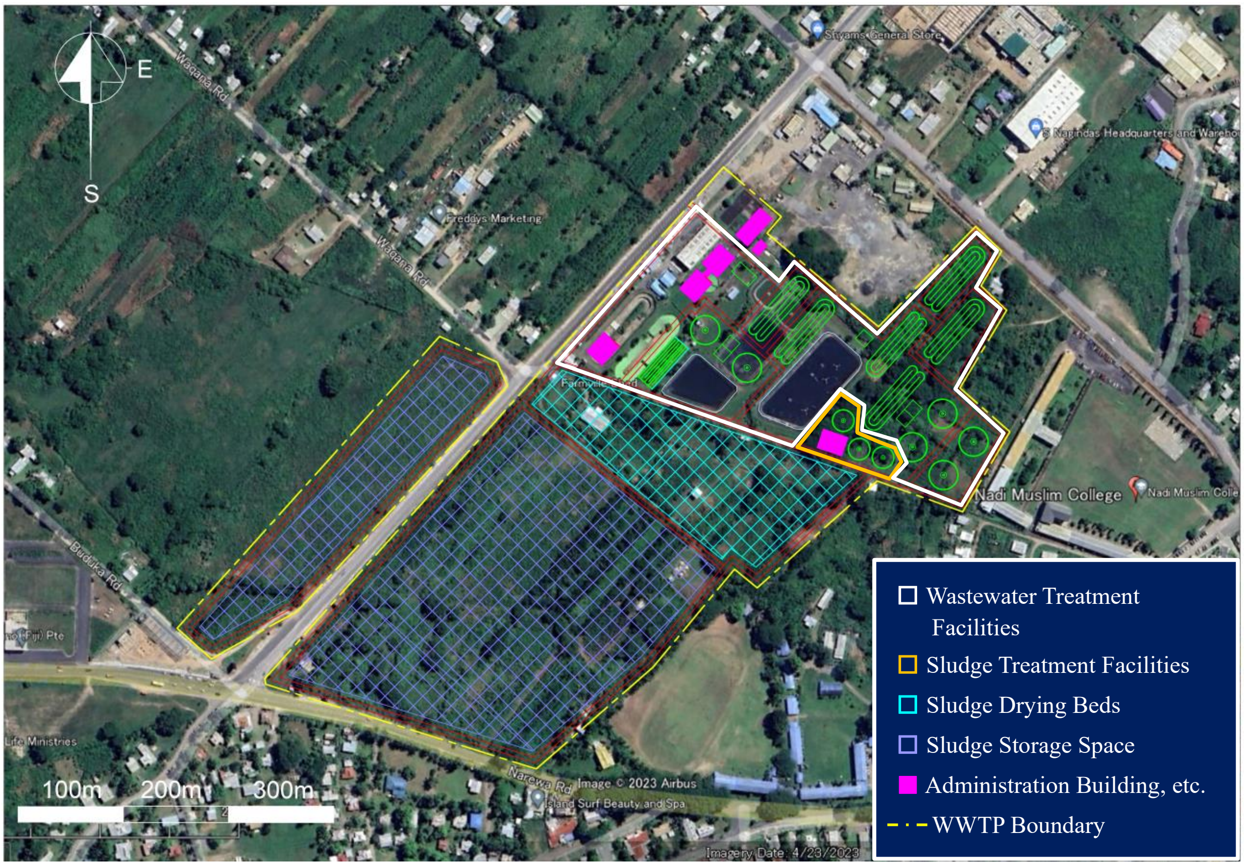
*2 Including current Navakai WWTP boundary

Source: JET

Table 4-1.2 Navakai WWTP Influent Water Quality and Target Effluent Quality

Parameters	Influent Water Quality	Target Effluent Quality (SEZ Standards*)
BOD (mg/L)	340	20
SS (mg/L)	500	30
T-N (mg/L)	37	10
T-P (mg/L)	6	2

*: SEZ = Significant Ecological Zone
Source: JET

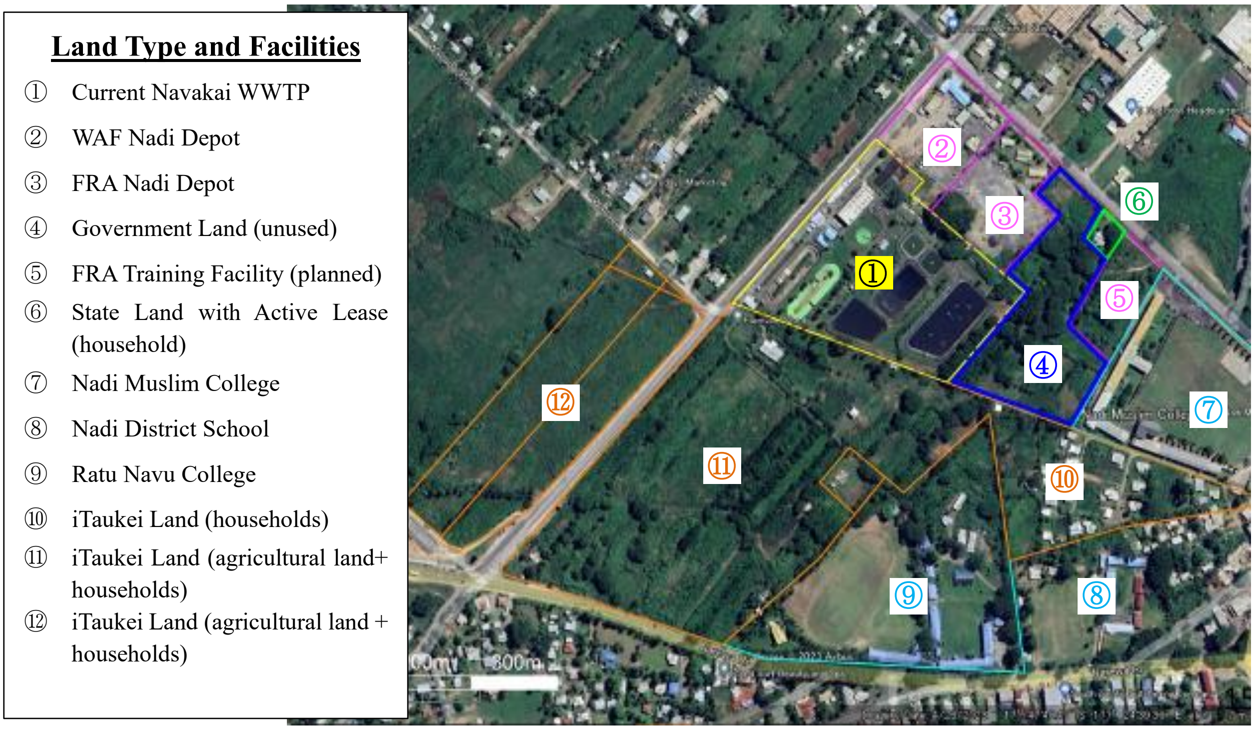


Source: JET

Figure 4-1.2 Navakai WWTP Facility Layout

4-2 Current Land Use Situation around Natabua WWTP

Figure 4-2.1 shows the land use situation around Natabua WWTP as of March 2024.



Source: JET

Figure 4-2.1 Land Use Situation around Navakai WWTP (as of March 2024)

Navakai WWTP lies adjacent to the following existing government facilities (②③ in the figure), Government Land(④), and iTaukei Land currently used as farmland and households (⑪).

- WAF Water division Nadi Depot (office and storehouse)
- Fiji Road Authority (FRA) Nadi Depot (office, storehouse, workspace, employee housing)

Of these, Government Land is undeveloped land reserved for government organizations such as WAF, and assumed to be most easily acquirable for Navakai WWTP's expansion. On the other hand, development by other government organizations is underway, such as the National Fire Authority of Fiji that acquired part of this land (⑤) for the construction of a new training facility; securing the remaining undeveloped land is and urgent issue. The iTaukei Land lying southwest is mostly farmland, but it should be noted that consent must be obtained from 60% of the tribe owning the land in order to acquire it, possibly requiring lengthy negotiations.

After is expansion, Navakai WWTP will be in close proximity to school grounds (⑦⑧⑨) and residential areas (⑥⑩), so mitigation measures such as the installment of deodorization facilities and the inner-placement of odor-source facilities (namely sludge treatment-related) were taken.

In addition, WAF suggested the possibility of relocating the existing WAF Water Division and FRA depots (②③) to the iTaukei Land on the other side of the road (⑫), using the current lots as part of the new Navakai WWTP. As reference, an alternative layout plan under the above conditions is shown in **APPENDIX 4-3**.

4-3 Treatment Process and Civil Facilities

(1) Treatment Process

1) Wastewater Treatment

In accordance with the Municipal Sewerage M/P, the Oxidation Ditch (OD) process was selected, taking the following into consideration:

- Effluent quality satisfies Significant Ecological Zone effluent standards
- Economically efficient and relatively easy to operate and maintain compared to other treatment processes satisfying SEZ effluent standards

2) Sludge Treatment

The Phase 1 treatment flow for each sewerage sludge type is listed as below:

- Excess sludge: Mechanical Dewatering → Sun-drying

3) Sludge Storage

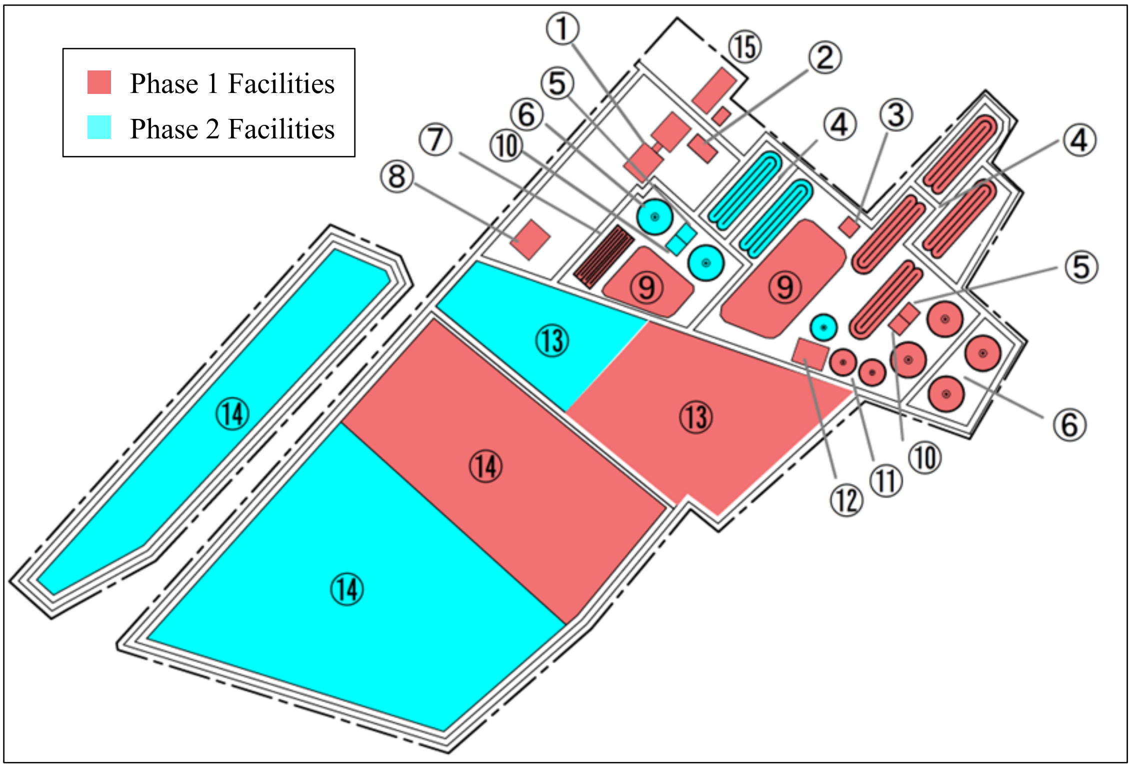
At the current state, there are no external landfills, etc. that accept sewerage sludge for their final disposal. In this Pre-F/S, sludge storage space is planned onsite in accordance with the Municipal Sewerage M/P.

(2) Layout Plans

Navakai WWTP's layout plan and facilities list are shown in **Figure 4-3.1** and **Table 4-3.1**. Since the current IDEA treatment system must continue its operation during the Phase 1 construction period, Phase 1 facilities (colored red in the Figure) are located outside the current WWTP, or placed in areas not interfering with current operating facilities. When Phase 1 facilities are completed and the current system ends its operation, construction of Phase 2 facilities (colored blue in the Figure) will commence within the current site.

The current IDEA Pond and Maturation Pond (⑨ in the figure) will be utilized as the stormwater sedimentation pond; since Navakai WWTP experiences overflow and onsite flooding every year during the rainy season, both stormwater sedimentation ponds will be operated starting Phase 1.

It should also be noted that the site area for sludge drying beds and sludge storage can be reduced or removed in case sludge utilization schemes or sludge final disposal sites are found/formulated outside the WWTP.



Source: JET

Figure 4-3.1 Navakai WWTP Layout Plan

Table 4-3.1 Navakai WWTP Facilities

Ref. No.	Facility	Remarks
1	Inlet Pump Station	Includes Sewerage and Stormwater pumps
2	Distribution Chamber①	Influent from: Inlet Pump Station Distribution to: Distribution Chamber②, Phase 2 OD tanks, Stormwater Sedimentation Ponds
3	Distribution Chamber②	Influent from: Distribution Chamber① Distribution to Phase 1 OD tanks
4	Oxidation Ditch Basin	HRT: 21.4 hr
5	Distribution Chamber③	Influent from: OD tanks Distribution to: Final Clarifiers
6	Final Clarifiers	Diameter: 27 m
7	Disinfection Tank	Minimum contact time: 15 min.
8	Effluent Pump Station	Pump to Nadi River
9	Stormwater Sedimentation Pond	Utilize existing IDEA pond
10	Return Sludge Pump Station	
11	Sludge Receiving Tank	Diameter: 20 m
12	Sludge Dewatering Building	
13	Sludge Drying Beds	3.02 ha
14	Sludge Storage Space	10.77 ha
15	Administration Building	Includes emergency power generator and electricity room

Source: JET

(3) Summary of Treatment Facilities

The scale and equipment specifications of major sewerage/sludge treatment facilities (Phase 1) are shown in **Table 4-3.2** and **Table 4-3.3**. Refer to **APPENDIX 4-8** for capacity calculations.

Table 4-3.2 Summary of Major Wastewater Treatment Facilities (Phase 1)

Facility	Load	Shape and Number of Basins
Sewerage Grit Chamber	Hydraulic Load 1,800 m^3/m^2・day	3 chambers Rectangular, 3 m × 3.5 m
Stormwater Grit Chamber	Hydraulic Load 1,800 m^3/m^2・day	3 chambers Rectangular, 3 m × 5 m
Oxidation Ditch Basin	HRT 21.4 hrs	4 basins Horseshoe Shape, 4.5m × 282.5 m × 3.5m
Final Clarifier	Overflow Rate 9 m^3/m^2・day	4 basins Circular, φ 27 m
Disinfection Tank	Minimum Chlorine contact time: 15 min	1 basin Rectangular, 2m × 360 m × 2 m
Stormwater Sedimentation Pond	HRT: 2.5 hrs	2 basins* Open cut, 43m × 91 m × 3.0 m Open cut, 35m × 54 m × 3.0 m

*Utilize existing IDEA Pond and Maturation Pond
Source: JET

Table 4-3.3 Summary of Major Sludge Treatment Facilities (Phase 1)

Facility	Load	Shape and Number of Basins
Mechanical Dewatering Machines	Dewatering Capacity 400 kg-DS/hr・unit	2 units Multi-plate screw press dewaterer
Sludge Drying Beds	Drying period: 3 months	1.8 ha
Sludge Storage Space	Storage of 20 years-worth dried sludge	2.7 ha

Source: JET

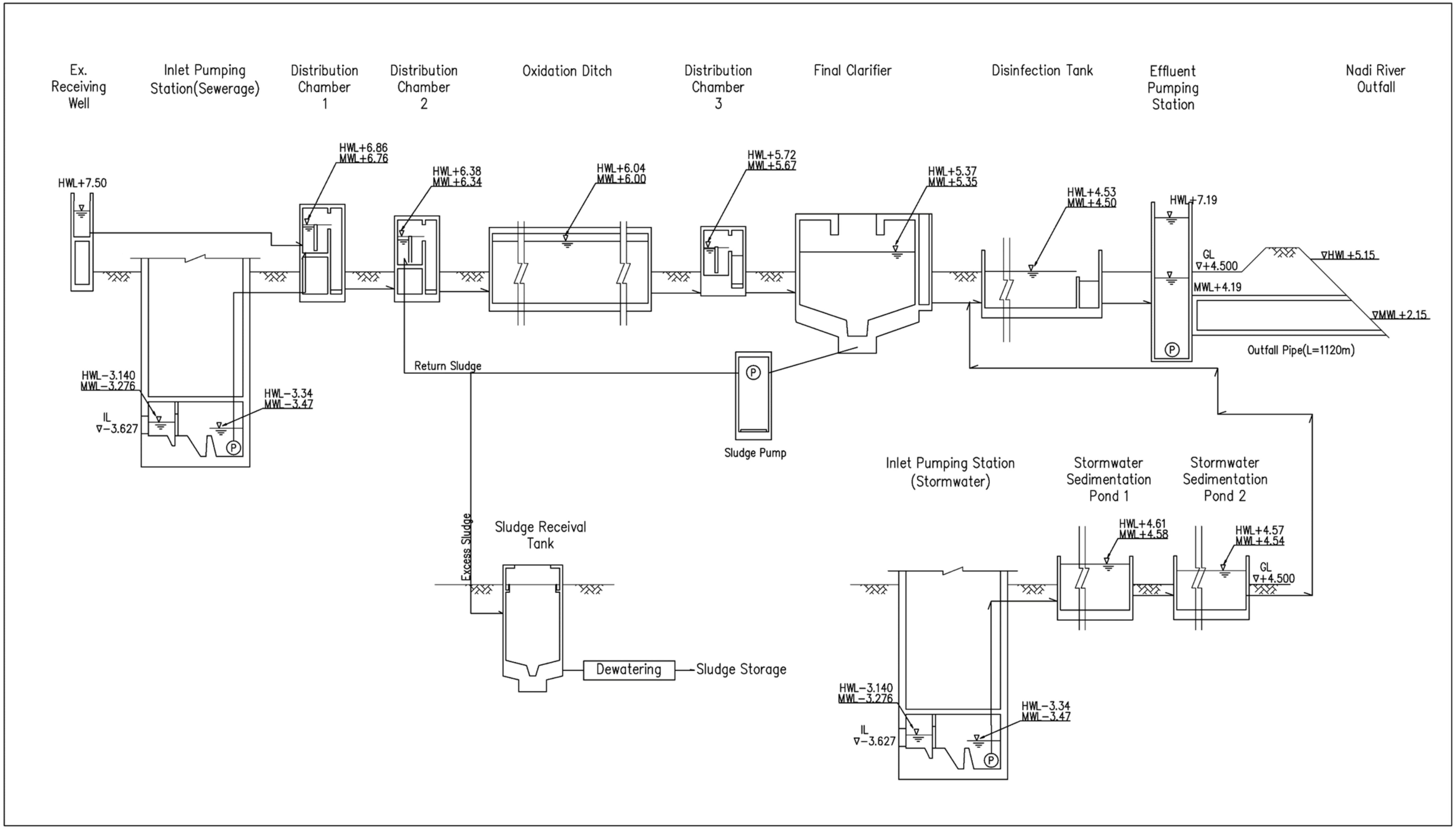
(4) Water Level Conditions

Based on the assumed inlet/outfall water levels, the water levels of each sewerage treatment facility were calculated. The water level conditions are shown in **Table 4-3.4.** The hydraulic profile is shown in **Figure 4-3.2**.

Table 4-3.4 Water Level Conditions

Component	Water Level*	Location
Inlet	-3.14 M	Inflow channel
Water in river outfall	+5.15 M	Nadi River

*HWL
Source: JET



Source : JET

Figure 4-3.2 Navakai WWTP Hydraulic Profile

(5) Soil Survey Results and Foundation Structures

1) Selecting the Supporting Soil layer

Results of the soil boring test performed at Navakai WWTP (**APPENDIX 4-5**) was studied to find candidate supporting soil layers for the foundation structures. In general, sand/gravel soils with N≧30, or clay soils with N≧20 can provide enough support for civil structures.

For Navakai WWTP, the sandy conglomerate layer (N=50+) at depth GL-14.0～GL-17.0m met these conditions and was chosen as the supporting soil layer in the Pre-F/S.

2) Determining Foundation Type

For the structures of Navakai WWTP, the supporting soil layer is found at GL-14.0 m, thus pile foundations were applied. Since pile lengths would be between 13. 5~15.m, both pre-cast piles and cast-in-place piles become an option for the foundation. The pile foundations' bearing capacity was compared against each structures' load requirement, and for structures which both pile options were supportable, a cost comparison was performed to choose the economically advantageous pile-type for each structure.

4-4 Mechanical Equipment

Navakai WWTP's mechanical equipment options were examined and determined as follows. Refer to **APPENDIX 4-6** for details. Mechanical equipment drawings are shown in **APPENDIX 4-7**.

(1) Inlet Gate Equipment

The main inlet gate is placed at the at the inlet culverts where sewerage flows into the WWTP. The sewerage and stormwater grit chamber following the inlet culvert are each equipped with separate inlet gates, allowing individual inspection/equipment cleaning. "Cast-iron outside screw-type gate" was selected due to its durability and easy maintenance features.

Table 4-4.1 Inlet Gate Equipment

Equipment	Specifications
Main Inlet Gate (motorized)	Effective opening 1.2m×1.2m, 1 gate
Sewerage Grit Chamber Inlet Gate (manual)	Effective opening 0.45m×0.45m, 3 gates
Stormwater Grit Chamber Inlet Gate (manual)	Effective opening 1.0m×1.0m, 3 gates

Source: JET

(2) Screen Equipment

The grit removal screen is installed to protect the following sewerage/stormwater pumps from damage caused by debris/sediment. Large debris will be removed by manually operated coarse screen (coarse screen, opening size: 50 mm); smaller debris/grit will be removed by the automated grit removal screen (fine screen, opening size: 25 mm).

1) Fine screen opening size

The opening size for the automated grit removal screen was selected based on the pump diameter size ("Grit Removal Equipment Design Guidelines," Watergate and Iron Pipe Association), and set at 25 mm.

2) Automated Grit Removal Screen

The "automatic belt-running grit screen + biaxal screw type" was selected for the automated grit removal screen, due to its high score in overall evaluation and economic efficiency.

Table 4-4.2 Screen Equipment

Number of Grit Chambers	Sewerage: 3 chambers Stormwater: 3 chambers
Screen Equipment	Sewerage: Coarse screen + Automated grit removal screen (3 units) Stormwater: Coarse screen + Automated grit removal screen (3 units)

Source: JET

(3) Grit Chamber Equipment

The sediment mixed in the influent must be removed to prevent wearing of the pump impellers. Sediment settles to the bottom of the sand pit, where it is collected and pumped up along with water. A sand separator separates the sand and removes it from the grit chamber, and returns the water back for further treatment. The "sand pump + cyclone-type sand separator" was selected, due to its simple system, economic efficiency, and easy maintenance features

Table 4-4.3 Grit Chamber Equipment

Number of Grit Chambers	Sewerage: 3 chambers Stormwater: 3 chambers
Screen Equipment	Sand pump: 6 units Cyclone-type sand separator+ Grit container: 2 units

Source: JET

(4) Influent Pump Equipment

Two pump wells with a connecting gate between the wells will be installed to facilitate pump maintenance (cleaning, replacement). The capacity and number of pumps was determined based on the design flow, with at least 2 pumps of equal capacity, along with 1 spare unit. The "submersible sewerage pump" was selected, due to its economic efficiency, easy procurement, and easy maintenance features. **Table 4-4.4** shows the pump units/capacity, and **Table 4-4.5** shows the pump specifications.

Table 4-4.4 Number of Pump Units and Capacity

Target Flowrate	Flowrate (m^3/min)	Number of Units	Pump Capacity (m^3/min・unit)*2	
Average Daily Flowrate	18.82	2 units	9.41	9.5
Maximum Daily Flowrate	20.76		10.39	9.5
Maximum Hourly Flowrate	37.64	2 units (1 standby unit) *1	12.55	19.0
Peak Wet Weather Flowrate	56.32	3 units (1 standby unit)*1	28.16	29.0

*1: Standby pump units to be installed in pump well
*2: Red font: Rated capacity
Source: JET

Table 4-4.5 Pump Specifications

Pump	Specifications
Phase 1 Sewerage Pump	Φ300mm × Discharge 9.5 m^3/min × Pump Head 11m × Motor Capacity 30kW × 2 units
Phase 2 Sewerage Pump	Φ450mm × Discharge 19 m^3/min × Pump Head 11m × Motor Capacity 55kW × 2 units (1 standby unit)
Stormwater Pump	Φ600mm × Discharge 29 m^3/min × Pump Head 8.5m × Motor Capacity 55kW × 3 units (1 standby unit)

Source: JET

(5) Oxidation Ditch Equipment

The Oxidation Ditch performs biological treatment of the sewerage by supplying oxygen to microorganisms through mixers and air diffusers.

1) OD Basin Mixer

The following five mixer types were considered as possible options for the OD mixer: the vertical shaft type mixer, horizontal shaft type mixer, vertical axis mixer + air diffuser, and oblique-shafted type mixer, and submerged propeller + air diffuser. The equipment cost, O&M cost, and treatment capacity were compared, and the "vertical axis mixer + air diffuser" and "submerged propeller + air diffuser" scored equally highest in the overall examination. In this project, the latter was chosen for further examinations. Two units will be installed per OD basin (**Table 4-4.7**).

2) Blower

The following three blower types were considered as possible options for the OD's blower: the steel plate multi-stage turbo blower, rotary (roots-type) blower, and screw-type blower. The equipment cost, O&M cost, installment space requirement, and weight were compared, and the "screw-type blower" which ranked the highest in the overall examination was selected.

Since the Phase 1 OD basins (treatment lines 1~4) and Phase 2 OD basins (treatment lines 5~6) will be located some distance apart from each other, the following number of blower units will be installed for each Phase:

Table 4-4.6 Blower Specifications

Blower	Airflow (m^3/min)	Discharge Pressure (kPa/m)	Motor Capacity (kW)	Number of Units (units)
Phase 1 Screw-type Blower	5～17	30	18.5	3 units (1 standby unit)
Phase 2 Screw-type Blower	5～17	30	18.5	2 units (1 standby unit)

Source: JET

3) Air Diffuser

Whilst the mixer circulates the sewerage within the OD basin, the air diffuser placed at the bottom of the basin converts the blown in air to ultra-fine bubbles, efficiently supplying oxygen needed for biological treatment. The "high-rate air diffuser" was selected, which has a high oxygen transfer rate.

Table 4-4.7 Air Diffuser Specifications

Mixer＋Air Diffuser	Number of OD Basins	SOR	Number of Mixer Units	Number of Air Diffuser Units
Phase 1 Mixer + Air Diffuser	4 basins	9,035 kg-O2/d	8 units	4 units
Phase 2 Mixer + Air Diffuser	2 basins	4,518 kg-O2/d	4 units	2 units

Source: JET

(6) Final Clarifier

The water treated by the OD basin flows into the final clarifier, where the clear supernatant and sludge are separated by sedimentation. The supernatant flows out to the disinfectant tank, while the sludge is sent to the sludge receiving tank by the excess sludge pump

1) Sludge Scraper

There are two types of sludge scrapers: central-driven types and peripheral-driven types. Since the final clarifier has a large diameter, a type that can generate large torque with less driving force/power is preferred. For the final clarifier the "peripheral drive column-supported type," where a cart running on the clarifier's peripheral wall pulls the collector's arm to make it rotate, was selected.

Table 4-4.8 Final Clarifier Sludge Scraper

Sludge Scraper	Specifications
Phase 1 Sludge Scraper	Φ25m × Water Depth 4m × Motor Capacity 0.75kW × 4 units
Phase 2 Sludge Scraper	Φ25m × Water Depth 4m × Motor Capacity 0.75kW × 2 units

Source: JET

2) Excess Sludge Pump

Four excess sludge pumps (1 as a spare unit) will be installed per two treatment lines. Since the pump will withdraw sludge from the final clarifier's sludge pit, the "dry-installed suction screw pump" was selected, considering its O&M features.

Table 4-4.9 Excess Sludge Pump Specifications

Pump	Specifications
Phase 1 Excess Sludge Pump	φ150mm × Discharge 1.25 m³/min × Pump Head 10m × Motor Capacity 3.7kW × 4 units (2 standby units)
Phase 2 Excess Sludge Pump	φ150mm × Discharge 1.25 m³/min × Pump Head 10m × Motor Capacity 3.7kW × 2 units (1 standby unit)

Source: JET

(7) Disinfection Tank Equipment

1) Sodium Hypochlorite Storage Tank

The decomposition of sodium hypochlorite (disinfectant) is accelerated when exposed to sunlight/high temperatures and must be properly stored in a tank. The tank's storage capacity was set as one-weeks' worth of sodium hypochlorite to be used for the Peak Wet Weather Flowrate, at an injection dosage of 3 mg/L.

2) Sodium Hypochlorite Injection Pump

The "diaphragm metering pump," which uses a rotation speed control device to control the injection volume based on a fixed ratio against the disinfection tank flowrate, was selected for the sodium hypochlorite injection pump, due to its low equipment cost and proven track record.

Table 4-4.10 Sodium Hypochlorite Injection Pump Specifications

Pump	Discharge Diameter	Injection Volume Control Range	Max Injection Pressure	Motor Capacity	Units
Sodium Hypochlorite Injection Pump	25 mm	0.0637～1.2 L/min	0.7 MPa	0.4 kW	3 units (1 standby unit)

Source: JET

(8) Effluent Pump Equipment

Natabua WWTP's effluent is discharged into Nadi River. When the river's water level rises above MWL 4.19 M, gravitational flow cannot discharge the treated water, thus needing an effluent pump. The "submersible sewerage pump" was selected due to its low equipment cost and easy maintenance features. **Table 4-4.11** shows the pump units/capacity, and **Table 4-4.12** shows the pump specifications.

Table 4-4.11 Number of Pump Units and Capacity

Pump	Flowrate (m^3/min)	Number of Units	Pump Capacity (m^3/min・unit)*2	
Effluent Pump	93.89	3 units (1 standby unit) *1	46.95	47.0

*1: Standby pump units to be installed in pump well
*2: Red font: Rated capacity
Source: JET

Table 4-4.12 Pump Specifications

Pump	Specifications
Effluent Pump	Φ600mm × Discharge 47 m³/min × Pump Head 10m × Motor Capacity 110kW × 3 units (1 standby unit)

Source: JET

(9) Stormwater Sedimentation Pond

The stormwater sedimentation pond will retain four times the maximum daily flowrate for 2.5 hours to let solids and particles to sedimentate. The water will then bypass the disinfection tank before being discharged to the ocean.

(10) Reclaimed Water Utilization Equipment

Part of the treated water will be reclaimed and used for equipment washing, dilution of sodium hypochlorite, etc. The "pressurized sand filtration system," which is a packaged system (including the control panel), was selected due to its low equipment cost and easy maintenance features.

(11) Sludge Dewatering Equipment

1) Sludge Storage Tank Mixer

The sludge storage tank will have a capacity to store 2 days-worth of sludge, and install 1 tank per two treatment lines (total of 3 tanks). The "submerge mixer" was selected due to its low equipment cost and easy maintenance features. Each tank will be equipped by 3 mixers, placed 5 m apart from each other.

2) Sludge Dewaterer

The sludge feed pump sends sludge to the dewatering machine, which reduces the water content and volume of sludge. The "multi-plate screw press dewaterer" was selected, due to its high dewatering efficiency and low equipment/O&M cost. The dewatering capacity and number of units was based on a daily nine-hour operation time.

Table 4-4.13 Dewatering Machine Specifications

Sludge Solids Content (t/day)	10.8
Input Sludge (kg/day)	1,200
Dewatering Method	Multi-plate screw press dewaterer
Dewatering Capacity	400 kg-DS/h×8.3 kW×3 units
Operation (hr/day)	7 days a week, 9-hour operation per day
Dewatered Sludge (m^3/day)	46

Source: JET

(12) Odor Control Facilities

Odor control facilities will be installed to prevent foul odors (emitted from sewerage/sludge) adversely affecting the surrounding area. The "activated carbon adsorption process" and "packed-column tower bio-deodorization process" were selected, due to their relatively easy maintenance features, high deodorization efficiency, and procurement features. Other candidate odor control processes were not adopted for the following reasons:

- Gas combustion: Both construction and maintenance costs are high; requires relatively high technical skills for facility O&M

- Chemical scrubbing: Chemical scrubbing agents lead to high maintenance costs; requires additional facilities to treat liquid chemical waste produced from deodorization
- Soil bed filters: Construction and maintenance costs are relatively low; however, vast amounts of new media must be imported for replacement, (approximately every five years) unlikely being feasible in terms of procurement

For these reasons, the activated carbon adsorption process was adopted for Navakai WWTP's wastewater treatment system; for the sludge treatment system, which emits stronger odors, the combination of packed-column tower bio-deodorization will be adopted.

Table 4-4.14 Odor Control Facilities

Treatment System	Sewerage Treatment System	Sludge Treatment System
Target Facilities	・Influent Pump Station (Influent chamber, grit removal chamber, pump well)	・Sludge Receival Tank ・Sludge Dewatering Building
Odor Control Process	Activated carbon adsorption	Packed-column tower bio-deodorization ＋Activated carbon adsorption

Source: JET

4-5 Electrical Equipment

Navakai WWTP's electrical equipment options were examined and determined as follows. Refer to **APPENDIX 4-7** for equipment drawings.

(1) Power Receiving Equipment

1) Power Receiving System and Distribution Voltage

Upon selecting the power receiving equipment, meetings with EFL were held to confirm equipment specifications. Fiji's transmission voltages are 3-phase 3-wire 11kV, with a frequency of 50Hz. Under full installment cost coverage by WAF, EFL will install a transformer within the WWTP site, which will step down the voltage from 11kV to 415V.

On the WAF equipment side, this transformer secondary voltage of 3-phase 4-wire 415V is received by the WWTP main distribution panel, which supplies power to each facility equipment's motor control center's power load.

Table 4-5.1 Receiving and Distribution Voltages

Voltage	Specifications
Received Voltage and Power Load Voltage	3 phases 4 line 50Hz, 415V
Building Power and Lighting Load Voltage	Power distribution voltage: 3 phases 4 line 50 Hz, 415V Lighting distribution voltage: single phase 2-line 50 Hz, 240V

Source: JET

2) Load Capacity

The loads for each facility are listed in **Table 4-5.2**.

Table 4-5.2 Equipment Load List

Facility Equipment	Phase 1 Load (kW)	Phase 2 Load (kW)
Grit Chamber	47.3	
Influent Pump	118.7	
Stormwater Pump	110	
Oxidation Ditch	207	126
Final Clarifier	31.75	16.25
Disinfection Tank	24.4	
Effluent Pump	220	
Sludge Dewatering	123.32	26.77
Building Equipment Power	201.00	
Building Lighting Power	106.00	
Subtotal (kW)	1189.47	179.02
	Total (kW)	1368.5

Source: JET

3) Transformer Capacity and Contract power

In Fiji, the contract power (maximum power demand) of Natabua WWTP is calculated by the construction contractor based on the AS/NZS 3000:2018 ELECTRICAL INSUTALLATIONS STANDARD. Before construction commences, calculation results are submitted along with an application form to EFL for their approval, namely to confirm the transmission line capacity and construction schedule.

It was confirmed with EFL that for the Navakai WWTP transformer capacity requirement of 1,500 KVA, can be provided by existing transformer models currently used by EFL. It should be taken note that these contents be re-confirmed with EFL in future design stages and before construction.

The transformer capacity, contract power, and electricity tariff of the Pre-F/S stage are listed as follows:

Table 4-5.3 Transformer Capacity and Contract Power

Phase	Total Load (kW)	Contract Power (kW)	Daily Electricity Demand (kWh/d)	Annual Electricity Demand (kWh/yr)
Phase 1	1198.0	617	10,366	3,783,444
Phase 2	170.9	705	11,844	4,323,060

Source: JET

(2) Emergency Generator Equipment

1) Past Power Outage Records

Past power outage records of Nadi between 2018-2023 were studied to determine the necessity of emergency power generators. Results are shown in **Table 4-5.4**. Records indicate that an average of 59 power outages occur annually (all unplanned), some lasting over 12 hours (average length 15.8 hrs). Commercial-level emergency generators are needed as backup.

Table 4-5.4 Past Records of Power Outages

Contents	Unplanned	Planned
Number of cases (2018-2023)	354	0
Maximum outage time (hr)	24	—
Average outage time (hr)	3.4	—
Minimum outage time (hr)	0.1	—
Annual average of cases	59	—
Monthly average of cases	5	—
Number of outage cases lasting over 12 hours	6	—
Average length of over-12-hour outages	15.8	—

Source: JET

2) Emergency Generator Targets

Navakai WWTP will install emergency generators to cope with frequently-occurring power outages of the Nadi area. Major target loads of the emergency generator are listed below.

Table 4-5.5 Emergency Generator Target Loads

Target Equipment	Target Units
Inlet Gate	1 unit
Sewerage Pump	All units (excluding spares)
Stormwater Pump	All units (excluding spares)
OD Basin Blowers	1 unit per two treatment lines
Sodium Hypochlorite Injection Pump	All units
Effluent Pump	All units (excluding spares)
Water equipment for daily use	All units
Emergency generator auxiliaries	All units
Building power/lighting needed for O&M	Required minimum

Source: JET

3) Emergency Generator Engine Type

The “diesel engine generator (radiator mounted package, air-cooled)” was selected, due to its low equipment cost and maintainability. One unit will be installed at Navakai WWTP.

(3) Instrumentation Equipment

The instrumentation equipment necessary for the proper operation/monitoring/control of grit chamber/pump, wastewater treatment, and sludge dewatering facilities are listed in **Table 4-5.6.**

Table 4-5.6 Instrumentation Equipment

Facility	Instrumentation Equipment	Type	Reason of Installment
Grit Chamber/ Pump Facilities	Pump well water level gauge	Submersible water level gauge	To control/adjust number of operating pump units
	Influent sewerage flowmeter	Electromagnetic type	To record actual influent flowrate
Wastewater Treatment Facilities	OD basin DO meter	Optical type	To control/adjust return sludge pumps
	OD basin MLSS meter	Optical type	To control/adjust return sludge pumps
	Excess sludge flowmeter	Electromagnetic type	To control/adjust excess sludge withdrawal
	Sodium hypochlorite storage tank level gauge	Pressure type	To record consumption/ remaining stock of sodium hypochlorite
	Sodium hypochlorite injection flowmeter	Electromagnetic type	To inject proper amount of sodium hypochlorite proportional to actual effluent flowrate
	Effluent flowmeter	Weir system	To control sodium hypochlorite injection quantity
	Effluent pump well water level gauge	Submersible water level gauge	To control/adjust number of operating pump units
Sludge Dewatering Facilities	Chemical tank level gauge	Pressure type	To record consumption/ remaining stock of chemicals
	Sludge storage tank level gauge	Pressure type	To control/adjust excess sludge withdrawal
	Chemical injection flowmeter	Electromagnetic type	To inject proper amount of chemicals in proportion to actual sludge feed
	Sludge feed flowrate	Electromagnetic type	To control chemical injection quantity
	Sludge feed concentration meter	Microwave type	To control sludge solids feed to dewaterer
	Sludge cake hopper load	Load cell type	To record amount of produced sludge cake

Source: JET

(4) Monitoring and Control Equipment

Monitoring and control equipment allows or the centralized management of all WWTP information, essential for operators to monitor and operate the plant’s equipment based on real-time information. It also records the plant’s O&M data that can be utilized for future projects such as stock management. For the Pre-F/S, the “SCADA monitoring and control system,” a highly versatile system using computer networking technology, was selected.

CHAPTER 5 OPERATION AND MAINTENANCE (O&M)

5-1 Proposed O&M Contents and Implementation Method

5-1-1 Operation Plan of Wastewater Treatment Plants

WWTPs consist of a wide variety of facilities and equipment, as well as associated devices, and if any one of these goes out of order, it will adversely affect the whole system. Since wastewater treatment is generally a biological treatment, once an abnormal condition occurs and even if the cause is removed, it takes a long time for effluent qualities to recover. The most important thing is to manage it properly. Sewerage facilities are important social capital, and in today's social context, it is required to effectively utilize limited resources to realize a “sustainable society.” It is important to systematically manage facilities, effectively utilize the facilities for as long as possible (extend the service life) and reduce costs. In addition, continuity of management records, analysis of records and continuous review of management works are necessary. (Guidelines for Sewerage Maintenance and Management 2014, JSWA)

For systematic O&M of WWTPs, it is necessary to first formulate the plans shown in **Table 5-1.1**, and then implement O&M according to the plans.

Table 5-1.1 Plans Needed to be Formulated for Systematic O&M of WWTP Facilities

1	**Operation**	
	Operation plan	Formulate an operation plan to comply with effluent standards, considering cost reduction related to treatment and response to abnormal conditions
	Water quality management plan	Formulate a water quality management plan to comply with effluent standards, and to obtain optimal operating conditions for influent volume/quality and activated sludge conditions
	Crisis management plan	Formulate a crisis management plan showing the management system and countermeasures against power-outages, fires, water outages, inundation, chemical leaks, equipment failures, etc.
	Health & Safety plan	Formulate a H&S plan stipulating management systems/methods to prevent work-related accidents
2	**Daily inspection**	
	Daily inspection plan	Formulate a daily inspection plan defining inspection item, routes, methods (visual inspection numerical values, etc.), frequency (once/day, twice/week, etc.), and inspection standards (appropriate numerical range, etc.)
3	**Periodical Inspection, Administration of Repair**	
	Significance rank of equipment	Use the facility ledger, setting of a significance rank based on the impact on treatment functions, impact on safety, presence/absence of stand-by units, repair costs, years since installation, etc.
	Selection of administration method	Select preventive/corrective maintenance according to equipment significance
	Setting of administration standards	Setting inspection criteria showing the range of abnormal condition Establishing repair standards indicating the necessary state of repair
	Administration plan, performance sheet	Creating a table of periodic inspections for each facility, specifically showing implementation year, month, and inspection results

Source: JET based on the “Guidelines for Maintenance of Sewerage Facilities 2014,” Japan Sewerage Works Association

(1) O&M

According to the established operation plan, operation and maintenance (hereinafter referred as O&M) of the treatment facility will be carried out to comply with the effluent standards at all times and to reduce treatment costs.

The activated sludge process such as OD process proposed in this project and IDEA process owned by WAF should be operated while paying attention to the points shown in **Table 5-1.2**.

Table 5-1.2 Notes on O&M of Activated Sludge Treatment Process

	Facility		Notes
1	Wastewater Treatment (OD Process/ IDEA Process)	Screen	• Transport the screen residue (preferably after washing) to the disposal site as soon as possible.
		Reaction Tank	• Supply the necessary amount of air (oxygen) to the tank. • Maintain the activated sludge concentration required for treatment • Properly withdraw excess sludge to obtain an appropriate activated sludge concentration. • Operate at an appropriate return sludge ratio. (OD process) • Secure enough time for the activated sludge to settle. (IDEA process
		Disinfection Tank	• Adjust chlorine dosage so that the number of *E.coli* is below the standard value.
	Wastewater Treatment (TF Process)	Screen	• Transport the screen residue (preferably after washing) to the disposal site as soon as possible.
		Primary Clarifier	• Withdraw raw sludge so about 1% sludge concentration is maintained • Periodically measure the sludge layer depth so sludge does not overly accumulate in the clarifier for a prolonged time
		Trickling Filter	• Periodically clean the water distributers' nozzles to prevent clogging and slowing down/stopping of the distributor rotation
		Disinfection Tank	• Adjust chlorine dosage so that the number of *E.coli* is below the standard value.
2	Sludge Treatment	Gravity thickener	• Determine the inflow sludge volume to ensure an appropriate thickened sludge concentration and prevent the sludge from rotting.
		Anaerobic digester	• Determine the inflow sludge volume so that methane fermentation proceeds sufficiently. • Make sure that the sludge mixer in the tank works well.
		Aerobic digester (Navakai WWTP)	• Determine the inflow sludge volume so that aerobic digestion proceeds sufficiently.
		Mechanical dewaterer	• Select and adding coagulant to achieve an appropriate sludge moisture content. • Supply the amount of sludge suitable for the capacity of the dewaterer.
		Drying bed	• Operate according to the weather conditions.

Source: JET based on the "Guidelines for Maintenance of Sewerage Facilities 2014" (JSWA) and O&M status of WAF facilities

(2) Water Quality Management

Water quality examinations at WWTPs include (1) examinations to ensure compliance with effluent standards, and (2) examination to operate treatment facilities under optimal operating conditions for the amount and quality of influent and the properties of activated sludge.

Operational factors such as the aeration amount, activated sludge concentration etc. are adjusted based on results of water quality examinations to achieve efficient and economical treatment.

The examinations are usually carried out with water samples, analyzing parameters, and frequency determined based on the water quality management plan. At WWTPs, it is common practice to use simple analysis tests to grasp the real-time treatment status.

The most common methods are transparency and sludge volume (SV). The transparency is an index for the suspended solids (SS) and BOD concentration, and the SV is an index for the activated sludge concentration and sedimentation property of the activated sludge, so it is an extremely useful analysis.

(3) Crisis Management Plan

In sewerage facilities, emergencies may occur even if maintenance is sufficiently implemented. Emergency situations at sewerage facilities are listed in **Table 5-1.3**. In order to minimize damage to surrounding residents and functions of sewerage facilities, a crisis management plan that stipulates a communication system between related organizations, a management system for emergencies, response methods, etc. must be formulated.

In the plan, it is necessary to clearly specify the implementation method and frequency of training for staff assuming an emergency situation, and to actually implement training on a regular basis.

Table 5-1.3 Emergency Situations at Sewerage Facilities

Emergency	Damages for the function of sewerage facilities
Power outages	Shutdown of equipment (if there is no generator)
Fire hazards	Long-term stop operation due to equipment damage at a fire facility H&S issues
Water outages	Inability to secure cleaning water for equipment H&S issues
Flooding	Damage caused by submersion of equipment H&S issues
Chemical leakage	Damage on equipment H&S issues for staff and surrounding residents
Machine malfunctions/breakdowns	Long-term impact on the function of facility (if prompt repairs are not made)
Pipe damage	Long-term impact on the function of facility (if prompt repairs are not made)

Source: JET based on the Guidelines for Maintenance of Sewerage Facilities 201

(4) Health & Safety (H&S) Plan

Even if no occupational accidents have occurred in a workplace, it does not necessarily mean that the workplace is “free from the risk of occupational accidents." It must be recognized that the risk of occupational accidents is always inherent. (“Guidelines for Maintenance of Sewerage Facilities 2014,” JSWA)

It is necessary to establish an “occupational H&S committee” to manage Health and Safety (H&S) in the workplace, and to formulate a H&S plan that indicates the H&S management system and management method.

1) Management System

It is necessary for each workplace to establish a management system that appoints personnel responsible for dangerous work such as scaffold assembly, oxygen deficiency work, crane work, etc., and appoints qualified personnel for electrical work, gas welding, boiler handling, etc.

2) Management Method

i) Health and Safety Education

Health and Safety education is important for staff to acquire the knowledge necessary for H&S issues that arise in the performance of their duties. Education is necessary when hiring new staff, when changing work content, and when staff performs dangerous or harmful work.

Table 5-1.4 shows examples of implementation items for H&S education. In addition to the items listed in the table, for example, arc welding, electrical work, crane work, and work in hazardous locations (ex. closed and confined spaces which may be lacking oxygen), it is necessary to provide specified education for safe work execution.

Table 5-1.4 Examples of Implementation Items for H&S Education

1	Dangers of, hazards of, and handling methods of machinery and materials
2	Function and handling method of safety devices, hazardous substance control devices, and personal protective equipment (PPE)
3	Standard operation procedure (SOP)
4	Inspection at the start of work
5	Causes of work-related illnesses and preventive measures
6	Sort, Set in order, Shine, Standardize, Sustain
7	First-aid measures for accidents, Evacuation

Source: JET based on the "Guidelines for Maintenance of Sewerage Facilities 2014," Japan Sewerage Works Association

ii) Hazards at Workplace

The H&S committee on each workplace has to grasp various hazards hidden in the workplace (such as falling, lack of oxygen, toxic gas, rotating equipment, high voltage, etc.) and take necessary measures (such as proper clothing, set in order, safety inspection, enforcement of SOP, evacuation drills in the event of a disaster, etc.) to safely carry out works.

iii) Securing Work Environments

Based on national safety standards and work standards, each workplace has to ensure working environment such as air environment (odor, harmful gas, oxygen, etc.), thermal environment (temperature, humidity), illuminance environment (brightness suitable for work), workspace (passage width, floor maintenance).

iv) First Aid

In addition to the communication system and emergency transportation destinations in the event of an occupational accident, it is necessary to consider first-aids at workplace. Sewerage facilities deal with polluted sewerage and dangers such as lack of oxygen are also latent. Therefore, it is necessary to invite experts as instructors and conduct regular training on wound care, hemostasis, artificial respiration, etc.

v) Safety Devices, Personal Protective Equipment (PPE)

Staff must use helmets and safety shoes at work sites. It is necessary to prepare safety belts for work at heights, ventilators, air respirators, oxygen analyzers, gas detectors, dust masks, earplugs, etc. for work in confined spaces. It is necessary to conduct regular training on how to use them.

5-1-2 Daily Inspection

Daily inspection is a basic task to properly maintain facilities, and is an important duty that complements O&M and periodic inspection/repair.

Daily inspection work involves patrol inspections using the inspector's five senses, indicated values of instruments, simple tools and measuring instruments, etc., to understand daily trends in operation conditions and the presence of abnormalities, etc. for preventing failures and functional deterioration. This work is equivalent to a simple diagnosis related to the operational status of equipment.

It is important to continuously record the results of daily inspections in order to perform planned maintenance of equipment properly ("Guidelines for Maintenance of Sewerage Facilities 2014," JSWA).

Therefore, a daily inspection plan that defines inspection items, routes, methods (visual inspection, recording machine readings, etc.), frequency, and inspection standards (appropriate numerical range of machine readings, etc.) has to be formulated. And based on this, daily inspections are carried out and inspection records are created. **Table 5-1.5** shows examples of daily inspection items.

Table 5-1.5 Examples of Daily Inspection Items

Inspection item	Details
Sensory inspection	Check for abnormal noise, odor, vibration, heat generation, etc.
Indicating value of gauge	Check whether the indicated gauge values such as current value and pressure are within the normal range
lubrication state	Check oil temperature, level, leakage
Connecting part of equipment	Check for looseness
State of deterioration	Check deterioration such as rust, corrosion, deformation, cracks, and damage
Environmental conditions	Check for abnormal noise, odor, dirt, etc. on the inspection route

Source: JET based on the "Guidelines for Maintenance of Sewerage Facilities 2014," Japan Sewerage Works Association

5-1-3 Periodical Inspection, Repair Management

Periodic inspection and repair management will be carried out in the order of (1) setting significance rank of equipment, (2) selecting management methods, (3) setting management standards, and (4) creating a management plan and performance table.

i) Setting Significance Rank of Equipment

The level of significance for major equipment is ranked based on the evaluation items shown in **Table 5-1.6**.

Table 5-1.6 Evaluation Items of Significance Rank of Equipment

1	Impact on treatment function
2	Impact on safety (man-made disasters, pollution, secondary disasters)
3	Presence or absence of stand-by machine (or backup capacity)
4	Impact on repair/replacement costs and repair/replacement period
5	Passed years after installation of equipment
6	Impact on operation load (daily operation, emergency operation)
7	Presence or absence of legal restrictions

Source: JET based on the “Guidelines for Maintenance of Sewerage Facilities 2014,” Japan Sewerage Works Association

ii) Selecting Management Methods

“Preventive maintenance” is selected for facilities judged to be of high importance by the significance ranking so as not to cause failures and outages. “Corrective maintenance” is selected for equipment of low significance and with stand-by units.

iii) Setting Management Standards

To systematically repair equipment and replace parts, it is necessary to confirm the state of deterioration quantitatively. Management standards for judging the state of deterioration (such as wearing) for facilities are set, and repairs/parts replacement is implemented according to the standards.

iv) Creating a Management Plan and Performance Table

In order to guarantee the reliability of facilities from a long-term perspective, and to develop economical/efficient facility management, a management plan that indicates management items and inspection frequency is formulated. It is necessary not only to make a plan for a single year, but also to create a mid-term and long-term plan based on a macro perspective spanning several years.

Table 5-1.7 is an example of a mid-term management plan for a submersible pump, showing the inspection frequency and inspection details for the main machine body, bearings, submersible motors, and protective device, as well as the frequency of parts replacement and repair by the manufacturer.

Table 5-1.7 Example of Mid-Term Management Plan

Submersible Pump	Inspection frequency								Inspection items	Spare parts & Manufacturer maintenance
	day	week	1 month	3 months	6 months	1 year	2 years	3 years		
Main Machine	*					✔			*: noise, vibration, pressure ✔: wear, corrosion	Spare parts: 2~5 years Manufacturer maintenance: 5~8 years
Bearing							✔		✔: refueling, Exchange	
Submersible motor					✔				✔: insulation, Resistance	
Protection device						✔			✔:conduction, operation check	

Source: JET based on the "Guidelines for Maintenance of Sewerage Facilities 2014," Japan Sewerage Works Association

5-2 Operational Plan of Sewerage Facility

The organizational structure and division of work for proper operation and maintenance of the sewer networks, pumping stations, and wastewater treatment plants in the sewerage area proposed in this project are shown below.

5-2-1 Budget and Implementation System

For appropriate O&M of sewerage facilities, it is important to secure a budget and determine various implementation systems as well as establish O&M system.

(1) Budget for O&M

At present, due to lack of personnel and budget, WAF has hardly performed even basic maintenance for ME equipment such as oil changes, and various ME equipment installed at WWTPs and pump stations is markedly degraded. By recognizing that the total cost can be reduced by extending the service life of equipment through priority maintenance (based on the judgment of importance and diagnosis of deterioration), and by using the equipment beyond its normal service life, it is necessary to secure a budget for replacement parts and consumables for preventive maintenance.

Even if proper maintenance is performed, equipment may fail and breakdown at times due to various reasons. For such failures, it is always necessary to secure a budget for prompt repairs according to the importance of the facility. In the future, it will be necessary to consider approaches improving operation efficiency, such as PPP concession agreements outsourcing facility O&M to private sectors.

(2) Improvement of Working Conditions

The experience and expertise of staff are extremely important for O&M of sewerage facilities. According to WAF, salaries for staff are not as low as those of private sectors, but there have been frequent cases of experienced staff leaving their jobs and moving to countries with higher salaries such as Australia. This makes it difficult to inherit knowledge at sewerage facility. In order to improve this situation, it is necessary to review the staff salary system. If it is difficult to improve salaries, it is necessary to consider outsourcing a large amount of work to the private sector for ensuring the quality of O&M.

(3) Simplification of Procedures for Implementation of Outsourced Work

Even when proper maintenance is performed for mechanical and electrical equipment, failures and outages may occur. It is necessary to predetermine the priority of each facility according to its significance, the presence/absence of standby machine, etc., and to quickly conclude a repair contract with a manufacturer or a repairer so that emergency repairs can be made in the event.

(4) Outsourcing of O&M of Complex Treatment Facilities

In the case of introduction of facilities such as biogas power generation, the O&M of ME equipment will be extremely complicated, so it is necessary to consider outsourcing plant O&M to manufacturers. Therefore, it is necessary to secure the required budget and smoothly conclude a contract with the manufacturer.

(5) Proposal of Work Content and Implementation Method

To obtain optimum effluent quality in the activated sludge process such as Navakai's current IDEA process/proposed OD process, as well as the TF process proposed for Natabua, the proper operation of various equipment/operating conditions (ex. activated sludge concentration) must be conducted. To do so, operation staff must conduct patrols, inspections, and simple water quality tests to constantly grasp the plant's real-time operation status.

Table 5-2.1 shows daily patrol and inspection works at the WWTP using the activated sludge process. O&M staff will inspect and record the items shown in the table at the treatment site.

Table 5-2.1 Daily Patrol and Inspection Works at Activated Sludge Process WWTPs

Item	Details of work
Visual inspection of treatment status	• Offensive odors: For example, rotten odors from screen facilities, depositing site of screen residue, reaction tanks, sedimentation tanks, gutters, etc. • Abnormal colors: For example, blackening due to decay of activated sludge or effluent
Operating status of mechanical and electrical equipment	• Failure stop, abnormal noise, abnormal vibration, etc. • Operating status of machinery equipment • Check and record of indicated value of gauges, such as temperature, current, voltage

Source: JET based on the "Guidelines for Maintenance of Sewerage Facilities 2014," Japan Sewerage Works Association

In Japan, staff-stationed WWTPs are instructed to implement simple water quality tests such as air temperature, water temperature, transparency, pH, and activated sludge sedimentation rate (SV) at fixed times every day ("Guidelines for Maintenance of Sewerage Facilities 2014," JSWA)

But at the four WWTPs in the Western Division, no such tests are carried out, except for monthly tests conducted by the WAF Central Water Quality Laboratory. This is because field staff do not have knowledge on the importance of water quality measurement, its testing methods, and the most importantly lacks the equipment needed for the tests. Routine water quality testing is an important task for judging the O&M status, and WAF must improve the situation.

Table 5-2.2 shows recommended daily water quality test parameters, test objectives, and implementation methods for WWTPs using activated sludge treatment processes. Measurement of dissolved oxygen of activated sludge (MLDO) in the table requires relatively expensive instrument; until WAF can procure it, measurement of transparency and activated sludge settling rate (SV) are recommended.

Table 5-2.2 Daily Water Quality Test Works in Activated Sludge WWTPs

Parameter	Objective of test	Measuring method
Transparency	Can be manually measured using a graduated cylinder. The transparency of effluent is correlated with the suspended solids (SS) and BOD and serves as an indicator of effluent quality.	Measure the effluent transparency at the same time/location/depth every day and record it Periodically graph the transparency data (horizontal axis: date, vertical axis: transparency) and observe monthly and yearly fluctuation. Graph the transparency and SV data (horizontal axis: transparency, vertical axis: SV) and analyze the effect on effluent quality when the activated sludge concentration in the reaction tank is high or low.
Activated Sludge Settling Rate (SV)	Can be manually measured using a graduated cylinder. Serves as an indicator for activated sludge concentration. For the IDEA process, the settling time required in the IDEA tank can be estimated from the settling properties of the sludge.	Measure the SV of the activated sludge in the reaction tank at the same time/location/depth every day and record it. Periodically graph the SV data (horizontal axis: date, vertical axis: SV) and use it as an indicator for the excess sludge withdrawal from the reaction tank.
Dissolved Oxygen of Activated Sludge (MLDO)	Serves as an indicator for controlling the air supply. Serves as an indicator to monitor the active condition of microorganisms in activated sludge.	Measure the dissolved oxygen concentration (MLDO) in the reactor at the same time/location/depth every day and record it. If the MLDO is too low, the activity of activated sludge microorganisms will drop, and the treatment performance will decrease.

Source: JET based on "Guidelines for Maintenance of Sewerage Facilities 2014," Japan Sewerage Works Association

Excess sludge is not removed periodically in the IDEA tank of the Navakai WWTP, and the sludge concentration sometimes becomes too high, resulting in the deterioration of effluent quality. Therefore, as shown in the table, it is necessary to continuously measure the effluent transparency and SV to accumulate data, and graphically show the relationship between the transparency/SV to understand how much the SV increases (the activated sludge concentration increases) and the effluent transparency decreases (a.k.a., the effluent quality deteriorates). This relationship can then be used to estimate the appropriate sludge withdrawal interval.

In the course of this project, equipment for measuring transparency and activated sludge settling rate (SV), was provided to Navakai WWTP's operation staff. An OJT session was held to train the staff on the measurement methods and record keeping, and measurements are continuing onsite since then.

The results of patrols, inspections, and water quality tests shall be recorded in the prescribed record form and stored appropriately. If an abnormality is found, a report including the items shown in **Table 5-2.3** shall be prepared and submitted. Upon receipt of the report, the supervisor writes instructions on how to respond to the abnormality. The report will be valuable information for O&M, so it should be recorded/saved properly.

Table 5-2.3 Items in the Report of Abnormal Condition

Reporting items	Name of staff who found
	Date and time found
	Abnormal facilities and equipment
	Specific condition of the anomaly
	Possible causes
	Possible counter measures
Instruction of supervisor	Name of supervisor
	Instructions on how to respond to abnormality
Response to the instruction	Name of staff who respond
	Date and time responded
	Result of response
	Need for further action

Source: JET

It is necessary to provide training to the O&M staff at WWTPs on the meaning of patrols/inspections, and regular water quality tests, how to conduct them, and how to record and report them.

(6) Proposing Organization Structures

The organizational structure for implementing O&M of WWTPs differs depending on the sewerage and sludge treatment process. Natabua and Navakai WWTP's treatment process, treatment capacity, and proposed O&M methods are shown in **Table 5-2.4**.

Table 5-2.4 Treatment Process/Capacity and Proposed O&M Method for Natabua/Navakai WWTP

Municipality	WWTP	Wastewater Treatment		Sludge Treatment	O&M Method
		Process	Capacity (m^3/day)		
Lautoka	Natabua	TF	44,400	Raw Sludge*1 : thickening → digestion → dewatering → sun-drying Excess Sludge : digestion → dewatering → sun-drying Septage*2 : dewatering → sun-drying	M-1
Nadi	Navakai	OD	29,800	Excess Sludge : dewatering⇒sun-drying	M-1

*1 Receive thickened raw sludge from other WWTPs/Pretreatment Plant sludge to anaerobic digester
*2 Accept septage collected from six municipalities in Western Division
Source: JET

Table 5-2.5 shows specific O&M implementation methods for O&M implementation method M-1.

Table 5-2.5 O&M Implementation Method

M-1	Operation	Operation of sewerage/sludge treatment facilities in 3 shifts
	Maintenance	Patrol/inspection/maintenance works during daytime
	Water quality test	Simple test of pH, transparency, SV (in OD process), Dissolved Oxygen

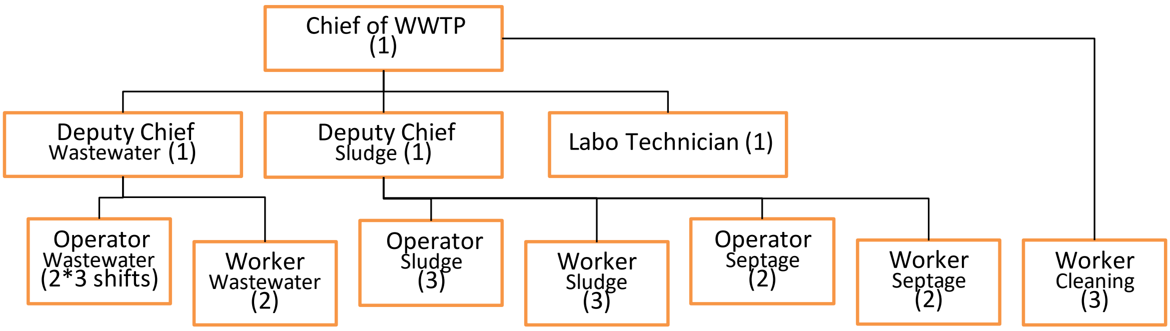
Source: JET

5-2-2 Proposed O&M Organization Structure (Phase 2)

(1) Natabua WWTP

For Natabua WWTP in Lautoka, the trickling filter process is proposed for wastewater treatment, and thickening/anaerobic digestion/mechanical dewatering/ sun drying process for sludge treatment. The WWTP plans to receive thickened sludge from three other WWTPs (excluding Navakai WWTP), and septage from Ba and Ra provinces to the anaerobic digesters. Since the operation of the Biogas Power Generation Plant will be outsourced to the private sector, O&M of the digesters and biogas utilization facility will not be included in the proposed organization.

The proposed organization structure of the WWTP is shown in **Figure 5-2.1,** and the proposed duties of each staff in charge in the figure are shown in **Table 5-2.6**.



Source: JET

Figure 5-2.1 Proposed Organization Structure of Natabua WWTP

Table 5-2.6 Proposed Duties of Staff in charge of Natabua WWTP

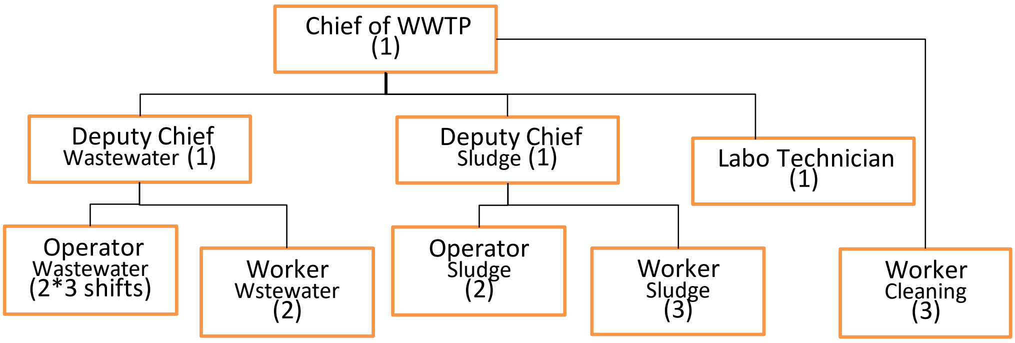
<table>
<tr><th colspan="2">Position</th><th>Main duties</th></tr>
<tr><td colspan="2">Chief of WWTP</td><td>• Management of WWTP</td></tr>
<tr><td rowspan="3">Wastewater treatment</td><td>Deputy Chief (Wastewater)</td><td>• Operation management of wastewater treatment facilities
• Management of daily/monthly reports</td></tr>
<tr><td>Operator (Wastewater)</td><td>• 3 shifts
• Operation of wastewater treatment facilities
• Visual inspection of treatment status
• Checking the operation status of mechanical/electrical equipment
• Preparation of daily reports</td></tr>
<tr><td>Worker (Wastewater)</td><td>• Support for visual inspection and inspection of operation status
• Screenings/scum removal works</td></tr>
<tr><td rowspan="3">Sludge treatment</td><td>Deputy Chief (Sludge)</td><td>• Operation management of sludge treatment facilities
• Operation management of septage acceptance/ treatment facilities
• Management of daily/monthly reports</td></tr>
<tr><td>Operator (Sludge)</td><td>• Operation of sludge treatment facilities
• Preparation of coagulant liquid
• Measurement of sludge moisture contents
• Preparation of daily reports</td></tr>
<tr><td>Worker (Sludge)</td><td>• Support for preparation of coagulant liquid
• Cleaning of sludge treatment facilities</td></tr>
<tr><td rowspan="2">Septage treatment</td><td>Operator (Septage)</td><td>• Septage accepting works
• Operation of septage treatment facilities
• Preparation of septage acceptance and treatment reports</td></tr>
<tr><td>Worker (Septage)</td><td>• Support for septage acceptance
• Support for operation of septage treatment facilities
• Cleaning of septage acceptance and treatment facilities</td></tr>
<tr><td colspan="2">Laboratory Technician</td><td>• Implementation of simple water quality test
• Preparation of daily water quality report
• Management of water quality data of other WWTPs</td></tr>
<tr><td colspan="2">Worker (Cleaning)</td><td>• Housekeeping, cleaning of WWTP
• Routine tasks</td></tr>
</table>

Source: JET

(2) Navakai WWTP

OD process in wastewater treatment and thickening/mechanical dewatering/sun drying in sludge treatment is proposed in Navakai WWTP in Nadi. Since the treatment capacity is large and the effluent must comply with the SEZ, it is more necessary to pay attention to operation compared to other WWTPs.

The proposed organization is shown in **Figure 5-2.2** and the proposed duties of each staff in charge in the figure are shown in **Table 5-2.7**.



Source: JET

Figure 5-2.2 Proposed Organization Structure of Navakai WWTP

Table 5-2.7 Proposed Duties of Staff in Charge of Navakai WWTP

Position		Main duties
Chief of WWTP		• Management of WWTP
Wastewater treatment	Deputy Chief (Wastewater)	• Operation management of wastewater treatment facilities • Management of daily/monthly reports
	Operator (Wastewater)	• 3 shifts • Operation of wastewater treatment facilities • Visual inspection of treatment status • Checking the operation status of mechanical/electrical equipment • Preparation of daily reports
	Worker (Wastewater)	• Support for visual inspection and inspection of operation status • Screenings/scum removal works
Sludge treatment	Deputy Chief (Sludge)	• Operation management of sludge treatment facilities • Management of daily/monthly reports
	Operator (Sludge)	• Operation of sludge treatment facilities • Preparation of coagulant liquid • Measurement of sludge moisture contents • Preparation of daily reports
	Worker (Sludge)	• Support for preparation of coagulant liquid • Cleaning of sludge treatment facilities
Laboratory Technician		• Implementation of simple water quality test • Preparation of daily water quality reports • Management of water quality data of other WWTPs
Worker (Cleaning)		• Housekeeping, cleaning of WWTP • Routine tasks

Source: JET

5-2-3 Proposed O&M Organization Structure for Phase 1

(1) Phase 1 O&M Organization Structure

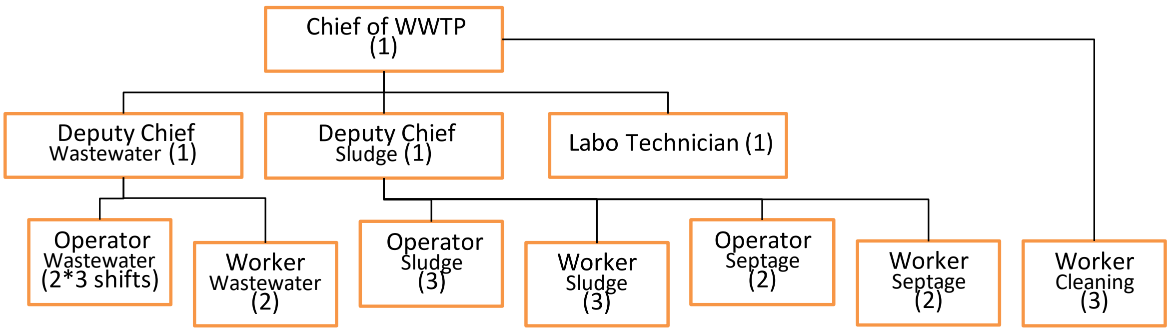
In Phase 1, Natabua WWTP is planned to construct a 30,000 m^3/day-capacity TF treatment system (3/4 of its overall capacity), and Navakai WWTP is planned to construct a 20,000 m^3/day-capacity OD treatment system (2/3 of its overall capacity). As today's WWTP O&M procedures are highly automated, the number of operators required for sewerage and sludge treatment facilities is not affected by slight increases/decreases in facility size. On the other hand, the number of workers to perform tasks such as washing and equipment cleaning will increase or decrease depending on the number of equipment units

For this reason, the number of wastewater/sludge/septage operators for both WWTPs will not change from the contents shown previously in **Figure 5-2.2**.

On the other hand, the number of sludge/septage/cleaning workers may change. In **Figure 5-2.1**, 3 sludge workers/2 septage workers/2 cleaning workers were proposed for the Natabua WWTP. For Phase 1 facilities (with 3/4 of the total capacity), the number of necessary workers will be calculated as follows:

- Sludge workers: 3 staff×3/4＝2.25 ⇒ 3 staff
- Septage workers: 2 staff×3/4＝1.5 ⇒ 2 staff
- Cleaning workers: 2 staff×3/4＝1.5 ⇒ 2 staff

As a result, the number of staff for Phase 1 and Phase 2 facilities does not change for Natabua WWTP (**Figure 5-2.3**)



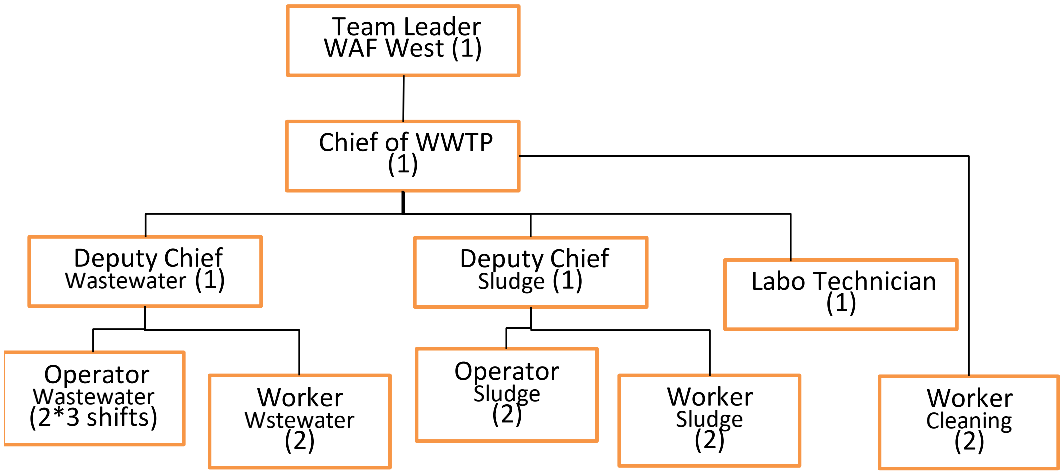
Source: JET

Figure 5-2.3 Proposed Organization Structure of Natabua WWTP (Phase 1)

For Navakai WWTP, 3 sludge workers/2 cleaning workers were proposed as shown in **Figure 5-2.2**. For Phase 1 facilities (with 2/3 of the total capacity), the number of necessary workers will be calculated as follows:

- Sludge workers: 3 staff×2/3＝2 ⇒ 2 staff
- Cleaning workers: 2 staff×2/3＝1.3 ⇒ 2 staff

As a result, one less sludge worker staff is needed, so Phase 1 Navakai WWTP's O&M organization structure will be as shown in **Figure 5-2.4** .



Source: JET

Figure 5-2.4 Proposed O&M Organization Structure of Navakai WWTP (Phase 1)

To carryout proper O&M from the commencement of the new WWTP facilities, it is important to first secure the necessary O&M budget for the existing Navakai WWTP (IDEA method) and repair the broken equipment; after so, the capacity development of operators/workers will be performed as a type of on-the-job training, so they will be capable of performing the necessary O&M works.

Under current WAF conditions, the implementation of such staff training programs is difficult. Instead, capacity building through JICA technical cooperation etc. will be effective in formulating an O&M organization structure that can properly manage the new WWTP facilities.

(2) Water Analysis Lab

In addition to general water quality parameters such as BOD and TSS, Fijian effluent standards include harmful substances such as heavy metals, cyanide, etc. However, due to the lack of analytical equipment, WAF's water analysis lab is currently not able to properly analyze all regulated parameters, unable to analyze heavy metal contents in sewerage sludge generated at its WWTPs. Therefore, in order to conduct proper WWTP water quality management/sludge management and properly regulate liquid trade waste, it is essential to equip the lab with analytical equipment, as well as strengthen the lab technicians' capacity.

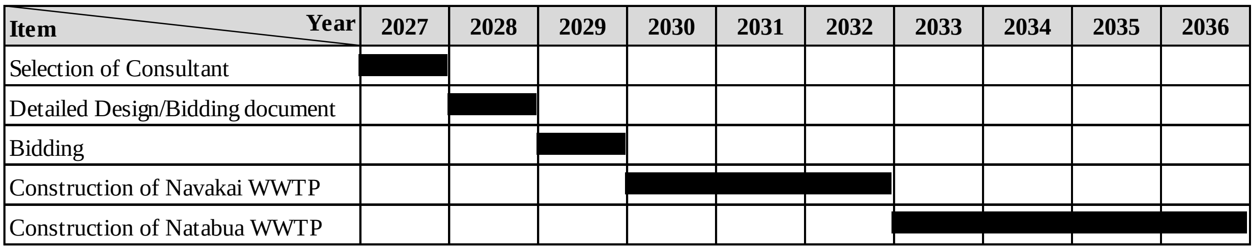
In addition, when mechanical treatment processes such as the OD process are introduced to the WWTPs, daily on-site water quality examinations become important to determine optimal operating conditions. To do so, it is necessary to set up water analysis labs at the WWTPs, which can perform simple tests/measurements such as DO and activated sludge concentration. It is proposed in **Figure 5-2.2** and **Figure 5-2.1** to assign one lab technician to each WWTP.

The implementation/realization of such proposed measures is difficult through the efforts of WAF alone, which has little experience in WWTP O&M. To achieve these goals, measure such as equipment procurement and capacity building of lab technicians through JICA technical cooperation projects will be effective.

CHAPTER 6 IMPLEMENTATION SCHEDULE AND PROJECT COSTS

6-1 Implementation Schedule of the Prioritized Projects

The implementation schedule for the prioritized projects follows the development schedule for the Natabua and Navakai WWTP considered in the Municipal Sewerage M/P and is shown in **Figure 6-1.1**. Given WAF's opinion that there is an opportunity to advance the development of the two WWTPs, the Water Sector Strategy 2050 schedule will not be applied. Construction of the facilities is expected to be completed around 2036 for the Natabua WWTP and around 2032 for the Navakai WWTP.



Source: JET

Figure 6-1.1 Assumed Implementation Schedule (Phase 1)

The implementation schedule is estimated based on the required period shown in **Table 6-1.1**.

Table 6-1.1 Required Period of Each Phase

Phase	Duration
F/S study	1 year
Consultant Selection	1 year
Detailed Design	1 year
Bidding procedure for the contractor	1 year
Construction of Natabua WWTP	4 years
Construction of Navakai WWTP	3 years

Source: JET

6-2 Estimation of Construction Costs and O&M Costs

(1) Condition of Cost Estimation

Outline design of each facility was conducted in the Pre-F/S. Construction cost was estimated by multiplying the approximate quantity of civil items by the unit prices quoted in Fiji. The consideration and precondition for estimating outline construction costs are as follows.

- For civil works, the construction cost was estimated by multiplying the approximate quantity by the unit price.
- The unit price of Fiji was used as a reference for the major items of civil works, and the unit price that is difficult to obtain was adopted with reference to the examples of Japan and third countries.

- The costs of major mechanical and electrical equipment were estimated based on the quotation in Fiji, while other small to medium scale equipment were calculated based on unit prices referring to Japan.
- Land acquisition costs for the WWTPs were included in the Project costs based on the comment from MOF[2]. However, since the unit price of land varies greatly depending on the type of land for the WWTP site, etc., the land acquisition cost calculated here needs to be revised in the future F/S study.
- Approximate unit prices are before the COVID-19 pandemic and before the Russian invasion of Ukraine in 2022. Price contingencies were properly considered in cost estimations.

The cost estimation results for each facility are shown below.

(2) WWTP Construction Costs

The approximate quantities of civil works were estimated based on the outline design of the facilities, and mechanical and electrical costs were also estimated based on quotations in Fiji. The construction costs for both WWTPs in Phase 1 are presented in **Table 6-2.1**. Land acquisition costs are not included in the construction costs but are included in the project costs. The upgrade costs for Phase 1 are expected to be approximately 201 million FJD for Natabua WWTP and 133 million FJD for the Navakai WWTPs.

Table 6-2.1 Summary of Construction Costs for WWTPs (Phase 1)

WWTP	Treatment Process	Construction Costs (million FJD)				Equivalent JPY (million JP)
		Civil/Arc.	Mechanical	Electrical	Total	
Natabua	TF	128	44	29	201	13,578
Navakai	OD	71	43	19	133	8,984

* 1 FJD = 67.55 JPY (April 2024)
Source: JET

(3) WWTP O&M Costs

O&M costs for WWTP are estimated as the sum of electricity costs, maintenance costs, and labor costs, as shown in **Table 6-2.2**.

Table 6-2.2 Summary of O&M Costs for WWTPs (Phase 1)

WWTP	Treatment Process	O&M Costs (1000 FJD/ year)				Equivalent JPY (million JPY/yr)
		Electricity	Maintenance	Labor	Total	
Natabua	TF	1,554	1,791	355	3,700	250
Navakai	OD	2,028	1,184	266	3,478	235

* 1 FJD = 67.55 JPY (April 2024)
Source: JET

6-3 Project Costs

(1) Condition of Cost Estimation

The conditions for the project cost estimation are shown in **Table 6-3.1**. Although the project cost scale for the upgrade of WWTPs is the scale of a loan project, the donor has not been decided, so the conditions are

[2] MOF: former Ministry of Economy

only for reference.

Table 6-3.1 Conditions for the Project Cost Estimation

No.	Item	Value	Remarks/ Sources
1	Exchange Rate	1 USD = 151.37 JPY 1 USD = 2.2409 FJD 1 FJD = 67.5498 JPY	JICA Rate April 2024
2	Price Escalation Rate (Foreign Currency)	2.70 %/year	Japan Ministry of Internal Affairs and Communications Year 2020-standard Consumer Price Index (as of April 2024)
	Price Escalation Rate (Local Currency)	3.60 %/year	Consumer Price Index by Fiji Bureau of Statistics (as of April 2024)
3	Physical Contingency Rate	5 %	JICA Cost Estimation Manual
4	Value Added Tax (VAT)	15 %	From Fiji Government website
5	Import Tax	15 %	From Fiji Government website
6	Administration Cost	5 %	JICA Cost Estimation Manual
7	Interest rate (Construction)	2.00 %	Terms and Conditions of Japanese ODA Loan
	Interest rate (Consulting Service)	0.20 %	Terms and Conditions of Japanese ODA Loan
8	Front End Fee	0.2 %	JICA Cost Estimation Manual

Source: JET

(2) Consulting Service Fee

Consulting services will be allocated 10% of the construction cost (excluding price escalation and physical contingency).

(3) Land Acquisition Costs

The items for land acquisition costs are as shown in **Table 6-3.2**, and are expected to be approximately 36.8 million JPY. As this area includes the storage area for dried sludge, the necessary land cost will be reduced if an effective reuse method for the sludge is determined.

Table 6-3.2 Land Acquisition Costs

WWTP	Required Area (ha)	Cost (million FJD)	Remarks
Natabua	42.1	27.4	
Navakai	14.5	9.4	
Total	56.6	36.8	(2,488 million JPY)

* 1 FJD = 67.55 JPY (April 2024)
Source: JET

(4) Project Costs

The results of the Phase 1 project cost estimation are presented in **Table 6-3.3**. The project cost is estimated to be 816 million FJD, and the loan amount is 547 million FJD. Fiji's share of the cost (including land acquisition costs, VAT, administrative costs and import taxes) will be approximately 269 million FJD.

Table 6-3.3 Phase 1 Project Costs and Loan Amount

Component	Foreign Currency (million JPY)	Local Currency (million FJD)	Total (million FJD)
A. FOREIGN PORTION	**29,128**	**116**	**547**
I) Procurement / Construction	26,668	106	501
ICB1:WWTP1_Const	7,202	27	133
ICB2:WWTP2_Const	12,633	46	233
Base cost	19,835	73	367
Price escalation	5,564	28	111
Physical contingency	1,270	5	24
II) Consulting services	2,460	9	46
Base cost	1,983	7	37
Price escalation	253	1	5
Physical contingency	224	1	4
B. BORROWER PORTION	**-**	**229**	**229**
I) Procurement / Construction	-	-	-
a. Land Acquisition	-	46	46
b. Administration cost	-	30	30
c. VAT	-	89	89
d. Import Tax	-	65	65
TOTAL (A+B)	**29,128**	**345**	**776**
C. Interest during Construction	2,626	-	39
For Construction	2,573	-	38
For Consultant	53	-	1
D. Front End Fee	**79**	**-**	**1**
GRAND TOTAL (A+B+C+D)	**31,834**	**345**	**816**

Source: JET

CHAPTER 7 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

7-1 Environmental and Social Considerations in Pre-F/S

Environmental and social considerations at the Pre-F/S stage include scoping for the selected priority projects, as well as support for preparing Environmental Impact Assessment (EIA) reports in accordance with the Fijian laws to obtain the environmental clearance. Ambient water quality and land use status of the target areas were also confirmed at Initial Environmental Examination (IEE) level.

7-2 Environmental and Social Consideration Systems/Organizations

7-2-1 Policies and Plans for Environmental and Social Considerations

APPENDIX 7-1 shows policies and plans related to sewerage sector and environmental and social considerations.

7-2-2 Environmental Clearance

According to Schedule 2 Part 1 of the Environmental Management Act, projects requiring EIA approval from the DOE (Part 1 projects) include "(q) a proposal for the construction of a landfill facility, composting plant, marine outfall or wastewater treatment plant." Both priority projects, expansion of the Navakai Treatment Plant and the Natabua Treatment Plant, are likely to fall under this category. Regarding the treated water discharge and sludge disposal, permits must be obtained from Pollution Control Unit of the DOE (usually included as a condition of the EIA permit). **APPENDIX 7-2** shows a summary of the EIA process for Part 1 projects.

7-2-3 Land Acquisition Process

Land ownership in Fiji is classified into three types: indigenous land (iTaukei land), freehold land, and state/crown land. The Fiji Constitution does not permit compulsory acquisition of land, and indigenous land cannot be transferred except for public use. In the case of land acquisition by the government, compensation is required for all land and rights, regardless of the land type, and specific provisions are made in the State Acquisition of Lands Act. Land acquisition processes (acquisition, lease, and easement) for the priority project are summarized in **APPENDIX 7-3**.

7-3 Natabua Wastewater Treatment Plant

7-3-1 Overview

Refer to **CHAPTER 3**

7-3-2 Current Environmental and Social Conditions

(1) Pollution Control

1) Water Quality Analysis by WAF

WAF's water quality laboratory regularly analyzes the water quality of the sea, which is a recipient of the effluent from Natabua WWTP. **APPENDIX 7-4** shows the water quality results for the past two years. In the 2022 survey, the fecal coliforms count was more than 100,000 MPN/100mL at the discharge point, and 50,000MPN/100mL or more even at locations 300-500m far from the point. However, significant improvement of fecal coliform count was seen in the 2023 survey as 6,000-10,000 MPN/100mL at the discharge point and less than 1,000 MPN /100mL at other locations. One possible cause could be dredging of the ponds conducted in the fiscal year of 2021. Although fecal coliform count is not set in Japanese environmental standards, all points in the 2023 survey, except for the discharge points, are considered as "swimmable" under the Japanese swimmable water criteria[3] (less than 1,000 MPN/100 mL).

2) Water Quality Analysis by the Project

As part of data collection for the EIA preparation, water quality analysis (rainy and dry seasons) was conducted in the surrounding water bodies. The results are shown in **APPENDIX 7-5**. The surface water results are generally similar to the WAF's survey data mentioned above, and the same as the bottom water results.

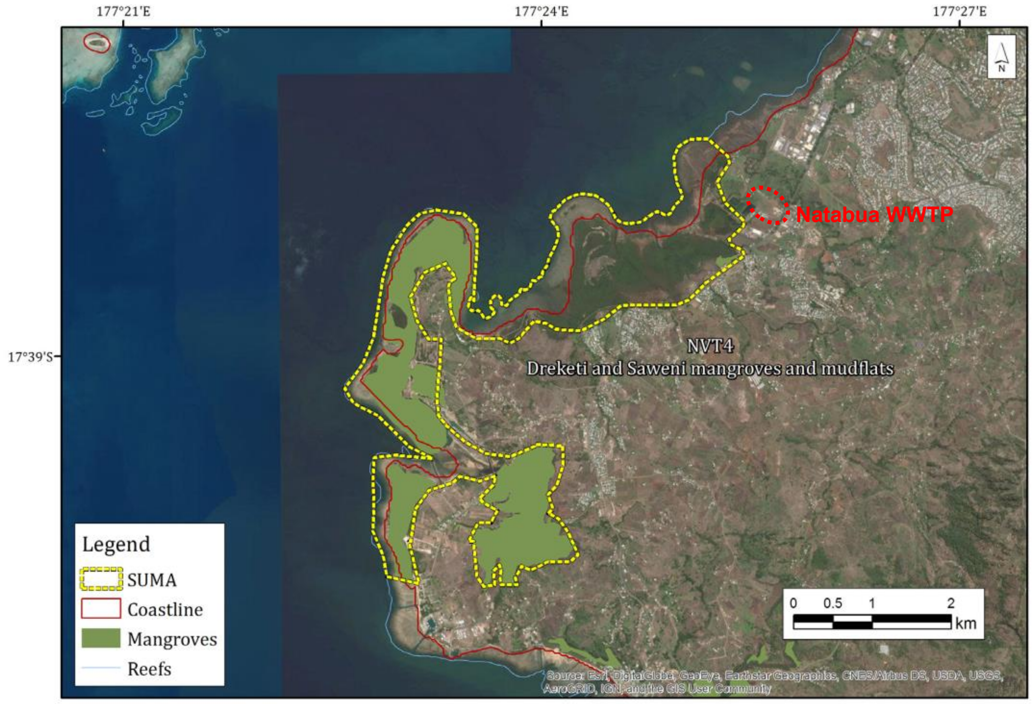
3) Water Quality and Ecological Monitoring by SPD

At the Natabua WWTP, wastewater from a distillery process brought in from SPD in Lautoka is directly connected to the ocean outfall pipe and discharged into the sea together with the treated water from the WWTP. The SPD conducts a monitoring survey of the ambient water, bottom sediment, and organisms near the outfall end every year, and submits the survey reports to WAF. Therefore, these survey reports over the past five years, from 2018 to 2022, were reviewed (**APPENDIX 7-8**). It should be noted that SPD's monitoring items do not include indicators related to *E. coli*.

(2) Natural Environment[4]

There are no designated areas for nature conservation or cultural heritage protection in the vicinity of the target site. However, Natabua WWTP are located at coastal wetlands that have important marine ecosystems, known as Special Unique Marine Areas (SUMAS) that the DOE and DOF identified for future marine protected areas (**Figure 7-3.1**).

[3] Ministry of Environment (Japan). Swimmable Water Quality Criteria; https://www.env.go.jp/content/000141595.pdf
[4] 1) National Biodiversity Strategy and Action Plan for Fiji 2020-2025, and 2) Biophysically Special, Unique Marine Areas of Fiji



Biophysical Justification of NVT4: Coastal and inland mangrove connectivity, mud crabs, mud lobsters, juvenile reef fish, shorebirds.

Figure 7-3.1 SUMA location near Natabua WWTP (NVT4: Dreketi and Saweni mangroves and mudflats)

(3) Social Environment

1) Socio-economic Status

Major socio-economic indicators of Lautoka, where the Natabua WWTP is located, are shown in **APPENDIX 7-6**.

2) Land Use

The Natabua WWTP is located on the outskirts of Lautoka, on flat land between coastline mangrove forests/swamps and inland residential areas. The land and water body use around the target site are as follows:

East:	The adjacent land along Queens Road is used for private companies. The residential area (Natabua settlement) is located across the Road, and schools (Natabua Primary School, St. Thomas High School, and Fiji National University) and a hospital (Natabua Health Center) at 1km southeast of the site.
West:	Mangrove forests and mudflat are located right next to the site along the coastline.
South:	Mangrove forests and mudflat are located right next to the site. The proposed expansion area includes mangrove forests and mudflat as well as an informal settlement at south.
North:	Small communities (Saru and Taiperia) are located at north of the existing WWTP with the nearest house at 50 m from the northern site boundary.
Water body:	Local residents occasionally collect crabs and other fish in the mangrove forests. The outfall end for the effluent discharge is 2km offshore, and fishing activities around the point is unknown.

3) Land Acquisition

This priority project requires land acquisition of land adjacent to the existing facility, so a land inventory was prepared based on currently available information such as cadastral maps and site visit, as shown in **APPENDIX 7-7**.

4) Involuntary Resettlement

Naqiroso Settlement, known as an informal settlement, is located to the south of the existing WWTP treatment plant is the informal settlement, and although not large scale, 18 houses are subject to resettlement. MHCD is currently working on formalizing informal settlements, and according to the interview with the Commissioner Western, MHCD, local governments, TLTB and other related organizations are working together to formalize informal settlements and relocate them as necessary.

7-3-3 Scoping

Table 7-3.1 shows scoping results for the Natabua WWTP.

Table 7-3.1 Scoping results for Natabua WWTP

Item			Scoping		Reasons
			Const.	Ope.	
Pollution control	1	Air pollution	X		Const.: Suspended dust and gas emission from the construction machinery are generated in a certain period of time. Ope.: No impacts on air quality are expected.
	2	Water pollution	X	X	Const.: Downstream of the construction area may be temporarily affected by turbid water from the construction work. Ope.: Wastewater treatment at the plant generally contributes to improvement of ambient water quality. On the other hand, low treatment performance of the plant may result in adverse effect on the local ambient water quality.
	3	Waste	X	X	Const.: Waste soil and materials are generated. Ope.: Other than solid waste generated by operators and litter cleanup, sludge from the plant needs to be treated and disposed properly.
	4	Soil and groundwater Contamination	X	X	Const.: Soil contamination may happen caused by oil leakage etc. Ope.: In addition to oil leakage etc., raw sewerage overflow may result in the contamination.
	5	Noise and Vibration	X	X	Const.: Noise and vibration are generated from construction work and machinery. Ope.: Pumps and motors at the plant may generate noise and vibration.
	6	Ground Subsidence			The site location is flat area, and no ground subsidence is expected.
	7	Offensive Odor	X	X	Const.: When rehabilitating the existing treatment plant, offensive odor may be generated due to disturbance of the ongoing operation. Ope. : Improvement offensive odor issues is expected with the proper facility installation and operation. On the other hand, low treatment performance of the plant may generate offensive odor.

Item			Scoping		Reasons
			Const.	**Ope.**	
	8	Bottom Sediment	X	X	Const.: Bottom sediments of the coastal area may be disturbed temporarily due to construction of an outfall pipe. Ope.: The bottom sediment quality in water bodies may be improved together with the better effluent water quality. On the other hand, low treatment performance of the plant may result in the poor bottom sediment quality.
Natural Environment	9	Protected Areas			There are no protected areas in or nearby Lautoka.
Natural Environment	10	Biodiversity	X	X	Const.: Construction work may temporarily disturb the Special Unique Marine Area (SUMA) NVT4 located on shoreline adjacent to the site. Ope.: Poor facility operation may cause degradation of the SUMA.
Natural Environment	11	Hydrology	X		The area is vulnerable to cyclones and monsoonal floods, windstorm, high tides etc., so the facility planning need to take them into account.
Natural Environment	12	Topography and Geographical Features	X		The site is located near coastline where mangrove stands, and mudflat exist so topographical features may be changed.
Social environment	13	Involuntary Resettlement and Land Acquisition	X		Const.: Natabua WWTP expansion and new plant construction need land acquisition and possibly small-scale involuntary resettlement.
Social environment	14	Poverty	X	X	There are informal settlements at southwest of the site and need to be relocated. These informal settlements have to be taken into account carefully by discussing with the local government.
Social environment	15	Minority and Indigenous Peoples			There are no Indigenous Peoples classified by the WB's safeguard policy. iTaukei is legally recognized as the indigenous in Fiji and their traditional culture and custom is respected and protected under the Fijian laws.
Social environment	16	Local Economy (Employment, Livelihood etc.)	X	X	Const.: Land acquisition and involuntary resettlement might give adverse impacts on the affected people's livelihood. Construction work may provide employment opportunities to local people.
Social environment	17	Land Use and Utilization of Local Resources	X	X	Local people who use mangrove stands a mudflat for their foods might be affected by the land development.
Social environment	18	Water Use	X		Const: Construction work may temporarily affect water environment of the sea. Ope: It is expected that better quality of discharged water from the plant will result in improvement of the water environment.
Social environment	19	Existing Social Infrastructure and Services	X		Const.: Construction of the facility may involve traffic disturbance due to increasing construction vehicles in-and-out of the site. Restriction of user's access may occur such as de-tour, and temporary blocking. Power, gas, water lines may be impacted by the construction work as well.
Social environment	20	Social Institutions such as Local Decision-Making Institutions			There is the iTaukei system legally institutionalized in Fiji, and no impacts on decision making process and social institutions are expected.
Social environment	21	Misdistribution of Benefit and Damage / Local Conflict of Interest		X	Poor land acquisition process may result in misdistribution of benefit, and local conflict of interest among community people.
Social environment	22	Cultural Heritage			There are no traditional or cultural sites at the site.

Item			Scoping		Reasons
			Const.	Ope.	
	23	Landscape			The Western Division is a famous tourist destination, so facility designs, and construction work appearance need to be considered.
	24	Gender / Children's Right			No impact on gender or children's right issues is expected, but the consideration may need to be studied considering that schools are located approximately 1km south of the site.
	25	Sanitation and Infectious Diseases (HIV/AIDS)			It is expected that improvement of the treatment system at the plant makes an advanced sanitary environment and reduce risks on infectious diseases.
	26	Work environment (including occupational safety) / Accidents	X	X	Const.: Work environment for construction workers should be considered. Ope.: Gas poisoning and oxygen deficiency may occur during maintenance work, so the working environment for the operators should be considered.
Others	30	Global Warming	X	X	Const.: CO2 emission from heavy equipment for construction work is expected. Ope.: GHG (CH4 and CO) will be generated from the treatment process.

Const.= Before/during construction
Ope. = During operation
Source: JET

7-4 Navakai Wastewater Treatment Plant

7-4-1 Overview

Refer to **CHAPTER 4** .

7-4-2 Current Environmental and Social Conditions

(1) Pollution Control

1) Water Quality Analysis by WAF

WAF's water quality laboratory regularly analyzes the water quality of Nadi River, which is a recipient of the effluent from Navakai WWTP. **APPENDIX 7-4** shows the water quality results for the past two years. Comparing Fecal Coliforms at the discharge point with the upstream and downstream data (excluding the Denarau Bridge, which is quite far away), the value was the highest at the discharge point and lowest at downstream. Although Fecal Coliform is not set in Japanese environmental standards, the results at all points far exceed the Japanese swimmable water criteria[5] of 1,000 MPN/100 mL, which corresponds to "unswimmable."

2) Water Quality Analysis by the Project

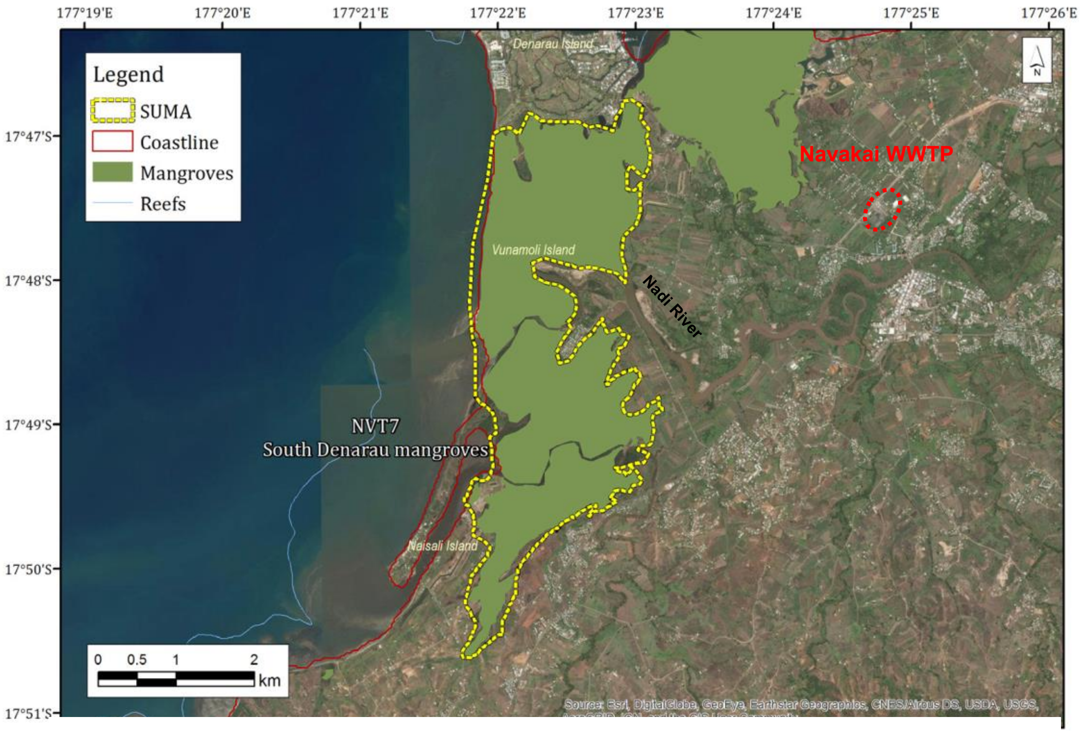
As part of data collection for the EIA preparation, water quality analysis (rainy and dry seasons) was conducted in the surrounding water bodies. The results are shown in **APPENDIX 7-5**. The results are

[5] Ministry of Environment (Japan). Swimmable Water Quality Criteria; https://www.env.go.jp/content/000141595.pdf (Japanese)

generally similar to the WAF's survey data mentioned above.

(2) Natural Environment[6]

There are no designated areas for nature conservation or cultural heritage protection in the vicinity of the target site. However, the estuary of the Nadi River, which receives effluent from the Navakai WWTP, has important marine ecosystems, known as Special Unique Marine Areas (SUMAS) that the DOE and Ministry of Fisheries identified for future marine protected areas (**Figure 7-4.1**).



Biophysical Justification of NVT7: Coastal mangroves and mudflats, river estuaries, seagrass beds, juvenile tiger, hammerhead and blacktip reef sharks and endemic fish.

Source: Biophysically Special, Unique Marine Areas of Fiji

Figure 7-4.1 SUMA location near Navakai WWTP (NVT7: South Denarau Mangroves)

(3) Social Environment

1) Socio-economic Status

Major socio-economic indicators of Nadi, where the Navakai WWTP is located, are shown in **APPENDIX 7-6**.

2) Land Use

The Navakai WWTP is located at the flat land of Nadi, which is a highly developed residential and

6 1) National Biodiversity Strategy and Action Plan for Fiji 2020-2025, and 2) Biophysically Special, Unique Marine Areas of Fiji

commercial area. The land and water body use around the target site is as follows:

East:	There are schools nearby (Nadi Muslim Collage and Natu Navula College adjacent to the site, and Nadi District School located at 200m east), and residential and farmland area of Namotomo Village. The closest hospitals are located in the downtown Nadi, at 500m far from the site.
West:	The land across Wailoaloa Road is used mainly for agriculture with some residential houses.
South:	In the proposed expansion area of the WWTP, there are farmlands with some houses and buildings. A community (Narewa) is located across Narewa Road, where a discharge pipe from the WWTP goes through.
North:	FRA warehouse with lodging houses, and NFA site are located adjacent to the site. There are residential area, commercial facilities, and warehouses across Navakai Road.
Water body:	There is no fishing activity around the outlet of the discharge pipe, but small-scale fishing is carried out in downstream communities near the sea. In addition, residents and children sometimes enjoy swimming at Nadi River.

3) Land Acquisition

This priority project requires land acquisition of land adjacent to the existing facility, so a land inventory was prepared based on currently available information such as cadastral maps and site visit, as shown in **APPENDIX 7-7**.

4) Involuntary Resettlement

The proposed expansion site is mostly vacant land and farmlands, but there are seven houses, and although not large-scale, they will be subject to resettlement. The legal status of these houses and residents needs to be confirmed in future investigations.

7-4-3 Scoping

Table 7-4.1 shows scoping results for the Navakai WWTP.

Table 7-4.1 Scoping results for Navakai WWTP

Item			Scoping		Reasons
			Const.	Ope.	
Pollution control	1	Air pollution	X		Const.: Suspended dust and gas emission from the construction machinery are generated in a certain period of time. Ope.: No impacts on air quality are expected.
	2	Water pollution	X	X	Const.: Downstream of the construction area may be temporarily affected by turbid water from the construction work. Ope.: Wastewater treatment at the plant generally contributes to improvement of ambient water quality. On the other hand, low treatment performance of the plant may result in adverse effect on the local ambient water quality.
	3	Waste	X	X	Const.: Waste soil and materials are generated. Ope.: Other than solid waste generated by operators and litter cleanup, sludge from the plant needs to be treated and disposed properly.
	4	Soil and groundwater Contamination	X	X	Const.: Soil contamination may happen caused by oil leakage etc. Ope.: In addition to oil leakage etc., raw sewerage overflow may result in the contamination.

Item			Scoping		Reasons
			Const.	**Ope.**	
	5	Noise and Vibration	X	X	Const.: Noise and vibration are generated from construction work and machinery. Ope.: Pumps and motors at the plant may generate noise and vibration.
	6	Ground Subsidence			The site location is flat area, and no ground subsidence is expected.
	7	Offensive Odor	X	X	Const.: When rehabilitating the existing treatment plant, offensive odor may be generated due to disturbance of the ongoing operation. Ope: Improvement offensive odor issues is expected with the proper facility installation and operation. On the other hand, low treatment performance of the plant may generate offensive odor.
	8	Bottom Sediment	X	X	Const.: Bottom sediments of the river and the coastal area may be disturbed temporarily due to construction of a discharge pipe. Ope.: The bottom sediment quality in water bodies may be improved together with the better effluent water quality. On the other hand, low treatment performance of the plant may result in the poor bottom sediment quality.
Natural Environment	9	Protected Areas			There are no protected areas in or nearby Nadi.
	10	Biodiversity	X	X	Const.: Construction work may temporarily disturb the Special Unique Marine Area (SUMA) NVT7 located downstream of the site. Ope.: Poor facility operation may cause degradation of the SUMA.
	11	Hydrology	X		The area is vulnerable to cyclones and monsoonal floods, windstorm, high tides etc., so the facility planning need to take them into account.
	12	Topography and Geographical Features			The site is developed land for agriculture and other uses, located inland adjacent to the existing plant, so no topographical changes are expected.
Social environment	13	Involuntary Resettlement and Land Acquisition	X		Const.: Navakai WWTP expansion needs land acquisition with small involuntary resettlement.
	14	Poverty	X	X	There is no informal settlement nearby the site, but the poor may be affected by the land acquisition.
	15	Minority and Indigenous Peoples			There are no Indigenous Peoples classified by the WB's safeguard policy. iTaukei is legally recognized as the indigenous in Fiji and their traditional culture and custom is respected and protected under the Fijian laws.
	16	Local Economy (Employment, Livelihood etc.)	X		Const.: Land acquisition of the agricultural land might affect local people's livelihood. Construction work may provide employment opportunities to local people.
	17	Land Use and Utilization of Local Resources			No adverse impacts on land use land utilization of local resources are expected.
	18	Water Use	X		Const: Construction work may temporarily affect water environment of Nadi River that the neighboring people use. Ope: It is expected that better quality of discharged water from the plant will result in improvement of the water environment.
	19	Existing Social Infrastructure and Services	X		Const.: Construction of a facility may involve traffic disturbance, specifically when constructing a discharge pipe that is buried under roads from the plant. Restriction of user's access may occur such as de-tour, and temporary blocking. Power, gas, water lines

Item			Scoping		Reasons
			Const.	Ope.	
					may be impacted by the construction work as well.
	20	Social Institutions such as Local Decision Making Institutions			There is the iTaukei system legally institutionalized in Fiji, and no impacts on decision making process and social institutions are expected.
	21	Misdistribution of Benefit and Damage / Local Conflict of Interest		X	Poor land acquisition process may result in misdistribution of benefit, and local conflict of interest among community people.
	22	Cultural Heritage			There are no traditional or cultural sites at the site.
	23	Landscape	X		The Western Division, especially Nadi, is a famous tourist destination, so facility designs, and construction work appearance need to be considered.
	24	Gender / Children's Right			No impact on gender or children's right issues is expected, but the consideration may need to be studied considering that schools are located at the southeast of the site.
	25	Sanitation and Infectious Diseases (HIV/AIDS)			It is expected that improvement of the treatment system at the plant makes an advanced sanitary environment and reduce risks on infectious diseases.
	26	Work environment (including occupational safety) / Accidents	X	X	Const.: Work environment for construction workers should be considered. Ope.: Gas poisoning and oxygen deficiency may occur during maintenance work, so the working environment for the operators should be considered.
Others	30	Global Warming	X	X	Const.: CO2 emission from heavy equipment for construction work is expected. Ope.: GHG (CH4 and CO) will be generated from the treatment process.

Const.= Before/during construction
Ope.= During operation
Source: JET

7-5 Stakeholder Meetings

7-5-1 Stakeholder Meetings at Scoping Stage

As a result of discussions with WAF in carrying out the Pre-F/S, individual consultations were conducted with WAF for key stakeholders such as government agencies and local governments that have jurisdiction over the target areas in order to share more specific information and identify concerns in the implementation of the priority projects. The major discussions include the upgrade plan of the treatment plants as well as land acquisition of the neighboring areas, and variety of comments were received. In particular, the neighboring village who is the landowner of the expansion area is planning to use their land for the village expansion, NTC and related agencies were participated in the discussion. **APPENDIX 7-9** shows the meeting minutes.

Table 7-5.1 Stakeholder meeting summary (at scoping stage)

Date	Contents	Participated stakeholders
April 24, 2024	Priority project overview and discussions with MRMD	・Commissioner Western, Ministry of Rural and Maritime Development and Disaster Management (MRMD) ・Divisional Planning Officer, MRMD ・Provincial Office Lautoka, MRMD ・District Office Lautoka/Yasawa, MRMD ・District Office Nadi, MRMD
April 24, 2024	Priority project overview and discussions with LCC	・Chief Executive Officer, LCC ・Acting Manager Building/Engineering Services, LCC ・Team Leader Assets, LCC ・Acting Head of Services, LCC ・Acting Director Building/Engineering Services, LCC ・Health Department Officer, LCC
April 24, 2024	Priority project overview and discussions with NTC and related parties	・Estate Assistant (Operation), TLTB ・Principal Town Planner, DTCP Lautoka ・Acting CEO, NTC ・Building Inspector, NTC ・Manager Com. Service, NTC ・Planning & Engineering Officer, NTC ・Special Administrator, NTC
May 27, 2024	Priority project overview and discussions with DOL	・Assistant Director, DOL ・Officers, Land Use Planning & Development Team, DOL
May 27, 2024	Priority project overview and discussions with National Fire Authority (NFA)	・Manager, NFA
July 22, 2024	Priority project overview and discussions with Nadi Airport agencies	・Representatives from Airport Fiji Limited (AFL) ・Representatives from Civil Aviation Authority of Fiji (CAAF)
July 22, 2024	Community meetings for the Navakai plant	・Representatives, NTC ・Representative, District Office Nadi ・Representative, Ba Provincial Office ・Representative, DTCP ・Senior Estate Officer, TLTB ・Estate Assistant, TLTB ・Representatives of Navoci Village

Source: JET

7-5-2 Stakeholder Meetings at DFR Stage

A workshop was held on August 1, 2024, for stakeholders involved in the priority projects to inform them of the Pre-F/S study results and to solicit their comments . In the workshop, 60 people were participated including the central and local government officials, community representatives of the treatment plants, the public service providers, hotel and resort industry related groups. The participants inquired and commented on not only land acquisition and candidate site alternatives, but also illegal connections, odor measures, energy saving of the plants, and ambient water quality. The necessity of the plant update was well understood by the participants although land issues remain, and WAF committed to continue to discuss and coordinate with the stakeholders. **APPENDIX 7-10** shows the meeting minutes.

7-6 Recommendations for the F/S Study

At the F/S stage of each priority project, an EIA (including a social impact assessment) will be prepared to obtain the environmental clearance. Taking into account the environmental and social characteristics clarified in this Pre-F/S, the following surveys and activities should be implemented in particular

<u>Environmental aspects</u>

- Mangrove impact assessment around the effluent discharge point and its vicinity
- Dispersion modeling and assessment of the effluent

<u>Social aspects</u>

- Public consultations for all stakeholders including the landowners and local residents
- Socio-economic impact assessment of the affected people
- Presence or absence of fishery rights around the discharge point and its downstream (with confirmation with DOL, DOF, and iTLFC)
- Fishery impact assessment for the traditional fishing ground (Qoliqoli area) for setting compensation
- All asset valuation for land acquisition, lease, and easement setting
- Consultations for the resettlement, and preparation of the RAP and livelihood restoration program

CHAPTER 8 PROJECT EFFCT

8-1 Quantitative Effect

8-1-1 Operation and Effect Indicators

Generally, the sewerage population coverage rate and improvement on water quality are used as effect indicators. In this project, the sewerage population coverage rate is used as the effect indicator. The operational indicator will be set as the WWTP's treated water flowrate and treated population.

The measurement and calculation of each operation and effect indicator are as follows:

- WWTP effluent water quality (BOD_5, TSS): Measured at the effluent outflow channel
- Treated water flowrate: Measured using a flowmeter installed at the WWTP
- Treated population: Calculated based on the treated water flowrate and equivalent unit wastewater flow

(1) Target Value of Indicators

The target value of the indicators is expected to be achieved two years after the new WWTP facilities commence their operation; 2037 for Natabua WWTP, and 2040 for Navakai WWTP. Each indicator and its target are listed in **Table 8-1.1**.

Table 8-1.1 Operation and Effect Indicator Target Values

WWTP	Indicator	Current (2024)	Target Value
Natabua	Effluent quality (mg/L)	BOD_5 : 35、TSS : 27	$BOD_5 \leqq 40$、$TSS \leqq 60$
	Effluent standard compliance rate (%)	BOD_5 : 62.5%、TSS : 87.5%	BOD_5 : 100%、TSS : 100%
	Daily average flowrate (m^3/day)	10,800 (Estimated value from revenue water)	26,800
	Treated Population (people)	54,000	134,000
Navakai	Effluent quality (mg/L)	BOD_5 : 60、TSS : 91	$BOD_5 \leqq 20$、$TSS \leqq 30$
	Effluent standard compliance rate (%)	BOD_5 : 40%、TSS : 62.5%	BOD_5 : 100%、TSS : 100%
	Daily average flowrate (m^3/day)	8,800 (Estimated value from revenue water)	17,900
	Treated Population (people)	44,000	89,000

Source: JET

(2) Measuring Indicators

The effluent water quality will be sampled at the outflow point of the disinfection tank. The average daily flowrate of treated water will be automatically recorded by the flowmeter installed at the WWTP. The treated population will be calculated from the treated water flowrate, assuming the conversion ratio to be 5 people per 1 m^3/day treated water

8-2 Financial Analysis

In economic and financial analysis, the internal rate of return (IRR) is calculated and analyzed. Financial analysis measures the financial profitability of the project for the implementing agency. On the other hand, economic analysis measures the degree of efficiency in resource allocation in the national economy.

8-2-1 Preposition for economic and financial analysis

(1) With Project and Without Project

- With Project Case

  The project is implemented. Wastewater treatment capacity and number of connections are increased. The wastewater treatment system is improved and expanded.

- Without Project Case

  The project is not implemented. Wastewater treatment capacity and number of connections remain as they are.

(2) Incremental Analysis

Compare the implementation of the project (With Project) with the standard of not implementing the project (Without Project). Financial evaluation is based on expenditures and revenues related to implementation, and economic evaluation is based on the increment in costs and benefits related to implementation, and IRR is measured as the increment in costs and benefits.[7]

(3) Analysis Period

The analysis period is 26 years from 2028 to 2053.

(4) Average Treated Water Volume, Construction Period/Connection Preparation Period for WWTPs, Sewer Pipes and Pump Stations

The average treated water volume and construction period for the WTP to be constructed in Lautoka and Nadi are shown in **Table 8-2.1**.

Table 8-2.1 Average Treated Water Volume and Construction Period of WWTPs

Municipality	Place	Average Treated Water (m^3/day)	Plant, Pipe, Pump Construction Period (year)
Lautoka	Natabua	30,325	2033-2036
Nadi	Navakai	18,011	2028-2032

Source: JET

(5) Number of Connected and Non-connected Residential/Business customers

The number of connected and non-connected residential and business customers is shown in **Table 8-2.2**

[7] The cash flow table used in the evaluation is shown in the Appendix.

below.

Table 8-2.2 Number of Connected and Non-connected Residentias/Business Customers

Year	Household Connected	Business Connected	Household Not Connected	Business Not Connected
2028	11,111	2,678	43,220	10,417
2029	11,111	2,678	43,220	10,417
2030	11,111	2,678	43,220	10,417
2031	11,111	2,678	43,220	10,417
2032	11,111	2,678	43,220	10,417
2033	11,889	2,937	40,960	10,119
2034	12,889	3,269	39,631	10,052
2035	14,706	3,873	39,625	10,436
2036	14,706	3,873	39,625	10,436
2037	14,706	3,873	39,625	10,436
2038	17,817	4,449	35,192	8,787
2039	21,817	5,189	32,514	7,733
2040	25,416	5,855	28,916	6,661
2041	25,416	5,855	28,916	6,661
2042	25,416	5,855	28,916	6,661
2043	25,416	5,855	28,916	6,661
2044	25,416	5,855	28,916	6,661
2045	25,416	5,855	28,916	6,661
2046	25,416	5,855	28,916	6,661
2047	25,416	5,855	28,916	6,661
2048	25,416	14,304	28,916	6,661
2049	25,416	14,304	28,916	6,661
2050	25,416	14,304	28,916	6,661
2051	25,416	14,304	28,916	6,661
2052	25,416	14,304	28,916	6,661
2053	25,416	14,304	28,916	6,661

Source: JET

8-2-2 Expenditure

(1) Wastewater Treatment Plants Expenditure

The project costs are shown in **Table 8-2.3** Expenditures include construction costs, consultant fees, land acquisition costs, physical contingency, management fees, and taxes. Price contingency and interest during construction are not included.

Table 8-2.3 Expenditure for WWTP

(Units: 1000FJD)

Year	2028	2029	2030	2031	2032	2033	2034	2035	2036
Construction Cost	0	0	45,604	45,604	45,604	65,214	65,214	65,214	65,214
Consulting Service	22,460	22,460	0	0	0	0	0	0	0
Land Acquisition	0	38,681	0	0	0	0	0	0	0
Administration Cost	1,123	3,057	2,280	2,280	2,280	3,261	3,261	3,261	3,261
Tax	6,738	12,540	12,318	12,318	12,318	17,612	17,612	17,612	17,612
Total Project Cost	30,320	76,737	60,202	60,202	60,202	86,087	86,087	86,087	86,087

Source: JET

(2) Sewer Pipes/Pump Stations Construction Expenditure

The Pre-F/S did not include expenditure estimates for sewer pipes and pumping stations. The expenditure is used by calculated figure in the Municipal Sewerage M/P [8] (**Table 8-2.4)**.

Table 8-2.4 Construction Expenditure for Sewer Pipes and Pump Stations

(Units: 1000FJD)

Municipality	Sewer Pipes	Pump Station
Lautoka	225,475	30,871
Nadi	265,300	34,377

Source: JET

(3) Operation and Maintenance (O&M) Expenditure

The operation and maintenance (O&M) expenditure [9] for each facility are shown in **Table 8-2.5**.

Table 8-2.5 O&M Expenditure for Facilities

(Units: 1000FJD)

Municipality	WWTP	Pipes	Pump Station
Lautoka	3,698	155	2,387
Nadi	3,486	174	2,735

Source: JET

(4) Salvage Value

The salvage value of capital goods that can be used continuously in the final year and beyond, or that can be diverted to other uses, is recorded as a negative expense in the final year. The value is calculated by the following formula by applying the straight-line method (assuming scrap value = 10% of the initial investment).

- Salvage Value＝ CAPEX of asset facility/equipment ×（1.0-0.9 ×years of use ÷ Depreciation period based on statutory useful life[10].

The Salvage values of the treatment plants, sewer systems, and equipment are shown in **Table 8-2.6**.

[8] Calculations were made using the cost ratios of Navakai x 0.667, Natabua x 0.75 for Municipal Sewerage M/P.
[9] Reference was made to Japan's domestic cost functions and the Prefectural Wastewater Plan Development Manual in accordance with the guidelines of the Ministry of Land, Infrastructure, Transport and Tourism,
[10] The usable period was set at 50 years for civil engineering and architectural facilities and sewerage systems, and 15 years for mechanical and electrical equipment.

Table 8-2.6 Salvage Value

(Units: 1000FJD)

WWTP	CAPEX category	CAPEX	Period in Use (year)	Salvage Value
Natabua	C/A (WTP, pipe & pump)	466,818	16	332,374
	M/E	132,161	15	13,216
	Land	1,716	-	1,716
	Total	600,695		347,307
Navakai	C/A (WTP, pipe & pump)	470,136	20	300,887
	M/E	115,238	15	11,524
	Land	21,307	-	21,307
	Total	606,681		333,718

* C/A ＝ Civil/Architecture, M/E=Mechanical/Electrical
Source: JET

8-2-3 Revenue

(1) Wastewater Sales Revenue

Incremental wastewater treatment volume is calculated as revenue. The annual increment is calculated using the following formula. The amount of processing during the connection preparation period is proportional to the connection rate.

- Increased annual sewerage revenue = (amount treated from the project implementation – amount treated before project implementation) x sewerage tariff (FJD/m^3)
- Amount of water treated per day before project implementation [11] ： 15,600 m^3
- Current tariff: 0.20 FJD/m^3

(2) New Connection Service Revenue

Revenue from new connection service is calculated by the following formula.

- Revenue from new connection charge = Increment of new connection x Application Fee
- Application fee per customer: Household 22 FJD, Business customer 101 FJD

(3) Sludge Acceptance Service Revenue

Revenue related to sludge accepted from unconnected households and businesses is calculated using the following formula.

- Revenue related to sludge accepted = Number of sludge acceptance per year x Sludge acceptance fee
- Fee for Sludge acceptance[12] ： Household 12 FJD (every 5 years), Business Customer 12 FJD (every year)

[11] WAF internal documentation/data is referred
[12] The disposal fee per household was calculated and Regional Wastewater M/P

8-2-4 Results of Financial Analysis

(1) Financial Internal Rate of Return: FIRR

The calculated FIRR is a negative return of minus 2.8%.

A sensitivity analysis will not be performed as the FIRR under the base scenario is a negative return.

(2) Financial Feasibility

The implementation of the project is not justified from the perspective of financial profitability for the project implementing body.

8-3 Economic Analysis

8-3-1 Costs

(1) Project Cost

Taxes and other transfer payments that do not directly affect the increase or decrease of national wealth are not included in the economic costs. The project costs in the economic analysis are calculated by deducting land acquisition costs and various taxes from the costs shown in the financial analysis.

(2) O&M Cost

The O&M costs calculated in the financial analysis are considered as non-traded goods and are multiplied by the standard conversion factor (SCF)[13] of 0.96 to calculate the cost.

(3) Salvage Value

The salvage value of the project facilities that calculated through financial analysis is treated as a negative cost.

8-3-2 Benefits

Some of data for benefit calculation was collected from interviews conducted in Nadi and Lautoka, details of which are given in **APPENDIX 8-2**.

(1) Benefits for Sewerage Service Users

User benefits are calculated based on the incremental wastewater usage and willingness to pay (WTP). [14]

- Annual user benefit = (Average daily wastewater volume by the project– Daily treated water volume before the project implementation) x WTP /m^3

[13] Standard conversion factor (SCF) was calculated in the M/P

[14] WTP was calculated based on the average WTP/month from the interview survey and the average sewerage usage fee per household

- WTP: 0.69 FJD/m^3

(2) Benefits of Reduced Costs for Installing/Managing Septic Tanks

The reduction in costs for installing septic tanks, pumping out septic tanks, and space for septic tanks, which becomes unnecessary as a result of connecting to sewer network,[15] is calculated as a user benefit.

- Benefit = increase in the number of connections x (septic tank installation cost + bailing cost)
- Installment cost for sceptic tank:
  Household 8,800 FJD/house ÷ 20 years of use = 440 FJD/year,
  Business customer 8,800 FJD/business x 2 ÷ 20 years of use = 880 FJD/year
- Bailing cost of sceptic tank:
  Household 300 FJD/every 5 years = 60 FJD/year
  Business customer 600 FJD/every year = 600 FJD/year
- Installation space cost:
- General Household 1,400 FJD/year
- Business 2,800 FJD/year

(3) Benefits of Reduced Medical Expenses

Improving the water quality environment through sewerage system construction reduces the cost of visiting hospitals and treating diarrhea. The amount of reduced medical expenses [16] is calculated as the user benefit.

- Benefit = Increase in number of users x cost of diarrhea-related treatment
- Treatment cost: 11 FJD/year per average household

(4) Benefits of Water Environment Protection

The willingness to pay (hereinafter referred to as “WTP”) for environmental protection through improved water quality[17] is calculated as the benefit.

- Benefit = Increase in number of connections x WTP for environmental protection
- WTP for environmental protection: 65 FJD/year per household

(5) Benefits to the Operator from New Connections

The benefits to the operator are the revenues from new connections and sludge acceptance calculated in the financial analysis.

[15] Based on septic tank related costs from M/P
[16] Annual average medical expenses per household based on survey results
[17] Annual average WTP for environmental protection per household based on survey results

(6) Benefits from Retained Tourism Revenues

The implementation of the project will prevent deterioration of environmental water quality and prevent a decrease in tourism revenues due to environmental degradation. Benefits will be calculated based on tourism revenues in 2023 in Nadi and Lautoka, the target areas of the project (**Table 8-3.1**). Accumulated benefits will increase by 0.5% each year, with a maximum cap of 10% per year.

Table 8-3.1 Benefits from Preventing a Decline in Tourism Revenue

Benefit from Tourism	(1000 FJD)	Ratio
Earnings from Fiji Tourism 2023	2,367,700	
Earnings in Nadi	828,695	35%
Earnings in Lautoka	71,031	3%
Tourism Earnings in Nadi & Lautoka	899,726	
Benefit, cumulative annually	4,499	0.50%

Source: JET

8-3-3 Results of Economic Analysis

(1) Economic Internal Rate of Return: EIRR

The EIRR from the implementation of this project is plus 9.0%.

The implementation standard [18] for projects such as preventing environmental pollution, reducing poverty in rural areas, and combating natural damage is set at 6.0%. The EIRR from the implementation of this project exceeds this standard. Sensitivity analysis of EIRR

A sensitivity analysis of benefits relative to changes in costs is shown in **Table 8-3.2** below. Even if benefits are held constant and costs rise by 20% from the base scenario, the EIRR will be over 7%, exceeding the implementation target.

Table 8-3.2 EIRR Sensitivity Analysis for Cost Changes

Cost	Down 20%	Down 10%	Unchanged	Up 10%	Up 20%
EIRR	11.5%	10.1%	9.0%	8.1%	7.2%

Source: JET

(2) Economic Feasibility of the Project

The project implementation is feasible. The efficiency of resource allocation in the Fiji national economy is high.

8-3-4 Project Financing and Repayment

(1) Financing

Fiji, being a small island developing state (SIDS), can consider utilizing concessional loans[19] from the Asian

[18] Based on the Asian Development Bank's Cost-Benefit Manual (2017).
[19] Ordinary Capital Resources: OCR blend lending, etc.

Development Bank and other aid agencies for long-term low-interest loans for the environmental sector.

Funds are needed to implement the project, and the capital investment required is approximately 1.2 billion Fijian dollars. This amount, which accounts for 30% of the annual expenditure budget, is too large to be covered by tax revenues alone. Domestic and international investment and loans are required to cover the project costs, but it will be difficult to raise a sufficient amount through government or private investment alone. Therefore, financing through loans borrowing is essential, and priority should be given to utilizing concessional loans from international aid agencies, which have favorable terms for the Fiji government.

(2) Repayment of Funds

If the project costs are raised through loans, an adequate tariff fee level is required to secure sufficient revenue to repay the loans. The tariff level required for each loan ratio is shown in **Table 8-3.3** below.

When the loan ratio is 100%, the required tariff is 4.0 FJD/m^3, which is unrealistic when compared with the current tariff. When the loan ratio is 50%, the tariff is 1.5 FJD/m^3, which is still significantly higher than the current tariff. In either case, debt repayment requires keeping the loan ratio low and setting tariff higher that reflect the cost of wastewater service.

Table 8-3.3 Level of Tariff Required for Loan Repayment

Debt Ratio	100%	80%	50%
Required Tariff for repayment (FJD/m^3)	4.0	3.0	1.5

Source: JET

8-3-5 Other Qualitative Evaluations and Recommendations

(1) Tariff Increase

Interviews with residents show that their willingness to pay (WTP) for sewerage charges is much higher than the current tariff. The government and WAF should implement a tariff increase with the understanding of users.

Sewerage services are a highly public service that is essential for improving public hygiene, and for business operators, profitability is not everything. However, in order to make this project feasible, generating revenues that can at least cover O&M costs are crucial, so revenues through a tariff increase of at least 0.72 FJD/m^3 is required. Furthermore, further rate increases will be necessary when repayment of project loans is also taken into account.

(2) Independent Operation and Financing

Sewerage services are based on the principle of user fees and the application of the cost principle, meaning that the necessary operating expenses are covered by fee revenues.

WAF's operating funds are not sufficient from fee revenues, and it operates on the premise of receiving government budgets and subsidies. WAF should aim to operate its business financially independent of the government based on the cost principle.

8-4 Qualitative Effects

In previous sections, the quantitative effects of the project were explained; this section will summarize the major quantitative effects that are expected by the implementation of this project, as follows:

- Reduction of absenteeism from workplaces due to sickness
- Increase in agricultural/fishery productivity
- Increase in land value

(1) Reduction of Absenteeism from Work due to Sickness

By providing properly treated water to areas downstream of the WWTP discharge points, the number of patients infected by waterborne diseases (diarrhea, infectious gastroenteritis, indigestion, dysentery, etc.) is expected to decrease. Along with the improvement of public hygiene, this reduction of patients/absenteeism from workplaces is one of the expected effects of this projects; however, since it is difficult to quantitatively estimate the correlation between the project implementation and the decrease in the absenteeism, this is considered to be a qualitative effect.

(2) Increase in Fishery Productivity

Fishermen living along the coast downstream of the WWTP discharge point can utilize the properly treated water, eventually leading to increased productivity of their livelihood. This increase can be considered as one of the expected effects of the project, but since it is difficult to collect/analyze this productivity data, it will be regarded as a qualitative effect.

(3) Increase in Land Value

By providing properly treated water to the areas downstream of the WWTP discharge point, public hygiene improves in the area, possible leading to the increase in land value. This is one of the important ripple effects brought forth by the development/installation of sewerage systems. However, it is difficult to estimate the correlation between the project implementation and land value increase, as well as quantify its effects as benefits in the economic analysis. Therefore, this is also considered as a qualitative effect in this project.

CHAPTER 9 CONCLUSION AND RECCOMENDATIONS

9-1 Conclusion

The Nadi-Lautoka region will account for approximately 40% of the population of Viti Levu's Western Division as of 2023, and is one of Fiji's leading tourist destinations. However, inadequately treated sewerage that does not meet Fiji's effluent standards is discharged into coastal areas of Viti Levu. This project will properly treat this untreated wastewater, improving the water quality of the coastal waters and allowing for the continued development of tourism in Fiji, which has abundant tourism resources.

This project is considered to contribute to the sustainable economic development of Nadi-Lautoka by reducing water pollution in public waters and improving public hygiene. This project is also in line with Fiji's National Development Plan and the Japanese government's aid policy for Fiji.

9-2 Sustainability

Project impacts will be sustainable through (i) the use of innovative technologies appropriate to the conditions in the Nadi-Lautoka region, (ii) efforts to build O&M capacity, (iii) an appropriate wastewater tariff structure, and (iv) the development and implementation of an appropriate sludge reuse and disposal plan.

(1) Sustainability of the Project

The proposed Navakai and Natabua WWTPs will be directly managed by WAF in the initial phase of operation. Since WAF already operates and maintains the existing WWTPs, there should be no technical problems if the number of maintenance personnel for the WWTP is increased, and they are properly trained. In addition, while outsourcing maintenance to the private sector is an option, financial decisions (including possible considerations to increase tariffs) are required as the maintenance costs will be higher than if the WWTP is managed directly by WAF. In addition to the income from sewerage tariffs, one proposal is to collect it from tourists in the name of an environmental tax to compensate for the operating costs of the sewerage project.

The Navakai and Natabua WWTPs proposed in this Pre-F/S also include a sludge storage space in the WWTP's boundary. This will ensure that there will be no problems with the disposal of sludge from the WWTP for the time being, but this sludge storage space approach is only a physical response. For fundamental improvement, it is necessary to formulate and implement a plan for the effective use and disposal of sludge.

(2) Financial sustainability

With public financial support, such as debt repayments from MOF, WAF has operated a number of projects related to the construction of water supply and sanitation facilities in Fiji with little disruption. However, WAF has posted deficits in its financial management in the last three years. Consequently, payments for these losses are covered as borrowings by MOF. Therefore, it could be vulnerable for WAF to ensure funds, especially liquidity at hand.

9-3 Recommendations

The recommendations for the implementation of the priority projects identified in this Pre-F/S are as follows.

(1) Consultation on the WWTP site

WAF needs to conduct awareness-raising activities on the importance of the WWTP, deepen understanding of the project objectives, and expedite the land acquisition process. In order to identify the site for the Natabua WWTP and Navakai WWTP, it is necessary to conduct sufficient consultations with relevant parties after evaluating potential relocation issues and studying the negotiation/acquisition process for the land of existing residential areas.

(2) Formulation of the Effective Sludge Utilization and Disposal Plan

WWTP planned in the Pre-F/S have a sludge storage space within its site boundaries. Obviously, a large area is required for a sludge storage area, which is also a factor that increases the construction cost of WWTP. Ideally, it would be desirable to find an effective way to utilize the dried sludge or to dispose of the sludge in an off-site landfill. To achieve this, it is necessary to formulate an effective utilization and disposal plan. A realistic approach would be to formulate a plan for the effective use and disposal of sludge through programs such as JICA Technical Cooperation Projects.

In addition, this Pre-F/S collected sludge from the Natabua and Navakai WWTPs and analyzed its components. The results of the analysis were compared with the standards for sludge disposal/effective use set by WHO, US EPA, Australian Water Association (AWA), EU, Japan Sewerage Works Association, etc. The following points were found as a reference of reuse methods on the sludge generated at Natabua and Navakai WWTPs when each standard value was used as a reference (**APPENDIX 9-1**).

- Although there are limitations on long-term use, it can be used as a fertilizer or conditioner for green spaces.
- Although there are some limitations, it can be effectively used and recycled without adversely affecting agricultural products, the natural environment, and human health.

- It can be disposed of in landfills without liner sheets or leachate collection and treatment systems.

The relatively high concentrations of copper and zinc may be the result of higher concentrations in the natural soil of Fiji, a volcanic island, which may have been introduced through sewer pipe infiltration of groundwater. For this reason, it is recommended that the composition of surrounding soil samples be analyzed along with the sludge and that the results be considered in setting future sludge disposal or effective utilization standards in Fiji.

(3) Consideration of the Water Quality Impacts on the Discharge Ocean Area in the Feasibility Study

Regarding the basic data required for the environmental impact assessment, it is necessary to organize the items to be studied in the implementation of the F/S with reference to the Kinoya WWTP, which has already been studied. In order to study the effects of discharging treated water through the ocean outfall pipe to the destination waters, actual data such as water quality surveys of the inflowing rivers/discharge area, current tidal surveys, etc. will be required. In addition, it will be necessary to formulate a simulation model of the sea area that can describe the water quality obtained from these data.

After formulating the simulation model, it will be necessary to quantitatively estimate the extent to which the volume and quality of water discharged from the WWTP will affect the water quality of the surrounding sea areas.

(4) Additional Soil Surveys During the Feasibility Study

In the outline design of the Pre-F/S, two boring surveys were conducted at each WWTP. Although boring surveys were conducted at the existing WWTP site in Natabua, most of the facilities in the Phase 1 will be constructed outside the existing WWTP site. During the design of the feasibility study, borehole survey will need to be conducted at the expanded south of existing site. The same is true for the Navakai WWTP, where additional boring will be required in the expanded area east of the existing site.

(5) Septage Treatment

There are many residents in the surrounding areas of the target service area who will not receive sewerage services. WAF will provide the benefits of sewerage services to the target service area through this project, as well as accept sludge from outside the sewerage service area and treat it at the Natabua WWTP.

(6) Secure the O&M Budget

In the Municipal Sewerage M/P and Pre-F/S, it became clear that in order to cover the O&M costs of the sewerage facilities with sewerage tariffs, the current tariffs would have to be four times higher. Increasing sewerage tariff is difficult as a national policy, but if it is to be implemented, the burden on beneficiaries must be taken into account such as a step-wised increase. WAF and MOF need to hold thorough discussions to ensure that necessary O&M costs are secured from the national budget. In addition to the income from sewerage tariffs, one proposal is to collect environmental taxes from tourists to compensate for the O&M cost of sewerage systems.

(7) Organizational Structure on O&M

1) WWTP

Navakai WWTP in Nadi, which is currently the only one among the existing four WWTPs in the Western Division that uses a mechanical wastewater treatment process, is unable to comply with the effluent standards due to insufficient treatment capacity for inflow sewerage. In addition, due to the lack of budget and equipment for O&M, the facilities are severely deteriorated, making it difficult to carry out appropriate O&M.

In the future, the introduction of mechanical wastewater treatment such as OD process and TF process into all five WWTPs in Nadi and Lautoka is proposed in the Municipal Sewerage M/P, and it is essential to secure the O&M budget/equipment.

In order to implement appropriate O&M at WWTPs to be constructed in the future, first of all it is necessary to secure O&M budget for the current Navakai WWTP, followed by WWTP staff capacity building, and implementation of appropriate O&M. Such capacity building is difficult to implement at WAF, and it would be effective, for example, to strengthen capacity through JICA Technical Cooperation Project and to build an appropriate O&M system for the newly constructed WWTPs.

2) Water Quality Laboratory

In Fiji, the wastewater discharge standards are set for hazardous substances such as heavy metals and cyanide as well as for general substances such as BOD and SS. However, due to the lack of analytical equipment, the water quality laboratory of WAF is not able to properly analyze all the substances, and the heavy metals in the sludge cannot be analyzed at all. Therefore, it is essential to prepare analytical equipment for the laboratory and strengthen the capacity of the laboratory staff for the wastewater quality and sludge management, and regulation of liquid trade waste. It will be effective to prepare the necessary equipment and materials through JICA Technical Cooperation Project and to strengthen the capacity of the staff.

3) Mechanical and Electrical Equipment

Currently, the mechanical and electrical team is in charge of the maintenance of the mechanical and electrical equipment at all water supply and sewerage facilities in the Western Division. However, the team has implemented only visual inspection of pumps and repair of some equipment, leading to the rapid aging/deterioration of equipment.

The reasons are as follows:

i. It is difficult to secure the necessary number of personnel for maintenance due to the outflow of appropriate personnel overseas.
ii. Budget, necessary materials and consumables to implement preventive/predictive maintenance of equipment is not prepared.
iii. Periodical maintenance of equipment by manufacturers has not been implemented due to budget shortages.

In order to improve this situation, first of all, what is the most important is to secure a budget for equipment maintenance. In addition, so that maintenance can be carried out with a small number of staff, it is important to establish a system that the pipe maintenance team and the operation team in WWTPs carry out visual inspections of the equipment, and the mechanical and electrical team conducts daily and periodical inspections such as grease/oil and spare parts replacement. To maintain stable wastewater treatment, periodic maintenance by manufacturers is important, preventing equipment breakdowns and extending equipment lifespan; prompt emergency repairs in the event of breakdowns are also essential. It is common to outsource maintenance and repair of complex equipment to manufacturers/maintenance companies, since they often cannot be directly handled by WAF M/E staff. In addition to budget-securing, WAF must implement measures to smoothly and promptly conclude contracts with such companies.

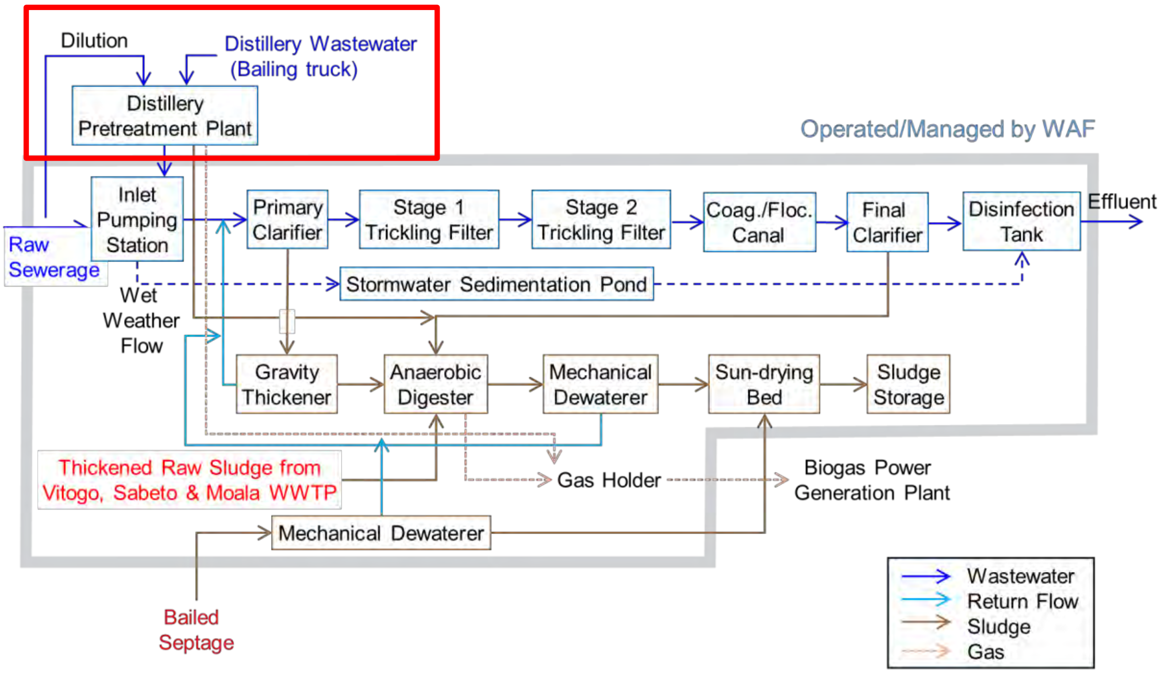
APPENDIX

APPENDIX 3-1 Examinations/Estimations of the Distillery Pretreatment Plant

(1) Overview

For the Pre-F/S, WAF requested to take into consideration a pretreatment plant treating liquid trade waste bailed in from South Pacific Distilleries Ltd., a local distillery brewing rum and other liquors. Currently the distillery's liquid waste is bailed to a receival pit located next to Natabua WWTP. The pit's waste merges with the treated effluent from Natabua WWTP through a pipeline, eventually discharged to the ocean through an ocean outfall pipe. Since the waste is released into the environment without any type of treatment, WAF recognized the proper pretreatment of distillery waste as an urgent issue to be dealt with, setting the construction of the Distillery Pretreatment Plant (hereinafter referred as "Pretreatment Plant") to be at the same time period as Natabua WWTP's Phase 1 Facilities.

Figure A3-1.1 shows the flow of the Pretreatment's influent and effluent. Since the plant's treatment target is trade waste, it was agreed that the Pretreatment Plant itself was not to be included in the scope of the project. However, since the plant's pretreated effluent and sludge was requested to be further treated by Natabua WWTP's treatment system, a simplified examination of the Pretreatment Plant was done to estimate the expected quality and quantity of wastewater/sludge to be received by Natabua WWTP.



Source: JET

Figure A3-1.1 Natabua WWTP Treatment Flow Diagram

(2) Influent Water Quality Parameters

Unfortunately, South Pacific Distilleries Ltd. did not respond to the data request for their distillery waste. As a substitute, multiple literature references were looked into to assume the water quality of wastewater to be bailed to the Pretreatment Plant (**Table A3-1.1**).

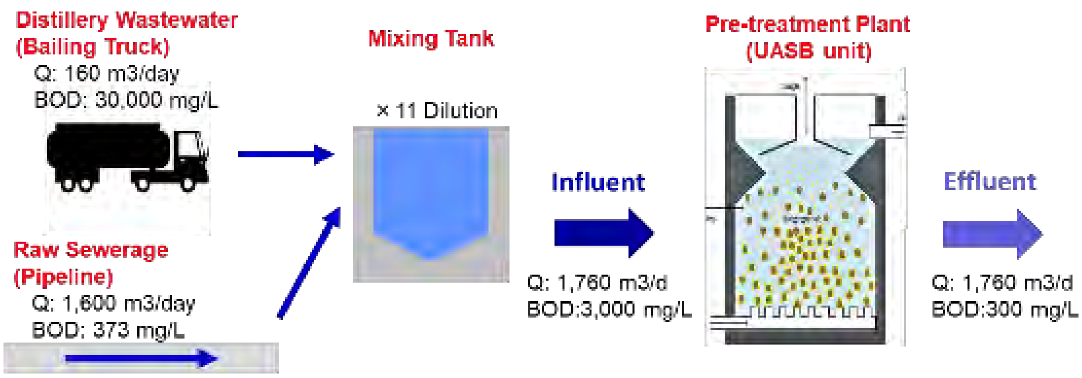
Table A3-1.1 Distillery Wastewater Quality*

Data Set	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
Data Range from References	24,652-50,000	2,400-5,000	1,148-4,200	225-308

Source: Created by JET based on below references

1. Mikucka, W., Zielińska, M. Distillery Stillage: Characteristics, Treatment, and Valorization. *Appl Biochem Biotechnol Vol.192*, 770–793 (2020). https://doi.org/10.1007/s12010-020-03343-5
2. Manyuchi M.M., Mbohwa C., Muzenda E.: Biological treatment of distillery wastewater by application of the vermifiltration technology. *South African Journal of Chemical Engineering Vol 25*, 74-78 (2018). https://www.sciencedirect.com/science/article/pii/S1026918517300707?ref=pdf_download&fr=RR-2&rr= 83be3dc6cfdaaf25
3. Patel, S.: Treatment of Distillery Waste Water: A Review. *International Journal of Theoretical & Applied Sciences Vol. 10*, 117-139 (2018). https://www.researchgate.net/publication/324551084_Treatment_of_Distillery_Waste_Water _ A_ Review? enrichId=rgreqbfe7f600eeb85f550bf8b6240d96e74eXXX&enrichSource=Y292ZXJQYWdlOzMyNDU1MTA4NDtBUzo2MTYyMDA5MzM0OTQ3ODVAMTUyMzkyNTE1OTEyNA%3D%3D&el=1_x_2

WAF's original proposal was to dilute the distillery wastewater with raw sewerage, which enters a UASB (Upflow Anaerobic Sludge Blanket) unit, estimating an effluent BOD of 300 mg/L. Setting a hypothetical influent BOD of 30,000 mg/L, and assuming the UASB unit's BOD removal rate to be 90%, the distillery waste's dilution rate was set to x11.



Source: Created by JET

Figure A3-1.2 Distillery Wastewater Dilution and Pretreatment based on WAF Initial Proposal

Since these water quality and flowrate data are based off literature references and assumed values provided by WAF, it is strongly advised to collect past distillery wastewater data from South Pacific Distilleries Ltd. Sampling and analysis by WAF is also strongly recommended to verify the accuracy of the provided data. If no past data exists, sampling and analysis should be done monthly for at least three years to study seasonal variations and to eliminate possibilities of non-normal events.

(3) Treatment Process

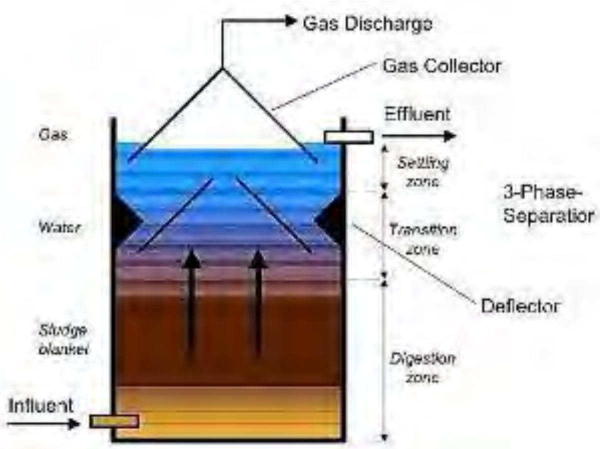
WAF's original proposal for the Pretreatment Plant's treatment process was the UASB (Upflow anaerobic sludge blanket) Method.

UASB is a type of anaerobic treatment, featured by its high reduction of BOD/TSS, small sludge production, small footprint requirement etc. A schematic diagram of the process is shown in **Figure A3-1.3**. Influent enters from the bottom of the reactor, flowing upward to a blanket of sludge granules. The blanket retains suspended solids, as well as breaks down organic matter through anaerobic digestion, partially converting it to biogas. These gas bubbles and upward flow naturally mixes the liquor, allowing mixing without mechanical equipment. Baffles/deflectors at the top of the reactor collects biogas, as well as retain the sludge blanket from flowing out.

Table A3-1.2 General Design Parameters of UASB units*

Parameter	General Range
HRT	6.3 - 7.85
Temperature	35 - 38℃
pH	2 - 20 hrs
Upflow Velocity	0.7 - 1 m/h
BOD Removal	60 - 90%
TSS Removal	60 - 85%
T-N Removal	Minimal
T-P Removal	Minimal

Source: Created by JET based on Source: Sustainable Sanitation and Water Management Toolbox, https://sswm.info/factsheet/uasb-reactor



Source: Sustainable Sanitation and Water Management Toolbox, https://sswm.info/factsheet/uasb-reactor

Figure A3-1.3 Schematics of UASB Reactor

WAF's original proposal was to pre-treat the diluted distillery wastewater singly by the UASB unit. However, as **Table A3-1.2** shows, nitrogen and phosphorus are minimally removed by the treatment, leading to industrial-levels nitrogen/phosphorus inflow to Natabua WWTP (Table A3-1.1). Even after being diluted by the remaining raw sewerage flowing into Natabua WWTP, its system cannot treat wastewater up to the required effluent quality (General standards).

Therefore, the UASB method must be coupled with some kind of nitrogen/phosphorus removal procedure, or apply a completely different type of pre-treatment process that can treat distillery waste down to effluent qualities acceptable to Natabua WWTP. Detailed exploration of the treatment process is to be studied in future projects, since the Pretreatment Facility itself is not included in the Pre-F/S scope.

(4) Effluent Water Quality Parameters

Due to the lack of actual distillery wastewater data and undetermined pre-treatment processes, the plant's effluent quality cannot be estimated at the current state. For this reason, this study assumes that the Pretreatment Plant will treat its wastewater down to levels of "allowable liquid trade waste entering the sewerage system" set in Fiji's National Liquid Trade Waste Standards.

Since Fijian standards do not state the upper limit of T-N and T-P of allowable liquid trade waste, similar Australian standards with the same BOD/TSS limits were adopted as substitute values. **Table A3-1.3** shows assumed effluent water quality parameters of the Pre-treatment Plant.

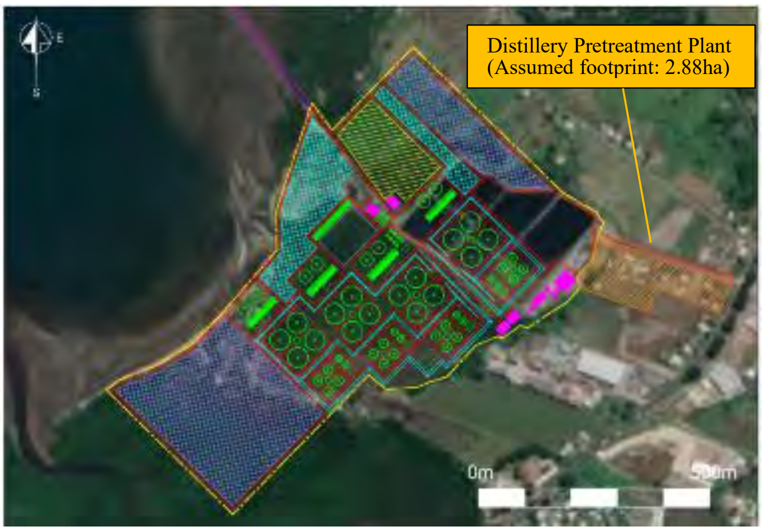
Table A3-1.3 Assumed Pretreatment Plant Effluent Water Quality

Data Set	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
Data Range from References	600	600	100	20

Source: Created by JET based on Fiji National Liquid Trade Waste Standards (2017),
New South Wales Liquid Trade Waste Policy (New South Wales Federation Council, 2018)

(5) Footprint Requirement (Reference)

Similar to effluent qualities, the Pretreatment Plant's footprint requirement cannot be precisely estimated due to lack of data and undetermined treatment processes. However as reference, the footprint requirement for a "UASB unit (TSS, BOD removal) + high-rate Oxidation Ditch (TSS, BOD, T-N removal) + Coagulation/Flocculation Channel (T-P removal)" system with the same flowrate was roughly estimated, summing up to be about 1.7 ha. Considering that the facility will need additional space for receival tanks and drive-throughs for bailing trucks etc., the 2.88ha lot just east of Natabua WWTP was proposed as a candidate site for the Pre-treatment Plant .



Source; Created by JET

Figure A3-1.4 Proposed Site for Distillery Pretreatment Plant

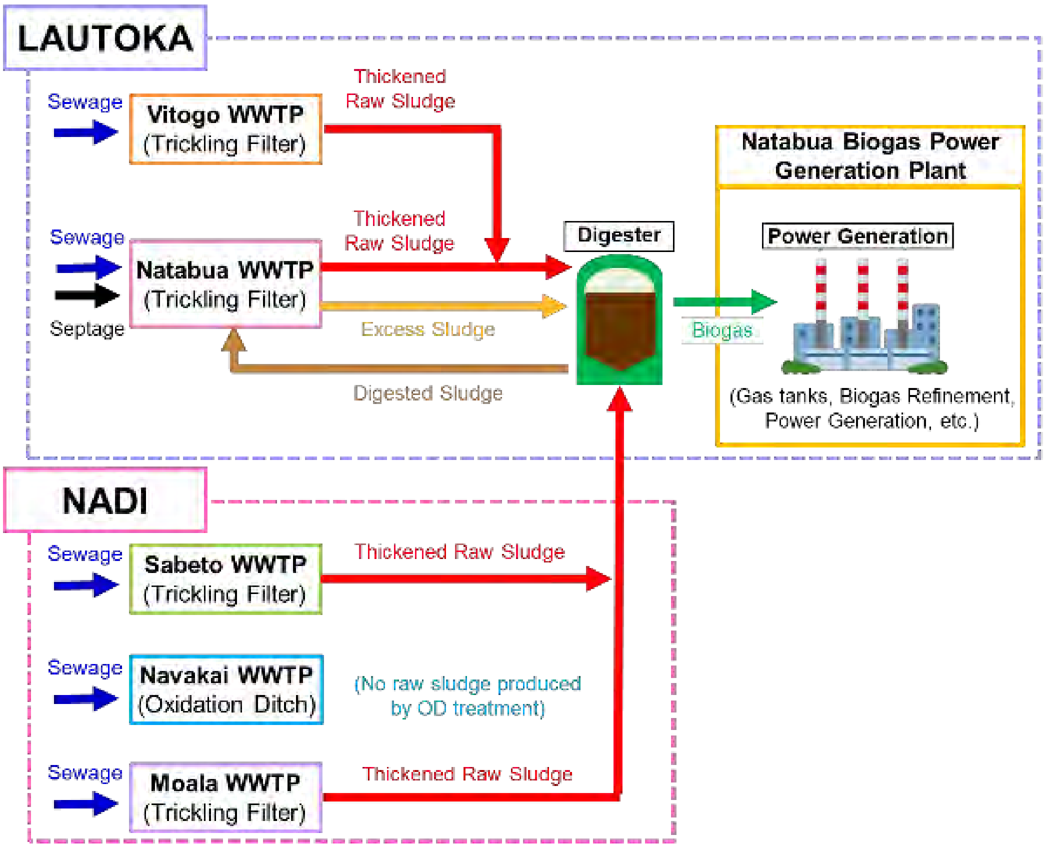
APPENDIX 3-2 Sludge Utilization(Biogas Power Generation) Flow of Lautoka/Nadi WWTPs

In the Regional Wastewater M/P, WAF request to incorporate the utilization of sewerage sludge, specifically energy recovery though biogas production. Considering economies of scales, it was determined that a single, large-scale anaerobic digester + biogas power generation plant was to be built.

Since excess sludge is low in calorific value, the digester's input target was set to be mainly raw sludge produced from primary clarifiers of WWTPs with Trickling Filter systems (Oxidation Ditch systems do not have primary clarifiers).

Out of the four WWTPs with TF systems (Vitogo, Natabua, Sabeto, Moala), Natabua WWTP has the largest treatment capacity, producing the largest amount of sewerage sludge. Thus, the anaerobic digester + biogas power generation plant was placed at Natabua WWTP. Raw sludge from the other three WWTPs are to be gravitationally thickened, then bailed to Natabua for receival.

Figure A3-2.1 shows the sludge utilization flows of the Lautoka/Nadi WWTPs.



Source: JET

Figure A3-2.1 Sludge Utilization(Biogas Power Generation) Flow of Lautoka/Nadi WWTPs

APPENDIX 3-3 Setting Natabua WWTP Influent Water Quality Parameters

In the previous Regional Wastewater M/P and Municipal Sewerage M/P, the influent water quality for all WWTPs were set at a uniform value, applying the maximum value taken from adjusted raw influent data (2014-2018 annual averages, all WWTPs) and values adopted in past donor projects.

For the Pre-F/S, WWTP-specific influent water quality values were adopted, taking into consideration of additional raw data (2019-2023) and the addition of pretreated distillery waste (refer to **APPENDIX 3-1** for details).

The influent water quality parameters for Natabua WWTP was set as shown in **Table A3-3.1**.

Table A3-3.1 Natabua WWTP Influent Water Quality*

BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
398	500	45	11

*Including Raw sewerage, pretreated distillery waste, and dewatered septage leachate
Source: JET

(1) Raw Sewerage (Pipeline Sewerage)

1) Selection of Raw Data

Due to the COVID-19 pandemic, Fiji shut down its borders to all foreign nationals (March 2020-November 2021), leading to the sharp drop of tourist population visiting Fiji. It is believed that the influent flowrate and water quality of sewerage also was affected by this decrease, producing off-normal data.

Statistics show that visitor arrivals significantly decreased from 2020-2022, but recovered back to pre-COVID (2019) levels from 2023 (**Table A3-3.2, Figure A3-3.1**). Therefore, in this report the raw data from 2014-2019 and 2023 was adopted for examination.

Table A3-3.2 Annual Visitor Arrivals to Fiji

Year	Arrivals to Fiji
2017	842,884
2018	870,309
2019	894,389
2020	146,552
2021	31,618
2022	636,312
2023	Refer to graph

Source: Created by JET based on Tourism Fiji data

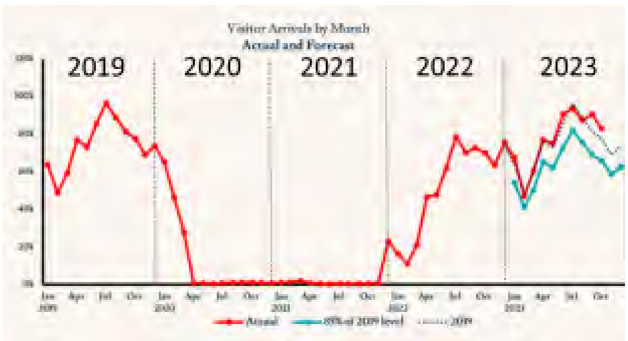
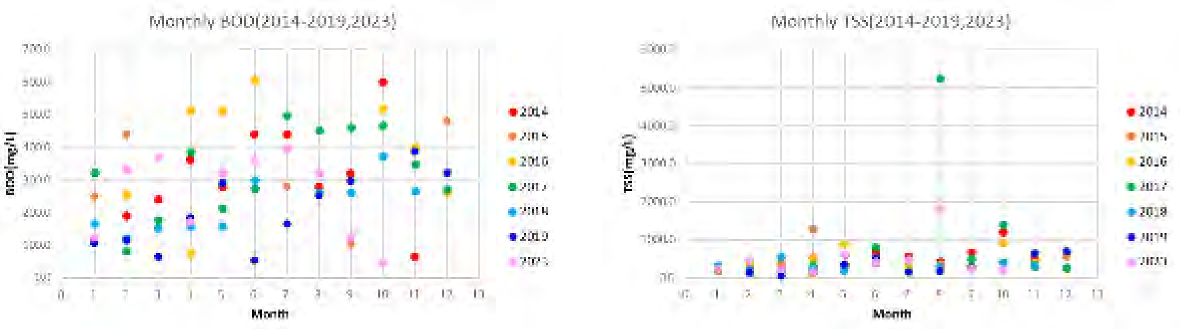


Figure A3-3.1 Visitor Arrivals to Fiji
Source: Tourism Fiji, "Statistics and Insights: Visitors Arrival" (https://corporate. fiji. travel/statistics-and-insights/visitors-arrival)

2) Removing Outlier Data

WAF collects/analyzes influent samples taken from their WWTPs once a month. Raw influent data for Natabua WWTP showed unusually extreme high/low results: BOD levels ranging from 47.4-607 mg/L, and TSS levels ranging from 108.3-5252 mg/L. The collected data was examined for possible seasonal/annual trends but showed no apparent patterns, several being abrupt one-time events (**Figure A3-3.2**).

It was inferred that these readings were possible due to sample contamination or mis-recording of data, and direct application of all raw data would lead to over/under-estimation of influent water quality. Before further examination, outlier data (top 10% and bottom 10%) was removed from each data group. From the remaining data sets, the 80%tile value was set as Natabua WWTP's raw sewerage influent water quality (**Table A3-3.3**).



Source: JET

Figure A3-3.2 Checking Seasonal Trends for Natabua WWTP Raw Influent Water Quality Data

Table A3-3.3 Natabua WWTP Raw Sewerage Water Quality

Max Daily Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
44,477	373	486	37	9

Source: JET

(2) Influent from other Facilities

1) Septage Treatment Facility

A septage treatment facility prior to Phase 1, and Natabua WWTP will receive dewatered leachate produced from dewatering to its wastewater treatment system. Since Fiji does not have past records of septage water quality data, the recorded data from "Adoption/Demonstration Experiment Project of Johkaso Sludge Dewatering Machines in Cebu City (Philippines)" (2016) was adopted as a substitute. This project publicly provides data of the leachate and sludge cakes of mechanically dewatered Johkaso sludge.

Table A3-3. 4 Adopted Water Quality Input Data of Domestic Septage

Leachate					Dewatered Sludge		
Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)	Sludge Volume (m^3/day)	Water Content	TSS (mg/L)
59	250	620	37	9	6	75%	20,000

Source: "Adoption/Demonstration Experiment Project of Johkaso Sludge Dewatering Machines in Cebu City (Philippines)" (AMCON INC.) (2016)

2) Distillery Waste Pretreatment Facility

As explained earlier in **APPENDIX 3-1**, Natabua WWTP is planned to receive pretreated distillery wastewater starting from Phase 1. Since the plant's specific treatment processes are out of this project's scope, this report sets the Pretreatment Plant's effluent (aka. Natabua WWTP's influent) based on Fijian and Australian Liquid Trade Waste Standards (**Table A3-3.5**).

Table A3-3.5 Expected Pretreated Distillery Wastewater Quality

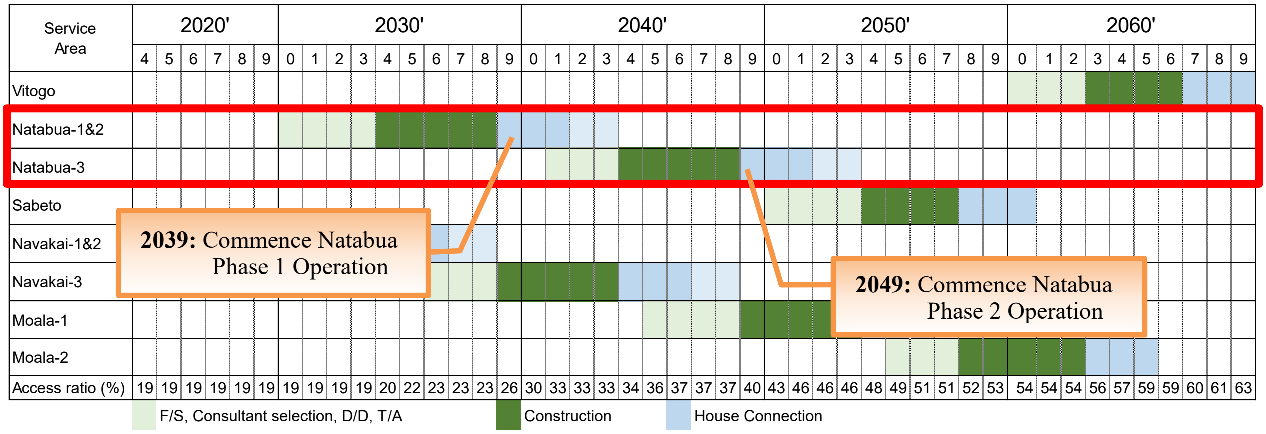
Max Daily Flowrate (m^3/day)	BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
1,760*	600	600	100	20

*Includes raw sewerage used for dilution. Refer to **APPENDIX 3-1** for details
Source: JET, WAF, NSW Department of Planning Industry and Environment

APPENDIX 3-4 Determining Number of Treatment Line in Natabua WWTP

(1) Setting Influent Flowrates for each Construction Phase

Due to its large requirement in treatment capacity, Navakai WWTP's facility will be constructed in two construction phases (**Figure A3-4.1**).

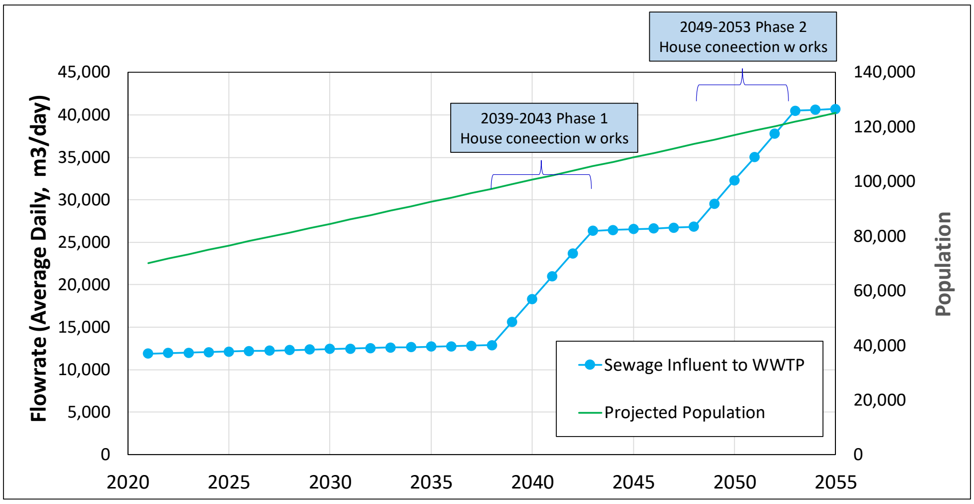


Source: Created by JET

Figure A3-4.1 Implementation Schedule for Natabua WWTP

Required treatment capacities of each phase was calculated based on their commencement schedule and the projected sewerage discharge (based on projected population growth of the sewerage service area) corresponding with that year. Namely, Natabua WWTP Phase 1 facilities must have the capacity to treat sewerage up until the commencement of Phase 2 facilities (2049), and Phase 2 facilities must be able to fulfill demands up until the completion of all house connection works (2053).

The projected population and sewerage flowrate to be treated by Natabua WWTP are shown in **Figure A3-4.2** and **Table A3-4.1**.



Source: Created by JET

Figure A3-4.2 Natabua WWTP Sewerage Discharge vs. WWTP Treatment Capacity

Table A3-4.1 Sewerage Discharge vs. Phase 1/Phase2 Treatment Capacity

Navakai WWTP Facilities	Year of Operation Commencement	Sewerage Influent to WWTP (Average Daily Flowrate) (m^3/day)
Phase 1	2039	26,820
Phase 2	2049	13,685
Total	2049 (Full Operation)	40,505

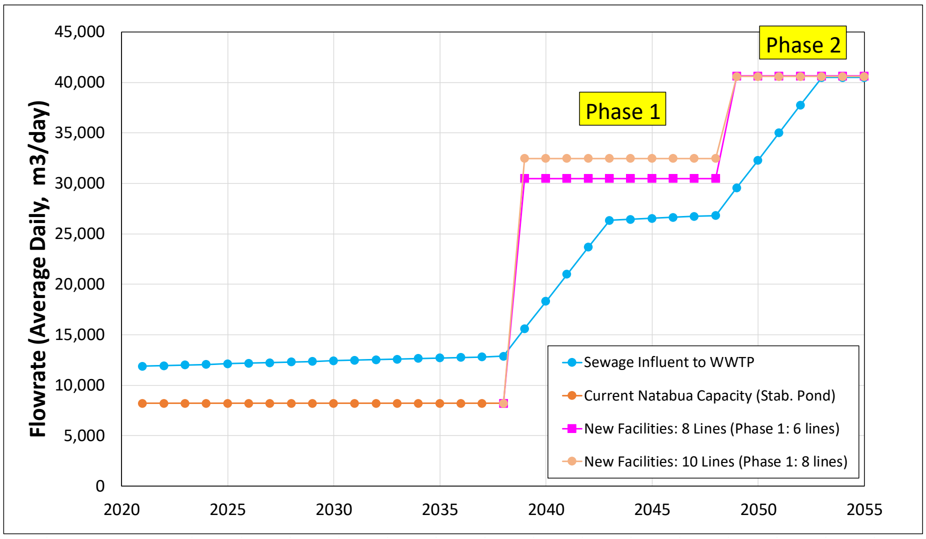
Source: Created by JET

(2) Determining Number of Treatment Lines

WWTPs often have even-number treatment lines, since this generally facilitates O&M and lessens required ME equipment units. Natabua WWTP's 4, 6,8, and 10-line scenarios were compared under the following conditions.

- Capacity of the operating treatment lines must fully cover the expected sewerage flowrate
- All treatment lines have same capacity throughout Phase 1 and Phase 2
- Even-number treatment lines in both Phase 1 and Phase 2 to facilitate O&M (ex. unified operation for all distribution chambers) and lessen required ME equipment units
- Treatment capacity of the treatment line does not exceed design constraints of treatment facilities (ex. maximum diameter of trickling filters)
- Capacity of the operating treatment lines do not overly exceed sewerage flowrate

Figure A3-4.2 and **Table A3-4.1** shows the result of each scenario. The 4-line and 6-line scenario's per-line flowrate would require trickling filters exceeding the design maximum (45 m diameter), and thus were excluded. The excess treatment capacity of the remaining 8-line and 10-line scenarios were compared, showing that the 8-line scenario was better in overall efficiency. Thus, the 8-line scenario was chosen for Natabua WWTP, constructing 6 lines in Phase 1, and 2 lines in Phase 2.



Source: Created by JET

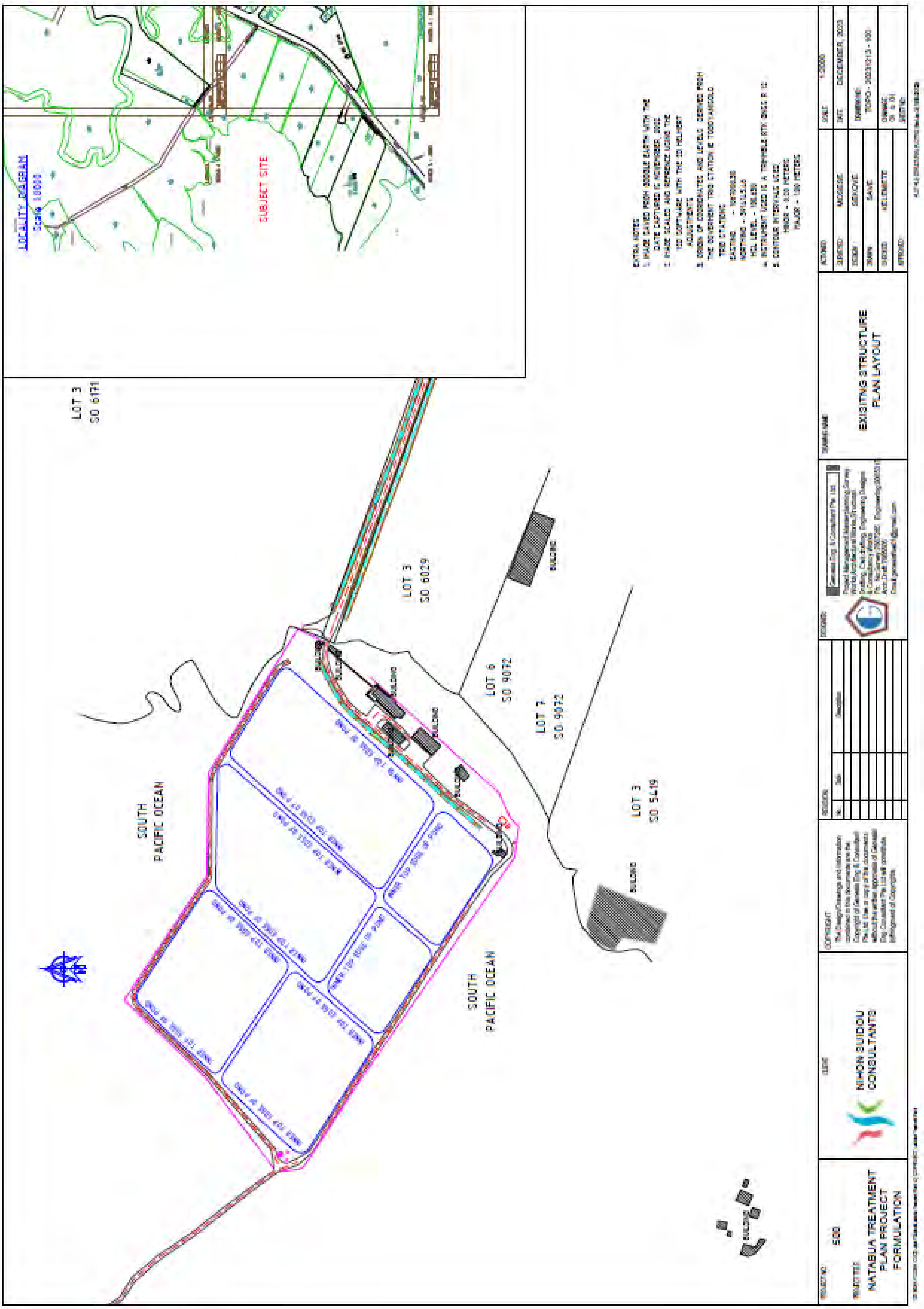
Figure A3-4.3 Natabua WWTP Multi-line System Scenario Comparison

Table A4-4.2 Natabua WWTP Multi-line System Scenario Comparison

Year	Event	Facility in Operation	4 Line Scenario 10150 m3/d per line					6 Line Scenario 6770 m3/d per line					8 Line Scenario 5080 m3/d per line					10 Line Scenario 4060 m3/d per line				
			Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)
2021		Current	-	-	8,200	11,880	-	-	-	8,200	11,880	-	-	-	8,200	11,880	-	-	-	8,200	11,880	-
2022		Current	-	-	8,200	11,943	-	-	-	8,200	11,943	-	-	-	8,200	11,943	-	-	-	8,200	11,943	-
2023		Current	-	-	8,200	12,005	-	-	-	8,200	12,005	-	-	-	8,200	12,005	-	-	-	8,200	12,005	-
2024		Current	-	-	8,200	12,066	-	-	-	8,200	12,066	-	-	-	8,200	12,066	-	-	-	8,200	12,066	-
2025		Current	-	-	8,200	12,127	-	-	-	8,200	12,127	-	-	-	8,200	12,127	-	-	-	8,200	12,127	-
2026	Current Plant Operation	Current	-	-	8,200	12,187	-	-	-	8,200	12,187	-	-	-	8,200	12,187	-	-	-	8,200	12,187	-
2027		Current	-	-	8,200	12,247	-	-	-	8,200	12,247	-	-	-	8,200	12,247	-	-	-	8,200	12,247	-
2028		Current	-	-	8,200	12,306	-	-	-	8,200	12,306	-	-	-	8,200	12,306	-	-	-	8,200	12,306	-
2029		Current	-	-	8,200	12,365	-	-	-	8,200	12,365	-	-	-	8,200	12,365	-	-	-	8,200	12,365	-
2030		Current	-	-	8,200	12,423	-	-	-	8,200	12,423	-	-	-	8,200	12,423	-	-	-	8,200	12,423	-
2031		Current	-	-	8,200	12,480	-	-	-	8,200	12,480	-	-	-	8,200	12,480	-	-	-	8,200	12,480	-
2032		Current	-	-	8,200	12,537	-	-	-	8,200	12,537	-	-	-	8,200	12,537	-	-	-	8,200	12,537	-
2033		Current	-	-	8,200	12,593	-	-	-	8,200	12,593	-	-	-	8,200	12,593	-	-	-	8,200	12,593	-
2034		Current	-	-	8,200	12,649	-	-	-	8,200	12,649	-	-	-	8,200	12,649	-	-	-	8,200	12,649	-
2035	Phase 1 WWTP Construction	Current	-	-	8,200	12,704	-	-	-	8,200	12,704	-	-	-	8,200	12,704	-	-	-	8,200	12,704	-
2036		Current	-	-	8,200	12,758	-	-	-	8,200	12,758	-	-	-	8,200	12,758	-	-	-	8,200	12,758	-
2037		Current	-	-	8,200	12,814	-	-	-	8,200	12,814	-	-	-	8,200	12,814	-	-	-	8,200	12,814	-
2038		Current	-	-	8,200	12,869	-	-	-	8,200	12,869	-	-	-	8,200	12,869	-	-	-	8,200	12,869	-
2039		Phase 1		4	40,600	15,600	25,000		4	27,080	15,600	11,480		6	30,480	15,600	14,880		8	32,480	15,600	16,880
2040	Phase 1 House Connections	Phase 1		4	40,600	18,314	22,286		4	27,080	18,314	8,766		6	30,480	18,314	12,166		8	32,480	18,314	14,166
2041		Phase 1		4	40,600	21,011	19,589		4	27,080	21,011	6,069		6	30,480	21,011	9,469		8	32,480	21,011	11,469
2042		Phase 1		4	40,600	23,690	16,910		4	27,080	23,690	3,390		6	30,480	23,690	6,790		8	32,480	23,690	8,790
2043		Phase 1		4	40,600	26,352	14,248	4	4	27,080	26,352	728	6	6	30,480	26,352	4,128	8	8	32,480	26,352	6,128
2044		Phase 1		4	40,600	26,446	14,154		4	27,080	26,446	634		6	30,480	26,446	4,034		8	32,480	26,446	6,034
2045	Phase 2 WWTP Construction	Phase 1		4	40,600	26,539	14,061		4	27,080	26,539	541		6	30,480	26,539	3,941		8	32,480	26,539	5,941
2046		Phase 1		4	40,600	26,633	13,967		4	27,080	26,633	447		6	30,480	26,633	3,847		8	32,480	26,633	5,847
2047		Phase 1		4	40,600	26,727	13,873		4	27,080	26,727	353		6	30,480	26,727	3,753		8	32,480	26,727	5,753
2048		Phase 1	4	4	40,600	26,820	13,780		4	27,080	26,820	260		6	30,480	26,820	3,660		8	32,480	26,820	5,660
2049		Phase 1 + Phase 2		4	40,600	29,557	11,043		6	40,620	29,557	11,063		8	40,640	29,557	11,083		10	40,600	29,557	11,043
2050		Phase 1 + Phase 2		4	40,600	32,294	8,306		6	40,620	32,294	8,326		8	40,640	32,294	8,346		10	40,600	32,294	8,306
2051	Phase 2 House Connections	Phase 1 + Phase 2		4	40,600	35,031	5,569		6	40,620	35,031	5,589		8	40,640	35,031	5,609		10	40,600	35,031	5,569
2052		Phase 1 + Phase 2		4	40,600	37,768	2,832	6	6	40,620	37,768	2,852	8	8	40,640	37,768	2,872	10	10	40,600	37,768	2,832
2053		Phase 1 + Phase 2		4	40,600	40,505	95		6	40,620	40,505	115		8	40,640	40,505	135		10	40,600	40,505	95
2054		Phase 1 + Phase 2		4	40,600	40,505	95		6	40,620	40,505	115		8	40,640	40,505	135		10	40,600	40,505	95
2055		Phase 1 + Phase 2		4	40,600	40,505	95		6	40,620	40,505	115		8	40,640	40,505	135		10	40,600	40,505	95
			Total Excess Capacity				195,900	Total Excess Capacity				60,840	Total Excess Capacity				94,980	Total Excess Capacity				114,700

Source: Created by JET

APPENDIX 3-5 Natabua WWTP Survey Results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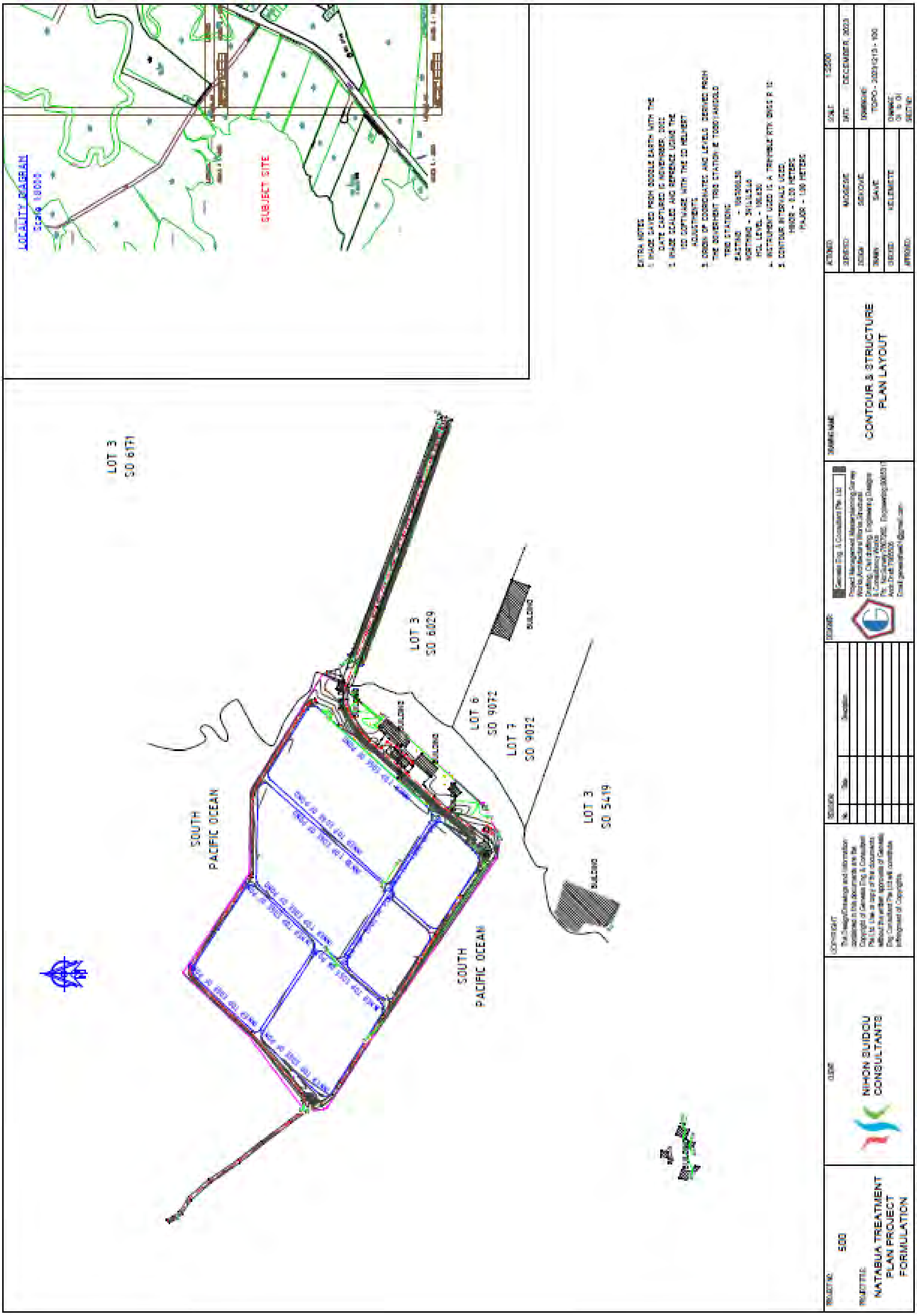
SUBJECT SITE
LOT 3
SO 6171
LOT 3
SO 6029
LOT 6
SO 9072
LOT 7
SO 9072
LOT 3
SO 5419
SOUTH
PACIFIC OCEAN
SOUTH
PACIFIC OCEAN
BUILDING
EXISITNG STRUCTURE
PLAN LAYOUT
NIHON SUIDOU
CONSULTANTS
NATABUA TREATMENT
PLAN PROJECT
FORMULATION
DECEMBER, 2023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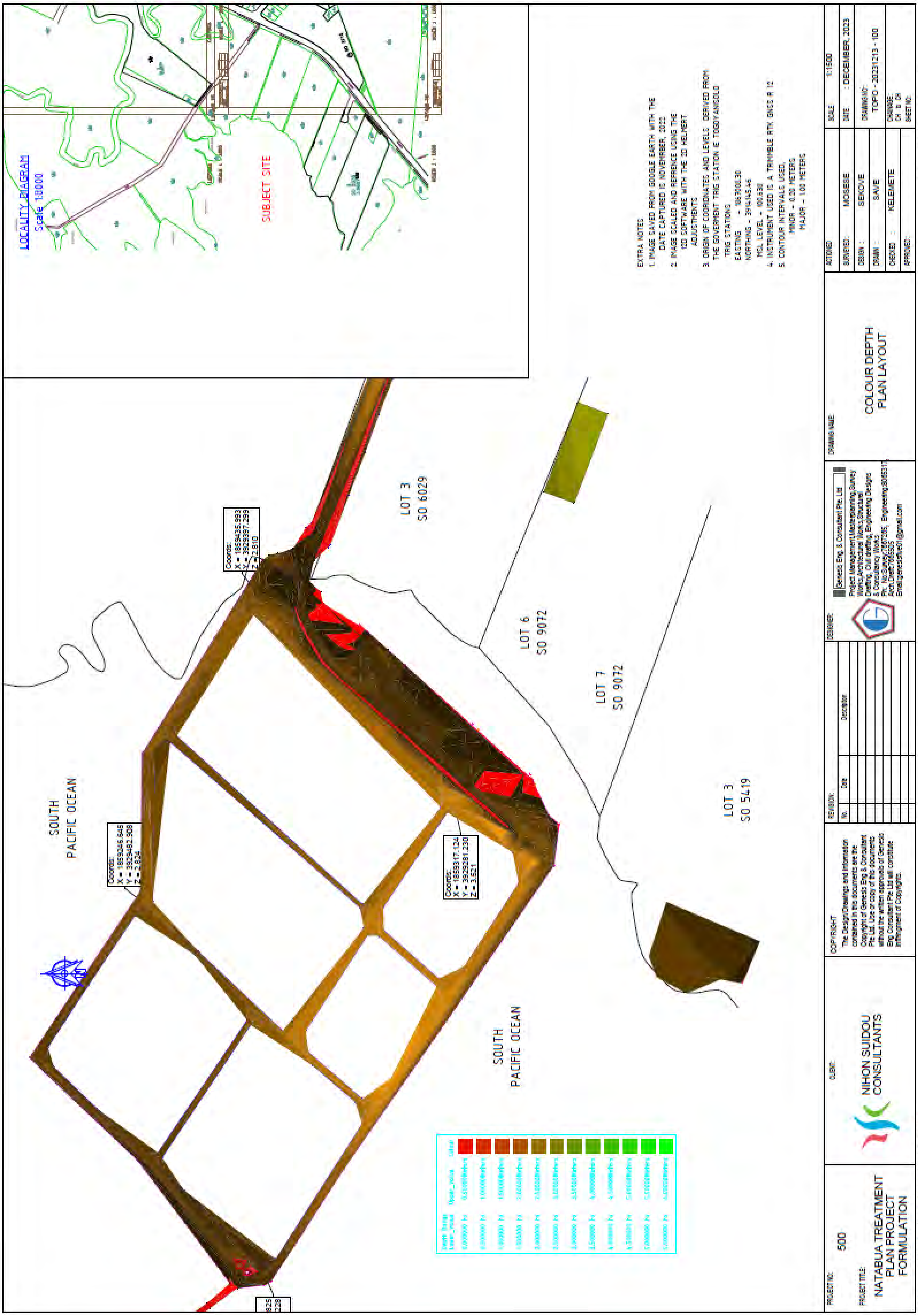
SUBJECT SITE
LOT 3
SO 6171
LOT 3
SO 6029
LOT 6
SO 9072
LOT 7
SO 9072
LOT 3
SO 5419
SOUTH
PACIFIC OCEAN
SOUTH
PACIFIC OCEAN
CONTOUR & STRUCTURE
PLAN LAYOUT
NATABUA TREATMENT
PLAN PROJECT
FORMULATION
NIHON SUIDOU
CONSULTANTS


LOCALITY DIAGRAM
Scale 1:8000
SUBJECT SITE
SOUTH PACIFIC OCEAN
LOT 3
SO 6029
LOT 6
SO 9072
LOT 7
SO 9072
LOT 3
SO 5419
SOUTH PACIFIC OCEAN
COLOUR DEPTH PLAN LAYOUT
NIHON SUIDOU CONSULTANTS
NATABUA TREATMENT PLAN PROJECT FORMULATION

APPENDIX 3-6 Natabua WWTP Soil Survey Results

Soil survey studies were conducted at Natabua WWTP to obtain geotechnical data of the area. Soil boring tests were performed at two locations, Boring HoleL1 and Boring Hole L2, within the current WWTP boundaries **(Figure 3-6.1**). The soil boring test results are shown in the following pages.

It should be noted that in future stages of facility designs, additional boring tests should be conducted for the planned construction area outside of the current WWTP boundaries.

Source: ENTEC PTE Ltd.

Figure 3-6.1 Navakai WWTP Soil Boring Test Locations

(1) Boring Hole L1

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050136.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 1 of 6

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description | TCR (SCR) RQD (%) | Samples | Tests

Geological Description — Soil Description: subordinate, particle size, MAJOR, minor colour, structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; geologic unit.

Fluid & Water: 28-03-24 09:08 Waterlevel @0.12mbgl

Run (m)	Geological Description	Geological Unit	TCR (%)	Samples	Tests
0.00	FILL: GC gravel with some clay and sand and minor organics; trace silt; dark grey mottled brown. Dense to loose, recovered as medium to coarse grained; angular to subangular; moist. CORE LOSS.	FILL	10		
1.00	CORE LOSS. FILL: GP gravel, trace clay, silt and sand; dark grey. Loose, recovered as medium to coarse grained; subangular to angular; moist. CORE LOSS.	FILL	10		SPT 1.00 m 3,1,3 N=4 REC=0
2.00	CH CLAY with traces fine sand and silt, dark brown. Very soft, wet. CORE LOSS.	QUATERNARY SURFICIAL DEPOSITS	35	SPT Sample 1 2.00	SPT 2.00 m 1 for 450mm N=1 REC=0.43
3.50	CH Sandy CLAY with some silt, greyish brown. Very soft, wet. CORE LOSS.	QUATERNARY SURFICIAL DEPOSITS	0		SPT 3.50 m 3,1 for 300 N=1 REC=0

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
Small Disturbed Sample
Large Disturbed Sample
SPT - blows/300mm
Permeability Test
U100 Undisturbed Sample
Insitu Vane Shear Strength (kPa)
UTP = Unable to penetrate

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #51 efficiency: 72.9%

Water Level:
28/03/24, 9:08am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050138.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 2 of 6

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
5.00	ML Sandy SILT with trace gravels and shell fragments; dark grey mottled white. Very soft, wet.		QUATERNARY SURFICIAL DEPOSITS	97	SPT Sample 3 5.00	SPT 5.00 m 1 for 300mm 1 N=1 REC=0.45; WC= 53.8%
	ML Sandy SILT with trace gravels and shell fragments; dark grey mottled white. Very soft, wet.	6			Sample 1 6.10	
	CORE LOSS.					
6.50	ML Sandy SILT with trace gravels and shell fragments; dark grey mottled white. Very soft, wet.	7		67	PUSHTUBE 1 6.50	
	CORE LOSS.					
8.00	ML Sandy SILT; dark grey mottled white. Very soft, wet.	8		83	PUSHTUBE 2 8.00	
		9				
	CH CLAY; dark brown. Very soft, moist.				Sample 2 9.25	WC= 88% LL= 94% PL= 47% PI= 47%
	CORE LOSS.					
9.50	CH CLAY with trace silt and fine sand; dark brown. Very soft, moist.			100	SPT Sample 3 9.50	SPT 9.50 m 1 for 300mm 1 N=1 REC=0.45

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
Hammer #01 efficiency: 72.9%

Water Level:
28/03/24, 9.58am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050138.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 3 of 6

Column headings: Type; Run; Fluid & Water; Piezometer; Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit); Legend; Weathering; Field Strength; Elevation (m MSL); Depth (m); Geological Unit; Defect Spacing (mm); Defect Description; TCR (SCR) RQD (%); Samples; Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR (%)	Samples	Tests
9.50	CH CLAY with trace silt and fine sand, dark brown. Very soft, moist. (continued)		QUATERNARY SURFICIAL DEPOSITS	100	PUSH TUBE 3 9.70	
11.00	ML SILT with clay, trace fine sand and gravel, dark brown mottled grey. Firm, moist to wet.	11		100	SPT Sample 4 11.00	SPT 11.00 m 3,2,3 N=5 REC=0.45; WC= 67.3% LL= 80% PL= 40% PI= 20%
12.50	GM Gravelly sandy SILT with minor clay, dark brown. Firm, low to medium plasticity, moist.	12, 13		97		SPT 12.50 m 2,3,4 N=7 REC=0
	CORE LOSS.					
14.00	ML Gravelly sandy SILT with minor clay, dark brown. Soft, moist.	14		93	SPT Sample 5 14.00	SPT 14.00 m 2,2,3 N=5 REC=0.40

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- insitu Vane Shear Strength (kPa)
- UTP - Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
28/03/24, 9:08am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2)		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050138.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 4 of 6

Geological Description header: Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
14.00	ML Gravelly sandy SILT with minor clay, dark brown. Soft, moist. (continued)		QUATERNARY SURFICIAL DEPOSITS	93		UCS @ 15.1m-.4m UCS= 31kPa E= 1MPa
	CORE LOSS					
15.50	ML Sandy SILT with gravel, brown motled dark grey. Stiff, low to medium plasticity, moist.	16		100	SPT Sample 6 15.50 Sample 5 16.40	SPT 15.50 m 4,3,8 N=11 REC=0.45
17.00	SM Silty SAND with gravels, brown grey. Medium dense, recovered as coarse grained, moist to wet.	17			SPT Sample 7 17.00	SPT 17.00 m 4,6,9 N=15 REC=0.45
	ML Sandy SILT with gravels, brown motled grey. Stiff, low plasticity, moist.	18		100		
18.50	ML Sandy SILT with gravels, brown motled grey. Very stiff, low plasticity, moist.	19		93	SPT Sample 8 18.50	SPT 18.50 m 4,8,13 N=21 REC=0.45
	CORE LOSS					

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil(RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR = Total Core Recovery
SCR = Solid Core Recovery
RQD = Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.5%

Water Level:
28/03/24, 9:08am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwall Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED

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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050136.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 5 of 6

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description (type, orientation, spacing, roughness, coherence, aperture, infilling, etc.) | TCR (SCR) RQD (%) | Samples | Tests

Run (m)	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
20.00	Sandy SILT with gravels, brown mottled grey. Very stiff, low plasticity, moist.		QUATERNARY SURFICIAL DEPOSITS	93	SPT Sample 9 20.00	SPT 20.00 m 5,10,11 N=21 REC=0.45; WC= 45.7%
		21				
	CORE LOSS.					
21.50	XW SILTSTONE (Sandy SILT with gravels, brown mottled grey. Hard, low plasticity, moist).		MIOCENE PLIOCENE UPPER VUDA BED	60	SPT Sample 10 21.50	SPT 21.50 m 7,11,9 N=50+ DS REC=0.45
	CORE LOSS.	22				
	XW SILTSTONE (Sandy SILT with gravels, brown mottled grey. Hard, low plasticity, moist).				Sample 4 22.70	
23.00	XW SILTSTONE (Sandy SILT with gravels, brown mottled grey. Hard, low plasticity, moist).	23			SPT Sample 11 23.00	SPT 23.00 m T:5,7 for 20mm N=50+ DS REC=0.3
	CORE LOSS.			40		
		24				
	XW SILTSTONE (Sandy SILT with gravels, brown mottled grey. Hard, low plasticity, moist).					
24.50				40	SPT Sample 12 24.50	SPT 24.50 m 8,11 for 150mm N=50+ DS REC=0.2
	CORE LOSS.					

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (KPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
- D - Dry
- M - Moist
- W - Wet

Remarks
-Hammer #01 efficiency: 72.5%

Water Level:
28/03/24: 9:08am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L1**
Job No.: 1381123.B	Start Date: 23-3-2024 Finish Date: 25-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 545014.000 N: 8050138.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 29.00 m	Inclination: -90°	Sheet: 6 of 6

Geological Description: Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
24.50	CORE LOSS. (continued)		MIOCENE PLIOCENE UPPER VUDA BED	40		
	XW SILTSTONE (Sandy SILT with gravels, brown mottled grey, hard, low plasticity, moist)					
26.00	HW dark grey SILTSTONE, very low strength, moist.	26			SPT Sample 13 26.00	SPT 26.00 m 9,11 for 130mm N=50+ CB REC=0.26
	CORE LOSS.			07		
	HW dark grey SILTSTONE, very low strength, moist.	27				
27.50					SPT Sample 14 27.50	SPF 27.50 m 3 for 80mm N=50+ CB REC=0.08
		28		25		
	CORE LOSS.					
	HW dark grey SILTSTONE, very low strength, moist.					
	Hole Terminated at 29.00 m	29			SPT Sample 15 29.00	SPT 29.00 m 8,12 for 40mm N=50+ CB REC=0.15

Other columns: Type, Fluid & Water, Piezometer, Legend, Weathering, Field Strength, Elevation (m MSL), Defect Spacing (mm), Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc.).

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Hand Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.6%

Water Level:
28/03/24: 9:08am WL @0.12mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

(2) Boring Hole L2

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1381123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 1 of 7

Run	Fluid & Water	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
0.00	28-03-24 10:30, Waterlevel @0.6mbgl	FILL: (GAP65) gravel, dark grey. Dense to loose, recovered as coarse grained, well graded: moist. (100mm). CORE LOSS.		FILL	16		
1.00		CH CLAY with sand and silt, trace gravel, dark brown. Firm; high plasticity, moist. CORE LOSS.	1	QUATERNARY SURFICIAL DEPOSITS	46	SPT Sample 1 1.00	SPT 1.50 m/ 7, 2, 3 N= 6 REC= 0.2
2.00		CH CLAY with sand and silt, trace gravel, dark brown. Soft to firm, high plasticity, moist. GW Gravelly SAND with silt, trace clay, dark grey. Medium dense to denser, gravel recovered as coarse grained, well graded: moist to wet. CORE LOSS.	2		17	Sample 1 1.80; SPT Sample 2 2.00	WC= 46.1% LL= 76% PL= 38% PI= 38%; SPT 2.00 m 10, 9, 4 N= 13 REC= 0.28
3.50		GW Gravelly SAND with silt, trace clay, dark grey. Very loose to loose, gravel recovered as coarse grained, well graded: moist to wet. CORE LOSS.	3, 4		17	SPT Sample 3 3.50	SPT 3.50 m 3, 3, 1 N= 4 REC= 0.05

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
-28/03/24, 10:30am @0.6mbgl

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
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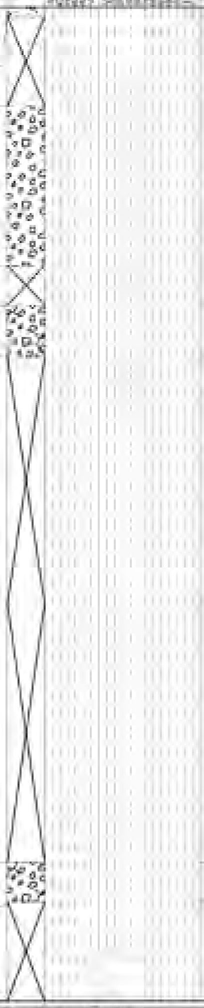
ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1381123 B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 2 of 7

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure; geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description (type, inclination, spacing, roughness, persistence, aperture, infilling etc.) | TCR (SCR) RQD (%) | Samples | Tests



Run	Geological Description	Depth (m)	Geological Unit	TCR (%)	Samples	Tests
5.00	GW Gravelly SAND with silt, trace clay: dark grey. Very loose; gravel recovered as coarse grained, well graded; moist to wet. (continued)		QUATERNARY SURFICIAL DEPOSITS		SPT Sample 4 5.00	SPT 5.00 m 3, 1 for 300mm N= 1 REC= 0.05
	CORE LOSS.					
	GP Coral COBBLES and GRAVEL(GP): pale white mottled grey. Very loose; gravel, recovered as coarse grained, angular; moist.	6		17		
	CORE LOSS.					
6.50	GP Coral GRAVEL: pale white mottled grey. Loose; moist.				SPT Sample 5 6.50	SPT 6.50 m 4, 4, 6 N= 10 REC= 0.5
	CORE LOSS.	7		12		
8.00	CORE LOSS.	8				SPT 8.00 m 1, 1 for 300mm N= 1 REC= 0
		9		13		
	GP Coral GRAVEL with silt, trace sand and clay, grey mottled pale white, mottled grey. Very loose; moist.					
9.50	CORE LOSS.			0		SPT 9.50 m 4, 2, 1 N= 1 REC= 0

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR = Total Core Recovery
SCR = Solid Core Recovery
RQD = Rock Quality Designation
Rec. = Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
-28/03/24, 10:30am @0.6mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).	Location: Natabua WWTP, Off Queens Road, Lautoka		No.: BH_L2
Job No.: 1381123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 3 of 7

Geological Description: Soil Description: subordinate, particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; geologic unit.

Geological Unit: QUATERNARY SURFICIAL DEPOSITS

Run	Geological Description	Depth (m)	TCR (SCR) RQD (%)	Samples	Tests
9.50	CORE LOSS, (continued)		6		
11.00	GP Coral GRAVEL with silt, trace sand and clay; grey mottled pale white, mottled grey. Very loose, moist.	11		SPT Sample 6 11.00	SPT 11.00 m 1, 1 for 300mm N= 1 REC= 0.15
	CORE LOSS.		60		
	ML SILT trace sand and gravel; dark brown. Soft to firm, moist.			Sample 2 11.45	WC= 35.7%
11.75	CORE LOSS.				
	CH CLAY with trace silt; dark brown mottled grey. Firm to stiff, moist.	12	33		
12.50	CH CLAY with trace silt; dark brown. Stiff, moist.			SPT Sample 7 12.50	SPT 12.50 m 5, 6, 8 N= 14 REC= 0.35 WC= 44.8% LL= 87.4% PL= 47% PI= 40%
	CORE LOSS.	13	70		
	MH SILT with clay; dark grey. Stiff, moist.			Sample 3 13.30	UCS= 0.13MPa E= 2MPa
14.00	MH SILT with clay; dark grey. Very stiff, moist.	14		SPT Sample 8 14.00	SPT 14.00 m 5, 8, 10 N= 18 REC= 0.45
	CORE LOSS.		70		
	XW SILTSTONE; (SILT with clay, dark grey. Stiff, moist.)				

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
-28/03/24, 10:30am @0.6mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1381123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 4 of 7

Columns: Type | Run | Fluid & Water | Piezometer | Geological Description | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description | TCR (SCR) RQD (%) | Samples | Tests

Geological Description: Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications: weathering of clasts, subordinate qualifications, minor qualifications: additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Defect Description: (type, orientation, spacing, roughness, persistence, aperture, infilling etc.)

Run	Geological Description	Depth (m)	TCR (%)	Samples	Tests
14.00	XW SILTSTONE; [SILT with clay, dark grey. Stiff, moist.] (continued)				
	XW to HW dark grey CONGLOMERATE; low strength, moist. (Recovered as dense gravel).		70		
15.50	CORE LOSS	16			SPT 15.50 m 0 for 00mm N= 50+ D0 REC= 0
	HW dark grey CONGLOMERATE very low to low strength, matrix supported, moist.		47		
17.00	HW dark grey CONGLOMERATE, low to medium strength, moist.	17		SPT Sample 8 17.00	SPT 17.00 m 5.6 for 75mm N=50+ D8 REC=0.28
	CORE LOSS	18	51		
	HW dark grey CONGLOMERATE, low to medium strength, moist.			Sample 4 19.00	
18.50	CORE LOSS	19	0		SPT 18.50 m 4 for 40mm N=50+ D8 REC=0

Geological Unit: MIOCENE PLIOCENE UPPER VUDA BED

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

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- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
Hammer #01 efficiency 72.9%

Water Level:
28/03/24, 10:30am @0.5mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1381123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 5 of 7

Geological Description — Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Type	Run	Fluid & Water	Piezometer	Geological Description	Legend	Weathering	Field Strength	Elevation (m MSL)	Depth (m)	Geological Unit	Defect Spacing (mm)	Defect Description	TCR (SCR) RQD (%)	Samples	Tests
	20.00			HW dark grey CONGLOMERATE medium strength, moist, (recovered as broken coarse gravel).						MIOCENE PLIOCENE UPPER VUDA BED				SPT Sample 12 20.00	SPT 20.00 m 10 for 80mm N=50+ DB REC=0.04
				CORE LOSS.											
				HW to MW dark grey, mottled white pale brown CONGLOMERATE medium strength, moist.					21				89		
	21.50			CORE LOSS.											SPT 21.50 m 5 for 10mm N=50+ DB REC=0
				HW to MW dark grey, mottled white CONGLOMERATE medium strength, moist.					22				97		
	23.00			HW to MW dark grey, mottled white CONGLOMERATE medium strength, moist.					23				100		SPT 23.00 m 3 for 30mm N=50+ DB REC=0
									24						
	24.50			CORE LOSS.									63		SPT 24.50 m 11 for 40mm N=50+ DB REC=0
				HW to MW dark grey, mottled white CONGLOMERATE medium strength, moist.											

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength.
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
-28/03/24, 10:30am @0.6mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2)		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1391123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 6 of 7

Type	Run	Fluid & Water	Piezometer	Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit)	Legend	Weathering	Field Strength	Elevation (m MSL)	Depth (m)	Geological Unit	Defect Spacing (mm)	Defect Description	TCR (SCR) RQD (%)	Samples	Tests
	24.50			HW to MW dark grey, mottled white CONGLOMERATE, medium strength, moist. (continued)						MIOCENE PLIOCENE UPPER VUDA BED			[illegible]		
	26.00			HW to MW dark grey, mottled white CONGLOMERATE, medium strength, moist.					26				100		SPT 26.00 m 3 for 40mm N=50+ DB RED=0
									27					Sample 6 27.38	
	27.50			CORE LOSS					28				23		SPT 27.50 m 3 for 30mm N=50+ DB RED=0
				HW to MW dark grey, mottled white CONGLOMERATE, medium strength, moist.											
	29.00			CORE LOSS					29				0		SPT 29.00 m 3 for 20mm N=50+ DB RED=0

Explanations:
Rock Mass Weathering - Fresh(FR),
Slightly Weathered (SW), Moderately Weathered (MW)
Highly Weathered (HW), Extremely Weathered (XW),
Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
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- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (KPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.5%

Water Level:
-28/03/24, 10:30am @0.6mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwall Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Natabua WWTP, Off Queens Road, Lautoka	No.: **BH_L2**
Job No.: 1381123.B	Start Date: 25-3-2024 Finish Date: 27-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 544688.000 N: 8050330.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.50 m	Inclination: -90°	Sheet: 7 of 7

Type	Run	Fluid & Water	Piezometer	Geological Description (Soil Description: subordinate, particle size; MAJOR; minor; colour, structure strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; geologic unit.)	Legend	Weathering	Field Strength	Elevation (m MSL)	Depth (m)	Geological Unit	Defect Spacing (mm)	Defect Description (Type, orientation, infilling, roughness, continuity, aperture, infilling etc.)	TCR (SCR) RQD (%)	Samples	Tests
	29.00			CORE LOSS (continued)									0		
				Hole Terminated at 30.50 m											SPT 30.50 m 2 N= 150 N=30+ (dr) RE(Ch)
									31						
									32						
									[illegible]						
									34						

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
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Water
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Moisture Condition
D - Dry
M - Moist
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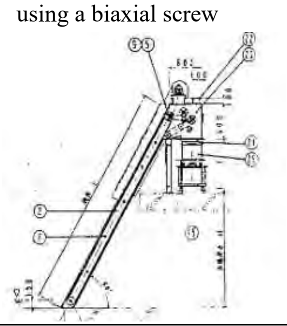
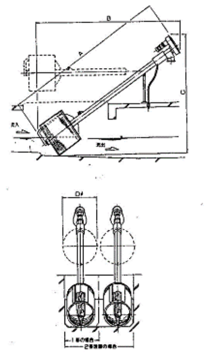
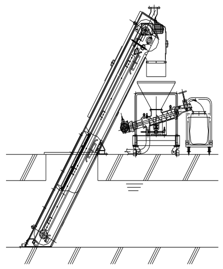
Remarks
-Hammer #01 efficiency: 72.9%
Water Level:
-28/03/24, 10:30am @0.6mbgl

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

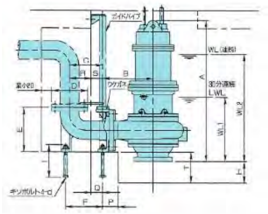
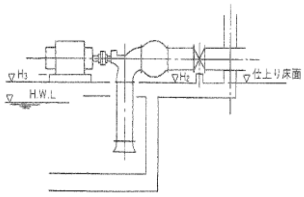
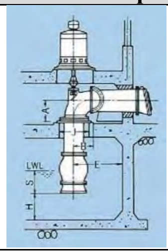
APPENDIX 3-7 Natabua WWTP Comparison/Selection of Mechanical Equipment

(1) Grit Removal Screen

	Automatic belt-running grit screen + Biaxal Screw Type	**Drum type screen with dewatering mechanism**	**Continuous back-scraping type automatic grit screen + Residue dewaterer (Biaxial screw type)**
Description	・Automatic screen and residue dewaterer integrated into a single unit. ・Automatic screen: rotating screen with V-shaped grooves that runs and scrapes up residue ・Residue Dewaterer: dewaters scraped residue using a biaxial screw 	・Residue supplemented by drum-type screen is conveyed by screw conveyor and dewatered in the press section ・Washing device can be installed in the drum-type screen section to wash the residue to some extent. 	・Residue trapped in front of the bar screen is scraped up by a comb-like rake attached to an endless chain at the back, scraped off when it returns at the top, and fed into a residue dewaterer connected to a chute 
Specifications	Screen width: 20-30mm Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.6m^3/h	Scree Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.1-0.5m^3/h	Screen width: 15-25mm Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.6m^3/h
Advantages	・Continuous scraping rakes allows large capacity ・Simple and reliable operation mechanism	・Continuously scraping rakes allows large capacity	・Continuous scraping rakes allows large capacity. ・Simple and reliable operation mechanism.
Disadvantages	・Necessary to cover the open machine to prevent odors	・The closed structure makes maintenance and management of the system less efficient ・Maintenance is performed by pulling it up to the top of the waterway	・A part of the screen needs to be cut off to allow the rake to pass through at the bottom of the channel ・An auxiliary screen must be installed to prevent residue from flowing downstream from the cut off part
Construction Cost	80	120	100
Maintenance Cost	100	110	100
Overall Cost Evaluation	90	110	100
8. Machine Performance	A	C	A
Overall Evaluation	A	C	B
	The "belt-run automatic grit screen+ residue dewaterer (two-axle screw type)" is highly efficient in combination with a dewaterer because of its high residue capturing performance and economic efficiency.		

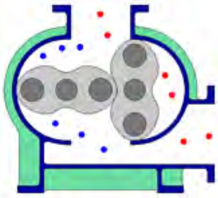
Source: Created by JET

(2) Main Pump

	Submersible sewerage pumps	**Horizontal-shaft semi-axial flow pump**	**Vertical-shaft semi-axial flow pump**
Description			
Pump efficiency	50 - 80% (φ100 -800)	70 - 85% (φ300 -3400)	75 - 80% (φ200 -1000)
Maintenance fee	・Detachable type is relatively easy to install/remove for maintenance and inspection. ・Regular mechanical seal maintenance is needed	・Pumps are set up external of the tank, allowing easy maintenance ・Installation of waterless shaft seal system requires maintenance of the mechanical seal.	・Pumps are set up external of the tank, allowing easy maintenance ・Installation of waterless shaft seal system requires maintenance of the mechanical seal.
	90%	100%	100%
Size and space	・Pump is placed inside the tank → smaller footprint ・Pumps and motors are submerged underwater, so only the machine hatch is on the dry floor.	・Requires largest vertical and horizontal installation footprint, (horizontal setup type external of the tank)	・The upper drawer installation footprint is larger due to the setup external of the tank
Construction cost	40 ～ 50 %	100 %	100 %
Auxiliary equipment	No shaft-sealed water pump required.	Requires a shaft-sealed water pump	No shaft-sealed water pump required.
Measures to be taken in case of flooding	If a waterless shaft seal is installed, no vacuum pump or shaft water supply is required.	Requires a shaft-sealed water pump.	If a waterless shaft seal is installed, no vacuum pump or shaft water supply is required.
Evaluation	A	B	B
	In this plan, 'submersible sewerage pumps' will be adopted, considering flood prevention measures, maintainability, and economic efficiency and installment track record		

Source: Created by JET

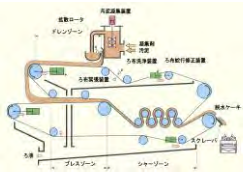
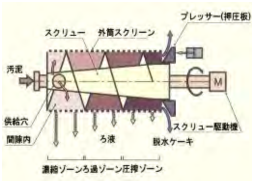
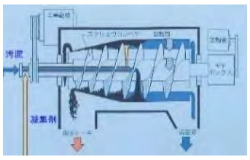
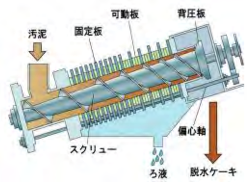
(3) Blowers

	Steel plate multi-stage turbo blowers	Rotary (Roots-type) blowers	Screw-Type Blower
Description	 	 	
caliber	Suction side: φ200 Output side: φ150	Suction side: φ200 Output side: φ150	Suction side: φ200 Output side: φ150
air volume	30 m³/min	30 m³/min	30 m³/min
pressure	Suction pressure: 2kPa Discharge pressure: 60kPa	Suction pressure: 2kPa Discharge pressure: 60kPa	Suction pressure: 2kPa Discharge pressure: 60kPa
Advantages	・No refueling equipment or cooling water equipment is required. ・Air flow analysis and other technologies have improved efficiency. ・Smooth operation with low rotational vibration.	・Equipment costs are low. ・Experienced in small-scale or initial response.	・Packaged and compact. ・High efficiency due to continuous internal compression by screw. ・Auxiliary equipment is built into the package. ・High blower total thermal efficiency. ・No surging due to the volumetric system.
Disadvantages	・Surging occurs in some areas, so a surging limiter setting is required in the air flow control.	・Silencers required for noise control as they are not packaged. ・Inverter controllers use electronic equipment, so it is necessary to secure unit replacement parts for version upgrades and to take renewal measures corresponding to the service life of the equipment.	・Matrix converter control units use electronic equipment, so it is necessary to secure unit replacement parts for version upgrades and to take renewal measures corresponding to the service life of the unit.
Total thermal efficiency	57%	57%	70%
Pressure loss	・Silencers are not required, resulting in low pressure losses in the piping system.	・Silencers are required and pressure losses are high.	・Silencers are not required, resulting in low pressure losses in the piping system.
Airflow Control	・Inlet guide vane ・Controlled by adjusting the opening of the inlet guide vane, rather than by adjusting the speed of rotation ・Smooth operation with low rotational vibration.	・Inverter device ・Controlled by rotational speed. ・There is no surging area, but the noise level increases as the RPM increases.	・Matrix converter devices ・ It is controlled by the speed of rotation, but unlike inverters, it does not require harmonic countermeasures. ・No surging area and it is quiet due to the integrated cover, even when the speed increases.
Size	5,000×2,200×1,600	5,000×2,200×1,600	5,000×2,200×1,600
Weight	6.2 t	1.87 t	1.87 t

	Steel plate multi-stage turbo blowers	Rotary (Roots-type) blowers	Screw-Type Blower
Maintenance	・Protective instrument panels and individual forced lubrication devices are included and installed on the machine side for easy inspection. ・The centrifugal force of the cylindrically arranged runners (forward facing blades) draws in air and creates a swirling flow in a direction almost perpendicular to the axis of rotation. ・The swirling flow generated is rectified in one direction by the scroll and the required pressure is generated and supplied according to the number of runner stages, resulting in less pulsation and vibration and fewer failures.	・Protective devices are not attached but installed separately. ・Pressure pulsation due to 2- and 3-leaf rotors, requiring vibration countermeasures for piping, etc. ・Equipment body, rotor and inverter inspections are required.	・The operating panel, auxiliary equipment and protective devices are installed in a package that is easy to inspect, safe and reliable. ・The operating panel, auxiliary equipment and protective devices are installed in a package that is easy to inspect, safe and reliable. ・Since the air is compressed and blown by the screw, pulsation is smaller than with rotary blowers and smooth operation is possible.
Equipment Cost	100%	95%	90%
Maintenance cost	100%	97%	79%
Overall Evaluation	・High equipment and maintenance costs ・Low thermal efficiency. ・Building costs are high due to the large volume and heavy weight	・Resonance measures should be taken for piping where resonance occurs. ・Resonance measures should be taken for piping where resonance occurs. ・Low thermal efficiency.	・The control panel is installed on the surface of the package and allows for full operation and monitoring, making it easy to manage operations. ・No concern about surging caused by airflow control. ・Many have been introduced in other countries.
	Screw-type blowers are adopted in this project because they are superior in terms of thermal efficiency, equipment cost, maintenance cost, installation space and weight.		

Source: Created by JET

(4) Sludge Dewatering Machine

	Belt-press Dewaterer	Press-in screw press Dewaterer	Centrifugal Dewaterer	Multi-plate screw press Dewaterer
Description	The sludge is fed onto a filter cloth, gravity dewatered, then clipped between two filter cloths and pressed against rollers using the tension of the filter cloth to dewater it.  	Flocculated sludge is pressurized and fed at a constant pressure into the gap between the screen and the screw shaft, and the sludge is continuously dewatered through thickening, filtration and pressing by volume changes while moving from the inlet to the outlet due to the low-speed rotation of the screw.  	Sludge is fed into a rotating cylinder rotating at high speed, where centrifugal force separates solids of different specific gravity from water, and sludge cake is discharged by a screw-shaped discharger (conveyor) that is slightly differentiated from the rotating cylinder.  	Flocculated sludge flocculated in the service tank and mixing tank in the front section of the machine is gravity dewatered and separated into sludge and filter liquid. The screws are progressively thicker and narrower in pitch. Dewatering is carried out by the internal pressure created by this and the pressure applied from the back pressure plate. 
Target Sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・OD excess sludge, thickened sludge
Auxiliary equipment	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・wash water pumps. ・Chemical injection system (polymeric and inorganic coagulants)
Pre-treatment	Thickener tank required	Thickener tank required	Thickener tank required	Thickener tank unnecessary
Maintenance and management	・Sludge flocculation equipment, diffusion rotor, filter cloth tensioning device, filtration cloth meander corrector, filtration filter cleaning equipment, driving unit. ・One type of chemical	・Screws, outer casing screen, Screw driving unit ・One type of chemical .	・High-speed rotating equipment to be taken back to the factory for overhaul. ・One type of chemical	・Screws, fixed plate, movable plate, dorsal pressure plate, eccentric axis, driving device ・Two types of chemicals
	Difficult due to number of required parts	Easy due to small number of required parts	Needs to be taken back to the factory for overhaul/ minor repairs	Easy due to small number of required parts
Equipment cost	100%	82%	86%	35%
	Includes gravity thickener, dewatering/ conditioning equipment	Includes gravity thickener, dewatering/ conditioning equipment	Includes gravity thickener, dewatering/ conditioning equipment	Includes dewatering/ conditioning equipment
Maintenance costs	100%	68%	89%	89%
Overall Evaluation	In this project, the multiple plate screw press dewaterer will be adopted due to the following reasons ・Does not require a thickening process (thickening tank). ・Lowest sludge cake water content and excellent dewatering performance. ・Low equipment and maintenance costs			

Source: Created by JET

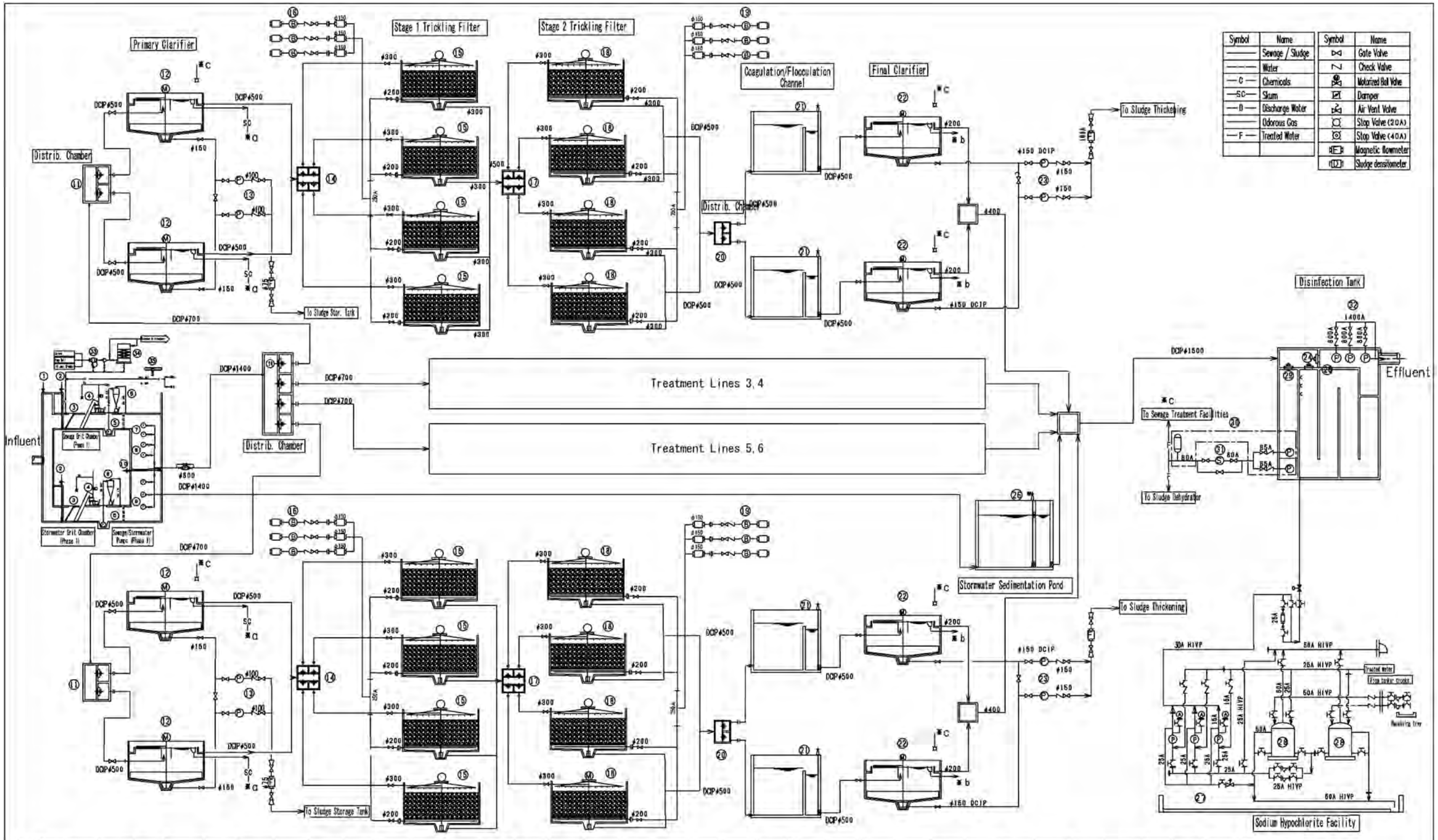
(5) Emergency Generator

	Diesel Engine Generator	Gas Turbine Generator
Description		
	The thermal energy of the intermittently exploding combustion gas is once converted into the reciprocating motion of the piston, which is then converted into the rotational motion of the crankshaft.	The thermal energy of the continuously burning combustion gas is directly converted into rotational motion by the turbine.
Generator Speed	Diesel, generator: 1,500rpm	Turbine: 22,000rpm, Generator: 1,500rpm
Fuel	Heavy oil, diesel oil	Heavy oil, kerosene, diesel oil
Fuel consumption	Small: 0.23-0.31 kg/kW・h	Large: 0.52-0.68 kg/kW・h
Grease consumption	Large: 1.36-2.72 g/kW・h	Small: 0.05-0.27 g/kW・h
Size/ Weight	Large and heavy	Small and light
Fuel air ratio	less	2.5-3 times more than the diesel
Maintenance Cost	Overhaul possible locally. Maintenance and inspection available by car mechanic.	Maintenance/overhaul must be conducted at factory
	50%	100%
Equipment Cost	100%	140%
Overall Evaluation	Diesel generators, which are advantageous in terms of equipment and maintenance costs, will be adopted in this project.	

Source: Created by JET

APPENDIX 3-8 Natabua WWTP Mechanical/Electrical Drawings

(1) Mechanical Equipment



NO	1	2	3	4	5	6
Name	Main Inlet gate	Grit Chamber Inlet Gates (Sewage/Stormwater)	Coarse Screen (Sewage/Stormwater)	[illegible] (Sewage/Stormwater)	Sand Pump (Sewage/Stormwater)	Sand Separator (Sewage/Stormwater)
Type	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Material: Steel Plate	Material: Stainless steel	Suction screw type submersible pump	Cyclone type sand separator
Specification	1500W×1500H	[illegible]	Opening size 50mm X Width 0.5m	Opening Size 25mm X Width 0.5m	80A×0.5m³/min×13m	80A×30m³/h×13m
	Motorized	Manual type	Manual type	[illegible]	-	-
Motor Capacity	2.2KW	-	-	0.4KW	5.5KW	
Units Ph1 / Ph2	1 / -	8 / -	8 / -	8 / -	8 / -	2 / -
Remarks						

NO	7	8	9	10	11	12
Name	Phase 1 Sewage Pump	Phase 2 Sewage Pump	Stormwater Pump	Pump Well Connection Gate	[illegible] (Sump)	Primary Clarifier Sludge Scraper
Type	Suction screw type submersible pump	Suction screw type submersible pump	Non-clogging submersible pump	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Central-drive suspended type
Specification	φ400×14.5m³/min×20m	φ600×29m³/min×20m	φ700×42.5m³/min×9.5m	500W×500H	500W×500H	Dia:14m×water depth2.5m
	-	-	-	Manual		-
Motor Capacity	75	132KW	90KW	-	-	0.4KW
Units Ph1 / Ph2	2 / -	2 (1) / -	3 (1) / -	1 / -	4 / -	6 / 2
Remarks	Detachable type	Detachable type	Detachable type			

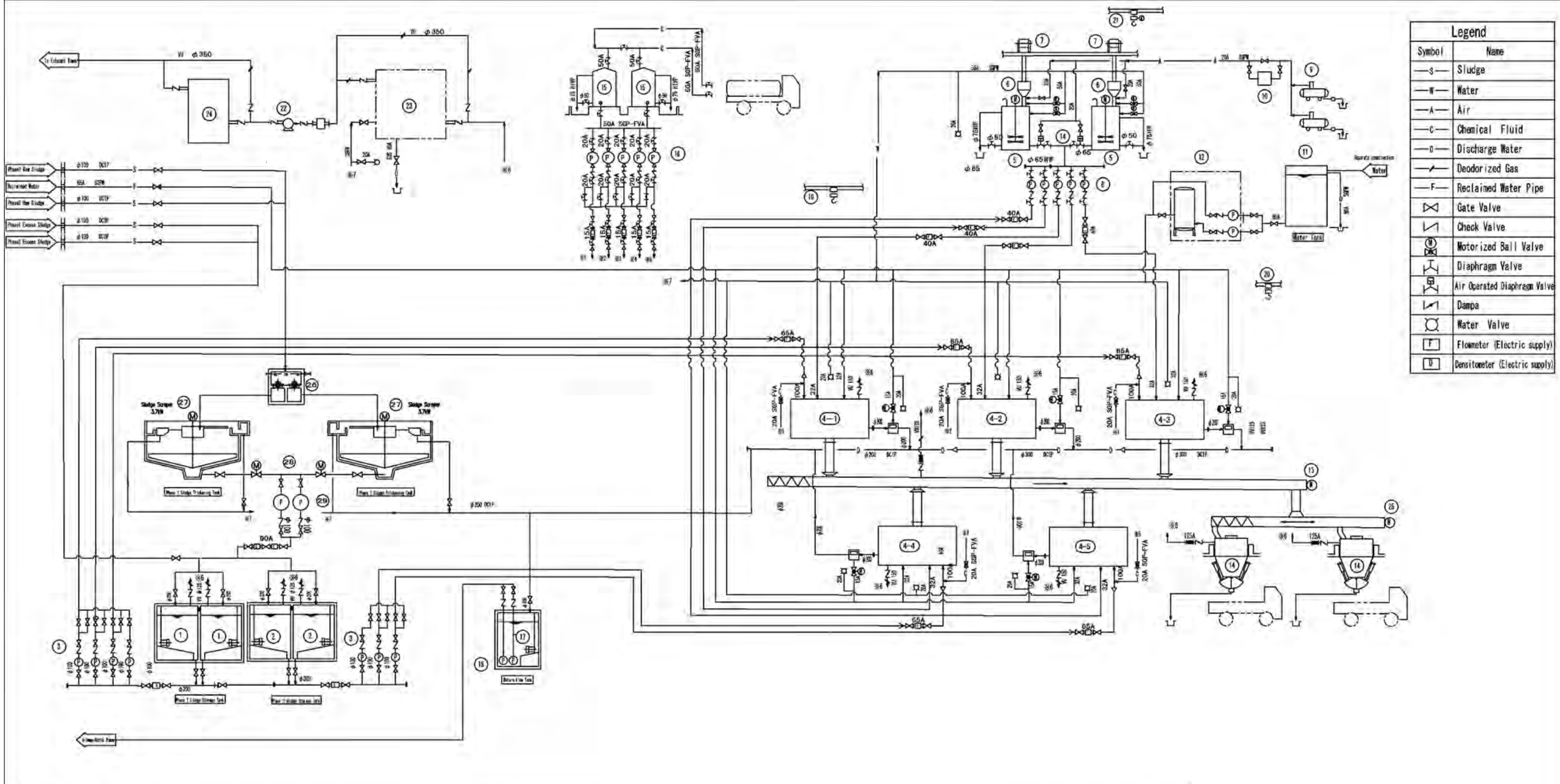
NO	13	14	15	16	17	18
Name	Raw Sludge Pump	Stage 1 Trickling Filter Movable Weir	Stage 1 Trickling Filter Distributor	Stage 1 Trickling Filter Blower	Stage 2 Trickling Filter Movable Weir	Stage 2 Trickling Filter Distributor
Type	Suction screw type	Type: Outside Screw Material: Cast Iron	Head Difference-driven Rotator	Screw-type blower	Type: Outside Screw Material: Cast Iron	Head Difference-driven Rotator
Specification	φ100×0.5m³/min×8m	400W×300H	Diameter: 19m	[illegible]	400W×300H	Diameter: 43m
	-	Movable Range: 300mm	-	-	Movable Range: 300mm	-
Motor Capacity	1.5KW	-	-	18.5KW	-	-
Units Ph1 / Ph2	6 (3) / 2 (1)	12 / 4	12 / 4	9 / 3	12 / 4	12 / 4
Remarks						

NO	19	20	21	22	23	24
Name	Stage 2 Trickling Filter Blower	Coagulation/Flocculation Channel Movable Weir	Coagulation/Flocculation Pond Outlet Gate	Final Clarifier Sludge Scraper	Excess Sludge Pump	Disinfection Tank Inlet Gate
Type	Screw type	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Peripheral-drive Column-supported type	Suction Screw type	Type: Outside Screw Material: Cast Iron
Specification	[illegible]	400W×300H	400W×400H	Dia: 27m×water depth3m	φ150×1.0m³/min×10m	1500W×1500H
	-	Movable Range: 300mm	Movable Range: 400mm	-	-	-
Motor Capacity	26KW	-	-	0.75KW	3.7KW	-
Units Ph1 / Ph2	9 (3) / 3 (1)	6 / 2	6 / 2	6 / 2	6 (3) / 2 (1)	1 / -
Remarks						

NO	25	26	27	28	29	30
Name	Disinfection Tank Bypass Gate	Stormwater Sedimentation Pond Outlet Gate	Hypochlorite Injection Pump	Hypochlorite Storage Tank	Inlet Gate for Treated Water	Treated water Pressure tank unit
Type	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Diaphragm metering type	FRP cylindrical tank	Type: Outside Screw Material: Cast Iron	Pressure tank unit
Specification	1500W×1500H	400W×400H	φ25×0.7~1.8mL/min×0.7MPa	8m³	400W×400H	80A×2.5m³/min×28m
	-	-	With VVF speed control	-	-	Made of FRP Tanks 3m³
Motor Capacity	-	-	0.4KW	-	-	7.5KW×2
Units Ph1 / Ph2	1 / -	1 / -	3 (1) / -	2 / -	1 / -	1 / -
Remarks			With control panel			With control panel

NO	31	32	33	34	35
Name	Automatic Strainer	Effluent Pump	Deodorizer Fan	Activated Carbon Adsorption Tower	Chain Hoist
Type	Automatic washing type	Non-clogging submersible pump	Single-suction turbo fan	[illegible]	Manual chain hoist
Specification	φ80×2.5m³/min	φ800×71m³/min×5m	50m³/min×200mmAq	50m³/min	2t×10mH
	-	-	-	Activated carbon cartridge type	-
Motor Capacity	0.75KW	90KW	3.7KW		-
Units Ph1 / Ph2	1 / -	3 (1) / -	1 / -	1 / -	1 / -
Remarks	With control panel				

Natabua WWTP (Lautoka)
Sewage Treatment Equipment Flowsheet

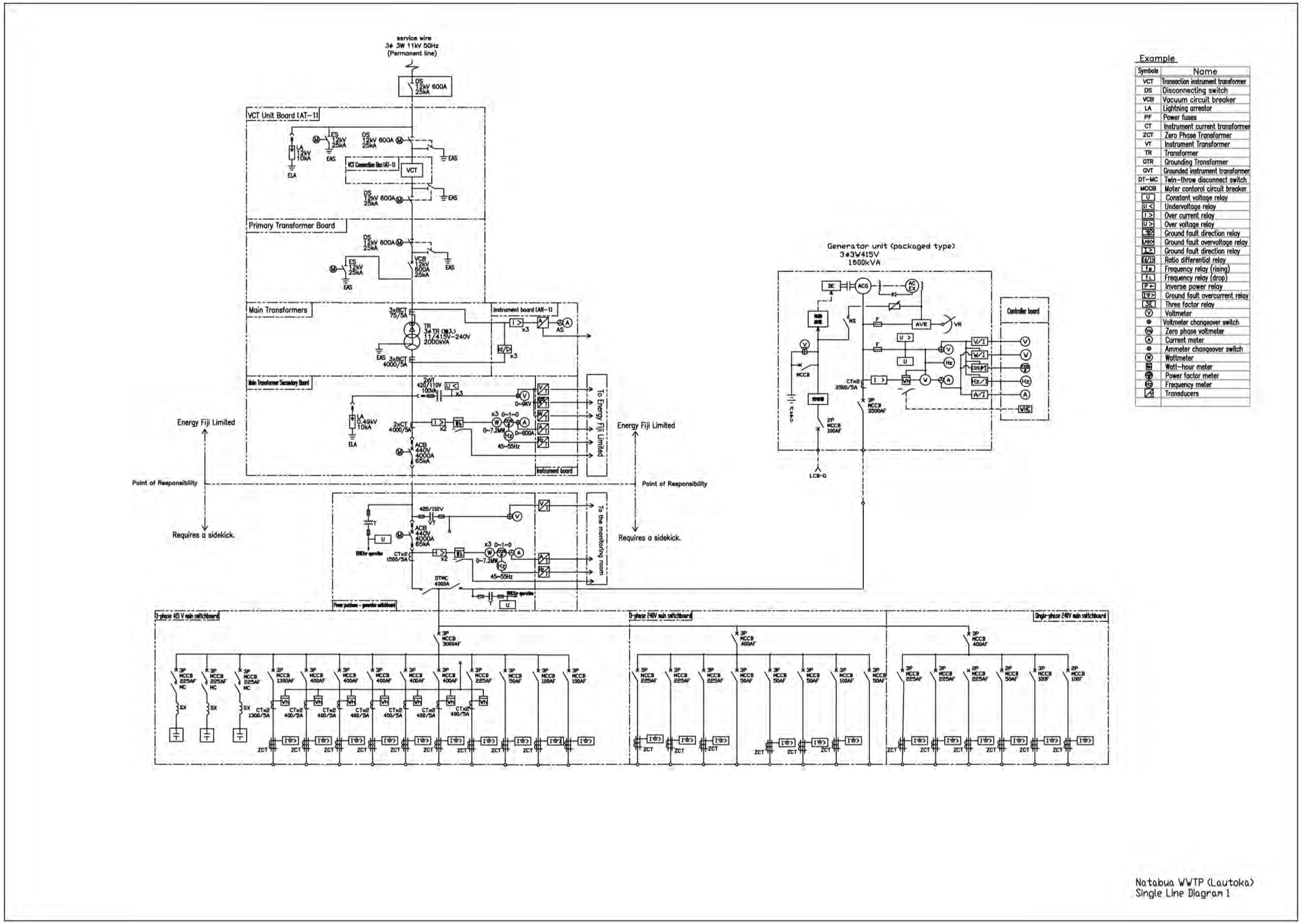


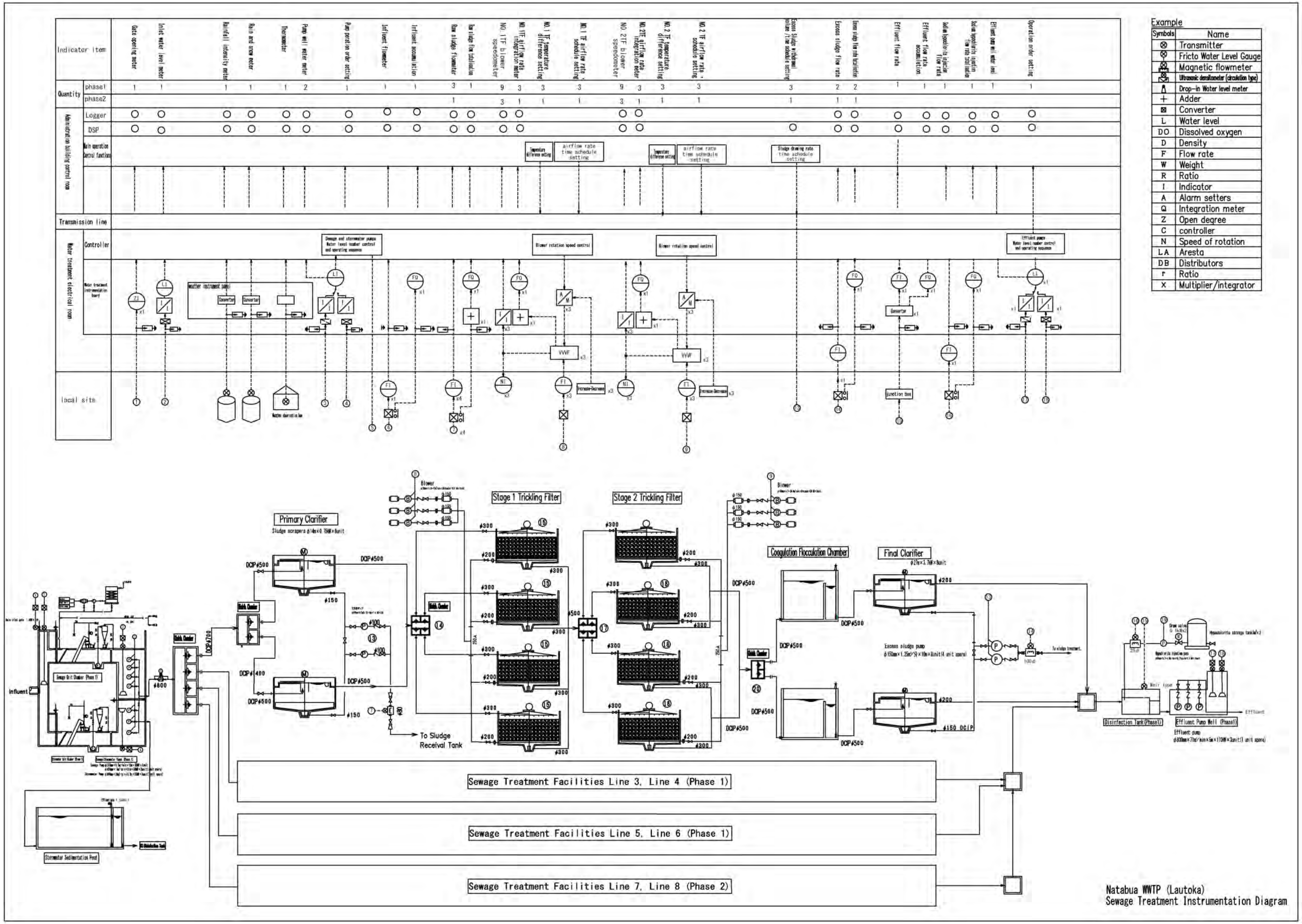
Equipment No.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯
Name	Phase 1 Sludge Storage Tank Mixer	Phase 2 Sludge Storage Tank Mixer	Sludge Supply Pump	Sludge Dewaterer	Chemical Storage Tank	Chemical Dosing Device	Chemical Container	Chemical Supply Pump	Air Compressor	Dehumidifying Device	Water Tank	Water Supply Unit	Sludge Cake Conveyor	Sludge Cake Storage Hopper	Inorganic Flocculant Storage Tank	Inorganic Flocculant Supply Pump
Type	Submerged Mixer	Submerged Mixer	Single Screw Type	Multi-plate Screw Press Dewaterer	Vertical Mixing Tank	Adjustable Continuous Feeder	Inverted Type	Single Screw Type Pump	Portable Type	Freezer Type	Rectangular Tank	Pressurized Tank Type Water Supply Pump Unit	Flight Conveyors	Material: Steel Plate Type: Square Cut Rato	Vertical Mixing Tank	Diaphragm Type Electromagnetic metering pump
Specification	φ580 mm	φ580 mm	φ200×13.0~32.0m³/h ×196Kpa	400kg-DS/day	8 m³	MAX 18,000L/h Hopper 200L	0.5 m³	φ32×400ℓ~600ℓ/h ×196Kpa	0.1m³/min ×0.73Mpa	0.1m³/min	8 m³	0.5m³/min ×343Kpa(35m)	600mm×32m	10 m³	8 m³	φ13×10~100L/h ×98Kpa
Motor Capacity (kW)	5.5	5.5	5.5	8.3 or Lower	3.7	0.4	-	2.2	1.5	0.075(Single phase)	[illegible]	7.5×2	7.5	2.2×2	FRP Type	2.2
Unit (All / Ph1 / Ph2)	9 / 9 / -	3 / - / 3	7 / 4(1) / 3(1)	5 / 3 / 2	2 / 2 / -	2 / 2 / -	2 / 2 / -	5 / 3 / 2	2(1) / 2(1) / 0	1 / 1 / 0	1 / 1 / 0	1 / 1 / 0	1 / 1 / 0	2 / 2 / 0	2 / 2 / -	5 / 3 / 2
Remarks			VVVF Control Equipment	With Control Panel	FRP Type			VVVF Control Equipment	With Control Panel	With Control Panel		With Control Panel		With Control Panel		

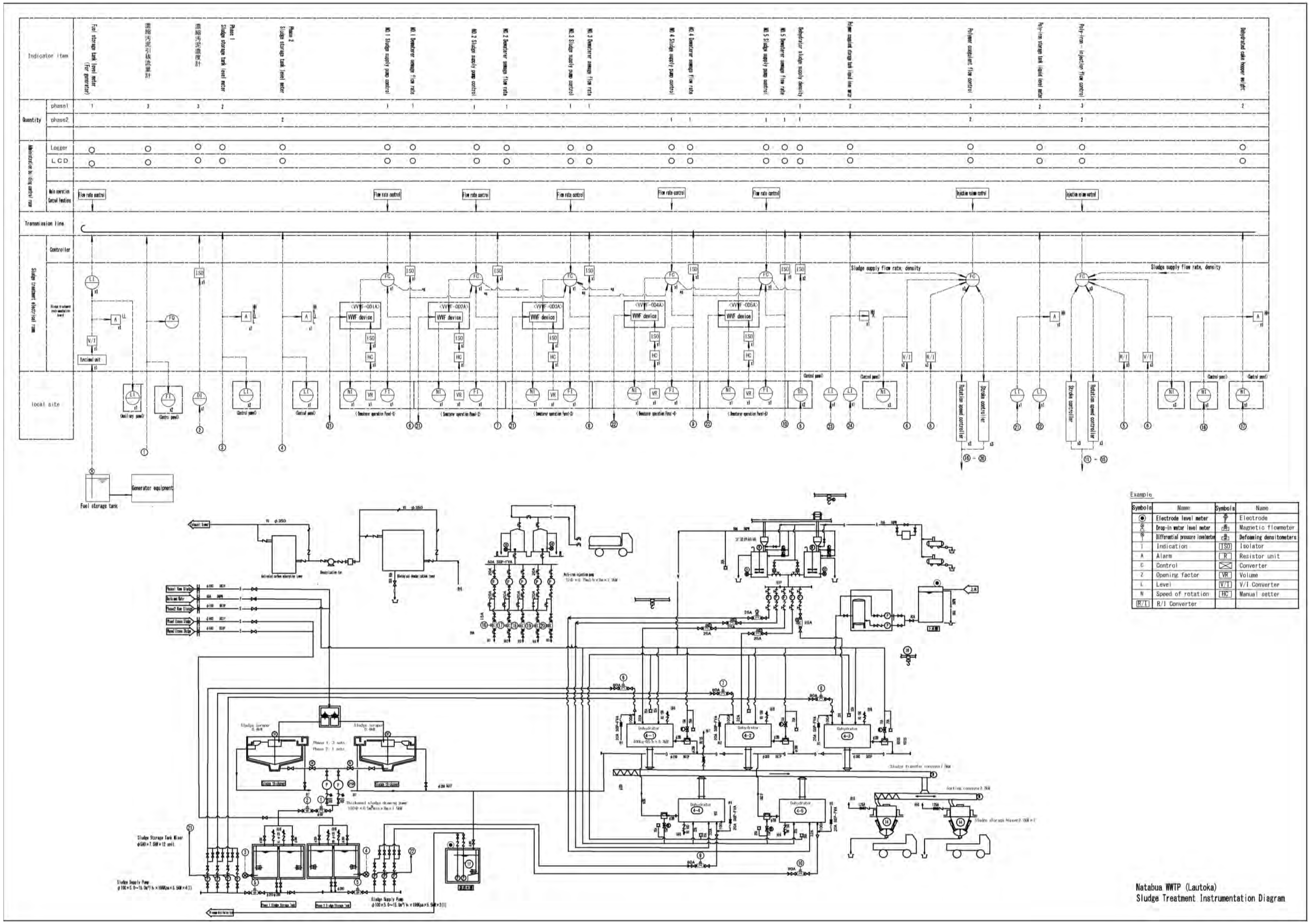
Equipment No.	⑰	⑱	⑲	⑳	㉑	㉒	㉓	㉔	㉕	㉖	㉗	㉘	㉙			
Name	Return Flow Tank Mixer	Return-flow Pump	Lifting Machine for Dewaterer Inspection	Lifting Machine for Loading/Unloading Machinery	Lifting Machine for Loading/Unloading Chemicals	Deodorizing Fan	Biological Deodorization Tower	Activated Carbon Adsorption Tower	Sludge Cake Distribution Conveyer to Hopper	Sludge Thickener Distribution Chamber Movable Weir	Thickening Tank Sludge Scraper	Thickened Sludge Withdrawal Valve	Thickened Sludge Withdrawal Pump			
Type	Submerged Mixer	Screw Type Submersible Pump Detachable Type	Manual-type Chain Block	Manual-type Chain Block	Motorized Chain Block	Single Suction Turbo Fan	Packed Column Tower	Vertical Type Tower	Flight Conveyor	Type: Outside Screw Material: Cast Iron	Center-drive Suspension type	Type: Outside Screw Material: Cast Iron	Suction Screw Type Sludge Pump			
Specification	φ580 mm	100φ×0.5m³/min×10m	2t×8m	2t×10m	1t×4m	50 m³/min	50 m³/min	50 m³/min	600mm×10m	Width 400mm x Height 300mm	φ5.5m×water depth 4m	φ100m	φ100mm×0.5m³/min×8m			
Motor Capacity (kW)	7.4 or higher	0.2			Hoist 0.8 + Traverse 0.4	3.7	–	Activated Carbon Cartridge Type	1.5	–	0.4	0.2	1.5			
Units (All / Ph1 / Ph2)	1 / 1 / -	2(1) / 2(1) / 0	2 / 2 / 0	1 / 1 / 0	1 / 1 / 0	2 / 1 / 0	1 / 0 / 1	1 / 1 / 0	1 / 1 / 0	8 / 6 / 2	8 / 6 / 2	8 / 6 / 2	8(4) / 6(3) / 2(1)			
Remarks																

Natabua WWTP (Lautoka)
Sludge Treatment Equipment Flowsheet

(2) Electrical Equipment


service wire
3φ 3W 11kV 50Hz
(Permanent line)
VCT Unit Board (AT-1)
Primary Transformer Board
Main Transformers
Instrument board (AR-1)
To Energy Fiji Limited
Energy Fiji Limited
Point of Responsibility
Requires a sidekick.
To the monitoring room
Generator unit (packaged type)
3φ3W415V
1500kVA
Controller board
3-phase 415 V main switchboard
3-phase 240V main switchboard
Single-phase 240V main switchboard
Example
Symbols | Name
VCT Transaction instrument transformer
DS Disconnecting switch
VCB Vacuum circuit breaker
LA Lightning arrestor
PF Power fuses
CT Instrument current transformer
ZCT Zero Phase Transformer
VT Instrument Transformer
TR Transformer
GTR Grounding Transformer
GVT Grounded instrument transformer
DT-MC Twin-throw disconnect switch
MCCB Moter contorol circuit breaker
Constant voltage relay
Undervoltage relay
Over current relay
Over voltage relay
Ground fault direction relay
Ground fault overvoltage relay
Ground fault direction relay
Ratio differential relay
Frequency relay (rising)
Frequency relay (drop)
Inverse power relay
Ground fault overcurrent relay
Three factor relay
Voltmeter
Voltmeter changeover switch
Zero phase voltmeter
Current meter
Ammeter changeover switch
Wattmeter
Watt-hour meter
Power factor meter
Frequency meter
Transducers
Natabua WWTP (Lautoka)
Single Line Diagram 1


Example
Symbols | Name
Transmitter
Fricto Water Level Gauge
Magnetic flowmeter
Drop-in Water level meter
Adder
Converter
L Water level
DO Dissolved oxygen
D Density
F Flow rate
W Weight
R Ratio
I Indicator
A Alarm setters
Q Integration meter
Z Open degree
C controller
N Speed of rotation
LA Aresta
DB Distributors
r Ratio
X Multiplier/integrator
Indicator item
Quantity
phase1
phase2
Logger
DSP
Transmission line
Controller
local site
Primary Clarifier
Stage 1 Trickling Filter
Stage 2 Trickling Filter
Coagulation Flocculation Chamber
Final Clarifier
Influent
To Sludge Receival Tank
Effluent
Sewage Treatment Facilities Line 3, Line 4 (Phase 1)
Sewage Treatment Facilities Line 5, Line 6 (Phase 1)
Sewage Treatment Facilities Line 7, Line 8 (Phase 2)
Natabua WWTP (Lautoka)
Sewage Treatment Instrumentation Diagram


Natabua WWTP (Lautoka)
Sludge Treatment Instrumentation Diagram

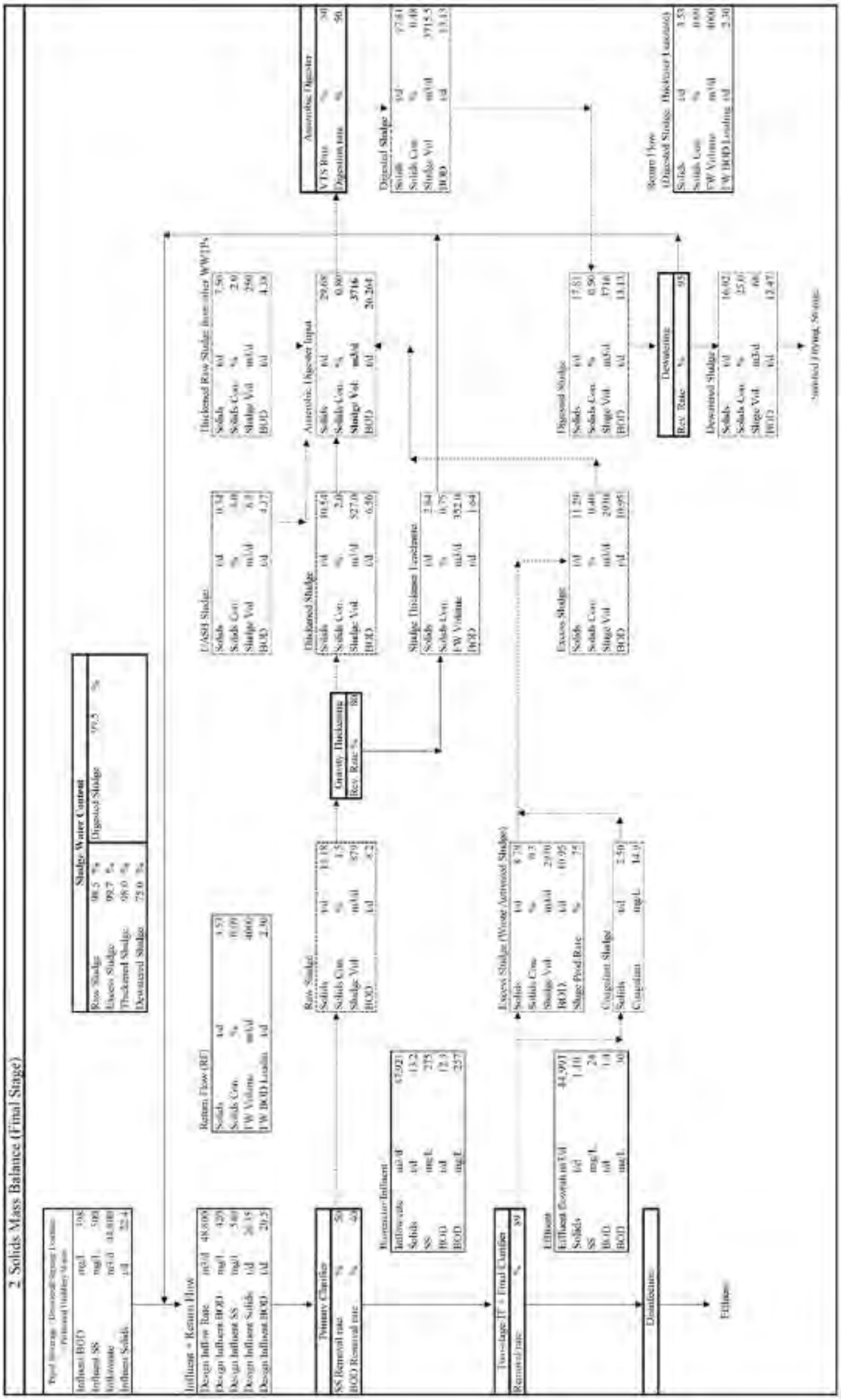
APPENDIX 3-9 Natabua WWTP Capacity Calculations

(1) Natabua WWTP

Item	Calculation
1. Design Parameters	
1-1 Outline of Wastewater Treatment	
(1) Type of Collection System	Separate Sewer System
(2) Water Treatment Process	Two-stage Trickling Filter (with ventilation / no recirculation)
1-2 Design Flowrate	
【Pipeline Sewerage】	
(1) Average Daily Flowrate	40,434 m³/d
(2) Peak Dry Weather Flowrate	44,477 m³/d
(3) Peak Wet Weather Flowrate	202,170 m³/d
【Bailed Domestic Septage】	
(1) Peak Daily Quantity	65 m³/d
(2) Dewatered Leachate	59 m³/d
【Pretreated Distillery Waste】	
(1) Bailed-in Distillery Waste	160 m³/d
(2) Pretreatment Influent	1760 m³/d
(Diluted using pipeline sewerage)	1600
【Total Influent Flowrate】	
(1) Average Daily Flowrate	40,700 m³/d
(2) Maximum Daily Flowrate	44,800 m³/d
(3) Maximum Hourly Flowrate	81,100 m³/d
(4) Peak Wet Weather Flowrate	202,400 m³/d
1-3 Influent Wastewater Quality	
【Pipeline Sewerage】	
(1) BOD	373 mg/L
(2) SS	486 mg/L
【Bailed Domestic Septage Dewatered Leachate】	
(1) BOD	250 mg/L
(2) SS	620 mg/L
【Pretreated Distillery Waste】	
(1) BOD	600 mg/L
(2) SS	600 mg/L
【Total Influent Flowrate*】	
(1) BOD	398 mg/L
(2) SS	500 mg/L
(3) T-N	45 mg/L
(4) T-P	11 mg/L
*: Based on pipeline sewerage/ pretreated distillery waste after comissioning of Season 1	

Item	Calculation
1-4 Design Influent Wastewater (Including Return Flow)	
(1) BOD	420 mg/L
(2) SS	540 mg/L
1-5 Removal Efficency (Primary Clarifier)	
(1) BOD	40 %
(2) SS	50 %
(Primary TF)	
(1) BOD	40%
(2) SS	40%
(Secondary TF + Final Clarifier)	
(1) BOD	80%
(2) SS	80%
Total	
(1) BOD	93 %
(2) SS	94 %
(3) T-N	45 %
(4) T-P	60 %
1-6 Effluent Wastewater Quality	General
(1) BOD	30.4 mg/L 40 mg/L →OK
(2) SS	32.5 mg/L 60 mg/L →OK
(3) T-N	24.7 mg/L 25 mg/L →OK
(4) T-P	4.4 mg/L 5 mg/L →OK
Sludge Production (Maximum Daily Flowrate)	
1-7 Excess Sludge	Solids= Maximum Daily Flowrate × Influent SS × $0.95 \times 0.75 \times 10^{-6}$ Solids= 44,800 m3/d × 540 mg/L × 94 %×0.75× 10^-6 = 17.1 ds-t/d Solid Concentration = 0.3 % Sludge = Solids ÷ Solids Concentration × 10^2 Sludge = 17.10 t/d ÷ 0.3 % × 10^2 Sludge(OUT) = 5,700 m^3/d
1-8 Raw Sludge	Solids = 2.27 ds-t/d Solid Concentration = 1.5 % Sludge = 2.27 t/d ÷ 1.5 % × 10^2 Sludge(OUT) = 152 m^3/d
1-9 Thickening	Solids (IN) = 17.1 ds-t/d Solids(OUT) = WAS × Recovery Rate × 10^{-2} Solids (OUT) = 17.10 t/d × 85 % × 10^-2 Ricovery Rate = 85 % = 14.6 ds-t/d Sludge(OUT) = Solids ÷ Solids Concentration × 10^2 Sludge(OUT) = 14.60 t/d ÷ 2 % × 10^2 Solid Concentratio = 2 % Sludge(OUT) = 730 m^3/d

Item	Calculation
1-10 Trucked-in Thickened Raw Sludge (from other WWTPs)	Solids (IN) = 7.5 ds-t/d Sludge(IN) = 250 m^3/d
1-11 Anaerobic Digestion	Solids (Excess) = 17.1 ds-t/d Solids (Raw) = 14.6 ds-t/d Solids (Raw from other WWTP) = 7.5 ds-t/d Solids (IN) = 39.2 ds-t/d Solids(OUT) = Input Sludge×VTS rate×Digestion Rate×10^{-2} Solids (OUT) = 39.20 t/d × 95 % × 10^-2 VTS Rate = 95 % Digestion Rate Solids(OUT) = Input Sludge × Recovery Rate×10^{-2} Solids (OUT) = 39.20 t/d × 95 % × 10^-2 Recovery Rate = 95 % = 37.3 ds-t/d Sludge(OUT) = Solids ÷ Solids Concentration×10^2 Sludge(OUT) = 37.30 t/d ÷ 25 % × 10^2 Solid Concentratio = 25 % Sludge(OUT) = 150 m^3/d
1-12 Dewatering	Solids (Excess) = 17.1 ds-t/d Solids (Raw) 2.3 ds-t/d Solids (IN) = 19.4 ds-t/d Solids(OUT) = WAS × Recovery Rate×10^{-2} Solids (OUT) = 19.37 t/d × 95 % × 10^-2 Recovery Rate = 95 % = 18.5 ds-t/d Sludge(OUT) = Solids ÷ Solids Concentration×10^2 Sludge(OUT) = 18.50 t/d ÷ 25 % × 10^2 Solid Concentratio = 25 % Sludge(OUT) = 74 m^3/d


2 Solids Mass Balance (Final Stage)
Influent BOD mg/L 398
Influent SS mg/L 500
Inflowrate m3/d 44,800
Influent Solids t/d 22.4
Sludge Water Content
Raw Sludge 98.5 %
Excess Sludge 99.7 %
Thickened Sludge 98.0 %
Dewatered Sludge 75.0 %
Digested Sludge 99.5 %
Influent + Return Flow
Design Inflow Rate m3/d 48,800
Design Influent BOD mg/L 420
Design Influent SS mg/L 540
Design Influent Solids t/d 26.35
Design Influent BOD t/d 20.5
Return Flow (RF)
Solids t/d 3.53
Solids Con. % 0.09
FW Volume m3/d 4000
FW BOD Loadin t/d 2.30
UASB Sludge
Thickened Raw Sludge from other WWTPs
Primary Clarifier
SS Removal rate % 50
BOD Removal rate % 40
Raw Sludge
Solids t/d 13.18
Solids Con. % 1.5
Sludge Vol m3/d 879
BOD t/d 8.2
Gravity Thickening
Rev. Rate % 80
Thickened Sludge
Solids t/d 10.54
Solids Con. % 2.0
Sludge Vol m3/d 527.0
BOD t/d 6.56
Anaerobic Digester Input
Solids t/d 29.68
Solids Con. % 0.80
Sludge Vol m3/d 3716
BOD t/d 20.264
Anaerobic Digester
VTS Rate %
Digestion rate %
Bioreactor Influent
Inflow rate m3/d 47,921
Solids t/d 13.2
SS mg/L 275
BOD t/d 12.3
BOD mg/L 257
Sludge Thickener Leachate
Solids t/d 2.64
Solids Con. % 0.75
FW Volume m3/d 352.0
BOD t/d 1.64
Digested Sludge
Solids t/d 17.61
Solids Con. % 0.48
Sludge Vol m3/d 3715.5
BOD t/d 13.13
Two-stage TF + Final Clarifier
Removal rate % 89
Excess Sludge (Waste Activated Sludge)
Solids t/d 8.79
Solids Con. % 0.3
Sludge Vol m3/d 2930
BOD t/d 10.95
Sludge Prod.Rate % 75
Effluent
Effluent flowrate m3/d 44,991
Solids t/d 1.10
SS mg/L 24
BOD t/d 1.4
BOD mg/L 30
Coagulant Sludge
Solids t/d 2.50
Coagulant mg/L 14.9
Excess Sludge
Solids t/d 11.29
Solids Con. % 0.40
Sludge Vol m3/d 2930
BOD t/d 10.95
Digested Sludge
Solids t/d 17.51
Solids Con. % 0.50
Sludge Vol m3/d 3716
BOD t/d 13.13
Disinfection
Effluent
Dewatering
Rev. Rate % 95
Dewatered Sludge
Solids t/d 16.92
Solids Con. % 25.0
Sluge Vol. m3/d 68
BOD t/d 12.47
Return Flow
Solids t/d 3.53
FW Volume m3/d 4000
FW BOD Loading t/d 2.30

Item	Calculation
3. Sewerage Pump	
3-1 Grit Removal Chamber	
Design Flowrate	
Maximum Daily Flowrate	= 44,800 m^3/d
Maximum hourly Flowrate	= 81,300 m^3/d
Number of Chambers	= 4
Flowrate per Chamber	= 81,300 m3/d ÷ 4 = 20,325 m3/d
Width	W = 3.0 m
Target Grit	Specific Weigh = 2.65 Diameter = 0.2 mm and larger Settling Velocit = 21 mm/sec
Average Velocity	= 0.3 m/s
Retention Time (T)	= 60 sec Range: 30~60 sec
Hydraulic Load	= 1800 m3/m2/d
Chamber Length(L)	$= \frac{Q}{Ls \times W}$ $= \frac{20,325}{1800 \times 3.0}$ = 3.8 m → 4.0 m
Water Depth	$= \frac{T \times Q}{W \times L}$ $= \frac{60 \times 20,325 /(60\times60\times24)}{3.0 \times 3.8}$ = 1.3 m
Sand pit Depth	= 0.2 × 1.3 m = 0.3 m →Minimun 0.3 m → OK
Expected Grit Removal	0.05 m3-removed Grit/ 1000m3-sewerage = 0.05 × 81300.0 ÷ 1,000 = 4.065 m3/d
3-2 Screen	
Average Velocity	= 0.45 m/s
Water Depth	= 1.3 m
Width	$= \frac{Q}{V \times H}$ $= \frac{20,325 /(60\times60\times24)}{0.45 \times 1.3}$ = 0.5 m
Expected Screen Waste	0.05 m3-removed screen waste/ 1000m3-sewerage = 0.05 × 81300.0 ÷ 1,000 = 4.065 m3/d

Item	Calculation
4. Stormwater Pump	
4-1 Grit Removal Chamber	
Design Flowrate	
Maximum hourly Flowrate	= 133,667 m^3/d
Number of Chambers	= 4
Flowrate per Chamber	= 133,667 m3/d ÷ 4
	= 33,417 m3/d
Width	W = 3.0 m
Target Grit	Specific Weigh = 2.65
	Diameter = 0.2 mm and larger
	Settling Velocit = 21 mm/sec
Average Velocity	= 0.3 m/s
Retention Time（T）	= 60 sec Range: 30~60 sec
Hydraulic Load	= 1,800 m3/m2/d
Chamber Length(L)	$= \frac{Q}{Ls \times W}$
	$= \frac{33{,}417}{1800 \times 3.0}$
	= 6.2 m → 6.5 m
Water Depth	$= \frac{T \times Q}{W \times L}$
	$= \frac{60 \times 33{,}417 /(60 \times 60 \times 24)}{3.0 \times 6.2}$
	= 1.3 m
Sand pit Depth	= 0.2 × 1.3 m
	= 0.3 m →Minimun 0.3 m → OK
Expected Grit Removal	0.05 m3-removed Grit/ 1000m3-sewerage
	= 0.05 × 133666.5 ÷ 1,000
	= 6.68333 m3/d
4-2 Screen	
Average Velocity	= 0.45 m/s
Water Depth	= 1.3 m
Width	$= \frac{Q}{V \times H}$
	$= \frac{33{,}417 /(60 \times 60 \times 24)}{0.45 \times 1.3}$
	= 0.7 m
Expected Screen Waste	0.05 m3-removed screen waste/ 1000m3-sewerage
	= 0.05 × 133666.5 ÷ 1,000
	= 6.68 m3/d

Item	Calculation
4. Primary Clarifier	
4-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 44,800 m^3/d
Maximum hourly Flowrate	= 81,100 m^3/d
Overflow rate	= 35 $m^3/m^2/d$
Required Area for settling	= 44,800 ÷ 35 = 1,280 m^2
Diameter of Basin	14 m
No. of basin	= 8 basins
Effective Area	= 14 ^ 2 ÷ 4 × π × 8 = 1,232 m^2
Depth of basin	= 2.5 m Diameter vs. Depth: 6 : 1 Range: 6:1~12:1 → **OK**
Overflow rate	= 44,800 m^3/d ÷ 1,232 m^2 = 36.4 $m^3/m^2/d$ Range: 35～70m3/m2/d → **OK**
Settling Time	= (1,232 × 2.5 × 24) ÷ 44,800 = 1.7 hrs Range:About 1.5 hrs → **OK**
Req. Length of weir	= (14 − 1.6) × π = 39 m
Weir Loading rate	= 44,800 ÷ (39) ÷ 8 = 143.6 $m^3/m/d$

Item	Calculation
5. Primary Trickling Filter	
5-1 Reactor Requirements	
Design Flowrate	
Maximum Daily Flowrate	= 44,800 m^3/d
Maximum hourly Flowrate	= 81,100 m^3/d
Number of Reactor	n = 16 Reactors
Treatment Capacity	Qin = 2,800 m3/d per reactor
5-2 Trickling Filter Media	
Media Type	Plastic Cross-flow or vertical-flow bundle
Material	Plastic
5-3 Reactor Volume	
(1) Design Parameters	
Maximum Daily Flowrate	= 44,800 m^3/d
Design PrimClar Flowrate	= 48,800 m^3/d
Design Reactor Flowrate	= 47,921 m^3/d
BOD loading ※	= 1.20 kg-BOD/(m3・d)
Influent BOD (of PC)	= 420 mg/L
BOD removal rate of Primary Clarifier	= 40 %
Filter Media Height	= 2.0 m (1.5 ~ 2 m)
Influent BOD into TR	= c_{BOD} x (1-$R_{BOD\ removal}$) = 420 mg-BOD/L x (1- 0.4) = 252 mg/L
(2) Hydraulic Loading	
Hydraulic Loading	$= \frac{\text{BOD loading} \times \text{Filter Media Height}}{c_{BOD\ TFinflow}}$ $= \frac{1.20\ \text{kg-BOD}}{(\text{m3}\cdot\text{d})} \times \frac{2.0\ \text{m}}{1} \times \frac{\text{L}}{252\ \text{mg-BOD}} \times \frac{1,000}{1}$
Hydraulic Loading	= 9.52 $m^3/m^2/d$
Diameter of TF	19 m (Max 45 m)
No. of basin	= 16 basins
Effective Area	= 19 ^ 2 ÷ 4 × π × 16 = 4,536 m^2
Actual Hydraulic Loading	= Q/A = 47,921 m3/d ÷ 4,536 m2 = 10.57 $m^3/m^2/d$ Range: 10~40 $m^3/m^2/d$(High-rate)
Actual BOD Loading	$= \frac{\text{Act. Hydraulic loading} \times c_{BOD\ TFinflow}}{\text{Filter Media Height}}$ → **OK** $= \frac{10.57\ \text{m3}}{(\text{m2}\cdot\text{d})} \times \frac{252.0\ \text{mg-BOD}}{\text{L}} \frac{\text{L}}{2.0\ \text{m}} \times \frac{1}{1,000}$ = 1.33 kg/m3/d → Range: 0.3~16kg/m3/d → **OK**

Item	Calculation

(3) Effluent BOD IWEM Eq.

$$\frac{S_e}{S_i} = \frac{1}{1 + k_{IWEM} \cdot \theta^{T-20} \left(\dfrac{a^m}{VLR^n} \right)} \quad (13.54)$$

Where,

S_i = influent BOD_5 (mg/L);
k_{IWEM} = kinetic coefficient ($m^{m-1} d^{n-1}$);
θ = temperature coefficient;
a = media specific surface area (m^2/m^3);
m = reduction factor for surface loss with increasing area;
VLR = volumetric hydraulic loading rate ($m^3/d \cdot m^2$) of trickling filter media; and
n = hydraulic rate coefficient.

Equation 13.52 has reported coefficients that account for 90% of data variability:

- k_{IWEM} = 0.0204 (rock and random); 0.40 (modular plastic).
- θ = 1.111 (rock and random); 1.089 (modular plastic).
- m = 1.407 (rock and random); 0.732 (modular plastic).
- n = 1.249 (rock and random); 1.396 (modular plastic).

k_IWEM = 0.4
Θ = 1.089
m = 0.732
n = 1.396
VLR = 10.57 $m^3/m^2/d$

T = 20 ℃

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TABLE 13.25 Physical properties of commonly used trickling filter media [illegible]

Media type	Material	Nominal size, m (feet)	Bulk density, kg/m^3 ($lb/cu\ ft$)	Specific surface area m^2/m^3 (sq ft/cu ft)	Void space, percent
Rock (river)		[illegible]	1442 (90)	[illegible]	[illegible]
Rock (slag)		[illegible]	1600 (100)	[illegible]	[illegible]
Corrugated plastic modules					
[illegible]	PVC	[illegible] × 1.22 (2 × 2 × 4)	[illegible]	[illegible]	[illegible]
Vertical flow	PVC	[illegible] × 1.22 (2 × 2 × 4)	[illegible]	[illegible]	[illegible]
Random pack	PP	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

a = 100 m2/m3

Eq. 13.54 Denominator

= 1 + 0.4 × 1.089 ^(20 -15) ×((100 ^ 0.732) / (10.57 ^ 1.396))

= 1 + 0.4 × 1.53 × 1.082
= 1.663

Se
= Si / 1.663
= 252 / 1.663
= **151.6 mg-BOD/L**

Removed BOD
= Si -Se
= 252 − 152 mg-BOD/L
= 100.4 mg-BOD/L

Item	Calculation

Actual Hydraulic Loading

= Q/A
= 47,921 m3/d ÷ 23,235 m2
= 2.07 $m^3/m^2/d$ Range: 1.4~4.2 m3/m2/d (Nitirifying TF)
1.0~4.0 m3/m2/d (Low-rate TF)
→ **OK**

Actual BOD Loading

$$= \frac{\text{Act. Hydraulic loading} \times C_{BOD\ Tinflow}}{\text{Filter Media Height}}$$

$$= \frac{2.07\ \text{m3}}{(\text{m2}\cdot\text{d})} \times \frac{151.6\ \text{mg-BOD}}{\text{L}} \quad \frac{\text{L}}{2.0\ \text{m}} \times \frac{1}{1{,}000}$$

= 0.16 kg/m3/d →
Range: 0.16~0.19kg/m3/d

→ **OK**

(3) Effluent BOD
IWEM Eq.

$$\frac{S_e}{S_i} = \frac{1}{1 + k_{IWEM} \cdot \theta^{(T-15)} \left(\frac{a^m}{VLR^n}\right)} \qquad (13.54)$$

Where,
S_i = influent BOD_5 (mg/L);
k_{IWEM} = kinetic coefficient ($m^{m-1}\ d^{n-1}$);
θ = temperature coefficient;
a = media specific surface area (m^2/m^3);
m = reduction factor for surface loss with increasing area;
VLR = volumetric hydraulic loading rate ($m^3/d \cdot m^3$) of trickling filter media; and
n = hydraulic rate coefficient.

Equation 13.52 has reported coefficients that account for 90% of data variability:

- k_{IWEM} = 0.0204 (rock and random); 0.40 (modular plastic).
- θ = 1.111 (rock and random); 1.089 (modular plastic).
- m = 1.407 (rock and random); 0.732 (modular plastic).
- n = 1.249 (rock and random); 1.396 (modular plastic).

k_IWEM = 0.4
Θ = 1.089
m = 0.732
n = 1.396
VLR = 2.07 $m^3/m^2/d$
T = 20 ℃

13-116 Design of Municipal Wastewater Treatment Plants

Table 13.25 Physical properties of commonly used trickling filter media [illegible]

Media type	Material	Nominal size, m (feet)	Bulk density, kg/m³ (lb/cu ft)	Specific surface area, m²/m³ (sq ft/cu ft)	Void space, percent
Rock (river)		[illegible]	[illegible]	[illegible]	[illegible]
Rock (slag)		[illegible]	[illegible]	[illegible]	[illegible]
[illegible]					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

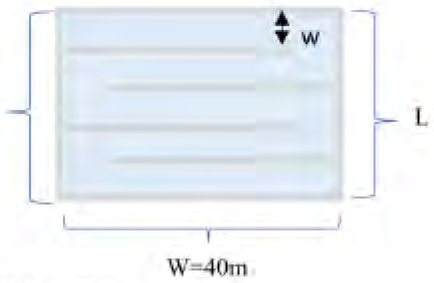
a = 100 m2/m3

Eq. 13.54 Denominator

$$= 1 + 0.4 \times 1.089^{(20-15)} \times \left(\frac{100^{0.732}}{2.07^{1.396}}\right)$$

= 1 + 0.4 × 1.53 × 10.54
= 7.458

Item	Calculation
Se	= Si / 7.458
	= 151.6 / 7.458
	= **20.4 mg-BOD/L**
Removed BOD	= 151.6 − 20.4 mg-BOD/L
	= 131.2 mg-BOD/L
(4) Nitrogen Removal	
Influent N	= 45 mg/L
Nitrogen Removal Rate: PC	= 18 %
Nitrogen Removal Rate: Double Tl	= 33 %
Effluent T-N	= 45 mg/L ×(1 − 0.18)×(1 − 0.33)
	= 24.7 mg/L
Effluent T-N Standard	= 25 mg/L (General Standards)
	⇒ **OK**
6-4 Forced air Ventilation	
(1) Required Airflow（Qa）	= 10～20 m3-air/kg-BOD removed × BOD removed per tower
Q per tower(q)	= 47,921 m3/d ÷ 16 towers
	= 2,995 m3/d per tower
	= 2.08 m3/min per tower
Removed BOD	= 131.2 mg-BOD/L
	= 0.131 kg-BOD/m3
BOD removed per tower	= 0.131 kg-BOD/m3 × 2,995 m3/d per tower
	= 393 kg-BOD/d per tower
	= 0.273 kg-BOD/min per tower
Required Airflow（Qa）	= 20 m3-air/kg-BOD removed × 0.273 kg-BOD/min per tower
	= **5.46 m3-air/min per tower**
7. Coagulation/Flocculation Canal	
7-1 Requirements	
Maximum Hourly Flowrate	= 81,100 m^3/d
Number of Canals	= 8
Flocculant Type	Polyferric Sulfate
Flowrate per canal(q)	= 81,100 m^3/d ÷ 8
	= 10,138 m^3/d
Soluble Phosphorus Ratio	= 75%
Soluble P	= 11 mg/L × 75%
	= 8 mg/L
Coagulant Dosage	$= \frac{\text{Soluble P}}{\text{P Atomic Weigh}} \times$ (Fe:P Ratio) × Fe Atomic Weight
	$= \frac{8}{31} \times 1 \times 56$
Coagulant Dosage	= 15 mg/L

Item	Calculation
7-2 Rapid Mixing Canal	
Mixing Time(=HRT)	= 2 minutes Range: 1~5 min
Velocity(v)	= 1.5 m/s
Depth (D)	= 0.3 m
Total Volume	= q × HRT
	= 10,138 m^3/d × 2 min / (60 min × 24 hr)
	= 15 m3
Canal Width(w)	= q ÷ (v×D)
	= 10,138 m^3/d ÷ (1.5 m/s × 0.30 m) ÷ (24×60×60)
	= 0.261 m
	→ 0.26 m
Actual Velocity	= q ÷ (w×D)
	= 10,138 m^3/d ÷ (0.3 m× 0 m) ÷ (24×60×60)
	= 1.504 m/s
	→ **OK**
Canal Length(l)	= V ÷ A = V ÷ (W×D)
	= 15 m3 ÷ (0.26 m× 0.3 m)
	= 192.3 m
Let: Canal Structure Width(W)	= 40 m
Canal Structure folds(f)	= 5 folds
Let: Wall width	= 0.2 m
	
Canal Structure Length(L)	= w×f + Wall width × Wall numbers
	= 0.26 m× 5 + 0.2 m × (5 - 1)
	= 2.1 m
7-3 Flocculation Canal	
Hydraulic Retention Time	= 20 minutes Range: 20~30 min
Velocity Range(v)	= 15.0 ~ 30 cm/s Range: 15~30 cm/s
	= 0.15 ~ 0.3 m/s
Depth(D)	= 0.3 m
Total Volume(V)	= q × HRT
	= 10,138 m^3/d × 20 min / (60 min × 24 hr)
	= 141 m3
Cross Sectional Dimension per Velocity 【v=15 cm/s】	
Target Velocity	= 0.15 m/s
Canal Width	= q÷(v×D)
	= 10,138 m^3/d ÷ (0.2 m/s × 0.30 m) ÷ (24×60×60)
	= 2.607 m
	→ 2.5 m

Item	Calculation
Effective Area	= 27 × 2 ÷ 4 × π × 8
	= 4,580 m²
Depth of basin	= 3 m
	Diameter vs. Depth: 9 : 1
	Range: 6:1~12:1 → **OK**
Overflow rate	= 44,800 m³/d ÷ 4,580 m²
	= 9.8 m³/m²/d Range: 8～12m3/m2/d → **OK**
Req. Length of weir	= (27 − 1.6) × π = 79.8 m
9. Disinfection	
9-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 44,800 m³/d
Maximum hourly Flowrate	= 81,100 m³/d
Peak Wet Weather Flowrate	= 202,400 m³/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 202,400 ÷ 24 ÷ 60 ÷ 60 × 900
	= 2109 m³
Depth	= 2 m
Width	= 2 m
Length	= 530 m = 108 m × 5 folds
Volume	= 2 × 2 × 530
	= 2120 m³
Actual Contact Time	= 2120 ÷ 202,400 × 24 × 60
	= 15.08 min → **OK**
10. Sludge Treatment	
10-1 Sludge Thickening	
Target : Natabua Raw Sludge Only	
Solids (IN)	= 13.18 t/d
Solid Concentration	= 1.50 %
Sludge(IN)	= 879 m3/d
Solid Concentration(OUT)	= 2.00 %
SS loading	= 75 kg-DS/m2/d
Tank Depth	= 4 m
Maximum retention time	= 12 hrs
Number of Thickeners	= 8 tanks

Item	Calculation
Required Surface Area	= 13.18 t/d × 1000 kg/t ÷ 75 kg-DS/m2/d
	= 175.73 m2
Diameter of Basin(D)	= 6 m
Effective Area	= 6 ^ 2 ÷ 4 × π × 8 tanks
	= 226.0 m^2
	> 175.7 m^2
	→**OK**
Actual Loading	= 13.18 t/d × 1000 kg/t ÷ 226.0 m^2
	= 58.32 kg-DS/m2/d
	Range: 60~90 kg-DS/m2/d
	→**OK**
【Thickened Raw sludge from other WWTPS】	
Solids (IN)	= 7.50 t/d
Solid Concentration	= 2.00 %
Sludge(IN)	= 250 m3/d
Receiving Volume	2 days worth
Number of Tanks	2 tanks
Required Tank Volume	= 250 m3/d × 2 d ÷ 2 tanks = 250 m3 per tank
Storage Tank Depth	= 4 m
Tank Size	
r	= (250 m3 ÷(4 m ×π))^0.5
	= 5.00 m × 2 tanks
10-3 Sludge Dewatering	
(1) Input Sludge	
【Septage】	
Solids (IN)	= 1.56 t/d
Solid Concentration	= 0.02 %
Sludge(IN)	= 65 m3/d
【Excess Sludge】	
Solids (IN)	= 2.50 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 833 m3/d
【Digested Sludge】	
Solids (IN)	= 17.81 t/d
Solid Concentration	= 0.50 %
Sludge(IN)	= 3716 m3/d
(2) Sludge Receival Tank	
Sludge Dewatering Operation	7 days in a week
Septage	1 days worth
Digested Sludge	1 days worth
Required Volume	
【Septage Storage】	= 65 m3/d × 1 d = 65 m3
【Digested Sudge Receival】	= 3,716 m3/d × 1 d = 3716 m3

Item	Calculation
Storage Tank Depth	= 4 m
Tank Size	
【Septage】 r	= (65 m3 ÷(4 m ×π))^0.5 ÷ 1 tanks
	= 3.00 m
【Digested Sudge】 r	= (3716 m3 ÷(4 m ×π))^0.5 ÷ 4 tanks
	= 5.00 m
(3) Septage Dewatering	
Sludge(IN)	= 65 m3/d
(All septage collected to Natabua)	
SS	= 24,000 mg/L
Solids	= V × SS ×10^-6
	= 65 × 24,000 × 10^-6
	= 1.56 ds-t/d
Operation Conditions	9 hrs in one day and 7 days in a week
	Solids (IN) = 1.56 ds-t/d
	Solids(OUT) = Septage×Recovery Rate×10^{-2}
	Solids (OUT) = 1.56 t/d × 95 % × 10^-2
	Recovery Rate = 95 %
	= 1.50 ds-t/d
	Sludge(OUT) = Solids÷Solids Concentration×10^{2}
	Sludge(OUT) = 1.50 t/d ÷ 25 % × 10^2
	Solid Concentration = 25 %
	Sludge(OUT) = 6 m^3/d
	Leachate(OUT = 59 m^3/d
Solids	= 1.56 × 7 ÷ 7 ÷ 9
(Required Dewatering Cap.)	× 1,000
	= 173.3 kg/d
Actual Dewatering capacity	= 70 kg/d
Number of Units	= 3 units
(4) Digested Sludge Dewatering	
	Solids (IN) = 17.81 ds-t/d
	Solids(OUT) = Digested Sludge×Recovery Rate×10^{-2}
	Solids (OUT) = 17.81 t/d × 95 % × 10^-2
	Recovery Rate = 95 %
	= 17.00 ds-t/d
	Sludge(OUT) = Solids÷Solids Concentration×10^{2}
	Sludge(OUT) = 17.00 t/d ÷ 25 % × 10^2
	Solid Concentration = 25 %
	Sludge(OUT) = 68 m^3/d

Item	Calculation
Solids (Required Dewatering Cap.)	= 17.81 × 7 ÷ 7 ÷ 9 × 1,000 = 1978.9 kg/d
Actual Dewatering capacity Number of Units	= 400 kg/d = 5 Units
11. Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge = 150 d
【Septage】	
Sludge Volume	= 6 m3/d × 150 d = 900 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 900 m3 ÷ 0.3 m = 3,000 m2
Drying Bed Area	= 30 m × 100 m = 3,000 m2 Phase 1 2250 m2 → **OK** = 0.3 ha Phase 2 750 m2
Dried Sludge	Dried Sludge Water Content 65 % Sludge Concentration 35 %
Solids (OUT) Dried Sludge (OUT)	= 1.50 t/d = 4.3 m3/d
【Digested Raw Sludge】	
Sludge Volume	= 68 m3/d × 150 d = 10200 m3
Sludge Depth	= 0.3 m 42,446
Required Drying Bed Area	= 10200 m3 ÷ 0.3 m = 34,000 m2
Drying Bed Area	= 340 m × 100 m = 34,000 m2 → **OK** = 3.4 ha = 25,500 m2(第1期) = 200 x 127.5 = 8,500 m2(第2期) = 200 x 42.5
Dried Sludge	Dried Sludge Water Content 65 % Sludge Concentration 35 %

Item	Calculation
Solids (OUT) Dried Sludge (OUT)	= 17.00 t/d = 48.6 m3/d
【Total Sludge Drying Bed Area】	= 3.7 ha = 2.9 ha Phase 1 + 0.8 ha Phase 2
12. Sludge Storage Space Sludge Storage Period	 = 20 yrs
【Septage】 Sludge Volume	 = 4.3 m3/d × 20 yrs × 365 d = 31,390 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 31,390 m3 ÷ 3.0 m = 10,464 m2
Septage Storage Area	= 105 m × 100 m = 10,500 m2 = 1.05 ha →**OK**
【Digested Sludge】 Sludge Volume	 = 48.6 m3/d × 20 yrs × 365 d = 354,780 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 354,780 m3 ÷ 3.0 m = 118,260 m2
Sludge Storage Area	= 1183 m × 100 m = 118,300 m2 Phase1 88,725 m2 →**OK** = 11.83 ha Phase 2 29,575 m2
【Total Sludge Storage Area】	= 12.90 ha = 9.9 ha (Phase 1) + 3.0 ha Phase 2

Item	Calculation
7. Primary Treatment (Stormwater Sedimentation)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 44,800 m/d
	= 179,200 m^3 /d
Required Retention Time	= 2.50 hrs
Required Volume	= 179,200.00 m3/d × 2.50 hrs ÷ 24
	= 18,667 m^3
Design Depth	= 3 m
Required Surface Area	= 6,222 m2
Stormwater Pretreatment Plant	= 85 m × 75 m × 3 m
	= 19125 m3 > 18,667 m^3
	→ **OK**

(2) Natabua Sludge Digestion + Biogas Power Generation Plant

Ⅰ. Input Parameters

1. Treatment Capacity of WWTPs

WWTP	Treatment Method	ADFW (m3/day)	MDFW (m3/day)	Digester Input
Vitogo	Two-stage TF	6,365	7,100	Thickened raw sludge
Natabua	Two-stage TF	40,434	44,500	Thickened raw sludge + Excess sludge + UASB sludge
Sabeto	Two-stage TF	6,393	7,100	Thickened raw sludge
Navakai	Oxidation Ditch	27,003	29,800	No input
Moala	Two-stage TF	17,483	19,300	Thickened raw sludge

2. Sludge

※Reffering from capacity calculation sheets

A. Thickened raw sludge from Vitogo, Sabeto, Moala

Solids	7.50	t/day
Solids Con.	2.0	%
Sludge Vol.	250	m3/day

B. Thickened raw sludge from Natabua

Solids	10.54	t/day
Solids Con.	2.0	%
Sludge Vol.	527	m3/day

C. Excess sludge from Natabua

Solids	11.29	t/day
Solids Con.	0.4	%
Sludge Vol.	2,930	m3/day

D. UASB Sludge

Solids	0.34	t/day
Solids Con.	4.0	%
Sludge Vol.	9	m3/day

E. Total Input

Total actual sludge input

= 250 + 527 + 2,930 + 9

= 3,716 m3/day

Total SS = 7.5 + 10.5 + 11.3 + 0.34

= 29.67 t-ds/day

= 10,832 t-ds/year

SS Concetration		Sludge Volume Conversion	
1.0	%	2,967	m3/day
		1,083,200	m3/year
2.0	%	1,484	m3/day
		541,600	m3/year
3.5	%	848	m3/day
		309,486	m3/year

3. Removed SS

A. Vitogo, Sabeto, Moala WWTP

Total MDWF = 7,100 + 7,100 + 19,300
= 33,500 m3/day
= 12,227,500 m3/year

Input Sludge = Raw Sludge only
SS removal rate = 50 % (Primary Clarifier)

Influent SS = 486 mg/L
Effluent SS of primary clarifier = 486 mg/L x (100%− 50 %)
= 243 mg/L
SS removed by primary clarifier = 486 − 243
= 243 mg/L

Annual removed SS = 243 mg/L x 12,227,500 m3/year ÷ 1,000,000
= 2,972 t-ds/year

Volume Conversion

SS Concetration		Volume Conversion
1.0	%	297,200 m3/year
2.0	%	148,600 m3/year
3.5	%	84,915 m3/year

B. Natabua WWTP

Total MDWF = 44,500 m3/day
= 16,242,500 m3/year

Input Sludge = Raw Sludge + Excess Sludge
SS removal rate = 95 % (Primary Clarifier+TF+Final Clarifier)

Influent SS = 500 mg/L
Effluent SS of treatment system = 500 mg/L x (100%− 95 %)
= 25.1 mg/L
SS removed by treatment system as raw/excess sludge = 500 − 25.054
= 475 mg/L

SS included in UASB sludge = 0.34 t-ds/d x 365 days/yr
= 124 t-ds/yr

Annual removed SS = 475 mg/L x 16,242,500 m3/year ÷ 1,000,000 + 124 t-ds/yr
= 7,839 t-ds/year

Volume Conversion

SS Concetration		Volume Conversion
1.0	%	783,900 m3/year
2.0	%	391,950 m3/year
3.5	%	223,972 m3/year

C. Total Sludge Input into Anaerobic Digester

Total MDWF	=	33,500	+	44,500
	=	78,000	m3/day	
	=	28,470,000	m3/year	
Annual SS Removed	=	2,972	+	7,839
	=	29.6	t-ds/day	
	=	10,811	t-ds/year	

Volume Conversion

SS Concetration		Volume Conversion	
1.0	%	2,962	m3/day
		1,081,100	m3/year
2.0	%	1,481	m3/day
		540,550	m3/year
3.5	%	846	m3/day
		308,886	m3/year

Ⅱ. Biogas and Power Genertation

Category	No.	Parameter	Unit	Value	Calculation
WWTP Influent	①	Maximum daily flow rate of all input WWTPs	m^3/日	78,000	Input
	②	Annual total flow	m^3/年	28,470,000	Input
	③	Influent SS concetration (Natabua)	mg/l	540	Input
		(Other WWTPs)	mg/l	486	Input
	④	SS removed	t-ds/year	10,811	Input

Category	No.	Parameter	Unit	Value	Calculation
Thickened Sludge	⑤	SS removed	t-ds/year	10,811	Input
	⑥	SS removed (2% concentration)	m3/year	540,550	Input

Category	No.	Parameter	Unit	Value	Calculation
Calculation Constants	⑦	Ratio of organic matter		80%	–
	⑧	Biogas production per unit organic matter	(Nm3/t-VS)	550	–
	⑨	Ratio of methane in produced biogas		60%	–
	⑩	Heating value of methane gas	(MJ/Nm3)	35.8	–
	⑪	Power generation efficiency		32%	–

Category	No.	Parameter	Unit	Value	Calculation
Biogas	⑫	Annual biogas production	Nm^3/year	4,756,840	= ⑤×⑦×⑧
	⑬	Annual methane gas production	Nm^3/year	2,854,104	= ⑫×⑨
	⑭	Hourly methane gas production	Nm^3/hr	326	= ⑬÷365÷24

Category	No.	Parameter	Unit	Value	Calculation
Power Generation	⑮	Annual energy production from methane gas	MJ/year	102,176,924	= ⑬×⑩
	⑯	Annual biogas power generation	kWh/year	9,082,394	= ⑮×⑪÷3.6
	⑰	Annual biogas power generation	MWh/year	9,082	=⑯÷1000
	⑱	Daily biogas power generation	kWh/day	24,884	=⑯÷365
	⑲	Hourly biogas power generation	kW	1,037	=⑱÷24

III. Construction and O/M Costs

1. Anaerobic Digester

Category	Field	No.	Parameter	Units	Value	Calculation
Construction Cost	Input	①	Input Sludge Volume (1%SS Concetration)	m3/day	2,967	Input
	Civil/Architectural	②	Cost	million JPY	1,257.4	= 0.169×①^0.539 ×100
	Mechanical/Electrical	③	Cost	million JPY	1,120.8	= 0.516×①^0.385 ×100
	TOTAL	④	Construction Cost	million JPY	2,378.2	= ②+③
		⑤		million FJD	37.9	= ⑥÷62.9

Category	Field	No.	Parameter	Units	Value	Calculation
O/M Costs	Input	⑥	Input Sludge Volume (1%SS Concetration)	m3/year	1,083,200	Input
	Labor,celectricity, consumables, etc.	⑦	Cost	million JPY	38.6	= 0.171×⑥^0.390
	Repairs and Maintenance	⑧	Cost	million JPY	22.4	= ③×0.02
	TOTAL	⑨	O/M Cost	million JPY	61.0	= ⑦+⑧
		⑩		million FJD	0.970	= ⑨÷62.9

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2. Biogas Power Generation Plant

Category	Field	No.	Parameter	Units	Value	Calculation
Construction Cost	Input	①	Power Generation	kW	1,037	Input
	Civil/Architectural	②	Construction Cost	million JPY	33.1	= 0.0263×①+5.8284
	Mechanical/Electrical	③	Construction Cost	million JPY	1,361.8	= 1.3132×①
	TOTAL	④	Construction Cost	million JPY	1,394.9	= ②+③
		⑤		million FJD	22.2	= ④÷62.9

Category	Field	No.	Parameter	Units	Value	Calculation
O/M Cost	Input	⑥	Power Generation	kW	1,037	Input
	TOTAL	⑦	O/M Cost (Including labor and electricity)	million JPY	60.0	= 0.0579×⑧
		⑧		million FJD	1.0	= ⑨÷62.9

3. Total

Category	Construction Cost* (million FJD)	O/M Cost (million FJD)
Anaerobic Digestor	37.9	1.0
Biogas Power Generation Facility	22.2	1.0
TOTAL	60.1	2.0

* Does not include land acquisition cost

IV. Required Foot Print and Land Acquisition Costs

1. Anaerobic Digester

No.	Parameter	Value	Unit	Calculation
①	Total Actual daily input to Digester	3,716	m3/day	Input
②	Digester Retention Time	40	days	Constant
③	Total Digester Volume	148,620	m3	= ①×②
④	Digester Footprint	22,160	m2	= 0.1491×③
⑤	Digester Footprint	2.2	ha	= ④÷10000

23,213

2. Biogas Power Generation Plant

No.	Parameter	Value	Unit	Calculation
①	Power Generation	1,037	kW	Input
④	Digester Footprint	926	m2	= 0.8927×①
⑤	Digester Footprint	0.1	ha	= ④÷10000

3. Total

Category	Footprint (ha)	Land Acquisiton Cost (million FJD)
Anaerobic Digestor	2.2	1.4
Biogas Power Generation Facility	0.1	0.1
TOTAL	2.3	1.5

APPENDIX 4-1 Setting Navakai WWTP Influent Water Quality Parameters

In the previous Regional Wastewater M/P and Municipal Sewerage M/P, the influent water quality for all WWTPs were set at a uniform value, applying the maximum value taken from adjusted raw influent data (2014-2018 annual averages, all WWTPs) and values adopted in past donor projects.

For the Pre-F/S, WWTP-specific influent water quality values were adopted, taking into consideration of 2019-2023 Navakai WWTP raw influent data provided by WAF.

The influent water quality for Navakai WWTP was set as shown in **Table A4-1.1**. Details on its calculation is explained in the following pages.

Table A4-1.1 Navakai WWTP Influent Water Quality

BOD (mg/L)	TSS (mg/L)	T-N (mg/L)	T-P (mg/L)
367	544	37	6

Source: Created by JET based on WAF data

(1) Raw Sewerage (Pipeline Sewerage)

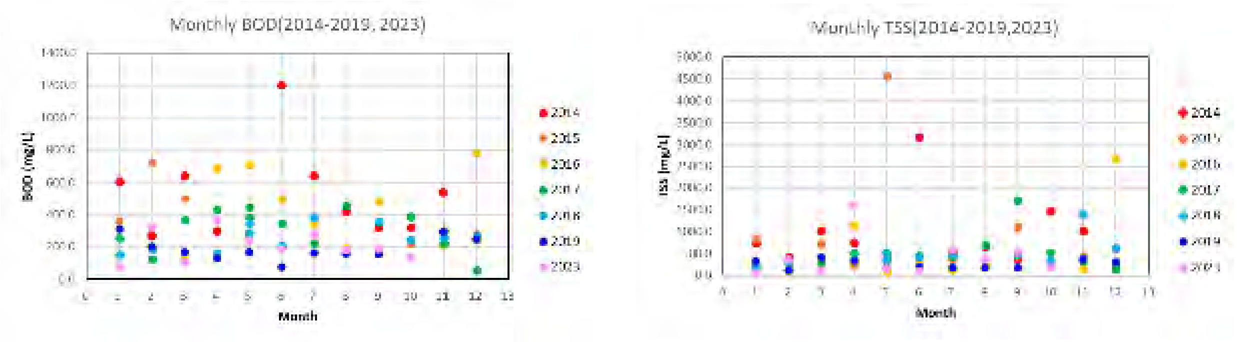
1) Selection of Raw Data

As previously stated in **APPENDIX 3-3**, raw influent data from 2014-2019 and 2023 was adopted for examination, excluding periods that were believed to be significantly affected by the decrease in tourist populations during the COVID-19 pandemic and Fiji border shutdowns.

2) Removing Outlier Data

WAF collects and analyzes influent samples taken from their WWTPs once a month. Raw influent data for Navakai WWTP showed some unusually extreme high/low results: BOD levels ranging from 4.0-1200.0 mg/L, and TSS levels ranging from 52.3-4563.0 mg/L. The collected data was examined for possible seasonal/annual trends but showed no apparent patterns, several being abrupt one-time events **(FigureA4-1.2**).

It was inferred that these readings were possible due to sample contamination or mis-recording of data, and direct application of all raw data would lead to over/under-estimation of influent water quality. Before further examination, outlier data (top 10% and bottom 10%) was removed from each data group. From the remaining data sets, the 80%tile value was set as Navakai WWTP's influent water quality (**Table A4-1.1**.).



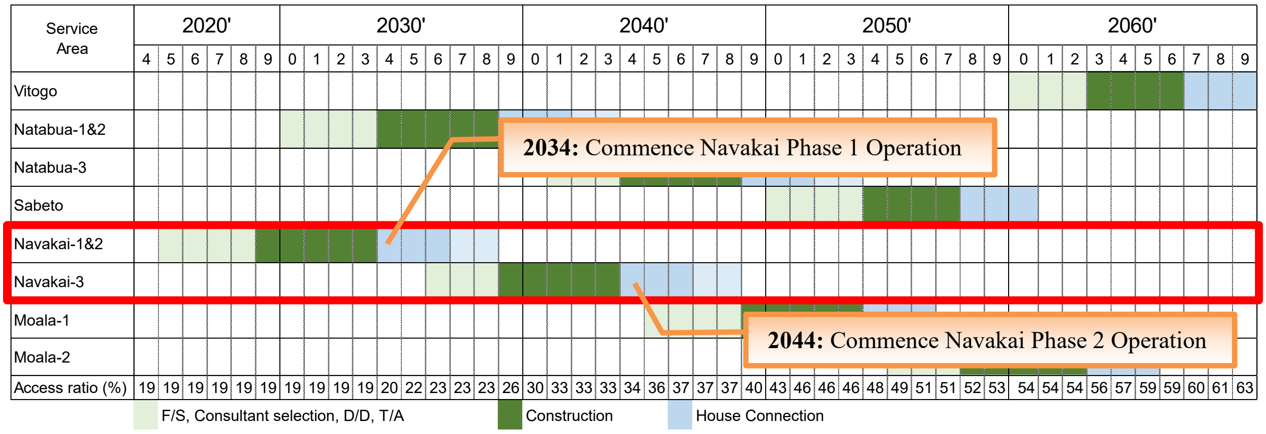
Source: Created by JET based on WAF data

Figure A4-1.1 Checking Seasonal Trends for Navakai WWTP Raw Influent Data

APPENDIX 4-2 Determining Navakai WWTP Phase 1/ Phase2 Treatment Line Numbers

(1) Setting Influent Flowrates for each Construction Phase

Due to its large requirement in treatment capacity, Navakai WWTP's facility will be constructed in two construction phases (**Figure A4-2.1**).



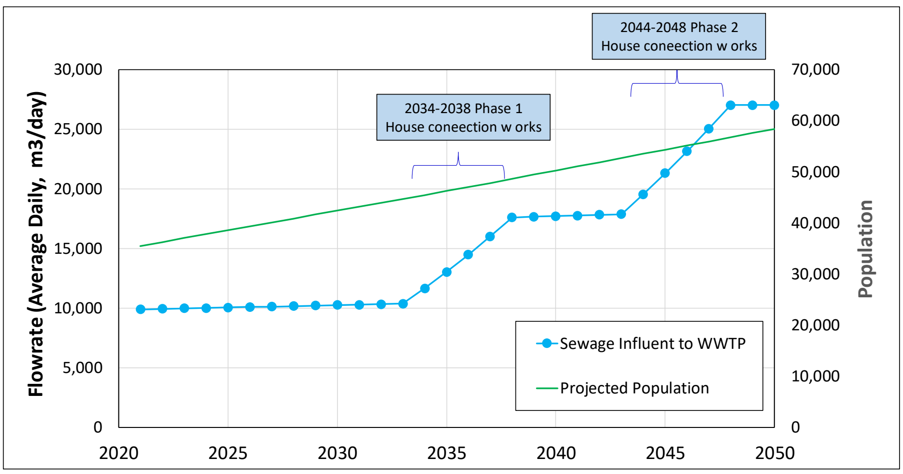
Source: Created by JET

Figure A4-2.1 Implementation Schedule for Navakai WWTP

Required treatment capacities of each phase was calculated based on their commencement schedule and the projected sewerage discharge (based on projected population growth of the sewerage service area) corresponding with that year. Namely, Navakai WWTP Phase 1 facilities must have the capacity to treat sewerage up until the commencement of Phase 2 facilities (2044), and Phase 2 facilities must be able to fulfill demands up until the completion of all house connection works (2048).

The projected population and sewerage flowrate to be treated by Navakai WWTP are shown in **Figure A4-2.2** and **Table A4-2.1**.

Figure A4-2.2 Navakai WWTP Sewerage Discharge vs. WWTP Treatment Capacity



Source: Created by JET

Table A4-2.1 Sewerage Discharge vs. Phase 1/Phase2 Treatment Capacity

Navakai WWTP Facilities	Year of Operation Commencement	Sewerage Discharge to be Treated (Average Daily Flowrate) (m^3/day)
Phase 1	2043	17, 879
Phase 2	2044	9,161
Total	2044 (Full Operation)	27,040

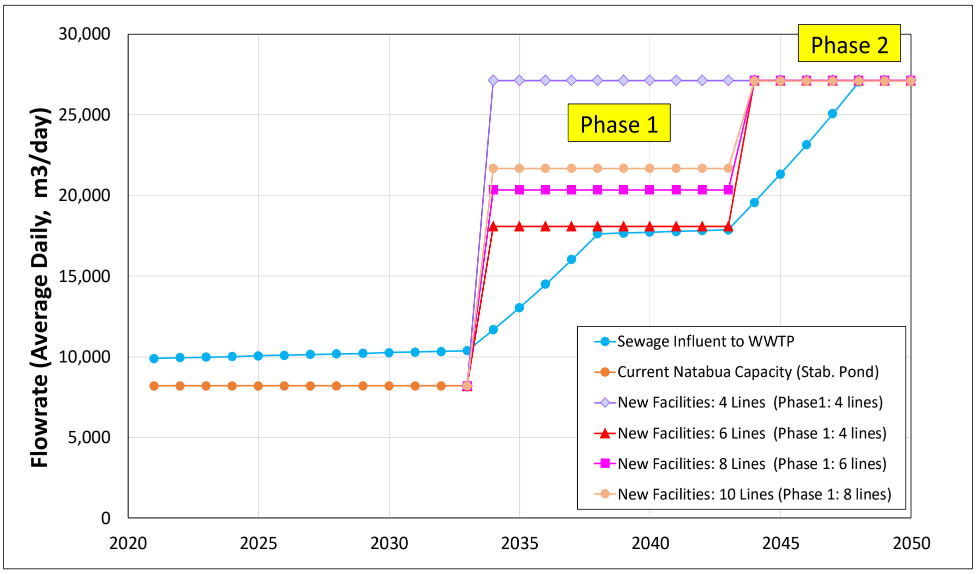
Source: Created by JET

(2) Determining Number of Treatment Lines

WWTPs often have even-number treatment lines, since this generally facilitates O&M and lessens required ME equipment units. Navakai WWTP's 4, 6,8, and 10-line scenarios were compared under the following conditions.

- Capacity of the operating treatment lines must fully cover the expected sewerage flowrate
- All treatment lines have same capacity throughout Phase 1 and Phase 2
- Even-number treatment lines in both Phase 1 and Phase 2 to facilitate O&M (ex. unified operation for all distribution chambers) and lessens required ME equipment units
- Treatment capacity of the treatment line does not subceed/exceed design constraints of treatment facilities (ex. HRT of oxidation ditches)
- Capacity of the operating treatment lines do not overly exceed sewerage flowrate

Figure A4-2.3 and **Table A4-2.2** shows the result of each scenario. Out of the four scenarios, the 6-line scenario had the least excess treatment capacity overall Thus the 6-line scenario was adopted for Navakai WWTP, constructing 4 line in Phase 1 and 2 lines in Phase 2.



Source: Created by JET

Figure A4-2.3 Navakai WWTP Multi-line System Scenario Comparison

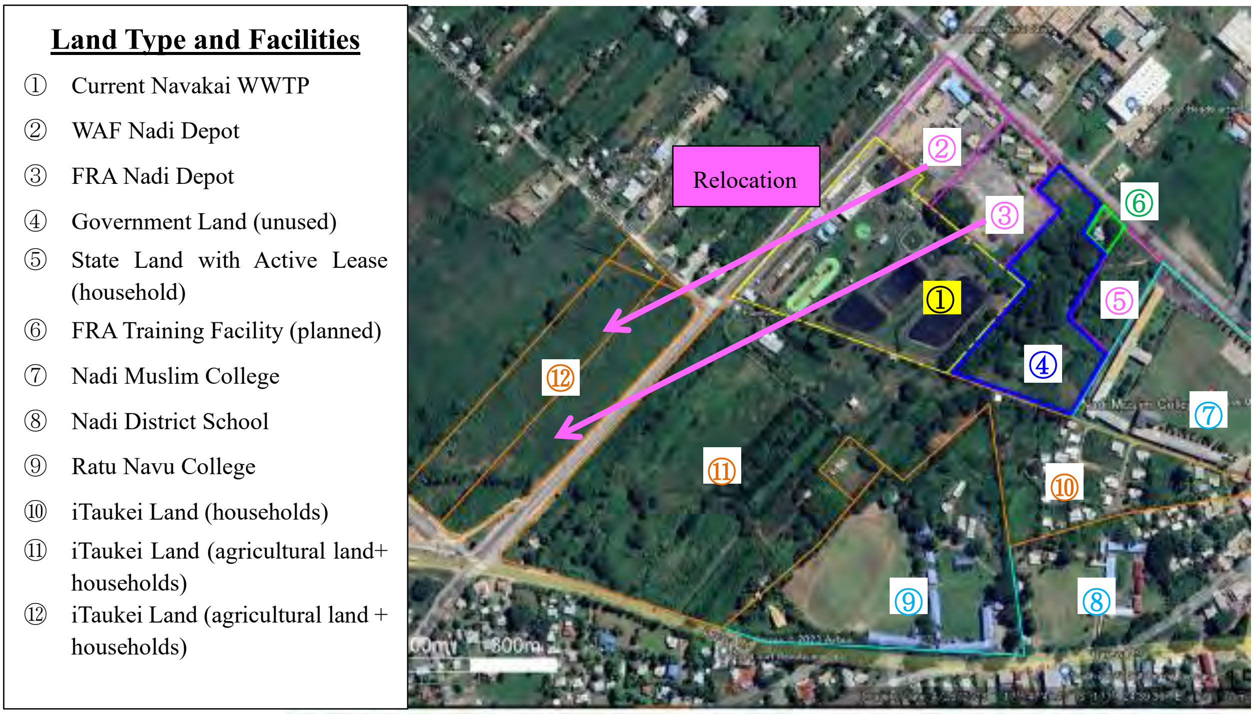
Table A4-2.2 Navakai WWTP Multi-line System Scenario Comparison

Year	Event	Facility in Operation	4 Line Scenario 6780 m3/d per line					6 Line Scenario 4520 m3/d per line					8 Line Scenario 3390 m3/d per line					10 Line Scenario 2710 m3/d per line				
			Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)	Lines Costructed	Lines Operating	Treatment Capacity (m3/d)	Sewage Influent (m3/d)	Excess Capacity (m3/d)
2021		Current	-	-	8,200	9,900	-	-	-	8,200	9,900	-	-	-	8,200	9,900	-	-	-	8,200	9,900	-
2022		Current	-	-	8,200	9,939	-	-	-	8,200	9,939	-	-	-	8,200	9,939	-	-	-	8,200	9,939	-
2023		Current	-	-	8,200	9,979	-	-	-	8,200	9,979	-	-	-	8,200	9,979	-	-	-	8,200	9,979	-
2024	Current Plant Operation	Current	-	-	8,200	10,018	-	-	-	8,200	10,018	-	-	-	8,200	10,018	-	-	-	8,200	10,018	-
2025		Current	-	-	8,200	10,058	-	-	-	8,200	10,058	-	-	-	8,200	10,058	-	-	-	8,200	10,058	-
2026		Current	-	-	8,200	10,097	-	-	-	8,200	10,097	-	-	-	8,200	10,097	-	-	-	8,200	10,097	-
2027		Current	-	-	8,200	10,136	-	-	-	8,200	10,136	-	-	-	8,200	10,136	-	-	-	8,200	10,136	-
2028		Current	-	-	8,200	10,176	-	-	-	8,200	10,176	-	-	-	8,200	10,176	-	-	-	8,200	10,176	-
2029		Current		4	27,120	10,215	16,905		4	18,080	10,215	7,865		6	20,340	10,215	10,125		8	21,680	10,215	11,465
2030	Phase 1 WWTP Construction	Current		4	27,120	10,254	16,866		4	18,080	10,254	7,826		6	20,340	10,254	10,086		8	21,680	10,254	11,426
2031		Current		4	27,120	10,294	16,826		4	18,080	10,294	7,786		6	20,340	10,294	10,046		8	21,680	10,294	11,386
2032		Current		4	27,120	10,333	16,787		4	18,080	10,333	7,747		6	20,340	10,333	10,007		8	21,680	10,333	11,347
2033		Current		4	27,120	10,373	16,747		4	18,080	10,373	7,707		6	20,340	10,373	9,967		8	21,680	10,373	11,307
2034		Phase 1		4	27,120	11,673	15,447		4	18,080	11,673	6,407		6	20,340	11,673	8,667		8	21,680	11,673	10,007
2035	Phase 1 House Connections	Phase 1		4	27,120	13,047	14,073		4	18,080	13,047	5,033		6	20,340	13,047	7,293		8	21,680	13,047	8,633
2036		Phase 1		4	27,120	14,497	12,623	4	4	18,080	14,497	3,583	6	6	20,340	14,497	5,843	8	8	21,680	14,497	7,183
2037		Phase 1		4	27,120	16,020	11,100		4	18,080	16,020	2,060		6	20,340	16,020	4,320		8	21,680	16,020	5,660
2038		Phase 1		4	27,120	17,618	9,502		4	18,080	17,618	462		6	20,340	17,618	2,722		8	21,680	17,618	4,062
2039		Phase 1		4	27,120	17,671	9,449		6	27,120	17,671	9,449		6	20,340	17,671	2,669		8	21,680	17,671	4,009
2040	Phase 2 WWTP Construction	Phase 1	4	4	27,120	17,723	9,397		6	27,120	17,723	9,397		6	20,340	17,723	2,617		8	21,680	17,723	3,957
2041		Phase 1		4	27,120	17,775	9,345		6	27,120	17,775	9,345		8	27,120	17,775	9,345		8	21,680	17,775	3,905
2042		Phase 1		4	27,120	17,827	9,293		6	27,120	17,827	9,293		8	27,120	17,827	9,293		8	21,680	17,827	3,853
2043		Phase 1		4	27,120	17,879	9,241		6	27,120	17,879	9,241		8	27,120	17,879	9,241		8	21,680	17,879	3,801
2044		Phase 1 + Phase 2		4	27,120	19,562	7,558		6	27,120	19,562	7,558		8	27,120	19,562	7,558		10	27,100	19,562	7,538
2045		Phase 1 + Phase 2		4	27,120	21,320	5,800		6	27,120	21,320	5,800		8	27,120	21,320	5,800		10	27,100	21,320	5,780
2046	Phase 2 House Connections	Phase 1 + Phase 2		4	27,120	23,152	3,968		6	27,120	23,152	3,968		8	27,120	23,152	3,968		10	27,100	23,152	3,948
2047		Phase 1 + Phase 2		4	27,120	25,059	2,061	6	6	27,120	25,059	2,061	8	8	27,120	25,059	2,061	10	10	27,100	25,059	2,041
2048		Phase 1 + Phase 2		4	27,120	27,040	80		6	27,120	27,040	80		8	27,120	27,040	80		10	27,100	27,040	60
2049		Phase 1 + Phase 2		4	27,120	27,040	80		6	27,120	27,040	80		8	27,120	27,040	80		10	27,100	27,040	60
2050		Phase 1 + Phase 2		4	27,120	27,040	80		6	27,120	27,040	80		8	27,120	27,040	80		10	27,100	27,040	60
			Total Excess Capacity				213,228	Total Excess Capacity				122,828	Total Excess Capacity				131,868	Total Excess Capacity				131,488

Source: Created by JET

APPENDIX 4-3 Navakai WWTP Alternative Layout Plan

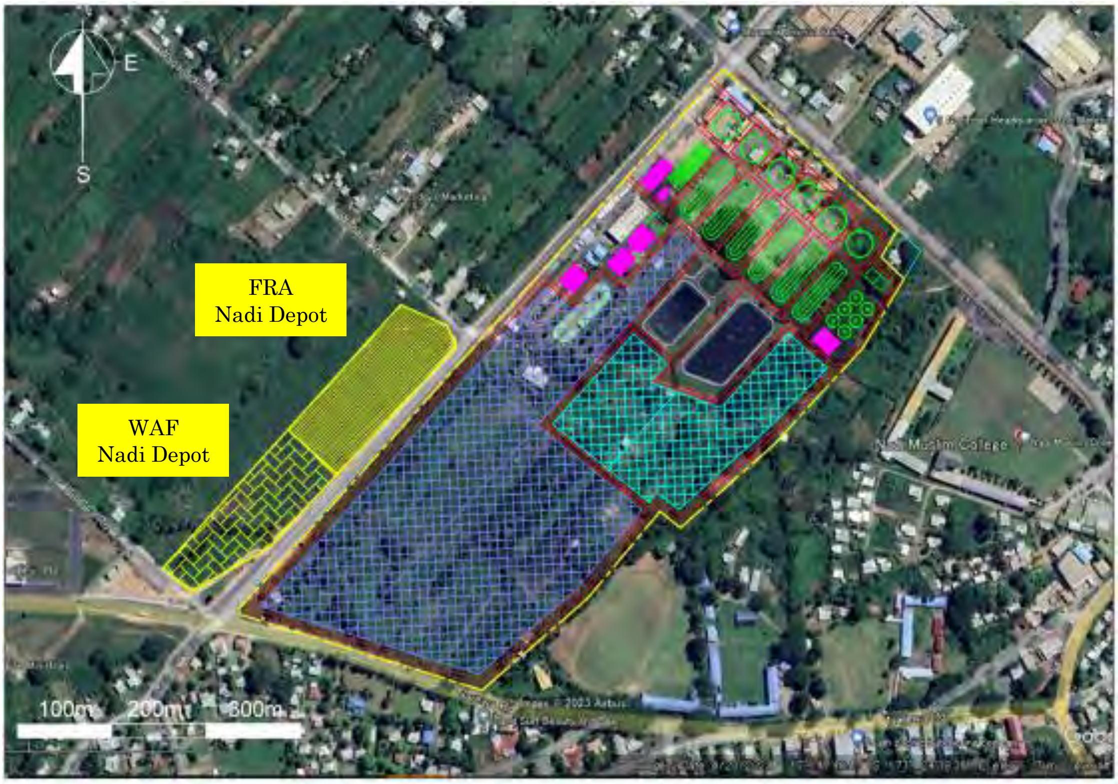
Upon examining the current land use conditions around Navakai WWTP, WAF notified that the exiting WAF Nadi Depot (**Figure A4-3.1**, ②) and FRA Nadi Depot (**Figure A4-3.1**, ③) could possibly be relocated to the iTaukei land lots across the street from Navakai WWTP (**Figure A4-3.1**, ⑫).



Source: Created by JET based on Ministry of Land data

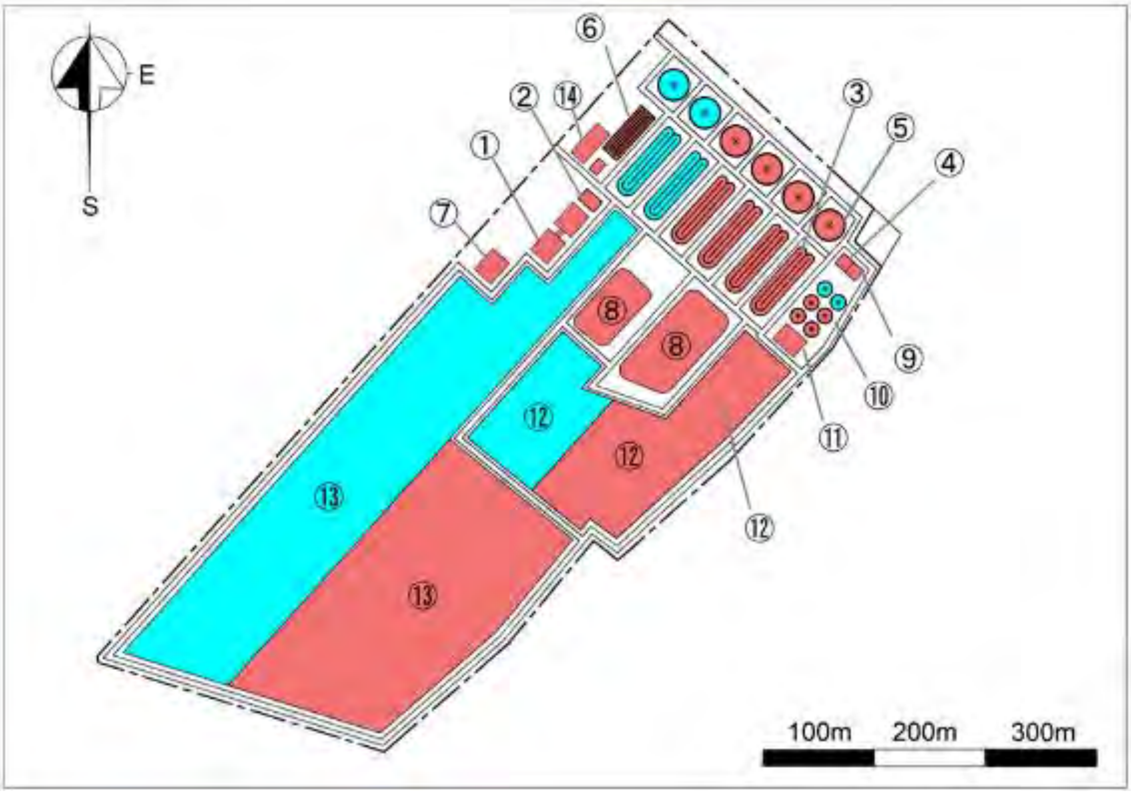
Figure A4-3.1 Current Land Use Situation around Navakai WWTP (March 2023)

Figure A4-3.2, **Figure A4-3.3**, **Table A4-3.1** shows the alternative layout plan for Navakai WWTP considering the relocation of the WAF and FRA depots, requested by WAF



Source: Created by JET

Figure A4-3.2 Navakai WWTP Alternative Layout Plan (Assuming Depot Relocation)



Source: Created by JET

Figure A4-3.3 Navakai WWTP Alternative Layout Plan (Phase 1/Phase 2 Facilities)

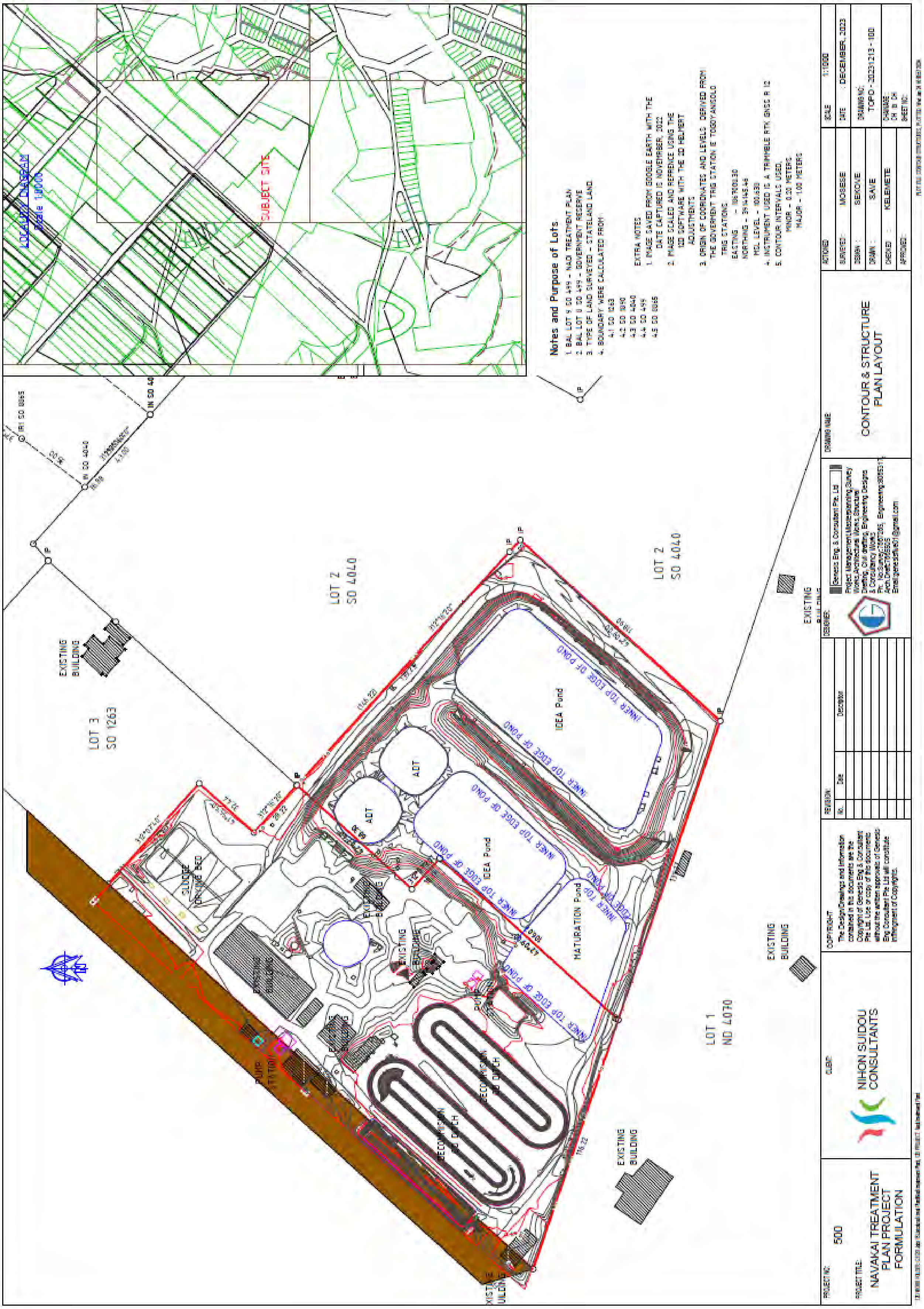
Table A4-3.6 Navakai WWTP Facilities (Alternative Layout)

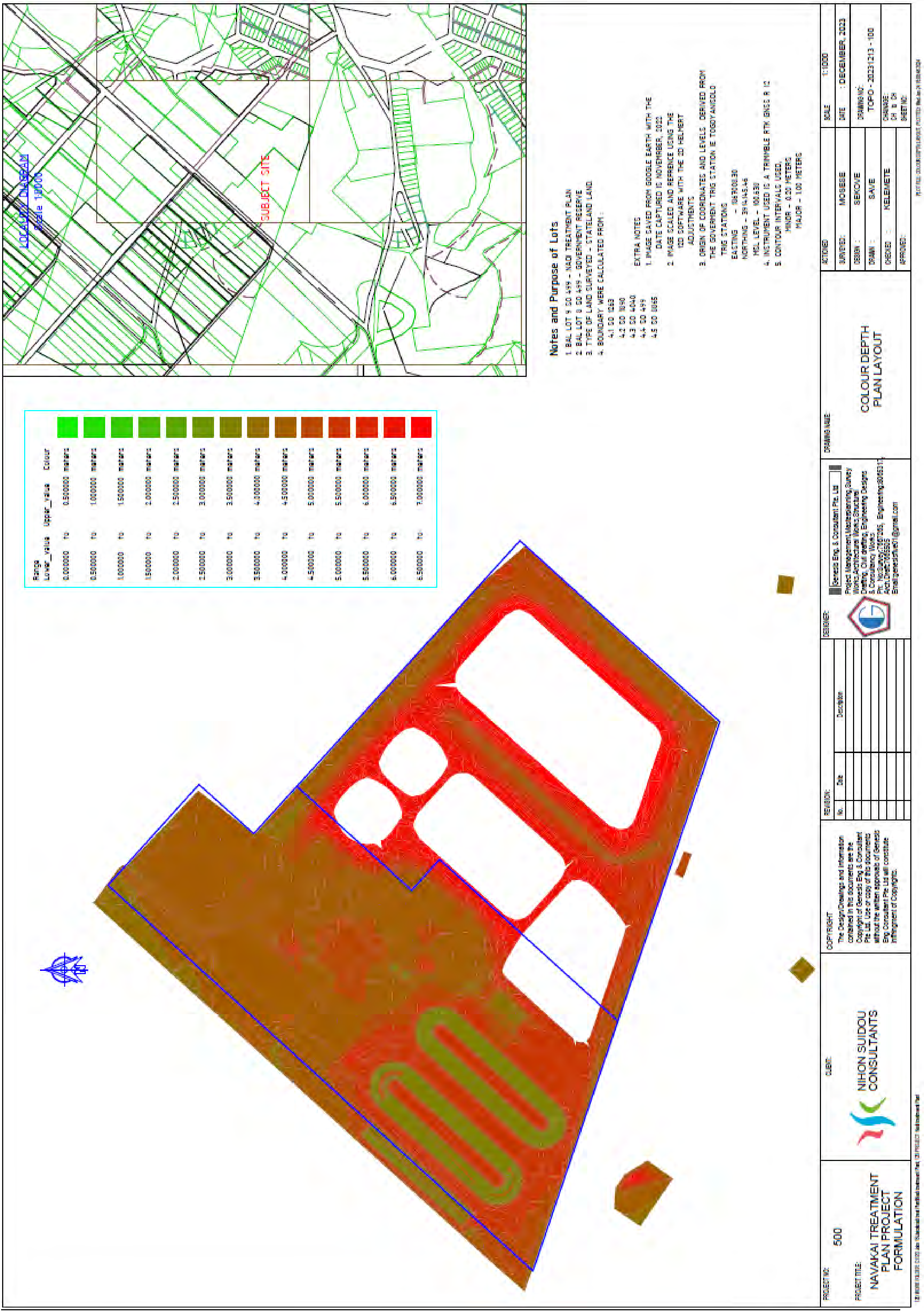
Ref. No.	Facility	Remarks
1	Inlet Pumping Station	Includes Sewerage and Stormwater pumps
2	Distribution Chamber	Influent from: Inlet Pumping Station Distribution to: OD tanks, Stormwater Sedimentation Ponds
3	Oxidation Ditch Tanks	HRT: 21.4 hr
4	Distribution Chamber	Influent from: OD tanks Distribution to: Final Clarifiers
5	Final Clarifiers	Diameter: 27 m
6	Disinfection Tank	Minimum contact time: 15 min.
7	Effluent Pumping Station	Pump to Nadi River
8	Stormwater Sedimentation Pond	Utilize existing IDEA pond
9	Return Sludge Pump Station	
10	Sludge Receiving Tank	Diameter: 14 m
11	Sludge Dewatering Building	
12	Sludge Drying Beds	3.02 ha
13	Sludge Storage Space	10.77 ha
14	Administration Building	Includes emergency power generator and electricity room

Source: JET

APPENDIX 4-4 Navakai WWTP Survey Results


LOCATION DIAGRAM
Scale 1:8000
SUBJECT SITE
Notes and Purpose of Lots
1. BAL LOT 9 SO 499 - NADI TREATMENT PLAN
2. BAL LOT 8 SO 499 - GOVERNMENT RESERVE
3. TYPE OF LAND SURVEYED - STATELAND LAND
4. BOUNDARY WERE CALCULATED FROM :
4.1 SO 1263
4.2 SO 1090
4.3 SO 4040
4.4 SO 499
4.5 SO 0065
EXTRA NOTES
1. IMAGE SAVED FROM GOOGLE EARTH WITH THE DATE CAPTURED IS NOVEMBER, 2022
2. IMAGE SCALED AND REFRENCE USING THE 12D SOFTWARE WITH THE 2D HELMERT ADJUSTMENTS
3. ORIGIN OF COORDINATES AND LEVELS DERIVED FROM THE GOVERMENT TRIG STATION E TOGOYANISOLO
TRIG STATIONS
EASTING - 1867008.30
NORTHING - 3914145.46
MSL LEVEL - 100.638
4. INSTRUMENT USED IS A TRIMMBLE RTK GNSS R 12
5. CONTOUR INTERVALS USED,
MINOR - 0.20 METERS
MAJOR - 1.00 METERS
LOT 2
SO 4040
LOT 3
SO 1263
NAVAKAI TREATMENT PLAN PROJECT FORMULATION
NIHON SUIDOU CONSULTANTS
BUILDINGVS AERIAL PLAN LAYLOUT
SCALE 1:1500
DATE : DECEMBER, 2023
SURVEYED : MOSESE
DESIGN : SEKOVE
DRAWN : SAVE
CHECKED : KELEMETE
PROJECT NO: 500


CONTOUR & STRUCTURE PLAN LAYOUT
NAVAKAI TREATMENT PLAN PROJECT FORMULATION
NIHON SUIDOU CONSULTANTS
LOCALITY DIAGRAM
SUBJECT SITE
LOT 2 SO 4040
LOT 3 SO 1263
LOT 1 ND 4070
IDEA Pond
MATURATION Pond
ADT
EXISTING BUILDING
SLUDGE DRYING BED
PUMP STATION
INNER TOP EDGE OF POND
Notes and Purpose of Lots.
DECEMBER, 2023
1:1000


LOCATION DIAGRAM
Scale 1:10000
SUBJECT SITE
Notes and Purpose of Lots
COLOUR DEPTH PLAN LAYOUT
NIHON SUIDOU CONSULTANTS
NAVAKAI TREATMENT PLAN PROJECT FORMULATION
500
MOSESE
SEKOVE
SAVE
KELEMETE
: DECEMBER, 2023
1:1000
TOPO - 20231213 - 100

APPENDIX 4-5 Navakai WWTP Soil Survey Results

Soil survey studies were conducted at Navakai WWTP to obtain geotechnical data of the area. Soil boring tests were performed at two locations, Boring Hole N1 and Boring Hole N3, within the current WWTP boundaries **(Figure A3-5.1**) The soil boring test results are shown in the following pages.

It should be noted that in future stages of facility designs, additional boring tests should be conducted for the planned construction area outside of the current WWTP boundaries.

Source: ENTEC PTE Ltd.

Figure A3-5.1 Navakai WWTP Soil Boring Test Locations

(1) Boring Hole N1

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2)		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N1**
Job No.: 1381123.A	Start Date: 21-3-2024 Finish Date: 23-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543736.000 N: 8032594.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 24.60 m	Inclination: -90°	Sheet: 1 of 5

Column headings: Type; Run; Fluid & Water; Piezometer; Geological Description (Soil Description: soil/rock name, particle size, MAJOR name, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clastic, subordinate qualifications, minor qualifications, additional structures, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.); Legend; Weathering; Field Strength; Elevation (m MSL); Depth (m); Geological Unit; Defect Spacing (mm); Defect Description; TCR (SCR) RQD (%); Samples; Tests

Fluid & Water: 23.03.24 10:30 WL @ GL

Depth	Geological Description	Depth (m)	Geological Unit	TCR	Samples	Tests
0.00	FILL: GW gravel with trace of silt and sand, grey-brown, loose, moist. Fine to coarse grained, subangular to angular. CORE LOSS		FILL	30		
1.00	FILL: SW sand with trace of gravel, grey-brown, very loose, wet, fine to coarse grained. FILL: GW gravel trace silt and sand, grey-brown, very loose to loose, moist. Fine to medium grained, angular to subangular. CORE LOSS	1		25	SPT Sample 1 1.00	SPT 1.00 m 1 for 300mm 1 N=1 REC=0.15
2.00	CH Silty CLAY: brown. Soft to firm, moist. CORE LOSS	2		30	SPT Sample 2 2.00	SPT 2.00 m 2,2,2 N=4 REC=0.35 WC= 40.6%
		3	SURFICIAL DEPOSITS			
3.50	CH Silty CLAY: brown. Very soft to firm, moist.				SPT Sample 3 3.50	SPT 3.50 m ?,1,1 N=2 REC=0.45 WC= 37.5% LL= 58% PL= 33% PI= 25%
	CORE LOSS	4		50		

Explanations:
Rock Mass Weathering – Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength – very low strength, low strength, medium strength, high strength, very high strength
TCR – Total Core Recovery
SCR – Solid Core Recovery
RQD – Rock Quality Designation
Rec – Core Recovery
Spacing of defects: VW – very widely spaced, W – widely spaced, M – moderately widely spaced, C – closely spaced, VC – very closely spaced, EC – extremely closely spaced.

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT – blows/300mm
- Permeability test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP – Unable to penetrate

Water
- Level (date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D – Dry
M – Moist
W – Wet

Remarks
Hammer #01 efficiency: 72.0%

Water Level:
21/03/24: 5.07m WL @ 0.42mbgl.
23/03/24: 10:30am WL @ ground level

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N1**
Job No.: 1381123.A	Start Date: 21-3-2024 Finish Date: 23-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543736.000 N: 8032594.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 24.60 m	Inclination: -90°	Sheet: 2 of 5

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure; geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME; strength; geologic unit) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description (type, orientation, spacing, roughness, persistence, infill etc.) | TCR (SCR) RQD (%) | Samples | Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR (%)	Samples	Tests
5.00	SP SAND with trace of gravel and silt; grey. Loose; moist; fine to coarse grained.		SURFICIAL DEPOSITS	40	SPT Sample 4 5.00	SPT 5.00 m 4,3,5 N=8 REC=0.32 SGH [illegible]
	SP Gravelly SAND; grey. Loose; moist; fine to coarse grained; gravel fine to medium grained; subrounded to subangular.				Sample 1 5.46	
	CORE LOSS.	6				
6.50	SP SAND with gravel; grey. Loose; moist; fine to coarse grained; gravel fine grained, subrounded to subangular.	7			Sample 2 7.02	
	CORE LOSS.	8		31		
		9				
9.50	SM SAND with silt, trace of clay and gravel; grey. Loose; moist; fine to coarse grained.			73	SPT Sample 5 9.50	SPT 9.50 m 2,2,3 N=5 REC=0.4

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
21/03/24, 5.07pm WL @ 0.42mbgl.
23/03/24, 10:30am WL @ ground level.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi		No.: **BH_N1**
Job No.: 1381123.A	Start Date: 21-3-2024 Finish Date: 23-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543736.000 N: 8032594.000	
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 24.60 m	Inclination: -90°		Sheet: 3 of 5

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
9.00	SP SAND with silt, trace of gravel, whitish grey. Loose, moist; fine to coarse grained sand; gravel, fine grained.		SURFICIAL DEPOSITS	75	Sample 3 10.00	
	CORE LOSS.					
11.00	SP SAND with trace of gravel and silt; whitish grey. Loose; moist; fine to coarse grained.	11		80	SPT Sample 5 11.00	SPT 11.00 m 3,3,5 N=8 REC=0.45 [illegible]
		12			Sample 4 11.90	SG= 2.11
	CORE LOSS.					
12.00	CH Silty CLAY with trace sand; pale white mottled grey. Soft, high plasticity, moist.				SPT Sample 7 12.50	SPT 12.50 m 4,5,7 N=12 REC=0.45
		13		75	Sample 5 13.32	WC= 25.3%
	CORE LOSS.					
14.00	SW SAND with trace of gravel and silt; pale brown. Medium dense; moist; fine to coarse grained.	14		80	SPT Sample 8 14.00	SPT 14.00 m 5,11,15 N=26 DB REC=0.1
	CORE LOSS.					

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
21/03/24, 5:07pm WL @ 0.42mbgl.
23/03/24, 10:30am WL @ ground level.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N1**
Job No.: 1381123.A	Start Date: 21-3-2024 Finish Date: 23-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543736.000 N: 8032594.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 24.60 m	Inclination: -90°	Sheet: 4 of 5

Geological Description: Soil Description: subordinate particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Geological Unit: NADI SEDIMENTARY GROUP

Run	Geological Description	Depth (m)	TCR (SCR) RQD (%)	Samples	Tests
14.00	CORE LOSS. (continued)		80		
15.50	HW-MW GP CONGLOMERATE with cobbles, matrix supported, pale brown mottled white, recovered as medium to coarse grained, angular to subangular, moist. CORE LOSS.	16	10		SPT 15.50 m 6,9,15 for 150mm N=50+ DB REC=0
17.00	CORE LOSS.	17			SPT 17.00 m 3,5,6 N=11 REC=0
	GP CONGLOMERATE, matrix supported, greyish black, recovered as medium to coarse grained, subrounded to subangular, moist. CORE LOSS.	18	7		
18.50	ML SILT with some sand and gravel, greyish black. Hard, moist.			SPT Sample 6 18.50	SPT 18.50 m 8,8,12 for 80mm N=50+ DB REC=0.34; WC=35.7%, LL=49%, PL=31%, PI=18%
	CORE LOSS.	19	45		
19.20	HW-MW GP CONGLOMERATE, matrix supported, pale grey/ dark brown, medium to coarse grained, subrounded to subangular, moist. CORE LOSS.		13		

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests:
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
Hammer #01 efficiency: 72.8%

Water Level:
21/03/24, 5.07pm WL @ 0.42mbgl.
23/03/24, 10.30am WL @ ground level.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N1**
Job No.: 1381123.A	Start Date: 21-3-2024 Finish Date: 23-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543736.000 N: 8032594.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 24.80 m	Inclination: -90°	Sheet: 5 of 5

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
20.00	HW-MW GP CONGLOMERATE, matrix supported, pale grey/ dark brown, dense to very dense, medium to coarse grained, moist.		NADI SEDIMENTARY GROUP		SPT Sample 10 20.00	SPT 20.00 m 5 for 50mm N=50+ DB REC=0.03
	CORE LOSS.			5		
20.75		21		3		
21.50	HW-MW GP CONGLOMERATE, matrix supported, pale grey/ dark brown, very dense, medium to coarse grained, moist.				SPT Sample 11 21.50	SPT 21.50 m 5 for 90mm N=50+ DB REC=0.02
	CORE LOSS.	22		1		
23.00	GW SAND with traces of silt, dark grey. Very dense, fine to coarse grained, wet.	23			SPT Sample 12 23.00 Sample 6 23.15	SPT 23.00 m 8 for 90mm N=50+ DB REC=0.09
	CORE LOSS.	24		19		
24.50	HW SUVA MARL: very low strength, dark grey, moist. Hole Terminated at 24.80 m			20	SPT Sample 13 24.50	SPT 24.50 m 10 for 150mm N=50+ DB REC=0.1

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - Blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
- D - Dry
- M - Moist
- W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

Water Level:
21/03/24, 5:07pm WL @ 0.42mbgl.
23/03/24, 10:30am WL @ ground level.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: IT	Checked by: AV

(2) Boring Hole N3

ENTEC PTE LIMITED
ENGINEERING & SCIENCE CONSULTANTS

ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E 543499.000 N: 8032581.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 1 of 7

Column headings: Type; Run; Fluid & Water; Piezometer; Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of clasts, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit); Legend; Weathering; Field Strength; Elevation (m MSL); Depth (m); Geological Unit; Defect Spacing (mm); Defect Description (type, orientation, roughness, infill, aperture, etc.); TCR (SCR) RQD (%); Samples; Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR	Samples	Tests
0.00	FILL: CI Silty CLAY with gravel, trace of sand, brown, Firm, moist; gravel fine to medium grained.		FILL	50		
	CORE LOSS.					
1.00	FILL: SM SAND: grey-black, Loose, fine to coarse grained.	1		50	SPT Sample 1 1.00	SPT 1.00 m: 2,2,3 N=5 REC=0.4; WC=34.8%, LL=64%, PL=28%, PI=36%
	FILL: GP GRAVEL: grey, Loose, moist, fine to coarse grained; subrounded to rounded.					
	CORE LOSS.					
2.00	CH Silty CLAY with trace of sand, brown, Firm, moist.	2	SURFICIAL DEPOSITS	32	SPT Sample 2 2.00	SPT 2.00 m: 3,3,4 N=7 REC=0.2
	CH Silty CLAY with gravel, trace of sand, brown, grey, Firm, moist.					
	CORE LOSS.	3				
3.50	ML Sandy SILT, trace gravel, brown, Very soft, moist.	4		50	SPT Sample 3 3.50; Sample 1 3.95	SPT 3.50 m: 1,1,1 N=2 REC=0.45; Sv=1.3kN/m²
	CORE LOSS.					

Fluid & Water: 13-03-24 WL @ GL

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
Small Disturbed Sample
Large Disturbed Sample
SPT - blows/300mm
Permeability Test
U100 Undisturbed Sample
Insitu Vane Shear Strength (kPa)
UTP - Unable to penetrate

Water
Level (Date)
Inflow
Partial Loss
Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
Hammer #01 efficiency: 72.9%
*Note Siltstone (Suva marl) encountered after 30-30.6m.
Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 6:40pm WL @ 1.54mbgl.
19/03/24, 7:02am WL @ 1.36mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543499.000 N: 8032561.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 2 of 7

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate, particle size, MAJOR, minor: colour, structure; strength, moisture condition, grading; bedding, plasticity, sensitivity, major qualifications; weathering of clasts; subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation: NAME, strength, geologic unit) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description (type, orientation, infilling, roughness, persistence, aperture, rating etc.) | TCR (SCR) RQD (%) | Samples | Tests

Run (m)	Geological Description	Geological Unit	TCR (%)	Samples	Tests
5.00	SW SAND with trace of organics and gravel, grey. Medium dense, moist, fine to coarse grained.	SURFICIAL DEPOSITS	43	SPT Sample 4 5.00; Sample 2 5.40	SPT 5.00 m 4,6,5 N=11 REC=0.4; WC= 8.5%, BD= 1.28t/m³
	CORE LOSS.				
6.50	CORE LOSS.		0		SPT 6.50 m 2,2,2 N=4 REC=0
8.00	SW SAND with trace of gravel and silt, pale grey. Very loose, moist, fine to coarse grained.		41	SPT Sample 5 8.00; Sample 5 8.35	SPT 8.00 m 1 for 450mm N=0 REC=0.05
	CORE LOSS.				
9.50	SM SAND with silt and gravel, grey. Loose, moist, fine to coarse grained.		60	SPT Sample 6 9.50	SPT 9.50 m 2,3,5 N=8 REC=0.45; WC= 30.8%

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP - Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
- D - Dry
- M - Moist
- W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

*Note Siltstone (Suva marl) encountered after 30-30.6m.

Water Level:
13/03/24, 6.11pm WL @ ground level.
14/03/24, 6.43pm WL @ 1.54mbgl.
19/03/24, 7.02am WL @ 1.38mbgl.
20/03/24, 9.51am WL @ 0.83mbgl.
20/03/24, 4.43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E 543499.000 N 8032561.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 3 of 7

Geological Description: Soil Description: subordinate, particle size, MAJOR, minor colour, structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structures; geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.

Columns: Type | Run | Fluid & Water | Piezometer | Geological Description | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description | TCR (SCR) RQD (%) | Samples | Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
9.50	SM SAND with silt and gravel; grey. Loose; moist; fine to coarse grained. (continued)		SURFICIAL DEPOSITS	60	Sample 4 10.15	
	CORE LOSS.					
11.00	SW Gravelly silty SAND with clay; brown. Medium dense; moist; fine to coarse grained; gravel, fine grained, subrounded to subangular.	11		30	SPT Sample 7 11.00	SPT 11.00 m 5,5,7 N=12 REC=0.45
	CORE LOSS.	12				
12.50	ML Sandy SILT with gravel; brown. Stiff; moist; sand, recovered as fine to coarse grained; gravel, fine grained, subrounded to subangular.	13		67	SPT Sample 8 12.50; Sample 5 13.00	SPT 12.50 m 4,4,6 N=10 REC=0.3
	CORE LOSS.					
14.00	GW Gravelly SAND with silt, trace of clay; brown. Medium dense; moist; fine to coarse grained; gravel, fine to medium grained, subrounded to subangular.	14		55	SPT Sample 9 14.00	SPT 14.00 m 5,6,9 N=15 REC=0.27
	SC Gravelly CLAY with sand; brown. Stiff; moist; gravel, fine to medium grained; sand, fine to medium grained.				Sample 6 14.60	
	CORE LOSS.					

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS)
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/150mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

*Note Siltstone (Suva marl) encountered after 30-30.6m.
Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 8:43pm WL @ 1.54mbgl.
19/03/24, 7:02am WL @ 1.36mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP: Nawaka Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543499.000 N: 8032581.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 4 of 7

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate, particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering, colour, texture, fabric and orientation; NAME; strength; geologic unit.) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description (type, orientation, spacing, roughness, persistence, aperture, infilling etc) | TCR (SCR) RQD (%) | Samples | Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
14.00	CORE LOSS. (continued)		SURFICIAL DEPOSITS	05		
15.50	SW Clayey SAND with silt and gravel; brown. Medium dense; moist; fine to medium grained; sand, fine to medium grained. CORE LOSS. (sand washout)	16	SURFICIAL DEPOSITS	16	SPT Sample 10 15.50	SPT 15.50 m 8,8,9 N=17 REC=0.2
17.00	SC Clayey SAND with silt and gravel; brown. Medium dense; moist; fine to medium grained; sand, fine to medium grained. Sandy GRAVEL; brown. Medium dense; moist; fine to coarse grained; subrounded to subangular; sand, fine to coarse grained. CORE LOSS. (sand washout)	17 18	SURFICIAL DEPOSITS	30	SPT Sample 11 17.00	SPT 17.00 m 7,7,8 N=15 REC=0.25
18.50	HW-MW CONGLOMERATE; pale brown-grey. Very dense; moist; medium to coarse grained; subrounded to subangular. CORE LOSS. (sand washout)	19	NADI SEDIMENTARY GROUP	7		SPT 18.50 m 50 for 75mm N=50+ [illegible] REC=0

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%
*Note Siltstone (Suva marl) encountered after 30-30.6m.
Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 6:43pm WL @ 1.54mbgl.
19/03/24, 7:02am WL @ 1.38mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543499.000 N: 8032561.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 5 of 7

Column headings: Type | Run | Fluid & Water | Piezometer | Geological Description (Soil Description: subordinate, particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; geologic unit.) | Legend | Weathering | Field Strength | Elevation (m MSL) | Depth (m) | Geological Unit | Defect Spacing (mm) | Defect Description | TCR (SCR) RQD (%) | Samples | Tests

Run	Geological Description	Depth (m)	Geological Unit	TCR (SCR) RQD (%)	Samples	Tests
20.00	XW-HW CONGLOMERATE, matrix supported, whitish grey brown, very dense, recovered as (Sandy GRAVEL trace silt, whitish mottled brown. Very dense, coarse grained, moist.		NADI SEDIMENTARY GROUP		SPT Sample 12 20.00 Sample 7 20.26	SPT 20.00 m 11,12 for 100mm N=50+ DB REC=0.25
	HW-MW CONGLOMERATE, matrix supported, whitish grey brown, very dense, recovered as medium to coarse grain, subrounded to subangular, clasts of Marl, Limestone and Andesite. CORE LOSS.	21		49		
21.50	SW SAND with trace of gravel, grey. Very dense, moist, fine to coarse grained. GP HW-MW CONGLOMERATE, matrix supported, brown-grey, very dense, medium to coarse grained, subrounded to subangular, clasts of Marl, Limestone and Andesite. CORE LOSS.	22		30	SPT Sample 13 21.50	SPT 21.50 m 50 for 150mm N=50+ DB REC=0.15
23.00	GP XW-HW CONGLOMERATE, recovered as sand and gravel. CORE LOSS.	23 24		29	SPT Sample 14 23.00	SPT 23.00 m 15,14,20 N=50+ DB REC=0.30
24.50	GP XW-HW CONGLOMERATE, matrix supported, pale brown, grey, very dense, recovered as medium to coarse grain, subrounded to subangular. CORE LOSS.			25	SPT Sample 15 24.50	SPT 24.50 m 12,18,18 for 80mm N=50+ DB REC=0.28

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
Hammer #01 efficiency: 72.6%
*Note Siltstone (Suva marl) encountered after 30-30.6m.
Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 8:43pm WL @ 1.64mbgl.
19/03/24, 7:02am WL @ 1.36mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 18-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543489.000 N: 8032561.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 6 of 7

Geological Description: Soil Description: subordinate, particle size, MAJOR, minor; colour; structure; strength; moisture condition; grading; bedding; plasticity; sensitivity; major qualifications; weathering of clasts; subordinate qualifications; minor qualifications; additional structure; geologic unit. Rock Description: weathering; colour; texture; fabric and orientation; NAME; strength; geologic unit.

Geological Unit: NADI SEDIMENTARY GROUP

Run	Geological Description	Depth (m)	TCR (SCR) RQD (%)	Samples	Tests
24.50	CORE LOSS. (continued)		48		
26.00	SP SAND with trace of silt and clay, grey. Very dense, moist, fine to coarse grained.	26		SPT Sample 15 26.00	SPT 26.00 m 10,25,1 for 20mm N=50+ DB REC=0.06
	GP HW-MW CONGLOMERATE, matrix supported, pale brown, grey, medium to coarse grained, subrounded to subangular.				
	CORE LOSS.	27	15		
27.50	SW SAND with trace of silt and clay, grey. Very dense, moist, fine to coarse grained.			SPT Sample 17 27.50	SPT 27.50 m 15 for 80mm N=50+ DB REC=0.02
	GP HW-MW CONGLOMERATE, matrix supported, pale brown, grey, medium to coarse grained, subrounded to subangular, clasts of Limestone and Andesite.				
	CORE LOSS.	28	19		
28.25			0		
29.00	SP SAND with trace of silt and clay, grey. Very dense, moist, fine to coarse grained.	29		SPT Sample 18 29.00	SPT 29.00 m 15, 27 for 120mm N=50+ DB REC=0.04
	GP HW-MW CONGLOMERATE, matrix supported, pale brown, grey, medium to coarse grained, subrounded to subangular.				
	CORE LOSS.		20		

Explanations:
Rock Mass Weathering - Fresh (FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR = Total Core Recovery
SCR = Solid Core Recovery
RQD = Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced.

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/300mm
- Permeability Test
- U100 Undisturbed Sample
- Insitu Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
D - Dry
M - Moist
W - Wet

Remarks
-Hammer #01 efficiency: 72.9%
*Note Siltstone (Suva marl) encountered after 30-30.6m.
Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 6:43pm WL @ 1.54mbgl.
19/03/24, 7:02am WL @ 1.36mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

ENTEC PTE LIMITED
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ENGINEERING LOG BOREHOLE

Project: The Project for Formulation of Wastewater Treatment Master Plan in Western Division (Phase 2).		Location: Navakai WWTP, Narewa Bypass, Nadi	No.: **BH_N3**
Job No.: 1381123.A	Start Date: 13-3-2024 Finish Date: 19-3-2024	Ground Level (m MSL):	Co-Ordinates (FMG): E: 543499.000 N: 8032561.000
Client: Nihon Suido Consultants Co. Ltd	Hole Depth: 30.60 m	Inclination: -90°	Sheet: 7 of 7

Type	Run	Fluid & Water	Piezometer	Geological Description (Soil Description: subordinate, particle size, MAJOR, minor, colour, structure, strength, moisture condition, grading, bedding, plasticity, sensitivity, major qualifications, weathering of class, subordinate qualifications, minor qualifications, additional structure, geologic unit. Rock Description: weathering, colour, texture, fabric and orientation, NAME, strength, geologic unit.)	Legend	Weathering	Field Strength	Elevation (m MSL)	Depth (m)	Geological Unit	Defect Spacing (mm)	Defect Description	TCR (SCR) RQD (%)	Samples	Tests
				HW grey SUVA MARL; very low strength, moist.										SPT Sample 19 30.00	SPT 30.00 m 13,20 for 150mm N=50+ CB REC=0.2
				Hole Terminated at 30.60 m					31 32 33 34						

Explanations:
Rock Mass Weathering - Fresh(FR), Slightly Weathered (SW), Moderately Weathered (MW), Highly Weathered (HW), Extremely Weathered (XW), Residual Soil (RS).
Relative Rock Strength - very low strength, low strength, medium strength, high strength, very high strength
TCR - Total Core Recovery
SCR - Solid Core Recovery
RQD - Rock Quality Designation
Rec. - Core Recovery
Spacing of defects: VW - very widely spaced, W - widely spaced, M - moderately widely spaced, C - closely spaced, VC - very closely spaced, EC - extremely closely spaced

Samples and Tests
- Small Disturbed Sample
- Large Disturbed Sample
- SPT - blows/100mm
- Permeability Test
- U100 Undisturbed Sample
- Hollis Vane Shear Strength (kPa)
- UTP = Unable to penetrate

Water
- Level (Date)
- Inflow
- Partial Loss
- Complete Loss

Moisture Condition
- D - Dry
- M - Moist
- W - Wet

Remarks
-Hammer #01 efficiency: 72.9%

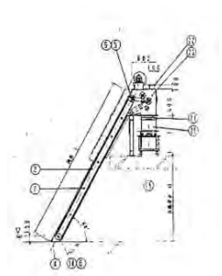
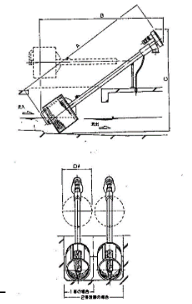
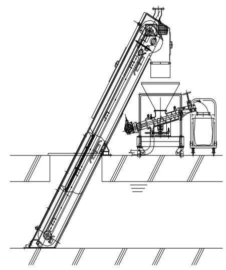
*Note Siltstone (Suva marl) encountered after 30-30.6m.

Water Level:
13/03/24, 6:11pm WL @ ground level.
14/03/24, 6:43pm WL @ 1.54mbgl.
19/03/24, 7:02pm WL @ 1.36mbgl.
20/03/24, 9:51am WL @ 0.83mbgl.
20/03/24, 4:43pm WL @ 0.46mbgl.

All dimensions in metres Scale 1:31	Contractor: Rockwell Pacific Pte Ltd	Rig/Plant Used: HANJIN	Logged by: AM	Checked by: AV

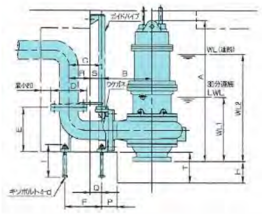
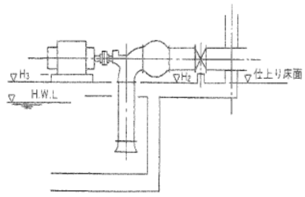
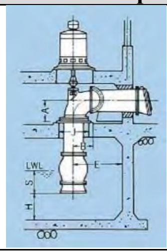
APPENDIX 4-6 Navakai WWTP Comparison/Selection of Mechanical Equipment

(1) Grit Removal Screen

	Automatic belt-running grit screen + Biaxal Screw Type	**Drum type screen with dewatering mechanism**	**Continuous back-scraping type automatic grit screen + Residue dewaterer (Biaxial screw type)**
Description	・Automatic screen and residue dewaterer integrated into a single unit. ・Automatic screen: rotating screen with V-shaped grooves that runs and scrapes up residue ・Residue Dewaterer: dewaters scraped residue using a biaxial screw 	・Residue supplemented by drum-type screen is conveyed by screw conveyor and dewatered in the press section ・Washing device can be installed in the drum-type screen section to wash the residue to some extent. 	・Residue trapped in front of the bar screen is scraped up by a comb-like rake attached to an endless chain at the back, scraped off when it returns at the top, and fed into a residue dewaterer connected to a chute 
Specifications	Screen width: 20-30mm Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.6m^3/h	Screen width: 15-25mm Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.1-0.5 m^3/h	Screen width: 15-25mm Electric motor capacity: 0.4kW (600 width) Capacity of residue dewatering machine: 0.6 m^3/h
Advantages	・Continuous scraping rakes allows large capacity ・Simple and reliable operation mechanism	・Continuously scraping rakes allows large capacity	・Continuous scraping rakes allows large capacity. ・Simple and reliable operation mechanism.
Disadvantages	・Necessary to cover the open machine to prevent odors	・The closed structure makes maintenance and management of the system less efficient ・Maintenance is performed by pulling it up to the top of the waterway	・A part of the screen needs to be cut off to allow the rake to pass through at the bottom of the channel ・An auxiliary screen must be installed to prevent dust from flowing downstream from the cut off part
Construction Cost	80	120	100
Maintenance Cost	100	110	100
Overall Cost Evaluation	90	110	100
Machine Performance	A	C	A
Overall Evaluation	A	C	B
	The "belt-run automatic grit screen+ residue dewaterer (two-axle screw type)" is highly efficient in combination with a dewaterer because of its high residue capturing performance and economic efficiency.		

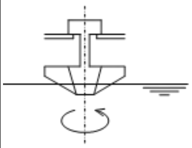
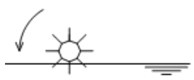
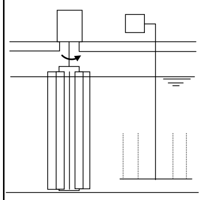
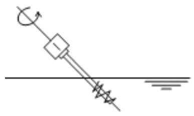
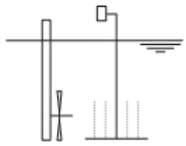
Source: Created by JET

(2) Main Pump

	Submersible sewerage pumps	**Horizontal-shaft semi-axial flow pump**	**Vertical-shaft semi-axial flow pump**
Description			
Pump efficiency	50 - 80% (φ100 -800)	70 - 85% (φ300 -3400)	75 - 80% (φ200 -1000)
Maintenance fee	・Detachable type is relatively easy to install/remove for maintenance and inspection. ・Regular mechanical seal maintenance is needed	・Pumps are set up external of the tank, allowing easy maintenance ・Installation of waterless shaft seal system requires maintenance of the mechanical seal.	・Pumps are set up external of the tank, allowing easy maintenance ・Installation of waterless shaft seal system requires maintenance of the mechanical seal.
	90%	100%	100%
Size and space	・Pump is placed inside the tank → smaller footprint ・Pumps and motors are submerged underwater, so only the machine hatch is on the dry floor.	・Requires largest vertical and horizontal installation footprint, (horizontal setup type external of the tank)	・The upper drawer installation footprint is larger due to the setup external of the tank
Construction cost	40 ～ 50 %	100 %	100 %
Auxiliary equipment	No shaft-sealed water pump required.	Requires a shaft-sealed water pump.	No shaft-sealed water pump required.
Measures to be taken in case of flooding	If a waterless shaft seal is installed, no vacuum pump or shaft water supply is required.	Requires a shaft-sealed water pump.	If a waterless shaft seal is installed, no vacuum pump or shaft water supply is required.
Evaluation	A	B	B
	In this plan, 'submersible sewerage pumps' will be adopted, taking into account flood prevention measures, maintainability, and economic efficiency and installment track record		

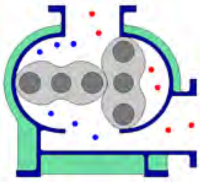
Source: Created by JET

(3) OD Basin Mixer

	Vertical shaft type	Horizontal shaft type	Vertical axis mixer + diffuser	Oblique-shafted type	Submerged propeller + diffuser
Description	・Vertical-shaft rotor is rotated near the water surface to provide a dispersing action by the dispersing blades. ・Simultaneously, the air/water-mixed liquid at the bottom of the aeration zone is pumped up to dissolve oxygen while mixing. 	・When the mixing blades are 20% to 30% submerged in water, they rotate to entrain air bubbles in the water, which are then subdivided. ・When the mixing blades exit the water, they bounce off the water droplets to supply oxygen. 	・Air is fed by a blower into a diffuser installed at the bottom of the tank. ・An out-of-tank driven mixer (with a vertical axis) rotates to mix and push out the air/ water-mixed liquid, creating a current underwater 	・A screw placed at an angle in the under-water section is swirled to draw in air using negative pressure to push out the air/water-mixed liquid, while mixing it with the screw blades. 	・Air is blown by a blower into a diffuser located at the bottom. ・A propeller installed in the underwater section rotates to mix the air bubbles and water, simultaneously creating a current underwear. 
Oxygen supply capacity (kg-O2/kWh)	2.5	2.3	3.0	2.2	3.5
Mixing capacity (power input density) (W/m^3)	5.9	8.1	2.3	6.4	2.9
Economic Efficiency					
Equipment cost (%)	85	100	87	100	87
Required Power (kWh/m^3・d)	0.28	0.325	0.25	0.28	0.22
Maintenance cost (%)	86	100	68	86	68
Restrictions on OD Channel Width	Required channel width: 5.5m - 7m	If the channel width is large, shaft deflection will occur and cause failure.	No restrictions on channel width	No restrictions on channel width	No restrictions on channel width
Overall Evaluation	Cannot be adopted with the channel width of this plan.	Currently, they are rarely employed.	Best overall score for equipment cost, maintenance cost, oxygen supply capacity, and power input density.	Equipment costs are higher because the number of units installed is greater in relation to the number of tanks.	Best overall score for equipment cost, maintenance cost, oxygen supply capacity, and power input density.
	D	C	A	B	A
	In this project, the 'vertical axis mixer+ diffuser' or 'underwater propeller + diffuser' which are equally economically advantageous for both equipment and maintenance cost., and can be applicable to the design width of the tank, can be adopted. For the project, the latter will be adopted for further works.				

Source: Created by JET

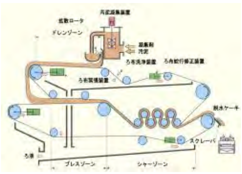
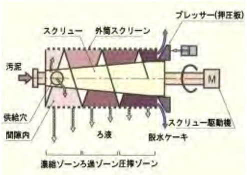
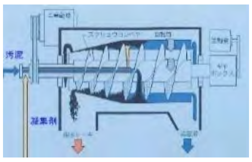
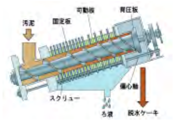
(4) Blowers

	Steel plate multi-stage turbo blowers	Rotary (Roots-type) blowers	Screw-Type Blower
Description	 	 	
caliber	Suction side: φ200 Output side: φ150	Suction side: φ200 Output side: φ150	Suction side: φ200 Output side: φ150
air volume	30m³/min	30m³/min	30m³/min
pressure	Suction pressure: 2kPa Discharge pressure: 60kPa	Suction pressure: 2kPa Discharge pressure: 60kPa	Suction pressure: 2kPa Discharge pressure: 60kPa
Advantages	・No refueling equipment or cooling water facilities are required. ・Air flow analysis and other technologies have improved efficiency. ・Smooth operation with low rotational vibration.	・Equipment costs are low. ・Experienced in small-scale or initial response.	・Packaged and compact. ・High efficiency due to continuous internal compression by screw. ・Auxiliary equipment is built into the package. ・High Blower Total thermal efficiency. ・No surging due to the volumetric system.
Disadvantages	・Surging occurs in some areas, so a surging limiter setting is required in the air flow control.	・Silencers required for noise control as they are not packaged. ・Inverter controllers use electronic equipment, so it is necessary to secure unit replacement parts for version upgrades and to take renewal measures corresponding to the service life of the equipment.	・Matrix converter control units use electronic equipment, so it is necessary to secure unit replacement parts for version upgrades and to take renewal measures corresponding to the service life of the unit.
Total thermal efficiency	57%	57%	70%
Pressure loss	・Silencers are not required, resulting in low pressure losses in the piping system.	・Silencers are required and pressure losses are high.	・Silencers are not required, resulting in low pressure losses in the piping system.
Airflow Control	・Inlet guide vane ・Controlled by adjusting the opening of the inlet guide vane, rather than by adjusting the speed of rotation ・Smooth operation with low rotational vibration.	・Inverter device ・Controlled by rotational speed. ・There is no surging area, but the noise level increases as the RPM increases.	・Matrix converter devices ・ It is controlled by the speed of rotation, but unlike inverters, it does not require harmonic countermeasures. ・No surging area and it is quiet due to the integrated cover, even when the speed increases.
Size	5,000×2,200×1,600	5,000×2,200×1,600	5,000×2,200×1,600
Weight	6.2 t	1.87 t	1.87 t

	Steel plate multi-stage turbo blowers	Rotary (Roots-type) blowers	Screw-Type Blower
Maintenance	・Protective instrument panels and individual forced lubrication devices are included and installed on the machine side for easy inspection. ・The centrifugal force of the cylindrically arranged runners (forward facing blades) draws in air and creates a swirling flow in a direction almost perpendicular to the axis of rotation. ・The swirling flow generated is rectified in one direction by the scroll and the required pressure is generated and supplied according to the number of runner stages, resulting in less pulsation and vibration and fewer failures.	・Protective devices are not attached but installed separately. ・Pressure pulsation due to 2- and 3-leaf rotors, requiring vibration countermeasures for piping, etc. ・Equipment body, rotor and inverter inspections are required.	・The operating panel, auxiliary equipment and protective devices are installed in a package that is easy to inspect, safe and reliable. ・The operating panel, auxiliary equipment and protective devices are installed in a package that is easy to inspect, safe and reliable. ・Since the air is compressed and blown by the screw, pulsation is smaller than with rotary blowers and smooth operation is possible.
Equipment Cost	100%	95%	90%
Maintenance cost	100%	97%	79%
Overall Evaluation	・High equipment and maintenance costs ・Low thermal efficiency. ・Building costs are high due to the large volume and heavy weight	・Resonance measures should be taken for piping where resonance occurs. ・Resonance measures should be taken for piping where resonance occurs. ・Low thermal efficiency.	・The control panel is installed on the surface of the package and allows for full operation and monitoring, making it easy to manage operations. ・No concern about surging caused by airflow control. ・Many have been introduced in other countries.
	Screw-type blowers are adopted in this project because they are superior in terms of thermal efficiency, equipment cost, maintenance cost, installation space and weight.		

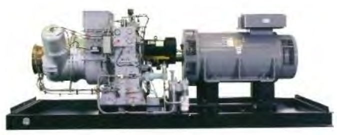
Source: Created by JET

(5) Sludge Dewatering Machine

	Belt-press Dewaterer	**Press-in screw press Dewaterer**	**Centrifugal Dewaterer**	**Multi-plate screw press Dewaterer**
Description	The sludge is fed onto a filter cloth, gravity dewatered, then clipped between two filter cloths and pressed against rollers using the tension of the filter cloth to dewater it. 	Flocculated sludge is pressurized and fed at a constant pressure into the gap between the screen and the screw shaft, and the sludge is continuously dewatered through thickening, filtration and pressing by volume changes while moving from the inlet to the outlet due to the low-speed rotation of the screw. 	Sludge is fed into a rotating cylinder rotating at high speed, where centrifugal force separates solids of different specific gravity from water, and sludge cake is discharged by a screw-shaped discharger (conveyor) that is slightly differentiated from the rotating cylinder. 	Flocculated sludge flocculated in the service tank and mixing tank in the front section of the machine is gravity dewatered and separated into sludge and filter liquid. The screws are progressively thicker and narrower in pitch. Dewatering is carried out by the internal pressure created by this and the pressure applied from the back pressure plate. 
Target Sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・Digested sludge. ・OD excess sludge, thickened sludge	・Mixed raw sludge ・OD excess sludge, thickened sludge
Auxiliary equipment	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・Chemical dosing system (polymer coagulant) ・Wash water pumps, ・Air compressors	・Sludge supply system ・wash water pumps. ・Chemical injection system (polymeric and inorganic coagulants)
Pre-treatment	Thickener tank required	Thickener tank required	Thickener tank required	No need for a thickener tank
Maintenance and management	・Sludge flocculation equipment, diffusion rotor, filter cloth tensioning device, filtration cloth meander corrector, filtration filter cleaning equipment, driving unit. ・One type of chemical	・Screws, outer casing screen, Screw driving unit ・One type of chemical .	・High-speed rotating equipment to be taken back to the factory for overhaul. ・One type of chemical	・Screws, fixed plate, movable plate, dorsal pressure plate, eccentric axis, driving device ・Two types of chemicals
	Difficult due to number of required parts	Easy due to small number of required parts	Needs to be taken back to the factory for overhaul/ minor repairs	Easy due to small number of required parts
Equipment cost	100%	82%	86%	35%
	Includes gravity thickener, dewatering/ conditioning equipment	Includes gravity thickener, dewatering/ conditioning equipment	Includes gravity thickener, dewatering/ conditioning equipment	Includes dewatering/ conditioning equipment
Maintenance costs	100%	68%	89%	89%
Overall Evaluation	In this project, the multiple plate screw press dewaterer will be adopted due to the following reasons ・Does not require a thickening process (thickening tank). ・Lowest sludge cake water content and excellent dewatering performance. ・Low equipment and maintenance costs			

Source: Created by JET

(6) Emergency Generator

	Diesel Engine Generator	Gas Turbine Generator
Description		
	The thermal energy of the intermittently exploding combustion gas is once converted into the reciprocating motion of the piston, which is then converted into the rotational motion of the crankshaft.	The thermal energy of the continuously burning combustion gas is directly converted into rotational motion by the turbine.
Generator Speed	Diesel, generator: 1,500rpm	Turbine: 22,000rpm, Generator: 1,500rpm
Fuel	Heavy oil, diesel oil	Heavy oil, kerosene, diesel oil
Fuel consumption	Small: 0.23-0.31 kg/kW・hr	Large: 0.52-0.68 kg/kW・hr
Grease consumption	Large: 1.36-2.72 g/kW・hr	Small: 0.05-0.27 g/kW・hr
Size/ Weight	Large and heavy	Small and light
Fuel air ratio	less	2.5-3 times more than the diesel
Maintenance Cost	Overhaul possible locally. Maintenance and inspection available by car mechanic.	Maintenance/overhaul must be conducted at factory
	50%	100%
Equipment Cost	100%	140%
Overall Evaluation	Diesel generators, which are advantageous in terms of equipment and maintenance costs, will be adopted in this project.	

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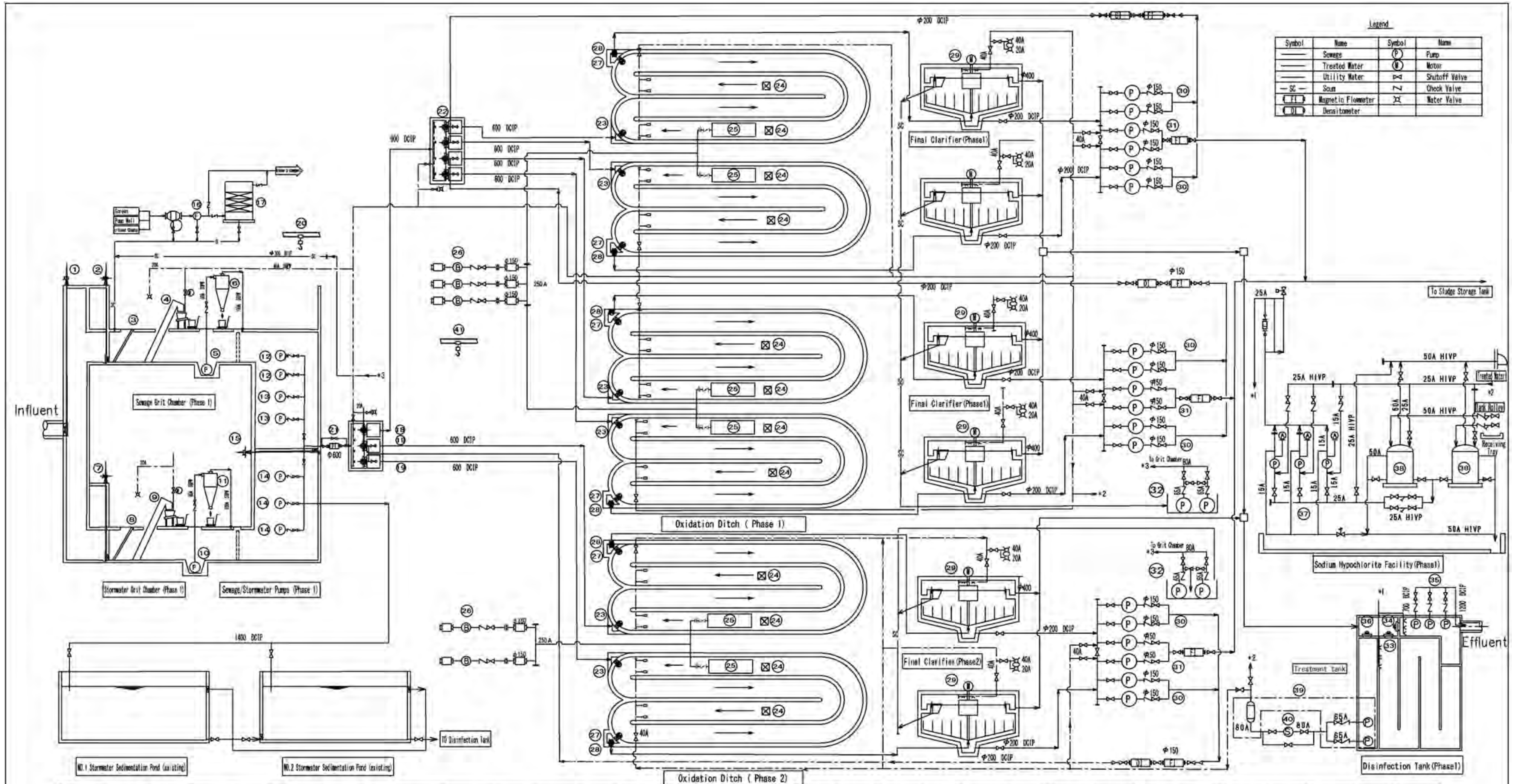
Source: Created by JET

APPENDIX 4-7 Navakai WWTP Mechanical/Electrical Drawings

(1) Mechanical Equipment

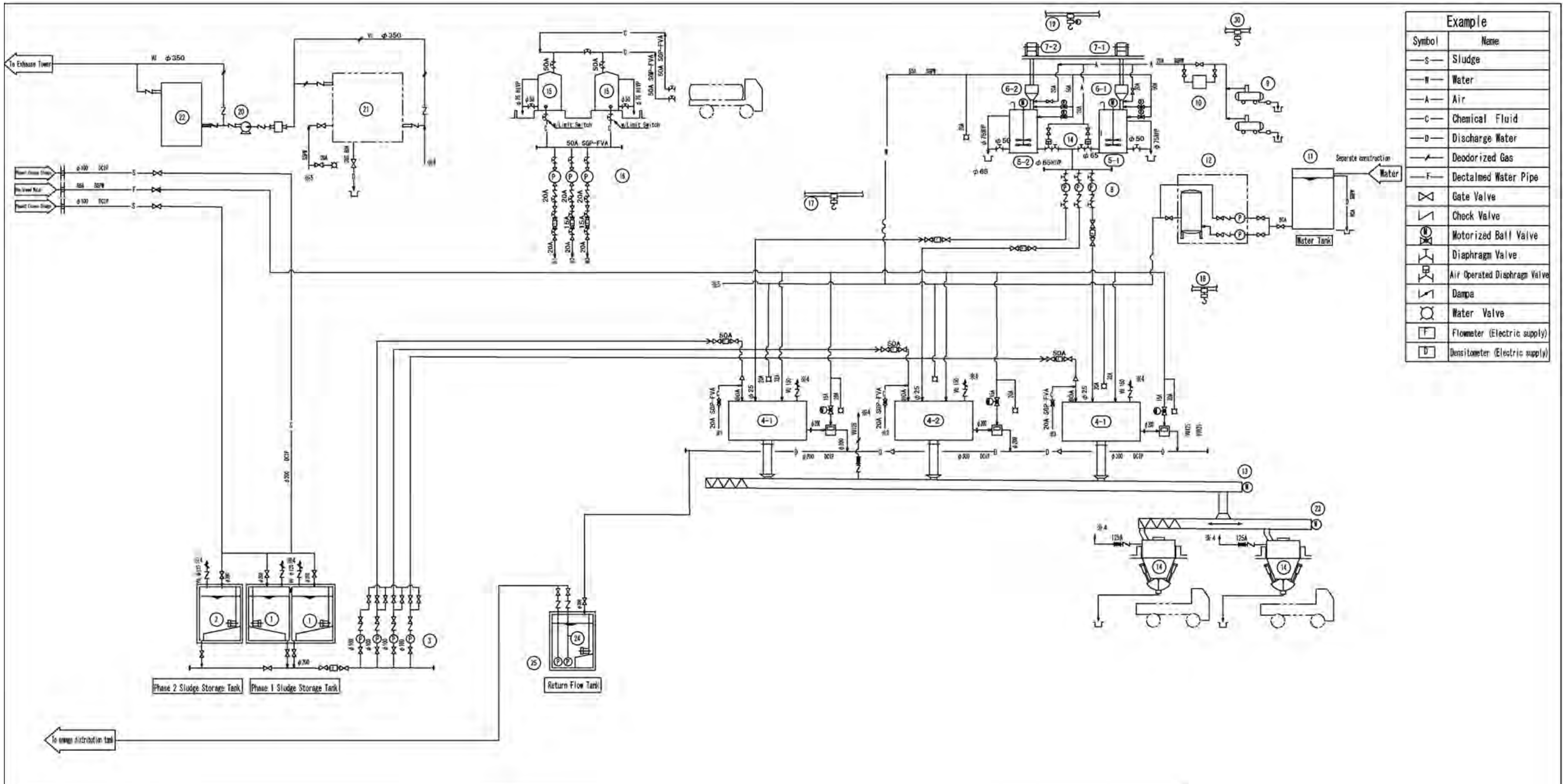


NO	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Name	Main Inlet Gate	Inlet Gate (Sewage)	Coarse Screen (Sewage)	Automated Grit Removal Screen (Sewage)	Sand Pump (Sewage)	Cyclone-type Sand Separator (Sewage)	Inlet Gate (Stormwater)	Coarse Screen (Stormwater)	Automated Grit Removal Screen (Stormwater)	Sand Pump (Stormwater)	Cyclone-type Sand Separator (Stormwater)	Phase 1 Sewage Pump	Phase 2 Sewage Pump	Stormwater Pump	Pump Well Connecting Gate
Type	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Hand-raked screen	Automatic belt-running grit screw + Blast screw	Suction screw type submersible pump	Capacity: 10m³/hr	Type: Outside Screw Material: Cast Iron	Hand-raked screen	Automatic belt-running grit screw + Blast screw	Suction screw type submersible pump	Capacity: 30m³/hr	Suction screw type submersible pump	Suction screw type submersible pump	Suction screw type submersible pump	Type: Outside Screw Material: Cast Iron
Specification	Width 1200×Height 1200	Width 450×Height 450	[illegible]	[illegible]	φ80mm×0.5m³/min×13m	Pressure loss: 60kPa	Width 1000×Height 1000	[illegible]	[illegible]	φ80mm×0.5m³/min×13m	Pressure loss: 60kPa	φ300mm×9.5m³/min×11m	φ450mm×19m³/min×11m	φ600mm×29m³/min×6.5m	Width 500×Height 500
Motor output(kW)	1.5	Manual type		0.4	5.5	—	Manual type	—	0.4	5.5	—	30	55	55	
Units (All / Phase1 / Phase2)	1 / 1 / —	3 / 3 / —	3 / 3 / —	3 / 3 / —	3 / 3 / —	1 / 1 / —	3 / 3 / —	3 / 3 / —	3 / 3 / —	3 / 3 / —	1 / 1 / —	2 / 2 / —	2(1) / — / 2(1)	3(1) / 3(1) / —	1 / 1 / —
Remarks												Detachable type	Detachable type	Detachable type	

NO	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Name	Deodorizer Fan	Activated Carbon Adsorption Tower	Phase1 OD Distribution Movable Weir	Phase2 OD Distribution Movable Weir	Chain Hoist	Main Pump Flowmeter	OD Distribution Movable Weir	OD Inlet Movable Weir	Oxidation Ditch Mixer	Oxidation Ditch Diffusers	Blower	OD Outlet Movable Weir	OD Outlet Gate	Final Clarifier	Return Sludge Pump
Type	Single-suction turbo fan	Vertical activated carbon adsorption tower	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Motorized chain hoist	Magnetic flowmeter	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Submerged propeller + air diffuser	Ultrafine diffuser	High-rate positive displacement screw blowers	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Peripheral-drive Column-supported type	Suction screw sewage pump
Specification	40m³/min×210mmaq	40m³/min	Width 1000×Height 400	Width 300×Height 400	1.0t×7m	Diam.: 700mm	Width 400×Height 300	Width 400×Height 300	φ1.8m	Supplied Oxygen 1,130kg-O₂/day·unit	Max air volume 17 m³/min x 30 kPa/e	Width 400×Height 300	Width 600×Height 600	Dia:25m×Water depth:4m	φ150mm×1.8m³/min×10m
Motor output(kW)	3.7	—	Manual type	Manual type	0.9+0.4(hoist + traverse)	—	Manual type	Manual type	9		45.0	Manual type	Manual type	0.75	5.5
Units (All / Phase1 / Phase2)	1 / 1 / —	1 / 1 / —	1 / 1 / —	2 / 2 / —	3 / 3 / —	1 / 1 / —	4 / 4 / —	6 / 4 / 2	12 / 8 / 4	6 / 4 / 2	5(2) / 3(1) / 2(1)	6 / 4 / 2	6 / 4 / 2	6 / 4 / 2	12 / 8 / 4
Remarks	Grit Chamber machine room	Grit Chamber machine room								32 panels per unit	Packaged with control panel			With manual scum skimmer	

NO	31	32	33	34	35	36	37	38	39	40	41
Name	Excess Sludge pump	Scum pump	Disinfection Tank Inlet Gate	Bypass Gate	Effluent Pump	Treated Water Tank Inlet Gate	Hypochlorite Injection Pump	Hypochlorite Storage Tanks	Treated Water Pressure Tank Unit	Automatic Strainer	Chain Hoist
Type	Suction screw sewage pump	Suction screw type submersible pump	Type: Outside Screw Material: Cast Iron	Type: Outside Screw Material: Cast Iron	Non-clogging submersible sewage pump	Type: Outside Screw Material: Cast Iron	Diaphragm metering pump	FRP cylindrical tank	Pressure tank unit	Automatic washing type	Motorized chain hoist
Specification	φ150mm×1.25m³/min×10m	φ65mm×0.2m³/min×8m	Width 1200×Height 1200	Width 1200×Height 1200	φ600mm×47m³/min×10m	Width 500×Height 500	φ25mm×0.064ℓ/min~1.3ℓ/min×0.7Mpa	5m³	φ80mm×1m³/min×28m	17m³/min	1.0t×7m
Motor output(kW)	3.7	0.75	Manual type	Manual type	110		0.4		7.5×2	0.4	0.9+0.4(hoist + traverse)
Units (All / Phase1 / Phase2)	6(3) / 4(2) / 2(1)	4(2) / 2(1) / 2(1)	1 / 1 / —	1 / 1 / —	3(1) / 3(1) / —	1 / 1 / —	3(1) / 3(1) / —	2 / 2 / —	1 / 1 / —	1 / 1 / —	3 / 3 / —
Remarks		Detachable type							[illegible]	With control panel	

Navakai WWTP(Nadi)
Sewage Treatment Equipment Flowsheet



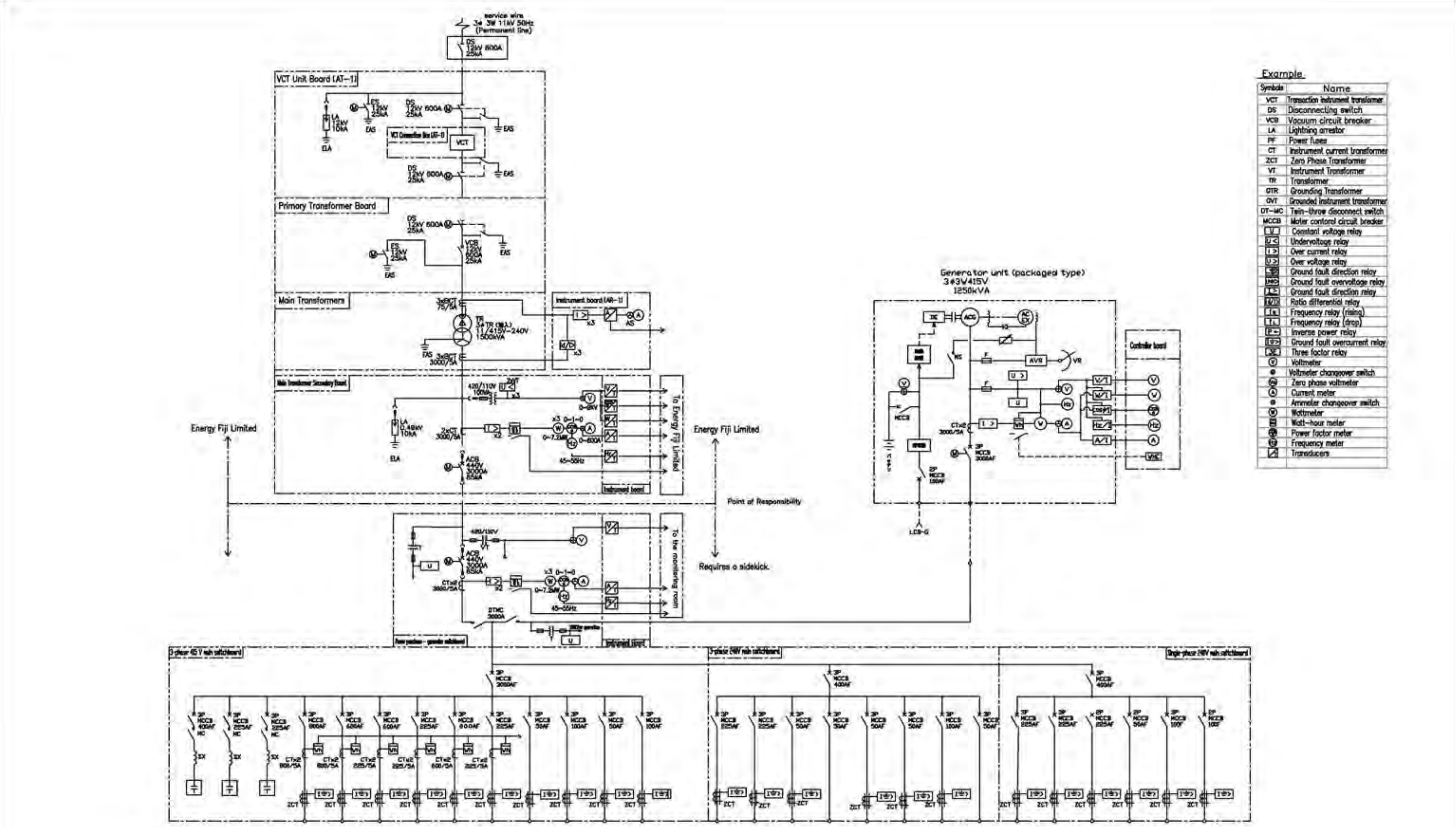
Equipment No.	①	②	③	④	⑤	⑥	⑦	⑧
Name	Phase 1 Sludge Storage Tank Mixer	Phase 2 Sludge Storage Tank Mixer	Sludge Supply Pump	Sludge Dewaterer	Chemical Storage Tank	Chemical Dosing Device	Chemical Container	Chemical Supply Pump
Type	Submerged mixer	Submerged mixer	Single screw type	Multi-plate screw press dewaterer	Vertical mixing tank	Adjustable continuous feeder	Invertable type	Single screw type
Specification	φ580 mm	φ580 mm	φ100×18.0~45.0m³/h ×196Kpa	400kg-DS/d	8 m³	Max 9000L/h Hopper 200L	0.5 m³	φ32×400~6000L/h ×196Kpa
Motorized output (kW)	5.5	5.5	7.5	8.3 or Lower	3.7	0.4	–	2.2
Unit	6 / 6 /	3 / – / 3	4(1) / 3(1) / 1	3 / 2 / 1	2 / 2 / –	2 / 2 / –	2 / 2 / –	3 / 2 / 1
Remarks			VVVF Control Equipment	With Control Panel		With Control Panel		VVVF Control Equipment

Equipment No.	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯
Name	Air Compressor	Dehumidifying Device	Water Tank	Water Supply Unit	Cake Transfer Conveyor	Sludge Cake Storage Hopper	Inorganic Flocculant Storage Tank	Inorganic Flocculant Supply Pump
Type	Portable type	Freezer type	Rectangular tank	Pressurized tank type water supply pump unit	Flight conveyors	Material: Steel plate Type: Square cut gate	Vertical mixing tank	Diaphragm type Electromagnetic metering pump
Specification	0.1m³/min ×0.73Mpa	0.1m³/min	8 m³	0.5m³/min ×343Kpa (35m)	600mm×32m	10 m³	5 m³	φ13×10~100L/h ×98Kpa
Motorized output (kW)	1.5	0.075 (Single phase)	With FRP automatic water supply valve	7.5×2	7.5	2.2×2	FRP Type	2.2
Unit	2(1) / 2(1) / –	1 / 1 / –	1 / 1 / –	1 / 1 / –	1 / 1 / –	2 / 2 / –	2 / 2 / –	3 / 2 / 1
Remarks	With Control Panel	With Control Panel		With Control Panel		With Control Panel		VVVF Control Equipment

Equipment No.	⑰	⑱	⑲	⑳	㉑	㉒	㉓	㉔	㉕
Name	Lifting Tool for Dewaterer Inspection	Lifting Tool for Loading/Unloading Machinery	Lifting Tool for Loading/Unloading Chemicals	Deodorizer Fan	Biological Deodorization Tower	Activated Carbon Adsorption Tower	Sludge Cake Distribution Conveyer to Hopper	Return Flow Tank Mixer	Return-flow pump
Type	Manual-type chain block	Manual-type chain block	Motorized chain block	Single suction turbo fan	Packed column tower	Vertical type tower	Flight conveyer	Submerged mixer	Screw-type submersible pump (Detachable type)
Specification	2t×8m^H	2t×10m^H	1t×4m^H	40 m³/min	40 m³/min	40 m³/min	600mm×10m	φ580 mm	100φ×0.5m³/min×10m
Motorized output (kW)			Hoist 0.8 + Traverse 0.4	3.7			1.5	7.4 or higher	0.2
Unit	1 / 1 / –	1 / 1 / –	1 / 1 / –	1 / 1 / –	1 / – / 1	1 / 1 / –	1 / 1 / –	1 / 1 / –	2(1) / 2(1) / –
Remarks									

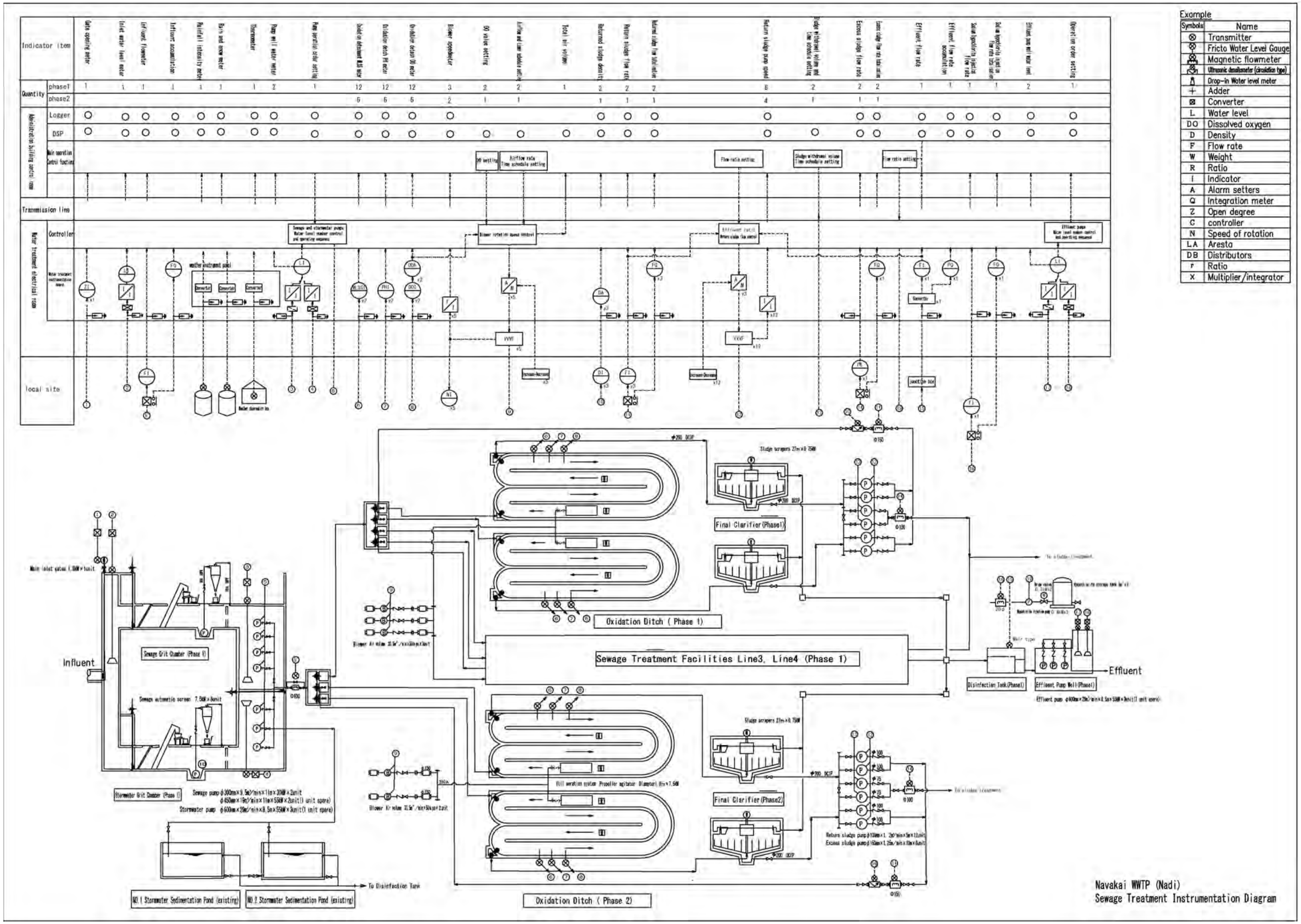
Navakai WWTP (Nadi)
Sludge Treatment Equipment Flowsheet

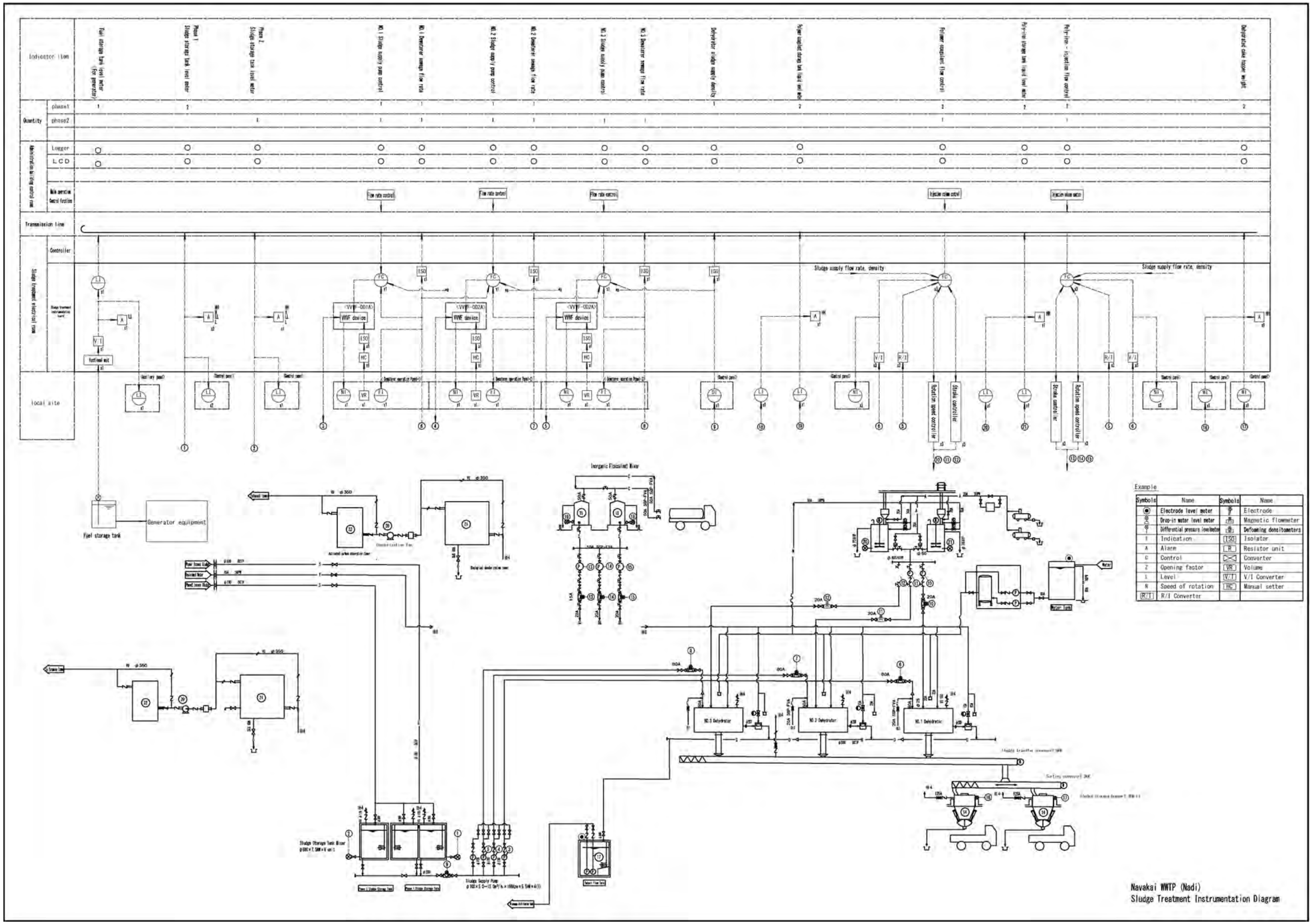
(2) Electrical Equipment



Load Name		SC	SC	SC	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Spare (1)	Spare (2)		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Spare (3)	Spare (4)	[illegible]	[illegible]	[illegible]	[illegible]	Spare (5)	Spare (6)
Capacity	Phase1	150kVar	75kVar	–	290	200	200	–	250	50	5kVA	10	–	–		70	70	50	5kVA	10	10	–	–	50	50	50	5kVA	–	–
	Phase2	–	–	75kVar	–	–	–	100	–	15	–	–	–	–		–	–	–	–	–	–	–	–	–	–	–	–	–	–
Remarks																													

Navakai WWTP (Nadi)
Single Line Diagram 1


Example
Symbols
Name
Transmitter
Fricto Water Level Gauge
Magnetic flowmeter
Drop-in Water level meter
Adder
Converter
L Water level
DO Dissolved oxygen
D Density
F Flow rate
W Weight
R Ratio
I Indicator
A Alarm setters
Q Integration meter
Z Open degree
C controller
N Speed of rotation
LA Aresta
DB Distributors
r Ratio
X Multiplier/integrator
Indicator item
Quantity
phase1
phase2
Logger
DSP
Transmission line
Controller
local site
Influent
Sewage Grit Chamber (Phase 1)
Oxidation Ditch (Phase 1)
Final Clarifier(Phase1)
Sewage Treatment Facilities Line3, Line4 (Phase 1)
Effluent
Disinfection Tank(Phase1)
Effluent Pump Well(Phase1)
Final Clarifier(Phase2)
Oxidation Ditch (Phase 2)
To Disinfection Tank
NO.1 Stormwater Sedimentation Pond (existing)
NO.2 Stormwater Sedimentation Pond (existing)
Navakai WWTP (Nadi)
Sewage Treatment Instrumentation Diagram

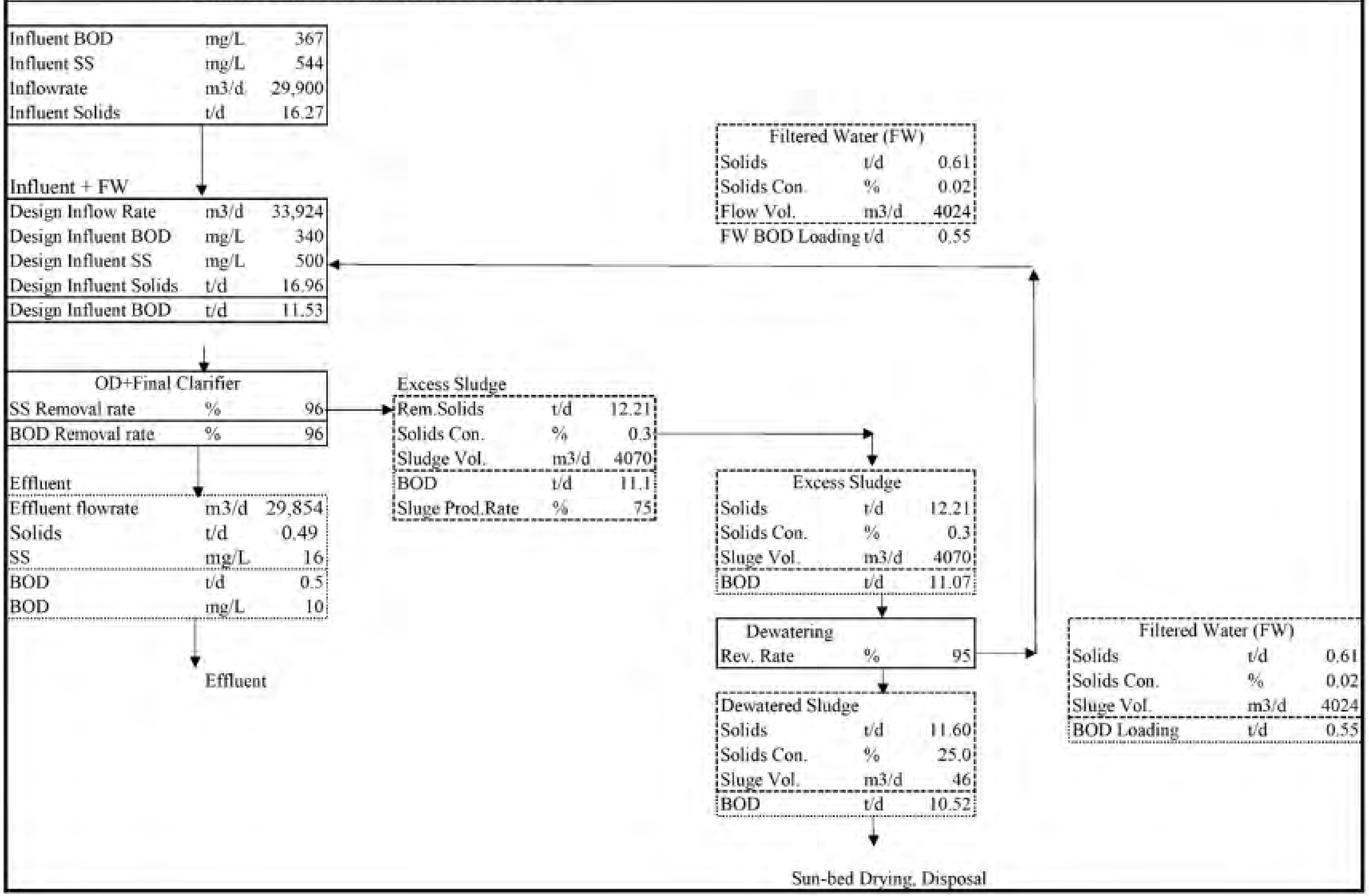

Indication item
Quantity
phase1
phase2
Logger
LCD
Transmission line
Controller
local site
Flow rate control
VVVF device
Sludge supply flow rate, density
Fuel storage tank
Generator equipment
Inorganic Flocculant Mixer
Example
Symbols
Name
Electrode level meter
Drop-in water level meter
Differential pressure levelmeter
Indication
Alarm
Control
Opening factor
Level
Speed of rotation
R/I Converter
Electrode
Magnetic flowmeter
Defoaming densitometers
Isolator
Resistor unit
Converter
Volume
V/I Converter
Manual setter
Navakai WWTP (Nadi)
Sludge Treatment Instrumentation Diagram

APPENDIX 4-8 Navakai WWTP Capacity Calculation

Item	Calculation				
1. Design Parameters					
1-1 Outline of Wastewater Treatment					
(1) Type of Collection System	Separate Sewer System				
(2) Water Treatment Process	Oxidation ditch				
1-2 Design Flowrate					
【Pipeline Sewerage】					
(1) Average Daily Flowrate	27,040 m^3/d	→	27,100 m^3/d		
(2) Peak Dry Weather Flowrate	54,100 m^3/d				
(3) Peak Wet Weather Flowrate	135,200 m^3/d				
【Trucked-in Domestic Septage】					
(1) Average Daily Quantity	0 m^3/d				
(2) Peak Daily Quantity	0 m^3/d				
【Total Influent Flowrate】					
(1) Average Daily Flowrate	27,100 m^3/d				
(2) Maximum Daily Flowrate	29,900 m^3/d				
(3) Maximum Hourly Flowrate	54,200 m^3/d				
(4) Peak Wet Weather Flowrate	135,300 m^3/d				
1-3 Influent Wastewater Quality					
【Pipeline Sewerage】					
(1) BOD	367 mg/L				
(2) SS	544 mg/L				
【Trucked-in Domestic Septage】					
(1) BOD	250 mg/L				
(2) SS	620 mg/L				
【Total Influent Flowrate】					
(1) BOD	367 mg/L				
(2) SS	544 mg/L				
1-4 Design Influent					
(1) BOD	340 mg/L				
(2) SS	500 mg/L				
(3) T-N	37 mg/L				
(4) T-P	6 mg/L				
1-5 Removal Efficency					
(1) BOD	96 %				
(2) SS	96 %				
(3) T-N	85 %				
(4) T-P	80 %				
1-6 Effluent Wastewater Quality		SEZ Standards			
(1) BOD	13.6 mg/L	20	mg/L	→	OK
(2) SS	20 mg/L	30	mg/L	→	OK
(3) T-N	5.6 mg/L	10	mg/L	→	OK
(4) T-P	1.2 mg/L	2	mg/L	→	OK

Item	Calculation
Sludge Production (Maximum Daily Flowrate)	
1-7 Waste Activated Sludge	Solids = Maximum Daily Flowrate × Influent SS × 0.96×0.75×10^{-6} Solids = 29,900 m3/d × 500 mg/L × 96 %×0.75× 10^-6 = 10.8 ds-t/d Solid Concentration = 0.3 % Sludge = Solids ÷ Solids Concentration×10^{2} Sludge = 10.80 t/d ÷ 0.3 % × 10^2 Sludge(OUT) = 3,600 m^3/d
1-9 Thickening	Solids (IN) = 10.8 ds-t/d Solids(OUT) = WAS × Recovery Rate×10^{-2} Solids (OUT) = 10.80 t/d × 95 % × 10^-2 Recovery Rate = 95 % = 10.3 ds-t/d Sludge(OUT) = Solids ÷ Solids Concentration×10^{2} Sludge(OUT) = 10.30 t/d ÷ 25 % × 10^2 Solid Concentratio = 25 % Sludge(OUT) = 42 m^3/d

2 Solids Mass Balance (Final Stage)



Item	Calculation
3. Sewerage Pump	
3-1 Grit Removal Chamber	
Design Flowrate	
Maximum Daily Flowrate	= 29,900 m^3/d
Maximum hourly Flowrate	= 54,200 m^3/d
Number of Chambers	= 3
Flowrate per Chamber	= 54,200 m3/d ÷ 3 = 18,067 m3/d
Width	W = 3.0 m
Target Grit	Specific Weigh = 2.65 Diameter = 0.2 mm and larger Settling Velocit = 21 mm/sec
Average Velocity	= 0.3 m/s
Retention Time (T)	= 60 sec Range: 30~60 sec
Hydraulic Load	= 1800 m3/m2/d
Chamber Length(L)	$= \frac{Q}{Ls \times W}$ $= \frac{18,067}{1800 \times 3.0}$ = 3.4 m → 3.5 m
Water Depth	$= \frac{T \times Q}{W \times L}$ $= \frac{60 \times 18,067 /(60\times60\times24)}{3.0 \times 3.4}$ = 1.3 m
Sand pit Depth	= 0.2 × 1.3 m = 0.3 m →Minimum 0.3 m → OK
Expected Grit Removal	0.05 m3-removed Grit/ 1000m3-sewerage = 0.05 × 54200.0 ÷ 1,000 = 2.71 m3/d
3-2 Screen	
Average Velocity	= 0.45 m/s
Water Depth	= 1.3 m
Width	$= \frac{Q}{V \times H}$ $= \frac{18,067 /(60\times60\times24)}{0.45 \times 1.3}$ = 0.4 m
Expected Screen Waste	0.05 m3-removed screen waste/ 1000m3-sewerage = 0.05 × 54200.0 ÷ 1,000 = 2.71 m3/d

Item	Calculation
4. Stormwater Pump	
4-1 Grit Removal Chamber	
Design Flowrate	
Maximum hourly Flowrate	= 81,100 m^3/d
Number of Chambers	= 3
Flowrate per Chamber	= 81,100 m3/d ÷ 3
	= 27,033 m3/d
Width	W = 3.0 m
Target Grit	Specific Weigh = 2.65
	Diameter = 0.2 mm and larger
	Settling Veloci = 21 mm/sec
Average Velocity	= 0.3 m/s
Retention Time (T)	= 60 sec Range: 30~60 sec
Hydraulic Load	= 1800 m3/m2/d
Chamber Length(L)	$= \frac{Q}{Ls \times W}$
	$= \frac{27,033}{1800 \times 3.0}$
	= 5 m
Water Depth	$= \frac{T \times Q}{W \times L}$
	$= \frac{60 \times 27,033 /(60\times60\times24)}{3.0 \times 5}$
	= 1.3 m
Sand pit Depth	= 0.2 × 1.3 m
	= 0.3 m →Minimum 0.3 m → OK
Expected Grit Removal	0.05 m3-removed Grit/ 1000m3-sewerage
	= 0.05 × 81100.1 ÷ 1,000
	= 4.055 m3/d
4-2 Screen	
Average Velocity	= 0.45 m/s
Water Depth	= 1.3 m
Width	$= \frac{Q}{V \times H}$
	$= \frac{27,033 /(60\times60\times24)}{0.45 \times 1.3}$
	= 0.6 m
Expected Screen Waste	0.05 m3-removed screen waste/ 1000m3-sewerage
	= 0.05 × 81100.1 ÷ 1,000
	= 4.055 m3/d

Item	Calculation
5. Oxidation Ditch	
5-1 Reactor Volume	
Design Flowrate	4983.33
Maximum Daily Flowrate	= 29,900 m^3/d
Maximum hourly Flowrate	= 54,200 m^3/d
Hydraulic Retention Time	= 24 hours
Req. Volume	= 29,900.00 m3/d × 24.00 hrs ÷ 24
	= 29,900 m^3
Shape of Reactor	Horseshoe
Water Depth	D = 3.5 m
Width	W = 4.5 m
Length	L = 60 m (Length of Tank's straight ditch)
Area	A = Width ×Water depth - 0.3 ×0.3×2/2
	= 4.50 m × 3.50 m − 0.3 × 0.3 × 2 ÷ 2
	= 15.7 m^2
Volume per Reactor	v = A * (4L+3πW)
	= (15.7 *(4* 60 +3π * 4.50)
	= 4433.8 m3/reactor
Number of Reactor	n = 6 Reactors
Total Volume	V = n*v = 6 * 4,434
	= 26,603 m^3
Actual Hydraulic Retention Time	HRT = V ÷ Q*24
	= 26,603 ÷ 29,900 *24
	= 21.4 hrs
	Range(Metcalf&Eddy): 16~30hr OK
5-2 Aerator	
(1) Design Parameters	
Maximum Daily Flowrate	= 29,900 m^3/d
Influent BOD	= 340 mg/L
Influent S-BOD	= 170 mg/L
Influent SS	= 500 mg/L
Influent Kj-N	= 37 mg/L
MLSS	= 4,000 mg/L
Effluent BOD	= 40 mg/L
Aerobic volume ratio	= 0.5
HRT	= 21.4 hrs

Item	Calculation
(2) ASRT	
ASRT	$= \frac{t_a}{24} \times \frac{X_A \times V}{X_w \times Q_w}$
	$= \frac{t_a}{24} \times \frac{X_A \times V}{Q \times X_i \times \alpha}$
	ASRT ; Aerobic Sludge Retention Time
	ta ; Aeration Time in a day
	= 12 hours
	Xw ; SS in WAS, mg/L
	V ; Reactor Volume, m3
	Qw ; Volume of WAS, m3
	Q ; Maximum Daily Flowrate/Reactor
	= 29,900 ÷ 6 = 4,983 m3/d
	X_i ; Influent SS = 500 mg/L
	α ; Sludge production rate per SS
	0.75
ASRT	$= \frac{12 \times 4{,}000 \times 4{,}434}{24 \times 4{,}983 \times 500 \times 0.75}$
	= 4.7 日
(3) Empirical ASRT	
	ASRT > 29.7 EXP (-0.102 × T)
	T ; Lowest water temperature in monthly average
	= 20 Celsius
ASRT	= 29.7 exp (-0.102 × 20)
	= 3.90 d < 4.70 d OK
(4) Prediction of C-BOD based on ASRT	
T	= 20 Celsius
C-BOD	= 9.75 × ASRT ^ -0.671
	= 9.75 × 4.7 ^ -0.671
	= 3.46 mg/L
	Assumming BOD/C-BOD is 3
BOD	= 3 × C-BOD
	= 3 × 3.46
	= 10.4 mg/L < 40 mg/L OK
	(General Standards)
	= 10.4 mg/L < 20 mg/L OK
	(Significant Eco Zone Standards)

Item	Calculation
(5) Oxygen requirement for	
OD1	= A × (Removed BOD − Denitrified N × K)
	A ; Reqired O_2/Removed BOD
	= 0.6 kg as O_2/kg as BOD
	K ; Consumed BOD by Denitrification
	= 2.5 kg as BOD/kg as N
	Removed BOD = (0.34 - 0.04) × 29,900
	= 8,970 kg as BOD/d
	Denitrified N ; Assuming all nitrified N is denitrified.
OD1	= 0.6 × (8,970 − 1106.3 × 2.5)
	= 3,723 kg as O_2/d
(6) Oxygen requirement for	
OD2	= B × Va × MLVSS
	B ; O_2 Volume for internal aspiration
	= 0.1 kg as O^2/kg as MLVSS/d
	Va ; Aerobic zone volume
	= Volume ÷ 2
	Assuming MLVSS/MLSS is 0.8
OD2	= 0.1 × 26,603 ÷ 2 × 4 × 0.8
	= 4,257 kg as O_2/d
(7) Oxygen requirement for	
OD3	= C × Nitrified N
	C ; O_2 consumed by nitrification
	= 4.57 kg as O_2/kg as N
	Nitrified N ; Amount of nitrifired nitrogen
	; Influent N − Effluent nitrified N
	− nitrogen of WAS
	Influent N ; 0.037 × 29,900
	= 1106.3 kg as N/d
	Effluent N ; Assuming all N is nitrified
	Nitrogen of WAS = 0.07 (kg as N/kg as MLSS)
	× Qw×Xx

Item	Calculation
	$Q_W \times X_X = Q_{in}(a \times C_{S\text{-}BODin} + b \times C_{ss,in} - c \times X_A \times \tau_A) \times 10^{-3}$
	a ; Rate of Sludge coversion from S-BOD = 0.5 gMLSS/gS-BOD
	$C_{S\text{-}BOD}$; Influent soluble BOD = 170 mg/L
	b ; Rate of Sludge production from SS = 0.75 gMLSS/gSS
	c ; Decay rate = 0.04 1/d
	τ_A ; Aeration time = 0.5 d
	Qw×Xa = 29,900 ×(0.5 × 170 + 0.75 × 500 − 0.04 × 4,000 × 0.5)× 10^-3
	= 11,362 kg/d
	Nitrogen of WAS = 0.07 × 11,362
	= 795.4 kg as N/d
OD3	= 4.57 ×(1106.3 − 0 − 795.4)
	= 1,421 kg as O_2/d
(8) Oxygen requirement in	
	Assuming Sludge return rate of: 100 %
OD4	= Oxygen in effluent
	= 1.5 × 29,900 ×(1+ 1.00) × 10^-3
	= 90 kg as O_2/d
(9) Actual Oxygen Requirement AOR	= OD_1 + OD_2 + OD_3 + OD_4
	= 3,723 + 4,257 + 1,421 + 90
	= 9,491 kg as O_2/d
(10) Standard Oxygen Requirement SOR	= $\dfrac{AOR \times C_{SW}}{1.024^{(t-20)} \times \alpha \times (\beta \times C_S - C_a)} \times \dfrac{760}{P}$
	C_{SW} ; Oxygen saturation concentration in clean water at 20 Celsius
	= 8.84 mg/L
	Ca ; Average DO = 1.5 mg/L
	Cs ; Oxygen saturation concentration in clean water at t Celsius
	= 8.84 mg/L
	t = 20.0 Celsius

Item	Calculation
	α ; 0.93
	β ; 0.97
	P ; 760
Number of Aerators	= 12 Aerators
	(2 raerators per OD)
SOR	= **12,752** kg as O_2/d
SOR/reactor	= **1063** kg as O_2/d (per aerator)
	Required Oxygen
	$= \frac{12,752}{0.34 \times 29,900} = 1.3$ kg as O_2/kg per unit BOD
6. Secondary clarifier	
6-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 29,900 m^3/d
Maximum hourly Flowrate	= 54,200 m^3/d
Overflow rate	= 12 $m^3/m^2/d$
Required Area for settling	= 29,900 ÷ 12 = 2,492 m^2
Diameter of Basin	= 27 m
No. of basin	= 6 basins
Effective Area	= 27 ^ 2 ÷ 4 × π × 6
	= 3,435 m^2
Depth of basin	= 4 m
Overflow rate	= 29,900 m^3/d ÷ 3,435 m^2
	= 8.7 $m^3/m^2/d$ Range: 8～12m3/m2/d **OK**
Settling Time	= (3,435 × 4 × 24)
	÷ 29,900
	= 11.0 hrs Range: 6～12hr **OK**
Req. Length of weir	= (27 − 1.6) × π = 79.8 m
	(Outer Weir)
Weir Loading rate	= 29,900 ÷ (79.8 +) ÷ 6
	= 62.4 $m^3/m/d$
	Range: 25~100m3/m/d
	OK

Item	Calculation
7. Disinfection	
7-1 Basin Volume	
Design Flowrate	
Maximum Daily Flowrate	= 29,900 m^3/d
Maximum hourly Flowrate	= 54,200 m^3/d
Peak Wet Weather Flowrate	= 135,300 m^3/d
Chlorine Contact Time	= 15 minutes
	= 900 seconds
Req. Volume	= 135,300 ÷ 24 ÷ 60 ÷ 60 × 900
	= 1410 m^3
Depth	= 2 m
Width	= 2 m
Length	= 360 m
Volume	= 2 m × 2 m × 360 m
	= 1440 m^3
Actual Contact Time	= 1440 ÷ 135,300 × 24× 60
	= 15.33 min OK
8. Sludge Treatment	
8-1 Sludge Dewatering	
Solids (IN)	= 10.8 t/d
Solid Concentration	= 0.30 %
Sludge(IN)	= 3,600 m3/d
(Sludge Storage Tank)	
Sludge Dewatering Operation	7 days in a week
Storage	1 days worth
Required Volume	= 3,600 m3/d × 1 d = 3600 m3
	Phase 1 = 2,400 m3
	Phase 2 = 1,200 m3
Storage Tank Depth	= 4 m
Tank Size r	= 7.0 m
Number of Tanks(n) Ph1	= 4 tanks
Ph2	= 2 tanks
Volume(V) Ph1	= π×r^2×h×n = 2463 m3 → OK
Ph2	= π×r^2×h×n = 1232 m3 → OK

Item	Calculation
(Sludge Dewaterer)	
Operation Conditions	9 hrs in one day and 7 days in a week
Solids	= 10.8 × 7 ÷ 7 ÷ 9
(Required Dewatering Cap.)	× 1,000
	= 1200.0 kg/d
Actual Dewatering capacity	= 400 kg/d
Number of Units	= 3 Units
Solids (OUT)	= 10.30 t/d
Solid Concentration(OUT)	= 25.00 %
Sludge(OUT)	= 42 m3/d
8-2 Sludge Drying Bed	
Sludge Drying Period	= 3 month
Drying Bed Volume	= 5 month's worth sludge
	= 150 d
Sludge Volume	= 42 m3/d × 150 d
	= 6,300 m3
Sludge Depth	= 0.3 m
Required Drying Bed Area	= 6,300 m3 ÷ 0.3 m
	= 21,000 m2
Drying Bed Area	= 115 m × 100 m × 2 Bed areas
	= 23,000 m2 OK
	= **2.3 ha**
	= 1.6 ha (Phase 1)
	+ 0.70 (Phase 2)
Dried Sludge	Dried Sludge Water Conter 65 %
	Sludge Concentration 35 %
Solids (OUT)	= 10.30 t/d
Sludge (OUT)	= 29.4 m3/d

Item	Calculation
8-3 Sludge Storage Space	
Sludge Storage Period	= 20 yrs
Sludge Volume	= 29.4 m3/d × 20 yrs × 365 d
	= 214,620 m3
Sludge Depth	= 3.0 m
Required Storage Area	= 214,620 m3 ÷ 3.0 m
	= 71,540 m2
Sludge Storage Area	= 48,000 m2 = **4.8** ha (第1期)
	24,000 m2 = **2.4** ha (第2期)
	= 72,000 m2 = **7.2** ha
	OK
9. Primary Treatment (Stormwater)	
Design Flowrate	= 4* Maximum Daily Flowrate
	= 4* 29,900 m³/d
	= 119,600 m³/d
Required Retention Time	= 2.50 hrs
Required Volume	= 119,600.00 m3/d × 2.50 hrs ÷ 24
	= 12,459 m^3
Design Depth	= 3 m
Required Surface Area	= 4,153 m2
Maturation Pond Volume	= 40 m × 55 m × 3 m × 2 ponds
	= 13200 m3 > 12,459 m^3
	OK
Existing IDEA Pond Volume	= 8233 m3
Existing Maturation Pond Volu	= 4289 m3
Total	= 12,522 m3 > 12,459 m^3 OK

APPENDIX 7-1 Policies and Plans Related to Sewerage Sector Development and ESC

(1) Fiji Government National Development Plan 2017-2036

The 5-Year and 20-year National Development Plan recognizes the importance of tourism to the overall development of the country. Emphasised key long-term priorities include increasing the range of tourism products (sports tourism, cruise tourism, wedding tourism, retirement villages, medical tourism and conference tourism), filmmaking, regional communications/transport services, and other new initiatives.

Ecotourism and adventure tourism are also prioritised as opportunities to promote our unique biodiversity. The development of stronger tourism value chains is prioritised, including strengthened agricultural and fisheries links to promote locally grown foods and opportunities to promote traditional handicrafts and natural body products. There is a particular emphasis on expanding opportunities for women and MSMEs and ensuring that cultural heritage and heritage sites are both protected and promoted by the industry.

Investments in new sporting facilities built to international standards is recognised as necessary to position Fiji as a host for more international events. Expansion of the Fiji Airways fleet is identified as important for growing tourism through leasing of new aircrafts, and the development of new air connections and new routes. Domestic air services and upgrading works at domestic airports and airstrips over the next 20 years is also emphasised to support tourism dispersal.

Building on this, the Ministry of Finance, Strategic Planning, National Development and Statistics is currently leading the formulation of a new national development plan that seeks to strengthen the policy and planning within government, improve coordination, appraisal and selection of public investment projects, monitoring and evaluation of projects and strengthen national workforce planning and economic intelligence analysis.

(2) Fiji National Sustainable Tourism Framework (2024-2027)

The Fiji Government, through the Ministry of Tourism and Civil Aviation (MTCA), is developing a 10-year National Sustainable Tourism Framework (NSTF) that shares a collective vision for a sustainable Fijian tourism sector. With the support of the International Finance Corporation, (IFC), between August 2022-May 2023, over 600 stakeholders took part in a series of public private dialogues and focus group discussions on a range of topics.

The NSTF will articulate the strategic direction of the tourism sector from 2024 to 2034, providing a blueprint for Fijians to develop and benefit from the country’s tourism resources. The design of the NSTF is based on thorough research, qualitative and quantitative evidence, recommendations from the National Economic Summit held in March 2023 and broad stakeholder consultations and feedback from tourism and tourism-related industries, government, civil society, communities, and development partners.

The NSTF will lay out a clear policy direction, with the high-level framework accompanied by an initial three-year Action Plan (2024-2027) focused on the continued tourism recovery from the COVID-19 pandemic, mitigating future economic shocks and striving for sustainable growth.

Fiji has made strong policy commitments to economic, environmental, social, and cultural sustainability across various international, regional and national policies, strategies and plans. This includes as part of the Climate Change Policy 2018-2030 and Climate Change Act, the Green Growth Framework, and the National Oceans Policy. By 2030, Fiji aims to source 100 percent of its electricity from renewable energy sources and be net-zero by 2050. Fiji is a signatory to various international conventions including the United Nations Framework for Action on Climate Change, Convention on Eliminating Violence Against Women, United Nations Declaration on the Rights of Indigenous Peoples and several others indirectly linked to the tourism sector.

In 2019, when 894,389 visited Fiji, the sector employed an estimated 34.5 percent of total formal economy workers or 62,277 employees. According to the Fiji Bureau of Statistics (FBoS) earnings in 2019, it contributed over 500 million FJD directly to total tax revenue representing around 18 percent of the government’s total tax revenue and over 2 billion FJD in foreign exchange earnings. Statistics from the provisional visitor arrivals show that from January 2023 to October 2023, approximately 772,172 visitors arrived in Fiji.

(3) Fiji National Economic Summit 2023

The Fiji National Economic Submit 2023 highlights the tourism industry as a key growth sector for Fiji. The Summit outlined achievable long-term (beyond five years), medium -term (three to five years), and short-term (less than two years) solutions for seven major issues the industry is now facing. These challenges and opportunities include:

1. Need for climate -resilient infrastructure in different areas of the country, particularly in the rural, northern, and outer islands zones
2. Migration of skilled labour
3. Growing tourism -related investments, particularly in line with Fiji Airways' development strategy and the need for the hotel inventory to match growing flight capacity
4. Improving sector -specific links to increase Fiji's agricultural outputs and lessen the country's dependency on imports
5. Greening the existing inventory and infrastructure to meet the sustainability agenda, including recycling and renewable energy
6. Accelerate business reforms to assist the development, expansion, and creation of new markets or niches by removing legislative bureaucracy
7. Prioritizing community -based operators and ecotourism

(4) Fiji National Culture Policy 2022-2032

Tourism is a cross-cutting theme within the culture policy and cultural tourism is identified as a specific priority to promote sustainable cultural tourism that nurtures culture, heritage, and the arts in Fiji. Cultural Tourism is identified as an important avenue to build local, regional, and international understanding and provide opportunities to strengthen intercultural relations, reduce conflicts and support peacebuilding. The support of partners to address challenges presented by tourism is critical. These include potential sexual exploitation, drug abuse, distortion of aesthetic and ethical values, commercialization and loss of artistic tangible and intangible culture and undermining and distortion of cultural norms and values.

Close collaboration between the Department of Culture, Heritage and Arts of the Ministry of iTaukei Affairs, Culture, Heritage & Arts and the Department of Tourism is emphasised to support the development of quality cultural tourism experiences and products, and for fair and equitable provision and use of cultural and creative products and services. Specific strategies to support this include the establishment of public and private sector networks, strengthened marketing of cultural products, festivals, and services, improvements to the preparedness and accessibility of specific heritage sites, promotion of biodiversity (marine and natural land-based heritage); and actions to minimize the negative impacts to cultural and natural heritage sites and local communities. An indigenous tourism framework that aligns with the National Sustainable Tourism Framework is currently under development.

(5) iTaukei Land Trust Board (TLTB) The Greater West Land-use Master Plan (GWLMP)

The Greater West Landuse Master Plan (GWLMP) has finally been approved by the Department of Town & Country Planning (DTCP) for use in the high-potential areas between Serua and Tailevu North. The planning process commenced in 2018 and the Plan was submitted for endorsement to Director Town & Country Planning in October 2019.

This is a regional land use plan for the Western Division which aims to assist in directing key investment decisions for developers as well as decision-making authorities at what is now known to be “a hotspot for development”.

The Greater West Landuse Master Plan boundary stretches from Galoa in Serua to Korovou in Tailevu along the corridor of the Kings Road and Queens Road; from the high-water mark to the road and 10km inland from these highways for the purpose of strategically allocating and apportioning land uses for development, conservation and other land use types. The GWLMP will also be useful for the identification of growth centres for future planning and releasing of land by TLTB for leasing.

The DTCP, the key development approving authority in Fiji, had closely worked with TLTB in the entire planning process and the production of this Plan. As a result, this Plan becomes a synergized and integrated plan for TLTB, DTCP, and other key agencies in consultation with relevant stakeholders from government ministries, private institutions and NGO’s that had been a part of this project.

The GWLMP is important to guide TLTB in ensuring that more land is available and most importantly to guide our officers in the type of development and land to be released for leases that will create sustainable land use practices. In effect, this will also create LOU empowerment and enable them to make decision on the types of leases to be issued on their land as well as feeding the TLTB platform for on-going lease application process.

(6) iTaukei Land Trust Board (TLTB) Regional Land Release Plan for the Greater West and Coastal Region 2019-2039

The iTaukei Land Trust Board (TLTB) Regional Master Plan for the Greater Nadi – Lautoka corridor was approved by the Director of Town and Country Planning (DTCP) in 2008, and it serves to guide the overall character, physical form, growth, and development of iTaukei Land within the Greater West and Coastal Region (GWCR). In 2017, TLTB decided to revise its Greater West and Coastal Region Land Use Master Plan due to the changing conditions on the ground and also in terms of the increase in competing demand for various land uses in the region.

The Greater West and Coastal Area is Fiji's second fastest growing region, after the Greater Suva, and it accommodates approximately 315,838 people as compared to 884,887 people, which is slightly more than one third of the total population in Fiji (FBoS, 2017). The unprecedented growth in population and housing over the past decade has also brought inevitable challenges associated with rapid growth, such as increased traffic congestion, overcrowding, increased demand on land for various uses, increased demand on utilities, services and infrastructure, etc. These challenges are also part of the reason why the TLTB decided to revise its existing plans by using land as a key resource for development that considers both the needs of the present and future generations.

(7) Ministry of Local Government & Singapore Corporation Enterprise (SCE) 50 Year Master plan

The Ministry of Local Government in collaboration with the Singapore Corporation Enterprise (SCE) have finalized the Strategic Master Plan for Viti Levu and Concept Master Planning for Greater Suva, Nadi and Lautoka. The Concept Master Plan has been finalized and the final report has been handed over to the Ministry of Local Government. In the final stages of the project consultations, all stakeholders especially the strategic assets agencies and infrastructure agencies had supported the Master Plan. A Cabinet paper has been prepared and is being circulated for final comments prior submission to Cabinet. The Master Plan may be shared following a decision made by the Cabinet.

(8) Greater Western Corridor Master Plan for All State Land

The Land Use Planning & Development (LUPD) Team of the Ministry of Lands is currently working on its Master Plan for all State land in Fiji across the three divisions.

In 2023, the LUPD team started the first pilot project for the for the Greater West Corridor Master Plan. The second draft of the West master plan has been completed and submitted to the various stakeholders including the Department of Town & Country Planning for their final comments.

Notably, the State lands around Navakai have been ear marked for future Special Use tourism development and commercial development. In Natabua, the surrounding state leases have also been ear marked for Industrial and commercial development. The LUPD indicated that they had not consulted with other utility provider including WAF in their earlier consultation processes. Therefore, WAF had requested they take on board the issues with water and wastewater for both Nadi and Lautoka as since they are proposing high density developments other than agricultural their Master Plans may not yield the outcomes if the development is not able to connect to these basic services and utilities.

The LUPD was asked to review the Regional Wastewater Master Plan's current and future land needs for WWTPs to be factored into their Landuse Master Plans prior to finalising their Greater Western Corridor Plan. WAF may also need to relook at the capacity and future demand calculation to factor in Lands Department's Master Plan and also for their land acquisition plans as well. There was no indication as to whether the Greater Western Corridor Plan would include the foreshore areas.

(9) Draft Mangrove Management Plan 2013

The draft Mangrove Management Plan was prepared for the Department of Environment as the focal point for the Mangrove Eco Systems for Climate Change Adaptation and Livelihood Project (MESCAL). It acts as a tool to administer, manage, facilitate and control development and management of mangroves in Fiji. Whilst the draft was prepared in 2013, it has yet to be endorsed by DoE and approved by the Parliamentary Cabinet and hence why it remains a draft despite going through a few reviews.

In 2013 with the Environmental Management Act (EMA 2005) in place, the adopted approach is to put in place a rigorous Environmental Impact Assessment (EIA) procedure. The EMA (2005) and its EIA Regulations (2007) appear to have had no positive impact at all on sustainable management of mangrove resources, rather poor EIA preparation and review has enabled unsustainable mangrove management.

Under the EMA, the Department of Environment (DoE) have considerable mangrove management responsibilities but is current capacity precludes the ability to address this. It has strong provisions for enforcement of many illegal activities, however, DoE's ability to use its legislation for enforcement purposes remain poorly developed. The DoE requires to work cooperatively with other agencies to monitor projects for compliance with conditions it has set.

Under current legislation as state land, mangroves may be converted to other uses by the Department of Land under Crown Lands Act. Before it can issue a development or other lease for mangrove conversion, Department of Land has to ensure that an EIA of the conversion proposal has been approved by the Department of Environment under the Environmental Management Act. The conversion of mangrove in the absence of an EIA is an offense even if a foreshore lease has been granted, an/or the mangrove is included in a freehold title.

According to the draft Mangrove Management Plan, research showed that mangroves are among the most carbon-rich forests in the tropics, containing on average 1,023mg carbon per hectare. Much if not most of the carbon storage (49-98%) is in the organic mangrove-rich soils. As such loss of mangroves contributes an order of magnitude more carbon emissions than terrestrial tropical forest (Donato *et al.,* 2011).

In a meeting with the DoE (held on 22 July, 2022), mangrove protection policies were discussed. The DoE strongly recommends that all projects should first think of avoiding mangroves or any sensitive areas, but depending on situations, other options such as offsetting (6-10 planting per cutting etc.) or compensation might be accepted in a project EIA.

(10) Draft Mangrove Conservation & Management Regulation 2022

In 2022, DoE has drafted the Mangrove Conservation and Management Regulations under the Environmental Management Act, which has underground rounds of consultations with key stakeholders in the public and private sector throughout Fiji. The feedback and comments made as part of the consultation process is currently undergoing review but DoE is still accepting review comments. The DoE is also planning to map all the mangroves across Fiji.

The DoE believes that with the condition of the effluent satisfying the effluent standards at the end of the discharge point, discharging to the ocean could be better, as more dilution is expected. However, this should be determined on a case-by-case basis, since discharge of nutrient rich water into low nutrient (oligotrophic) waters on coral coasts can negatively impact on the coral reef ecosystem. It is unclear as to whether effluent standards for discharging into mangrove areas will also be included into the Regulations.

This regulation may have impacts on any future site development works located in and around mangrove areas especially where it may require mangroves to be removed. Replanting programmes may be required or a total ban on removal of mangroves may hinder any development plans to existing or proposed new sites in and around mangrove areas.

(11) National Biodiversity Strategy Action Plan Year 2020-2025

In 1992, Fiji signed the International Convention on Biological Diversity (CBD) with 150 joining countries who were required to develop a National Biodiversity Strategy & Action Plan outlining the national strategies and actions that will contribute to the half of biodiversity loss. Fiji's 5th National Report to the CBD noted that the country's rich biodiversity contributes significantly towards food, agriculture, tourism, coastal protections, etc. However, the biodiversity is also under pressure including unsustainable forest management practices, mangrove removal, poor waste management practices, etc.

The NBSAP supports many legal acts Fiji, including but not limited to the Sewerage Act and Water Supply Act. It also took into account the latest environment national strategies and reports some of which are the Fiji National Climate Change Policy (2012), Fiji REDD+ Policy (2011), Fiji Integrated National Waste Management Strategy (2016-2020 draft), Forest Policy (2007), Mangrove Management Plan (2013) and National Policy Plan for Fijian Managements (1986).

(12) National Biodiversity Threat Assessment 2022

According to the latest report published by IUCN Oceania 2022 Ambition for Biodiversity, Fiji has the third largest mangrove resource in the Pacific Islands after Papua New Guinea (372,770 ha) and the Solomon Islands (64,200ha) (Mangrove Management Committee 2013). The Forest Resource Assessment and Conservation (2017) recorded Fiji's mangrove cover to be 45,940 ha from Viti Levu, Vanua Levu and Taveuni. The assessment was updated in the 2019 to 47,440 ha which covered Cicia, Gau, Lakeba, Matuku, Moala, Ovalau, Viti Levu and Vanua Levu (O'Brien *et al*., 2021). There are eight mangrove species recorded from Fiji.

In 2016, Fiji's nearshore and offshore marine areas were evaluated against a set of criteria to identify Special, Unique Marine Areas or SUMAs. In total, 98 sites were identified as SUMAs. Along the coastline of Western Fiji, there are 12 SUMA sites.

(13) Fiji Forest Policy Statement 2007

The first National Forest Policy for Fiji was adopted in 1950 and gave rise to the 1953 Forest Act which together placed forestry primarily in the context of forest management for timber. In the 21st century, forestry's policy environment continues to change with increased emphasis on sustainable forest management, increased landowner's aspirations, climate change and globalization. The Fiji Forest Policy Statement was later established in 2007 providing an explicit requirement in respect of mangroves with priority to be given to the management of mangroves to maintain its ecological, cultural and social values as priority. In accordance with Department of Forestry current policy, commercial mangrove harvesting should be prohibited.

Under the Forest Decree (1992) mangroves are "forest" and the Forestry Department regulates the utilisation and management of all forest resources, but they only do so after Department of Lands have approved an application for mangrove harvesting and Forestry only regulate harvesting. They do not have a continual monitoring role or presence.

(14) Fiji REDD+ Policy 2021

The Fiji REDD+ Policy is implemented within the framework of the National Forest Policy 2007 and contributes to the national Forest Sector goal "Sustainable management of Fiji's forests to maintain their natural potential and to achieve greater social, economic and environmental benefits for current future generations." It has the overall objective of enhancing the national forest-based carbon balance by a) supporting and strengthening initiatives that address the drivers of forest-based carbon emission; b) encouraging the drivers of forest-based carbon sinks.

(15) Fiji National Climate Change Policy 2021

Climate change poses an ongoing threat to Fiji's constitutional commitments and values, national wellbeing, environmental stability, development priorities, and economic sustainability. To address this, the Fijian

Government developed Fiji's first National Climate Change Policy (NCCP) in 2012. The NCCP (2012) served as the overarching policy instrument for climate change in Fiji and encompassed these issues at local, national and international level.

The NCCP (2018) is closely aligned with the objectives of the 5-is closely aligned with the objectives of the 5-Year & 20-Year National Development Plan (NDP) and seeks to accelerate Fiji's progress towards achieving the Sustainable Development Goals (SDG), and other national, regional and global commitments.

The NCCP (2018) has three central policy pillars: human-rights based, gender-responsive and evidence-based, The Policy sets out the Governments' position on climate change and identifies eight core principles namely; sustainable well-being, social cohesion, inclusivity, partnership, agility, urgency, transparency and communication, and integrated learning.

Access to additional and alternative climate finance resources (bilateral, regional or multilateral and private sector resources) is urgently needed to enable the shifting of the paradigm to transform development and climate change challenges into tangible investments to scale up climate adaptation and mitigation solutions to achieve the NDP goals and climate goals.

(16) National Liquid Waste Management Strategy & Action Plan 2007

The Fiji National Liquid Waste Management Strategy & Action Plan (2007) prepared by the Ministry of Environment, funded by the International Waters Programme of the Global Environment Fund Facility, the United Nations Development Program and the Secretariat of the Pacific Regional Environment Programme. The stakeholders that contributed to the formulation of this Strategy included South Pacific Applied Geoscience Commission now known as SPC, Ministry of Works, Ministry of Fijian Affairs, Municipal Councils, Rural Local Authorities, Ministry of Health and the private sector representatives as well as other stakeholders.

The different types of liquid wastes covered under the strategy includes domestic wastewater such as sewerage and greywater, which is collected by sewerage systems or goes into septic tanks; commercial and industrial wastewater, including that from the tourism industry; animal waste, marine shipping; urban stormwater; leachates from landfills/dumps; and sludge (septic tanks, industries and WWTPs).

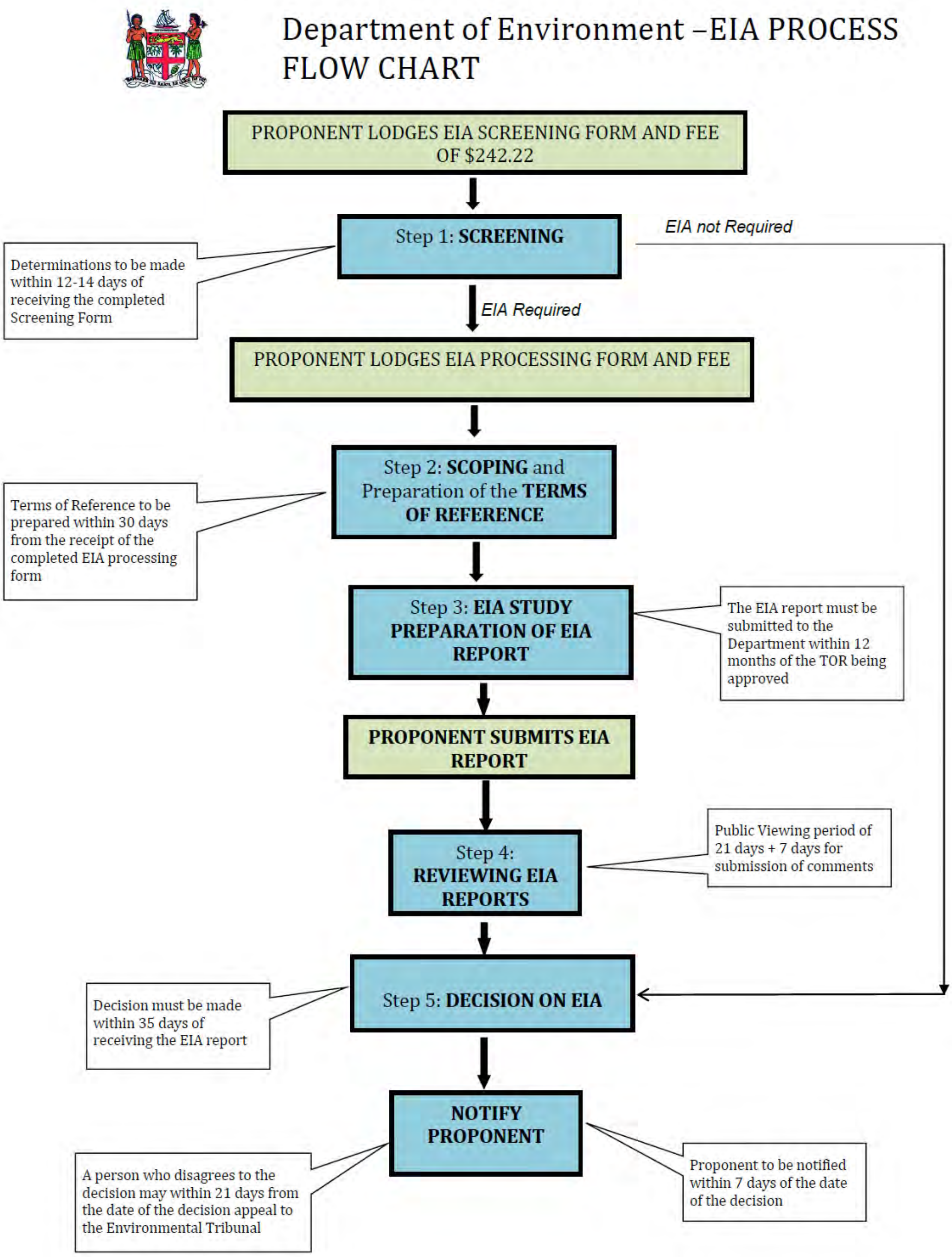
The key objectives of the strategy were to:

- Reduce the amount of wastewater produced in Fiji
- Improve and upgrade waste management and disposal systems to improve wastewater quality
- Improve coordination of departments/stakeholders involved in regulating and managing liquid waste
- Improve awareness and practices of public in relation to sanitation/wastewater management.

Whilst the International Water Programme no longer exists, and since the formulation of the National Liquid

Wastewater Management Strategy, the Waste Management Unit within the Department of Environment has tried to implement some of wastewater management strategies through the Waste Disposal & Recycling Regulations 2007 (commonly referred to as the Waste Regulations) under the Environmental Management Act 2005.

APPENDIX 7-2 Overview of Environmental Permit Procedures for Projects



Step	Process
Step 1: Screening	1. The proponent submits a Preliminary Form that contains the proponent's contact details and the project summary. DOE conducts a site visit if necessary. 2. Based on the collected information in 1., DOE provides advice informally or request a Screening Application Form with 250 FJD. The Form should describe the project summary, site location, land tenure information, major environmental characteristics, public consultation status etc. 3. Based on 2., DOE provides formal notification of the screening decision.
Step 2: Scoping	1. The proponent submits an EIA Processing Form with the processing fee (it depends on the development characteristics) 2. DOE conducts consultation with related parties and simple assessment. DOE conducts a site visit as needed. 3. DOE prepares a scoping report that includes TOR of the EIA and provide it to the proponent (the scoping process is sometimes outsourced). 4. The scoping report is publicly disclosed in Environmental Register. 5. If the proponent suggests EIA consultant when submitting the Processing Form, consultation with DOE is required. 6. DOE notifies the final decision of the TOR to the project proponent.
Step 3: The EIA study and report	1. Based on the approved TOR, EIA consultant start EIA studies and prepare a EIA report. 2. The proponent submits the EIA report to DOE.
Step 4: Review of and decision on the EIA report	1. The review Committee appointed by DOE reviews the EIA report. 2. The EIA report is publicly disclosed in the Environmental Register, and if necessary, notified through newspapers and radio. Public hearing is also required at the project site areas. The public comment shall be open for 28 days. 3. The proponent revises the EIA report and provides supplemental information, based on comments and questions during the review period. 4. DOE issues a decision of the EIA review, such as i) approved with/without conditions, ii) request for supplemental studies, iii) denied with reasons etc. 5. In case of ii), the proponent submits additional information etc., and the project is again reviewed by the Review Committee.

Source: Environmental Management Act 2005, Environmental Management (EIA Process) Regulations 2007, and Environmental Impact Assessment

APPENDIX 7-3 Outline of Land Acquisition Procedures

1. Issue of Draft Land Acquisition & Resettlement Plan (LARP)

2. WAF to obtain letter from DOL confirming the historical arrangement between DOL and previous Ministry of Infrastructure and Works, which did not require them to apply for foreshore development leases over areas of foreshore and waterways and/or pay fishing rights compensation to Qoliqoli users, particularly for the outfall at Navakai into Nadi River and also for the mangrove and foreshore area for outfall at Natabua.

3. Issue draft Land Acquisition Plans and Scope of Works to DOL to enable liaison with iTaukei Land and Fisheries Commission/Department of Fisheries to confirm if fishing rights compensation is applicable for the outfalls and foreshore mangrove areas, and therefore, if a Fisheries Impact Assessment is required at Navakai outfall and at Natabua foreshore and outfall.

4. Prepare draft letter of intent for the Affected Persons/Displaced Persons.

5. Prepare questionnaire and assessment templates as part of the engagement with the Affected Persons.

6. Issue Land Acquisition Plans outlining permanent and/or any temporary areas required for development and use both existing and new based on the detailed engineering design for the WWTP sites.

7. Confirm land ownership, areas, and tenure (iTaukei reserve, state/iTaukei leased, or freehold).

8. Verify and approve Land Acquisition Plans by WAF Management and issue to DOL and TLTB identifying areas (permanent and temporary) to be acquired or leased or for easements.

9. Conduct titles/leases search in Government titles registration office for affected land ownership.

DOL/TLTB to verify with WAF for records and compensation discussions and provide contact details for landowners.

10. Determine numbers in *mataqali* group, landowners and users affected – referred to as Affected Persons, and identify any other vulnerable households not yet noted, including the elder, persons with disabilities, widowed or sickly.

11. Prepare individual Letters of Intent for each Affected Household (AHH) or Affected Persons (AP)

12. Undertake Socio-economic surveys & Commercial surveys to gather baseline socio economic data for consideration

13. Hold a series of community consultation as part of the EIA process and to disseminate design information as well as, land acquisition plans and gather any concerns from the affected persons.

14. Issue individual Letters of Intent to the AHHs or APs.

15. Obtain consent of Mataqali landowners for iTaukei reserve land (minimum of 60% signatories registered in the Vola Ni Kaubula (VKV) from Native Reserve land owners

16. Obtain signatures for the customary Qoliqoli Resource Users for endorsement by iTLFC – if applicable.

17. Undertake Fisheries Impact Assessment & Ratification by the Chairman of ILFC.

18. Cadastral pre-survey of land.

19. Determine and mark areas for each land parcel required.

20. Conduct inventory of losses by WAF's i- house land valuation team – land, trees, crops and provide valuation for compensation.

21. Undertake disclosure of updated entitlements, Grievance Redress Mechanism (GRM) and LARP implementation arrangements to affected persons

22. Undertake detailed consultations with relocating households on resettlement arrangements (where applicable) involving Ministry of Housing, Housing Authority and Department of Lands.

23. Undertake detailed consultations with AHHs/APs with affected livelihoods on transitional support and livelihood restoration arrangements (if applicable).

24. Negotiate compensation with landowners (freehold and *mataqali)*, and holders of Native/State Leases.

25. Negotiate with landowning unit during various consultation meetings to agree on compensation and document the outcomes for vetting and confirmation with WAF, DoL and TLTB.

26. Acquire State Land from DOL following review of land valuation and compensation figures by the Chief Valuer.

Acquiring Native Reserve and Native Lease land through TLTB following review of land valuation and compensation figures by the Chief Valuer.

27. WAF to submit the updated LARP for approval to WAF Board and Ministry of Finance/Donor Agencies.

LARP Implementation by WAF

28. Preparation of Sale and Purchase Agreement to issue to freehold owners and State lease and native lease holders to be endorsed by TLTB if native land before issued to the APs.

29. Payment of compensation to the Qoliqoli resource users via DoL & iTLFC

30. Payment of compensation and allowances on the basis of 75% to the APs upon signing of the Sales & Purchases Agreement.

31. Issue Tender for Civil Works

32. Award of civil works contract, clearance of land, and briefing of contractor on safeguards.

33. Prepare LARP implementation verification reports for WAF Board and Ministry of Finance/Donor Agencies review and clearance.

34. Commencement of civil works (contingent on compensation and allowances being paid) – based on duration of construction period.

35. Contractor to complete as-built surveys particularly for pipeline easements and WAF to verify and prepare final survey plans for registration

36. Payment of balance compensation and allowances on the basis of 25% to the APs upon survey plan registration.

37. DOL & WAF Lands team completes land transfers or easement certificates for registration.

38. WAF submits the Land Acquisition and Compensation Completion Report to WAF Board and Ministry of Finance or Donor Agencies.

Monitoring Plan

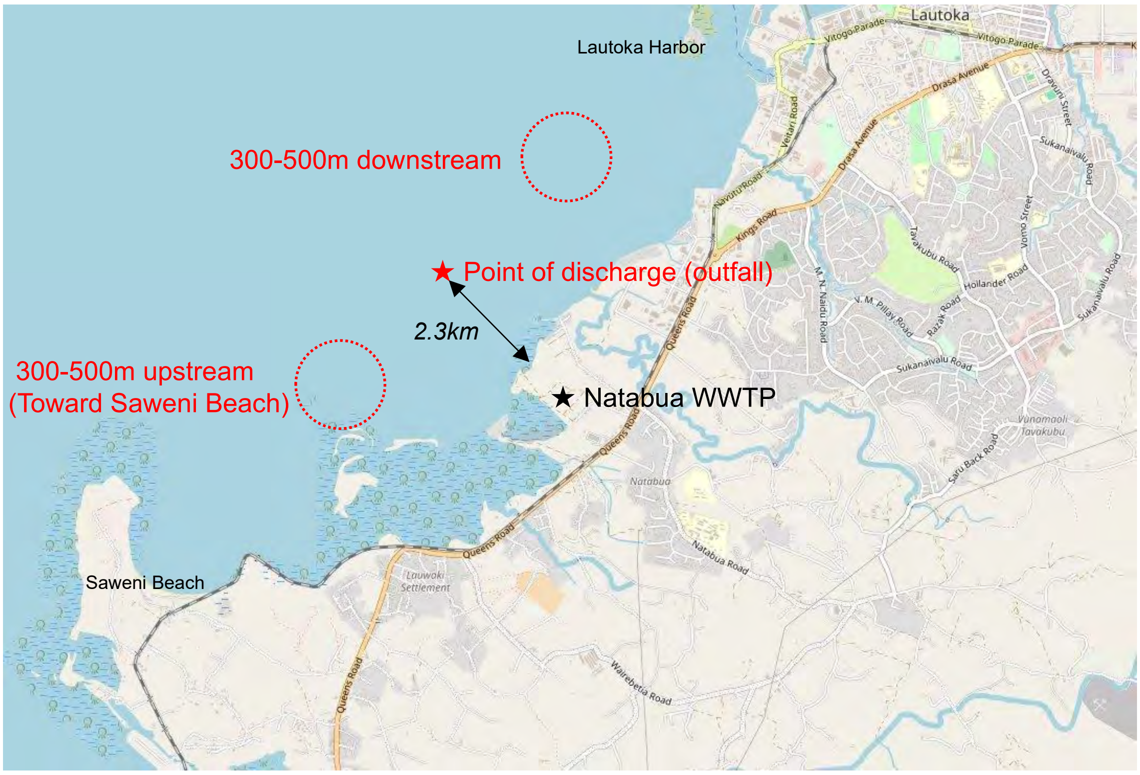
39. WAF starts APs socio-economic monitoring.

40. WAF submits progress report to WAF Board and Ministry of Finance/Donor Agencies on implementation of the LARP.

41. WAF conducts post-project survey and final monitoring report.

APPENDIX 7-4 Water Quality Survey by WAF

(1) Natabua Wastewater Treatment Plant



Red - sampling locations
Note) The locations are approximation due to no GPS data provided.

Source: JET with Open Street Map

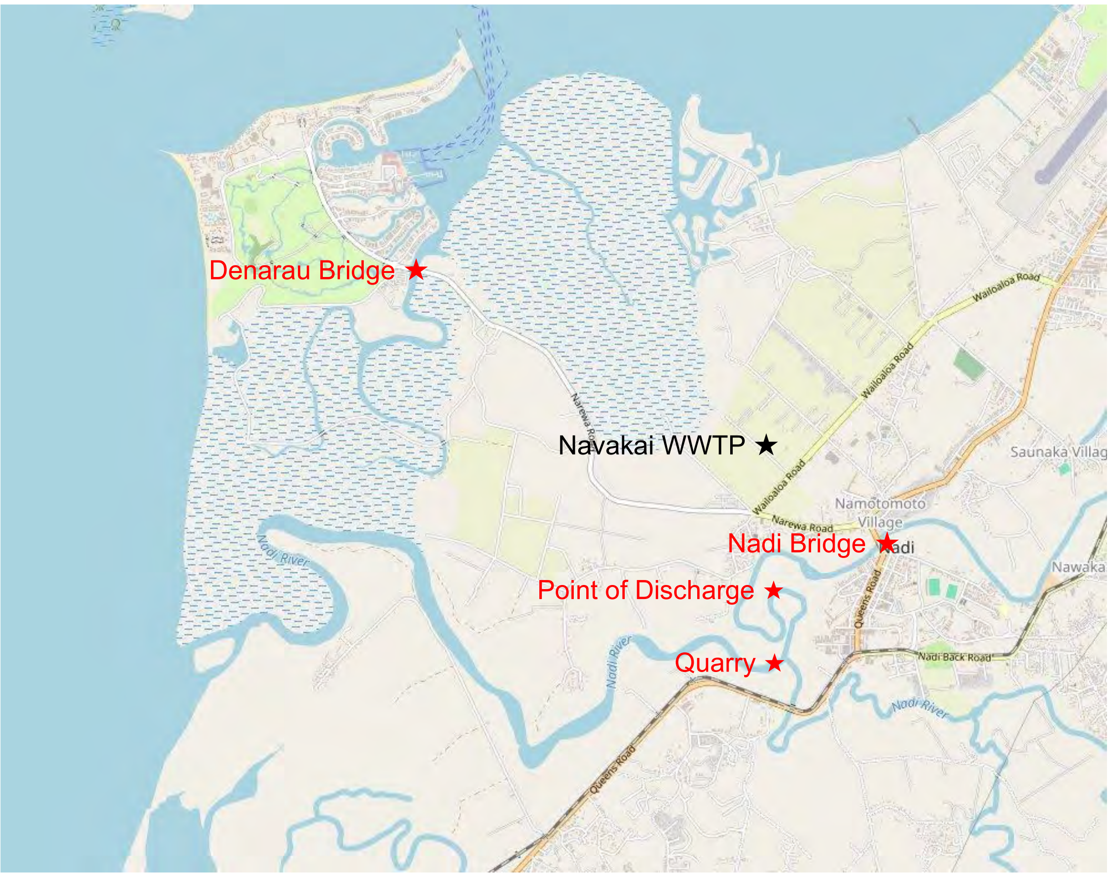
Figure A7-4.1 Sampling locations (Natabua Wastewater Treatment Plant)

Table A7-4.1 Ambient Water analysis results (Natabua Wastewater Treatment Plant)

Date	Weather	Location	ref #:	PHYSICAL ANALYSIS				SOLIDS	NUTRIENT SPECIES		OXYGEN DEMAND		MICROBIOLOGICAL ANALYSIS
				Temperature	pH	Conductivity	Salinity	Total Suspended Solids	Nitrate	Ortho-phosphates	Dissolved Oxygen	Biochemical Oxygen Demand	Faecal coliforms
				ºC	0-14	uS/cm	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	1cfu/100ml
2022/3/3	Fine	Point of Discharge [Surface]	10844/21-22	24.6	7.88	46520.0	30.2	116.6	0.09	0.10	4.40	0.82	110,000
		300m towards Saweni Beach		24.7	8.06	47540.0	31.0	79.4	0.09	0.09	3.63	0.47	84,000
		300m towards Lautoka Harbour		24.8	8.04	47610.0	31.0	112.6	0.08	0.09	3.24	0.44	76,000
2022/6/30	Fine	500m Upstream	11432/21-22	23.3	8.04	51820.0	34.0	153.6	0.09	0.12	9.35	2.43	64,000
		Point of Discharge		22.8	8.10	52120.0	34.2	150.1	0.11	0.13	9.34	3.15	108,000
		500m Downstream		23.1	8.15	52250.0	34.3	156.1	0.10	0.11	9.14	0.97	56,000
2022/9/8	Fine	500m Upstream	10217/22-23	25.3	7.94	44830.0	29.0	173.2	0.10	0.11	10.33	0.46	84,000
		Point of Discharge		25.0	8.09	44850.0	29.0	176.9	0.11	0.12	9.00	0.52	114,000
		500m Downstream		24.9	8.11	45060.0	29.1	162.6	0.09	0.11	9.68	0.42	72,000
2023/1/2	Fine	Point of Discharge	10815/22-23	24.4	8.08	48400.0	31.6	144.8	0.15	0.15	8.17	0.67	N/A
		500m Upstream		24.0	8.10	48640.0	31.7	143.6	0.15	0.16	8.86	0.76	N/A
		500m Downstream		25.2	8.11	48650.0	31.8	148.0	0.15	0.15	8.52	0.65	N/A
2023/5/4	Fine	500m Upstream	11328/22-23	23.9	8.18	51400	33.7	53.4	0.08	0.10	10.3	0.68	440
		Point of Discharge		24.1	8.19	51111	33.5	69.8	0.08	0.09	9.89	0.75	6800
		500m Downstream		24.1	8.12	51410	33.7	70.8	0.08	0.09	10.0	0.88	900
2023/8/1	Fine	500m Upstream	10008/23-24	23.2	8.7	53150	35	197.2	0.14	0.14	10.8	0.61	9,400
		Point of Discharge		23.5	8.15	53240	35.1	201	0.12	0.12	11.2	0.78	740
		500m Downstream		23.7	8.1	53070	34.9	193.2	0.13	0.17	11.5	1.11	800
2023/11/1	Fine	Point of Discharge	10504/23-24	24.1	8.15	53200	35.1	133.8	0.11	0.09	10.1	1.18	10000
		500m Upstream		24.3	8.15	53000	35.0	121.1	0.12	0.1	13.0	0.68	740
		500m Downstream		23.0	8.09	52980	34.8	159.1	0.15	0.12	12.3	2.12	620

Source WAF laboratory

(2) Navakai Wastewater Treatment Plant



Red - indicate sampling locations
Note) The locations are approximation due to no GPS data provided.
Source: JET with Open Street Map

Figure A7-4.2 Sampling locations (Navakai Wastewater Treatment Plant)

Table A7-4.2 Ambient Water analysis results (Navakai Wastewater Treatment Plant)

Date	Weather	Location	ref #:	PHYSICAL ANALYSIS				SOLIDS	NUTRIENT SPECIES		OXYGEN DEMAND		MICROBIOLOGICAL ANALYSIS
				Temperature	pH	Conductivity	Salinity	Total Suspended Solids	Nitrate	Ortho-phosphates	Dissolved Oxygen	Biochemical Oxygen Demand	Faecal coliforms
				ºC	0-14	uS/cm	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	1cfu/100ml
2022/6/29	Fine	500m Upstream [Nadi Bridge]	11431/21-22	24.1	7.42	267.9	0.1	24.4	0.11	0.14	8.74	2.15	640,000
		Point of Discharge		24.2	7.38	544.1	0.2	51.4	0.31	0.77	7.72	7.52	4,200,000
		500m Downstream [Quarry]		24.3	7.25	1562.0	0.8	153.7	0.12	0.14	8.85	5.80	40,000
		1km Downstream [Under Denarau Bridge]		24.3	7.49	45040.0	29.1	162.5	0.1	0.11	9.16	2.69	52,000
2022/9/6	Fine	500m Upstream [Nadi Bridge]	10216/22-23	25.1	7.69	5326.0	2.9	19.9	0.11	0.13	20.23	1.49	1,120,000
		Point of Discharge		25.1	7.63	17000.0	10.0	68.0	0.12	0.12	27.08	4.45	8,800,000
		500m Downstream [Quarry]		25.0	7.68	18270.0	10.8	44.2	0.11	0.12	23.54	4.79	46,000
		1km Downstream [Under Denarau Bridge]		25.3	7.30	45280.0	29.4	172.9	0.10	0.12	21.25	6.51	9,600
2023/1/2	Fine	500m Upstream	10817/23-24	25.6	7.48	149.3	0.1	103.1	0.17	0.22	8.86	0.88	N/A
		Point of Discharge		25.7	7.42	487	0.2	13.2	0.45	0.79	6.31	6.11	N/A
		500m Downstream		25.6	7.87	169.1	0.1	52.1	0.17	0.21	7.96	1.68	N/A
		Denarau Bridge		25.2	7.62	40330.0	25.8	129.9	0.16	0.16	8.01	1.23	N/A
2023/5/2	Fine	500m Upstream -Nadi Bridge	11326/22-23	23	7.62	921.8	0.4	51.4	0.25	0.12	10.4	6.09	1160
		Point of Discharge		22.9	7.54	7629	4.2	35.1	0.08	0.11	11.2	4.02	11000
		500m Downstream (Quarry)		22.8	7.4	9231	5.1	36.6	0.20	0.13	10.9	2.62	1180
		1km Downstream (Denarau Bridge)		22.5	7.85	50290	32.8	112.3	0.19	0.09	10	1.53	108000
	Fine	500m Upstream -Nadi Bridge	10506/23-24	24.3	7.11	14930	8.6	53.2	0.16	0.42	12.2	2.37	112000
2023/8/2		Point of Discharge		24.7	7.16	14250	8.2	47.9	0.17	0.45	10.0	2.8	11000000
		500m Downstream (Quarry)		24.5	7.16	14340	8.3	34.9	0.16	0.44	15.3	2.27	64000
		1km Downstream (Denarau Bridge)		24.5	7.18	14290	8.2	49.5	0.14	0.42	15.8	1.76	60000
2023/11/2	Fine	500m Upstream -Nadi Bridge	10011/23-24	22.6	7.28	942.7	0.4	16.5	0.10	0.15	11.5	2.56	88000
		Point of Discharge		22.7	7.14	6276	0.4	65.5	0.12	0.16	10.9	2.03	1020000
		500m Downstream (Quarry)		22.9	7.67	6250	0.4	139.5	0.11	0.17	11.8	2.11	8000

Source: WAF laboratory

APPENDIX 7-5 Water Quality Survey Results Conducted in the M/P Project

Additional water sampling (water samples and measurements with a YSI-multi-meter) was undertaken for this ESC report, with a wet season survey undertaken 17 February 2024 and a dry season survey undertaken 19 July 2024. The parameters measured and locations of sampling are presented in **Table A7-5.1** and **Figure A7-5.1**. The results are presented in **Table A7-5.2**. These results were found to be similar to the values that WAF has obtained in 2022-23 and indicate that the Nadi River is highly polluted, and that most parameters are above water standards most of the time.

Table A7-5.1 Field Survey Parameters for Natabua and Navakai service areas

	Field survey	Location	Parameter	Frequency	Total samples
#1-1	Ambient water (surface water)	- 3 locations in Lautoka - 3 locations in Nadi	pH, DO, COD, BOD, TSS, T-N, NH4-N, NO3-N, T-P, Fecal Coliform, E-Coli, salinity, water temperature	Rainy season: Oct-March. 2024 Dry season: April-Sept 2024	18
#1-2	Ambient water (bottom water)	- 3 locations in Lautoka			

Source: JET

Source: JET

Figure A7-5.1 Nadi/Navakai sampling locations

Source: JET

Figure A7-5.2 Lautoka/Natabua sampling locations

Table A7-5.2 Field Survey Results

Wet Season (17/2/24)

NAVAKAI

Date	Weather	Location	Physical Parameters			SOLIDS	NUTRIENT SPECIES					OXYGEN DEMAND			MICROBIOLOGICAL ANALYSIS		LOCATION	
			Temperature	pH	Salinity	Total Suspended Solids	Total Nitrogen	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Total Phosphorus	Dissolved Oxygen	Biochemical Oxygen Dem	Chemical Oxygen Demand	Faecal coliforms	E-coli	Lat	Long
			°C	0-14	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN / 100mL	MPN / 100mL		
17/02/2024	Overcast	500 m Upstream	24.9	7.8	0.2	54.4	10	0.22	25	0.39	0.15	8.01	5.89	8.66	>10,000	>5,000	17°48'3.42"S	177°24'38.18"E
		Point of Discharge	24.7	7.56	4.5	61.4	33	0.23	35	0.31	0.12	7.76	3.88	5.56	>10,000	>5,000	17°48'3.46"S	177°24'26.34"E
		500 m Downstream	24.7	7.67	12.2	72.7	23	0.38	17	0.39	0.17	7.26	6.58	8.9	>10,000	>5,000	17°48'20.68"S	177°24'18.44"E

NATABUA

Date	Weather	Location	Physical Parameters			SOLIDS	NUTRIENT SPECIES					OXYGEN DEMAND			MICROBIOLOGICAL ANALYSIS		LOCATION	
			Temperature	pH	Salinity	Total Suspended Solids	Total Nitrogen	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Total Phosphorus	Dissolved Oxygen	Biochemical Oxyg	Chemical Oxygen Demand	Faecal coliforms	E-coli	Lat	Long
		Surface samples	°C	0-14	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN / 100mL	MPN / 100mL		
		500 m offshore	24.1	7.34	31.8	144.8	2.2	0.15	15	0.22	0.15	8.78	0.72	0.96	355	196	17°37'35.50"S	177°24'58.62"E
17/02/2024	Overcast	Point of Discharge	23.8	7.33	32.2	143.6	12	0.15	17	0.27	0.17	8.11	0.82	1.12	7200	314	17°37'52.04"S	177°25'0.25"E
		500 m inshore	23.7	7.23	32.1	148	6.4	0.15	11	0.21	0.15	8.91	0.64	0.84	210	124	17°37'20.39"S	177°24'53.29"E
		Bottom samples																
		500 m offshore (~5.0 m)	22.5	7.23	34.8	144.8	1.3	0.15	12	0.22	0.15	8.21	0.3	0.41	121	84	17°37'35.50"S	177°24'58.62"E
17/02/2024	Overcast	Point of Discharge	22.9	7.19	35	143.6	13	0.15	17	0.26	0.15	8.34	0.76	0.94	6600	194	17°37'52.04"S	177°25'0.25"E
		500 m inshore (~2.0)	23.6	7.44	34.9	148	3.3	0.15	8	0.21	0.15	8.53	0.34	0.41	240	124	17°37'20.39"S	177°24'53.29"E

Dry Season (19/7/24)

NAVAKAI

Date	Weather	Location	Physical Parameters			SOLIDS	NUTRIENT SPECIES					OXYGEN DEMAND			MICROBIOLOGICAL ANALYSIS		LOCATION	
			Temperature	pH	Salinity	Total Suspended Solids	Total Nitrogen	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Total Phosphorus	Dissolved Oxygen	Biochemical Oxygen Dema	Chemical Oxygen Demand	Faecal coliform	E-coli	Lat	Long
			°C	0-14	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN / 100mL	MPN / 100mL		
19/07/2024	Overcast	500 m Upstream	23.8	7.23	0.5	53.4	24	0.19	28	0.32	0.15	8.01	5.89	9.12	>10,000	>5,000	17°48'3.42"S	177°24'38.18"E
		Point of Discharge	23.8	7.21	0.7	51.5	28	0.27	23	0.44	0.11	7.76	3.88	7.87	>10,000	>5,000	17°48'3.46"S	177°24'26.34"E
		500 m Downstream	23.9	7.21	2.6	58.5	26	0.23	28	0.45	0.12	7.26	6.58	8.87	>10,000	>5,000	17°48'20.68"S	177°24'18.44"E

NATABUA

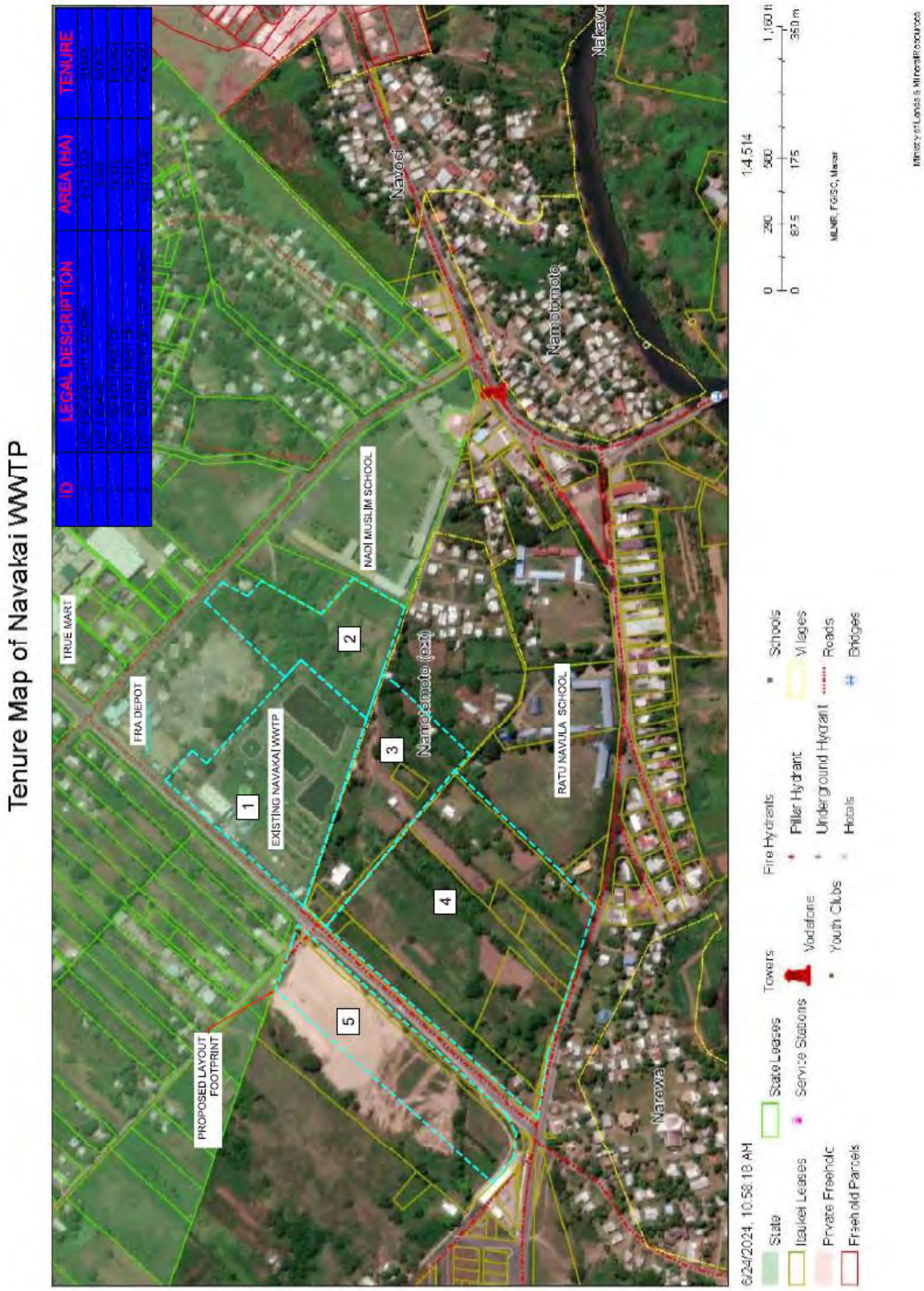
Date	Weather	Location	Physical Parameters			SOLIDS	NUTRIENT SPECIES					OXYGEN DEMAND			MICROBIOLOGICAL ANALYSIS		LOCATION	
			Temperature	pH	Salinity	Total Suspended Solids	Total Nitrogen	Nitrate-N + Nitrite-N	Total Kjeldahl Nitrogen (TKN)	Dissolved Reactive Phosphorus	Total Phosphorus	Dissolved Oxygen	Biochemical Oxygen	Chemical Oxygen Demand	Faecal coliform	E-coli	Lat	Long
		Surface samples	°C	0-14	ppt	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	MPN / 100mL	MPN / 100mL		
		500 m offshore	23.6	7.65	35.2	123.4	3.1	0.15	16	0.15	0.16	8.5	0.66	1.13	5400	337	17°37'35.50"S	177°24'58.62"E
19/07/2024	Overcast	Point of Discharge	23.6	7.67	35.2	132.3	8.1	0.15	12	0.16	0.17	8.99	0.89	0.95	1250	224	17°37'52.04"S	177°25'0.25"E
		500 m inshore	23.7	7.89	35.1	131.1	7.2	0.15	12	0.16	0.15	9.2	0.74	0.76	900	256	17°37'20.39"S	177°24'53.29"E
		Bottom samples																
		500 m offshore (~5.0 m)	22.7	7.34	35.4	147.7	5.2	0.15	12	0.19	0.13	8.21	0.77	0.56	3400	133	17°37'35.50"S	177°24'58.62"E
19/07/2024	Overcast	Point of Discharge	22.3	8.03	35.2	156.4	5.6	0.15	15	0.15	0.15	8.22	0.76	0.58	6500	165	17°37'52.04"S	177°25'0.25"E
		500 m inshore (~2.0)	22.5	7.45	35.7	168.6	5.6	0.15	12	0.11	0.12	8.44	0.55	0.44	1250	112	17°37'20.39"S	177°24'53.29"E

APPENDIX 7-6 Major Socio-Economic Indicators Around the Priority Project

Item		Total	Division	Province	Municipality	
			Western	Ba	Nadi	Lautoka
Polulation[1)]	Total	884,887	337,041	247,685	71,048	71,103
	Men	448,595	171,053	125,241	35,701	35,262
	Women	436,292	165,988	122,444	35,347	35,841
	Elderly persons (over age of 60)	80,483 (9.1%)	31,775 (9.4%)	23,147 (9.3%)	5,165 (8.6%)	9,008 (9.0%)
	Disabilities [2)] (% over age of 5)	113,595 (13.7%)	40,373 (12.7%)	30,242 (13.7%)	6,861 (10.7%)	7,632 (11.8%)
Ethnic composition [1)]	iTaukei	555,499	185,032	122,825	27,555	49,602
	Indo-Fijian	289,237	142,712	116,602	28,916	45,770
	Other groups	40,151	9,297	8,258	3,246	3,892
Informal settlement [1)]	Population	—	50,411	—	18,664	18,909
	Household	—	11,489	—	4,337	4,116
Unemployment rate [1)]	Total	4.5%	5.1%	5.3%	5.4%	7.5%
	Male	2.9%	3.1%	3.5%	3.7%	5.4%
	Female	7.8%	9.5%	9.4%	8.2%	11.5%
Poverty [2)]	Total	29.6%	28.6%	—	—	—
	Urban	23.0%	20.4%	—	—	—
	Rural	37.8%	30.5%	—	—	—
Average household size [1)]		4.6	—	—	—	—

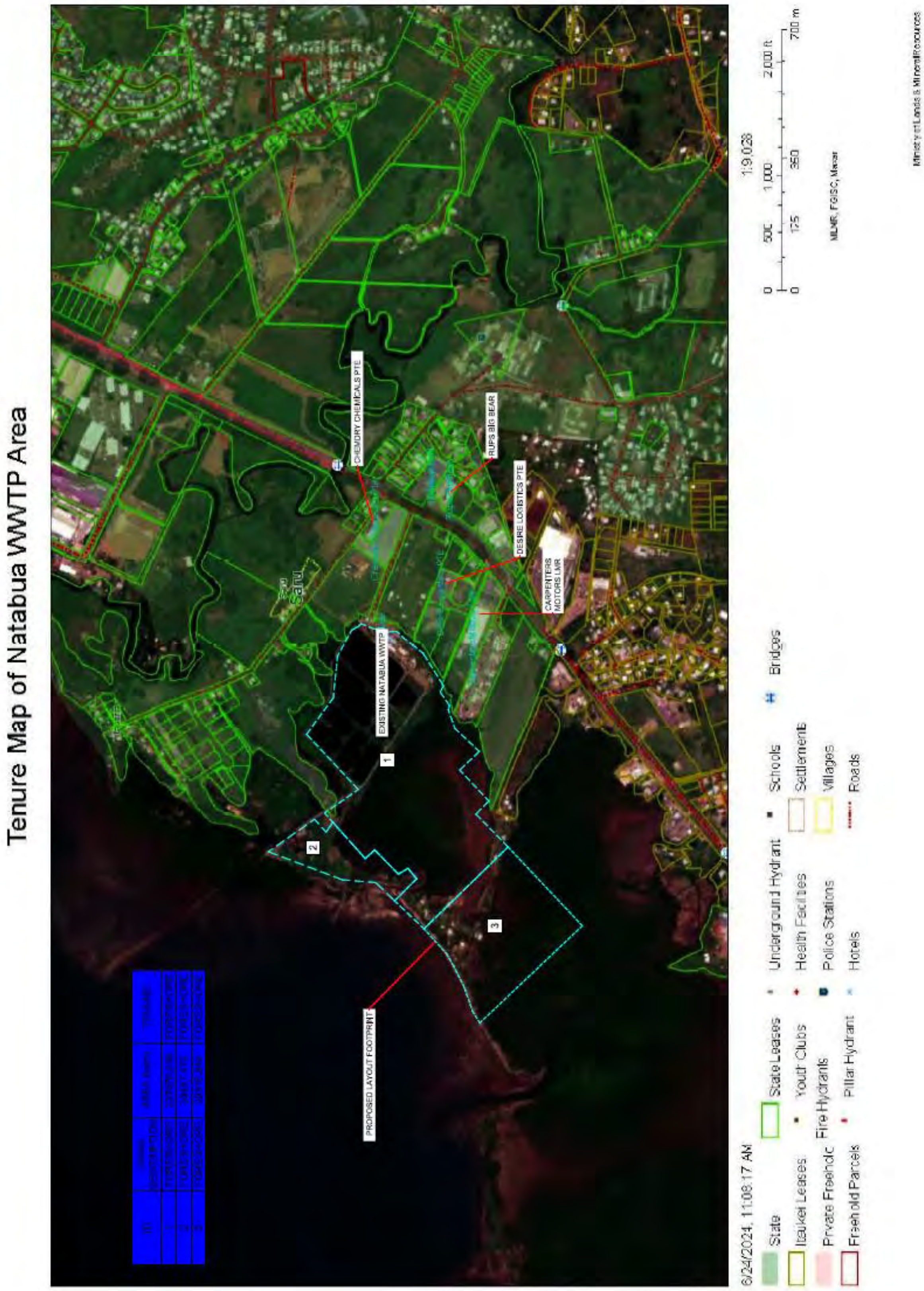
Note: The poverty rate is based on Multidimensional Poverty.
Reference:
1) Fiji Bureau of Statistics, Fiji Census 2017
2) Fiji Bureau of Statistics, 2019-20 Household Income and Expenditure Survey Main Report
Source: Created by JET based on abode references

APPENDIX 7-7 Land Use Inventory



[Navakai WWTP, Nadi]

Land type	Lot - Plan	Description	Required land (ha)	Required for displacement				Note
				# of buildings		# of residents		
				Total	houses	Legal	illegal	
State land	Lot 9 SO499	Existing WWTP	2.170	-	-	-	-	Structures and operation area
State land	Lot 2 SO1890	Existing WWTP	2.120	-	-	-	-	Existing ponds x 5 (different sizes)
State land	Lot 2 SO4040 (part of)	Government Reserve	3.990	-	-	-	-	Vacant land otherwise used as vehicular access for Ministry of Works on Lot 3 SO1236
iTaukei land	Lot 1 ND4070	Multiple Leases issues – as on TLTB Map	15.370	-	7	-	-	Part is Native lease agreements for commercial development and Village extension
iTaukei land	Lot 1 SO1932	Automart Ltd	3.010	-	-	-	-	Native Lease agreements for commercial development


Tenure Map of Natabua WWTP Area
CHEMDRY CHEMICALS PTE
RUPS BIG BEAR
DESIRE LOGISTICS PTE
CARPENTERS MOTORS LMR
EXISTING NATABUA WWTP
PROPOSED LAYOUT FOOTPRINT
1
2
3
6/24/2024, 11:08:17 AM
State
Itaukei Leases
Private Freehold
Freehold Parcels
State Leases
Youth Clubs
Fire Hydrants
Pillar Hydrant
Underground Hydrant
Health Facilities
Police Stations
Hotels
Schools
Settlements
Villages
Roads
Bridges
1:9,028
0
500
1,000
2,000 ft
0
175
350
700 m
MLMR, FG/SC, Maxar
Ministry of Lands & Mineral Resources

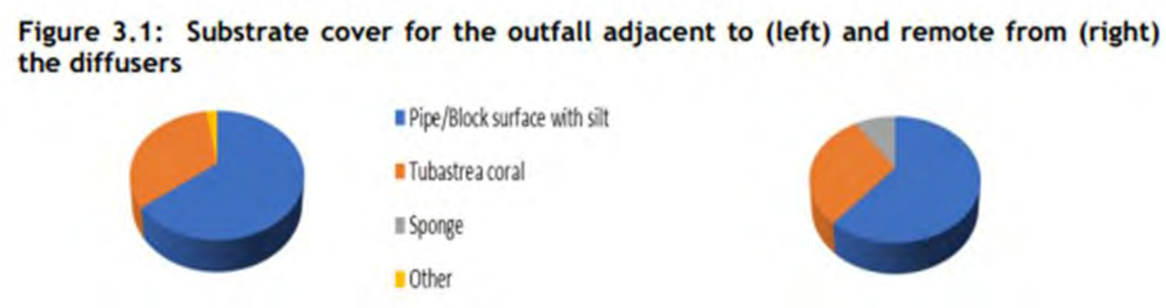
[Natabua WWTP, Lautoka]

Land type	Lot - Plan	Description	Required land (m2)	Required for displacement				Note
				# of buildings		# of residents		
				Total	houses	Legal	illegal	
State land	Area 1 F9-5	Natabua WWTP	23,677	-	-	-	-	Foreshore
State land	Area 2 F9-5	Mangroves/mud flats	33,488	-	-	-	-	Foreshore (Qoliqoli Resource Waiver needed)
State land	Area 3 F9-5	Naqiroso Settlement	90,319	-	18	-	105	Foreshore

APPENDIX 7-8 SPD Water Quality Survey Results

This summary presents the results of the 2022 FINAL monitoring report (Argo environmental Ltd), comparing to findings back at least 5 years of the biological characteristic (habitat, fish populations and benthic communities), water and sediment quality associated with South Pacific Distilleries dunder outfall at Natabua just south of Lautoka. The outfall is located in shallow coastal waters (approximately 20m water depth) 2.3km offshore from Natabua on the northwestern coast of Viti Levu. The local WWTP also discharges treated wastewater through the outfall. To reduce the risk of interference for other pollution sources, the sampling sites have been selected to include locations potentially impacted by the dunder discharge (diffuser pipe) and a control location (20m, 100m, and 500 m SW of the outfall).

The below figure shows the proportion of substrate cover on the outfall near the diffusers compared with that remote from the diffusers for the 2022 survey.



Source: JET

Figure A7-8.1 Proportion of substrate cover on the outfall near the diffusers compared with that remote from the diffusers

Fish species numbers for the pipe adjacent to and remote from the diffusers (6 and 7 species respectively) are similar to the range of those recorded in the last 7 years of surveys (5-15 and 6-9 respectively). As in previous surveys, the most abundant species observed at both locations are primarily the snappers and surgeonfish. The most consistently observed species, the surgeonfish and bannerfish, are once again present Appendix A.

A total of 11 species were identified in all samples including 4 species of crustacea (shrimps and crabs); 3 species of bivalve mollusc (clams); 1 species of gastropod mollusc (snail); and 1 species each of annelid and nemertean worm and a sipunculid. The total number of species recorded is similar to the 2020 survey and is lower than that of recent previous surveys (with the exception of 2010 survey) where between 14 and 20 species were recorded.

Mean invertebrate abundance ranges from 6.3 ± 1.5 (20m site) to 12.7 ± 1.2 (500m site). Mean number of taxa ranges from 2.7 ± 0.6 (20m site) to 4.7 ± 0.6 (100m site). Total abundances of 19, 23 and 38 at the 20m, 100m and 500m sites respectively are within the range (2-616, 0-134 and 0-102 respectively) of that found in previous surveys. Total numbers of species of 4, 9 and 5 found at the 20m, 100m and 500m sites respectively are within the range (2-26, 0-16 and 0-13 respectively) of that found in previous surveys. Overall, like the recent previous surveys, any effect of the discharge on the benthic communities appears to be limited to the area directly adjacent to the outfall.

Overall, there is little difference between the sites closest to the outfall (20 and 100m) and the control site (500m) for water quality parameters measured. All parameters are below recognized water quality guidelines, results in Appendix A. Turbidity is low at all sites (0.3-0.7 NTU), Dissolved oxygen concentrations (93.6-96.0 g/m^3) are within the range of those recorded previously. Total nitrogen concentrations are <0.01 g/ m^3 and Total phosphorus concentrations range from 0.007-0.014 g/ m^3 at all sites are below the ANZECC (2000) default trigger value range of 0.12 g/ m^3 and 0.015 g/ m^3 respectively for slightly disturbed tropical marine ecosystems.

Sediment quality parameters are similar across all sites and within those recorded previously. The coarse material fraction is highest at the site closest to the outfall (likely to be due to shell material) decreasing with distance away from the outfall which is similar to previous surveys.

Overall, based on the results of the 2022 survey, the discharge of dunder appears to be having little or no effect on the instantaneous water quality, habitat and biological communities present along and adjacent to the outfall. Like previous surveys it is possible that the discharge of dunder and treated wastewater is affecting the benthic communities and sediment quality confined to an area directly adjacent to the outfall, but this is limited and is more likely to be due to the physical presence of the outfall structure itself (Argo Environmental Ltd 2022).

Table 3.2: Fish species found along the outfall in the 2013 - 2022 surveys

		Diffusers							Remote from Diffusers						
Common name	**Scientific Name**	**2013**	**2014**	**2015**	**2016**	**2018**	**2019**	**2022**	**2013**	**2014**	**2015**	**2016**	**2018**	**2019**	**2022**
Surgeonfish	*Acanthurus sp.*	3	3		3		3	2	2	3	3	3	3	3	
Bluefin trevally	*Caranx melampygus*		3												
Brassy trevally	*Caranx papuensis*	3	3		3			3	3	3		3			4
Bigeye trevally	*Caranx sexfasciatus*	2				3				3	3		3		
Coachwhip trevally	*Carangoides oblongus*														
Butterflyfish sp	*Chaetodon sp.*	2								2	1				
Southseas devil damselfish	*Chrysiptera taupou*														
Grouper sp.	*Epinephelus sp*	1	3	1				3						2	1
Bannerfish sp	*Heniochus sp*	2	2	2	2	2	2	2	2	2	3	2	3	2	4
Bluestreak cleaner wrasse	*Labroides dimidiatus*	1				1	1			2		2			
Blackspot snapper	*Lutjanus ehrenbergii*	3	3	2	3	3	3	3	3	3	3	2	3		2
Flametail snapper	*L fulvus*	3	3	2	3					3	3		3		2
Dory snapper	*L fulviflamma*										2				
Onespot snapper	*L monostigma*	3							3						
Bluestripe snapper	*L kasmira*	3													
Mangrove jack	*L argentimaculatus*	2	3	3	3	2	3	3	3		3	3	3	2	
Circular spadefish	*Platax orbicularis*	2													
Longfin batfish	*Platax tiera*		3		1					3					
Sweetlips	*Plectorhinchus sp.*	2							1						
Semicircle angelfish	*Pomacanthus semicirculatus*												1		
Emperor angelfish	*Pomacanthus imperator*														1
Lemon damsel	*Pomacentrus moluccensis*	3										2			
Turkey lionfish	*Pterois volitans*														
Striped mackerel	*Rastrelliger kanagurta*		3		3		3					3			
Vermiculated spinefoot	*Siganus vermiculatus*														4
Pickhandle barracuda	*Sphyraena jello*				3										
	Total number of species	**5**	**15**	**10**	**5**	**9**	**5**	**6**	**6**	**6**	**9**	**8**	**8**	**7**	**7**

Notes: Numbers of fish are presented as one of four abundance codes: 1 = Single (one individual). 2 = Few (2 - 10), 3 - many (11- 100), 4 - Abundant (more than 100). Note that due to poor visibility both the 2008 and April and November 2009 surveys remote from the diffuser could not be completed. * likely to be the same school.

Table 3.3: Infaunal benthic invertebrate species identified in surveys conducted between 2008 and 2022

Order	Species	2008	Apr09	Nov09	2010	2011	2012	2013	2014	2015	2016	2018	2019	2022
Gastropoda	*Acteon* sp.				✓									
	Atys cyclindricus	✓	✓	✓	✓	✓								
	Atys sp.				✓									
	Architectonia sp.				✓									
	Balcius sp.	✓	✓		✓									
	Buccinum sp.										✓			
	Bullina lineata						✓	✓	✓	✓				
	Cavolina tridentata	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
	Cerithium sp.				✓	✓								
	Clavus sp.				✓									
	Dentalium sp.				✓									
	Epitonium sp.	✓	✓	✓	✓									
	Gemmula sp.				✓									
	Heliacus sp.				✓									
	Inella sp.				✓									
	Mitra sp.					✓	✓	✓		✓	✓			
	Mitrella sp.				✓									
	Murex tribulus				✓									
	Nassarius crematus	✓	✓	✓	✓		✓	✓		✓	✓			✓
	Natica sp.				✓						✓			
	Neritina sp.						✓							
	Peristernia sp.				✓	✓								
	Pterygia sp.	✓	✓	✓										
	Rhinoclavis sp.	✓	✓			✓								
	Rissoina sp.				✓									
	Sinum sp.	✓	✓	✓			✓	✓						
	Terebra sp.					✓	✓	✓		✓	✓			
	Turridrupa sp				✓									
	Turritella sp.	✓	✓		✓	✓								
	Vermetidae sp.			✓										
	Vexillum sp.	✓	✓	✓	✓	✓	✓	✓						
	Unided sp.				✓		✓							
	Unided whelk sp.							✓						

Table 3.3 (cont.): Infaunal benthic invertebrate species identified in surveys conducted between 2008 and 2022.

Order	Species	2008	Apr09	Nov09	2010	2011	2012	2013	2014	2015	2016	2018	2019	2022
Bivalvia	*Anadara antiquata*	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓
	Atactodea striata	✓	✓	✓			✓	✓	✓	✓				
	Codakia sp.												✓	✓
	Crassostrea sp.						✓							
	Fabulina sp.	✓	✓									✓	✓	✓
	Perna sp.								✓	✓				
	Septifer sp.						✓							
	Tellina sp.					✓	✓	✓	✓	✓				
	Terebra sp.											✓		
Crustacea	Unidentified amphipod sp.							✓	✓	✓	✓	✓	✓	
	Grapsid crabs	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓
	Mantis shrimp larvae	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	Hermit crab										✓			
	Unidentified shrimp sp.	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓
	Xanthidae crab sp unided												✓	✓
Echinodermata	Brittle star sp.					✓	✓	✓	✓	✓	✓	✓	✓	
Nematode	Unidentified sp.				✓			✓	✓	✓	✓	✓	✓	✓
Annelida	Unidentified sp.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Sipunculida sp.											✓		✓
Piscine	Unidentified fish larvae			✓	✓		✓	✓	✓	✓		✓		✓

APPENDIX 7-9 Stakeholder Consultations

Project Name:	**JICA SEA Project Specific Nadi Lautoka - Phase 2**		
Place of Meeting:	Commissioner Western Office, Lautoka		
Meeting Date:	Wednesday, April 24th 2024	**Meeting Time:**	10.00 AM
Prepared By:	PLANIT Pacific Pte Limited		

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific – Social Specialist
- Yuriko Kudo, JICA – Environmental Specialist (via zoom)

Stakeholders

- Tevita King, PLANIT Pacific – Social Team
- Tabitha King, PLANIT Pacific – Social Team
- Apolosi Lewaqai, Ministry of Rural & Maritime Development - Commissioner Western
- Alifereti Abeniaga, MRMD, District Officer Nadi
- Joseva Rokoroi, MRMD – Provincial Administrator Ba
- Sitiveni Tavaga, MRMD – District Officer Lautoka/Yasawa
- Jone Bacau, MRMD – Divisional Planning Officer

Item	Action
1. Introductions • The Commissioner Western welcomed and thanked the attendees for their presence. He then handed it over to Jacqueline Hughes (PLANIT Pacific Social Team) to briefly introduce the Wastewater Treatment Master Plan – Phase 2. She advised that the project team would then present the details of the project. • Commissioner Western made apologies as the WAF team had been in an accident and was unable to attend the meeting.	
2. Presentation by Project Team • A PowerPoint presentation was made by Yuriko Kudo (JICA Team via zoom) explaining the Project for Formulation of Wastewater Treatment Master Plant in Western Division (2nd Phase) and the Pre-F/S for Priority Project Stakeholder Consultation. • A brief overview of the project was explained detailing the background, project phasing, selection of the priority project and the pre-feasibility study and schedule.	

3. Discussion Session

- During the presentation the Commissioner Western commented on the need to discuss with TLTB how to get the approval of the landowners in Namotomoto (Nadi). He raised an issue that some of the land in the area has already been given out for lease for commercial purposes. He also stated that for the native reserve land, the villagers need to be informed that if the issues of capacity and expansion at Navakai WWTP are not addressed, it could impact them as the landowners by restricting any further development to other native land that they have because WAF will not be able to facilitate them and allow their development to connect to Navaikai WWTP. He stated that the government will not approve any further development to other land until this issue is resolved. He further detailed the process of acquisition of native reserve land stating that WAF will need to start this process to secure the land as soon as possible and if not identify alternative areas.
- The Commissioner further stated that the issue with the Natabua WWTP was that most of the state land identified for extended area has a lot of informal settlements to which Jackie (PLANIT) stated that resettlement/relocation would need to be factored in as a significant impact and whether the Commissioner thought it would be a difficult issue to deal with. The Commissioner confirmed that some relocation/resettlement of communities has already occurred and that the State needed to address this issue of relocation with WAF.
- Jackie (PLANIT) mentioned that Fiji Roads Authority (FRA) and Water Authority Fiji (WAF) have their own Lands Teams that usually work with the Lands Department Valuation Teams and that their internal teams will need to come up with the valuations and packages and take it to Lands Department to facilitate. She confirmed that the project team has been in touch with Lands Department to verify all the ownerships for any leases that have been issued and will verify all the settlements and affected persons in the area. Jackie stated that the key to this feasibility study is to know the timeframes then the resettlement timeframes and budgets can go hand in hand to be factored in.
- The Commissioner raised the issue of the amount of time being taken to do the feasibility study as the Commissioner's office has been receiving many development applications and noted the Vitogo-Sabeto corridor is developing very quickly. He added that a relocation was done from a settlement in Nasowata to land owned by the people of Vitogo. He stated that the challenge was working on the feasibility study of the areas that are currently under pressure (Natabua & Navakai), while also considering Vitogo and Sabeto to avoid multiple relocations down the line.
- Jackie (PLANIT) responded that the details/locations of the five areas are in the regional masterplan and they can shared with the Commissioner's office to be made aware of WAF's plans. She added that during earlier consultations there were questions raised as to why the WWTP was being put in prime foreshore areas but the key issue is that wastewater treatment plant needs to be at a lower level as the lines needs the gravity otherwise lots of money will be spent trying to pump it uphill rather than having it flow downhill by gravity. She stated that it was cost prohibiting to take these wastewater facilities and move them into the mountains which is why most of them are along the low-lying foreshore areas. She stated that unfortunately its playing catchup to current developments which is why Nadi and Lautoka will have to be accelerated because it is already over capacity.

- Commissioner Western stated that their Head of Division meetings, was one of the main issues that is brought up by the CO's is that even when there is little rain the wastewater overflows into the Nadi River/Lautoka area.
- Jackie responded that not only is the plant undersized and overcapacity but that the network lines are also outdated. Extensions of the network cannot be considered until the current plant and network can take the load. In addition to the areas that are to be acquired, there is also the need for large areas for more ponds and when they desludge the ponds, for storage of the sludge. At the moment there is nowhere to dump the sludge and the Councils and DoE have not agreed to dumping into the current dump sites at Vunato. The project team is also looking at other ways to use the sludge whether its for agricultural purposes or treated and reused. If an alternative use can be found, the area requirement for the sludge will reduce.
- Jackie (PLANIT) stated that another issue is the acquisition of a foreshore lease to extend the outfall pipe in Natabua to get better mixing of the treated wastewater being discharged out to sea and away from the land. A qoliqoli/Fisheries Impact Assessment will also need to be undertaken.
- Jackie (PLANIT) asked the stakeholders if there were any complaints from the current outfall in Natabua to which the response was none that they were aware of, however he stated that that foreshore area was well used for fishing and for crabbing by the local communities.
- The Commissioner Western questioned what the impact for the Navakai WWTP outfall had on the communities. Jackie (PLANIT) stated that WAF do have wastewater/water quality testing which is submitted to DoE and whatever is treated from the upgraded WWTP will have to be to DoE's discharge standard. She also stated that Dr Shaw Mead has been looking at all the past water quality results and it is something that has to be improved as the levels were high. Jackie (PLANIT) specified that during the JICA flood study in the area, it was identified that the Narewa village community near the outfall in Navakai did not use the river much for fishing but the concern was for the downstream communities (Moala and Yavusania) who mostly use it for fishing and crabbing. Alifereti (DO Nadi) mentioned that the upstream communities also use the river for harvesting kai (freshwater mussels). Jackie (PLANIT) stated that since it is also affected by tide, the upstream communities are likely to be impacted too.
- Jackie (PLANIT) mentioned that verification would also be needed on whether an FIA would be needed in the Nadi River area and who are the traditional qoliqoli owners in order for WAF to follow the process.
- The Commissioner asked the timeframe of the feasibility study and how far consultations gone to which Jackie responded that the final draft report would be presented in July of this year to all the stakeholders and that this was the beginning of the consultation process for this phase of the project.
- The Commissioner gave his full blessing for the project and restated that it was one of the recurring issues in their Head of Division meetings. He revealed that they are trying to control the development that is putting pressure on the already aged/aging infrastructure. He expressed his gratitude to JICA and the Govt of Japan for carrying out this feasibility study and hopes that they will also fund the project itself.
- Jackie (PLANIT) stressed the need for information sharing of developments/proposed developments across the board so that infrastructure providers can plan long term. The Commissioner Western agreed and stated that the government is supportive of the integrated approach and encouraged his team to share information not only within government but within business communities and NGOs to address the needs of the communities and to complement each other.

- The Commissioner Westerns office advised that should the project team and WAF require further assistance with other stakeholders and the landowners, his office will be happy to facilitate and assist.

With no further questions from the attendees, the meeting was closed.

4. Actions from Meeting

- Share presentation to the Commissioner Western's office, in particular, Mr Jone Bacau, MRMD – Divisional Planning Officer so that he can plug it into their programme.

Commissioner western Office

JICA WAF Phase 2 Wastewater Masterplan 10am.

Nadi & Lautoka 24/04/2024.

Name	Organisation/ Departments/Community	Role	Contact Details
Jackie Hughes	PLANIT Pacific	Social Consultant	[redacted]
Teuila King	PLANIT	- -	
Tabitha King	PLANIT	- -	
Atifeneh Abenwa	Rural Maritime Development	DO NADI	
Joseva Boikonou	✓ ✓ ✓	PA DO J [illegible]	
Litiveni Tavaga	✓ ✓ ✓	DO Lautoka / Yasawa	
Jone Bacan	✓ ✓ ✓	DPD	
Afolosi Lewaqai	✓ ✓ ✓	Commissioner Western	
Yuniko Kido	JICA Team	Environmental Specialist	
~~Shara Mead~~	~~eCoast~~	~~Local Environmental Consultant~~	

Project Name:	**JICA SEA Project Specific Nadi Lautoka - Phase 2**	
Place of Meeting:	Lautoka City Council, Lautoka	
Meeting Date:	Wednesday, April 24th 2024	**Meeting Time:** 11.30 AM
Prepared By:	PLANIT Pacific Pte Limited	

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific – Social Specialist
- Yuriko Kudo, JICA – Environmental Specialist (via zoom)
- Shaw Mead, eCoast – Environmental Consultant

Stakeholders

- Tevita King, PLANIT Pacific – Social Team
- Tabitha King, PLANIT Pacific – Social Team
- Abdul Mofid, LCC- Acting Manager Building/Engineering Services
- Shameer Khan, LCC- Team Leader Assets
- Rouhit Karan Singh, LCC- Acting Head of Services
- S Dass, LCC- Acting Director Building/Engineering Services
- Shalend P Singh, LTC, Health Department
- Mohammed Anees Khan, LCC- Chief Executive Officer

Item	Action
1. Introductions • The CEO Lautoka City Council welcomed and thanked the attendees for their presence. He then handed it over to Jacqueline Hughes (PLANIT Pacific Social Team) to briefly introduce the Wastewater Treatment Master Plan – Phase 2. She advised that the project team would then present the details of the project.	
2. Presentation by Project Team • A PowerPoint presentation was made by Yuriko Kudo (JICA Team) explaining the Project for Formulation of Wastewater Treatment Master Plant in Western Division (2nd Phase) and the Pre-F/S for Priority Project Stakeholder Consultation. • A brief overview of the project was explained detailing the background, project phasing, selection of the priority project and the pre-feasibility study and schedule.	

3. Discussion Session

- During the presentation Jackie (PLANIT) stated that the main reason for the large area of expansion is to cater for sludge disposal where one of the key issues is currently that WAF is not allowed to dispose the sludge taken out from the ponds at the Vunato dumpsite hence the extra area for the sludge to be placed onsite while looking for options where it can be treated/reused for agricultural purposes or any other purposes that may be allowed. Shalend (LCC Health Manager) stated that they have noted the idea of having the sludge mixed with compost but tests need to be done to see whether it is suitable for use and if so, LCC can take some of the sludge. Jackie (PLANIT) asked where that would be done to which the CEO responded that there is a compost yard in Vunato rubbish dumpsite – an opportunity to take the stockpile and be mixed with the organic compost. Yuriko (JICA) questioned what the organic compost would be used for. CEO stated that it will be for Council's use for agricultural purposes, flower gardens and some sold.
- Jackie (PLANIT) stated that the main concern is quality of the sludge. Yuriko (JICA) stated that the Department of Environment (DoE) had warned about the quality of the sludge and what if it contains heavy metals or other contaminants. She also stated that the soil testing and looking at the quality of the sludge is very important and it needs to be discussed with WAF and DoE to also be involved.
- Shalend (LCC) also raised concerns about the volume of the sludge as LCC is doing mini composting and unsure if they are able to cater for the whole amount of sludge. Jackie (PLANIT) requested quantities of sludge from JICA to see if the tonnage per month/ratio of mix is able to be accommodated. Yuriko (JICA) mentioned they can refer to the Municipal Sewerage Masterplan/comparison matrix for the information. Jackie (PLANIT) stated that the information will be extracted from the reports and sent to the LCC Health Department to have a look at the quantities, most likely that they will not be able to accept all but some. She stated that there might need to be talks with Fiji Sugar Corporation (FSC) or some other fertilizer companies and questioned what fertilizer companies were available.
- CEO stated that there is South Pacific Fertilizers which import and Rooster Poultry that started composting their own chicken waste. He stated that there could be potential partnership with FSC to combine it with the bagasse and other waste to use it in the sugarcane farms.
- LCC member stated that when human waste is dried it is not like chicken manure, and that it is has a sandy texture. It is to be seen whether mixing it with the market waste compost the nutrients and quality will be maintained.
- Shalen (LCC) encouraged the JICA Team experts to share whether it is possible or not or if there are any case examples. He also questioned what the current WQ level of compliance was for the outfall pipe at Natabua.
- Dr Shaw Mead (eCoast) stated the water quality results are similar to those that WAF has been taking. He discussed the faecal coliform levels and total suspended solids are high.
- LCC member questioned if there was any WAF advisory to the residents of the area to state the perimeters that is unsafe to swim/fish/crab. Jackie responded that at this stage there is none but it can be raised with WAF.
- CEO mentioned that most of the land demarcated for the WWTP expansion is state owned and has been earmarked for Industrial/Commercial uses.
- CEO also stated that it would be good to have some perimeters marked out in case of unforeseen circumstances where WAF might need to discharge without

treatment. Jackie (PLANIT) questioned whether there would need to be any buffers to restrict development so that businesses/residents are not close to the actual plant. CEO stated that a special purpose development can be discussed with DTCP to work out a buffer zone.

- Shalen recommended that an embankment be used as in Kinoya WWTP to prevent certain level of smell (so that the smell goes up from the bund and not across).
- CEO stated that once the masterplan is done there can be a meeting with DTCP to set development provisions.
- Jackie asked whether LCC is familiar with any resettlement programs/projects. CEO responded that there have been resettlements in Taiperia and Nasowata. She stated that the locations/areas/layouts for other WWTP's in Vitogo and Sabeto will be shared to preserve the buffer areas and to avoid multiple relocations.
- Shalen (LCC) asked whether WAF have spoken to the Vitogo landowners. Jackie responded that they have been attending stakeholder meetings but since Natabua and Navakai are priority sites, Vitogo has only been identified in the regional plan and once they decide to implement only then will the landowners be further consulted. She added that the issue to raise with WAF/TLTB/Lands Department and which Commissioner Western also raised was that they be engaged now so they do not lease out their land in support of the development. She added that if they lease out their other lands, they could be restricted in development because there are no wastewater facilities to connect to.
- CEO recommended that once WAF have identified their footprint needed, to begin acquiring the land instead of asking landowners to allow them to develop their infrastructure freely.
- Shalen (LCC) asked whether this project is only for developing a masterplan or if it will be executed. Jackie (PLANIT) responded that they are currently looking at feasibility and to know how much money it will actually cost and what issues will be faced before they decide how they are going to do the detailed design and roll it out.
- Shalen queried whether the network will be upgraded as it has been raised as a key issue to which Jackie (PLANIT) responded that until the WWTP has the capacity to receive, the waste and treat it they cannot move onto the network. Shalen (LCC) offered that instead of extending the current network, the existing network can be repaired/upgraded to which he listed the issues faced with the current network/WWTP. Jackie (PLANIT) requested LCC to provide that list of all the areas and issues faced to be passed onto the WAF Operations Asset Manager.
- Shalen also recommended that WAF create policies/laws/regulations for onsite treatment where businesses/restaurants must meet the WAF standards before discharging which Council is happy to enforce.
- Jackie (PLANIT) stated that the presentation would be shared with Council to allow them to provide the project team the list of issues there and also any other information that may be a concern in terms of the expansion of the WWTP.
- Yuriko (JICA) queried whether LCC was facing capacity issues with the Vunato dumpsite to which LCC responded that with increasing development and they now have problems managing solid waste – they cover Lautoka, Nadi, Denarau. He stated that they have the capacity to manage but are in need of funding to address operational issues.
- CEO stated that there is currently 50 acres at the Vunato dumpsite but in the long term there are plans to relocate in land like in Naboro.
- LCC questioned whether South Pacific Distilleries is required to have their own treatment plant. Yuriko (JICA) responded that currently they are not required but discharge their wastewater next to the inlet of the outfall pipeline

together with the treated wastewater effluent. She added there is some discussion between WAF and SPD for future treatment of SPD's wastewater.

- CEO (LCC) offered that WAF need to develop a policy/law to relieve their burden and to pass it on to those industries that generate this type of waste to treat it before discharging it. LCC also added that DoE should regulate these facilities at how best businesses/industries can do full treatment before connecting to a public system.

With no further questions from the Council attendees, the meeting was closed.

4. Actions from Meeting

- LCC to provide a running list of issues/concerns within the Lautoka town planning that is currently facing issues with wastewater for JICA team to pass on to WAF operations/assets manager.
- JICA team to share sludge quantities requiring storage or reuse to LCC for consideration of mixing with their organics for composting at Vunato.
- JICA team to share the locations of the land area requirements for Vitogo and Sabeto for LCC's future consideration
- LCC to provide list of developments already approved next to or in the area of extension for Natabua WWTP

JICA WAF Phase 2 Wastewater Masterplan

Nadi & Lautoka

11:30am
24/04/24

Name	Organisation/ Departments/Community	Role	Contact Details
Abdul Mofid	Lautoka City Council	Acting Manager Bldg/Eng. Servi	[redacted]
Shameer Khan	✓ ✓	Team Leader Assets	
Rohit Kalan Singh	✓ ✓	Ag. Head of Services	
S. Dass		Acting Director Building & Engineering Services	
Shalend P Singh	Lautoka City	shalends@lautokacitycouncil	
Mohammed Anees Khan	LCC	khanme@lautokacitycouncil.com	
Tevita King	PLANIT Pacific	Social Team	
Tabitha King	PLANIT Pacific	" "	
Jackie Hughes	" "	" "	
Yuiko Kudo	JICA Team	Environmental Specialist	
Shaw Mead	eCoast	Environmental Consultant	

Project Name:	**JICA SEA Project Specific Nadi Lautoka - Phase 2**		
Place of Meeting:	Nadi Town Council, Nadi		
Meeting Date:	Wednesday, April 24th 2024	**Meeting Time:** 2.30 PM	
Prepared By:	PLANIT Pacific Pte Limited		

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific – Social Specialist
- Yuriko Kudo, JICA – Environmental Specialist
- Shaw Mead, eCoast – Environmental Consultant

Stakeholders

- Tevita King, PLANIT Pacific – Social Team
- Tabitha King, PLANIT Pacific – Social Team
- Malakai R, TLTB – Estate Assistant (Operation)
- Saliceni Raiwalui, Nadi Town Council – Chairman
- Premila Pathak, NTC – Manager Com. Service
- Muni Gopal Reddy, NTC – Acting CEO
- Veceli Tuiweli, NTC – Building Inspector
- Aisake Raratabu, DTCP Lautoka – Principal Town Planner
- Meli Naco, NTC – Planning & Engineering
- Josaia Korilavesau, WAF – Infrastructure Planning
- Isireli Veitokiyaki, WAF – Infrastructure Planning
- Prem Chand, NTC – Special Administrator

Item	Action
1. Introductions • The Acting CEO of Nadi Town Council welcomed and thanked the attendees for their presence. He then handed it over to Jacqueline Hughes (PLANIT Pacific Social Team) to briefly introduce the Wastewater Treatment Master Plan – Phase 2. She advised that the project team would then present the details of the project.	
2. Presentation by Project Team • A PowerPoint presentation was done explaining the Project for Formulation of Wastewater Treatment Master Plant in Western Division (2nd Phase) and the Pre-F/S for Priority Project Stakeholder Consultation. • A brief overview of the project was explained detailing the background, project phasing, selection of the priority project and the pre-feasibility study and schedule.	

3. Discussion Session

- Veceli (NTC) commented during the presentation of the area required for the expansion of WWTP in Navakai that most of the land has already been earmarked for the Namotomoto and Navoci village extension as confirmed by TLTB that it is native reserve.
- NTC queried that if the current land that is proposed for the WTTP extension cannot be obtained/acquired what other options are to be considered. Jackie (PLANIT) responded that WAF will have to look at options within the state land or a different site for Navakai all together which will be a costly exercise and also will result in restriction of development.
- Yuriko (JICA) questioned whether the village reserve or the WWTP was the main priority as the land demarcated for expansion of the plant is critical to their design. Jackie (PLANIT) stated that the project will need to be explained to the landowners of Namotomoto and Navoci to see if other areas of native reserve land could be identified and considered for village expansion or whether other native reserve land close by can be considered for the sludge stockpiling. She added that the project team will need to organize a meeting with the landowners, TLTB, Commissioner Western and other relevant stakeholders on how to address land acquisition in these areas required for Navakai expansion.
- Premila (NTC) raised concerns of the close proximity of the WWTP to the schools in the area and if it will face any health impacts. Jackie (PLANIT) stated that it has been factored into the design where buffers will have to be incorporated to address odours etc.
- NTC further stated that with the upgrade of the Navakai WTTP so long WAF is in compliance with water quality standards there is no issue.
- A/CEO (NTC) stated that the whole area outlined for expansion is within the flood zone area and queried whether that would affect the storage of sludge. Jackie (PLANIT) stated that the JICA design team is aware of this and are factoring it into their design.
- Meli (NTC) suggested that it would be easier for FRA to find space to relocate their offices to avail some much-needed land to which Yuriko (JICA) responded that there would still not be enough area for the total expansion. Meli (NTC) added that the biggest issue for the Navakai WWTP would be acquiring land. Jackie (PLANIT) stated that this project will need assistance from government bodies to help deal with the landowners.
- Aisake (DTCP) commented that WAF should seek government assistance to which WAF representatives responded that budget submissions have already been made in October 2023 in anticipation for the new budget in the next financial year that includes the budget for acquiring land required for the expansion.
- Aisake (DTCP) questioned as to where most of the smell comes from at the WWTP, is it the sludge or ponds. WAF stated the smell comes from the raw sewerage and not the sludge. Aisake also queried whether sludge can be stored offsite. WAF responded that it is costly to transport it to a separate location and would increase their operational costs compared to having it onsite. Aisake suggested a state lease land that was for sale opposite the new Grace Roads commercial development which was going for $1m. WAF said they would consider it though it may still be far away and still require the transportation of sludge to that site which could be costly.
- NTC member questioned what the volume of outflow was from Navakai WWTP. He mentioned that the villages in the surrounding areas were advised

in their Tikina meetings not to eat anything from the river. He also mentioned that due to the tidal effect the sewerage is carried upstream and farmers cannot irrigate from the river because it is too polluted. It is critical that we get the quality of water discharged into the river improved. CEO Nadi Town Council also mentioned that Denarau too faced the same issue with DoE as they were using the Nadi river water for irrigation of the golf course but the water from the river also had high faecal coliform counts and were advise to refrain from using the river water.

- Aisake (DTCP) asked if there were any case studies from Japan or other countries of similar or new WWTP that could be imitated. WAF responded that they are currently still trying to standardize all WWTP across Fiji in terms of operations and eventually extract service providers to manage the WWTP while providing compliance. Jackie (PLANIT) reiterated that if WAF standardize it WAF will make sure they have the parts and people to service the system as it is no point in getting a high-tech mechanical plant that can give us the water quality standard but it breaks down and is not operational for months after being installed. Also, the mechanical plants also require a lot more power to operate which also raises the cost of operations. The system that is selected needs to be cost effective or else it will not be feasible to implement.
- NTC member queried how often the desludging process happens to which WAF responded every 4-5 years. NTC also commented that the main challenge is acquiring the land for expansion and the longer it takes the more the cost escalates in terms of compensation for land and other costs to increase over time. They mentioned that a way forward would be to incentivize the villages in the area by connecting them to the network.
- The meeting ended with all in attendance in support of meeting with the landowners in order to facilitate

With no further questions from the villagers, the meeting was closed.

4. Actions from Meeting

- PLANIT to liaise with WAF and Commissioner Western's office to organize a meeting with the landowners and Lands Department regarding the native reserve land for village extension and also any other native reserve land available in close proximity for consideration by WAF.
- Nadi Town Council and DTCP to confirm development approvals issued for the subject state land to enable contact with the developer to understand timeframes of development.

NTC.

JICA WAF Phase 2 Wastewater Masterplan 2:30pm

Nadi & Lautoka

24/04/24

Name	Organisation/ Departments/Community	Role	Contact Details
[illegible] R	TLTB, NADI	ESTATE ASSISTANT	[redacted]
SALICENI Roiwalu	CHAIRMAN NTC	–	
Premila Pathak	Nadi Town Council	Manager Com. Services	
Muni Gopal Reddy	Nadi Town Council	ACEO	
Veceli Tuiwe	NTC	Bldg. Inspector	
Aisake Rovatabu	DTCP Ltka	Principal Town Pl	
Meli Nawo	N.T.C	Planning & Engineering	
Josaia Kosilevesau	W.A.F	Infrastructure Plan	
Teineli Veitokiyaki	WAF	"	
Prem Chand.	NTC	Special Administrator	
Jackie Hughes	PLANIT Pacific	Social Team	
Tevita Kite	–	–	
Tabitha King	–	–	
Yuiko Kudo	JICA Team	Environmental Specialist	
Shaw Mead	eCoast	Environmental Consultant	

Project Name:	**JICA SEA Project Specific Nadi Lautoka - Phase 2**		
Place of Meeting:	Lands Department		
Meeting Date:	Monday, May 27th 2024	**Meeting Time:** 10:30 to 11:30 AM	
Prepared By:	PLANIT Pacific Pte Limited		

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific – Social Specialist
- Josaia Korilavesau, WAF – Infrastructure Planning
- Isireli Veitokiyaki, WAF – Infrastructure Planning

Stakeholders

- Apisai Vulawalu – Assistant Director of Lands
- Bulou M. Maka - Land Use Planning & Development Team (LUPD)
- Seini Nakawa - Land Use Planning & Development Team (LUPD)
- Sainimere Toalagi - Land Use Planning & Development Team (LUPD)

Item	Action
1. Introductions • The ADL Apisai Vulawalu welcomed and thanked the attendees for their presence. He informed those present at the meeting that the Ministry of Lands & Mineral Resources was in the process of working on its Master Plan for all State land in Fiji across the 3 regions.	
2. Presentation by Land Use Planning & Development Team & WAF Team • A PowerPoint presentation was made by LUPD to show WAF, the draft Master Plan for the state lands in and around Navakai Wastewater Treatment Plant and Natabua Wastewater Treatment Plant • A brief overview of the WAF Western Region Master Plan project was explained detailing the background, project phasing, selection of the priority project and the pre-feasibility study and schedule.	
3. Discussion Session • The LUPD team stated they started the 1st pilot project for the Greater West Corridor Master Plan in 2023. The 2nd draft of the West Master Plan has been completed and submitted to the various stakeholders including the Department of Town & Country Planning for their final comments.	

- Notably, the State lands around Navakai have been ear marked for future Special Use tourism development and commercial development. In Natabua, the surrounding state leases have also been ear marked for Industrial and commercial development. The LUPD indicated that they had not consulted with other utility provider including WAF in their earlier consultation processes.
- WAF had requested they take on board the issues with water and wastewater for both Nadi and Lautoka as since they are proposing high density developments other than agricultural their Master Plans may not yield the outcomes if the development is not able to connect to these basic services and utilities.
- The LUPD was asked to review the WAF Western Region's Wastewater Master Plans current and future land needs for WWTPs to be factored into their land use Master Plans prior to finalisng their Greater Western Corridor Plan.
- WAF agreed that they may also need to relook at the capacity and future demand calculation to factor in Lands Department's Master Plan and also for their land acquisition plans as well. There was no indication as to whether the Greater Western Corridor Plan would include the foreshore areas.
- During the presentation Jackie (PLANIT) stated that the main reason for the large area of expansion is to cater for sludge disposal where one of the key issues is currently that WAF is not allowed to dispose the sludge taken out from the ponds at the Vunato dumpsite hence the extra area for the sludge to be placed onsite while looking for options where it can be treated/reused for agricultural purposes or any other purposes that may be allowed.
- The LUPD team stated that they would look at some of the state lands in and around the Navakai wastewater treatment plant to see if there were any expired or expiring leases that could be of interest to WAF for sludge stockpiling but that the requirement would need to be in close proximity as WAF was trying to avoid the cost of carting sludge distances away thus increasing the operating costs.
- The LUPD team stated that WAF should talk to FRA and Ministry of Works to relocate their depot sites but WAF stated that even if that area was cleared, they would still need more land as the area of land occupied by FRA and Ministry of Works was not sufficient. LUPD also suggested to talk to NFA which WAF said they would start their land acquisition process as they had already allocated it in their next budget.
- The ADL also identified some area near airport held by either CAFFI or AFL that could also be considered as well as Housing Authority's site in Nawaka behind Martintar. WAF stated that they could consider another Wastewater Treatment Plant at Nawaka so would then have a discussion with Housing Authority to discuss this further.
- The LUPD stated that they would review WAF 's comments and consider talking to utilities like EFL regarding power supply and WAF stated that Water was also an issue for Nadi and that their Water Master Plan could also be shared for their consideration.

With no further questions or issues to discuss, the meeting was closed.

4. Actions from Meeting

- WAF shared the information and area of land required by the proposed expansion of the Navakai and Natabua Wastewater Master Plans.

Project Name:	**JICA SEA Project Specific Nadi Lautoka - Phase 2**		
Place of Meeting:	National Fire Authority		
Meeting Date:	Wednesday, July 24th 2024	**Meeting Time:** 2:00 PM	
Prepared By:	PLANIT Pacific Pte Limited		

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific – Social Specialist
- Tevita King, PLANIT Pacific – Planning Technician
- Isireli Veitokiyaki, WAF – Infrastructure Planning

Stakeholders

- Joel Israel – Manager Fire Safety & Compliance and Properties, NFA

Item	Action
1. Introductions • J Hughes of PLANIT Pacific gave an introduction to the JICA funded WAF wastewater regional master plan for Phase 1 and 2. Phase 2 focus was on the Navakai and Natabua Wastewater Treatment Plants. Specifically, NFA was being met to discuss NFA's vacant land adjacent to the Navakai Treatment Plant in order to ascertain as to whether they have plans for the site or whether they would be willing to relocate if WAF facilitated the relocation.	
2. NFA's Presentation of its Master Plan for State Lease Site • J Israel explained that NFA had a master plan recently approved to develop the site into their training centre. He explained that currently NFA did not have a training centre and when they undertake training for their new recruits, it is held at their national HQs site in Walu Bay. However, their training needs are required to be upgraded and their master plan to which he was referring to (and attached), has a mask structure for climbing stairs up to 25m for simulating fires in high rise structures which was now growing in the cities. Their training centre also has accommodation and telecommunications centre, but will not be run as a fire station. • J Israel explained that NFA finally received their budget in 24/25 to start the project and therefore, it would be difficult for them to stop now and give it up. He said he would need to brief his CEO and then come back to us but that he saw the need for the Navakai treatment plants expansion. He said they would also be willing to meet with the other agencies to see the best way forward for all.	

3. Discussion Session

- WAF explained that they had had discussions with AFL/CAAF on the availability of land to relocate the other utility services including Ministry of Works and Fiji Roads Authority depot sites also located adjacent to Navakai Treatment Plant. That there was a parcel of state lease land held by CAAF that was in the runway approach lights that could be a potential however, it did have height restrictions which we would need to have confirmed. ○
- During the presentation Jackie (PLANIT) stated that the main reason for the large area of expansion for both Navakai and Natabua Treatment plant sites is to cater for sludge treatment and disposal where one of the key issues is currently that WAF is not allowed to dispose the sludge taken out from the ponds at the Vunato dumpsite hence the extra area for the sludge to be placed onsite while looking for options where it can be treated/reused for agricultural purposes or any other purposes that may be allowed.
- WAF explained that currently the master plan does not show any use for the land for ponds or the treatment plant but want to use the land as a potential buffer with landscaping to provide screening from the existing school that is adjacent to the NFA site.
- J Hughes also explained that with NFA's master plan having accommodation units close to the treatment ponds at Navakai was not ideal in terms of odour so NFA would need to be mindful of this.
- NFA also indicated that they were approached by Nadi Town Council for the same land for NTC's depot but NFA advised them that they would not give it up as they really needed the training centre to which they now have their budget for.

With no further questions or issues to discuss, the meeting was closed.

4. Actions from Meeting

- WAF to organize a joint meeting with Minister of Infrastructure with Ministry of Works, Fiji Roads Authority and National Fire Authority to discuss the possibility of relocation to another site. Meeting to include CAAFi and AFL as well as Lands Department and iTLTB.
- NFA to inform their CEO of the proposed upgrade to Navaikai Treatment Plant and the need for their site as a buffer between the plant and the school.
- However, PLANIT received an email after the meeting from the new CEO of NFA, Mr. Puamau Tagivetaua Sowane, to confirm that they will not be giving up their land at Navakai as they plan to go ahead with their Master Plan. See attached email.

Project Name:	**JICA Nadi & Lautoka Master Plan**
Place of Meeting:	Nadi Airport – Operations Room
Meeting Date:	Monday, July 22nd 2024 **Meeting Time:** 2.30 PM
Prepared By:	PLANIT Pacific Pte Limited

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific— Facilitator/Presenter
- Tevita King, PLANIT Pacific - Land & Resettlement Team
- Tabitha King, PLANIT Pacific
- Aleksio Rabaka, PLANIT Pacific
- Isireli Temo Veitokiyaki, Water Authority of Fiji
- Emily Smith, Water Authority of Fiji

Stakeholders

- Manil Reddy, Fiji Airports
- Eliki Vakadranu, Fiji Airports
- Lorina Filipe, Civil Aviation Authority of Fiji (CAAF)
- Makiti Raratabu, CAAF
- Mosese Ratucicivi, CAAF
- Mushraan, Fiji Airports

Item	Action
1. Introductions • Jacqueline Hughes from PLANIT Pacific welcomed everyone and briefly introduced JICA SEA Project Specific Nadi Lautoka - Phase 2 project.	
2. Presentation by PLANIT • A PowerPoint presentation was done in the English language briefly explaining the project and to inform the stakeholders of land required by JICA & WAF. • Explanation of the reasons for the land required • Responding to the stakeholder comments and issues through Q & A • Explaining next steps and indicative timeframes	
3. Discussion Session • Jaqueline (PLANIT) further discussed the Navakai and Natabua Wastewater Treatment Plant (WWTP) in terms of upgrading it for current/existing development and future development in the next few years. She mentioned two	

additional plants in Sabeto and Moala as two other sites that will be developed for wastewater treatment plants.

- She added that Navakai has been struggling for a number of years with its capacity hence the need for upgrading to be able to take the current capacity as well as additional capacity. She added that the JICA study team in looking at the existing Navakai WWTP have identified some areas of land immediately adjacent to the existing plant as future areas being required for upgrade. However, the iTaukei land that has been identified has been indicated by the landowners in the earlier consultation meeting that the area has been earmarked for village extension area (village reserve) and would like to relocate some of the Navoci and Namotomoto villagers to that area due to overcrowding and flooding in the village. This relocation is a concern for WAF as it is too close to the WWTP.
- She further discussed that the surrounding areas needed to be acquired by WAF mainly for sludge drying and stockpiling and it is preferred that this be close to the existing plant as transportation costs would be too expensive. She stated that little by little the areas that the JICA study team have identified for the growth of the plant is slowly diminishing due to development interest and therefore, WAF is trying to look for possible alternative options of land parcels to potentially relocate FRA and Ministry of Works depot sites and maybe NFA or for options of stockpiling treated sludge.
- She stated that the Lands Department recommended that the project team talk to AFL & CAAF to see if they had any spare land in close proximity that WAF could purchase or lease from them as further options.
- Eliki (AFL) stated that the only available land near Navakai was the Fiji Airports transmitter site next to Enamanu cemetery. However, he added that what was not visible on Vanua view was the fact that there are 12 antennas with 24-hour security surveillance with no entry permitted unless access is allowed. He said given these access restrictions, it would not be viable to have truckloads of sludge stockpiled on this site.
- Isireli (WAF) queried what the purpose of the high-level security was for and Eliki (AFL) stated that it was mainly for people and animals which can affect transmission signals.
- Jacqueline (PLANIT) asked if it was a possibility to dump stockpiles in the area to which Eliki replied that they would not agree to it.
- Eliki (AFL) further added that their VHF radios are also installed there and if anything were to happen there, planes would not be able to land in Nadi. He stated that that land is a very strategic asset for AFL. He mentioned that they have received so many interests/offers for the land (leasing/development) before but their position remains the same – to restrict access and use. He stated that it is the only parcel of land that AFL owns.
- Makiti (CAAF) stated that they also have vacant land in the area. Jacqueline asked about having restricted access issues, to which Makiti responded that there are a few accesses to the area so that may help. He discussed that there is a strip of land in the middle on the approach to the airstrip where critical infrastructure is and that, belongs to Fiji Airports where the approach lights are.
- Eliki (AFL) revealed that part of the land is in the process of being transferred to AFL and that discussions have been ongoing at ministerial level and is for the extension of the runway which is why CAAF acquired it in 1994.
- Jacqueline (PLANIT) asked if there were any restrictions on either side of the strip. Eliki (AFL) shared that they are currently trying to fence the approach lights and maybe considering a 20-meter buffer on either side. Despite this there is a lot of land around this around that could be considered for use.
- Makiti stated that CAAF is looking at developing the area where the plan is for CAAF to move their current location of offices to this vacant land closer to behind

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Martintar Area. Jacqueline asked if there were issues with the height of stock piles, and CAAF said possibly but not as much as if the sludge would attract the presence of wildlife, which is one of the major issues at Nadi Airport that would result in CAAF reconsidering leasing the land to WAF.

- Jacqueline stated that WAF will be creating more ponds so the desludging will maybe happen once every three to five years and the sludge would need an area to dry so it could be that WAF dries it back where the plant is and then only transport it to CAAF land when needed or the people who need it for fertilizer will come and take it directly form the plant. Isireli (WAF) added that if there is no need for storage then there is no need for extra land but because there is no active sludge management plan in place at this stage, the space is needed for storage.
- Makiti (CAAF) questioned how long it would usually take for stockpile to be cleared by farmers or those in need of it. Jacqueline (PLANIT) responded that the consultants have spoken with fertilizer companies in Lautoka to see whether they would be interested to take it but the issue there is sludge content and parameters of the sludge will need to be confirmed. She added that at this time the sludge will probably sit there for a couple of years before it goes, especially depending on the content. Makiti asked how much land is WAF looking to acquire to which Jacquleine responded 21.28 hectares which is likely to come down if they can secure FRA and the extra area of land on the side.
- Makiti (CAAF) questioned with the current stockpiling are there any presence of wildlife or birds to which Isireli (WAF) responded not if it is dried well enough. Jacqueline discussed that the current Navakai treatment plant is currently over capacity and not treating the wastewater as well as WAF would like it to the standards and so once all the new treatment systems are in place it would be to the treat and discharge wastewater to World Health Standards. If they have enough drying area then it should dry a lot faster given the weather. Jacqueline added its mainly the ponds that attract the birds then the actual sludge itself. She stated that with the news system that the JICA study team are looking at they do no envisage the birds to be an issue if the system is running at 100 percent and at best rates.
- Jacqueline (PLANIT) stated that the native land area further in the back, off the Denarau By- Pass Road, is low lying area which floods and the landowners mentioned that they have a development lease over it, so WAF is running out of land options in close proximity.
- Eliki (AFL) shared that there was a vacant freehold land opposite of the CAAF freehold land on the corner of Wailoaloa Road and Denarau By Pass Road, and a title search should be conducted to liaise with the owner. He added that a compulsory acquisition be done as soon as possible and if it's for a public purpose which should not be too much of an issue - as they did for the Nadi Airport land.
- Makiti (CAAF) raised that judging from the amount of area required by WAF it is almost 60 percent of their total freehold area.
- Eliki (AFL) asked what the vision for WAF is for the next 20 years – will it still be there or relocated to another site. Jacqueline responded that because it's connected to all the existing development, to shut it down and relocate it is totally not viable since the network is already existing. She mentioned that the reason why its lower and closer to the foreshore is because of the force of gravity it has less cost and multiple pump stations are not needed to pump it all the way up to the highlands or rural back lands. Isireli (WAF) also added that new piping would also be needed and that would take too long.
- Jaqueline (PLANIT) stated that TLTB, Lands, and DTCP all have masterplans and Lands has identified all the area towards Wailoaloa, Enamanu and Navakai for future tourism and commercial purposes which will all need to be connected to Navakai WWTP. She added that if they cannot connect to a WWTP, the land developers will only develop 20 percent of the land in floor area for residential

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and for Commercial C only 50 per cent. Developers will not be able to get maximum yield and/or will have to give up land for their own treatment facility.

- Jacqueline added that currently WAF is discharging into Nadi River but because of its overcapacity the standard of discharge is compromised. She stated that of equal importance to have wastewater you need water which is also an issue for WAF in Nadi where there is not enough water as well and WAF are trying to solve both issues whilst still allowing development, hence trying to secure land for the future.
- Jacqueline (PLANIT) stated that WAF can write and have further discussions on the CAAF land as an option and will also look into the freehold land suggested as well.
- Makiti (CAAF) stated that there would be restrictions to the land in terms of height and the wildlife issue as it is a critical space approaching the runway.
- Manil (AFL) stated that they currently have a masterplan and will be looking into the extension of the runway and a cargo facility in the future, so WAF needs to get in quick.
- Jacqueline (PLANIT) asked about the old WWTP near the runway to which Makiti mentioned that it had been decommissioned and waste from the planes were discharged there. Eliki (AFL) stated that the area is already earmarked for runway extension in their masterplan.

4. Actions from Meeting

- WAF to look into relocating FRA and Ministry of Works depot to the CAAF site or look at the possibility of the site for stock piling
- WAF to look into freehold land opposite CAAF land and conduct title search.

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JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project - Priority Cities Nadi & Lautoka Pre-Feasibility
Consultation Meeting Attendance Register
AFL/CAAFi - 22nd July 2024

PLANIT

Name	Organisation/ Departments/Community	Position	Contact Details (mobile & email)
Manil Reddy	Fiji Airports	Senior PM - T	[redacted]
Eliki Vakadrau	✓	Estates Officer	
Lorina Filipe	CAAF	Legal officer	
Makiti Raratabu	✓✓	SANSI	
MOSESE RATUCAUCAU	✓✓	AI - RAUW	
Mushraan	Fiji Airports	Senior Drafting Tech	
Emily Smith	WAF		
Isireli Veitokiyaki	WAF		
Jackie Hughes	PLANIT		
Tavita King	✓		
Aleksio Rabaka	✓		
Tabitha King	✓		

Project Name:	**JICA Nadi & Lautoka Master Plan**
Place of Meeting:	Navoci Village Hall
Meeting Date:	Monday, July 22nd 2024 **Meeting Time:** 11.00 AM
Prepared By:	PLANIT Pacific Pte Limited

Attendees:

Project Team

- Jacqueline Hughes, PLANIT Pacific— Facilitator/Presenter
- Tevita King, PLANIT Pacific - Land & Resettlement Team
- Josaia Koroilavesau, Water Authority of Fiji
- Isireli Temo Veitokiyaki, Water Authority of Fiji
- Emily Smith, Water Authority of Fiji

Stakeholders

- Veceli Tuiweli, Nadi Town Council
- Meli Naevo, Nadi Town Council
- Antereh Abewuya, DO Nadi Office
- Nemani T, Ba Provincial Office
- Aisake Raratabu, DTCP
- Rachel Hoyt, Lands Department
- Lia Tuivuya, Lands Department
- Malakai Rayaqayaqa, EA iTLTB
- Milaele Koroivulaono, SEO iTLTB

Navoci Village members

- *Epeli S., Nakoyacake – Turaga ni Yavusa*
- *Viliame Vikoso, Nakoyacake - Turaga ni Yavusa Tukani*
- *Tomasi W. Nakoyacake - Turaga ni Yavusa*
- *Iliaseri Varo, Nakoyacake – Turaga ni Mataqali Naobeka*
- *Ovini Varoi, Natogo*
- *Tomasi Naulumatua, Nakoyacake, Natoutou*
- *Anare Naivatuov, Nakovacake, Navoci Secretary*
- *Lewavai Uluinadi, Nakovacake, Navoci Villager*
- *Navitatuai B., Nakovacake,Navoci Villager*
- *Kuini, Nakovacake, Navoci Villager*
- *Meredani. S, Nakovacake, Navoci Villager*
- *Merelesita Valu, Nakovacake, Navoci Villager*

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- *Vika. S, Nakovacake, Navoci Villager*
- *Mereisi N, Nakovacake, Navoci Villager*
- *Sakiasi Vonolagi, Nakovacake, Navoci Villager*

Item	Action
1. Introductions • The DO presented the project team's Sevusevu. • The Turaga ni Koro & Nemani from Ba Provincial office welcomed everyone and briefly introduced the project. He then handed it over to Jackie Hughes (Facilitator/Presenter) to present and inform the WAF development and land requirements	
2. Presentation by PLANIT • A PowerPoint presentation was done in the English language briefly explaining the project and to inform the landowners of land required by JICA & WAF. • Explanation of the reasons for the native land required • Responding to the villagers and stakeholder comments and issues through Q & A • Explaining next steps and indicative timeframes	
3. Discussion Session • A question was raised by a village leader on the village reserve land that is proposed to be used by WAF but which is to be noted as future village extension and relocation area – Jackie noted that the area being referred to and expressed concerns that the villagers will be moving closer to the sewerage treatment plant (STP) particularly, if they do relocate into that village extension area identified. • The village leader stated that this village extension area is needed not only for the relocation of their growing village population but also for future development for the Yavusa Nakayavucake. He asked why the treatment plant could not be moved to the interior as their land was prime land for development – Jackie mentioned that it would be very expensive to move the existing Navakai Treatment Plant in land and states that everyone is already connected to the existing Navakai Plant and whilst it would be a costly affair, it is just not practical and not that simple because those that are connected now cannot just simply be disconnected and reconnected, as WAF will have to build the new plant and then build the pipe networks to reconnect them all again, which makes upgrading the existing Plant the only feasible option. She also mentions that in the regional master plan, there are two other sites that have been identified to help cater for the additional load on the Navakai site	

and also those who are currently not on the network. These two new areas are in Sabeto and Moala, which are on either ends of Nadi Town.

- The village leader also questions about the waste that will be dried and left on the land, what will happen to it? – Jackie explains that after drying the spoil for a period, it will then be taken off site, hopefully by a company that may have use for it, like a fertilizer company. This all has to be identified and worked out, but for now that is why there is the additional area of land required adjacent to the site, to stock pile the sludge until WAF finds a use for it. If WAF is able to find a use for it, off site, then the area of land required for expansion will reduce significantly.
- A village member questions if this request has come through iTLTB and NLFC as they are the 2 arms of the government that come before the village level – Jackie mentions that the Nadi Town Council (NTC) has advised the JICA Study Team & WAF Project team to go through iTLTB which has been done, and iTLTB were supposed to confirm the areas within the identified land areas for acquisition, which ones have been issued with leases and so JICA & WAF can liaise NLFC for the balance areas (if within Native Reserve). But there will be more consultations so it can be made known to the landowners the status of the land as we get more detailed design information. The village members were advised that this was just an initial meeting to update the landowners of the project and the need for additional land and how this may affect native land, and that WAF's acquisition and projects team will come back for more consultation meetings with the landowners when they have firmed up the design options and land required for the future expansion.
- Jackie asked the question of relocation numbers and how many villagers from Namotomoto and Navoci villagers are likely to be relocated to the identified village extension area and when? – A village representative asked to the questions to be forwarded to NLC who can give exact numbers. The village secretary advised that there is a serious problem of overpopulation in the two village and not enough land space within the existing villages to cater for these numbers. It is mentioned that some homes house (ie. 3 families) have already relocated to the village extension area. Jackie mentioned that the WAF team will likely meet with Housing Authority to find out more information on their housing project in Waqadra for the Nadi area, and so it would be useful to know how many from the village may need housing. The village secretary mentions that they will try and get numbers and families affected and respond in writing to the team. The village secretary in addition to over-crowding in the villages, flooding and bursting of the river banks was also a concern requiring villages to move away from the river.
- Jackie informs the villagers that the JICA & WAF team are hoping to have talks with FRA and Ministry of Works on the potential relocation of their depots located adjacent to the site as well as have talks with NFA who also own a vacant property at the rear of the existing Navakai Treatment Plant site. This is mainly to maximize the space for development by WAF but also to look at including some buffer areas and landscaping areas where trees can be planted and bunds installed to help address some of the odour issues (in the event there is a problem with the Plant).
- A question was raised by a villager on whether or not the river is safe to fish from or use – Jackie informed those present at the meeting that currently, because the treatment plant is overloaded and working beyond its full capacity,

it is not able to treat the waste as effective and efficient as it is designed to do, so therefore, the discharged "treated" water is not to the standard it should be. This is the reason we need the expansion of the Plant. Therefore, if this development is successful and we are able to have more ponds, the treatment of the waste will be higher standard and the water going into the river will be of better quality that what is now. Nadi Town Council Health Department has raised this health concern with WAF and WAF continues to have on going water quality monitoring and hopefully the upgrade takes place soon.

- A question was asked if there will be more ponds built on the site and if WAF had looked at other treatment options. Jackie mentions that we will need more ponds built because this type of system works best for Fiji in terms of operational issues. Even though other options have been assessed and tried, like mechanized systems, these are very costly, requires trained technical maintenance team and availability of spare parts which is ongoing and hard to maintain.
- The village secretary mentions that the villagers are already relocating to the village extension areas – Jackie said that there will be a cut-off date, as to who will be considered as part of the relocation/resettlement if WAF decides to proceed with the upgrade, acquisition and relocation. So earlier and on-going consultation is key and important.
- A villager asked again the question of the relocation of the treatment plant as an option as the proposed site beside the existing WWTP is prime location for the village for relocation and future development that would generate income for the village, e.g using the river for River Saffari etc ; to which Jackie replied that it would be a costly affair and that everyone in Nadi is already connected to the current site, with piping works already in place, to relocate the plant, would not be feasible
- A villager raised a point that as a village, they do not have a lot of land to be able to give to WAF. They are already short of land and limited.
- Another villager asked if the land is given and the WWTP is upgraded, will the villages be connected also, to which Jackie informed them that that was WAF's intention to connect all the villages and the settlements nearby to the system and that is why the volume of the land is needed.
- A village member asked exactly how much area of land is needed, and Jackie responded approximately 21.28 Ha.
- Jackie asked about the land across the proposed additional area of native land to which she was advised that it had a 40-year development lease. Jackie also mentioned that they have been in talks with lands department for state leases but there are not many and it was a concern for WAF that Lands Department was also doing their Master Plan for all State lands earmarking the areas in Enamanu and Wailoaloa for Commercial and Tourism development which would also be required to connect to the Navakai Treatment Plant. Therefore, increase the demand and urgency for the upgrade.
- The secretary mentioned that WAF came to the village about a sewer line to be installed that would run through and between the native village extension land and the Ratu Navula School.
- The Yavusa Secretary asked if the ponds would be on Native land or State land, to which Jackie mentioned that most of the ponds would be on the State land while the Native land will be mainly used for the drying of sludge and

also buffer zones such as trees and bunds to help with screening some of the odour (if any).

- A villager and former employee of AFL, asked about the old sewerage treatment plant that was run by AFL and why they closed it and why WAF cannot just use that as the infrastructure is already exiting. Jackie noted that the team is having a meeting later on with AFL and CAAF and will raise it to them as well. However, Jackie mentioned that it is probably because the ponds attract birds and this would not be good within the airport and flight path zones.
- A village head complained about the foul smell that comes to the village and the 3 schools when the dry sludge gets wet in the rainy seasons and asked it to be taken care of; Jackie noted this and explains that it is likely to come from the ponds and this is mainly because the system is overloaded.
- The village secretary mentions that they will take in all the requests and issues that the JICA & WAF team have raised in this meeting and discuss with the villagers and respond in writing to the WAF team.
- The authorities present, iTLTB, DTCP, NTC, & Lands department, spoke on behalf of their offices and their future plans concerning this development and mentioned that it was really critical for the Navakai Treatment Plant expansion as all the development plans that the villagers or any other investors have for their land and properties in Nadi would be restricted and we would not be able to maximise returns on the development if Navakai does not have the capacity for them to connect to. They requested the landowners to really discuss carefully and asked if we can all work together to find a solution that will benefit all.

With no further questions from the villagers, the meeting was closed by the Assistant Roko.

4. Actions from Meeting

- WAF to follow up with on-going consultations with the Native landowners once the design is further detailed and firm up any future potential users of the treated sludge to reduce the expansion area required for the treatment and stockpile of the sludge
- WAF to include consultations with NLFC with regards to the native reserve land that may also be required and to discuss the operational impact to the native reserve land, particularly if it is to be used for residential purpose/relocation of villagers
- WAF to liaise with TLTB on the potential to acquire any development leases identified as part of the extension areas
- WAF to follow up with Department of Lands on any expiring state leases that WAF can acquire for potential relocation of FRA and Ministry of Works depot
- WAF to meet with Housing Authority to get an update on their Waqadra Housing development and also Ministry of Housing on resettlement options by Government

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JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project - Priority Cities Nadi & Lautoka Pre-Feasibility
Consultation Meeting Attendance Register
Navoci Village - 22nd July 2024

PLANIT

Name	Organisation/ Departments/Community	Position	Contact Details (mobile & email)
~~Nottaigoro~~	~~Nakovacake~~		[redacted]
Epeli · Sinilewa	Nakovacake	T/Y Nointi Gov	
Viliame · Vikoso	Nakovacake	T/Y - Tukani	
Tomasi Waqalevu	Nakovacake	T/Y - Boticake	
Liaseri Varo	Nakovacake	T/M · Naobeka	
Ahlesh Abenaya	DO Nadi Office	DO Nadi	
Nemani T	Ba Provincial Office	Nakovacake (Roko)	
Eviri Varo		Natogo	
Tomasi Naulumatua	Nakovacake	Nakovacake Town	
Veceli · V Tuiwel	NTC	Bldg · Inspector	
Meli Naevo	"	" "	
Anare Naivalurua	Nakovacake	Navoci/NDT Secretary	
Lewavai Ulunadi	"	Navoci Vill.	
Navitalai B Kurini	"	Navoci Village	
	—	Navoci "	
Meredani · S.	—	N "	
Merelesita · Valu	Nakovacake	Navoci	
Vika S.	Nakovacake	Navoci	
Mereisi N.	Nakovacake	Navoci	
Sakiasi Vonotaqa	Nakovacake	Navoci	
Aisake Ravatabu	DTCP	Lautoka	
Rachel Hoyt	Lands Dept.	Lautoka.	
Emily Smith · U	WAF	Suva	

JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project - Priority Cities Nadi & Lautoka Pre-Feasibility
Consultation Meeting Attendance Register
Navoci Village - 22nd July 2024

PLANIT

Name	Organisation/ Departments/Community	Position	Contact Details (mobile & email)
Ima Tuiwiriga	Lands	Depty SUO	[redacted]
Isireli Temo	WAF	SAP	
Josaia Koroilavesau	"	MAP	
Mataka [illegible]	TLTB	EA	
Mikaele Korokula[illegible]	TLTB	SEO	
* JOSAIA KOROI	WAF	MIP	
Jackie Hughes	PLANIT	Social Consultant	
Tevita K[illegible]	PLANIT	–	

APPENDIX 7-10 Stakeholder Consultations (Draft Final Report Stage)

Project Name:	**JICA Nadi & Lautoka Master Plan**		
Place of Meeting:	Tanoa Waterfront Lautoka – Conference Room		
Meeting Date:	Thursday, August 1st 2024	**Meeting Time:**	10:00 AM
Prepared By:	PLANIT Pacific Pte Limited		

Attendees:

Project Team

- Seru Soderberg, Water Authority of Fiji
- Emily Smith, WAF
- Thomas Hughes, WAF
- Isireli Temo Veitokiyaki, WAF
- Akash Chandra, WAF
- Salesi Uluilakeba, WAF
- Kelereyani Luvu, WAF
- Lidia Rakacikaci, WAF
- Satoshi Wakasugi, JICA
- Yoshiyuki Choso, JICA (zoom)
- Yoko Kotegawa, JICA (zoom)
- Shinichi Wada, JICA (zoom)
- Yuriko Kudo, JICA
- Nila Prasad, JICA
- Yoshinobu Nakajima, JICA
- Kiyohiko Hayashi, JICA
- Jacqueline Hughes, PLANIT Pacific
- Tevita King, PLANIT Pacific
- Tabitha King, PLANIT Pacific

Stakeholders

- Jimi Taniela, FMF Foods Limited
- Thomas Magnus, Investment Fiji
- Nirmala Devi, Natabua Community Member
- Rama Devi, Natabua Advisory Council Member
- Rosi Lele, Natabua Community Member Advisory Council
- Ratu Sireli V, Natabua Community Member
- Amelia Bai, Taiperia Community Member
- Siteri Metuisela, Taiperia Community Member
- Savenaca Kaunisela, Taiperia Community Member
- Marica Vayaru, Taiperia Community Member
- Josefa Saumailagi, Department of Waterways
- Peter Watts, Vulani Island Limited
- Fantasha Lockington, Fiji Hotel & Tourism Association
- Dick Lockington, Qanville Landlord & Tenants Association

- Jone Tabakaucoro, Housing Authority
- Paul Forrest, Model Towns Charitable Trust
- Vilikesa Nuku, Telecom Fiji Limited
- Semi Ravuaceva, TFL
- Vikant Sharma, Energy Fiji Limited
- Prasheel Chand, EFL
- Lavenia R, Department of Town & Country Planning West
- Vilashni, DTCP West
- Rouhit Singh, Lautoka City Council
- Shameer Khan, LCC
- Shalendra Dass, LCC
- Mohamed Anees Khan, LCC
- Maikeli L, Civil Aviation Authority of Fiji
- Mosese Ratucicivi, CAAF
- Alitia Namua, Public Rental Board
- Mataiasi Tabanikau, Ministry of Health & Medical Services
- Isimeli Tuiteci, MOHMS
- Vinceta, Natabua Community Member
- Jone Bacau, Commissioners Office West
- Ms. Freeda Fremlin – Principal Project Planning and Policy Analyst, Ministry of Economy (zoom)
- Ms. Makereta Tuima – Senior Monitoring and Evaluation Officer, MoE (zoom)
- Mr. Steven Shivneshwar – Project Assistant, MoE (zoom)
- Uraia Rakaria, Lands Department
- Shaolin Lay, Nadi Town Council
- Veceli Tuweli, NTC
- Apisai Vulawalu, Ministry of Lands
- Sitiveni Tavaga, Commissioner Westerns Office
-

Item	Action
1. Introductions Jacqueline Hughes (PLANIT Pacific) welcomed and thanked the attendees for their presence briefly introduced the Wastewater Treatment Master Plan – Phase 2. She advised that the project team would then present the details of the project.	

2. Presentation by PLANIT

- A PowerPoint presentation was done in the English language explaining the Project for Formulation of Wastewater Treatment Master Plan in Western Division (2nd Phase)
- Explanation of the Environmental and Social Considerations (ESC) Study for the Priority Project: Municipal Sewerage Plans for Lautoka and Nadi
- Responding to the stakeholder comments and issues through Q & A
- Explaining next steps and indicative timeframes

3. Discussion Session

- Mohammed Khan (Lautoka City Council) questioned whether WAF has already acquired land for the proposed master plan upgrade developments in Navakai and Natabua, to which Jacqueline Hughes (PLANIT Pacific) responded that WAF has already budgeted for this financial year to start the acquisition process. Seru Soderberg (Water Authority of Fiji) also mentioned they are trying to acquire land not just for these sites but the other sites in Vitogo, Sabeto and Moala.
- Fantasha Lockington (Fiji Hotels & Tourism Association) queried whether there were any considerations being given to reduce energy or greener energy options for keeping the wastewater treatment plants alive as Fiji is moving towards greener energy. Seru (WAF) stated that WAF have been looking into greener avenues to carry out the recommended works at the earliest stage as possible.
- Fantasha (FHTA) queried what was being done in relation to the illegally connected population that has been contributing to WAF's overcapacity and if any public announcements are being done to address the issue. Seru Soderberg (WAF) responded that public announcements will be taken on board in addition to smoke testing exercises to address the issue of illegal connections. He added that WAF has covered Suva City in the last financial year and discovered that 90% of all businesses are illegally connected to the sewer system which is one of the reasons the system is being overloaded due to flows that the system is not designed for. Once that reduction is addressed WAF has an opportunity to plan the infrastructure needed. Further, he mentioned that under the Trade Waste Policy, the proposed amendment to the Fees and Charges empowers WAF to go out and hold businesses who illegally dump chemicals into the system accountable.
- Fantasha (FHTA) also queried what was being done in the meantime to address overcapacity since the project timeframe is 9 years. Seru (WAF) stated that they are currently working towards the wastewater infrastructure from Denarau to Navakai treatment plant. WAF has done the tender and expect works to begin this financial year while there are also plans for expansions and upgrading for systems that connect to the main treatment plant. He stressed that the main target for WAF is to get rid of the illegal disconnections.
- Mohammed (LCC) representative elaborated that when building approvals are done, LCC and WAF vet the connections which is proof for them to legally connected. After the approval of plans or final certification, contractors cut corners and connect illegally which is why there is more coming out that is supposed to be like, stormwater and kitchen/shower water. He added that once they tackle the illegal connections, WAF will be able to address the capacity issue. Mohammed also shared that the Department of Town and Country Planning is currently undertaking a 50-year masterplan which should also be considered as it will open up land to development and also more loads for WAF to be required to take in the system.

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- Isimeli Tuiteci (Ministry of Health & Medical Services) asked whether the land owners for the land that is required by WAF will be fairly compensated or substituted. He also queried what would happen if there is a mechanical or electrical fault and how it would be addressed. Jacqueline Hughes (PLANIT Pacific) responded that there will be ongoing negotiations and consultations with the landowners and affected persons who may or may not be required to be resettled or relocated and this will only be confirmed once the design of the plant is further detailed. As for the any electrical faults, as part of the design, the plants will be required to have backup generators that will kick in as soon as the power goes off from the mains.
- Veceli Tuiweli (Nadi Town Council) asked that in terms of native land around Navakai, if the landowners do not give their consent would that be the end of the project or will WAF acquire land through compulsory acquisition. Jacqueline (PLANIT) stated that WAF has also met with Civil Aviation Authority of Fiji (CAAF) and Airports Fiji Limited (AFL) earlier as recommended by Lands Department for the availability of other lands. Lands Department are also looking for alternative sites that may have expiring leases potentially for the sludge stockpiling after drying treatment. She stated that CAAF have indicated that they have a site that they could potentially sell though it is located in the flight path of the runway where the approach lights are, so will need to be looked at quite carefully. She added that it is not too far from the existing site and is a possible option to be explored if the landowners do not agree to give up their land.
- Peter Watts (Vulani Islands Limited) questioned the urgency of the project and mentioned that while driving past the treatment sites there is the unsavory smell of the plant. He queried if something could be done in a staged way to deal with the crisis before any land would be obtained, as well as if the pump stations would also be upgraded. Seru (WAF) responded to the odour issue stating that this financial year they are investing in non-infrastructure interventions to deal with the odour with more of a chemical approach to assist with controlling odour at the treatment plant. Seru added that in terms of the pump stations an upgrade is required since some of the pump stations have already surpassed their loading and as stated it will be done in stages, as and when developments occur. Peter also asked if the treatment plants will be upgraded themselves and if some chemical treatment be put in before land is bought. Seru reemphasized that the focus was on disconnecting all illegal connections which contributes to 60% of the wastewater in the treatment plants, and if WAF can achieve this they can get some of their capacity back. He added that the biggest hindrance at the moment was that they do not have the legal tools to implement disconnections. He stated that they can serve businesses and households notices for illegal connections but not much can be done after that. He mentioned that they currently have a Fees and Charges which is at the SG's office being formalized which is what they will use to enforce to deal with the challenges of illegal connections.
- Mataiasi Tabanikau (MOHMS – Nadi Rural Health Office) stated that the ecoli and fecal coliform numbers are way over WHO standards. He stressed the need to manage or mitigate the number of microorganisms that are entering Nadi River and that he is hopeful that WAF has something in place for the next financial year to manage the current situation on site before going onto the bigger plans. Mataiasi added that they have received a lot of concerns from the surrounding communities in regards to the water quality where most of the communities rely on the river as a livelihood as well. He stated that they have also received cases from the government hospitals of children as young as 5 years old who have waterborne infections and skin infections and is looking forward to WAF implementing this financial year something to manage that. He stated that injecting chemicals for control at the Plant will be good and he would like to see

further tests to show that these chemicals also do not end up in the waterways too, causing more social and community health concerns.

- LCC representative stated that equally important to add to the list of legislations is the Public Health Act as well as the Litter Decree, which gives powers for the Councils to look at the nuisance in terms of fining the public/businesses, to ensure that litter is not being dumped into waterways. He added that municipalities have their own sewerage bylaws which is in line with WAF's so those households illegally connecting to WAF's sewer line must follow regulations in which council's can monitor and enforce on behalf of WAF.
- Peter (Vulani Islands Ltd) queried if the treatment ponds on Denarau are incorporated in the new plans. Seru (WAF) elaborated that the wastewater pump station in Denarau is part of the planned upgrade works and WAF has already gone out to tender with potential contractors to undertake the work. Seru stated that the challenges they are working around with the Denarau is the infiltration and are looking at how best to address the infiltration that is affecting the pump station. He shared that just two days ago there was an incident with a wastewater treatment plant overflowing in the Marriot and upon investigating there were gravel and rocks which had gone into the system. The issue had been fixed 3 times in 12 hours where the same thing was discovered – rocks.
- Jone Tabakaucoro (Housing Authority) queried how the 60% of illegal connections will be factored into the upcoming developments. Seru (WAF) stated that with the increasing developments, the loading will be staged and will not be as much as when the development is complete. He remarked that removing the illegal connections and the infiltration is key because the loading of the plants now is more to do with infiltration rather than anything else. He shared that for most of the sites, those legally connecting, the combined loading does not hit the maximum treatment capacity of the plant and for most of the sites.
- Jacqueline (PLANIT) questioned if there would come a time in the next 5-6 years where WAF may say to developers that they cannot connect to Navakai. Seru (WAF) stated that it is a possibility if the infrastructure cannot meet the demand but that is also why the Water Sector Strategy 2050 has been developed. The Western region is looking to spend $161 million dollars within the next 6 years and between 2031-2050 about $1billion dollars. He stressed the need for all sectors to invest in wastewater infrastructure in the coming years to ensure it is able to keep in par with development.
- Rosi Lele (Natabua Advisory Councilor Member) expressed her concerns of the rate of development going through Natabua causing the plant to choke and lack space to expand the treatment plant in Natabua in the next few years.
- Veceli (NTC) followed up his earlier questioned that since the native land in Navakai is the most viable option for the extension of the treatment plant are there any options available to the landowners for compensation through land swap with state land. Jacqueline (PLANIT) stated that it is a possibility to be discussed with Lands Department who are currently doing their masterplan. Jacqueline directed the question to Apisai Vulawalu (Ministry of Lands) to facilitate the exchange. Apisai (MoL) stated that it is something that needs to be considered because of the national interest. He added that they are still awaiting approval of their landuse masterplan from DTCP but if there is a need, amendments can be made to the masterplan.
- Fantasha (FHTA) added that Fiji cannot grow or develop more especially in terms of diversifying the economy if there is no support for WAF to put in their water systems and improve wastewater management systems which needs to be prioritized.

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- Mohammed (LCC) shared in terms of the sludge storage that the Cabinet has approved a project for a westernized landfill that will cater for Sigatoka up to Rakiraki and will be located somewhere around Nadi and Lautoka. He stated that he has been told that 100 acres is being looked at. He offered that if land is not able to be acquired by WAF, there could be allocations for WAF to stockpile at the new landfill which could potentially be used for composting. He stated that UNDP is currently doing the feasibility study and have already visited the landfills in the West, and he recommends that WAF consult with UNDP and Ministry of Local Government on the options available.
- Peter (Vulani Islands Ltd) queried if there was an opportunity to harvest biogas. Jacqueline (PLANIT) stated that biogas was looked at as an option. Yoshinobu Nakajima (JICA) also stated that the preferred option was to outsource the generation of biogas to company or to the private sector to come and take and process it themselves.

4. Actions from Meeting

- WAF to share powerpoint presentation and stakeholder list and contact details for the benefit of stakeholders continued networking and exchanging of information. Further for influential stakeholders such as Fiji Hoteliers Association, major developers and the Councils and other Ministries, to lobby government/Ministry of Finance, to support WAF's budget in order to accelerate funding to reduce the timeframes of rolling out these two major infrastructure upgrade projects which will help benefit development and investment in both Nadi and Lautoka.
- WAF to consider putting in a submission to Lands Department requesting a land swap for the native land owners.
- WAF to continue to pursue sludge management plans and options, including talking to Ministry of Agriculture, Fiji Sugar and UNDP on the use of the treated sludge to reduce the area required for stockpiling of the treated sludge.

JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project
Priority Cities Nadi & Lautoka Pre-Feasibility
Stakeholder Consultation Meeting Attendance Register
Tanoa Waterfront Conference Room
10:00am, 1 August 2024

Name	Organisation/ Departments/Community	Position	Contact Details
Jimi Tanebu	FMF Foods Ltd	GM Operations	[redacted]
Thomas Nyauwe	Investment Fiji	Regional Manager	
Nirmala Devi	NATA BUA		
RAMA DEVI	NATABUA DAC		
Rosi LELE	NATABUA COMMUNITY	SOCIAL WORKER	
Amelia Bai	Taipena Community	ADC	
SITERI METUISELA	TAIPERIA COMMUNITY	COMMUNITY SECT	
Savenaca Kaunisela	Taipena Community	Community settle	
Marica Vayaru	Taipena Community	Community settle sect	
THOMAS HUGHES	WAF	Strategic Asset Planner	
Sam Soderberg	WAF	Operations	
Akash Chand	WAF	Regional Asset Planner	
Sailesi ULUIWAKEBA	WAF	NAVAKAI SEWERAGE	
Satoshi Wakasugi	JICA Fiji	Resident Representative	
JOSEFA SAUMAILAGI	DEPARTMENT OF WATERWAYS	TECHNICAL OFFICER - WEST	
Peter Watts	Vulani Island Ltd	Director	
Fantasha Lockington	FHTA (Hotel & Tourism Ass)	CEO	
Dick Lockington	Granville Landlords Tenants Ass (GLTA)	VP	
Tone Tabakaucoro	Housing Authority (Nasese)	Engineer	
Emily S. Vanicoca	WAF		
Isireli Veitokiyaki	WAF		
Paul Forrest	MTCT	GM.	

(22)

JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project
Priority Cities Nadi & Lautoka Pre-Feasibility
Stakeholder Consultation Meeting Attendance Register
Tanoa Waterfront Conference Room
10:00am, 1 August 2024

Name	Organisation/ Departments/Community	Position	Contact Details
Keleraiyani Lavu	WAF	ENVIRONMENT OFFICER	[redacted]
VILIKESA. NUKU	TFL	TEAM LEADER	
Semi Ramaceva	✓	Planner.	
Vikant Sharma	EFL	Acting Team Leader	
Prashant Chand	EFL	Gov. Electrical Engineer	
Laxmi R.	DTCP - West	STPA - West	
Vilashni D	DTCP - West.	STPA - West	
R SIRELI. V	[illegible]	ENVIRONMENT	
Rohit Singh	LCC	Manager Health	
SHAMEER Khan	LCC	Team Leader AUD	
SHALENDRA DASS	L.C.C	ACTING DIRECTOR BUILDING ENGINEERING SERV	
M. Anis Khan	LCC	CEO	
Ma'Lulu Laligaca	CAAF	Snr AD Insp	
MOSESE KATUVAU	CAAF	AI - RAW	
Alitia Namua	PRB	Housing & Estate Officer	
MATAIASI T	MOHMS	EN. HEALTH Officers	
LAIMELI T			
VINCENT	NATABUA		
Jone Bacani	Commissioner Western Office	DPO	
Makarets Tuung	M. O Finance (Zoom)	(National Planning	
Yoshiyuki Choso	JICA (Zoom)	Expert Team	
Kaiviko Kudo	JICA		
Unaia Rakaria	Lands Department	DLMW	

(23)

JICA/Water Authority of Fiji - Phase 2 Social Environmental Assessment for Western Wastewater Project
Priority Cities Nadi & Lautoka Pre-Feasibility
Stakeholder Consultation Meeting Attendance Register
Tanoa Waterfront Conference Room
10:00am, 1 August 2024

Name	Organisation/ Departments/Community	Position	Contact Details
Shaclin	Nadi Town Council	Health Inspector	[redacted]
Veseli, T	NTC	Bldg. Inspector	[redacted]
Jacqueline Hughes	PLANIT Pacific	Social consulta	[redacted]
Teuita King	✓ ✓	✓	[redacted]
Tabitea King	✓ ✓	✓	[redacted]
Apisai Vulawalu	Ministry of Lands	Assistant Director La	[redacted]
Sitiveni Tavaga	Commissioner Westerns Office	District Officer Ltka	[redacted]
LIDIA RAKACIKACI	WAF	T/O LTW	[redacted]
Nila Prasad	JICA	Senior Program Officer	[redacted]
Yoshinobu Nakajima	JICA Team		[redacted]
Kiyohiko Hayashi	JICA Team		[redacted]
Freeda Franklin	Ministry of Finance	Principal Project	[redacted]
Steven Shivneshwar	✓	Project Assis	[redacted]
Shinichi Wada	JICA Expert Team		[redacted]
Yoko Kotegawa	JICA Expert Team		

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APPENDIX 8-1 Cash Flow

(1) FIRR: Cash Flow

Year	Expenditure Without Project	Capital Expenditure Total	O&M Expenditure Total	Incremental Expenditure Total	Incremental Income Total	Incremental Cash Flow for FIRR
2028	7,061	90,256	0	83,194	229	(82,966)
2029	7,061	136,673	0	129,611	229	(129,383)
2030	7,061	120,137	0	113,076	229	(112,847)
2031	7,061	120,137	0	113,076	229	(112,847)
2032	7,061	120,137	0	113,076	229	(112,847)
2033	7,061	150,174	3,773	146,885	263	(146,623)
2034	7,061	150,174	4,924	148,037	271	(147,765)
2035	7,061	150,174	6,395	149,507	497	(149,010)
2036	7,061	150,174	6,395	149,507	396	(149,111)
2037	7,061	0	10,076	3,015	1,702	(1,313)
2038	7,061	0	10,534	3,473	2,197	(1,941)
2039	7,061	0	11,784	4,723	2,723	(2,850)
2040	7,061	0	12,635	5,574	2,685	(2,888)
2041	7,061	0	12,635	5,574	2,539	(3,034)
2042	7,061	0	12,635	5,574	2,539	(3,034)
2043	7,061	0	12,635	5,574	2,539	(3,034)
2044	7,061	0	12,635	5,574	2,539	(3,034)
2045	7,061	0	12,635	5,574	2,539	(3,034)
2046	7,061	0	12,635	5,574	2,539	(3,034)
2047	7,061	0	12,635	5,574	2,539	(3,034)
2048	7,061	0	12,635	5,574	2,539	(3,034)
2049	7,061	0	12,635	5,574	2,539	(3,034)
2050	7,061	0	12,635	5,574	2,539	(3,034)
2051	7,061	0	12,635	5,574	2,539	(3,034)
2052	7,061	0	12,635	5,574	2,539	(3,034)
2053	7,061	(681,024)	12,635	(675,451)	2,539	677,990
					FIRR=	-2.8%

Source: JET

(2) EIRR: Cash Flow

Year	Cost Without Project	Capital Cost Total	O&M Cost Total	Incremental Cost Total	Incremental Benefit Total	Incremental Cash Flow for EIRR
2028	7,061	83,125	0	76,063	229	(75,835)
2029	7,061	83,125	0	76,063	4,727	(71,336)
2030	7,061	107,426	0	100,365	9,226	(91,139)
2031	7,061	107,426	0	100,365	13,725	(86,641)
2032	7,061	107,426	0	100,365	18,223	(82,142)
2033	7,061	132,133	3,617	128,688	25,958	(102,730)
2034	7,061	132,133	4,720	129,791	34,576	(95,215)
2035	7,061	132,133	6,130	131,201	47,208	(83,994)
2036	7,061	132,133	6,130	131,201	51,605	(79,596)
2037	7,061	0	9,659	2,598	60,610	58,012
2038	7,061	0	10,098	3,036	77,417	74,380
2039	7,061	0	11,296	4,235	97,620	93,385
2040	7,061	0	12,111	5,050	114,615	109,565
2041	7,061	0	12,111	5,050	118,967	113,917
2042	7,061	0	12,111	5,050	123,466	118,416
2043	7,061	0	12,111	5,050	127,964	122,914
2044	7,061	0	12,111	5,050	132,463	127,413
2045	7,061	0	12,111	5,050	136,962	131,911
2046	7,061	0	12,111	5,050	141,460	136,410
2047	7,061	0	12,111	5,050	145,959	140,909
2048	7,061	0	12,111	5,050	150,457	145,407
2049	7,061	0	12,111	5,050	150,457	145,407
2050	7,061	0	12,111	5,050	150,457	145,407
2051	7,061	0	12,111	5,050	150,457	145,407
2052	7,061	0	12,111	5,050	150,457	145,407
2053	7,061	(577,632)	12,111	(572,582)	150,457	723,040
					EIRR=	9.0%

Source: JET

APPENDIX 8-2 Results of the Households Survey

JET conducted a household interview survey on water supply and sanitation in March 2024. Interviews were conducted with 200 residents from each of the target cities of Nadi and Lautoka, for a total of 400 people who responded directly to questionnaires (the interview questionnaire is included in the end of this Appendix).

(1) Respondent Characteristics

The number of persons per household and the average and median income of the respondents are shown in **Table A8-2.1** below. Respondents were cooks, taxi drivers, office workers, agricultural workers, shop clerks, hotel workers, and many other occupations. Comparing respondents' household incomes, the median was the same in both Nadi and Lautoka at 1,000 FJD/month, but the average income in Nadi was 45% higher than in Lautoka. The average household size in both cities was 5 persons, the average income was 1,880 FJD/month and the annual income was 22,550 FJD/year.

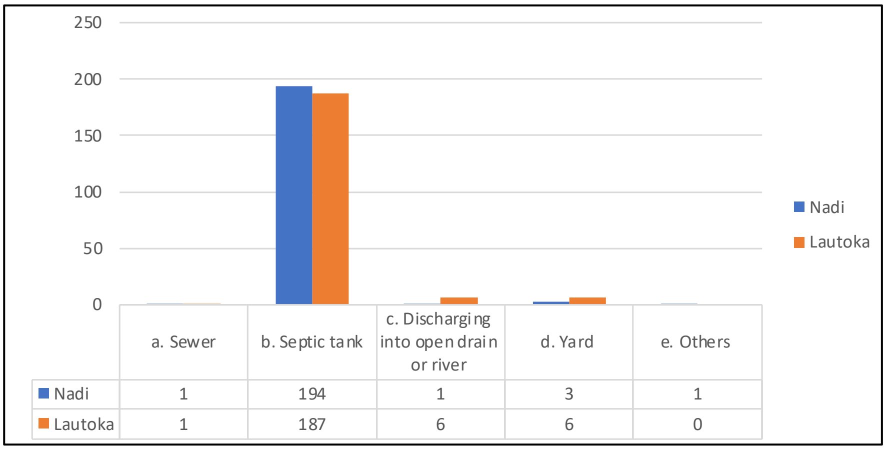
Table A8-2.1 Number of Persons per Household and Average and Median Household Income

Item	Nadi	Lautoka	Both Cities
Number of people in the household	5.3	4.7	5.0
Household income per month (FJD) Mean	2,202	1,522	1,879
Household income per month (FJD) Median	1,000	1,000	1,000

Source: JET

(2) Sewerage Connection Status

The house connection status of the surveyed households is shown in **Figure A8-2.1** below. In both cities, 95% of households use septic tanks for wastewater treatment, while 4% of households discharge untreated wastewater into rivers or gardens.

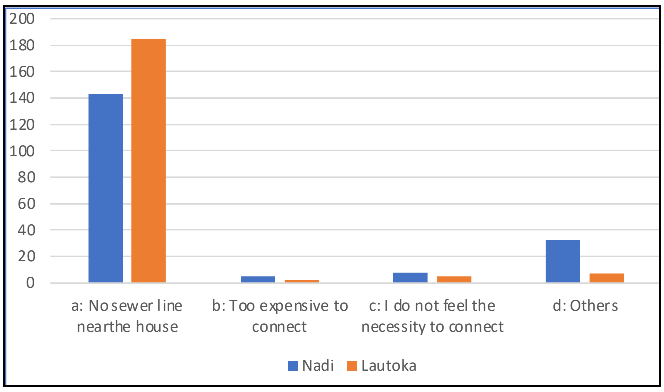


Source: JET

Figure A8-2.1 Sewerage Connection Status

There was one connected household in Nadi and one in Lautoka. Both households wanted the sewerage system to be improved, but did not want to incur additional costs for the improvement. There was also no response regarding the current level of sewerage payments.

The majority of unconnected households cited the lack of sewer network in their area as the reason (**Figure A8-2.2**). In Nadi, over 10% of respondents were unconnected, and other reasons included using self-treatment facilities due to the lack of sewerage facilities in their area.



Source: JET

Figure A8-2.2 Reasons for not being connected

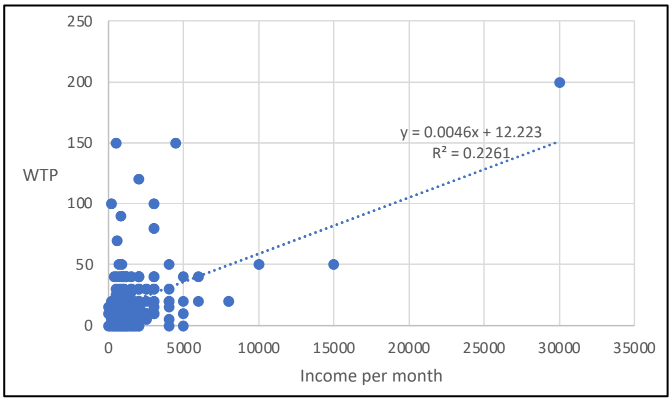
(3) Willingness to pay for sewerage services

Table A8-2.2 shows the willingness/month and income/month for households in Nadi and Lautoka. Both the mean and median willingness to pay are high in Nadi. There is a rough correlation between willingness to pay and household income.

Table A8-2.2 Willingness to Pay and Mean and Median Household Income

Item	Nadi	Lautoka	Both Municipalities
Willing to Pay: Mean (FJD)	25	16	21
Willing to Pay: Median (FJD)	20	15	15

Source: JET



Source: JET

Figure A8-2.3 Relation Between Household Income and Willingness to Pay

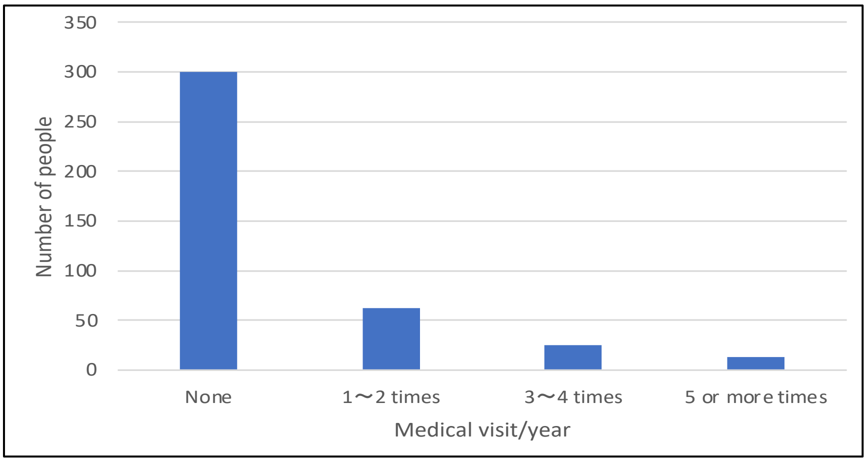
(4) Treatment for Inadequate Water Sanitation

Table A8-2.3 below shows the number of people treated per year, the average cost per treatment, the average number of treatments, and the average treatment cost in both cities for diseases caused by inadequate water sanitation (diarrhea, dysentery, typhoid, cholera). In this survey, all responses indicated that the cause of the illness was diarrhea. The average cost per treatment was 49 FJD. Of the total 400 people treated in both cities, 300 did not receive treatment even once a year (**Figure A8-2.4**). About 10% were treated three or more times per year.

Table A8-2.3 Number of people treated per year, average cost per treatment, average number of treatments/year, average treatment cost/year

Item	Nadi	Lautoka	Both Cities
Number of persons to medical visit	65	35	100
Average expense per treatment (FJD)	52	41	49
Average medical visit to the doctor/year	1.0	0.4	0.7
Average cost for treatment (FJD/year)	16	5.9	11.0

Source: JET



Source: JET

Figure A8-2.4 Histogram of Number of Diarrhea Treatments/ Year for Surveyed Residents in Both Cities

(5) Impact of Water Quality Protection on Public Water Body

The impacts of pollution caused by underdeveloped sewerage systems were presented as coastal pollution, foul odors, garbage, and a decrease in tourism. Next, respondents were asked about their willingness to pay for water quality protection measures implemented through the sewerage project for Nadi and Lautoka area.

To estimate willingness to pay for protection of public water body, Contingent Valuation Method (CVM) was applied, which allows for the valuation of non-use values of the environment. This is a stated choice method that directly asks people how much they are willing to pay and how much compensation they will accept for environmental changes.

The questions were presented in a double-bounded format, with two-branch willingness-to-pay choices presented twice. The averages and medians obtained through statistical processing are shown in **Table A8-2.4.**

Both the average and median willingness to pay for households in Nadi are higher than in Lautoka. As with the willingness to pay for sewerage, this may be due to the difference in average income between the two cities.

Table A8-2.4 Mean and Median Willingness to Pay by CVM

Item	Nadi	Lautoka	Both Municipalities
Willing to Pay: Mean	76	53	65
Willing to Pay: Median	38	18	27

Source: JET

(6) Water Supply

In this interview survey, we also asked questions related to water supply. The results are shown below. In the above survey, 30% of the respondents think that the current water tariff is high. In addition, 30% think that the water is not safe to drink and buy bottled water.

Table A8-2.5 Water Supply Responses

Item	Nadi	Lautoka	Both Cities
Usage cost for public water /month (FJD)			
Mean	47	35	41
Median	30	30	30
Evaluation for cost of public water supply			
Expensive	55	68	123
Normal	105	113	218
Cheap	40	19	59
Number of non-public water user	4	0	4
Average cost for non-public water /month (FJD)	26	-	26
Presence of private water vendor for tank water	29	10	39
Cost per water tank (18 litter, FJD): Median	20	20	20
Do you buy any bottled water? Yes	147	112	259
No	53	88	141
Reason: Water is contaminated. Not safe for drinking	70	49	119
Bottled water (500cc) consumed /day			
Mean	6	3	5
Median	4	2	3

Source: JET

(7) Cost of Electricity and Communication

In the same survey, we also asked questions related to electricity and communication costs. The results are shown in **Table A8-2.6.**

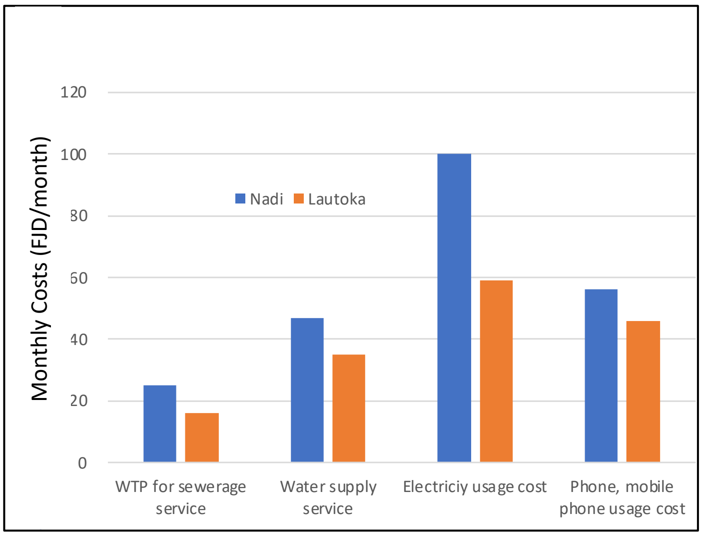
Table A8-2.6 Average cost of electricity and communication

Item	Nadi	Lautoka	Both Cities
Electricity usage cost per month (FJD/month) Mean	100	59	79
Phone, mobile phone cost per month (FJD/month) Mean	56	46	51

Source: JET

(8) Comparison of Willingness to Pay for Sewerage, Water, Electricity and Communication Costs

A comparison of willingness to pay for sanitation, water, electricity and communication costs (per FJD/month) is shown in **Figure A8-2.5**. Communication costs are the highest, about twice as high as water. On the other hand, willingness to pay for sewerage is the lowest, at half the cost of drinking water. Compared to other living expenses, willingness to pay for sewerage connection fees is relatively low.



Source: JET

Figure A8-2.5 Willingness to Pay for Sewerage, Clean Water Consumption, Electricity Consumption and Communication Costs

APPENDIX 9-1 Results of Sewerage Sludge Analysis

		Zinc (mg/kg)	Copper (mg/kg)	Arsenic (mg/kg)	Lead (mg/kg)	Chromium (mg/kg)	Cadmium (mg/kg)	Molybden (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Selenium (mg/kg)
Sludge Sample	Navakai	1300	750	9	400	160	2	17	< 0.5	28	4
	Natabua	310	135	22	13	93	< 1	< 5	< 0.5	37	1
Existing Guidelines	EPA *1	250	200	20	200		3		1	60	
	WHO *2			8	84		4		7	107	6
	AWA *3 (Grade C1)	200-250	100-200	20	150-300	100-400	1		1	60	3
	AWA *3 (Grade C2)	2500	2500	60	420	500-3000	20		15	270	50
	US EPA Land Application CCL*4	7500	4300	75	840	3000	85	75	57	420	100
	US EPA Land Application PCL*4	2800	1500	41	300	1200	39	—	17	420	100
	US EPA Surface Disposal *5	—	—	30	—	200	—	—	—	210	—
	EU Land Application *6	2500-4000	1000-1750		750-1200	—	20-40	—	16-25	300-400	—
	Japan Fertilizer Application *7	—	—	50	100	500	5	—	2	300	—

*1: EPA guidelines, Environment Protection Authority, Department of Environment and Natural Resources, ADELAIDE, October 1996 updated June 1997.

*2: WHO guidelines for the safe use of wastewater, excreta and greywater 2006. Maximum tolerable soil concentrations of various toxic chemicals based on human health protection.

*3: Guidelines for Sewerage Systems Biosolids Management, November 2004. Guideline Biosolids Contaminant Grade Values

"*4 US EPA, Land application

CCL＝Ceiling Concentration limits, Max allowable concentration of pollutant in sewerage sludge applied to land Sewerage sludge exceeds, cannot apply to land

PCL= Pollutant concentration limit Most stringent pollutant limit, ensure minimum quality of sewerage that can be applied on long-term basis"

*5: US EPA, Surface Disposal Unit boundary to property line 0 m ~ less than 25 m, https://www.ecfr.gov/current/title-40/chapter-I/subchapter-O/part-503

Source: Created by JET based on above references

APPENDIX 10-1 Minutes of Meeting on JCC

(1) Final JCC on August 6th, 2024

Minutes of Meetings
on
The Fifth Joint Coordinating Committee
For
Project for Formulation of Wastewater Treatment Master Plan in Western Division (2nd Phase)
Agreed upon between
Ministry of Public Works, Meteorological Services and Transport
and
Water Authority of Fiji
and
Japan International Cooperation Agency

The Final Joint Coordinating Committee (hereinafter referred to as "JCC") for the Project for Formulation of Wastewater Treatment Master Plan in Western Division (2nd Phase) (hereinafter referred to as "the Project") was convened on 6th August 2024 by the chairperson of the JCC and others.
As a result of the discussions, both sides understood and agreed upon on the matters referred to in the document attached hereto.

Suva, August 6th, 2024

Mr. Paula BALEILEVUKA
Permanent Secretary
Ministry of Public Works,
Meteorological Services and Transport

Mr. Seru SODERBERG
Chief Operating Officer
Water Authority of Fiji

若杉 聡

Mr. Satoshi WAKASUGI
Resident Representative
JICA Fiji Office

中嶋 宣信

Mr. Yoshinobu NAKAJIMA
Team Leader
JICA Expert Team

1

ATTACHED DOCUMENTS

1. Selection of the Priority Projects for Pre-F/S
The JICA Expert Team (hereinafter referred to as "JET") presented three case options for the Pre-F/S target projects.

Case	Target Area	Project Components
Case-1	Natabua	Upgrading of Natabua WWTP, ocean outfall pipe, septage treatment facilities, expansion of sewer networks and construction of pumping stations
Case-2	Navakai	Upgrading of Navakai WWTP, rehabilitation of main trunk, expansion of sewer networks and construction of pumping stations
Case-3	Natabua	Upgrading of Natabua WWTP, Ocean outfall pipe, Septage treatment facilities
	Navakai	Upgrading of Navakai WWTP

JET proposed to select Case-3 due to its high priority in terms of efficiency (cost per pollutant load removal), as well as meeting legal compliance for effluent quality. JCC had no objections to it.

2. Planning Basis and Design Conditions
JET explained that the design flow in Phase 1 is 29,600m³/day for Natabua WWTP (75% of the total treatment capacity), and 19,700m³/day for Navakai WWTP (66% of the total treatment capacity). JCC had no objections to it.

3. Natabua WWTP
JET presented the completed view layout of Natabua WWTP and explained the hydraulic loads, basin numbers and shapes of its main facilities. JCC had no objections to it.

4. Navakai WWTP
JET explained the completed layout view and alternative layout view (relocation of existing WAF and FRA depots) of Navakai WWTP, and explained the hydraulic loads, basin numbers and shapes of its main facilities. JET also explained the mechanical and electrical facilities (including odor control facilities) planned to be adopted in the WWTP. JCC had no objections to it.

5. Environmental and Social Considerations
JET summarized the key environmental and social effects of the WWTPs as follows:

[Natabua WWTP]
WWTP site expansions will require much mangrove removal; associated regulations were checked for potential methods to mitigate environmental impacts. The resettlement of a nearby informal settlement was concluded as inevitable, and considerations should relocation sites/alternative livelihoods due to poverty level of residents.

[Navakai WWTP]
Discharge of treated water to Nadi River is a concern for riverside communities due to possible impacts on livelihoods and coastal mangroves. ITaukei lands close to WWTP must be secured for sludge drying/storage space. The consideration of land availability will need to continue to be given careful attention for expansion of Navakai WWTP. JCC had no objections to it.

6. Implementation Schedule
JET explained the implementation schedule of the upgrading projects of Navakai WWTP and Natabua WWTP. The upgraded facilities are planned to start operation in 2033 for Navakai WWTP, and 2037 for Natabua WWTP. JCC had no objections to it.

7. Cost Estimation
JET explained the setting conditions for project cost estimations. The estimated construction cost was 232 million FJ$ for Natabua WWTP, and 133 million FJ$ for Navakai WWTP. JET also presented the estimated amounts of loan portion and Fijian portion (government overhead) when applying international funds. JCC had no objection to it.

8. Project Effect
JET first explained the target values for project effect indicators, such as effluent quality and daily average flowrate for Natabua WWTP and Navakai WWTP. JET indicated that the financial IRR is -2.8% at the current tariff of 0.20FJ\$/m^3, and that 0.70FJ\$/m^3 is necessary to cover the O&M expenses. For the economical IRR, JET indicated EIRR is 9.0% in the Pre-F/S stage considering additional benefit of maintaining tourism income through environmental protection. JCC had no objections to it.

9. Conclusion and Recommendation
In conclusion, JET explained the following four items.
- ✓ This priority project will properly treat wastewater and contribute to meet compliance for effluent standard
- ✓ Priority project is economically viable

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- ✓ Projects are in line with Fiji's National Development Plan
- ✓ Project impacts will be sustainable through securement of O&M budget and structure

For recommendation, JET explained the following seven items.

- ✓ Consultation for secure the WWTP site
- ✓ Formulation of the effective sludge utilization and disposal plan
- ✓ Water quality impacts on the discharge ocean area in the Feasibility Study
- ✓ Additional soil surveys during the Feasibility Study
- ✓ Septage treatment for regions outside of the planned service area
- ✓ Secure the O&M Budget
- ✓ Organizational Structure on O&M

10. Other Items Discussed

- ✓ The MoF's update of the National Development Plan is close to cabinet approval, with the target year set at 2040. The revised NDP's chapter for the wastewater sector is referring to the Master Plan by this project
- ✓ The launch of the Master Plans formulated in this project is proposed by JICA.
- ✓ WAF mentioned that it will be difficult to achieve 70% access by 2036 as the existing coverage is in the 20% range.
- ✓ WAF asked about the possibility of JICA co-financing with other donors for the WWTP upgrading project, and JICA explained that Climate Change Center to facilitate GCF access is going on.
- ✓ As part of efforts to reduce sludge disposal, WAF is in discussions to use dried sludge as a fertilizer. Direct application is currently not recommended by the DOE due to the high iron content in the sludge. A Memorandum of Understanding (MOU) is currently being drafted with the Ministry of Agriculture for future works.

ANNEX 1: Presentation material for Project for Formulation of Wastewater Treatment Master Plan in Western Division (2nd Phase), August 6th, 2024, JICA Expert Team

ANNEX 1

Project for Formulation of Wastewater Treatment Master Plan in Western Division (2nd Phase)

Joint Coordination Committee (Final)

6th August 2024

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
Nihon Suido Consultants Co., Ltd.
Yachiyo Engineering Co., Ltd.

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Table of Contents

1. Welcome and Introduction
2. Opening remarks form WAF
3. Opening remarks form JICA Fiji Office
4. Background and Previous Outcomes
5. Summary of the Pre-F/S
6. Discussion/ Q&A
7. Closing Remarks

Main Purpose of 5th JCC
To get basic approval above item 5

2

1. Welcome and Introduction

2. Opening remark from WAF

Mr. Seru Soderberg — Chief Operating Officer, Water Authority of Fiji

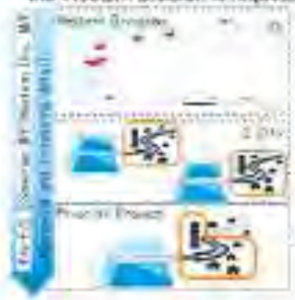
3. Opening remark from JICA Fiji Office

Mr. Wakasugi Satoshi — Resident representative, JICA Fiji Office

3

4. Background and Previous Outcomes

1. Background and Introduction
✓ Strategic improvement of the sewerage infrastructure in the Western Division is requested



- Regional Wastewater M/P in whole Western Division
- Municipal Sewerage M/P for Priority Cities
- Pre-F/S for the Priority Projects

4

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ANNEX 1

4. Background and Previous Outcomes

2. Target Area

5

4. Background and Previous Outcomes

3. Outline of the Project

Output 1: Regional Wastewater M/P that includes centralized and decentralized wastewater treatment systems for the Western Division of Viti Levu Island of Fiji (Wastewater treatment Master Plan in Western Division) will be formulated.

Output 2: Municipal Sewerage M/P in priority cities and/or towns identified in the Regional Wastewater M/P will be formulated. (2 cities)

Output 3: Pre-F/S including sludge management for priority sewerage project(s) selected in the Municipal Sewerage M/P will be conducted.

Output 4: Capacity on sewerage management of WAF and relevant agencies will be strengthened.

Overall objective
- Encourage treatment capacity improvement and facility expansion
- Contribute to improvement of sanitation and water environment

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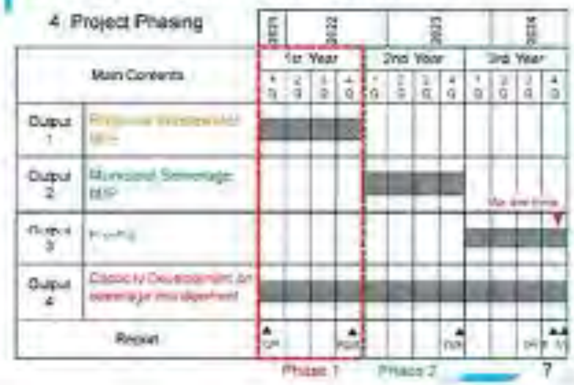
4. Background and Previous Outcomes

4. Project Phasing



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4. Background and Previous Outcomes

Summary of the 1st Year: Regional Wastewater M/P

- ✓ Wastewater Treatment Master Plan to achieve the National Development Plan (NDP) of "70% population of centralized treatment access in 2036"
- ✓ Targeting six municipalities in the Western Division (Lautoka, Nadi, Ba, Tavua, Rakiraki and Sigatoka)
- ✓ Setting sewerage area to achieve 70% access for the future projected population in 2036 (266,000/380,000 persons)
- ✓ Set priorities for sewerage system development
- ✓ Alternatives to achieve 70%, including decentralized treatment of septic tank sludge
- ✓ Minute of Meetings on 3rd JCC on September 19th 2022

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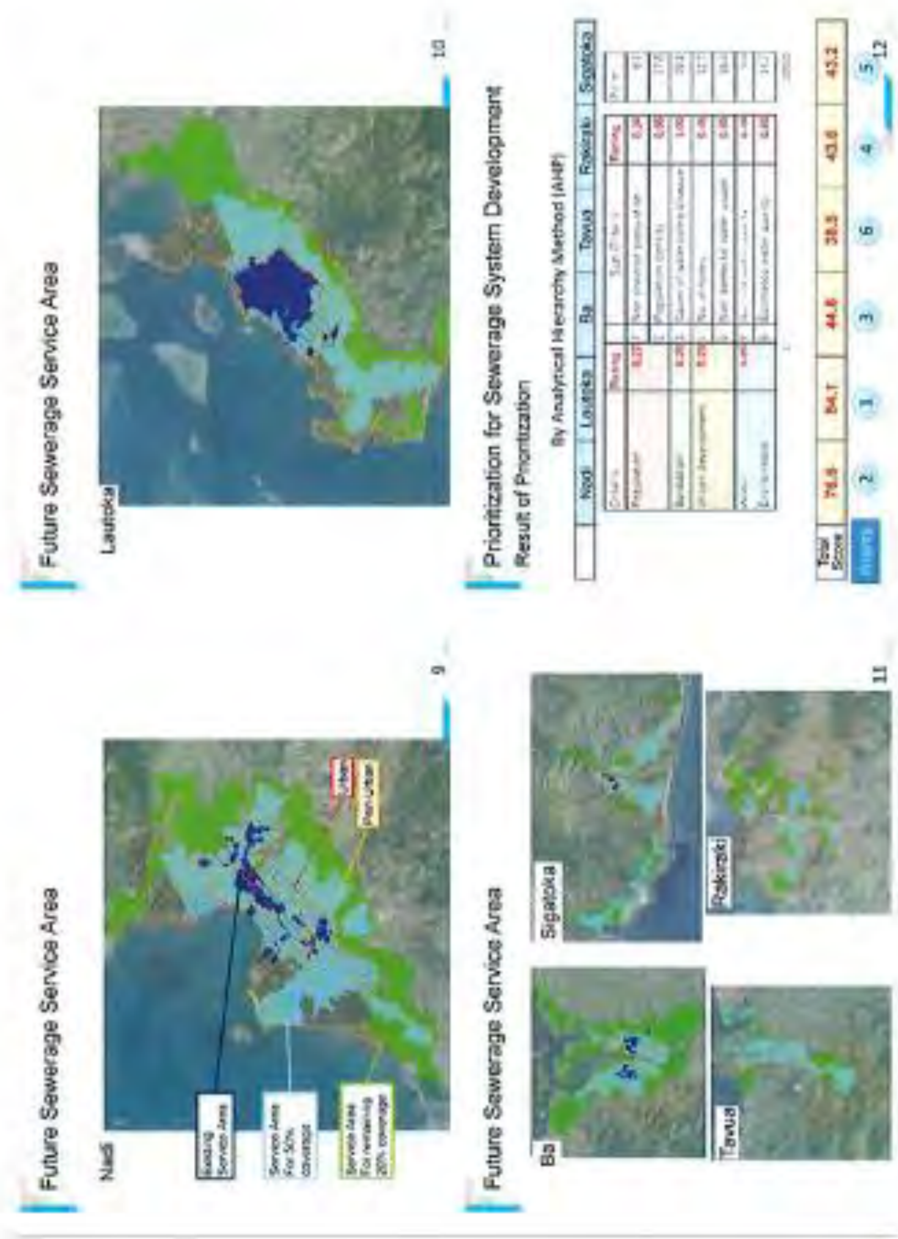
ANNEX 1


Future Sewerage Service Area
Nadi
Existing Service Area
Service Area For 50% coverage
Service Area For remaining 20% coverage
Urban
Peri-Urban
9
Future Sewerage Service Area
Lautoka
10
Future Sewerage Service Area
Ba
Sigatoka
Tavua
Rakiraki
11
Prioritization for Sewerage System Development
Result of Prioritization
By Analytical Hierarchy Method (AHP)
Nadi
Lautoka
Ba
Tavua
Rakiraki
Sigatoka
Total Score
76.6
84.1
44.6
38.5
43.6
43.2
Priority
2
1
3
6
4
5
12

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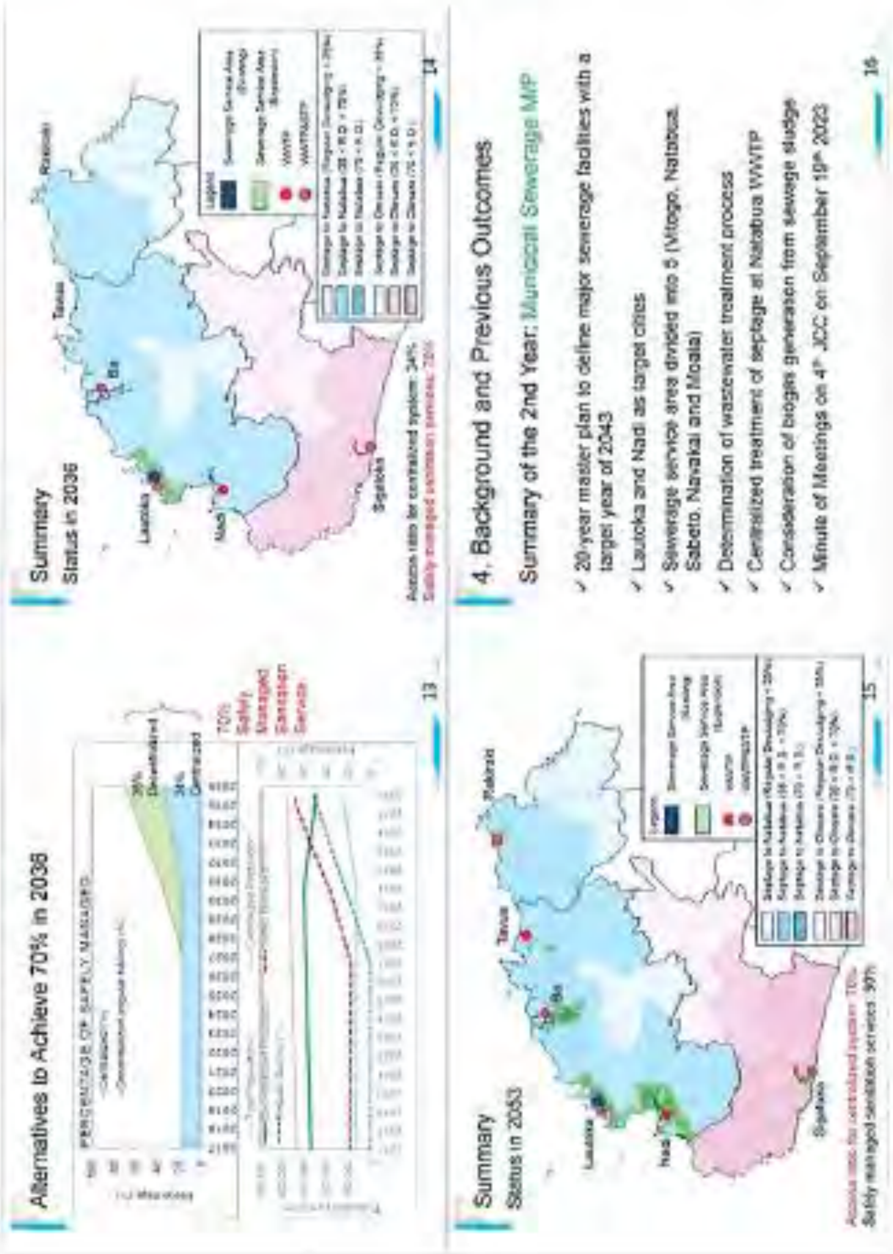
ANNEX 1


Alternatives to Achieve 70% in 2036
35% Decentralized
35% Centralized
70% Safely Managed Sanitation Service
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Summary
Status in 2036
Lautoka
Nadi
Ba
Tavua
Rakiraki
Sigatoka
Access ratio for centralized system: 34%
Safely managed sanitation services: 70%
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Summary
Status in 2053
Lautoka
Nadi
Ba
Tavua
Rakiraki
Sigatoka
Access ratio for centralized system: 70%
Safely managed sanitation services: 90%
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4. Background and Previous Outcomes
Summary of the 2nd Year: Municipal Sewerage M/P
✓ 20-year master plan to define major sewerage facilities with a target year of 2043
✓ Lautoka and Nadi as target cities
✓ Sewerage service area divided into 5 (Vitogo, Natabua, Sabeto, Navakai and Moala)
✓ Determination of wastewater treatment process
✓ Centralized treatment of septage at Natabua WWTP
✓ Consideration of biogas generation from sewage sludge
✓ Minute of Meetings on 4th JCC on September 19th 2023
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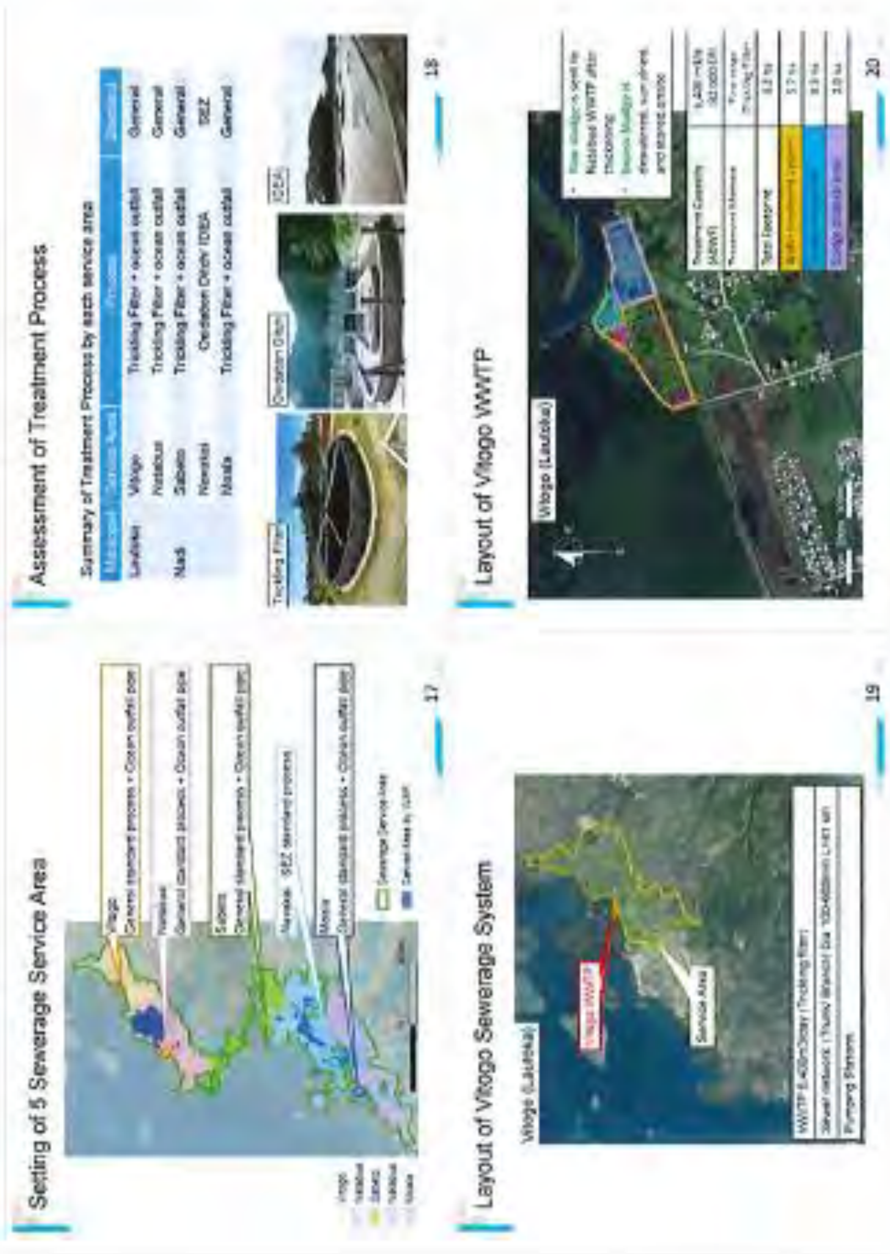
ANNEX 1


Setting of 5 Sewerage Service Area
Vitogo
General standard process + Ocean outfall pipe
Natabua
General standard process + Ocean outfall pipe
Sabeto
General standard process + Ocean outfall pipe
Navakai SEZ standard process
Moala
General standard process + Ocean outfall pipe
17
Assessment of Treatment Process
Summary of Treatment Process by each service area
Lautoka
Vitogo
Tricking Filter + ocean outfall
General
Natabua
Tricking Filter + ocean outfall
General
Nadi
Sabeto
Tricking Filter + ocean outfall
General
Navakai
Oxidation Ditch/ IDEA
SEZ
Moala
Tricking Filter + ocean outfall
General
Tricking Filter
Oxidation Ditch
IDEA
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Layout of Vitogo Sewerage System
Vitogo (Lautoka)
Vitogo WWTP
Service Area
Pumping Stations
19
Layout of Vitogo WWTP
Vitogo (Lautoka)
Total Footprint
20

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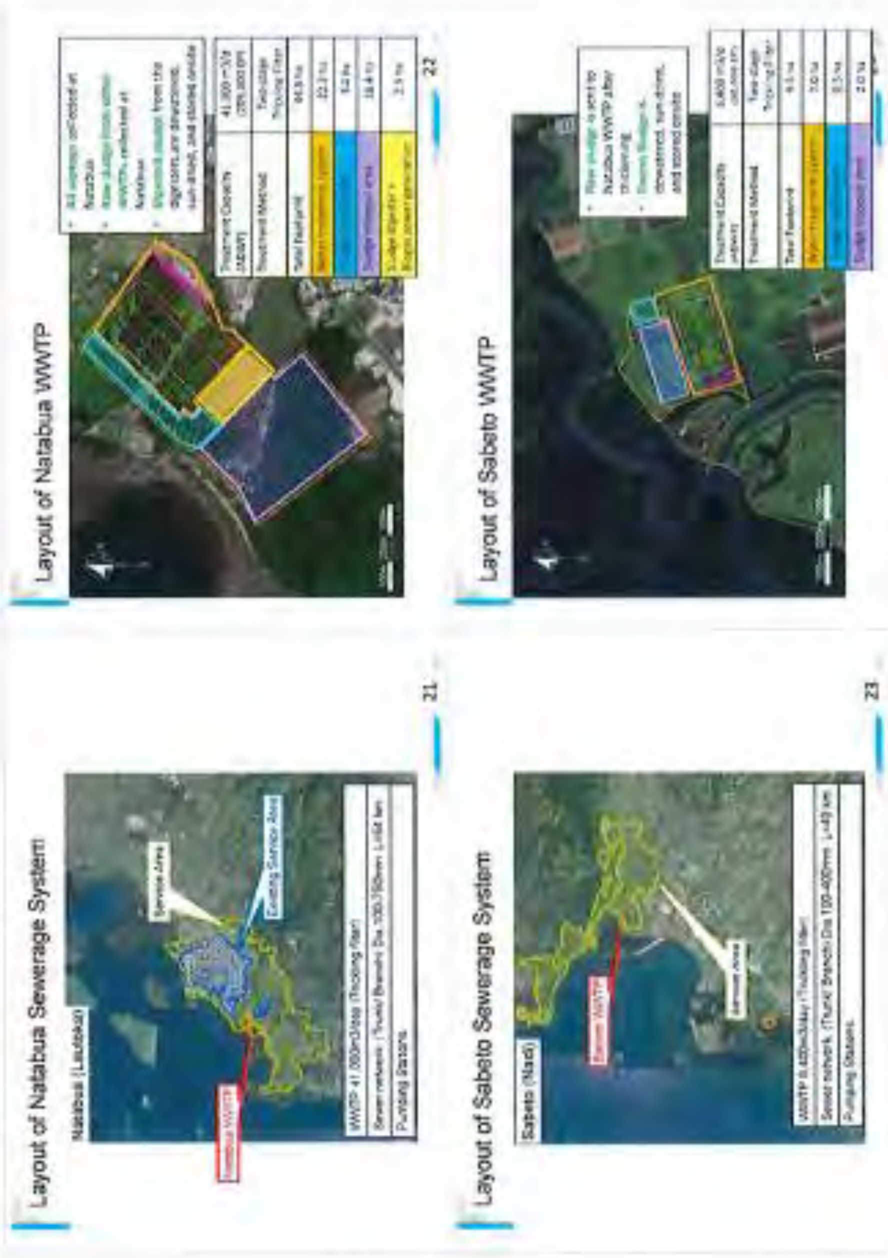
ANNEX 1


Layout of Natabua Sewerage System
21
Layout of Natabua WWTP
22
Layout of Sabeto Sewerage System
23
Layout of Sabeto WWTP

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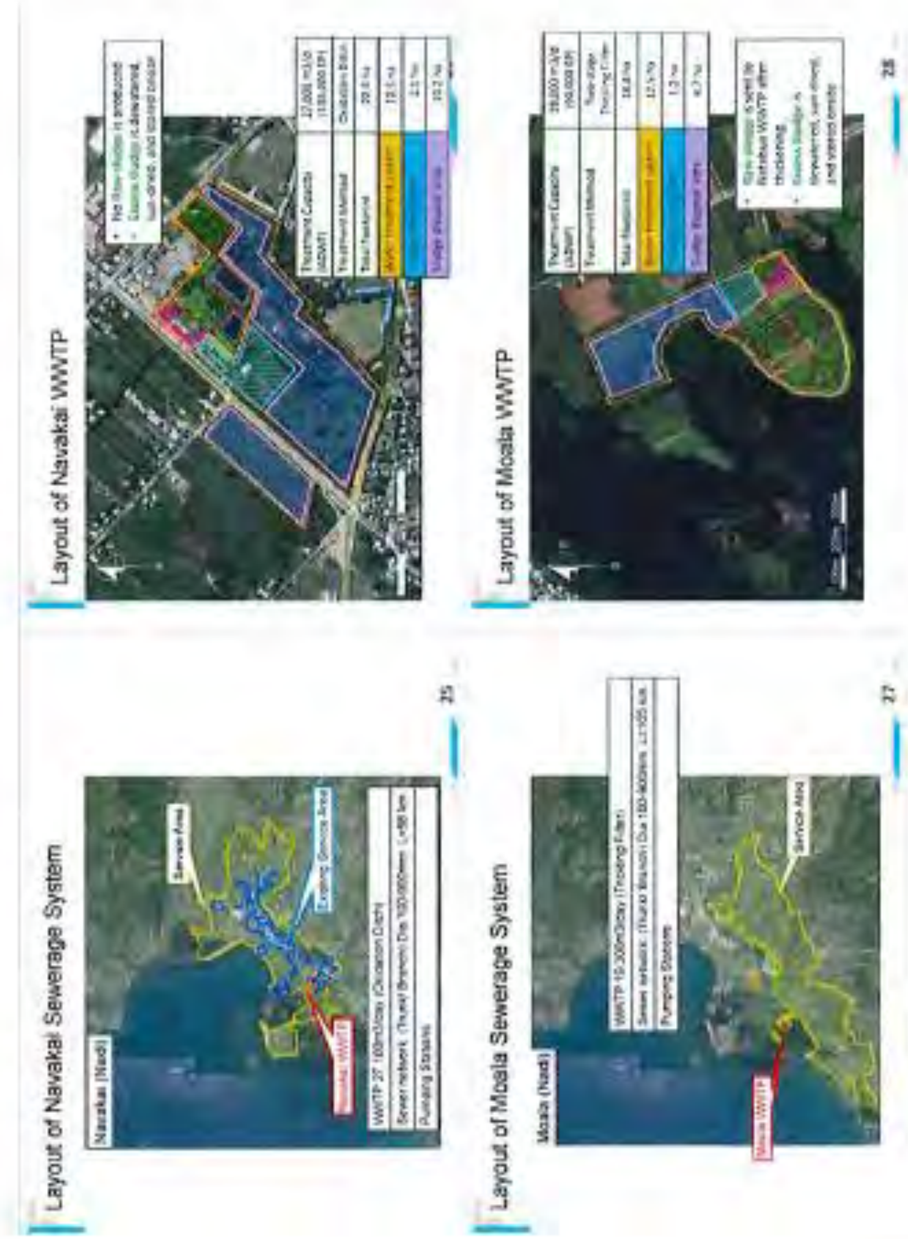
ANNEX 1


Layout of Navakai Sewerage System
Layout of Navakai WWTP
Layout of Moala Sewerage System
Layout of Moala WWTP
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ANNEX 1

Decentralized System

Option Service Assessment

- ✓ 2 cases are considered to evaluate the efficiency of Septage Treatment

Case 1	Case 2
Centralized STP at Natabua	Decentralized STP at Vitogo & Moala

STP: Septage Treatment Plant

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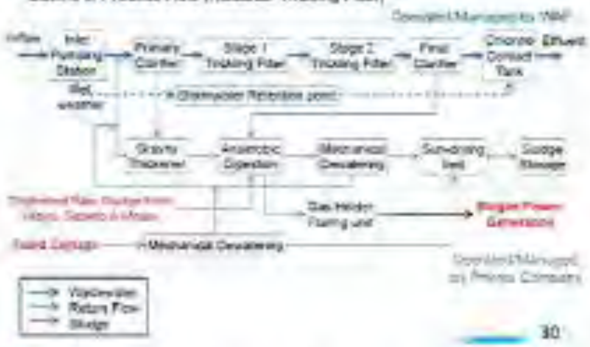
Centralized System

Sludge Reuse

Outline of Process Flow (Natabua: Trickling Filter)



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4. Background and Previous Outcomes

Summary of the Capacity Strengthening

- ✓ 9 Online trainings with the cooperation of Fukuoka City.
- ✓ As part of OJT, an On-site lecture was given on how to conduct a Transparency test at the Navakai WWTP.
- ✓ Japan Visit Program provided the knowledge and information on sewerage works with participants (MPW, WAF, MOF, DOE and MoLG)

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WEB Trainings by Fukuoka City

- ✓ 9 Online Trainings with assistance from Fukuoka City.

	Training Program	Date
1	Sewerage Business Operation	2022/April/20
2	Sewerage Planning	2022/Jul/13
3	Sewerage Pipeline Design	2022/July/19
4	Wastewater Treatment Plant Design (Mechanical, Electrical, Civil Works)	2022/July/28
5	Wastewater Treatment / Sludge Treatment Technology	2022/Nov/24
6	Pipeline Maintenance and Management	2023/Apr/24
7	Mechanical and Electrical Equipment Maintenance	2023/Apr/25
8	Regulation of Industrial Wastewater Discharge	2023/Jul/25
9	Project Management	2024/ May/23

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ANNEX 1

OJT Training in Navakai WWTP

- November 9th 2023 in Navakai WWTP
- Lecture for measurement of transparency & SV
- OJT for measurement of effluent transparency at the discharge point

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Japan Visit Program (Dec. 8th 2023/ 2weeks)

- Participants visited the facilities listed below and had discussions with Fukuoka City.
  - 5 WWTPs
  - Sewage pipe rehabilitation site
  - Sewage pipe cleaning site
  - Sewage public-awareness facility
  - Johkasou education center

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5. Summary of the Pre-FS

Draft Contents of Pre-F/S

- 5-1. Selection of the Priority Projects for Pre-F/S
- 5-2. Planning Basis and Design Conditions
- 5-3. Natabua WWTP
- 5-4. Navakai WWTP
- 5-5. Environmental and Social Considerations
- 5-6. Implementation Schedule
- 5-7. Cost Estimation
- 5-8. Project Effect
- 5-9. Conclusion and Recommendations

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5-1. Selection of the Priority Projects for Pre-F/S

(1) Outline of Municipal Sewerage M/P

WWTP	Outline of Facilities		[illegible]
[illegible]	WWTP	Trickling Filter (Q=[illegible] m³/day)	130
	Sewer	Dia 100-[illegible]mm L=[illegible] km	75
	P/S	12 pumping stations	30
Natabua	WWTP	Trickling Filter (Q=44,[illegible] m³/day)	401
	STP	Mechanical dewatering	11
	Sewer	Dia 100-750mm L=[illegible] km	82
	P/S	30 pumping stations	24
[illegible]	WWTP	Trickling Filter (Q=[illegible] m³/day)	130
	Sewer	Dia 100-[illegible]mm L=[illegible] km	120
	P/S	[illegible] pumping stations	27
Navakai	WWTP	OD (Q=29,[illegible] m³/day)	312
	Sewer	Dia 100-[illegible]mm L=[illegible] km	94
	P/S	37 pumping stations	28
[illegible]	WWTP	Trickling Filter (Q=19,[illegible] m³/day)	271
	Sewer	Dia 100-[illegible]mm L=155 km	161
	P/S	[illegible] pumping stations	58

Sewer includes Trunk and Branch only

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ANNEX 1

5-1. Selection of the Priority Projects for Pre-F/S

(2) Service area to be focused

- Natabua and Navakai have many residential area, and high commercial economic zone exist.
- Viogo, Sabeto and Moala is still developing area.
- Area-wised selection, Natabua and Navakai service area have high priority for sewerage development.

- Priority project is selected from the components of Natabua or Navakai.

5-1. Selection of the Priority Projects for Pre-F/S

(3) Selection of the Priority Projects for Pre-F/S

[illegible]	[illegible]	Components
Case 1	Natabua	WWTP 21,000m³/day (Trickling filter 1/2) Ocean Outfall (rem. Sewage Treatment)
		Sewer network (Trunk/ Branch) L=64 km, Pumping Stations
Case 2	Navakai	WWTP 13,500m³/day (OD Process: 1/2)
		Rehabilitation of Main trunk L=8.6km Sewer network (Trunk/ Branch) L=58km, Pumping Station
Case 3	Natabua	WWTP 21,000m³/day (Trickling filter 1/2) Ocean Outfall (rem. Sewage Treatment)
	Navakai	WWTP 13,500m³/day (OD Process: 1/2)

- Case 3, which involves upgrading both WWTPs, is a high priority in terms of efficiency (cost per removed pollutant load).
- Meet legal compliance for effluent quality from the existing WWTPs.
- Upgrading of both WWTPs is appropriate components as a priority project for Pre-F/S.

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5-2. Planning Basis and Design Conditions

(1) Target Area

✓ Natabua and Navakai Service Area

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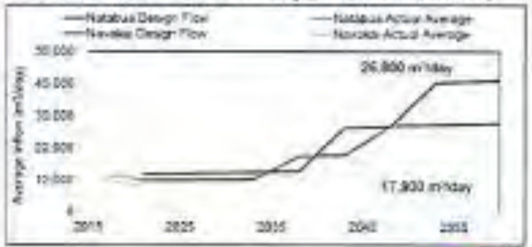
5-2. Planning Basis and Design Conditions

(2) Design Flow and Capacity for Phase 1

✓ Considering 2 step developments of both WWTPs
✓ Natabua WWTP: 29,600m³/day (75% of Ultimate flow)
✓ Navakai WWTP: 19,700 m³/day (88% of Ultimate flow)



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ANNEX 1


5-3. Natabua WWTP
Natabua WWTP
Completed View Layout
5-3. Natabua WWTP
5-4. Navakai WWTP
Navakai WWTP
Completed Layout View
5-4. Navakai WWTP(other option)
Navakai WWTP
Completed Layout View
(Alternative)

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ANNEX 1

5-4. Navakai WWTP

Facility	Load	Shape and Number of Basins
Sewerage Grit Chamber	Hydraulic Load 1,800m3/m2/d	3 chambers Rectangular, 3 m × 3.5 m
Stormwater Grit Chamber	Hydraulic Load 1,800m3/m2/d	3 chambers Rectangular, 3 m × 5 m
Oxidation Ditch Basin	HRT 21.4 hrs	4 basins Horseshoe Shape 4.5m × 282.5 m × 3.5m
Final Clarifier	Overflow Rate 9 m3/m2/d	4 basins Circular: Dia. 27 m
Disinfection Tank	Minimum Chlorine contact time 15 min	1 basin Rectangular: 3m × 380 m × 2 m
Stormwater Sedimentation Pond	HRT: 2.5 hrs	2 basin* Open cut, 43m × 91 m × 3.0 m Open cut, 35m × 54 m × 3.0 m

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5-4. Mechanical and Electrical Facilities

Considered in selecting M&E equipment:
Cost (initial /running cost); Ease of procurement in Fiji (or Australia, NZ)

- "**Belt-run automatic dust remover + residue dewaterer (biaxial screw type)**": highly efficient in combination with a dehydrator because of its high residue capturing performance and economic efficiency
- "**Submersible sewage pumps**": flood prevention measures/ maintainability/ economic efficiency/ track record
- "**Vertical water flow device + diffuser**" or "**submerged propeller + diffuser**": good equipment and maintenance costs/ tank width
- **Screw-type blowers:** thermal efficiency/ equipment cost/ maintenance cost/ installation space and weight.
- **Multiple plate screw press dehydrator:** not require a thickening process / Lowest cake moisture content/ Construction and maintenance costs
- **Diesel generators:** equipment and maintenance costs
- "**Activated carbon adsorption process**" and "**biological deodorization tower process**" for odor control facilities: easy maintenance / high deodorization efficiency/ ease of procurement

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5-4. Mechanical and Electrical Facilities

Odor Control Facilities

Treatment System	Wastewater Treatment System	Sludge Treatment System
Target Facilities	・Influent Pump Station (influent chamber, grit removal chamber, pump well)	・Sludge Receival Tank ・Sludge Dewatering Building
Odor Control Process	Activated carbon adsorption	Biological deodorization tower + Activated carbon adsorption

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5-4. Mechanical and Electrical Facilities

Load and Consumption of both WWTP

WWTP	Phase	Total Load (kW)	Operating Load (kW)	Daily Consumption (kWh/Day)	Annual Consumption (MWh/Day)
Navakai	Phase 1	[illegible]	[illegible]	[illegible]	[illegible]
	Phase 2	170.9	706	11,844	4,323
Natabua	Phase 1	[illegible]	[illegible]	[illegible]	[illegible]
	Phase 2	227.9	906	15,204	5,549

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ANNEX 1

5-5. Environmental and Social Considerations

Summary of Key Environmental and Social Effects: Natabua WWTP

- It would physically encroach heavily into the existing mangrove, and coastal wetland area. It is proposed to offset this by replanting mangroves in the periphery.
- The potential mitigation of impacts and the associated regulations (e.g., the Environmental Management Act (2005)), offset mitigation for the removal of vegetation (e.g., plant 8x the mangroves removed).
- When the social effects for Natabua are considered, resettlement of informal settlement is inevitable (approx. 18 households), with those required to be relocated are likely to be below the poverty line, so the area they are relocated to should have access to better services and considerations for their alternative livelihoods.

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5-5. Environmental and Social Considerations

Summary of Key Environmental and Social Effects: Navakai WWTP

- The informal community of Nagiroso and Taiperia Settlement and other local communities place significant value on the mangroves along the coast, that not only provides them with a source of gathering food and resources, but it also helps to mitigate some of the effects from sea level rise.
- The Nadi River is currently used as the discharge site, which is also a concern for the local village communities adjacent which include downstream villages.

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5-5. Environmental and Social Considerations

Summary of Key Environmental and Social Effects: Navakai WWTP

- The social effects for Navakai are similar but not as significant as the site in Natabua with regards to resettlement, with Fijian native land (iTaukei) Land needed for the sludge drying beds, and storage. These proposed sludge areas are adjacent to 3 schools, village extension area for settlement and future development plans, which may also have an impact. Land availability due to these pressures of development will be a significant issue for WAF in terms of Navakai WWTP's growth.

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5-5. Environmental and Social Considerations

- Individual stakeholder consultations between May and July 2024
- The final workshop on August 1 in Lautoka with 62 participants

1	Department of Environment
2	Department of Lands
3	Department of Town & Country Planning
4	Fiji Roads Authority
5	Provincial Office Ba
6	Nadi Town Council
7	Lautoka City Council
8	Taiperia & Nagiroso Settlement Leaders
9	[illegible]
10	Divisional Officer Nadi & Lautoka
11	TLTB Nadi
12	[illegible] Landowners (Navoci Village)
13	National Fire Authority
14	Airports Fiji Limited
15	Civil Aviation Authority of Fiji

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ANNEX 1

5-6. Implementation Schedule

✓ Operation of Upgraded WWTPs will start

Navakai WWTP: 2033

Natabua WWTP: 2037

Item \ Year	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Feasibility Study	■										
Selection of Consultant		■									
Detailed Design/Bidding document			■								
Bidding/ Evaluation				■							
Construction of Navakai WWTP					■	■	■				
Construction of Natabua WWTP								■	■	■	■

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5-7. Cost Estimation

(1) Construction Cost

	Component	Construction Cost (mil. FJD)
Natabua WWTP	WWTP 34,000m³/day (Trickling filter:75% capacity)	
	Civil facility	102
	Mechanical Equipment	44
	Electrical Equipment	29
	Ocean Outfall pipe	26
	Septage Treatment	31
	Total	232
Navakai WWTP	WWTP 20,000m³/day (OD Process: 67% capacity)	
	Civil facility	54
	Mechanical Equipment	43
	Electrical Equipment	19
	Outfall pipe	17
	Total	133

5-7. Cost Estimation

(2) Setting for estimation of Project Cost

No.	Item	Value
1	Exchange Rate (as of May 2024)	1USD=2.24FJD
		1USD=151.37JPY
		1FJD=67.55JPY
2	Price Escalation Rate (Foreign Currency)	2.7%
	Price Escalation Rate (Local Currency)	3.6%
3	Physical Contingency Rate	Construction:5%
		Consultant 10%
4	Value Added Tax (VAT)	15%
5	Import Tax	15%
6	Administration Cost	5%
7	Interest rate (Construction)	2%
	Interest rate (Consulting Service)	0.2%

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5-7. Cost Estimation

(3) Total Project Cost

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ANNEX 1

5-8. Project Effect

(1) Target Value of Indicators

	Indicator	Current (2023)	Target Value
Natabua WWTP	Effluent quality (mg/L)	BOD: 35, TSS: 27	BOD<40, TSS<60
	Effluent standard compliance rate (%)	BOD: 62.5% TSS: 87.5%	BOD: 100% TSS: 100%
	Daily average flowrate (m³/day)*	10,800	26,000
	Treated Population (people)	54,000	134,000
Navakai WWTP	Effluent quality (mg/L)	BOD: 60, TSS: 91	BOD<20, TSS<30
	Effluent standard compliance rate (%)	BOD: 40% TSS: 62.5%	BOD: 100% TSS: 100%
	Daily average flowrate (m³/day)*	8,800	17,900
	Treated Population (people)	44,000	89,000

* Estimated value from revenue water

Current treated population is estimated by dividing the inflow volume by unit water consumption of 200L/day/capita

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5-8. Project Effect

(2) Financial Analysis

- ❖ Financial & Economic Valuation of pre-F/S

Based on preliminary calculation of expenditure

- ➢ Financial IRR: Business return to WAF
  - Financial IRR = - 2.8% at tariff F$0.20/m³
  - Tariff F$0.70/m³ is necessary to cover O&M expense
- ➢ Rising tariff rate is necessary for business continuity

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5-8. Project Effect

(3) Economical Analysis

- ❖ Economic IRR: Economic Benefit to Fiji

Plan	Benefit	EIRR
M/P	- Willing to pay (WTP) for sewerage - Waiving cost for septic tank and maintenance and dredging sludge - Additional space by removing septic tank	1.5%
Pre-F/S	- WTP for environmental protection - Medical cost saving	Plus 0.5%
	- Maintaining tourism income through environmental protection	Plus 8.2%
	Total	9.0%

- ➢ 6.0% of ADB standard: Projects such as preventing environmental pollution, reducing poverty in rural areas etc.
- ➢ EIRR shows the priority project is economically viable.

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5-9. Conclusion and Recommendations

(1) Conclusion

- ✓ This priority project will properly treat wastewater and contribute to meet compliance for effluent standard
  - improving the water quality of the coastal area
  - allowing for the continued development of tourism
- ✓ Priority project is economically viable
- ✓ In line with Fiji's National Development Plan
- ✓ Project impacts will be sustainable through
  - Efforts to build O&M capacity
  - Securement of the O&M budget

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ANNEX 1

5-9. Conclusion and Recommendations

(2) Recommendations for F/S

1. Consultation for secure the WWTPs site
2. Formulation of the effective sludge utilization and disposal Plan
3. Water quality impacts on the discharge ocean area in the Feasibility Study
4. Additional soil surveys during the Feasibility Study
5. Seepage treatment for outside of the sewerage service area
6. Secure the O&M Budget
7. Organizational structure on O&M

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End of Explanation of
Summary of the Pre-Feasibility Study
for the Priority projects

Vinaka

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6. Q&A Session/ Discussion

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- ✓ The Draft Final Report (DFR) will be handed over by the JICA Fiji Office in mid-August.
- ✓ JET asked Fijian side to submit comments on the DFR within two weeks.
- ✓ JET will make modification based on the comments and submit the Final Report (FR) to JICA HQ.
- ✓ The FR will be sent from JICA HQ to the JICA Fiji Office, and shared with Fijian side.

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ANNEX 1


7. Closing Remark from MPW
Mr. Mohammed Nisar Khan
Director Water and Sewerage
Ministry of Public Works,
Meteorological Services and
Transport
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APPENDIX 10-2 Consideration of applying OD Process to Natabua WWTP

(1) MPW Comments

MINISTRY OF PUBLIC WORKS, METEOROLOGICAL SERVICES AND TRANSPORT

Nasilivata House
87 Ratu Mara Road, Samabula
Private Mail Bag, Suva, Fiji

Telephone : (679) 3384111
Website : www.mims.gov.fj

10th September, 2024

JICA Fiji Office
Level 8, Suva Central Buiding
Renwick Road
Suva
Fiji

Dear Mr.Hideaki Iwase

RE: FINAL DRAFT REPORT ON WASTEWATER MASTERPLAN FOR THE WESTERN DIVISION

Thank you for your submission of the above-mentioned report. The team has reviewed the reports and comments are listed below:

- Oxidation Ditch system would be a better treatment option compared to the trickling filters. The Department staff as part of the Technical Committee had seen similar system in Japan during the training workshop. This system is dual control and is very effective. The sludge is aerobic and there will be less odour from the plant considering the town vicinity. The major component is the Maezawa flow controller and the diffusers.
- According to our experience, oxidation ditches (Pasveer) had been very successful in Fiji and these could be further improved to MBBR system without much design change. The footprint will not change.
- The Trickling Filter will require a large footprint, and the coagulation and flocculation of the nutrients will be a burden on the chemical slag production. We would need storage space for the slag. While the Trickling filter has advantages if properly maintained, the primary and secondary clarifiers will have septic and denitrified sludge if not properly handled. This will be very odorous.
- The trickling filter media type is important because the plastic type is not very effective according to experience.

We thank JICA for the opportunity to be involved during the Project and the review of the Draft Final Report and look forward to hearing from you on the way forward for the Project.

Please feel free to contact Mr. Vishwa Jeet on email vishwa.jeet@moit.gov.fj or mobile 9708645 for further information.

Yours Sincerely,

M.N.KHAN
Director Water and Sewerage
For Permanent Secretary

(2) Response to MPW's comments dated on 10th September 2024

The Oxidation Ditch process and MBBR process are excellent wastewater treatment processes and the OD process was proposed for the Navakai WWTP in this project. However, the TF method was proposed for the other 4 WWTPs for the following reasons.

1. The selection of treatment process was considered with high-weighted on ease of maintenance and maintenance costs in the Municipal Sewerage M/P. The use of a treatment process that consumes much electricity such as the OD method, was limited to Navakai WWTP where the effluent standards are strict. And the TF method which consumes less electricity was proposed for the other WWTPs.

2. In the Municipal Sewerage M/P, the footprint of each process was also estimated that footprint of OD was about 80% of that of TF. OD was selected for Navakai WWTP, where it is difficult to extend the WWTP site around the existing site. Natabua WWTP has fewer restrictions than Navakai situation. And the other three WWTPs are new and candidate sites of WWTPs are considered to minimize the disturbance of urban development.
   The biggest problem with the land is not which process to be adopted. The problem is that there is no place to dispose of the treated dry sludge, so the on-site sludge storage must be planned in the WWTP site, and the first priority is to consider a plan for effective reuse/disposal of the sludge.

3. The TF process has a primary clarifier and produces raw sludge. Raw sludge is high in calories and it is possible to generate electricity from the digester gas produced by anaerobic digestion. This is in line with Fiji NET ZERO, which aims to reduce greenhouse gas emissions in the sewerage sector. In contrast, the sludge produced by the OD system is low in calories and it has been found that TF is better from an energy reuse perspective.

4. Regarding the filter media for TF process, the suitable media will be compared and selected in the F/S and detailed design. As for the selection of filter media, further discussion with your Ministry will be requested.

Of course, if the discharge standards for WWTPs are tightened in the future, it becomes necessary to comply with the standards for, the introduction of the OD method etc. will also have to be reconsidered.