SOLOMON ISLANDS WATER AUTHORITY

SOLOMON ISLANDS

BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR
IMPROVEMENT OF WATER SUPPLY SYSTEM
IN HONIARA AND AUKI
IN
SOLOMON ISLANDS

DECEMBER 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

Yachiyo Engineering Co., Ltd

PREFACE

In response to a request from the Government of the Solomon Islands, the Government of Japan decided to conduct a basic design study on the Project for Improvement of Water Supply System in Honiara and Auki in the Solomon Islands and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Solomon Islands a study team from 13th March to 4th May 2008.

The team held discussions with the officials concerned of the Government of the Solomon Islands and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Solomon Islands in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Arab Republic of Egypt for their close cooperation extended to the teams.

December, 2008

Masafumi Kuroki

Vice-President

Japan International Cooperation Agency

December 2008

LETTER OF TRANSMITTAL

We are pleased to submit to you the basic design study report on the Project for Improvement of Water Supply System in Honiara and Auki in the Solomon Islands.

This study was conducted by Yachiyo Engineering Co., Ltd., under a contract to JICA, during the period from February 2008 to December 2008. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Solomon Islands and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

Masahiro Takeuchi

Chief Consultant,

Basic Design Study Team on the Project for Improvement of Water Supply System in Honiara and Auki in the Solomon Islands

Yachiyo Engineering Co., Ltd.

SUMMARY

SUMMARY

The Solomon Islands is located to the northeast of Australia and consists of 6 main islands including Guadalcanal Island where Honiara City, the capital of Solomon Islands, is located and about 100 small islands. Area of the country is 29,785km^2 and the population in 2006 is about 530,000.

Climate of Solomon Islands belongs to the tropical rain forest climate. Annual precipitation for Honiara City (Guadalcanal Island) and Auki City (Malaita Island) which are the Project sites is about 1,900mm and about 3,100mm respectively. Annual average temperature is about 27 degree Celsius for both Honiara and Auki. Period having much precipitation differs from the region. Much rainfall is found between December and April for both Honiara and Auki.

GNI of Solomon Islands is USD590 in 2005 and it is considered as one of the least developed countries (LDC). Main industries are those related to primary articles such as marine products, wood, etc. and economy is mainly depending on these primary articles. Due to the aftermath of the ethnic tension occurred in 2000, Solomon Islands have been facing with much deficit in the economy.

There are few factories in Solomon Islands that can produce main industrial goods such as groceries, textile, machinery, petrochemical product, electrical appliance, etc. Therefore, prices of imported main products are as high as those of the developed countries. Especially, oil price has been raised by 50% in the half year from March to September 2008 due to the steep rise of the recent crude oil price. Accordingly, utility charges such as electricity and water supply have also been raised. In such sense, occurrence of economic turmoil has been concerned.

In Solomon Islands, the Government policy for formulating new national development plan has been announced as “Policy Statement” in January 2008 and the implementation plan based on the policy was formulated in February 2008 as “Translation and Implementation Framework”. In the implementation plan, securing safe and stable water supply for all the people in the country is set as a target. This Project aims at securing safe and stable water supply to the residents of Honiara City and Auki City as the capital and the provincial center of Solomon Islands. Therefore, this Project is considered as one of the necessary inputs for achieving the target of new national development plan.

Also, the Project was requested to the Japanese Government by the Solomon Islands side under the mid-term facility improvement plan (target year of 2010) which was prepared by the Solomon Islands Water Authority (SIWA) with assistance of development study by Japan International Cooperation Agency (JICA) in 2005. Therefore, the Project is positioned as the necessary component for completion of the above-mentioned plan.

In Honiara City, 59% of the water depends on the spring sources and 41% on the groundwater sources. At Konglai Spring which produces 45% of the water to Honiara, raw water intake volume has

been instable due to the frequent blockage at raw water inlets so called as "sinkholes" during heavy rain and flooding. Average daily water consumption in Honiara is usually 172 liter per capita per day (LCD). However, it falls down to 110 LCD during blockages which is 64% of the usual volume. Moreover, at Konglai Spring and Kombito Spring, water from these springs becomes unsuitable for drinking during and after heavy rain due to occurrence of high turbidity so that the residents are forced to use such water not satisfying drinking water quality standard.

In Honiara City, unserved area still exists and the current service ratio is 73%. Even if the areas have been served, water pressure is not enough. The existing distribution reservoirs are being deteriorated due to over usage against their service life and their capacities are not enough to meet the water demand during peak hours and in emergency cases. The capacity of the reservoirs is 5.7-hour volume of maximum daily water supply, which is less than half of 12-hour volume, the necessary volume for managing the peak-hour water demand and the emergency cases.

In Auki City, development of water sources is lagged behind and the residents are suffering from shortage of average daily water consumption per capita. 184 LCD is the average for other provincial centers, but 75 LCD is that of Auki City and they are forced to water rationing of only 4 hours a day.

Under these circumstances, the Solomon Islands Government had requested to the Japanese Government for implementing the project for improvement of water sources and water transmission/distribution facilities, construction of turbidity reduction facilities in Honiara City and development of new groundwater source in Auki City under the Japan's Grant Aid scheme.

In response to the request, the Japanese Government dispatched a preliminary study mission in August 2007 and confirmed that those contents are based on the mid-term facility improvement plan after examination of the contents of the requested project.

The Government of Japan confirmed appropriate contents of the requested project at the preliminary study stage and decided to conduct a basic design study for the Project. And JICA dispatched a basic design study team (the Team) to Solomon Islands from 13th March 2008 to 4th May 2008. During the field survey of the basic design study, the Team carried out discussions with the Solomon Islands Government and the related authorities such as SIWA, field survey of current conditions of the Project sites, and collection of the related data and information.

Based on the survey results, the Team confirmed the necessity of urgent improvement of water supply facilities in the Project sites and drafted the basic design including the Soft Component (or technical guidance) plan taking into account SIWA's capability for operation and maintenance.

Principles for the basic design of the facility improvement for the target year, summary of facility improvement plan and the contents of the Soft Component are described as follows:

[Main Parameters for Water Supply Improvement in Basic Design]

Parameter	2007	2010 (Target Year)	Remarks
[Honiara City]			
➢ Daily maximum water supply	25,685m^3/day	30,509m^3/day	
➢ Average water consumption	110 LCD	170 LCD	During blockage at Konglai Spring, ordinary water supply is secured.
➢ Service ratio	73%	83%	
➢ Occurrence of turbid water	18 times for Konglai 28 times for Kombito	Nil	Turbid water distribution in the network
➢ Low pressure area	25%	Nil	For population
[Auki City]			
➢ Daily maximum water supply	540m^3/day	1,106m^3/day	
➢ Average water consumption	75 LCD	170 LCD	
➢ Water supply hour	4 hours a day	24 hours a day	

[Plan and Specifications of Facilities for the Project]

Category	Facility Name	Components	Specifications
[Honiara City]			
Water source facility	Borehole facility	Borehole, submersible pump	Borehole: 16nos.(4 borefields x 4 bores/borefield) Submersible pump: 20 units. (1unit/bore x 4 bore/borefield x 4 borefields, stand-by 1 unit/borefield) Pumping capacity: 800m^3/day/unit Pump head: 65m - 85m
	Conveyance pipeline		5.4km, dia. 150mm, PVC
	Turbidity reduction facility	Settling basin, chlorine dozing equipment	Konglai spring: 4,100m^3/day Kombito spring: 1,600m^3/day
	Power receiving equipment	Power receiving equipment (low voltage)	2 sets (1 each for Konglai and Kombito springs)
	Improvement of spring intake facility	Screen	1 set for Rove spring
Water transmission facility	Water transmission pump station (PS)	Water transmission pump	4 stations (1 station per borefield) 1,600m^2/day x 2 unit (duty) per station 1 unit stand-by
		Water transmission pump house	4 houses (total floor area 132m^2/house, RC-made, 2-story)
		Disinfection facility	4 units (installed at each water transmission facility), Treatment cap.: 3,200m^3/day/unit
	Power receiving equipment (high voltage)	High voltage power receiving equipment, transformer	4 sets (installed at each water transmission facility)
	Emergency generator	Diesel engine generator	4 sets (installed at each water transmission facility)
	Water transmission main	Water transmission PS to distribution reservoir	4.1km, dia. 250mm
Water distribution facility	Distribution reservoir		5 reservoirs (Tasahe1,700m^3, Titinge1,300m^3, Lower West Kolaa450m^3, Skyline1,800m^3, Panatina2,100m^3)
	Water distribution main		22.9km, dia. 50mm - 200mm
[Auki City]			
Water source facility	Borehole facility	Borehole, submersible pump	Borehole: 2 nos. Submersible pump: 3 units (1 stand-by) Pumping capacity: 400m^3/day/unit Pump head: 105m
	Conveyance pipeline		0.4km, dia.150mm, PVC
	Emergency generator	Diesel engine generator	1 set
	Power receiving equipment	Power receiving equipment (low voltage)	1 set
	Associated civil & building works	Electrical house	1 house (total floor area 35m^2/house, RC-made, 1-story)

[Contents of Soft Component for the Project]

Item	Contents of the Soft Component
Understanding of water supply system	Class room training for learning water supply system from borehole facility to water transmission pump station and distribution reservoir
Learning operation & maintenance method for water supply facilities	Class room training and OJT for learning water quality and operation control methods of water sources, intake, water transmission & distribution and water supply to customers
Learning record & control and utilization method for water quality and quantity data	Class room training and OJT for learning sorting-out method of water quality and operation data for water sources, intake, water transmission & distribution and water supply to customers, and based on the data, learning water quality and operation control method

It is estimated that the Project implementation period will comprise approximately 4 months for the detail design, approximately 3.5 months for tendering work and selection of the Contractor, and approximately 21 months for construction of the facilities and approximately 1.5 months for the Soft Component.

Direct effects from the implementation of the Project are as follows:

[Honiara City]

(i) Served population for water supply will increase from 55,656 in 2007 to 71,685 in 2010.

(ii) Following units for water supply amount will increase:

- Maximum daily water supply will increase from 25,685m^3/day in 2007 to 30,509m^3/day in 2010.
- Daily average water consumption for domestic use will increase from 110LCD to 170LCD even during blockage of Konglai Spring.

(iii) 25% of the served area, where the water pressure becomes almost nil during the daily peak hours, will improve.

(iv) Capacity of distribution reservoir will increase from 5.7-hour volume (or 7,280m^3) to approx.12-hour volume (or 14,630m^3) of maximum daily water supply to meet peak demand during the day time and in emergency cases.

(v) Occurrence of high turbid water distribution to the network (18 times at Konglai Spring and 28 times at Kombito Spring) during and after heavy rain will disappear.

(vi) By implementation of the Soft Component, fundamental skills for appropriate operation and maintenance will be built in SIWA and this will enable SIWA to carry out a longer operation of the facilities constructed in the Project.

[Auki City]

(i) Following units for water supply amount are increased:

- Maximum daily water supply will increase from 540m^3/day in 2007 to 1,106m^3/day in 2010.
- Average daily water consumption for domestic use will increase from 75 LCD in 2007 which is

40% of that in other provincial centers to 170 LCD in 2010.

(ii) Water rationing for 4 hours will be improved to continuous 24-hour water supply.

Indirect effects from the implementation of the Project are as follows:

(i) Living standard of the residents in the target areas will be upgraded.

(ii) Reliance on SIWA by the residents in the target areas is enhanced and thereby, customers will increase and arrears of water charge will decrease.

SIWA has been making efforts to improve water supply services by revising water tariff, improving water charge collection ratio, renewing water distribution pipelines for reducing water leakage, recruiting new staff for UFW reduction activity, etc. based on the action plan formulated under JICA development study. As a result, the balance of SIWA's profit and loss statement became surplus in the fiscal year of 2007 even after excluding subsidy from the central government.

Annual operation and maintenance (O&M) cost of SIWA after completion of the Project is expected to be increased by SBD10.0 million. However, revenue from water sales will be increased by SBD10.3 million annually from the customers at expanded areas. Therefore, it is considered that expenses borne by the Project implementation can be covered by the increased water revenue.

For implementation of undertaking works by the Solomon Islands side for the Project, SIWA has been doing necessary procedures for securing the budget from the Solomon Islands Government through Ministry of Mines, Energy and Rural Electrification and Ministry of Development Planning and Aid Coordination.

However, for securing implementation of the Project and sustainable operation and maintenance, SIWA is required to tackle with the following matters:

- For smooth implementation of the Project and achievement of the Project purpose, SIWA is required to secure necessary budget for undertaking works by the Solomon Islands such as improvement of access roads to the facility construction sites, removal and relocation of underground utilities and obstacles, levelling of the sites, installation of branch distribution pipes and service pipes, etc., and carry out those works in accordance with the construction schedule by the Japanese Contractor.
- SIWA has basic skills for water quality analysis. However, they do not have water quality control system including daily water quality monitoring system and communication system when water quality exceeds its standard. They are required to establish water quality control system consisting of defining water quality items to be analyzed/frequency of analysis/sampling points, keeping and sorting-out of data, diagnosis for abnormal cases, procedures for taking actions in case of emergency, etc.
- It is assumed that unaccounted-for water (UFW) ratio accounts for about 40% in the water

supply service by SIWA according to JICA development study. Most part of UFW is from physical losses or water leakage in the water distribution network. In order to reduce such a high UFW ratio, SIWA is required to establish a leakage reduction unit or section by recruiting new staff in addition to the staff trained for leakage survey skills during JICA development study and conduct leakage reduction activity as a routine work.

When the Project is implemented under the Japan's Grant Aid scheme, even more safe and stable water supply will be provided to the residents in the Project sites and the Project may contribute to the stable economical and social development. Accordingly, the Project is deemed as highly significant and to have a high degree of viability.

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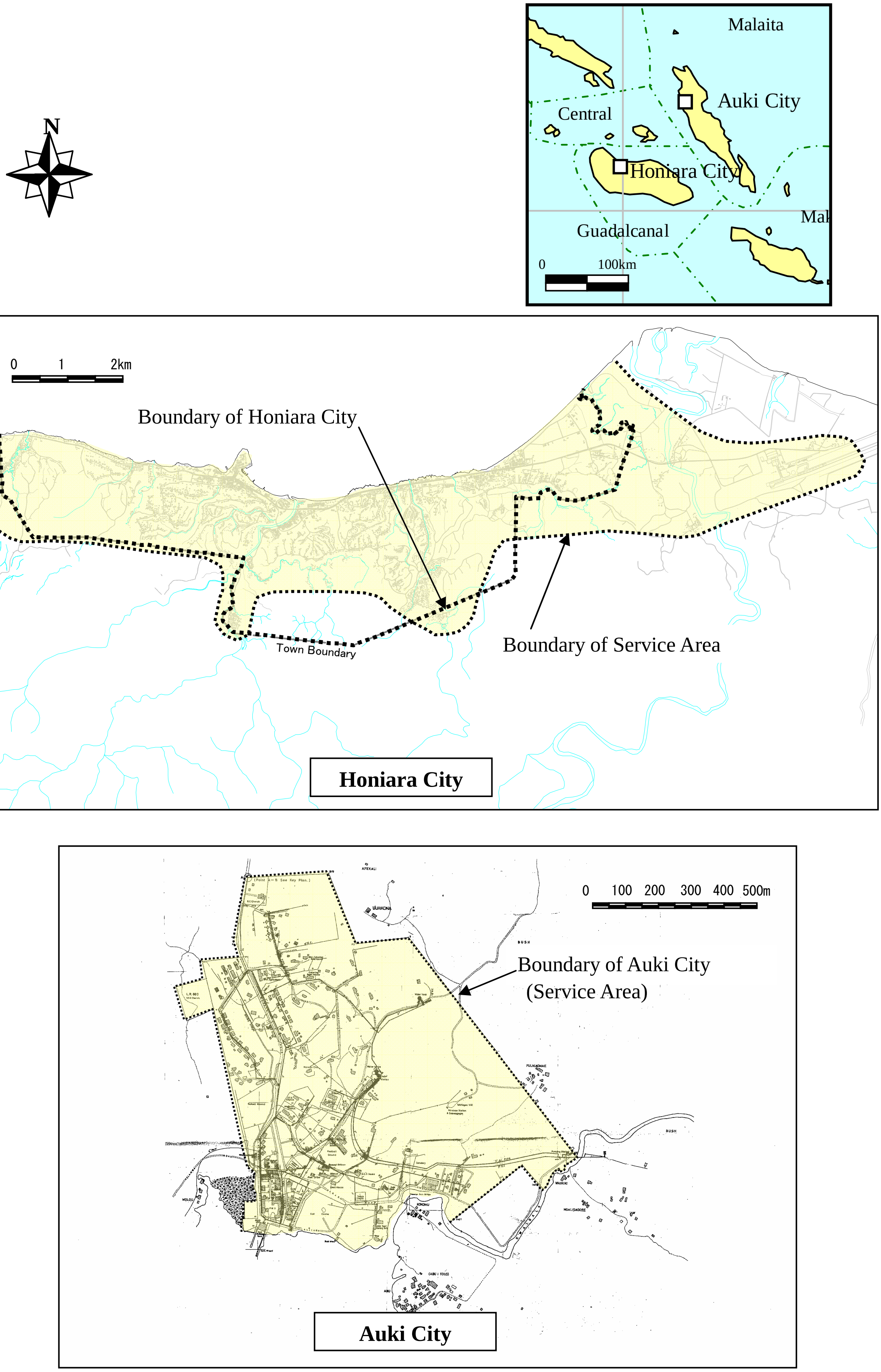
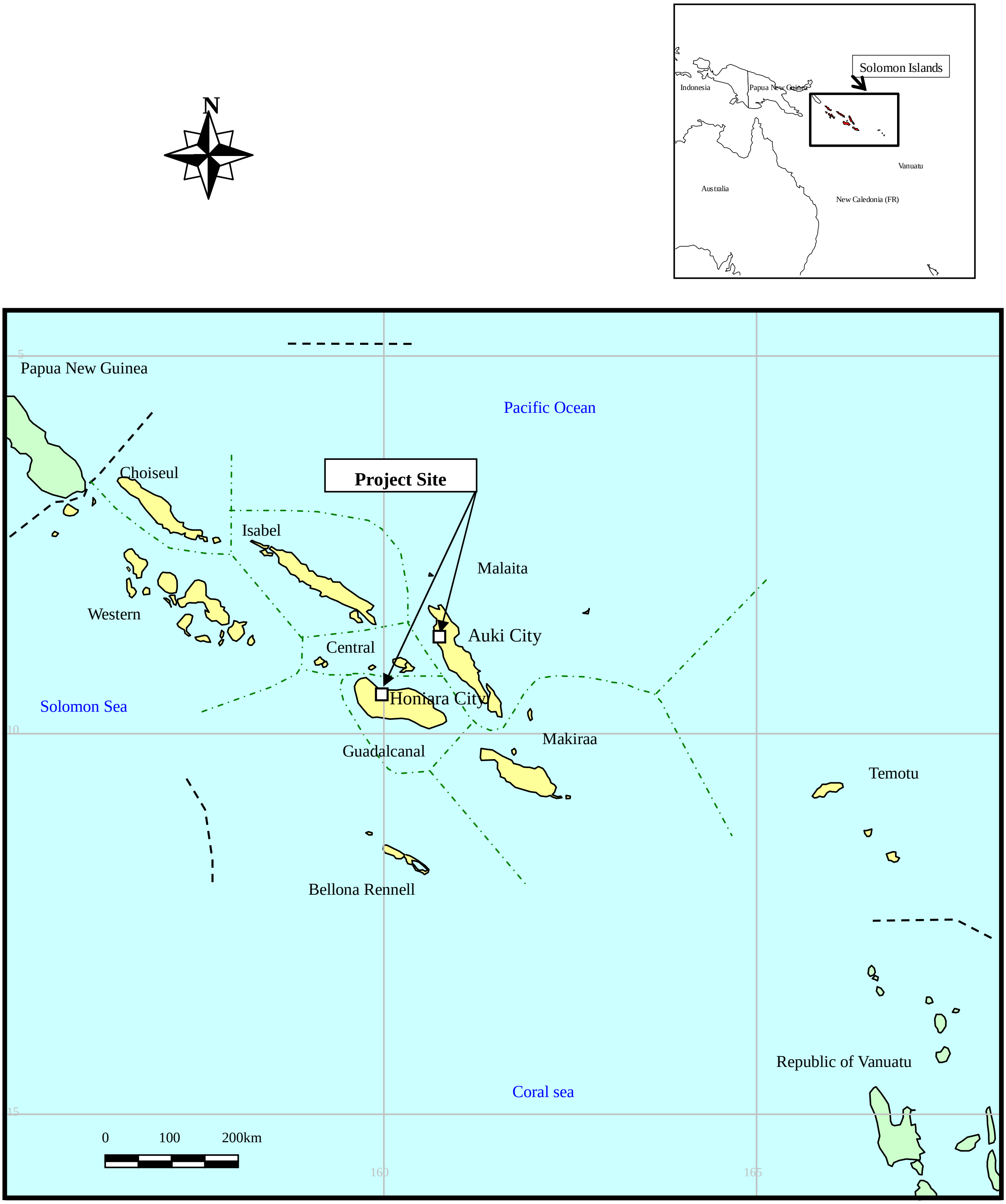
CHAPTER 3 PROJECT EVALUATION AND RECOMMENDATIONS

[Appendices]



Project Sites



Map of the Solomon Islands

The Perspective of This Project

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ABBREVIATIONS

[Organizations]

ADB	Asian Development Bank
AusAID	The Australian Agency for International Development
ECD	Environment & Conservation Department
JICA	Japan International Cooperation Agency
MMERE	Ministry of Mines, Energy and Rural Electrification
SIEA	Solomon Islands Electricity Authority
SIWA	Solomon Islands Water Authority
WHO	World Health Organization

[General]

AS/NZS	Australian – New Zealand Standard
BD	Basic Design
BOD	Biochemical Oxygen Demand
CI	Cast Iron pipe
COD	Chemical Oxygen Demand
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EL	Elevation
E/N	Exchange of Notes
EU	European Union
Fig.	Figure
FY	Fiscal Year (1st January – 31st December)
GI	Galvanized Iron pipe
GIS	Geological Information System
GL	Ground Level
GNI	Gross National Income
HIES	Household Income and Expenditure Survey
HWL	High Water Level
IEE	Initial Environmental Examination
IT	Information Technology
LDC	Least Developed Countries
LWL	Low Water Level
MIS	Management Information System
NRW	Non Revenue Water
O&M	Operation and Maintenance
PE	Polyethylene
PER	Public Environmental Report
pH	pH value
PVC	Polyvinyl Chloride pipe
RC	Reinforced Concrete
UFW	Unaccounted-for Water

[Unit]

%	Percentage
Ω-M	Ohm meter

[Unit]

Km	Kilometer
kV	Kilovolt
kVA	Kilovolt Ampere
kW	Kilowatt
kWh	Kilowatt hour
Hz	Hertz
L	Liter
LCD	Liter/capita/Day
J¥	Japanese Yen
m	Meter
m^2	Square meter
m^3	Cubic meter
Min	Minute
mm	Millimeter
No.	Number
NTU	Nephelometric Turbidity Unit
TCU	True Color Unit
SBD	Solomon Island Dollar
US$	U.S. Dollar
V	Volt

Exchange rate: US$1.0	= JPY106.07
SBD1.0	= JPY13.85

CHAPTER 1

BACKGROUND OF THE PROJECT

CHAPTER 1　BACKGROUND OF THE PROJECT

1-1　Background of the Requested Project

Honiara City, the capital of the Solomon Islands (hereinafter referred to as “Solomon Islands”), are facing with (i)unstable water intake volume at Konglai Spring, the main water source for the city, due to frequent blockages (the blockage occurred for 23 months in the past 12 years and the intake volume became as low as 110LCD during the blockage) of sinkholes which are inlet holes of raw water in the upstream water basin, (ii)existence of low pressure areas, (iii)inefficient water distribution system, (iv)inadequate pipeline diameters, (v)lack of distribution reservoir capacity and its deterioration from usage over service life, (vi)occurrence of high turbidity in the spring water during heavy rain and (vii)relatively high unserved ratio for water supply.

In Auki City, one of the provincial centers of the country, owing to the rehabilitation project for water supply facilities by the assistance of ADB which has been completed in September 2008, the water transmission and distribution facilities were improved. However, water source volume of the existing spring source can not meet the water demand of the customers in the city. Water for domestic use is much less than the satisfactory level because the customers of Auki city can receive water for only 4 hours a day and the average water consumption per capita is 75LCD in 2007 or only 40% of other provincial centers.

In order to improve the above-mentioned situation, the Government of the Solomon Islands requested the Japanese Government for implementation of the project for improvement of water supply system in Honiara City and Auki City by the Japan’s Grant Aid based on the results of JICA development study conducted in 2005-2006.

The request was submitted in August 2005 (hereinafter referred to as “the Original Request”) to the Japanese Government. However, the Original Request has been revised during JICA preliminary study in August 2007 and at the early stage of JICA basic design study in March 2008 as follows:

(1)　Stage of the Original Request (August 2005)

The Original Request was submitted to the Japanese Government by the Solomon Islands Government at the preparation stage of Interim Report of JICA development study. Following that stage, further study was carried out and a mid-term facility improvement plan for the target year of 2010 was formulated.

(2)　Stage of JICA Preliminary Study (August 2007)

During the preliminary study conducted in August 2007 Solomon Islands side requested the

Japanese side to revise the requested contents to those of mid-term facility improvement plan and the Japanese side agreed to their request for the change. Also, after several discussions during the preliminary study, both sides agreed to modify the requested contents as shown in Table 1-1-1[1].

(3) Early Stage of Basic Design Study (March 2008)

At the early stage of Basic Design Study, the requested component of borehole facility in Auki has been revised from the preliminary study stage.

The changes of the requested components as mentioned above are summarized in Table 1-1-1.

The requested components have been studied through the analysis in Japan based on the results of field survey and the optimum size and specifications for the facilities have been finalized. The results of the Basic Design Study are as indicated in Table 2-1-1 “Plan and Specifications of Facilities for the Project” and Table 2-1-2 “Contents of Soft Components for the Project”.

[1] Unless otherwise mentioned in this report, all the tables and figures have been prepared by the Basic Design Study Team based on the collected data and information in the field survey for the basic design conducted from March to May 2008.

Table 1-1-1 Changes occurred from the Original Request to the Early Stage of Basic Design Study

No.	Component	Original Request (August 2005)	Preliminary Study (August 2007)	At Signing of MD for Basic Design Study (19th March 2008)
A. Honiara City				
1	Borehole facilities			
	(1) Drilling borehole	13nos., 100m in depth	16 nos., 100m in depth	16 nos., 100m in depth
	(2) Supply of borehole pump	17nos., 800m^3/day x 50m head	20 nos., 800m^3/day x Head 50m	20 nos., 800m^3/day x Head 45m
	(3) Conveyance pipeline	150mm PVC x 5km	150mm PVC x 6.2km	150mm PVC x 6.2km
	(4) Collector tank	4 tanks (3 tank x 100m^3, 1 tank x 150m^3)	4 tanks (3 tanks x 100m^3、1 tank x 150m^3)	4 tanks (3 tanks x 100m^3、1 tank x 150m^3)
	(5) Layin of high-voltage cable	5,000m	Not applicable (Deleted from the Request)	Not applicable
	(6) Emergency generator	Not applicable	4 nos.	4 nos.
2	Disinfection & turbidity reduction facility			
	(1) Disinfection facility	7 nos., 2,900 to 4,400m^3/day	7 nos., 2,400～4,400m^3/day	7 nos., 2,400～4,400m^3/day
	(2) Turbidity reduction facility	3 nos., 2,000 to 4,300m^3/day	3 nos., 2,000～4,300m^3/day	3 nos., 2,000～4,300m^3/day
3	Water transmission pump facility			
	(1) Tasahe new borefield	3 nos., 1,200m^3/day/no. x Head 80m	3 nos., 1,600m^3/day x Head 80m	3 nos., 1,600m^3/day x Head 80m
	(2) Titinge new borefield	3 nos., 1,600m^3/day/no. x Head 60m } 10,400m^3/day	3 nos., 1,600m^3/day x Head 80m } 12,800m^3/day	3 nos., 1,600m^3/day x Head 80m } 12,800m^3/day
	(3) Skyline new borefield	3 nos., 1,200m^3/day/no. x Head 60m (1 unit stand-by)	3 nos., 1,600m^3/day x Head 60m (1 unit stand-by)	3 nos., 1,600m^3/day x Head 60m (1 unit stand-by)
	(4) Borderline new borefield	3 nos., 1,200m^3/day/no. x Head 50m	3 nos., 1,600m^3/day x Head 40m	3 nos., 1,600m^3/day x Head 40m
4	Distribution reservoir			
	(1) Tasahe reservoir	2,500m^3	1,600m^3	1,600m^3
	(2) Titinge reservoir	1,600m^3	1,400m^3	1,400m^3
	(3) Skyline reservoir	900m^3 } 8,200m^3	1,550m^3 } 7,005m^3	1,550m^3 } 7,005m^3
	(4) Lower West Kolaa reservoir	1,400m^3	455m^3	455m^3
	(5) Panatina reservoir	1,800m^3	2,000m^3	2,000m^3
5	Water transmission & distribution pipelines	50～300mm x approx. 27km	50～300mm x approx. 28.2km	50～300mm x approx. 28.2km
B. Provincial Centers				
1	Auki Borehole Facilities			
	(1) Drilling borehole	2 nos., 100m in depth	2 nos., 100m in depth	2 nos., 100m in depth
	(2) Supply of borehole pump	3 nos., 800m^3/day x Head 50m	3 nos., 800m^3/day x Head 50m	3 nos., 800m^3/day x Head 120m
	(3) Conveyance pipeline	150mm PVC x 100m	150mm PVC x 100m	150mm PVC x 100m
	(4) Emergency generator	Not applicable	1 no.	1 no.
2	Noro Borehole Facilities		Not applicable (Deleted from the Request)	Not applicable
	(1) Drilling borehole	2 nos., 100m in depth		
	(2) Supply of borehole pump	3 nos., 800m^3/day x Head 50m		
	(3) Conveyance pipeline	150mm PVC x 100m		

MD = Minutes of Discussions

1-2 Natural Conditions

In order to obtain the data for determining size of the facilities and conducting basic design of the facilities, natural conditions survey listed in Table 1-2-1 were conducted.

Table 1-2-1 Natural Conditions Survey in the Basic Design Study

No.	Name of Survey	Place	Purpose of Survey
1	Electric resistivity prospecting	Honiara & Auki	Confirming aquifer of the borefield for the Project and determining the location of each boreholes to be newly developed in the Project
2	Water source volume survey	Honiara	Confirming water source volume available in three (3) main water sources in Honiara City
3	Topographic survey & route survey	Honiara & Auki	Confirming configurations of the construction sites for borehole facilities, distribution reservoirs, water transmission pump stations, etc., and levels/configurations for routes of water transmission and distribution mains
4	Soil investigation	Honiara	Confirming strength of the strata on which facilities for the Project are constructed
5	Test pitting survey for water transmission & distribution pipeline	Honiara	Confirming current situation of strata for water transmission and distribution pipelines, especially the existing rock strata on the route
6	Water quality survey	Honiara	Confirming whether water from spring and new boreholes is suitable for drinking purpose or not

1-3 Environmental and Social Considerations

Impacts to be considered with regard to environmental and social considerations for implementing this Project are as follows:

1-3-1 Social Environment

Special considerations must be required for construction of facilities and water usage as the Project sites have customary lands and water possessed by local ethnic groups. Also, illegal shops still exist in the planned construction sites. The Project has obtained approval for facility construction/ water usage/ transfer of existing buildings, yet it still has to go through required procedures under the appropriate and lawful processes of the Solomon Islands.

Reduced dependency on Konglai Spring will lead to reduction of payment for water usage fees to the local ethnic groups. Although the overall agreement has been reached between the Solomon Islands government and the ethnic groups, further negotiations with specific figures and written agreements need to be exchanged. These negotiations as well as consensus building activities will be held by the Solomon Islands government.

1-3-2 Natural Environment and Pollution

This Project may have impact on the following items of natural environment and pollution: geographical features, soil erosion, groundwater and hydrology, air pollution, water pollution, soil pollution, waste and noise and vibration. Regarding these items, the Solomon Islands Water Supply Authority (SIWA) shall conduct the following environmental monitoring during construction and operation of the Project facilities. (See Appendix - 6 Draft of Monitoring Methods)

(1) Impact during construction of facilities

The Project may have impact on geographical features, soil erosion, air pollution, water pollution, soil pollution, waste and noise and vibration during construction of the planned facilities.

To avoid and/or reduce impact on these aspects, appropriate construction methods and construction period/schedule and checking of construction apparatuses and equipments shall be conducted. SIWA shall communicate and exchange information with residents as well as conduct regular meetings among SIWA, the consultant, and the contractor to check and instruct during construction as appropriate.

(2) Impact due to new groundwater development

The Project may have impacts of such as deterioration of groundwater quality and fall of groundwater level due to the groundwater pumping from the boreholes to be newly developed in the Project. Groundwater levels of the existing boreholes around the Project sites shall be observed before the excavation for the boreholes, and groundwater levels of the planned boreholes shall be monitored and analyzed after the excavation of the planned boreholes. In addition, changes in groundwater quality shall also be monitored.

(3) Impact due to wastewater from regulating reservoir for high-turbidity raw water

In this Project, a settling basin for turbidity reduction will be installed at Konglai Spring and Kombito Spring to avoid mud water from entering into drinking water coming from spring water sources after rainy weather.

Although sludge is generated from the regulating reservoir after sedimentation, it is very few in volume. Therefore, it is considered that it will not give an adverse impact on the surrounding environment. However, since much attention shall be made to the surrounding environment, SIWA is required to monitor the sludge accumulation at the discharge point as a regular checking item.

CHAPTER 2

CONTENTS OF THE PROJECT

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2-1　Basic Concept of the Project

In Honiara City, 59% of the water depends on the spring sources and 41% on the groundwater sources. At Konglai Spring which produces 45% of the water to Honiara, raw water intake volume has been instable due to the frequent blockage at raw water inlets so called as “sinkholes” during heavy rain and flooding. Average daily water consumption in Honiara is usually 172 liter per capita per day (LCD). However, it has fallen down to 110 LCD during blockages which is 64% of the ordinary volume. Moreover, at Konglai Spring and Kombito Spring, water from these springs becomes unsuitable for drinking during and after heavy rain due to occurrence of high turbidity so that the residents are forced to use such water not satisfying drinking water quality standard.

Unserved area still exists in Honiara City and the current service ratio is 73%. Even if the areas have been served, water pressure is not enough. The existing distribution reservoirs are being deteriorated due to over usage against their service life and their capacities are not enough to meet the water demand during peak hours and in emergency cases. The capacity of the reservoirs is 5.7-hour volume of maximum daily water supply which is less than half of 12-hour volume, the necessary volume for managing the peak-hour water demand and the emergency cases.

In Auki City, development of water sources is lagged behind and the residents are suffering from shortage of average daily water consumption per capita. 184LCD is the average for other provincial centers, but 75LCD is that of Auki City and they are forced to water rationing of only 4 hours a day.

In this connection, the Project aims at increasing served population in Honiara that will be able to receive safe and stable water supply in 2010 (design daily water consumption per capita of 170LCD) through shift to groundwater source for securing a stable water supply by reducing the dependence on Konglai Spring, construction of settling basin for turbidity reduction to cope with high turbidity by heavy rain, expansion of distribution reservoirs for stable water distribution and improvement of water distribution mains. The Project also aims at increasing served population in Auki City that will be able to receive stable water supply in 2010 (design daily water consumption per capita of 170LCD) through development of new boreholes.

This Project consists of facilities construction, the components and specifications of which are as mentioned in Table 2-1-1, and the Soft Component (technical guidance) as mentioned in Table 2-1-2.

Table 2-1-1 Plan and Specifications of Facilities for the Project

Category	Facility Name	Components	Specifications
[Honiara City]			
Water source facility	Borehole facility	Borehole, submersible pump	Borehole: 16nos.(4 borefields x 4 bores/borefield) Submersible pump: 20 units. (1unit/bore x 4 bore/borefield x 4 borefields, stand-by 1 unit/borefield) Pumping capacity: 800m^3/day/unit Pump head: 65m - 85m
	Conveyance pipeline		5.4km, dia. 150mm, PVC
	Turbidity reduction facility	Settling basin, chlorine dozing equipment	Konglai spring: 4,100m^3/day Kombito spring: 1,600m^3/day
	Power receiving equipment	Power receiving equipment (low voltage)	2 sets (1 each for Konglai and Kombito springs)
	Improvement of spring intake facility	Screen	1 set for Rove spring
Water transmission facility	Water transmission pump station (PS)	Water transmission pump	4 stations (1 station per borefield) 1,600m^2/day x 2 unit (duty) per station 1 unit stand-by
		Water transmission pump house	4 houses (total floor area 132m^2/house, RC-made, 2-story)
		Disinfection facility	4 units (installed at each water transmission facility) Treatment cap.: 3,200m^3/day/unit
	Power receiving equipment (high voltage)	High voltage power receiving equipment, transformer	4 sets (installed at each water transmission facility)
	Emergency generator	Diesel engine generator	4 sets (installed at each water transmission facility)
	Water transmission main	Water transmission PS to distribution reservoir	4.1km, dia. 250mm
Water distribution facility	Distribution reservoir		5 reservoirs (Tasahe1,700m^3, Titinge1,300m^3, Lower West Kolaa450m^3, Skyline1,800m^3, Panatina2,100m^3)
	Water distribution main		22.9km, dia. 50mm - 200mm
[Auki City]			
Water source facility	Borehole facility	Borehole, submersible pump	Borehole: 2 nos. Submersible pump: 3 units (1 stand-by) Pumping capacity: 400m^3/day/unit Pump head: 105m
	Conveyance pipeline		0.4km, dia.150mm, PVC
	Emergency generator	Diesel engine generator	1 set
	Power receiving equipment	Power receiving equipment (low voltage)	1 set
	Associated civil & building works	Electrical house	1 house (total floor area 35m^2/house, RC-made, 1-story)

Table 2-1-2 Contents of Soft Component for the Project

Item	Contents
Understanding of water supply system	Class room training for learning water supply system from borehole facility to water transmission pump station and distribution reservoir
Learning operation & maintenance method for water supply facilities	Class room training and OJT for learning water quality and operation control methods of water sources, intake, water transmission & distribution and water supply to customers
Learning record & control and utilization method for water quality and quantity data	Class room training and OJT for learning sorting-out method of water quality and operation data for water sources, intake, water transmission & distribution and water supply to customers, and based on the data, learning water quality and operation control method

2-2 Basic Design of the Requested Japanese Assistance

2-2-1 Design Policy

2-2-1-1 Basic Concept

Issues for the existing water supply system in Honiara and their countermeasures in the project are described in Table 2-2-1.

Table 2-2-1 Current Situations of Honiara Water Supply Facilities and their Countermeasures

Issue to be solved	Current Situation	Countermeasures in the Project
Securing raw water intake volume from spring sources	About 45% of water sources in Honiara City rely on Konglai Spring. This raw water intake volume is unstable due to frequent blockages. The blockages have occurred for a period of about 23 months for the past 12 years. Duration of each blockage is from 1 week to 7 months. The water consumption decreased to less than 110LCD from the regular amount of 172LCD during the blockage. Moreover, it is located in customary land, so SIWA has difficulties in O&M of this source. Therefore, SIWA wants to shift this spring source to the groundwater sources inside the town boundary.	Pumping system by which 65% of raw water from the spring is transmitted from Konglai Spring shall be used only for emergency case. Gravity system accounting for 35% of raw water intake from the spring is distributed shall be utilized as permanent water source. Water demand in the target year of 2010 is 30,509m^3/day. In order to cover water shortage against the demand in the target year, new groundwater shall be developed taking into account the reduction of water intake volume from Konglai Spring.
Stabilizing water pressure in water distribution network	Parts of service areas (25% of the population of the service area in Honiara) are suffering from low water pressure and can not receive water supply during peak demand hours.	Water distribution system shall be improved by block distribution system and optimization of pipe diameters, in order to stabilize the water pressure.
Formulating water distribution system	Since water transmission system and distribution pipeline are not separated, water distribution to the service areas is not stable and service reservoirs can not work with its original functions such as absorbing peak demand, water supply in emergency case, etc.	Each water distribution district shall have one water source and one distribution reservoir in principle so that water supply facilities in each district can function independently (see **Fig. 2-2-1**).
Optimizing pipe diameters	Pipe diameters are too small to transfer the required water to customers. Inadequate pipe diameter is also one of the causes of low water pressure.	Enough pipe diameters shall be adopted after the examination by hydraulic analysis of water distribution network to meet the water demand in 2010.
Securing storage capacity of distribution reservoirs	Currently, capacity of existing service reservoirs is less than 6 hour-volume of daily maximum water supply, and it is difficult to supply enough water during peak hours and in emergency case.	Storage capacity of distribution reservoirs shall have a 12 hour-volume of daily maximum water supply, to stabilize water supply during taking into account peak-hours demand and emergency case.
Reducing turbidity of spring water (improving tap water quality)	Tap water often shows high turbidity and become unsuitable for domestic use after heavy rain in the service areas of Konglai Spring and Kombito Spring sources.	Turbidity reduction facility shall be installed near the intake point of Konglai and Kombito Spring sources.
Enlarging water supply services to the unserved areas	Unserved water supply area accounts for 30% of water service areas of SIWA.	Water distribution mains shall be expanded to the unserved areas.
Leakage due to deterioration of reservoirs	Among existing service reservoirs which are made of steel plates, some of them have much leakage due to corrosion and become out of use.	New service reservoirs shall have capacity of the existing reservoirs to be replaced, while considering their durability

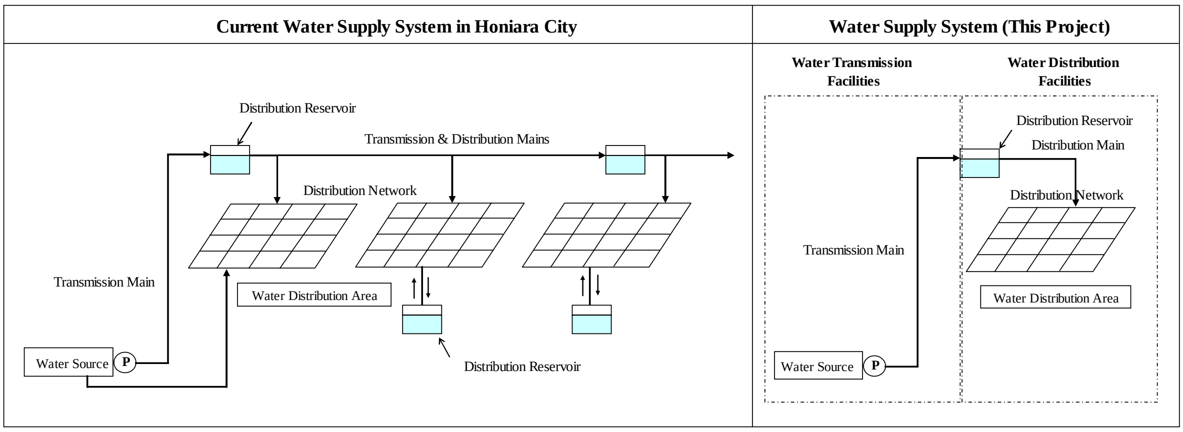


Fig. 2-2-1 Current Water Transmission/Distribution System in Honiara and Block Distribution System for the Project

Issues for the existing water supply facilities in Auki City and their countermeasures in the Project are mentioned in Table 2-2-2.

Table 2-2-2 Current Situations of Auki Water Supply Facilities and their Countermeasures

Issue to be solved	Current Situation	Countermeasures in the Project
Water source	Water intake volume from the existing Kwaibala Spring is less than the water demand in Auki City. Therefore, water consumption for domestic use is as low as 75LCD in 2007, which is only 40% of other provincial centers.	Since the water intake volume from the existing spring source is short of the water demand in 2010, two (2) new boreholes will be developed in the Project.
Water supply service	The residents in Auki City are suffering from water supply rationing being executed for 4 hours a day because the yield of water source is much short of the actual demand.	The groundwater newly developed in the Project will be distributed through the water distribution system which has been rehabilitated by ADB project so that the required water supply volume can be secured and 24-hour water supply is realized.

In this Project, the plan was formulated according to the following basic concept based on the request from Solomon Islands Government and the results of field survey and discussions with the authorities concerned for construction of borehole facilities, water conveyance pipelines, collector tanks, chlorination disinfection facilities, turbidity reduction facilities, water transmission facilities, distribution reservoirs, water transmission mains and water distribution mains for Honiara City and borehole facilities and water conveyance pipeline for Auki City.

(1) Target Year and Design Water Supply

The target year for the Project was set as 2010 in accordance with the mid-term facility improvement plan. The design daily maximum water supply for Honiara City was determined as 30,509m^3/day from the design served population and the design daily water consumption per capita of

170LCD. The design daily maximum water supply for Auki City was determined as 1,106m^3/day from the design served population and the design daily water consumption per capita of 170LCD.

Drinking water quality shall be conforming to the drinking water quality standards of WHO.

(2) Water Source Facilities

1) For achieving stable water supply in Honiara City, dependence on Konglai Spring of the unstable water intake volume will be reduced and four (4) new borefields (total yield of 12,800m^3/day) will be developed at each of four (4) water distribution districts with much water shortage for covering reduction of water intake volume from Konglai Spring and water demand in the target year of 2010.
2) Water from the new borefields will be collected at collector tanks for water transmission facility by borehole pumps and transferred to the distribution reservoir for each distribution district by water transmission pumps.
3) In Auki City, a new borefield with the design yield of 800m^3/day, the volume being deducted a production volume of the existing water source from the design water supply in 2010, will be developed and the water from the new borefield will be lifted and transferred to the existing high level distribution reservoir by borehole pumps.
4) In Honiara City and Auki City, 18 boreholes in total will be constructed.

(3) Turbidity Reduction Facility

At Konglai Spring and Kombito Spring where occurrence of high turbid water in the water distribution network is the key issue in Honiara City, a settling tank for turbidity reduction with plain settling basins will be constructed. This settling tank consists of two settling basins with a capacity of more than 8-hour retention time and reduces turbidity by settling suspended matters.

(4) Water Transmission and Distribution Facility

1) Block distribution system will be applied to establish a water distribution system for stable water supply and water transmission/distribution mains with appropriate diameters will be constructed. The service area of Honiara City will be divided into eight (8) distribution districts.
2) For each distribution district in Honiara City, distribution reservoirs having about 12-hour volume of the design daily maximum water supply will be planned and five (5) new distribution reservoirs (total volume of 7,350m^3) will be constructed. Distribution reservoirs will be designed taking into account seismic and wind loads in conformity with Australian and New Zealand standards applied in Solomon Islands.
3) Water distribution mains of about 27km will be constructed for replacing by pipelines with enough diameters for meeting the water demand in the target year, distribution to the unserved water supply areas and renewal of deteriorated pipelines by usage over service life.

(5) Implementation of the Soft Component

Upgrading water supply system will be achieved by capacity development for operation and maintenance as well as improvement of water supply facilities. By implementation of the Project, water supply facilities will be expanded and a settling basin for turbidity reduction will be added. In order to strengthen the capacity for facility operation understanding relations between those facilities by sorting out the information/data of the various facilities, the Soft Component (technical guidance) will be conducted to SIWA staff.

2-2-1-2 Policies to Cope with Natural Conditions

Policies of designing the facilities for the Project to suite the natural conditions shall be as follows:

- Design water intake volume shall be justified using the results of water source survey.
- Location of new boreholes shall be determined by the results of electric resistivity prospecting and existing survey data.
- Design pumping volume for new boreholes shall be justified by the existing data.
- Soil bearing capacity to be used for selection of foundation type shall be calculated based on the results of soil investigation.
- Seismic design of buildings in Solomon Islands needs to comply with Australia-New Zealand standard, AS/NZS4203:1994. Hence, a seismic design for this Project shall be based on the above standard. Also, if the allowable stress method is used, wind load shall be based on the standard wind force.

2-2-1-3 Socio-economic Conditions

For the construction of the facilities for the Project, the Solomon Islands side shall acquire new land. It was found that the number of land which requires lease from private fixed-term estate holders is 5 sites according to the result of the field survey of the Basic Design study. In addition, the number of illegal kiosks (shops) located at the Project sites to be relocated were identified as 2 shops. From now on, SIWA shall check the progress of land acquisition as appropriate and continuously monitor the Project sites so as to avoid any further illegal encroachments on the Project sites as well as construction areas.

Due to the decrease of the amount of water intake from Konglai Spring after the implementation of this Project, there may be possibility that the Project may affect the livelihood of the tribe(s) in the area from the decrease of water charges for the intake for the spring. SIWA has already conducted a stakeholder meeting (August 2007) with the customary landowners and residents in the area where Konglai Spring is located and explained the fact that the water intake from Konglai Spring will be reduce if the Project is implemented. There was no opposition against the implementation of the Project during that meeting.

In addition, SIWA together with the Ministry of Land, Housing & Survey is considering of revising the current land lease agreement with the customary tribes from the current contract including fixed-rate (25% of water sales) water charges to a contract which only includes fixed-amount land lease rent. SIWA has already explained the amount of possible decrease of water intake from Konglai Springs to the leader of the tribal landowners, and the leader has verbally agreed with considering the fixed-amount land lease contract. The actual land lease rent will depend on the negotiation with the tribes; however, the agreement with fixed-amount land lease should prevent sudden decrease of payment to the tribes due to the sudden decrease of water intake. SIWA shall continue to discuss with the relevant tribal landowners towards reaching mutual agreement to lease the land for the implementation of the Project.

2-2-1-4 Construction/Procurement and Utilization of Local Companies

Most building materials and equipment will require imports from other countries. Apart from sand and gravel aggregates, general construction materials and equipment are not produced locally.

Materials and equipment such as water transmission and distribution pipes, steel distribution reservoirs and pumps etc. have been procured on a project basis. Usually, these items are imported from Australia and New Zealand. For procurement in this Project, it is necessary to consider not only utilization of products from third countries such as Australia and New Zealand, but also the compatibility with existing systems and easy maintenance following the installation. Hence, the policy for material procurement in the Project is to import from Japan and a third country.

While some construction companies exist locally, they use technicians and construction machines from overseas for construction projects without successive orders. Hence, the Project will utilize staffing/procurement/shipment from either Japan or third countries to compensate skilled workers, technicians and construction equipment that are not fully available in the country.

In particular, borehole excavation equipment and technical personnel need to be brought from Japan or third countries, since they cannot be easily procured locally. In addition, no ready mixed concrete companies exist locally. While temporary aggregate plants and concrete plants are necessary for production of highly water-tight concrete, transportation of concrete to mountainous areas is difficult due to the inadequate road conditions. Under these circumstances, utilization of equipment including ready-to-assemble steel tanks that do not require concrete will be examined, through comprehensive consideration of the planned sites/schedule/cost/maintenance and operation, etc.

2-2-1-5 Operation & Maintenance Capability of Implementing Agency

SIWA has a total of 20 personnel dedicated to operation and maintenance duties apart from those in managerial positions. Because of its limited staff number, appropriate detection and operation of water supply suspension/resumption cannot be fully implemented when high turbid water arises at any of the springs. SIWA is able to operate and maintain pumping equipment at the similar technical level, but does not possess expertise for operating water treatment facilities and others that require daily water quality measurement and chemical dosing. In addition, pump usage is to be minimized to reduce electricity cost.

Under these circumstances, the facilities taking into account easy operation and maintenance by SIWA staff shall be planned, guaranteeing minimum countermeasures against turbid water.

2-2-1-6 Grade Setting of Facilities and Equipment

In order to enable easy operation and maintenance activities executed by SIWA after commencement of the operation, design of water supply facilities/equipment constructed and procured under the Project will be determined in consideration of the existing facility/equipment grades and the technical level of SIWA staff.

Most of the construction materials/ equipment used in Solomon Islands are imported, many of which come from Australia and New Zealand. Therefore, in the Project, it is required to determine specifications of materials and equipment in accordance with the standards in Australia and New Zealand (AS/NZ standards). In particular, specifications of pipe materials such as water distribution mains needs to be determined so as not to cause trouble as a result of inconsistency of inner diameter or thickness between existing and new pipes.

2-2-1-7 Construction / Procurement Methods and Construction Schedule

Installation work for water conveyance pipelines, water transmission mains and water distribution mains is expected to include rock excavation on the foothills of the southern region of Honiara. It is necessary to select appropriate machines suitable for the excavation method and to prepare construction schedule by estimating the percentage of necessary rock excavation work in the overall pipeline length.

Detail design and tendering procedures for the Project are expected to take approximately 7.5 months. Construction requires approximately 21 months after signing contract for construction. In addition, implementation of the soft components for facility operation and maintenance will require approximately 1.5 months after the completion of construction.

As a result, a period of 30 months is required in total, and the entire execution within a single fiscal year is difficult. Since completion of all the construction components constitutes a full water supply system, the Project cannot be divided into separate periods. Therefore, the Project is planned to be implemented as a multi-fiscal-year project under Japan’s grant aid scheme.

2-2-2 Honiara Basic Plan

2-2-2-1 Design Conditions

Terminology for designing water supply facilities to be used in this Project can be defined as follows:

[Design water supply]

Design daily water consumption per capita	Water consumption/person/day for general households (metered amount)
Design water supply	Basic water volume for defining specific scale of each facility
Design water intake volume	Water intake from a water source
Design treated water volume	Water volume for defining scale of turbidity reduction facility

[Facilities]

Borehole pump station	Consisting of borehole and submersible pumps
Turbidity reduction facility	A facility used for reducing high turbidity during and after rainfall
Water conveyance pipeline	A pipeline used for conveying water from a borefield to a borefield collector tank at a water transmission pump station
Water transmission pump station	A facility used for transmitting raw water to a distribution reservoir by pumps
Water transmission mains	A pipeline used for transmitting water from a water transmission pump station to a distribution reservoir
Distribution reservoir	A facility mitigating peak demand of its service area and coping with emergency case
Water distribution mains	A pipeline used for distributing water from a distribution reservoir to its service area and regarded as a primary pipeline for a water distribution network
Water distribution branch lines	A pipeline separated from water distribution mains and used for distributing water to households in need

Design conditions for Honiara Basic Plan of the Project can be summarized as follows:

(1) Design Population and Design Served Population

Design population was determined based on the annual growth rate used in Household Income and Expenditure Survey 2005/2006 (HIES, National Report) which was carried out by Solomon Islands National Statistics Office.

As indicated in Table 2-2-3, the report indicated the average annual population growth in Honiara from 1986 to 1999 as 3.8% based on the census held in 1999. On the other hand, the average annual growth from 1999 to 2005 is 5.7%, significantly higher than the previous figure This significant fluctuation of the growth rate between the two different periods can be explained by the temporary return of Malaitan settlers in Honiara to the Malaitan Province (Auki etc.) under the ethnic conflict between Guadalcanalans and Malaitans and their subsequent return to Honiara after the conflict subsided in 2003.

Under this social background, the annual growth rate of 1999-2005 alone should not be applicable to estimate the design population, and an intermediate figure between the two periods is considered more appropriate. Hence, 4.4%, an intermediate figure obtained from the average between 1986 and 2005, was used for the population estimate up to 2010.

Table 2-2-3 Annual Population Growth in Honiara

Period	Year 1986 - 1999	Year 1999 - 2005	Adopted Ratio (Year 1999 - 2010)
Annual Population Growth Ratio (%)	3.8	5.7	4.4

Source: Statistic Bureau of Solomon Islands

Table 2-2-4 shows design population in Honiara based on the annual growth rate obtained above.

Table 2-2-4 Design Population in Honiara and Auki

Year	1999	2005	2006	2007	2008	2009	**2010**
Population within Administrative Area	49,107	63,584	66,381	69,302	72,352	75,535	**78,859**
Population in Service Area	54,018	69,942	73,020	76,232	79,587	83,089	**86,745**

(2) Design Daily Water Consumption per Capita

Design daily water consumption per capita was determined based on the actual water usage of the past three years (2005 - 2007).

Table 2-2-5 Average Water Consumption in Honiara (2005 - 2007)

Year	Daily Per Capita Water Consumption (LCD)
2005	181
2006	171
2007	165
Average	172

As indicated above, the average water consumption for the past three years is 172 LCD. Under the Project, design daily water consumption per capita was defined as 170 LCD.

The actual water consumption from 2005 to 2007 is shown in Table 2-2-6, 2-2-7 and 2-2-8 respectively.

Table 2-2-6 Water Consumption in Honiara (2005)

Category of Customer	Pop. in Service Area	Number of Customer	Served Population *2	Water Distributed		Water Consumption (Effective Water)		Per Capita Per Day Consumption
	person	no.	person	m^3/year	m^3/day	m^3/year	m^3/day	LCD
Domestic		5,434	48,906			3,236,417	8,867	181
Commercial		617				1,214,479	3,327	
Governmental		198				1,273,718	3,490	
Apparent Loss*1						177,050	485	
Whole Honiara City	69,942	6,249	48,906	9,074,400	24,861	5,901,663	16,169	

Table 2-2-7 Water Consumption in Honiara (2006)

Category of Customer	Pop. in Service Area	Number of Customer	Served Population	Water Distributed		Water Consumption (Effective Water)		Per Capita Per Day Consumption
	person	no.	person	m^3/year	m^3/day	m^3/year	m^3/day	LCD
Domestic		5,824	52,416			3,276,637	8,977	171
Commercial		640				1,308,607	3,585	
Governmental		145				1,273,718	3,490	
Apparent Loss*1						181,205	496	
Whole Honiara City	73,020	6,609	52,416	8,792,000	24,088	6,040,167	16,548	

Table 2-2-8 Water Consumption in Honiara (2007)

Category of Customer	Pop. in Service Area	Number of Customer	Served Population	Water Distributed		Water Consumption (Effective Water)		Per Capita Per Day Consumption
	person	no.	person	m^3/year	m^3/day	m^3/year	m^3/day	LCD
Domestic		6,184	55,656			3,342,149	9,157	165
Commercial		691				832,966	2,282	
Governmental		117				1,273,718	3,490	
Apparent Loss*1						168,521	462	
Whole Honiara City	76,232	6,992	55,656	9,375,000	25,685	5,617,354	15,391	

Notes: 1. Administrative losses account for meter insensitive water volume.
2. Served population is calculated by multiplying 9 persons per connection to the number of customers.

(3) Design Effective Water Ratio

According to the data obtained from SIWA, the rate of non-revenue water (NRW) from 2005 to 2007 is as shown in Table 2-2-9. The effective water ratio is a figure obtained by deducting 3% of administrative losses identified by the JICA Development Study from the NRW ratio. As indicated in Table 2-2-9, the average effective water ratio for the past three years is 64%, and this percentage was applied for the Project as the design effective water ratio.

Table 2-2-9 Non-Revenue Water (NRW) Ratio and Design Effective Water Ratio for Honiara

Item	Year 2005	Year 2006	Year 2007
Non revenue water (NRW) ratio (%)	38.1	34.4	43.1
Administrative losses (%)	3.0	3.0	3.0
Ineffective water ratio (%)	35.1	31.4	40.1
Average NRW [A]	36		
Design effective ratio 100-[A]	64		

(4) Design Water Supply

Water supply (water demand) can be calculated from the following formula:

$$\text{Water supply (water demand)} = \frac{\text{Water consumption}}{\text{Effective water ratio}}$$

Table 2-2-10 shows design water supply (water demand) estimated based on the conditions below:

- Design daily water consumption per capita: 170 LCD
- Design effective water ratio: 64％
- Daily peak factor: 1.0
- No. of persons for one customer: 9 persons
- Increase of customers after improvement of unserved areas: 600 customers
- Administrative losses (=meter ineffective water loss): 3%

Table 2-2-10 Design Water Supply (water demand) of Honiara [2010]

Category of Customer		Pop. in Service Area	Number of Customer	Served Pop. [A]	Per Capita Per Day Consumption [B]	Water Consumption (Effective Water) [C]	Design Water Supply [C]/0.64
		(person)	(no.)	(person)	(LCD)	(m^3/day)	(m^3/day)
						[A] x [B]/1000	
1	Domestic		7,965	71,687	170	12,187	
						3-years average x $(1+0.01)^3$	
2	Commercial		712			3,158*3	
3	Governmental		121			3,596*3	
						3 x (metered vol.*1)/(100-3)	
4	Administrative Loss	(=meter ineffective water loss *2)				586	
	Whole Honiara	86,745	8,798	71,687 (83%)		19,526	30,509

Notes 1. Metered volume = (1. Domestic) + (2. Commercial) + (3. Governmental)
2. Metering error = (Metering error ratio) x (Metered volume) / (100－meter ineffective water loss)
3. Annual growth ratio of water consumption for commercial and governmental use is assumed as 1% (Source: AusAID Master Plan).

Table 2-2-11 shows design water supply for the service areas in the target year (2010).

Table 2-2-11 Design Water Supply of Service Areas in Honiara (2010)

No.	Service Area	Water Source	Supply Area	Design Water Supply (m^3/day)
1	Konglai Spring (gravity) -Tasahe	Konglai Spring (gravity) + Tasahe new borefield	Point Cruz	6,570
2	Tasahe	Tasahe new borefield	Tasahe and Ngossi	1,104
3	Titinge - Skyline	Titinge new borefield + Skyline new borefield	Titinge and Vavae, Mbokonavera	5,104
4	Rove spring	Rove spring	CBD	1,700
5	Mataniko	Mataniko existing (JICA) borefield	Chine Town	3,113
6	Skyline - Mataniko	Skyline new borefield + Mataniko existing (SIWA) borefield	West Kolaa and East Kolaa	3,410
7	Borderline - Kombito	Borderline new borefield + Kombito existing borefield	Naha/Vura	4,111
8	Panatina - Kombito	Panatina existing borefield + Kombito Spring	Panatina, Ranady and Henderson	5,397
	Total			30,509

Table 2-2-12 shows the comparison between available water intake of water sources and design water supply in 2010.

Table 2-2-12 Water Intake Capacities and Design Water Supply (2010)

Water Source	Available Intake Volume (m^3/day)	Remarks
[Spring]		
Konglai	4,100	Existing
Rove	1,697	Existing
Kombito	1,584	Existing
Spring - Total	7,381	
[Borefield]		
Mataniko	5,329	Existing + Increasing existing pump capacity
Kombito	1,754	Existing
Panatina	3,245	Existing
Tasahe	3,200	To be developed in the Project
Titinge	3,200	To be developed in the Project
Skyline	3,200	To be developed in the Project
Borderline	3,200	To be developed in the Project
Borefield - Total	23,128	
Design Intake Volume	30,509	Design intake volume can cover the design water supply in 2010.
Design Water Supply (Year 2010)	30,509	

(5) Design Water Quality

Design treated water quality defined based on the turbidity survey at the water sources shall be referred to Table 2-2-23 shown in “2-2-2-6 Settling Basin for Turbidity Reduction”.

(6) Soil Property Requirements

Table 2-2-13 shows soil properties conditions identified from the geological survey at the Project sites for distribution reservoir and turbidity reduction facility during the field survey of this Study.

Table 2-2-13 Soil Properties

Item	Panatina reservoir	Tasahe reservoir	Lower West Kolaa reservoir	Skyline reservoir	Titinge reservoir	Konglai turbidity reduction facility	Kombito turbidity reduction facility
Liquid Limit	1-4m:43% 6m :41%	2-6m:40% 8m :32% 10m :35%	1-4m:34% 6m :41%	0-2m:38% 4-10m:37%	4-6m:42% 8-10m:43%	8-10m:31%	1-4m:45% 5-10m:43%
Plastic Limit	1-4m:27% 6m :18%	2-6m:18% 8m :19% 10m :21%	1-4m:23% 6m :36%	0-2m:18% 4-10m:17%	4-6m:27% 8-10m:25%	8-10m:23%	1-4m:30% 5-10m:25%
Unit Volume Weight	Average 2.61ton/m^3	Average 2.56ton/m^3	Average 2.6ton/m^3	Average 2.58ton/m^3	Average 2.6ton/m^3	Average 2.53ton/m^3	Average 2.58ton/m^3
Estimated Allowable Bearing Capacity (0.5m below the ground)	Approx. 7ton/m^2	Approx. 10ton/m^2	Approx. 7ton/m^2	Approx. 5ton/m^2	Approx. 10ton/m^2	Approx. 10ton/m^2	Approx. 10ton/m^2

The soil at the Skyline Distribution Reservoir showed allowable bearing capacity as low as 5 tons/ m^2, and a large soil bearing capacity cannot be expected. Therefore, the soil at the bottom of the deck slab need to be replaced with improved soil mixed with sand and cement or to decentralize the load by enlarging the bottom of the deck slab, while deepening the embedment for the spread footing foundation.

Spread footing will also be applied to reservoirs other than the one at Skyline. No special ground reinforcement measures will be required since sufficient bearing capacity is anticipated and the foundation can be set deeper from the ground.

(7) Weather Conditions

Weather conditions are defined as below based on the meteorological data for 1998-2007.

Table 2-2-14 Weather Conditions in Honiara

	Item	Honiara city	Remarks
Rainfall	Annual rainfall	1,987mm	
	Monthly mean rainfall	166mm	
Temperature	Mean temperature	26.3℃	
	Monthly mean minimum temperature	23.1℃	August
	Monthly mean maximum temperature	28.4℃	January
Relative humidity	Monthly mean relative humidity	82.6%	
	Monthly mean minimum relative humidity	77.6%	October and November
	Monthly mean maximum relative humidity	86.6%	March

(8) Seismic Load

Seismic design of buildings in Solomon Islands needs to comply with Australian/New Zealand standard, AS/NZS4203:1994. Based on this standard, regional category [A] applies to seismic design of public buildings, and the following formula is used for the calculation.

$V = Cd \cdot Wt$

In this formula, Wt: Building weight, Cd: Base shear coefficient using:

$Cd = C \cdot I \cdot S \cdot M \cdot R$

C: Regional coefficient (Coefficient determined by ground type defined by each region and natural period of a building)

I: Coefficient for importance of a building

S: Coefficient determined by building configuration

M: Coefficient determined by structural type (M=1 for reinforced concrete buildings)

R: Risk coefficient based on building usage

(9) Wind Load

Australian/New Zealand standard, AS/NZS1170.2:2002 shall be applied to design wind load of buildings. When the allowable stress method is used, the standard wind must be set as 49m/ sec.

2-2-2-2 Facility Layout Plan

(1) Basic Concept

Current issues and their countermeasures of the water supply system in Honiara City are as described in Table 2-2-1. The current water transmission/distribution system of Honiara City and the improvement plan in the Project are shown in Figure 2-2-1.

(2) Facility Details

Under the Project, the following components shall be examined to improve the current water supply system in Honiara.

- Borehole development and construction of borehole facilities
- Construction of water transmission pump stations
- Expansion of distribution reservoirs
- Replacement of water distribution mains
- Expansion of service areas using different pipe diameter through installation of new distribution mains
- Construction of water treatment facilities to reduce turbidity of spring water
- Construction of chlorination facilities

(3) Overall Facility Layout Plan

Under the Project, facility layout is planned to enable stable water distribution as indicated in Fig. 2-2-1. As suggested in Fig. 2-2-2, facilities will be constructed in each service area, in accordance with the types of water sources in principle.

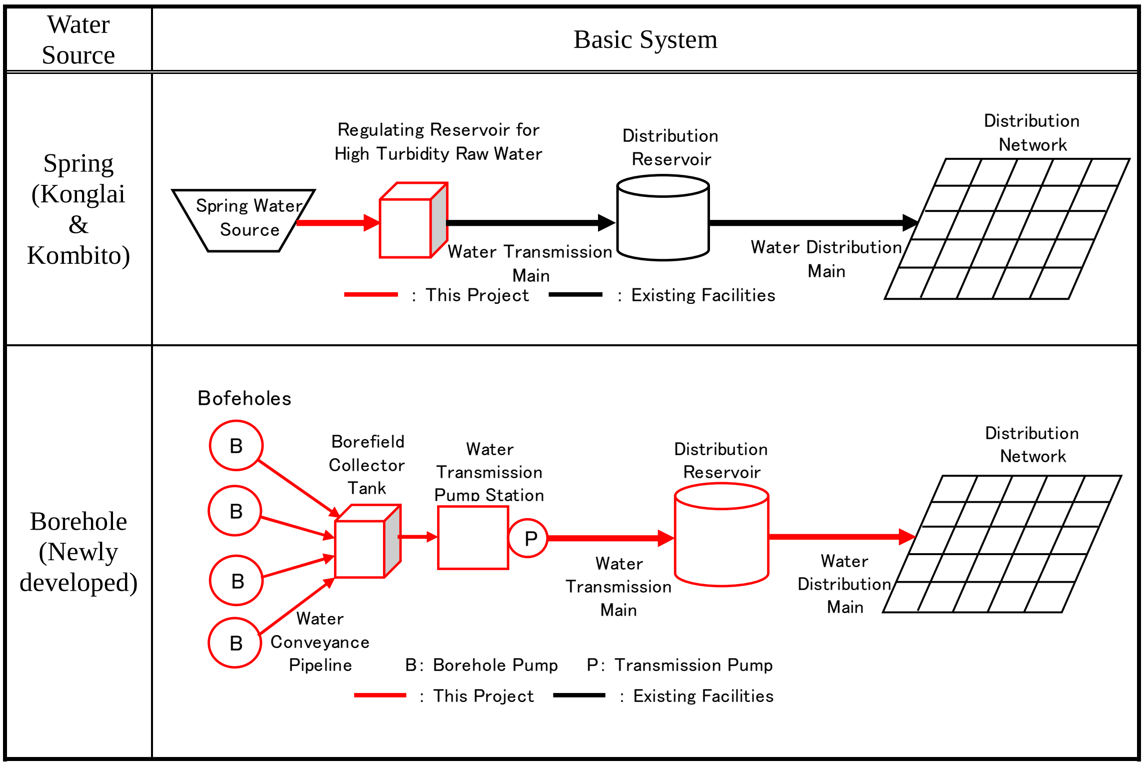
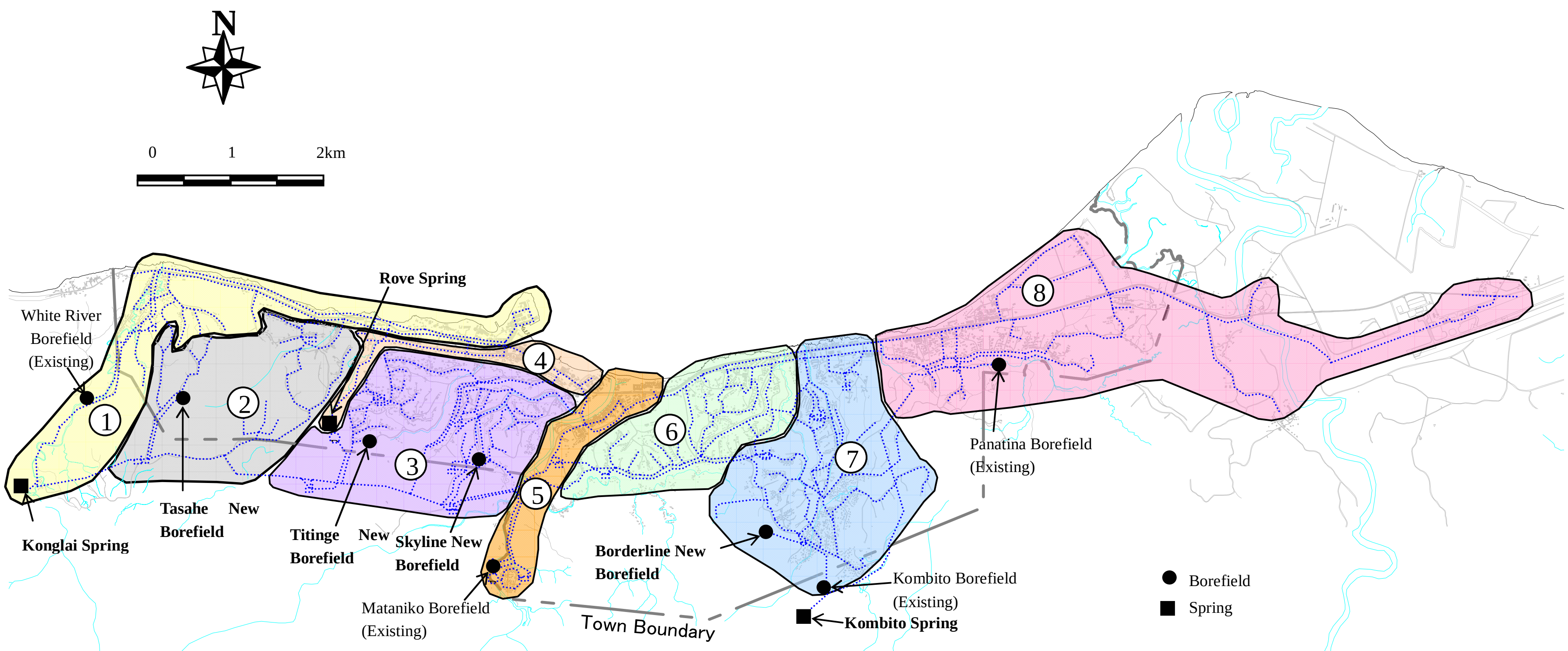


Fig. 2-2-2 Facility Layout Concept

Service areas through the establishment of block distribution system will be planned so that each service area has its own water source and distribution reservoir in principle, as indicated in Fig.2-2-3.

Fig. 2-2-4 shows overall facility layout based on the above principles. A detailed facility layout drawing is shown in “2-2-4 Basic design drawings”.



Area No.	Service Area
1	Konglai spring－White River
2	Tasahe
3	Titinge－Skyline
4	Rove spring
5	Mataniko
6	Skyline－Mataniko
7	Borderline－Kombito
8	Panatina－Kombito

Fig. 2-2-3 Service Areas by Block Distribution System of Honiara City for the Project

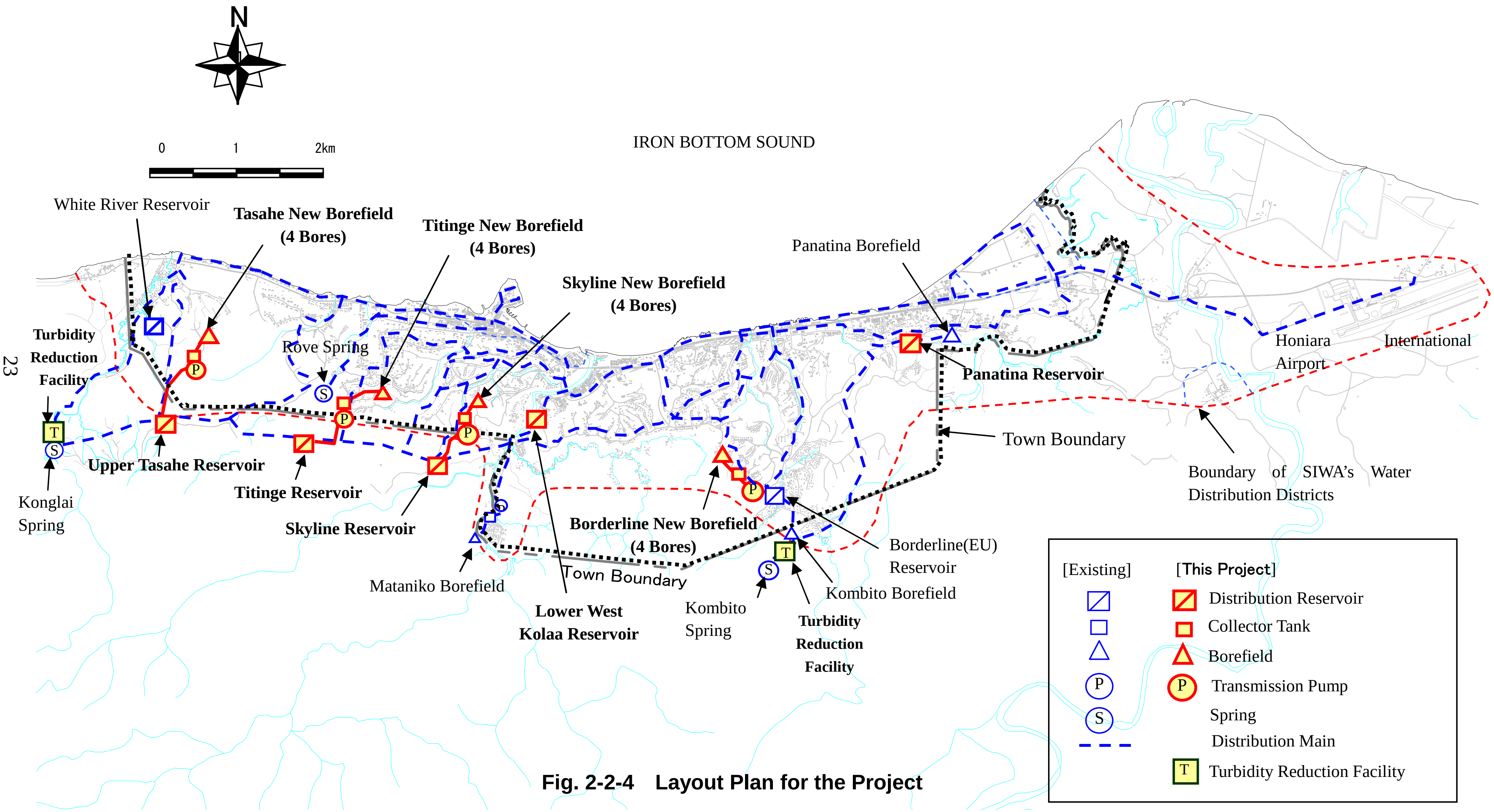


Fig. 2-2-4 Layout Plan for the Project

2-2-2-3 Improvement of Existing Water Intake Facility at Rove Spring

According to SIWA, although turbidity of Rove Spring is highly stable, in some seasons, the spring is affected by the problem of large infestations of tadpoles entering water distribution pipelines and eventually reaching water taps of the customers.

In this case, appropriate elimination of extraneous substances from the water source is required. Therefore, a screen shown in "2-2-4 Basic Design Drawings" shall be installed at the water intake facility of the spring.

2-2-2-4 Borehole Construction Plan

(1) Borehole Layout Plan

1) Location of Boreholes

Under the field survey of the Study, positions selected during the preliminary survey were confirmed at the planned sites with the presence of SIWA personnel, and more specific positions were defined, which were determined in consideration of land restrictions.

Positions of boreholes for respective borefields are shown in Table 2-2-15 and Fig. 2-2-5 (1/2-2/2)

Table 2-2-15 Location of Boreholes in Honiara

Name of Borefield	Borehole No.	Coordinate(m)		Ground Elevation (m)	Distance (m)
		N	E		
Tasahe	N-1	8,956,680	601,823	62	
	N-2	8,956,802	602,160	49	358
	N-3	8,956,926	602,363	43	237
	N-4	8,956,808	602,562	47	231
Titinge	M-1	8,956,221	603,410	69	
	M-2	8,956,335	603,704	48	315
	M-3	8,956,398	603,890	50	196
	M-4	8,956,394	604,072	38	182
Skyline	MB-1	8,956,126	604,717	49	
	MB-2	8,956,311	604,686	40	187
	MB-3	8,956,501	604,705	31	191
	MB-4	8,956,583	604,871	27	185
Borderline	KO-1	8,955,170	607,851	56	
	KO-2	8,955,323	607,787	54	193
	KO-3	8,955,511	607,598	48	266
	KO-4	8,955,701	607,456	45	237

Note: Coordinates shall be based on Universal Transverse Mercator (UTM) grid.
Figures are in meters.

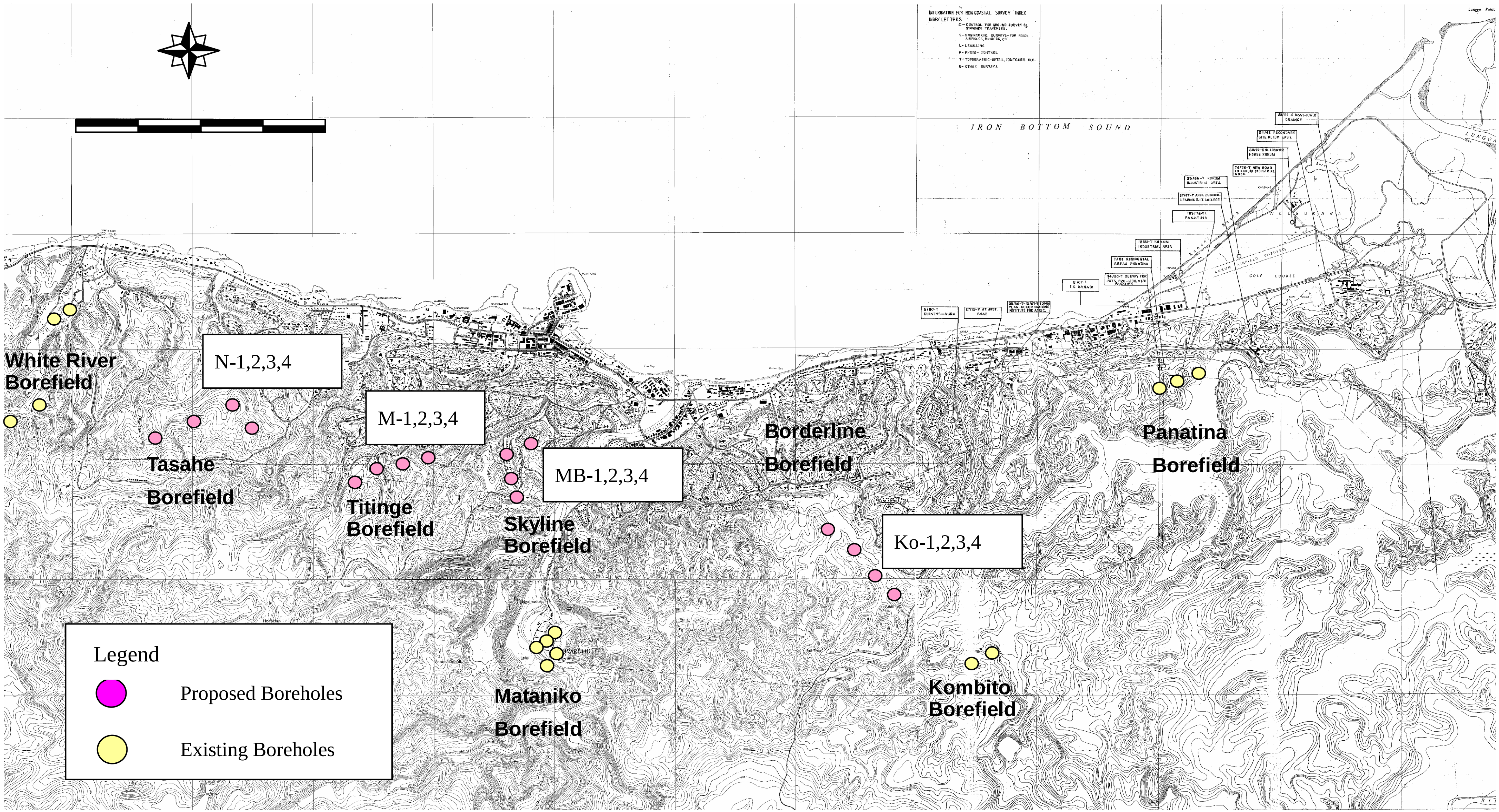
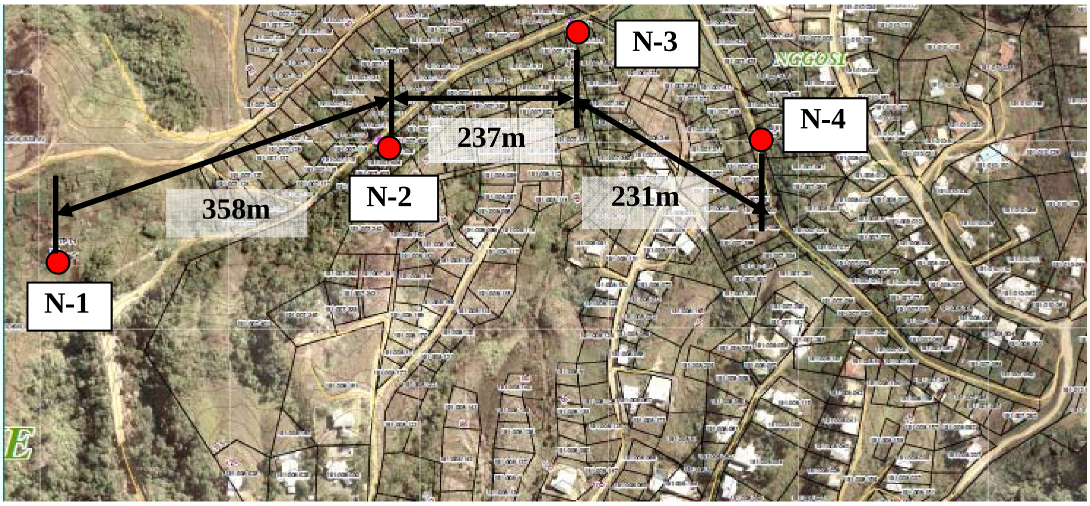
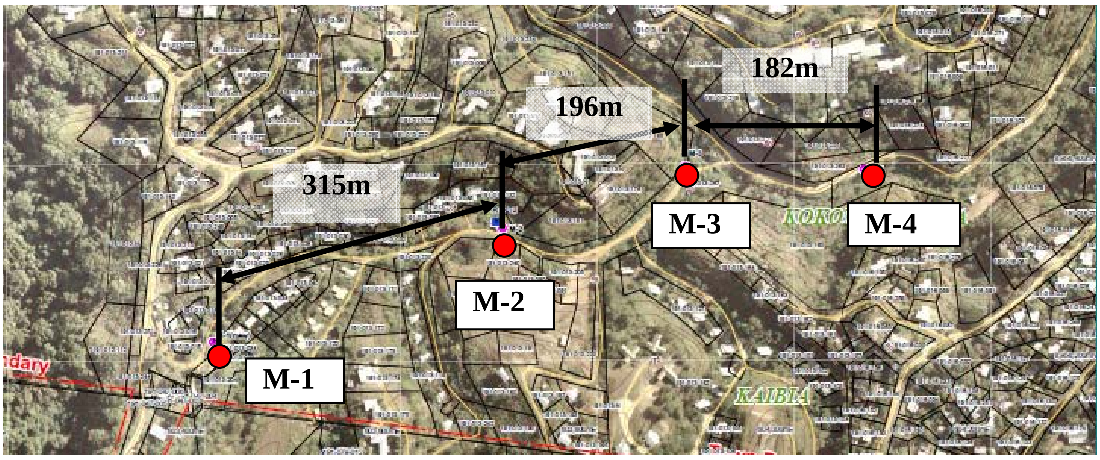


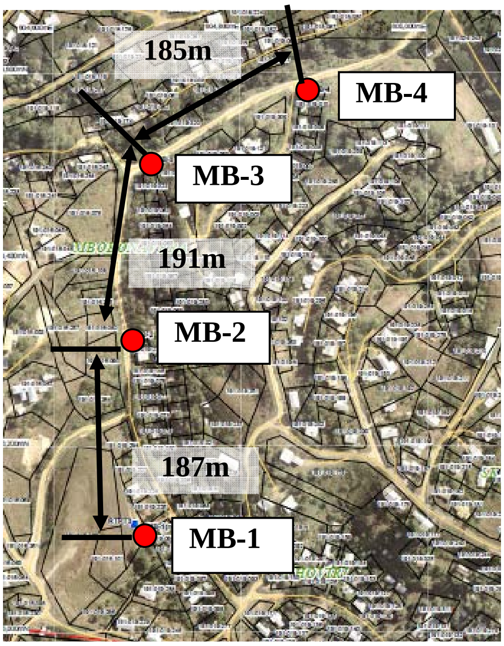
Fig. 2-2-5 Layout Drawing for Honiara Borefields (1/2)



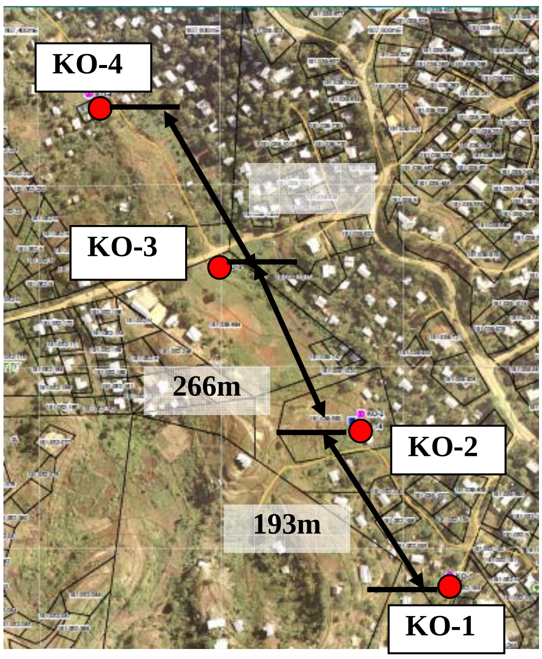
a) Tasahe Borefield



b) Titinge Borefield



c) Skyline Borefield



d) Borderline Borefield

Fig 2-2-5 Layout Drawing for the Honiara Borefields (2/2)

2) Examination of aquifer

① Estimated aquifer depth

Estimated aquifer depth based on the results of electric resistivity prospecting is shown in Table 2-2-16.

Table 2-2-16 Estimated Depth of the Honiara Aquifer

Borefield	Borehole No.	Estimated Depth of Aquifer (GL.-m)
Tasahe Borefield	N-1	40 - 150
	N-2	20 - 110
	N-3	20 - 110
	N-4	20 - 140
Titinge Borefield	M-1	50 - 140
	M-2	30 - 130
	M-3	30 - 180
	M-4	40 - 100
Skyline Borefield	MB-1	70 - 120
	MB-2	70 - 120
	MB-3	20 - 130
	MB-4	60 - 120
Borderline Borefield	KO-1	20 - 150
	KO-2	20 - 100
	KO-3	30 - 100
	KO-4	20 - 100

② Aquifers of the existing boreholes

Fig. 2-2-6 shows geological overview of the existing borefields and locations of screen installation.

White River Borefield-Mataniko Borefield

Although the existing White River Borefield and Mataniko Borefield are situated approximately 4km from each other, both borefields rely on the same aquifer within the Honiara Layer.

White River Borefield has a screen for EL.-20m to -60m. This suggests that there is a rich aquifer formed near this depth of the area between the above borefields within the Honiara Layer. It indicates that an aquifer exists near this depth of the area between the new borefields, supporting the results obtained from electric resistivity prospecting carried out under this survey.

On the other hand, terrain elevation of new borefields, Tasahe Borefield, Titinge Borefield and Skyline Borefield, is EL.+30m - +70m, higher than the elevation of the existing White River and Mataniko Borefields. Hence, length of the new boreholes must be made longer than 80m, length of the existing boreholes, if the depth of the aquifer used by the existing borefields also applies to the aquifer of the new borehole locations.

In that case, length of the new boreholes should be determined as terrain elevation - (-60m; the lowest depth of the aquifer of the existing boreholes) + Spare length

Mataniko Borefield - Kombito Borefield

The existing Kombito Borefield has a screen for EL.+20m - -20m, and relies on the aquifer within

Kombito Maar accumulated on top of the Honiara Layer where the other existing borefields are located. Borderline New Borefield located along the ocean is also within the distribution range of Kombito Maar, and an aquifer is likely to exist at the depth a little lower than the above elevation, supporting the results of electric resistivity prospecting carried out this time.

Hence, the appropriate borehole length for Borderline New Borefield is defined as 100m, as proposed during the JICA Development Study.

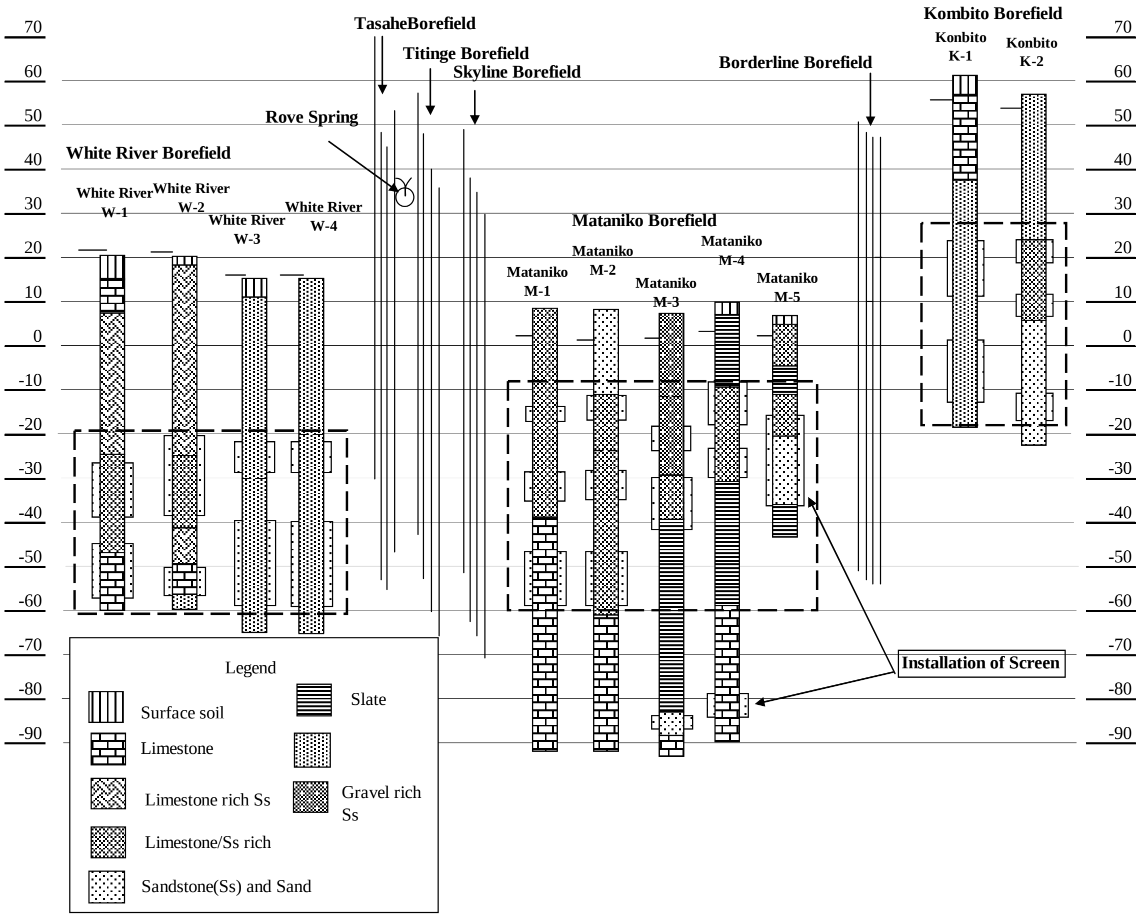


Fig. 2-2-6 Aquifer of the Existing Honiara Boreholes

3) Study of borehole interference

The following items were studied for interference of boreholes;

1. Drawdown at the new borefields
2. Impact on the existing boreholes
3. Impact on Konglai, Rove and Kombito Springs utilized as the existing water sources
4. Saline intrusion

① Drawdown at the new borefields

Examination was carried out for drawdown of the groundwater level of multiple boreholes within the new borefield. Based on the results of electric resistivity prospecting and the existing soil investigation and borehole data, the followings were considered assumptions for the status of the aquifer and hydraulic conditions of the examination:

- Average length of screens installed for the existing boreholes is defined as thickness of the aquifer.
- Groundwater level is defined based on the results of electric resistivity prospecting and the groundwater level of the existing boreholes.
- Permeability coefficient is defined based on the existing survey data and the existing water-pumping test results.
- Influence radius of the boreholes is defined based on the existing survey data.

Table 2-2-17 shows hydraulic conditions of each borehole location.

Table 2-2-17 Hydraulic Conditions of the Aquifer for New Borefields in Honiara

Borefield	Geology of Aquifer	Thickness of the Aquifer	Groundwater Level (EL.m)	Permeability Coefficient	Effective Radius
Tasahe Borefield	Honiara Bed Sandstone	30m	10m	4.0m/day	1,000m
Titinge Borefield	ditto	30m	20m	4.0m/day	1,000m
Skyline Borefield	ditto	30m	20m	4.0m/day	1,000m
Borderline Borefield	ditto	30m	10m	3.0m/day	1,200m

Also, results of the drawdown study based on the above conditions are shown in Table 2-2-18.

Table 2-2-18 Results of the Drawdown Study for New Honiara Borefields

(a) Tasahe Borefield

Borehole Nc	Coefficient of Permeability	Depth of Aquifer	Effective Radius	Distance between other Boreholes(m)				Calculated Drawdown	Estimated Grundwater Level (before pumping)	Estimated Groundwater Level at the time of Drawdown
	K (m/day)	(m)	R(m)	N-1	N-2	N-3	N-4	S (m)	EL..m	(EL..m)
N-1	4	30	1,000	0.1	358	593	750	11.67	15	3.3
N-2	4	30	1,000	358	0.1	237	402	13.31	15	1.7
N-3	4	30	1,000	593	237	0.1	231	13.41	15	1.6
N-4	4	30	1,000	750	402	231	0.1	12.62	15	2.4

Note: Above examination is done based on the pumping volume of 800 m^3/day.

(b) Titinge Borefield

Borehole Nc	Coefficient of Permeability	Depth of Aquifer	Effective Radius	Distance between other boreholes(m)								Calculated Drawdown	Estimated Grundwater Level (before pumping)	Estimated Groundwater Level at the time of Drawdown
	K (m/day)	(m)	R(m)	M-1	M-2	M-3	M-4	MB-1	MB-2	MB-3	MB-4	S (m)	EL..m	(EL..m)
M-1	4	30	1,000	**0.1**	**315**	**511**	**684**	1310	1279	1324	1505	12.12	15	2.9
M-2	4	30	1,000	**315**	**0.1**	**196**	**372**	1034	**982**	1179	1193	13.79	15	1.2
M-3	4	30	1,000	**511**	**196**	**0.1**	**182**	**870**	**800**	**821**	**998**	14.63	15	0.4
M-4	4	30	1,000	**684**	**372**	**182**	**0.1**	**698**	**635**	**642**	**821**	14.59	15	0.4

Note: Above examination is done based on the pumping volume of 800 m^3/day.

(c) Skyline Borefield

Borehole No	Coefficient of Permeability	Depth of Aquifer	Effective Radius	Distance between other boreholes(m)								Calculated Drawdown	Estimated Grundwater Level (before pumping)	Estimated Groundwater Level at the time of Drawdown
	K (m/day)	(m)	R(m)	MB-1	MB-2	MB-3	MB-4	M-1	M-2	M-3	M-4	S (m)	EL..m	(EL..m)
MB-1	4	30	1,000	**0.1**	**187**	**375**	**482**	1310	1034	**870**	**698**	13.91	15	1.1
MB-2	4	30	1,000	**187**	**0.1**	**191**	**328**	1279	**982**	**800**	**635**	15.23	15	-0.2
MB-3	4	30	1,000	**375**	**191**	**0.1**	**185**	1324	1179	**821**	**642**	15.05	15	0.0
MB-4	4	30	1,000	**482**	**328**	**185**	**0.1**	1505	1193	**998**	**821**	13.74	15	1.3

Note: Above examination is done based on the pumping volume of 800 m^3/day.

(d) Borderline Borefield

Borehole No	Coefficient of Permeability	Depth of Aquifer	Effective Radius	Distance between other boreholes(m)								Calculated Drawdown	Estimated Grundwater Level (before pumping)	Estimated Groundwater Level at the time of Drawdown
	K (m/day)	(m)	R(m)	KO-1	KO-2	KO-3	KO-4	K-1	K-2			S (m)	EL..m	(EL..m)
KO-1	3	30	1,200	**0.1**	**193**	**425**	**661**	**979**	**1062**			19.06	30	10.9
KO-2	3	30	1,200	**193**	**0.1**	**266**	**502**	**793**	**932**			19.77	30	10.2
KO-3	3	30	1,200	**425**	**266**	**0.1**	**237**	1349	1568			19.20	30	10.8
KO-4	3	30	1,200	**661**	**502**	**237**	**0.1**	**1196**	1428			17.67	30	12.3

Note: Above examination is done based on the pumping volume of 800 m^3/day.

② Impact on the existing boreholes

The existing White River boreholes (4 boreholes) are located approximately 1km west of Tasahe New Borefield. Since these boreholes are temporarily used for emergency purposes, they will not be affected by construction of the new boreholes.

On the other hand, K-1 and K-2, boreholes that are currently used as water sources of SIWA, are situated approximately 1km southeast of Borderline New Borefield. The examination on the impacts on K-1 and K-2 from water pumping at Borderline New Borefield is summarized in Table 2-2-18, which suggests no major impacts on K-1 and K-2 from the new boreholes.

③ Impacts on the existing source springs

The following two springs located near the planned new borefields in Honiara are used by SIWA as water sources:

<u>Konglai Spring</u>

Konglai Spring is situated approximately 2km southwest of N-1 in Tasahe New Borefield. Water of the spring comes from the underground cavern formed within the Bonege limestone at the bottom of the Honiara Layer, and the elevation of the spring is approximately 100m. Also, river water is supplied from the sinkhole (vertical hole stretching from the river to the underground cavern, Kobi sinkhole) formed within the Upper Bonege limestone to the underground cavern of the spring source, resurging from Konglai Spring after meeting with groundwater. Hence, the amount of water from Konglai Spring is affected by water precipitation as the amount of flow from the river is increased during flooding. It is also known that turbidity of the river source pronouncedly appears in the spring.

Since the aquifer of Konglai Spring is formed within the Bonege limestone of the Lower Honiara Layer and water is supplied from the river at the upper level, there will be no impacts from pumping at the new boreholes, which utilizes the aquifer in the Honiara Layer at the Upper Bonege limestone.

Rove Spring

Rove Spring is situated between two new borefields, Tasahe and Titinge Borefields, and the elevation of the spring is approximately 32m. It is considered that water of Rove Spring comes from the bottom of the Honiara Leaf limestone situated higher than the Honiara Layer, an aquifer used by the new boreholes.

Unlike Konglai Spring, changes in the amount of water from Rove Spring due to precipitation are not recognized, and the amount of flow from the weir of Rove Spring is stable at around the level of 0.018m^3/sec (1,555m^3/day) during the JICA Development Study and this Study. While Konglai Spring draws river water from the sinkhole, only groundwater is discharged from Rove Spring.

Since water pumping from the aquifer at the shallow part (around GL.30 - 40m) of Tasahe Borefield and Titinge Borefield is likely to reduce the amount of flow from the existing weir of Rove Spring and hence the amount of water available as an existing water source, Tasahe and Titinge Borefields need to utilize only the deep aquifer already used by the existing boreholes.

④ Saline intrusion

In general, a specific resistance value of saline groundwater is 10Ω-m or below. However, such a low value was not detected at the lower depth from electric resistivity prospecting carried out under this Study.

On the one hand, saline intrusion into groundwater during pumping of groundwater at the new boreholes was studied during JICA Development Study, but no specific saline-related problems were identified with regard to the new borefields.

4) Summary

- In some cases, boreholes are situated less than 200m from each other within the same borefield due to land restrictions. From the result obtained by the study, drawdown of respective boreholes as a result of water pumping at the new borefield is estimated to be around 20m at maximum. Location of the pump needs to take into account spare length for the above figure.
- The examination on impacts on the existing boreholes and springs from water pumping at the new boreholes concluded that the impacts would not be significant. Yet, design of the boreholes needs to take into account impacts on Rove Spring.
- According to the results of the JICA Development Study and the status of the existing borehole, it is considered that water pumping at the new borefields will not cause saline water intrusion into groundwater.

(2) Borehole Structure

1) Basic structure

In consideration of the structure of the existing boreholes and pump installation for enabling pumping of the required water volume, basic structure of the new boreholes is defined as shown in Fig. 2-2-7.

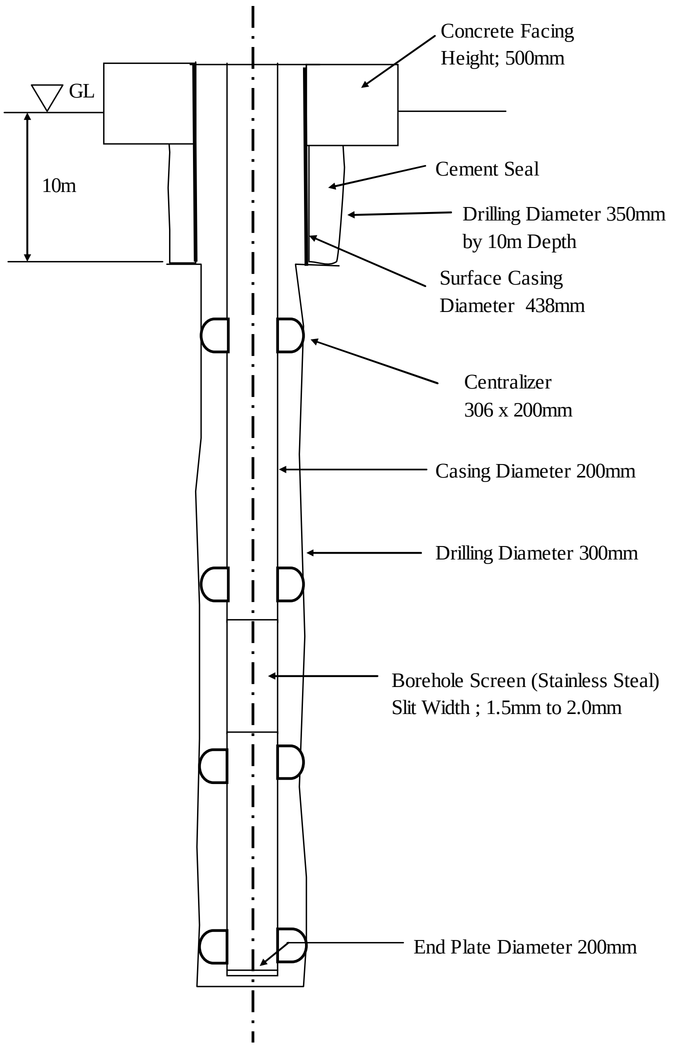


Fig. 2-2-7 Borehole Structure of New Borefields in Honiara

2) Borehole specifications

Based on the results of the aquifer study conducted under the natural condition survey and the study results in the previous chapter, specifications of the new boreholes and borefields are defined in Table 2-2-19.

Table 2-2-19　Specifications of New Boreholes in Honiara

Borefield	Borehole No.	Elevation of Borehole (EL.m)	Length of Borehole (m)
Tasahe	N-1	62	130
	N-2	49	120
	N-3	43	120
	N-4	47	130
Titinge	M-1	69	140
	M-2	48	130
	M-3	50	120
	M-4	38	110
Skyline	MB-1	49	130
	MB-2	40	120
	MB-3	31	120
	MB-4	27	110
Borderline	KO-1	56	100
	KO-2	54	100
	KO-3	48	100
	KO-4	45	100

(3)　Specifications of Borehole Pumps

Fig. 2-2-8 shows a borehole pump system.

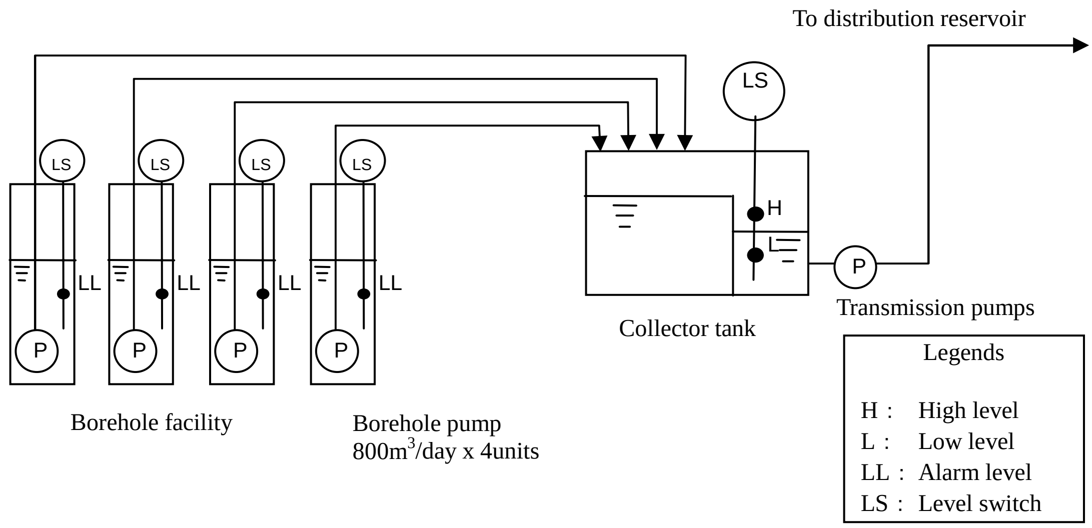


Fig. 2-2-8　New Borehole Pump System in Honiara

Under the borehole pump plan, one duty pump shall be installed for each borehole and one stand-by pump shall be secured (to be kept in a store) for each borefield. To avoid interference between the boreholes, an independent water conveyance pipeline shall be installed between each borehole and its collector tank.

Operation of the borehole pump shall follow the requirements below, and their control circuit shall be planned to realize these operational requirements.

- In principle, the amount of flow running through the borehole pump shall be equivalent to or less than that of the transmission pumps. Therefore, the borehole pump shall basically be operated for

24 hours without intermission.

- However, since the water level of the borefield collector tank rises when the transmission pump stops at the high water level (H) of its distribution reservoir, a borehole pump shall be automatically stopped as soon as the water level of the borefield collector tank reaches the high water level (H) (See 2-2-2-5 Water Transmission Pump Station).
- Interlocking shall be activated at the idling prevention water level (LL) to prevent idling of a borehole pump.
- A control panels for borehole pumps to be installed at a water transmission pump station shall be designed so as to realize remote automatic operation/stoppage of each borehole pump and input of warning signals.
- In routine check or repair work at each borefield, borehole pump operation shall be designed to enable switching from automatic operation to on-site manual operation.

A borehole pump control panel will be installed at both a water transmission pump station (center control panel) and each borehole site (local control panel).

For corrosion protection, pipes used at and around the borehole pumps shall be of stainless steel (SUS304 or equivalent).

Main specifications of the borehole pumps are as follows;

Type: Submersible borehole pump

Primary material: SUS

Motor: 2P x 415V x 50Hz x 3 phases

Performance of each borehole pump is shown in Table 2-2-20.

Table 2-2-20 Performance of Borehole Pumps at New Boreholes in Honiara

Borehole	Borehole No.	Capacity	Qty.
Tasahe	N-1	$0.56m^3$/min x 85mAq x 15kw	1
	N-2	$0.56m^3$/min x 85mAq x 15kw	1
	N-3	$0.56m^3$/min x 85mAq x 15kw	1
	N-4	$0.56m^3$/min x 85mAq x 15kw	1
Titinge	M-1	$0.56m^3$/min x 85mAq x 15kw	1
	M-2	$0.56m^3$/min x 70mAq x 13kw	1
	M-3	$0.56m^3$/min x 70mAq x 13kw	1
	M-4	$0.56m^3$/min x 70mAq x 13kw	1
Skyline	MB-1	$0.56m^3$/min x 70mAq x 13kw	1
	MB-2	$0.56m^3$/min x 70mAq x 13kw	1
	MB-3	$0.56m^3$/min x 70mAq x 13kw	1
	MB-4	$0.56m^3$/min x 70mAq x 13kw	1
Borderline	KO-1	$0.56m^3$/min x 65mAq x 11kw	1
	KO-2	$0.56m^3$/min x 65mAq x 11kw	1
	KO-3	$0.56m^3$/min x 65mAq x 11kw	1
	KO-4	$0.56m^3$/min x 65mAq x 11kw	1

(4) Water Hammer Protection

Since water conveyance pipelines from the borehole facilities to their borefield collector tanks will run through the undulating lands, thorough water hammer protection needs to be considered for planning of the conveyance pipelines.

For countermeasures against water hammer, options such as flywheels, high-speed air vent valves, open surge tank, pressure tank, etc., can be considered.

Among the above options, high-speed air vent valves shall be adopted because they are considered most suitable for the actual situation at site and most economical. They will be installed at appropriate positions of the pipelines.

Table 2-2-21 shows a list of installation positions of high-speed air vent valves in each borefield.

Table 2-2-21 Installation Positions for High-speed Air Vent Valves

Borehole	Borehole No.	Measures for Water Hummer	Installation Point
Tasahe	N1	75A High Speed Air Vent Valve	At the point of borehole
	N2	75A High Speed Air Vent Valve	At the distance of 300m from borehole
	N3	75A High Speed Air Vent Valve	At the distance of 550m from borehole
	N4	None	
Titinge	M1	75A High Speed Air Vent Valve	At the point of borehole
	M2	75A High Speed Air Vent Valve	At the point of borehole
	M3	75A High Speed Air Vent Valve	At the distance of 100m from borehole
	M4	75A High Speed Air Vent Valve	At the distance of 300m from borehole
Skyline	MB1	75A High Speed Air Vent Valve	At the point of borehole
	MB2	75A High Speed Air Vent Valve	At the distance of 100m from borehole
	MB3	75A High Speed Air Vent Valve	At the distance of 315m from borehole
	MB4	75A High Speed Air Vent Valve	At the distance of 500m from borehole
Borderline	KO1	75A High Speed Air Vent Valve	At the point of borehole
	KO2	75A High Speed Air Vent Valve	At the point of borehole
	KO3	75A High Speed Air Vent Valve	At the point of borehole
		75A High Speed Air Vent Valve	At the distance of 200m from borehole
	KO4	75A High Speed Air Vent Valve	At the distance of 300m from borehole
Auki	AK1	None	
	AK2	None	

Note: 75A means a nominal diameter of 75 mm.

To determine installation positions of high-speed air vent valves, a low pressure line was calculated from vertical sections of pipelines and pump properties, and negative pressure of each position was set as -7m or above.

2-2-2-5 Water Transmission Pump Station

(1) Basic Policy

Under the Project, water transmission pump station shall be installed at Tasahe New Borefield, Titinge New Borefield, Skyline New Borefield and Borderline New Borefield respectively. The transmission pump system is shown in Fig. 2-2-9.

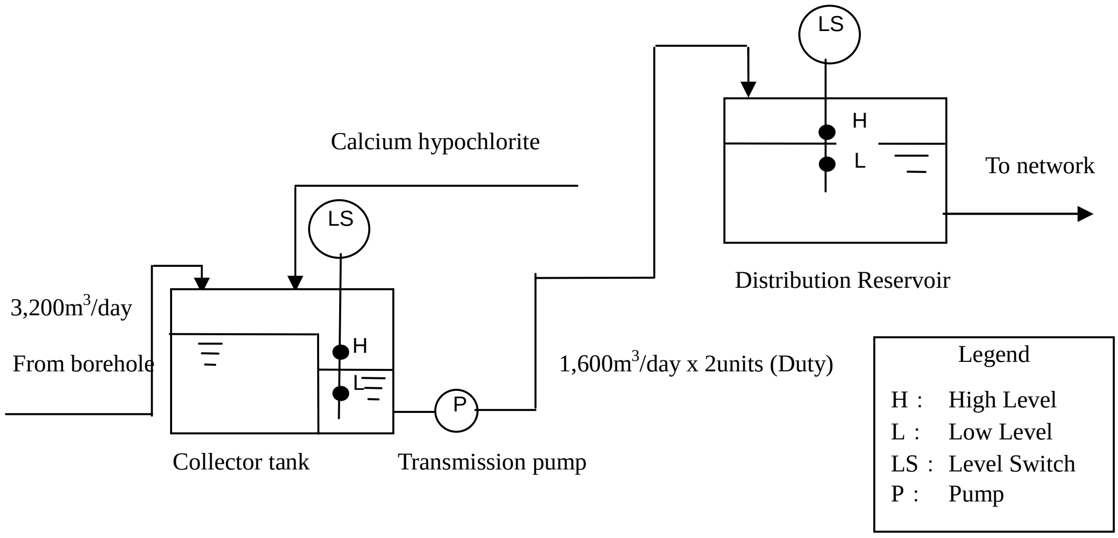


Fig. 2-2-9 Transmission Pump System in Honiara

A water transmission pump station is a facility used for transmitting water lifted from a borehole to a borefield collector tank, in which calcium hypochlorite is added to the water for disinfection, and transmitted to a distribution reservoir through a transmission pump. The pump station consists of borefield collector tanks, chlorination equipment, transmission pumps, power receiving equipment and an emergency diesel engine generator.

In consideration of maintenance, the collector tank shall have two basins.

Operation of the water transmission pump will be implemented based on the following requirements, and planning of the control circuit will take into account these operational requirements.

- A total of three pumps will be installed. Two of them will be used for regular operation to transmit the design water volume. The remaining pump is regarded as a stand-by.
- Automatic operation will be employed to stop water transmission at the high water level (H) of the distribution reservoir in order to prevent overflow from the reservoir.
- Automatic operation will be employed to stop water transmission at the low water level (L) of the collector tank.
- Interlocking must be activated at the idling prevention water level (LL) to prevent idling of the transmission pump.

A control panel for the transmission pump will be installed inside the electrical room of the pump station.

For corrosion protection, pipes used at and around the borehole pumps shall be equivalent to stainless SUS304.

Design conditions for the above equipment are summarized in Table 2-2-22. Design conditions of the chlorination equipment are the same as mentioned in 2) Chlorination facility of “2-2-2-6 Settling Basin for Turbidity Reduction”. Requirements for the power receiving facility and emergency diesel engine generator are explained in the respective sections of 2-2-2-9 and 2-2-2-10.

Table 2-2-22 Design Conditions for Water Transmission Pump Equipment in Honiara

Facility	Design condition	
Receiving tank	Retention time:	1 hour or more
Disinfection equipment	Chlorine agent:	Calcium hypochlorite (activechloride conc. 65%)
	Solution conc.:	30kg-activechloride/ m^3
	Dosing rate:	Max.3mg-activechloride/L, Ave.1.5mg-activechloride/L Min. 1mg-activechloride/L
	Storage tank:	2 units. Total volume for 7 days or more on average daily dosing volume basis.

(2) Specifications

Specifications of the pump stations are shown below. The same specifications except pump performance will be applied to the four stations.

1) Borefield collector tank

Material: Reinforced concrete (RC)

Shape: Square tank

Effective capacity: 72 m^3/basin (retention time 1.1 hours)

Usable dimension: W3.9m x L6.1m x H3.05m

Quantity: 2 basins

2) Chlorination equipment

① Calcium hypochlorite feeding device

Performance: Max. 0.23L/min, Min. 0.076L/min

Material: Polyvinyl chloride (PVC)

Effective capacity: 0.3 m^3/basin

② Calcium hypochlorite storage tank

Material: Polyethylene (PE)

Shape: Open-round

Effective capacity: 1m^3/basin

Dimension: Dia.1.06m x H1,255m

Quantity: 2 basins

③ Calcium hypochlorite storage tank agitator

Material:	Stainless+ Resin lining
Shape:	Portable, medium-speed
Motor:	0.4kW x 2P x 415V x 50Hz x 3 phases
Quantity:	2 agitators (1 agitator/basin)

3) Water transmission pump

Type:	Vertical multistage centrifugal pump
Material:	Stainless
Motor:	2P x 415V x 50Hz x 3 phases

Table 2-2-23 shows pump performance of the pump stations.

Table 2-2-23 Pump Performance of New Honiara Transmission Pump Station

Pump station	Capacity	Quantity
Tasahe	1.11m^3/min x 105m x 30kW	3 (Including 1 stand-by)
Titinge	1.11m^3/min x 100m x 30kW	3 (Including 1 stand-by)
Skyline	1.11m^3/min x 75m x 22kW	3 (Including 1 stand-by)
Borderline	1.11m^3/min x 35m x 11kW	3 (Including 1 stand-by)

(3) Water Hammer Protection

As in the case with water hammer protection for the pipelines between the boreholes and the collector tanks, pipelines from collector tanks to distribution reservoirs also require water hammer protection as they run through undulating lands.

The maximum negative pressure and positions were examined based on a low pressure line calculated from vertical sections of the pipelines and pump properties. As a result, negative pressure of the pipelines from all of the four pump stations to the distribution reservoirs was estimated as -5m or below, which indicates no risk of water column separation.

Therefore, no special equipment will be installed for water hammer protection for the pipelines from the pump stations to their distribution reservoirs.

2-2-2-6 Settling Basin for Turbidity Reduction

(1) Basic Concept for designing settling basin for turbidity reduction

1) Settling Basin for Turbidity Reduction

Based on the results of water quality tests conducted on the water from Konglai Spring and Kombito Spring during the Basic Design period, a settling basin for turbidity reduction (S/B) with plain sedimentation function has been planned considering the following factors:

① S/B shall have such three (3) functions of settlement, buffering (turbidity, volume) and sludge drainage.

- Turbidity buffering function: S/B shall be able to respond to and buffer the high raw water turbidity
- Distribution volume buffering function: S/B shall be able to supply the retained water in the settling basin in case of the unusual circumstances which may happen at the water sources.

② S/B shall exercise its settlement and buffering function as much as possible, since there is no filter basin attached to S/B, while typical water treatment plants have sedimentation basin equipped with filter basin.

③ S/B shall be easily and continuously operated and maintained by SIWA staffs without any high technical skills.

④ S/B shall be able to easily reduce or absorb high turbidity of raw water in order to prevent the rapid rise of high turbidity of water from the spring water sources.

Changes of water turbidity obtained from two water sources at the city of Honiara were confirmed at the time of Basic Design Study as follows:

(i) The water turbidity obtained from Konglai and Kombito Springs rose within hours after the occurrence of heavy rainfalls to 15NTU maximum and 40 NTU maximum respectively.

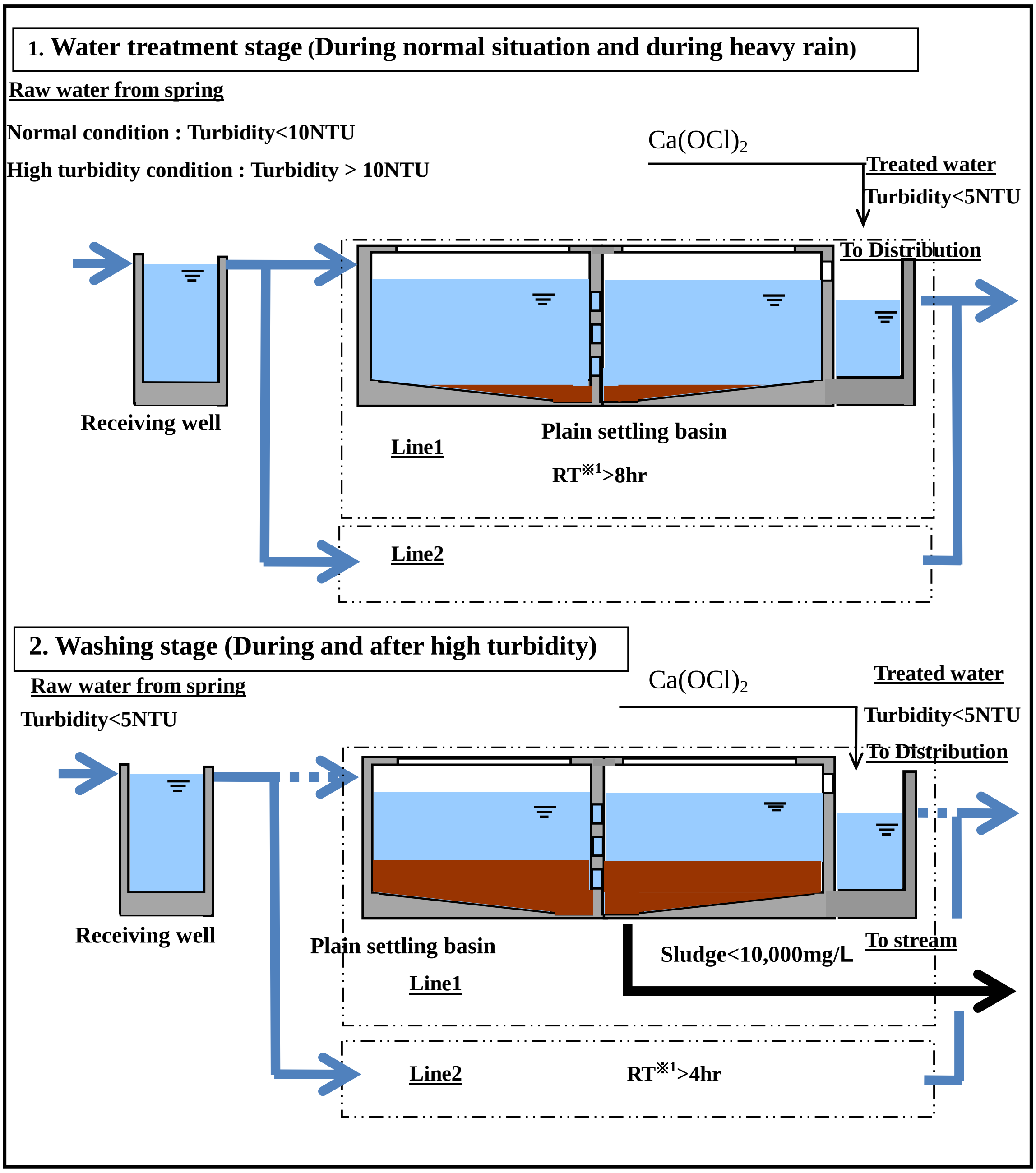
(ii) The water turbidity fell down to the normal turbidity within hours after the occurrence of the high turbidity.

⑤ The number of times which the raw water turbidity exceeds the drinking water standard of 5NTU is estimated at 18 times and 28 times in a year at Konglai Spring and Kombito Spring respectively according to the result of field study. S/B shall be operated without any sophisticated task even in the event of such emergency situations.

⑥ S/B shall be kept in good operating conditions for a long period.

⑦ S/B shall be composed of equipment which may be easily procured and does not require many kinds of spare parts, considering the situation of developing countries

Fig. 2-2-10 shows a flow sheet for a settling basin for turbidity reduction.



*1 RT means "Retention time".

Fig. 2-2-10 Flow Sheet of Settling Basin for Turbidity Reduction

Basic design and operational principles of the settling basin are as follows:

- Two lines must be operated for both normal condition with low turbidity (turbidity of 10NTU or below) and unusual condition with high turbidity of raw water (turbidity of 10NTU or above.)
- After decrease of high turbidity of raw water (to 5NTU or below,) cleaning shall be conducted for each line.
- High turbidity period which this reservoir can cope with shall be not more than 8 hours.
- Required number of maintenance staff shall be one or two in normal conditions. After occurrence of high turbidity, another one or two staffs are required for discharging and cleaning

sludge.

- In principle, measurement of turbidity shall be conducted by operators or workers with visual inspection. During trial operation and soft component period, relation between actual turbidity and turbidity determined through visual inspection shall be instructed to operators or workers in charge.
- When remarkable increase of sludge depth is found in routine check or after high turbidity causing stoppage of operation has occurred, discharging and cleaning work shall be conducted.

Design treated water quality and design conditions are shown in Table 2-2-24 and 2-2-25 respectively.

Table 2-2-24 Design Treated Water Quality

	Item	Raw water	Treated water
Normal condition	Turbidity	10 NTU or less	5 NTU or less
	Color	15 TCU or less	15 TCU or less
High turbidity Konglai spring	Turbidity	10 NTU or more, 30 NTU or less	5 NTU or less
	Color	15 TCU or more, 30 TCU or less	15 TCU or less
High turbidity Kombito spring	Turbidity	10 NTU or more, 50 NTU or less	5 NTU or less
	Color	15 NCU or more, 30 NCU or less	15 TCU or less

Table 2-2-25 Design Conditions for Settling Basin for Turbidity Reduction

	Design Conditions	Basis
Receiving Well	Detention time: more than 1.5 minutes	Design Criteria for Waterworks Facilities (Japanese Standard) shall be referred to.
Settling basin for Konglai	Surface loading: Less than 10 mm/min	Ditto
	Cross current velocity in reservoir: Less than 0.3 m/min as Average	Ditto
	Removal rate of turbidity: more than 50 %	Examination results by BD Team
	Removal rate of color: more than 50 %	Ditto
	Detention time: more than 8 hours	Field survey result by BD Team
Settling basin for Kombito	Surface loading: Less than 5 mm/min	Design Criteria for Waterworks Facilities (Japanese Standard) shall be referred to
	Cross current velocity in reservoir: Less than 0.3 m/min as Average	Ditto
	Removal ratio of turbidity: more than 50 %	Examination results by BD Team
	Removal ratio of color: more than 50 %	Ditto
	Detention time: more than 16 hours	Field survey result by BD Team

Table 2-2-26 shows the comparison between plain sedimentation and coagulating sedimentation. The field survey confirmed space for installing plain sedimentation and concluded that coagulation treatment at Konglai Spring and Kombito Spring would be difficult in terms of O&M technique and running cost as indicated in the comparison. Therefore, coagulation treatment will not be adopted in the Project.

Table 2-2-26 Comparison between Plain Sedimentation and Coagulating Sedimentation

		Plain sedimentation	Coagulating sedimentation
Theory		Turbidity is settled and separated by gravity	Coagulant is added in mixing basin then suspended substances are coagulated and flocculating to increase sedimentation rate in flocculating basin. Finally the floc are settled and separated at sedimentation basin
Composition		Receiving well, sedimentation basin	Receiving well, mixing basin, flocculating basin, sedimentation basin and facility for dosing coagulant
Strong point		・ Operation can be done against fluctuation from high-turbidity to low-turbidity in raw water. ・ Operation and maintenance is very simple because the only process is discharging sludge from the bottom of sedimentation basin. ・ Design overflow rate can be determined regardless of raw water turbidity on inlet. ・ It is the most conventional process and easiest to get stable water quality.	・ Operation can be done against fluctuation from high-turbidity to low-turbidity in raw water by changing dosing rate of coagulant. ・ Design overflow rate can be determined regardless of raw water turbidity.
Weak point		・ Removal rate for turbidity and color is less than that by coagulation and sedimentation.	・ This process requires chemicals. ・ It is difficult to control dosing rate of coagulant on fluctuation corresponding to turbidity. ・ Therefore, design overflow rate shall be nearly equal to plain sedimentation. ・ Process is generally combined with sand filter to prevent coagulant from leaking.
Economic point	Initial cost*1	1.0	1.2
	Running cost*2	-	0.2
Space		1.0	1.3
Service life of the facility		Service life of the reinforced-concrete tank is 50 years. However, service life of auxiliary equipments like piping or valves are approx. 20 years. With properly maintenance of the facility, service life is estimated from 25 to 30 years.	Service life of the reinforced-concrete tank is 50 years. On the other hand, legal service life of auxiliary equipments like piping, valves and chemical mixing system are approx. 20 years. With maintenance of the facility, service life will be estimated from 25 to 30 years.
Operation and maintenance		○	× ・ Operator will face some difficulty because solving and dosing of coagulant must be started after heavy rain occurs ・ Adjustment of dosing rate depending on fluctuation of turbidity is necessary ・ Sludge volume increase by about 20% ・ Coagulant dosing facility needs to be cleaned.

Note: 1. Indicates a relative figure to the initial cost of plain sedimentation set as 1.0
2. Indicates relative figures to the initial cost of plain sedimentation and the running cost of coagulating sedimentation for 20 years

2) Chlorination facility

Calcium hypochlorite (effective chorine concentration 65%) already used in the existing facilities will be used as a chlorine agent by agitation and dissolution with a mechanical agitator,. Transfer of the solution to the feeding point will be executed, through by gravity sedimentation without a pump

Table 2-2-27 shows design conditions of a chlorination facility.

Table 2-2-27　Design Conditions of Chlorination Facility

Item	Designed condition
Chlorine agent	Calcium hypochlorite (active chloride concentration 65%)
Solution conc.	30kg-active chloride/ m^3
Dosing rate	Max. 3mg- active chloride /L, Ave. 1.5mg- active chloride /L Min. 1mg- active chloride /L
Storage tank	2 units. Total volume for 7 days or more on average daily dosing volume basis.

3)　Water Quality Test Equipment

For operation of the turbidity reduction facility established under the Project, apparatuses shown in Table 2-2-28 are considered minimum necessary for SIWA to implement adequate operation and maintenance.

Table 2-2-28　Water Quality Test Apparatuses Needed for Operation & Maintenance of Turbidity Reduction Facility

Apparatus	Qty.
pH meter (desk type)	1
pH meter (portable type)	3
Conductivity meter (portable type)	3
Potable water analysis set (For turbidity and color check, etc.)	3
Residual chlorine meter	3
Thermometer	5

4)　Other facilities

Inflow to the settling basin will be measured by an electromagnetic flow meter to ensure accurate monitoring of accumulated flow.

(2)　Construction plan for Konglai Settling Basin

Currently, Konglai Spring serves as a primary source for water supply to Honiara, for which the spring water is transferred by two transmission pipelines: a gravity pipeline and a rising main by water transmission pumps to transmit water to Tasahe reservoir.

Since these transmission pipelines and pumps are located on the planned settlement basin site, installation of temporary pipes and transfer of transmission pumps will be required before construction of the basin. Planning of temporary and permanent reservoir construction must take into account the method for minimizing the duration of water supply stoppage.

The following outlines construction plan of Konglai settling basin:

① Construct new pump station building for existing water transmission pumps

② Install temporary pipe for the existing gravity pipeline and distribute water to Area-1 (refer to Fig.2-2-2)

③ Relocate existing water transmission pumps, transfer existing water transmission pipeline to new pump station and then transmit water to Tasahe reservoir

④ Construct Konglai settling basin and install gravity pipeline for the Project. After that distribute water to Area-1

(3) Specifications

Specifications for the settling basin for turbidity reduction are shown below.

1) Konglai settling basin

Design water purification 4,100m^3/ day

① Receiving borehole

Material:	Reinforced concrete (RC)
Shape:	Square tank
Effective capacity:	33 m^3/ basin
Usable dimension:	W1.0m x L7.0m x H4.8m
Quantity:	1 basin

② Sedimentation basin

Method:	General sedimentation
Material:	Reinforced concrete (RC)
Effective capacity:	710 m^3/basin
Usable dimension:	W11.85m x L15.0m x H4.0m
Quantity:	2 basins

③ Chlorination facility

③-1 Calcium hypochlorite feeding device

Performance:	Max. 0.28L/min, Min. 0.097L/min
Material:	Polyvinyl chloride (PVC)
Effective capacity:	0.3 m^3/tank

③-2 Calcium hypochlorite storage tank

Material:	Polyethylene (PE)
Shape:	Open-round
Effective capacity:	1 m^3/ basin
Dimension:	Dia.1,06m x H1,255m
Quantity:	2 tanks

③-3 Calcium hypochlorite storage tank agitator

Material:	Stainless + Resin lining
Shape:	Portable, medium-speed
Motor:	0.4kW x 2P x 415V x 50Hz x 3phases
Quantity:	2 agitators (1 agitator/tank)

2) Kombito settling basin

Design water purification: 1,600m^3/day

① Receiving borehole

Material:	Reinforced concrete (RC)
Shape:	Square tank
Effective capacity:	33 m^3/ basin
Usable dimension:	W1.0m x L7.0m x H4.8m
Quantity:	1 basin

② Sedimentation basin

Method:	General sedimentation
Material:	Reinforced concrete (RC)
Effective capacity:	540 m^3/ basin
Usable dimension:	W5.85m x L23.1m x H4.0m
Quantity:	2 basins

③ Chlorination facility

③-1 Calcium hypochlorite feeding device

Performance:	Max. 0.11L/min, Min. 0.055L/min
Material:	Polyvinyl chloride (PVC)
Effective capacity:	0.3 m^3/ tank

③-2 Calcium hypochlorite storage tank

Material:	Polyethylene (PE)
Shape:	Open-round
Effective capacity:	1 m^3/ basin
Dimension:	Dia.1.06m x H1.255m
Quantity:	2 tanks

③-3 Calcium hypochlorite storage tank agitator

Material:	Stainless + Resin lining
Shape:	Portable, medium-speed
Motor:	0.4kW x 2P x 415V x 50Hz x 3phases
Quantity:	2 agitators (1 agitator/tank)

2-2-2-7 Distribution Reservoir

(1) Reservoir Capacity

The following will be taken into consideration for determining capacities of distribution reservoirs.

- Each capacity shall meet water demands of its service area in 2010.
- Approximately, a 12-hour volume of the maximum daily water supply shall be made available in Honiara.
- The capacities of the existing distribution reservoirs need to be considered.
- Available land for facility construction shall be considered.

Since the existing Titinge and Lower West Kolaa (steel) distribution reservoirs constructed in the 80's are no longer used due to deterioration by usage over service life, the existing reservoirs shall be removed and new reservoirs should be constructed in the same location.

The existing Skyline distribution reservoir (450m^3, steel) is a steel tank installed approximately 23 years ago, and its bottom and side panels have been severely rusted due to usage over service life. In particular, severe water leakage at the bottom of the tank was found from the field survey. Under the circumstances, SIWA intends to remove the old tank and to build a new distribution reservoir at the same location.

The existing reservoir is made of a sectional panel made by a British manufacturer, and employs on-site bolt assembly of the steel panels. The tank has been apparently affected by corrosion due to rust at the bolts as well as the panels. From the result of the field survey on the local conventional repair practices, it was found that the partial repair work of the tank would be impossible and that full replacement of the tank would be needed.

From these perspectives, given the change of the required capacity from 1,550 m^3 to 1,800 m^3, replacement of the existing reservoir with a new 1,800 m^3-capacity reservoir was considered appropriate for dealing with the additional increase of 250m^3.

Design capacities and positions of the distribution reservoirs are shown in Table 2-2-29.

Table 2-2-29 Design Capacities of New Distribution Reservoirs in Honiara

No.	Name of Reservoir	Design Capacity (m^3)	Location
1	Tasahe-2	1,700	New reservoir will be constructed at a space beside the existing reservoir
2	Titinge-2	1,300	The existing abandoned reservoir will be dismantled and new reservoir will be constructed in a vacant lot
3	Skyline-2	1,800	The existing reservoir will be dismantled and new reservoir will be constructed in a vacant lot
4	Lower West Kolaa-2	450	The existing abandoned reservoir will be dismantled and new reservoir will be constructed in a vacant lot
5	Panatina-2	2,100	New reservoir will be constructed in a space beside the existing reservoir constructed in 10 years ago
	Total	7,350	

(2) Type/Structure

Many of the existing steel distribution reservoirs became much deteriorated due to usage for more than 23 years. Also, as suggested by severe water leakage caused by rusting as a result of inadequate coating, a thorough examination is needed before use of steel tanks. In general, use of long-life less-leaky reinforced concrete (RC) is preferred in terms of maintenance and service life. However, from the detailed field survey, it was found that access to the planned sites was extremely inconvenient, and that some of the planned sites were too small to secure sufficient temporary construction space. In addition, considering difficult delivery of heavy construction machinery and schedule under the above circumstances, some of the reservoirs need to employ steel tanks. Selection of steel tanks requires a thorough study of their quality and careful considerations on rusting. Different types and structures of distribution reservoirs based on the above conditions are shown in Table 2-2-30.

Table 2-2-30 Types and Structures of New Distribution Reservoirs in Honiara

No.	Name of Reservoir	Design capacity (m^3)	Type	Material	Shape
1	Tasahe-2	1,700	On the ground	RC made	rectangular
2	Titinge-2	1,300	On the ground	RC made	rectangular
3	Skyline-2	1,800	On the ground	RC made	rectangular
4	Lower West Kolaa-2	450	On the ground	Metal	circular
5	Panatina-2	2,100	On the ground	RC made	rectangular

While distribution reservoirs used for the water distribution can be categorized into ground and elevated water tanks, the new reservoirs will use the ground water tanks that are also used in the existing reservoirs in consideration of the water level at the existing reservoirs.

(3) Foundation

All of the planned reservoir sites are small and insufficient, but there will be no particular problems as the existing reservoirs except Panatina Reservoir will be replaced by the new reservoirs at their flat lands.

Panatina Reservoir requires land leveling due to its undulating land, yet the scale of the leveling is small enough to be undertaken by Solomon Islands. It also requires adequate depth setting on the ground in order to prevent the reservoir from standing on embankment.

Based on the result of the soil investigation, spread footing will be employed for the reservoirs except Skyline Reservoir since sufficient bearing capacity can be anticipated with adequate depth setting in the ground.

The result of the plate bearing test at Skyline Reservoir was approximately -0.5m from the existing ground height. Since sufficient soil bearing capacity cannot be anticipated at the reservoir, where allowable bearing capacity is as low as 5 tons/m^2, the soil at the bottom of the deck slab needs to be replaced with improved soil mixed with sand and cement or to decentralize the load by enlarging the bottom of the deck slab, in addition to greater depth setting.

Table 2-2-31 Foundation of New Honiara Distribution Reservoirs

No.	Name of Reservoir	Design capacity (m^3)	Material	Condition of land	Assumed allowable bearing capacity of soil at GL-0.5m (t/m^2)	Type of foundation
1	Tasahe-2	1,700	RC made	New tank will be constructed at flat land beside the existing tank	More than 10	Spread foundation
2	Titinge-2	1,300	RC made	The existing abandoned tank will be dismantled and new tank will be constructed in a vacant flat land	More than 10	Spread foundation
3	Skyline-2	1,800	RC made	The existing tank will be dismantled and new tank will be constructed in a vacant flat land	More than 5	Soil improvement under spread foundation or large dimension of foundation will be necessary in order to spread the load
4	Lower West Kolaa-2	450	Metal	The existing tank other than its foundation will be dismantled and the existing foundation will be utilized	More than 7	Spread foundation (improve the existing foundation)
5	Panatina-2	2,100	RC made	Reclamation will be necessary	More than 7	Spread foundation

2-2-2-8 Water Transmission Mains and Distribution Mains

(1) Water Transmission Mains

Water transmission mains are pipelines stretching from the planned borehole transmission pump stations in Honiara to respective distribution reservoirs.

Diameters and lengths of water transmission pipelines shall be determined based on the followings;

- Results of the JICA Development Study conducted in 2005-2006 and expected water demands in 2010
- Results of the route survey conducted under this field survey

Table 2-2-32 shows diameters and lengths of water transmission mains in Honiara.

Table 2-2-32 Diameters and Lengths of Water Transmission Mains in Honiara

Route	Type	Diameter (mm)	Length (km)
Tasahe Pump Station - Tasahe Distribution Reservoir	PVC	250	1.25
Titinge Pump Station - Titinge Distribution Reservoir	PVC	250	1.29
Skyline Pump Station - Skyline Distribution Reservoir	PVC	250	0.97
Borderline Pump Station - Existing Borderline Distribution Reservoir	PVC	250	0.61
Total		-	4.12

(2) Water Distribution Mains

Water transmission mains are pipelines from the planned respective distribution reservoirs in Honiara to the existing water distribution network, and also serve as distribution pipelines constituting primary pipelines in the whole distribution network. Diameters and lengths of water distribution mains shall be determined based on the following:

- Results of the JICA Development Study conducted in 2005-2006 and expected water demands in 2010
- Partial route changes identified by the results of the field survey
- Results of route survey conducted under this field survey

As a result of the hydraulic analysis of water distribution network under the JICA Development Study, it was confirmed that design water supply estimated during the development study was almost same as the amount estimated under this Study, and that the hydraulic analysis held under the development study is reasonable. The review was conducted based on the following conditions:

1) Hydraulic analysis data for water distribution mains

Design peak factors for hydraulic analysis are as follows. Design peak factors are parameters used for determining size of pipelines and values that are highly consistent with the actual situation shall be selected.

- Daily peak factor: 1.0
- Hourly peak factor for domestic use: 1.4
- Hourly peak factor for large customers: 1.3

2) Examination of pipe diameter

The pipe diameter shall be defined in accordance with the water demands in the target year of 2010. Under the Project, areas with low water pressure of 1.0kg/cm^2 or below will be eliminated, and the number of unserved areas will be reduced.

3) Water distribution mains

Approximately 50% of the existing pipelines became much deteriorated due to usage for more than 30 years and areas with low water pressure of 1.0kg/cm^2 or below exist due to the insufficient pipe diameter and deterioration of flow performance. Also, 30% of the SIWA service area is unserved.

For these reasons, the existing pipelines need to be replaced with pipes of bigger diameters to meet the water demand in the areas, and new water distribution mains need to be laid out in unserved areas. The results of the field survey revealed that these existing pipelines, which were installed 30 years ago, now exist under houses and office buildings and that maintenance of the pipelines would be difficult. As a result of the joint field survey with SIWA to determine pipe replacement and routes for the new pipelines, some of the locations proposed under the JICA Development Study need to be changed to different locations under roads so as to facilitate easy maintenance, but this change does not affect the pipe diameters and lengths.

Table 2-2-33 shows pipe diameters and lengths of water distribution mains in Honiara.

Table 2-2-33 Pipe Diameter and Lengths of Water Distribution Mains in Honiara

Route	Type	Diameter (mm)	Length (km)
Water Distribution Mains	PVC	200	5.67
	PVC	150	8.72
	PVC	100	7.33
	PVC	50	1.15
Total		-	22.87

2-2-2-9 Power Receiving Facility

(1) Scope of Work at the Solomon side

Power supply, power purchase agreements and installation of ancillary equipment concerning the facilities shown in Table 2-2-34 will be funded by Solomon Islands, and will be executed by responsible power distribution companies employed by SIWA.

Table 2-2-34 Power Supply for the Facilities for the Project

Facility	Structure of the Facility	Electricity	Additional Equipment
Settling Basin for Turbidity Reduction for Konglai Spring	Disinfection Facility, Settling Basin for Turbidity Reduction	415V	・Watt- Hour Meter ・Electric Pole
New Borefield and Pump Station of Tasahe	Borehole Pump, Water Transmission Pump, Disinfection Facility	11kV	・Watt- Hour Meter ・Electric Pole
New Borefield and Pump Station for Titinge	Borehole Pump, Water Transmission Pump, Disinfection Facility	11kV	・Watt- Hour Meter ・Electric Pole
New Borefield and Pump Station for Skyline	Borehole Pump, Water Transmission Pump, Disinfection Facility, Reservoir	11kV	・Watt- Hour Meter ・Electric Pole
New Borefield and Pump Station for Borderline	Borehole Pump, Water Transmission Pump, Disinfection Facility	11kV	・Watt- Hour Meter ・Electric Pole
Settling Basin for Turbidity Reduction for Kombito Spring	Disinfection Facility, Settling Basin for Turbidity Reduction	415V	・Watt- Hour Meter ・Electric Pole

(2) Equipment Overview

Power supply will be executed as one of undertakings by Solomon Islands and construction of power receiving facilities will be implemented by the Japanese side. Depending on facility configuration, received power is categorized into low-voltage power and high-voltage power. Low-voltage power is used for Konglai Settling Basin and Kombito Settling Basin and other facilities that consist of relatively low-load equipment. High voltage is used for facilities including borehole pumps and water transmission pumps that are associated with high-load.

The following shows overview of equipment deployed by the Japanese side and its scope of work for low voltage/ high-voltage power receiving systems.

[Low voltage power]

Facility name	•	Konglai and Kombito Settling Basin for Turbidity Reduction
Equipment outline	•	Electrical panel: 1 panel (indoor, self-standing)
	•	Agitator control panel: 1 panel (indoor, wall-mount)
	•	Sampling pump control panel: 1 panel (indoor, wall-mount)
	•	Lighting control panel: 1 panel (indoor, wall-mount)
	•	Ventilation control panel : 1 panel (indoor, wall-mount)
Work scope	•	Service wire installation
	•	Service wire installation for the secondary-side power of electric panels and control panels
	•	Service wire installation for ancillary lighting

[High voltage power]

Facility name	•	Pump stations at Tasahe new borefield, Titinge new borefield, Skyline new borefield and Borderline new borefield
Equipment overview	•	Pole transformer: 1unit
	•	Electrical panel: 1panel (indoor, self-standing)
	•	Booster pump control panel: 1panel (indoor, self-standing)
	•	Borehole pump control panel: 1panel (indoor, self-standing)
	•	DC power panel: 1panel (indoor, self-standing)
	•	Control panel at each borehole pump: 4 panels (outdoor, wall-mount)
	•	Agitator control panel: 1 panel (indoor, wall-mount)
	•	Control panel for internal water usage: 1 panel (indoor, wall-mount)
	•	Drainage pump control panel: 1 panel (indoor, wall-mount)
	•	Lighting control panel: 1 panel (indoor, wall-mount)
	•	Ventilation control panel : 1 panel (indoor, wall-mount)
Work scope	•	Pole transformer installation
	•	Service wire installation
	•	Service wire installation for the secondary-side power of electric panels and control panels
	•	Service wire installation for ancillary lighting

(3) Power receiving capacities

Power receiving capacities and transformer capacities of different facilities are determined in accordance with the load capacities shown in Table2-2-35.

Table 2-2-35 Power Receiving Capacities of the Facilities for the Project

No	Facility	Equipment Name	Output (kW)	Nos of Units (Unit)	Nos of Duty (Unit)	Load Factor (%)	Load Energy (kVA)
1	Settling Basin for Turbidity Reduction for Konglai Spring	Agitator	0.4	2	2	100	1.0
		Sampling Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	4.0	1	1	25	1.0
		Total					2.5
2	New Water Transmission Pump Station for Tasahe Boreholes	BoreholePump	15.0	4	4	100	75.0
		Transmission Pump	30.0	3	2	100	75.0
		Agitator	0.4	2	2	100	1.0
		Sampling Pump	0.4	1	1	100	0.5
		Drainage Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	8.0	1	1	25	2.0
		Total					154.0
3	New Water Transmission Pump Station for Titinge Boreholes	BoreholePump	13.0	3	3	100	48.75
		Transmission Pump	15.0	1	1	100	18.75
		Agitator	30.0	3	2	100	75.0
		Sampling Pump	0.4	2	2	100	1.0
		Drainage Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	0.4	1	1	100	0.5
		Borehole Pump	8.0	1	1	25	2.0
		Total					146.5
4	New Water Transmission Pump Station for Skyline Boreholes	BoreholePump	13.0	4	4	100	65.0
		Transmission Pump	22.0	3	2	100	55.0
		Agitator	0.4	2	2	100	1.0
		Sampling Pump	0.4	1	1	100	0.5
		Drainage Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	8.0	1	1	25	2.0
		Total					124.0
5	New Water Transmission Pump Station for Borderline Boreholes	BoreholePump	11.0	4	4	100	55.0
		Transmission Pump	11.0	3	2	100	27.5
		Agitator	0.4	2	2	100	1.0
		Sampling Pump	0.4	1	1	100	0.5
		Drainage Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	8.0	1	1	25	2.0
		Total					86.5
6	Settling Basin for Turbidity Reduction for Kombito Spring	Agitator	0.4	2	2	100	1.0
		Sampling Pump	0.4	1	1	100	0.5
		Lighting and Ventiration	4.0	1	1	25	1.0
		Total					2.5

Specifications of the power receiving equipment are summarized below:

➢ Konglai Settling Basin for Turbidity Reduction

Power receiving system	415V (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Low-voltage switchboard	415-240V, 3 phases 4 lines

➢ Tasahe new borefield pump station

Power receiving system	11kV (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Transformer	11kV/415-240V, 3 phases, 50Hz
	200kVA, Pole transformer
Low-voltage switchboard	415-240V, 3 phases 4 lines

➢ Titinge new borefield pump station

Power receiving system	11kV (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Transformer	11kV/415-240V, 3 phases, 50Hz
	200kVA, Pole transformer
Low-voltage switchboard	415-240V, 3phases 4 lines

➢ Skyline new borefield pump station

Power receiving system	11kV (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Transformer	11kV/415-240V, 3 phases, 50Hz
	200kVA, Pole transformer
Low-voltage switchboard	415-240V, 3 phases 4 lines

➢ Borderline new borefield pump station

Power receiving system	11kV (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Transformer	11kV/415-240V, 3 phases, 50Hz
	100kVA, Pole transformer
Low-voltage switchboard	415-240V, 3 phases 4 lines

➢ Kombito Settling Basin for Turbidity Reduction

Power receiving system	415V (City power grid,) 3 phases, 50Hz
	Regular 1-line system
Low-voltage switchboard	415-240V, 3 phases 4 lines

(4) Power Distribution Facilities

The electrical panel shall be located in the electrical room of each facility. The general specifications for power distribution facilities shall be as follows.

➢ Konglai Settling Basin for Turbidity Reduction

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	Regular 1-line system

➢ Tasahe new borefield pump station

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	This electrical panel shall receive power via the following 2 circuits, each of which is controlled by interlocking. • Circuit for normal use • Circuit for emergency power generation facilities.

➢ Titinge new borefield pump station

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	This electrical panel shall receive power via the following 2 circuits, each of which is controlled by interlocking. • Circuit for normal use • Circuit for emergency power generation facilities.

➢ Skyline new borefield pump station

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	This electrical panel shall receive power via the following 2 circuits, each of which is controlled by interlocking. • Circuit for normal use • Circuit for emergency power generation facilities.

➢ Borderline new borefield pump station

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	This electrical panel shall receive power via the following 2 circuits, each of which is controlled by interlocking. • Circuit for normal use • Circuit for emergency power generation facilities.

➢ Kombito Settling Basin for Turbidity Reduction

Type:	Self-standing enclosed electrical panel
Power receiving method:	415-240V, 3 phases 4 lines, 50Hz
Power receiving circuit:	Regular 1-line system

(5) Power distribution system

A cable rack will be primarily used for wiring, of which ground burial will utilize a flexible conduit system and the terminal will utilize an electrical conduit system. In consideration of the power systems of the planned sites, the following systems will apply;

- High voltage: 11kV, 3 phases 4 lines, 50Hz
- Low voltage: 415-240V, 3 phases 4 lines, 50Hz

2-2-2-10 Emergency Power Generation Facilities

(1) Necessity for emergency power generation facilities

Emergency power generation facilities shall be provided for each of the following facilities of borehole pumps and water transmission pumps to enable continuous water supply during power failure. The type of emergency power generation facilities shall be diesel engine generators, which cover 50% of the total load in normal use.

- Tasahe new borefield pump station
- Titinge new borefield pump station
- Skyline new borefield pump station
- Borderline new borefield pump station

(2) Composition of emergency power generation facilities

Emergency power generation facilities shall comprise the following equipment.

- Emergency generator
- Fuel tank
- Generator control panel

As explained in the previous section, in this Project, power is normally received from the 11-kV local distribution network, and the emergency power generation facilities are positioned as the backup to be used during power failure.

Emergency generators are operated manually in principle. After a power failure is confirmed, the power receiving circuit on the electrical panel is switched to the use of the emergency generator, and the generator is activated by the operation of the generator control panel. On the other hand, after the recovery of power supply, the generator is stopped and the circuit on the electrical panel is switched to normal power reception to restore purchased electric power. Because the emergency generator basically covers 50% of total normal load, the operation of individual loads must basically be performed manually. Therefore, the circuit construction should be designed to ensure that all operating loads are stopped after the detection of power failure and automatic re-energizing of equipment may not occur after restoration of power supply. In addition, the simultaneous use of purchased power and the emergency generator should be prohibited by the interlocking circuit on the electric panel.

With regard to the supply of fuel oil to the emergency generator, the fuel for the generator should be stored in the fuel tank in principle. Fuel is moved from a drum to the fuel tank by means of a hand rotary pump and stored there. The fuel tank should have the capacity to respond to power failure for 10 hours or more. Fuel is supplied gravitationally from the fuel tank to the generator.

(3) Required capacity of emergency power generation facilities

In this Project, the capacity of emergency power generation facilities is determined to support the function of respective facilities during power failure.

The capacity of emergency power generation facilities is determined based on the largest of the values calculated in 1), 2), and 3) for each operating load.

1) Output Power for steady-state load: PG1

$PG1 \geqq \Sigma PGi$

where, PG1: Generator output power

ΣPGi: Sum of load inputs (kVA)

2) Output power for maximum voltage dip during transient time: PG2

When a load with large starting kVA is turned on, the generator shows an instantaneous voltage dip due to the starting current of the load. Because this instantaneous voltage dip may alter the load and affect other facilities, it is necessary to calculate the power for the maximum voltage dip occurring when the load with the largest starting kVA is turned on.

$$PG2 = Ps \times \left(\frac{1}{Vd} - 1\right) \times Xd'$$

where, PG2: Generator output power (kVA)

Ps: Starting kVA of the motor with the largest starting kVA

Ps: Starting method coefficient x motor kW / (efficiency x power factor)

Vd: Permissible voltage dip (generally 20-30%)

Xd’: Transient reactance of generator (generally 0.2-0.3).

3) Output power for maximum temporary voltage dip immunity during transient time: PG3

If the starting sequence of loads is predetermined, the maximum temporary voltage dip immunity is calculated assuming that the starting kVA of each load is added to the base load consisting of the sum of the loads that have been turned on according to the starting sequence. If the starting sequence of loads is arbitrary and there is no predetermined sequence, the maximum temporary voltage dip immunity assuming that the load with the largest kVA is turned on when there is the base load consisting of all other loads.

$$PG3 = \frac{\sqrt{(PB + Pms)^2 + (QB + Qms)^2}}{KG}$$

Where, PG3: Generator output (kVA)

PB: Effective power of base load (kW)

QB: Ineffective power of base load (kVar)

Pms: Starting effective power of the load with the largest starting kVA (kW)

Qms: Starting ineffective power of the load with the largest starting kVA (kVar)

KG: Temporary voltage dip immunity of generator.

As a result of the calculation based on operating loads of the respective facilities, the general specifications for the emergency power generation facilities in this Project shall be as follows.

➢ Tasahe new borefield pump station

Capacity	100kVA, indoor type
Quantity	1 unit
Type	Diesel engine, 3-phase AC power generator
Power system	415-240V 3φ, 4 lines, 50Hz
Fuel tank capacity	400 L (Securing a capacity enough for the longest power outage of 10 hours or longer)
Generator control panel	Indoor, wall-mount
Accessory	Hand rotary pump

➢Titinge new borefield pump station

Capacity	100kVA, indoor type
Quantity	1 unit
Type	Diesel engine, 3-phase AC power generator
Power system	415-240V 3φ, 4 lines, 50Hz
Fuel tank capacity	400 L (Securing a capacity enough for the longest power outage of 10

	hours or longer)
Generator control panel	Indoor, wall-mount
Accessory	Hand rotary pump

➢Skyline new borefield pump station

Capacity	100kVA, indoor type
Quantity	1 unit
Type	Diesel engine, 3-phase AC power generator
Power system	415-240V 3φ, 4 lines, 50Hz
Fuel tank capacity	400 L
	(Securing a capacity enough for the longest power outage of 10 hours or longer)
Generator control panel	Indoor, wall-mount
Accessory	Hand rotary pump

➢ Borderline new borefield pump station

Capacity	100kVA, indoor type
Quantity	1 unit
Type	Diesel engine, 3-phase AC power generator
Power system	415-240V 3φ, 4 lines, 50Hz
Fuel tank capacity	400 L
	(Securing a capacity enough for the longest power outage of 10 hours or longer)
Generator control panel	Indoor, wall-mount
Accessory	Hand rotary pump

2-2-2-11 Associated Civil and Building Works

(1) Plan Details

The following are civil and building works associated with settling basin for turbidity reduction, distribution reservoirs and pump stations for the Project.

1) Konglai Settling Basin for Turbidity Reduction

(i) Building for electrical equipment and chlorine dozing equipment: 1 building

- Foundation: Crown slab of the reservoir
- Upper structure (beams, columns etc): Reinforced concrete, total floor area 50m^2, building facilities included
- Exterior wall: Concrete blocks

(ii) Building for existing water transmission pump: 1 building

- Foundation: Spread footing
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $35m^2$, building facilities included
- Exterior wall: Concrete blocks

(iii) Lighting/ ventilation equipment

(iv) Drainage facility (in-situ)

2) Kombito Settling Basin for Turbidity Reduction

(i) Building for electrical equipment and chlorine dozing equipment: 1 building

- Foundation: Crown slab of the reservoir
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $50m^2$, building facilities included
- Exterior wall: Concrete blocks

(ii) Lighting/ ventilation equipment

(iii) Drainage facility (in-situ)

3) Distribution reservoirs

(i) Lighting/ventilation equipment

(ii) Drainage facility (in-situ)

4) Pump stations

(i) Pump and machine room: (1 building)

- Foundation: Spread footing
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $70m^2$, building facilities included
- Exterior wall: Reinforced concrete

(ii) Building for chlorine dozing equipment (1 building)

- Foundation: Crown slab at the pump room
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $70m^2$, building facilities included
- Exterior wall: Concrete blocks

(iii) Lighting/ventilation equipment

(iv) Drainage facility (in-situ)

2-2-3 Auki Basic Plan

2-2-3-1 Design Conditions

The design conditions related to the basic plan in Auki City in this Project are summarized as follows:

(1) Design Population and Design Served Population

Similarly to Honiara City, the population of Auki City is estimated for the period from 1999 to 2010 using the 3.0% growth rate on the average from 1986 to 2005.

Table 2-2-36 Annual Population Growth in Auki City

Annual Growth Rate (%) (Year 1986 - 1999)	Annual Growth Rate (%) (Year 1999 - 2005)	Applied (Year 1999 - 2010)
3.3	2.3	3.0

Source: Statistics Bureau of Solomon Islands

Based on the annual population growth rate specified as above, the design population of Auki City is estimated as shown in Table 2-2-37.

Table 2-2-37 Design Population in Auki City

Year	1999	2005	2006	2007	2008	2009	**2010**
Population in city boundary (person)	4,022	4,802	4,947	5,095	5,248	5,405	**5,567**

(2) Design Daily Water Consumption Per Capita

The per capita daily water consumption in Auki City is 75 LCD in 2007. This is as low as approximately 40% of the figure in other provincial centers such as Noro and Tulagi. This is because the water supply potential of the city's water source at Kwaibala spring falls short of the water demand. As of April 2008, water rationing was being imposed in Auki City for approximately 4 hours a day.

Because the living standard in Auki City is similar to that in other provincial centers, the per capita water demand in this city would be comparable to that in other provincial centers, on condition that sufficient water intake volume is available at the water source. The socio-economic survey in Auki City conducted as part of the JICA Development Study has shown the income level similar to that in Tulagi City. Therefore, as the design daily water consumption per capita, 170 LCD shall be adopted as in Honiara City.

(3) Design Effective Water Ratio

According to the data obtained from SIWA, the non-revenue water (NRW) ratio from 2005 to 2007 is as shown in Table 2-2-38. The effective water ratio is calculated as the NRW ratio minus the administrative losses of 3% obtained in the JICA Development Study. As shown in Table 2-2-38, the effective water ratio during the past 3 years is 65% in average, and this value is adopted as the design effective water ratio.

Table 2-2-38 Non-Revenue Water (NRW) Ratio and Design Effective Water Ratio in Auki City

Item	Year 2005	Year 2006	Year 2007
Non revenue water (NRW) ratio (%)	35.0	38.0	40.0
Apparent losses (%)	3.0	3.0	3.0
Real losses (%)	32.0	35.0	37.0
Average NRW [A] (%)	35		
Design effective ratio 100-[A] (%)	65		

(4) Design Water Supply

The water supply (water demand) is calculated from the following formula:

$$\text{Water supply(water demand)} = \frac{\text{Water consumption}}{\text{Effective water ratio}}$$

Table 2-2-39 shows the design water supply (water demand) determined based on the following data:

- Design daily water consumption per capita: 170 LCD
- Design effective water ratio: 65%
- Daily peak factor : 1.0
- No. of persons for one customer: 8 persons
- Administrative losses (= metering error): 3%

Table 2-2-39 Design Water Supply (Water Demand) in Auki City [2010]

Category of Customer		Pop. in Service Area	Number of Customer	Served Pop. [A]	Per Capita Per Day Consumption [B]	Water Consumption (Effective Water) [C]	Design Water Supply [C]/0.65
		(person)	(no.)	(person)	(LCD)	(m^3/day)	(m^3/day)
						[A] x [B]/1000	
1	Domestic		453	3,620	170	615	
						3-years average x $(1+0.01)^3$	
2	Commercial		63			82*[3]	
						3 x (metered vol.*[1])/(100-3)	
3	Apparent losses	(= Metering error*[2])				22	
	Whole Auki	5,567	516	3,620 (65%)		719	1,106

Notes 1. Metered volume = (1. Domestic) + (2. Commercial)
2. Metering error = (Metering error ratio) x (Metered volume) / (100 - Metering error ratio)
3. Annual growth ratio of water consumption for commercial customers is assumed as 1% (Source: AusAID Master Plan).

(5) Soil Conditions

Considering the soil conditions in the construction sites for facilities in this Project, facility design shall be carried out taking into account the following points:

Test pitting was conducted along the water conveyance pipelines from the planned boreholes to the existing high-level distribution reservoir revealed. Gravelly cohesive soil was found in the pipeline routes. Since such stratum is expected to have a bearing capacity of 10tons/m^2, the Project does not include the construction of any large structures. Therefore, the use of the spread foundation method is considered satisfactory.

(6) Weather Condition

Based on the weather data for 1998 to 2007, the weather conditions shall be as shown in Table 2-2-40.

Table 2-2-40 Weather Condition in Auki City

	Item	Auki city	Remarks
Rainfall	Annual rainfall	3,239mm	
	Monthly mean rainfall	270mm	
Temperature	Mean temperature	26.3℃	Considered as the same as those in Honiara City
	Monthly mean minimum temperature	23.1℃	
	Monthly mean maximum temperature	28.4℃	
Relative humidity	Monthly mean relative humidity	82.6%	
	Monthly mean minimum relative humidity	77.6%	
	Monthly mean maximum relative humidity	86.6%	

(7) Seismic Load

The same standards as in Honiara City shall be applied.

(8) Wind Load

The same standards as in Honiara City shall be applied.

2-2-3-2 Facility Layout Plan

(1) Basic Policy

The facility layout plan in Auki in this Project shall be formulated in accordance with the following basic policy:

- The plan shall be consistent with the water transmission and distribution facilities constructed in the water distribution facility improvement project under the ADB assistance (completed in September 2008).
- The Project includes the construction of boreholes to provide a new water source within the administrative area of the city. Because the planned site of the boreholes is near the coastline, these should be planned to minimize the volume of pumped water per borehole, so that pumping of groundwater should not cause salt water intrusion.
- Because of the limited area of the planned site, it is impossible to arrange boreholes with sufficient spacing among them. Therefore, the volume of pumped water per borehole should be minimized also for the purpose of preventing mutual interference, in addition to the

problem of salt water intrusion.

(2) Facility details

This Project covers the following facilities for improvement of the water supply system in Auki City.

- Construction of boreholes and related facilities (construction of water conveyance pipelines and installation of emergency diesel engine generator)

(3) Facility Layout Plan

The arrangement of new boreholes is shown in Fig. 2-2-11. Fig. 2-2-12 shows the relationship among the existing water supply system in Auki, the facilities in this Project and the ADB project. Facility layout drawings are presented in "2-2-4 Basic Design Drawings".

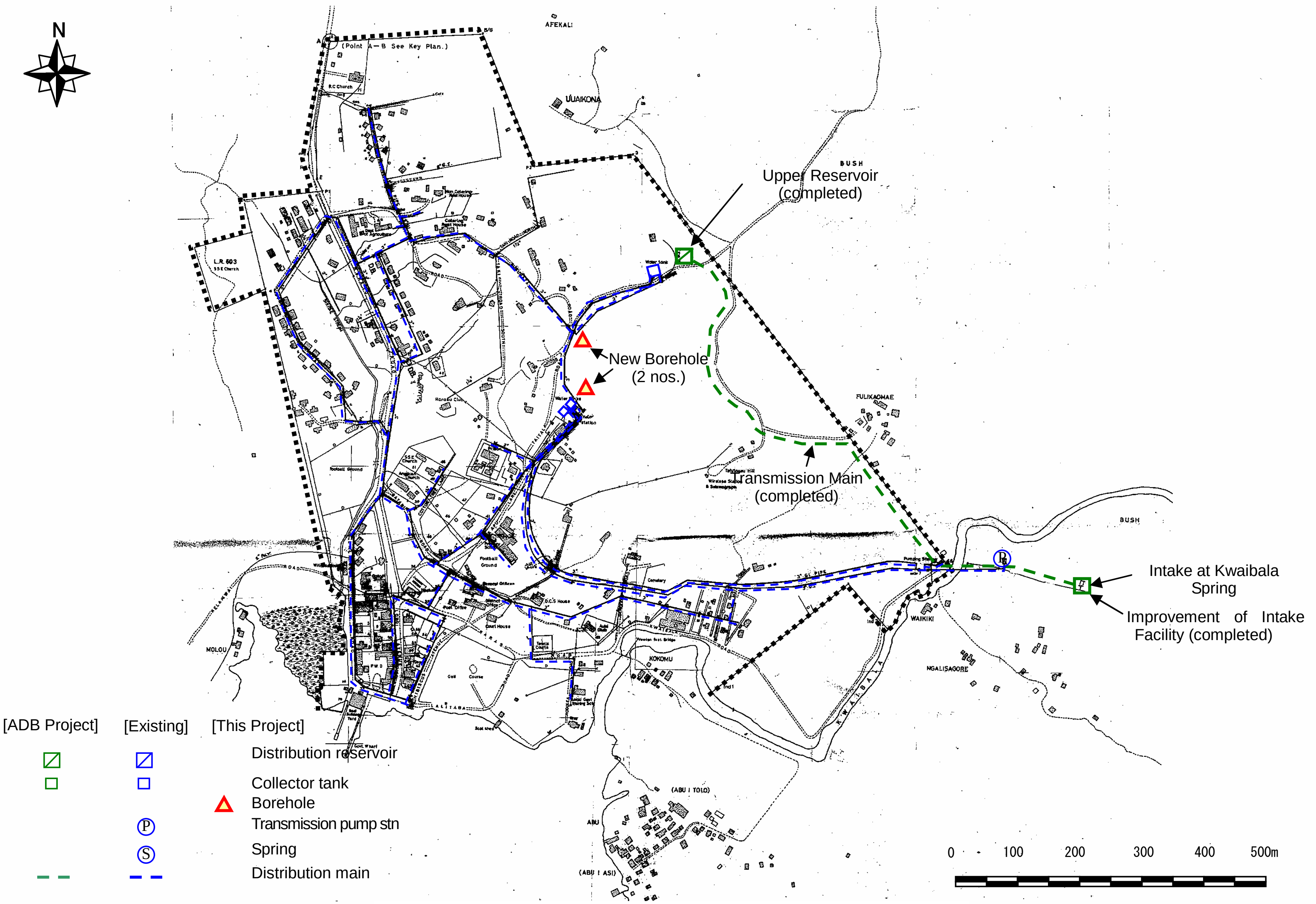


Fig. 2-2-11 Location of New Boreholes in Auki City

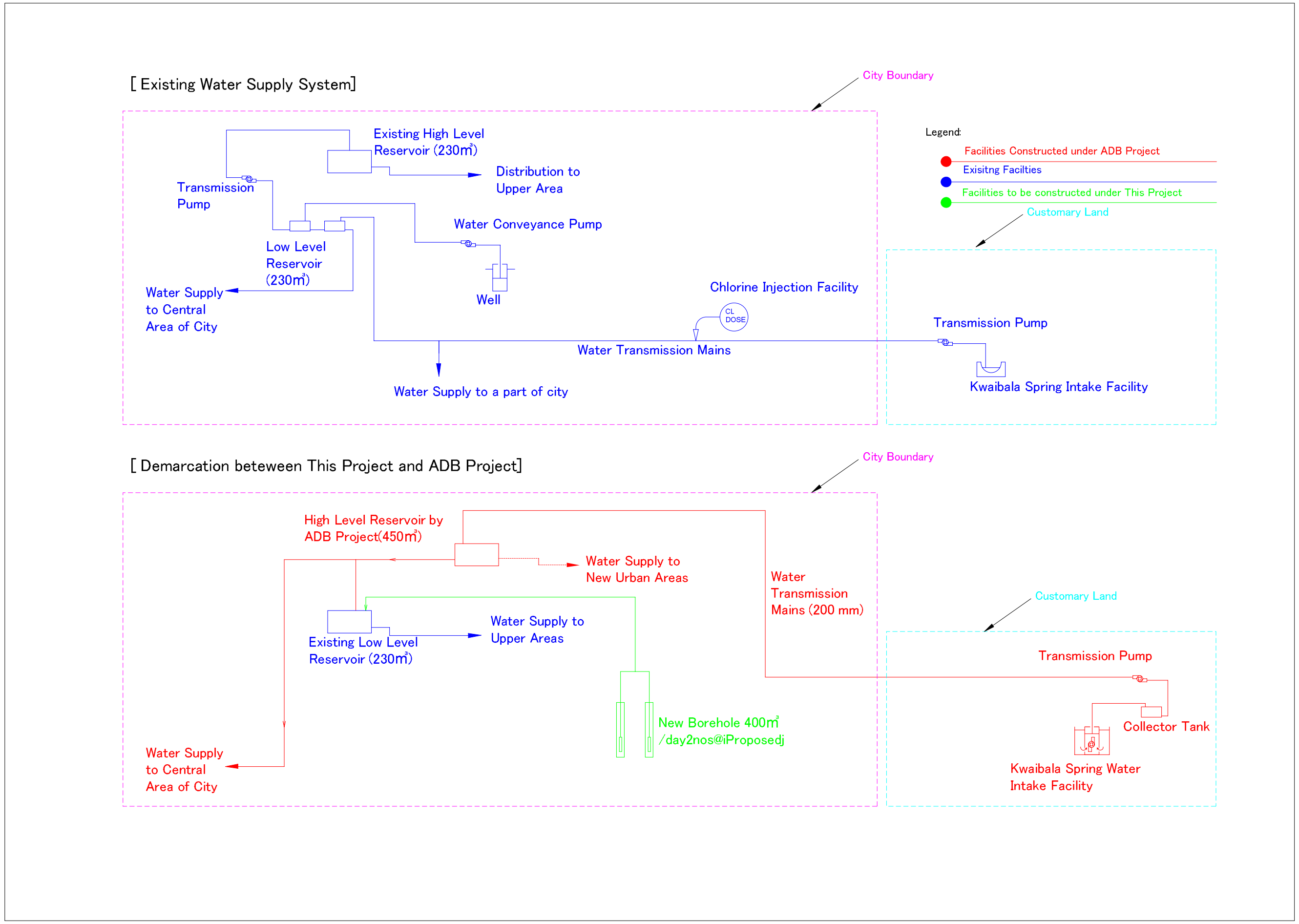


Fig. 2-2-12 Relationship between the Project and ADB Project for Improvement of Water Supply System in Auki City

2-2-3-3 Borehole Construction Plan

(1) Borehole Layout Plan

1) Location of Boreholes

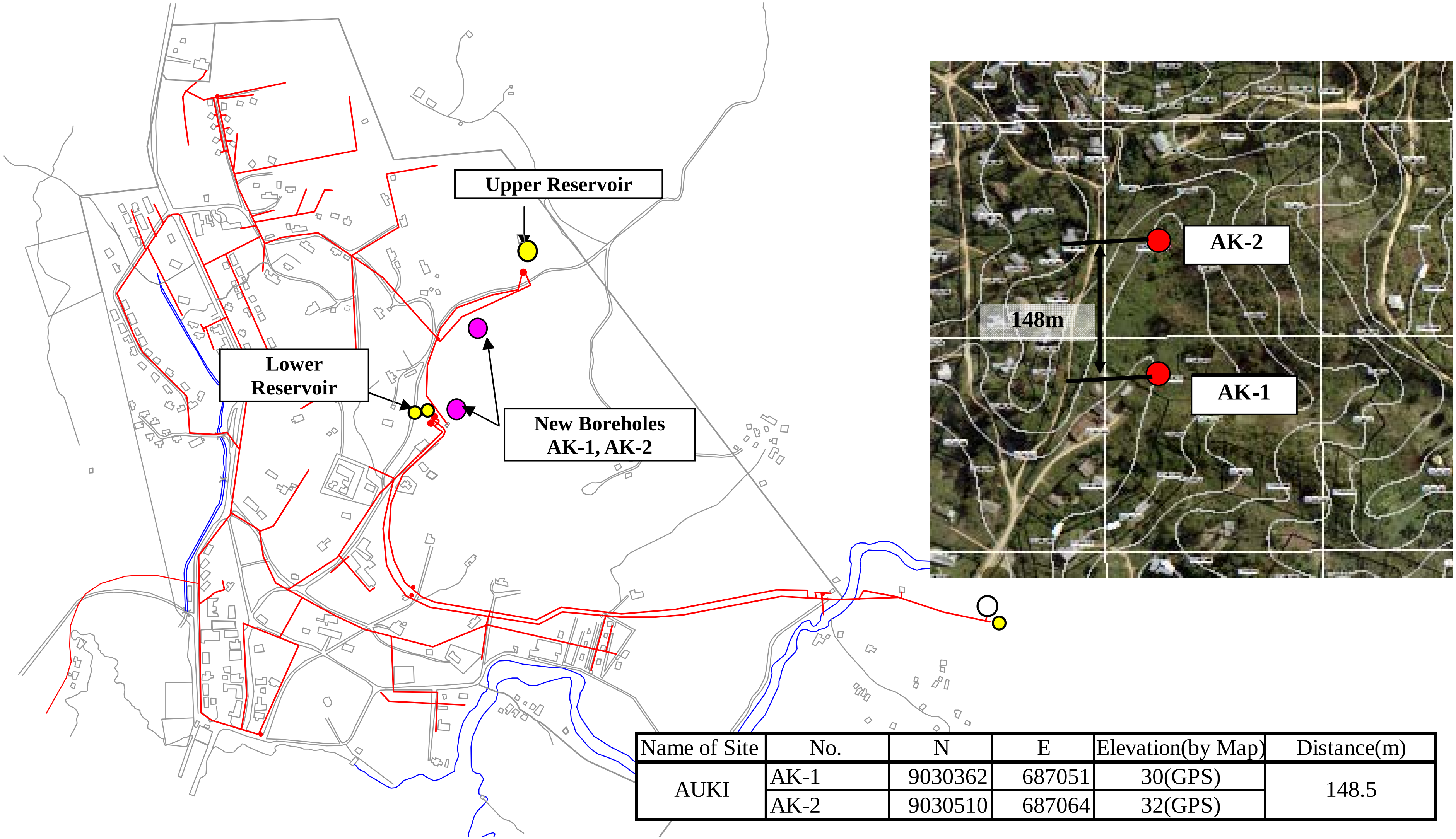
Regarding the location of boreholes, after discussions with SIWA, following matters were confirmed based on the results of past preliminary study. As a result, the location of boreholes was finally selected, mainly restricted by limited availability of land.

The borehole locations are as shown in Table 2-2-41 and Fig. 2-2-13.

Table 2-2-41 Location of Boreholes in Auki

Name of Borefield	Borehole No.	Coordinate (m)		Ground Elevation	Distance
		N	E	(m)	(m)
Auki	AK-1	9,030,362	687,051	29	148.5
	AK-2	9,030,510	687,064	37	

Note: Coordinates shall be based on Universal Transverse Mercator (UTM) grid.



Name of Site	No.	N	E	Elevation(by Map)	Distance(m)
AUKI	AK-1	9030362	687051	30(GPS)	148.5
	AK-2	9030510	687064	32(GPS)	

Figure 2-2-13 Layout Drawing for Auki Borefield

2) Examination of Interference among Boreholes

The following matters were examined regarding the interference among boreholes.

① Lowering of groundwater level at boreholes in new borefield

② Salt water intrusion

Because the shallow well water sources in current use are planned to be abandoned after the completion of new boreholes, examination to assess the effect of new boreholes on shallow well water sources is not necessary.

① Examination on Drawdown of Groundwater Level in Borefield

Hydraulic conditions for examining drawdown of the groundwater level are shown in Table 2-2-42.

Table 2-2-42 Hydraulic Conditions for Examining Drawdown of Groundwater Level Auki Borefield

Borefield	Geology of Aquifer	Thickness of Aquifer	Groundwater Level (EL.m)	Coefficient of Permeability	Effective Radius
Auki Borefield	Limestone (Cretaceous/Neocene)	30m	3m, 8m	2.0m/day	1,000m

The results of examination regarding lowering of groundwater level under the above conditions are shown in Table 2-2-43.

Table 2-2-43 Results of Examination on Drawdown of Groundwater Level in Auki Borefield

Borehole No.	Coefficient of Permeability K (m/day)	Thickness of Aquifer (m)	Effective Radius R (m)	Distance between other wells (m)	Drawdown S (m)	Estimated Groundwater Level (EL.m)	Estimated Groundwater Level at the time of Drawdown (EL.m)
AK-1	2	30	1,000	148	11.8	3	-8.8
AK-2	2	30	1,000	148	11.8	8	-3.8

② Examination of Salt Water Intrusion

AK-1, located on the seaward side of Auki borefield, showed relatively high specific resistance in deep parts, and this site is located approximately 600 m from the coastline.

The results of calculation in the above table are based on presumptions incorporating the results of examination conducted so far, and the figures for current conditions such as groundwater level have been set deeper than the expected depth (the actual groundwater level may be less deep than this level). However, as the results of examination suggest, pumping may cause the groundwater level at borehole locations to drop below the sea level. Therefore, pumping tests during the construction of boreholes is necessary to confirm the lowering of groundwater level at borehole locations and to determine the pumping volume that would not cause groundwater level to drop significantly below the sea level.

3) Summary

- Because of land restrictions, the intervals between adjacent boreholes in the same borefield are set at the relatively small distance of 148 m. This has been determined based on land restrictions and the topographic condition of the project sites. It should also be noted that the pumping volume examined in this study is 400m^3/day, which is half of the pumping volume obtained in the JICA Development Study.
- The examination of the lowering of groundwater level in new borefields has shown that the lowering of groundwater level at each borehole is expected to be about 12 m.
- Groundwater of the existing shallow well suffers from turbidity due to heavy rain even in current situations. The use of groundwater in these wells should be avoided, because future urbanization around the project site may cause the problem of contamination from ground surface.
- Although shallow depths may be applied for borehole because groundwater level of aquifers is shallow, exploitation of water occurring deeper than about 20 m is desirable because of the above consideration.
- For the both boreholes, the appropriate depth is considered to be 100 m, as proposed at the time of the JICA Development Study.

(2) Structure of Boreholes

1) Basic Structure

The basic structure of boreholes shall be as shown in Fig. 2-2-14, considering the structure of existing boreholes and the installation of pumps that can achieve required pumping volume.

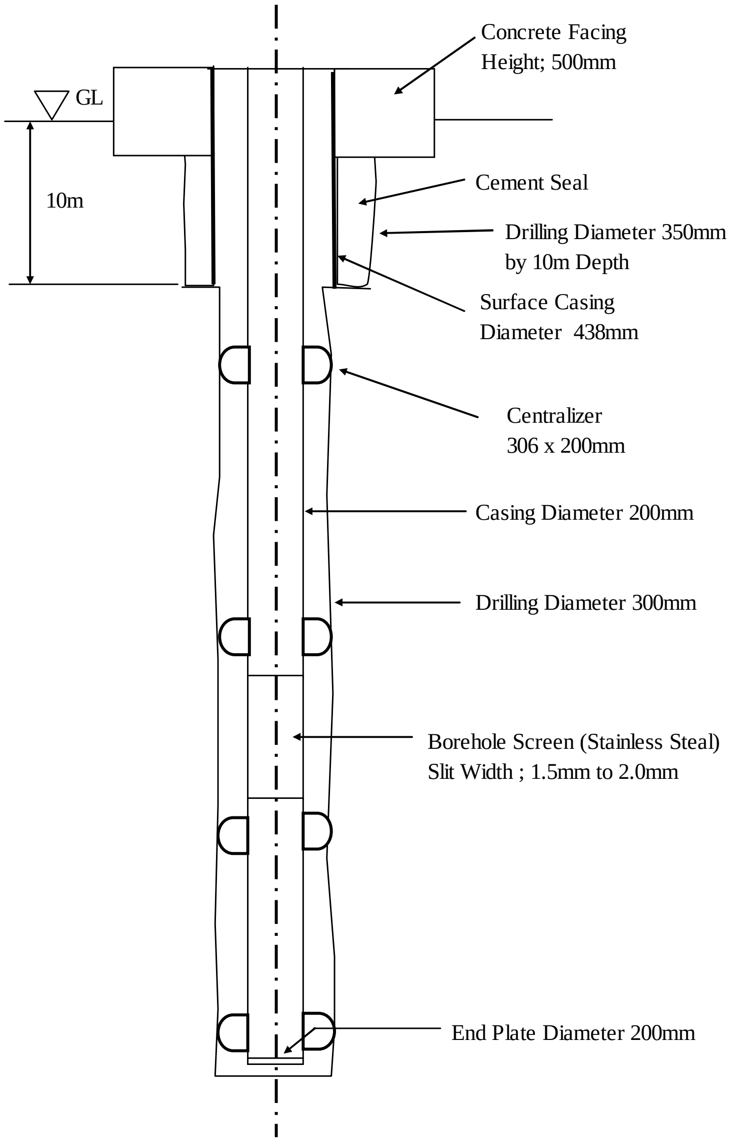


Fig. 2-2-14 Borehole Structure in New Borefield in Auki City

2) Specifications for Borehole

Based on the results of above examination, the specifications for each borehole shall be as shown in Table 2-2-44.

Table 2-2-44 Specifications for Borefield in Auki City

Borefield	Borehole No.	Elevation of Borehole (EL.+m)	Borehole Depth (m)
Auki Borefield	AK-1	29	100
	AK-2	37	100

(3) Specifications for Borehole Pumps

Fig. 2-2-15 shows the borehole pump system.

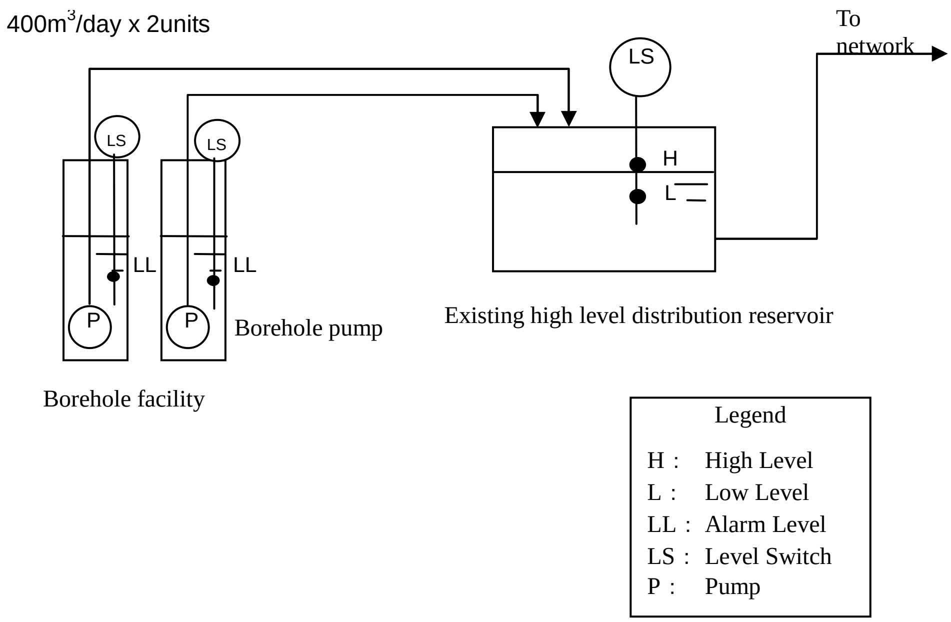


Fig. 2-2-15 Borehole Pump System in Auki City

Each borehole shall be planned to have one duty pump and an independent water conveyance pipeline connecting the borehole and the existing high level distribution reservoir to avoid interference among different boreholes. One stand-by pump is secured (to be kept in a store) for Auki borefield.

Borehole pumps shall be operated in the following manner, and be planned to have the control circuitry capable of such operation.

- Automatic operation in which the water transmission pump stops at the high water level (H) in the existing high-level distribution reservoir
- Interlocking shall be activated at the idling prevention water level (LL) to prevent idling of a borehole pump
- The system shall be capable of remote controlled automatic operation and stopping of each borehole pump, as well as receiving warning signal, at the water transmission pump station (central)
- At each borehole site, the borehole pump shall be capable of on-site manual operation

The control panels for borehole pumps shall be located at the water transmission pump station (central control panel) and each borehole site (local control panel), similarly to the borehole pumps in Honiara City.

The borehole pump and the piping around the pump shall be stainless steel (SUS 304 or equivalent), considering corrosion resistance.

The following shows the main features of specifications for borehole pumps.

Type: Submersible borehole pump.

Main material: Stainless steel.

Electric motor: 2P x 415V x 50Hz x 3 phases

The capacity of each pump is shown in Table 2-2-45.

Table 2-2-45 Borehole Pump Performance in Auki City

Borefield	Borehole No	Capacity	Qty.
Auki	AK-1	0.28m^3/min x 105mAq x 9.2kw	1
	AK-2	0.28m^3/min x 105mAq x 9.2kw	1

(4) Water Hammer Protection

Because the route from the borehole to the existing high-level distribution reservoir involves significant ups and downs, it is necessary to evaluate the need for water hammer protection.

The minimum pressure curve was obtained from the longitudinal profile of the pipelines and pump characteristics, and the magnitude and location of the largest negative pressure were determined. The result showed that the pipelines from the two borefields to the existing high-level distribution reservoir would not exceed -5 m, where water column separation would not take place.

Therefore, no special facilities for water hammer protection shall be added to the pipelines from borehole pump stations to the distribution reservoir.

2-2-3-4 Power Receiving Facility

(1) Scope of Work at the Solomon side

The provision of electric power supply to the facilities listed in the Table below, electricity purchase contracts, and installation of incidental equipment shall be borne by Solomon Islands. These shall be completed by SIWA, which shall place orders for relevant works to the power distribution company covering the area.

Table 2-2-46 Electric Power Supply to Facilities

Facility	Structure of the Facility	Supplied Voltage	Auxiliary Equipment
Electrical Room for Borehole Pump	Borehole Pump	415V	・ Watt- Hour Meter ・ Electric Pole

(2) Equipment Outline

Following the provision of electric power supply by the Solomon Islands side, the Japanese side shall conduct the works for power receiving. The power reception method shall be low-voltage power supply from 415 V local distribution lines.

The following describes the summary and scope of work regarding the facilities to be borne by the Japanese side.

Equipment outline	•	Electrical panel: 1 panel (indoor, self-standing)
	•	Borehole pump control panel: 1 panel (indoor, self-standing)
	•	DC power panel: 1panel (indoor, self- standing)
	•	Control panel at each borehole pump: 2 panels (outdoor, wall-mount)
	•	Lighting control panel: 1 panel (indoor, wall-mount)
	•	Ventilation control panel: 1 panel (indoor, wall-mount)
Work Scope	•	Service wire installation
	•	Service wire installation for the secondary-side power of electric panels and control panels
	•	Service wire installation for ancillary lighting

(3) Power Receiving Capacity

The power receiving capacity and transformer capacity for respective facilities shall be determined to accommodate the load capacity listed in Table 2-2-47 below:

Table 2-2-47 Power Receiving Capacity for Facilities

No	Equipment Name	Output (kW)	No. of Unit (Unit)	No. of Duty (Unit)	Load Factor (%)	Load Energy (kVA)
1	Borehole Pump	9.2	2	2	100	23.0
	Lighting and Ventilation	4.0	1	1	25	1.0
	Total					24.0

The general specifications for power receiving facilities shall be as follows:

Power receiving system	415V (City power grid), 3 phases, 50Hz Regular 1-line system
Low-voltage switchboard	415-240V, 3 phases 4 lines

(4) Power Distribution Facilities

The electrical panel shall be located in the electrical room. The general specifications for power distribution facilities shall be as follows.

Type	Self-standing enclosed electrical panel
Power receiving method	415-240 V, 3 phases 4 lines, 50 Hz
Power receiving circuit	This electrical panel shall receive power via the following 2 circuits, each of which is controlled by interlocking. • Circuit for normal use • Circuit for emergency power generation facilities

(5) Power Distribution System

A cable rack will be primarily used for wiring, of which ground burial will utilize a flexible conduit system and the terminal will utilize an electrical conduit system. In consideration of the power systems of the planned sites, the following systems will apply:

- Low voltage: 415-240 V, 3 phases 4 wires, 50 Hz.

2-2-3-5 Emergency Power Generation Facilities

(1) Necessity for Emergency Power Generation Facilities

Emergency power generation facilities shall be provided for borehole pumps to enable continuous water supply during power failure. The type of emergency power generation facilities shall be diesel engine generators, which cover 50% of the total load in normal use.

(2) Composition of Emergency Power Generation Facilities

Emergency power generation facilities shall comprise the following equipment.

- Emergency generator
- Fuel tank
- Generator control panel

In this Project, power is normally received from the 11-kV local distribution network, and the emergency power generation facilities are positioned as the backup to be used during power failure.

Emergency generators are operated manually in principle. After a power failure is confirmed, the power receiving circuit on the electrical panel is switched to the use of the emergency generator, and the generator is activated by the operation of the generator control panel. On the other hand, after the recovery of power supply, the generator is stopped and the circuit on the electrical panel is switched to normal power reception to restore the use of purchased electric power. Because the emergency generator basically covers 50% of total normal load, the operation of individual loads must basically be performed manually. Therefore, the circuit construction should be designed to ensure that all operating loads are stopped after the detection of power failure and automatic re-energizing of equipment may not occur after restoration of power supply. In addition, the simultaneous use of purchased power and the emergency generator should be prohibited by the interlocking circuit on the electric panel.

With regard to the supply of fuel oil to the emergency generator, the fuel for the generator should be stored in the fuel tank in principle. Fuel is moved from a drum to the fuel tank by means of a hand rotary pump and stored there. The fuel tank should have the capacity to respond to power failure for 10 hours or more. Fuel is supplied gravitationally from the fuel tank to the generator.

(3) Needed Capacity of Emergency Power Generation Facilities

In this Project, the capacity of emergency power generation facilities is determined to support the function of respective facilities during power failure.

The capacity of emergency power generation facilities is determined based on the largest of the values calculated in 1), 2), and 3) for each operating load.

1) Output Power for steady-state load: PG1

$PG1 \geqq \Sigma PGi$

Where, PG1: Generator output power
ΣPGi: Sum of load inputs (kVA)

2) Output power for maximum voltage dip during transient time: PG2

When a load with large starting kVA is turned on, the generator shows an instantaneous voltage dip due to the starting current of the load. Because this instantaneous voltage dip may alter the load and affect other facilities, it is necessary to calculate the power for the maximum voltage dip occurring when the load with the largest starting kVA is turned on.

$$PG2 = Ps \times \left(\frac{1}{Vd} - 1\right) \times Xd'$$

Where, PG2: Generator output power (kVA)
Ps: Starting kVA of the motor with the largest starting kVA
Ps: Starting method coefficient x motor kW / (efficiency x power factor)
Vd: Permissible voltage dip (generally 20-30%)
Xd': Transient reactance of generator (generally 0.2-0.3).

3) Output power for maximum temporary voltage dip immunity during transient time: PG3

If the starting sequence of loads is predetermined, the maximum temporary voltage dip immunity is calculated assuming that the starting kVA of each load is added to the base load consisting of the sum of the loads that have been turned on according to the starting sequence. If the starting sequence of loads is arbitrary and there is no predetermined sequence, the maximum temporary voltage dip immunity assuming that the load with the largest kVA is turned on when there is the base load consisting of all other loads.

$$PG3 = \frac{\sqrt{(PB + Pms)^2 + (QB + Qms)^2}}{KG}$$

where, PG3: Generator output (kVA)

PB: Effective power of base load (kW)

QB: Ineffective power of base load (kVar)

Pms: Starting effective power of the load with the largest starting kVA (kW)

Qms: Starting ineffective power of the load with the largest starting kVA (kVar)

KG: Temporary voltage dip immunity of generator.

As a result of the calculation based on operating loads, the general specifications for the emergency power generation facilities in this Project shall be as follows.

Capacity:	50 kVA, indoor type
Number of units:	1 unit
Type:	Diesel engine powered 3-phase AC power generator
Power system:	415-240V, 3 phases 4 wires, 50Hz
Fuel tank capacity:	400 L (Securing a capacity enough for the longest power outage of 10 hours or longer)
Generator control panel:	Indoor, wall-mount
Accessory:	Hand rotary pump.

2-2-3-6 Associated Civil and Building Works

(1) Content of Civil Engineering and Construction Facilities

The civil engineering and construction facilities to be constructed at pump stations are as follows:

1) Pump Station

(i) Pump and machine room: 1 building

- Foundation: Spread footing
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $60m^2$, building facilities included
- Exterior wall: Reinforced concrete

(ii) Building for chlorine feeding equipment (1 building)

- Foundation: Above the regulating reservoir
- Upper structure (beams, columns etc): Reinforced concrete, total floor area $50m^2$, building facilities included
- Exterior wall: Concrete blocks

(iii) Lighting/ ventilation equipment

(iv) Drainage facility (in-situ)