**Republic of Fiji**
**Ministry of Infrastructure and Meteorological Services**
**Fiji Roads Authority (FRA)**

# Preparatory Survey Report
# on
# the Project for the Reconstruction of Tamavua-i-wai Bridge

**July 2020**

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**Central Consultant Inc.**

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# PREFACE

The Japan International Cooperation Agency (JICA) has decided to conduct a preparatory survey for cooperation on the Tamavua-i-wai Bridge replacement project in the Republic of Fiji, and it has contracted Central Consultant Inc. to conduct this survey.

The survey team held discussions with Fijian government officials from April 11 to May 31, 2018 and conducted fieldwork in the area to be covered by the project. After returning to Japan, the survey team conducted in-country work, which has resulted in the completion of this report.

I hope that this report will contribute to the implementation of the project and to the further development of friendship and goodwill between Japan and Fiji.

In conclusion, I would like to express my sincere gratitude to all those who have cooperated with and supported this project.

July 2020

Amada Kiyoshi
Director General,
Infrastructure Department,
Japan International Cooperation Agency

# SUMMARY

## (1) Overview of the Country

Fiji is a country in Oceania, with its capital in Suva on the island of Viti Levu. It is an island nation in the South Pacific Ocean formed of the Fiji Islands and the protectorate of Rotuma Island about 500 km to the north. It consists of more than 300 volcanic islands and coral reefs. Fiji has a land area of 18,274 $km^2$, a total population of approx. 890,000 (2017: Fiji Bureau of Statistics), and a population density of 49 people/$km^2$. Vanuatu is to the west, Tonga is to the east, and Tuvalu is to the north.

Fiji has a typical tropical rainforest climate with a high temperature and high rainfall. Generally, the rainy season is from November to April of the following year, and the dry season is from May to October. The maximum monthly average rainfall during the rainy season observed at Suva's observing station over the past 5 years was 513 mm (December), and the minimum monthly average rainfall during the dry season was 83 mm (June).

The monthly average maximum temperature observed at Suva observing station (over the past 5 years) was 31.7°C (February), and the minimum temperature was 21.2°C (July). The difference between the maximum temperature and minimum temperature is small, with a maximum difference of 6.7°C (February).

Fiji's GDP (gross domestic product) is USD 5.479 billion (2018: World Bank), and the GDP per capita is USD 6,156 (2018: World Bank). GNI (gross national income) per capita is USD 5,860 (2018: World Bank). Real GDP growth is 5.0% (2018: World Bank), price inflation is 0% (2018: World Bank), and the total trade value is USD 861.5 million for exports and USD 2,785 million for imports (2018: Asian Development Bank). Major trade items include exports of clothing, sugar, gold, fish, and wood chips; and imports of machinery and transport equipment, industrial products, foodstuffs, miscellaneous goods, chemicals, and mineral fuels. Fiji's main industries are tourism, sugar, and clothing. The share of GDP is 13.4% for primary industry (agriculture, forestry and fisheries), 18.1% for secondary industry (mining, manufacturing, construction, and electricity), and 68.5% for tertiary industry (wholesale, retail, transportation, information and communication, finance, and other services).

In Fiji, the economic growth rate was negative 6.6% in 2007, immediately after the coup d'etat in December 2006, and then improved to 0.2% in 2008. However, the economic growth rate then fell to negative 3% in 2009 due to the decline in the sugar industry and the global economic crisis. In particular, the sugar industry, which has supported the Fijian economy for many years, is facing problems such as aging machinery. Since 2011, the Fijian economy has been generally stable, with growth in the 2% to 5% range.

## (2) Project background, conditions, and overview

Although there are about 1,231 bridges in Fiji, many of them are aging and there is generally not enough of a budget for renewal, and this is an issue. In addition, according to the Global Risks Report (FY2016) of the United Nations University, the disaster risk indicator for Fiji ranks high at 16th

among 171 countries ranked. Fiji frequently experiences cyclone damage, and Cyclone Winston in February 2016 caused damage equivalent to approx. 30% of the GDP.

The Tamavua-i-wai Bridge that is the target of the Project for the Reconstruction of Tamavua-i-wai Bridge (hereinafter, the “Project”) was built in 1975 in the western suburbs of the capital of Suva on Viti Levu Island as a bridge on Queens Road, which is a southbound ring road circling the island. The second largest city Lautoka and Nadi International Airport are located in the northwestern part of Viti Levu Island, and Queens Road is the only major arterial road that allows the passage of large vehicles. In addition, because there is no detour road around this bridge, it both supports the economic growth of the country and serves as an important lifeline for the community, as approx. 15,000 vehicles travel over the bridge every day. However, the road surface and structure have been damaged by overloading it with vehicles, and the bridge piers have suffered serious damage due to salt damage and floating wreckage from Cyclone. Although emergency repairs have been conducted as required, full repairs have not been achieved, which means that it would not be unusual for the existing bridge to collapse, so a prompt response is required.

Responding to these circumstances is one of the priorities of the infrastructure division of the government of Fiji. Furthermore, the Fiji Roads Authority positions the Project as one of the nine bridge renewal projects with the highest priority. This Project is the most important of these projects because it is on a major arterial road, has high volumes of traffic, and the longest bridge length.

In addition, disaster prevention has been stated as the first of the seven priority issues at the 7th Pacific Islands Leaders Meeting held in 2015 in Japan. The Project is positioned as an environment, climate change, and disaster prevention program that are Japan's assistance priority areas under the Republic of Fiji Project Deployment Plan (2016). In addition, disaster prevention was analyzed as a priority work area in the Asia-Pacific JICA Analysis Paper by Country (2014), and the Project is consistent with this policy and analysis. Japan has supported areas such as human resource development, institution building, and policy making support through the dispatch of experts including advisor for regional disaster risk reduction in this sector (September 2016 to August 2018).

Under these circumstances, the government of Fiji has requested grant assistance from the government of Japan for the replacement of the Tamavua-i-wai Bridge to ensure the functioning of the arterial road and to provide access to Suva, the capital city of Fiji, in the event of a disaster.

The objectives of this survey were to confirm the necessity and appropriateness of the requested project, to prepare an appropriate outline design for the grant aid project, to formulate a project plan, and to estimate project costs.

### (3) Overview of survey results and contents of the project

At the Eighth Pacific Islands Leaders Meeting (May 2018), strengthening the basis for resilient and sustainable development and the further implementation of disaster management capabilities were set as priorities, and the Development Cooperation Policy for Fiji (April 2019) identified support for overcoming vulnerabilities and environment and climate change as priority areas. Accordingly, this project is consistent with disaster management program, which is one of the development agendas of

the priority area environment and climate change. In addition, it has been confirmed that the project would be conducive to the pursuit of economic prosperity in a free and open Indo-Pacific region with a view to enhancing connectivity through the development of a land transport network.

During the preparatory survey in Fiji from April 11 to May 31, 2018, a survey team was dispatched to Fiji for a preparatory survey (general design survey), where the main points of the survey were investigated and confirmed through discussions with the Fijian counterparts, mainly with regard to the alignment of the bridge location and approach roads, the longitudinal section plan of the bridge and approach roads, the cross section configuration of the bridge and roadway, bridge type, environmental and social considerations, natural conditions, traffic volume, procurement of construction materials and equipment, and the operation, maintenance, and management structure.

Based on the results of the field survey, the location of the bridge, the alignment of the approach roads, the longitudinal section of the bridge and mounting road, and the construction plan were studied and an estimate of project costs was made. After conducting general design in Japan, the results and the costs to be borne by counterparts were explained and discussed with Fiji, and an agreement was reached.

The content of the agreement is that the current and future traffic volumes in Fiji require the development of a four-lane bridge. Because the government of Fiji is building a new bridge downstream of the existing bridge as an emergency response to the deteriorating existing bridge, this will be used as a detour during the construction period so that the existing bridge can be demolished, and the main bridge will be constructed at the location of the existing bridge. After the completion of the main bridge, the bridge built by the government of Fiji will be used as the outbound lane from Suva and the main bridge will be used as the inbound lane.

In light of the above, in order to clarify the distinction between the two new bridges, the main bridge will be referred to as the “New Tamavua-i-wai Bridge” and the bridge built by the government of Fiji will be referred to as the “New FRA Bridge” in this report.

For the longitudinal alignment of the Tamavua-i-wai Bridge and the approach roads, design water level as the clearance of the new bridge was adopted, assuming a sea level rise for 1/100-year recurrence interval tides, 1/100-year recurrence interval waves, and climate change with RCP 8.5. As a result, the road surface of the existing bridge would be raised by 2.545 m on the right bank side and 1.761 m on the left bank side.

In terms of the bridge type, we have adopted a PC 3-span post-tension type slab girder bridge after taking into account, in particular, salt damage, driftwood measures, the impact on the surrounding environment, executability, and economic efficiency. In selecting the construction method, we adopted a method for pursuing economic efficiency while aiming for the earliest possible completion of the work.

In addition, because the ground on the Lami side is very soft ground with an N-value of 0 and with a depth of 40 m, soft ground prevention work such as paper drain, sand matting, and pre-loading will be conducted.

As a result of the above, the outline of the ultimate proposed plan is as follows.

| Item | | | Type/specifications |
|---|---|---|---|
| Bridge location | | | Existing bridge location |
| Width | Bridge portion | | Roadway 3.5m×2=7.0m, shoulder 0.5m×2=1.0m,<br>single-sided sidewalk 2.0m Total 10.0m (effective width)<br>Road side wheel guard 0.6m, sidewalk side wheel guard 0.4m<br>Total 11.0m (total width) |
| | Approach roads | | Roadway 3.5m×2=7.0m, shoulder 0.5m×2=1.0m,<br>single-sided sidewalk 2.0m Total 10.0m (effective width)<br>Protection shoulder 1.0m×2=2.0m Total 12.0m (total width) |
| Bridge type | | | PC 3-span interconnected post-tension type slab girder bridge |
| Span ratio selection, bridge length | | | 3@30.0=90.0m (road centerline) |
| Bridge surface pavement | | | Asphalt pavement (road portion 80mm) |
| A1 bridge abutment (Lami side) | | Type | Inverted T abutment |
| | | Structure height | H=7.0m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=39.5m, n=12 units) |
| A2 abutment (Suva side) | | Type | Inverted T abutment |
| | | Structure height | H=9.4m |
| | | Foundation work | Spread foundation |
| P1 pier | | Type | Oblong pier |
| | | Structure height | H=11.8m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=31.0m, n=12 units) |
| P2 pier | | Type | Oblong pier |
| | | Structure height | H=11.8m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=11.5m, n=12 units) |
| Approach roads | | Length | Lami side: approx. 230m<br>Suva side: approx. 270m Total approx. 500m |
| | | Pavement | Asphalt pavement<br>(surface layer 50mm + base layer 50mm=100mm) |
| Revetments | Right bank | Type (length) | Rubble (upper layer D50-450mm,lower layer D50-150mm) 70m |
| | Left bank | Type (length) | Rubble (upper layer D50-450mm,lower layer D50-150mm) 60m |
| Bed protection | P1 bridge pier | Type (area) | Foundation consolidation mat, covering type 3t-type 303m2 |
| | P2 bridge pier | Type (area) | Foundation consolidation mat, covering type 3t-type 310m2 |

### (4) Project period and estimated project costs

In the case of implementation of this project with Japanese grant aid, 12 months will be required for implementation design (including bidding) and approx. 28 months will be required for facility construction.

In addition, the Fiji side would cover an estimated 341 million JPY of the rough project cost.

### (5) Project evaluation

#### 1) Appropriateness

It is considered appropriate to implement the project with Japanese grant aid in view of the following points.

① That the benefits of the project will reach a significant number of the general population in the Suva metropolitan area, northwest region of Viti Levu island that includes the second largest city Lautoka and Nadi International Airport to encourage the social and economic development of Fiji, and the northwest region of Viti Levu island where Nausori Airport is located (directly, 108,016 in the Suva metropolitan area, 247,708 in the northwest region of Viti Levu, and 177,678 in the northwest region of Viti Levu, for a total of 533,402 people; indirectly, about 890,000 Fijians).

② The effects of the project include the strengthening of the transport network on the Queen's Road and Kings Road that are Fiji's most important arterial roads, ensuring stable transport, facilitating traffic, and stimulating the society and economy, which are urgently needed to facilitate logistics and improve the livelihood of residents.

③ Fiji will be able to operate and maintain the project after completion with its own funds, human resources, and technology, without the need for excessively sophisticated technology.

④ The FRA began to establish short, medium, and long-term road network development plans for the Suva metropolitan area in 2014 under the Greater Suva Transportation Strategy 2015-2030 from August 2014. A project related to the maintenance of Queens Road, where the Tamavua-i-wai Bridge is located, has been proposed in this strategy, and accordingly, this Tamavua-i-wai Bridge Reconstruction Project is of a high level of importance.

⑤ The Development Cooperation Policy for Fiji (April 2019) identified support for overcoming vulnerabilities and environment and climate change as priority areas. Accordingly, this project is consistent with disaster management programs, which is one of the development agendas of the priority area environment and climate change.

⑥ The project will have almost no negative environmental impact.

⑦ The project can be carried out without any particular difficulties under the Japanese grant aid system.

⑧ Because the target bridges are PC 3-span post-tension type slab girder bridges, it would be difficult to design and construct them using technologies in Fiji, and there are needs and advantages to using Japanese technology.

**2) Effectiveness**

**i) Quantitative effects**

The quantitative effects expected from the implementation of the project are as follows.

| Indicator | Baseline (2018) | Target value (2027) [Project completion 3 years later] |
|---|---|---|
| Traffic volume (vehicles per day) | 21,414 | 29,500 |
| Transportation volume - Number of passengers (passengers/year) | 25,998,000 | 37,236,000 |
| Transportation volume - Volume of freight (tons/year) | 4,378,000 | 4,641,000 |

(Transportation volume is the volume of traffic passing over the bridge)

**ii) Qualitative effects**

The qualitative effects expected from the implementation of the project are as follows.

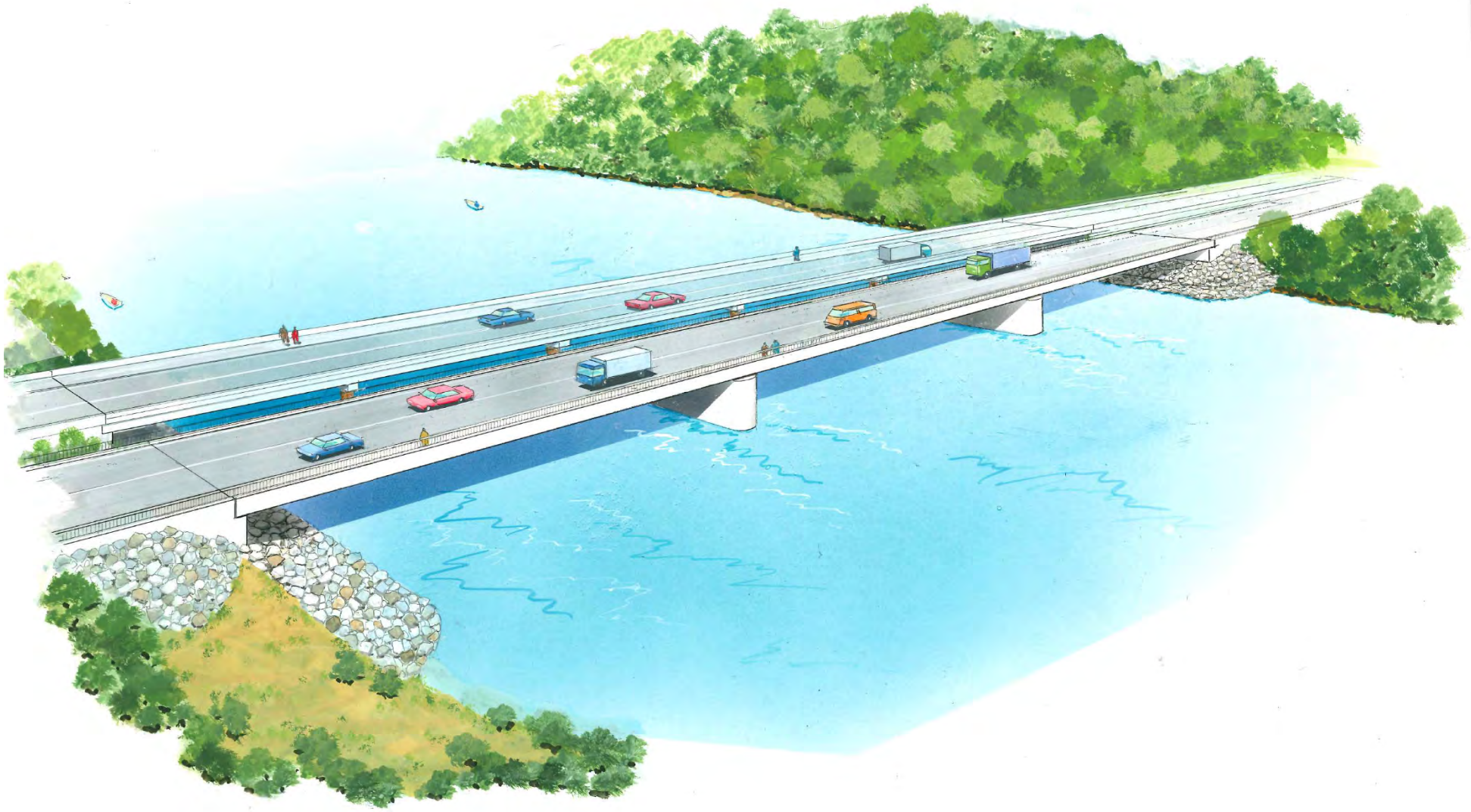
① The project will contribute to the country's sustainable economic development by ensuring smooth logistics and human traffic even in times of disaster.

② It will contribute to the improvement of traffic safety by eliminating face-to-face traffic.

Based on the above, we believe that this project will be highly appropriate and effective.

［ Appendices ］


Project Location Map



Rendering of the New Tamavua-i-wai Bridge

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## Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| AC | Asphalt Concrete |
| ADB | Asian Development Bank |
| ARAP | Abbreviated Resettlement Action Plan |
| CBR | California Bearing Ratio |
| DFR | Draft Final Report |
| EIA | Environmental Impact Assessment |
| E/N | Exchange of Notes |
| FRA | Fiji Roads Authority |
| FRCS | Fiji Revenue and Customs Service |
| GDP | Gross Domestic Product |
| GNI | Gross National Income |
| HIV/AIDS | Human immunodeficiency virus infection / acquired immunodeficiency syndrome |
| HWL | High Water Level |
| IEE | Initial Environmental Evaluation |
| JICA | Japan International Cooperation Agency |
| LARF | Land Acquisition and Resettlement Framework |
| LD | Lands Department |
| MCTTT | Ministry of Commerce, Trade, Tourism and Transport |
| M/D | Minutes of Discussion |
| MOE | Ministry of Environment |
| MSL | Mean Sea Lebel |
| MoIT | Ministry of Infrastructure and Transport (the term during field survey) |
| MIMS | Ministry of Infrastructure and Meteorological Services |
| O/D | Outline Design Study |
| ODA | Official Development Assistance |
| PC | Prestressed Concrete |
| PCU | Passenger Car Unit |
| RC | Reinforced Concrete |
| RCP | Representative Concentration Pathways |
| ROW | Right of Way |
| SALA | State Acquisition of Land Act |
| SHM | Stakeholder Meeting |
| TLTB | iTaukei Land Trust Board |
| UNDP | United Nations Development Programme |
| WB | World Bank |

# Chapter 1
# Background of the Project

# Chapter 1 Background of the Project

## 1-1 Background and Outline of the Grant Aid Project

Although there are about 1,231 bridges in Fiji, many of them are aging and there is generally not enough of a budget for renewal, and this is an issue. In addition, according to the Global Risks Report (FY2016) of the United Nations University, the disaster risk indicator for Fiji ranks high at 16th among 171 countries ranked. Fiji frequently experiences cyclone damage, and Cyclone Winston in February 2016 caused damage equivalent to approx. 30% of the GDP.

The Tamavua-i-wai Bridge, the target of the Project for the Reconstruction of Tamavua-i-wai Bridge (hereinafter, the "Project"), was built in 1975 in the western suburbs of the capital of Suva on Viti Levu Island as a bridge on Queens Road, which is a southbound ring road circling the island. The second largest city Lautoka and Nadi International Airport are located in the northwestern part of Viti Levu Island, and Queens Road is the only major arterial road that allows the passage of large vehicles. In addition, because there is no detour road around this bridge, it both supports the economic growth of the country and serves as an important lifeline for the community, as approx. 15,000 vehicles travel over the bridge every day. However, the road surface and structure have been damaged by overloading with vehicles and the bridge piers have suffered serious damage due to salt damage and floating wreckage from Cyclone. Although emergency repairs have been conducted as required, full repairs have not been achieved, which means that it would not be unusual for the existing bridge to collapse, so a prompt response is required.

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Under these circumstances, the government of Fiji has requested grant assistance from the government of Japan for the replacement of the Tamavua-i-wai Bridge to ensure the functioning of the arterial road and to provide access to Suva, the capital city of Fiji, in the event of a disaster.

# 1-2 Natural Conditions

## 1-2-1 Topographic survey

### (1) Topographical Overview

The Tamavua River near the existing bridge flows from the east-northeast to the west-southwest. A low marsh area with a width of approx. 300 to 400 meters full of mangroves is located on the right bank of the river. Downstream from the Queens Road on the right bank of the river, a former garbage dump with a width of 200m and height of 400m forms a hill that has a comparable height difference of approx. 10m. These mangrove forests on the right bank of the river are separated by marlstone hills.

One the left bank of the Tamavua River, while there is low marsh area with mangroves that has a width of approx. 50m downstream of the existing bridge, there is a steep cliff of marlstone across a road on the upstream side rather than a low marsh area.

### (2) Topographic survey result

The result of the topographic survey is shown below.

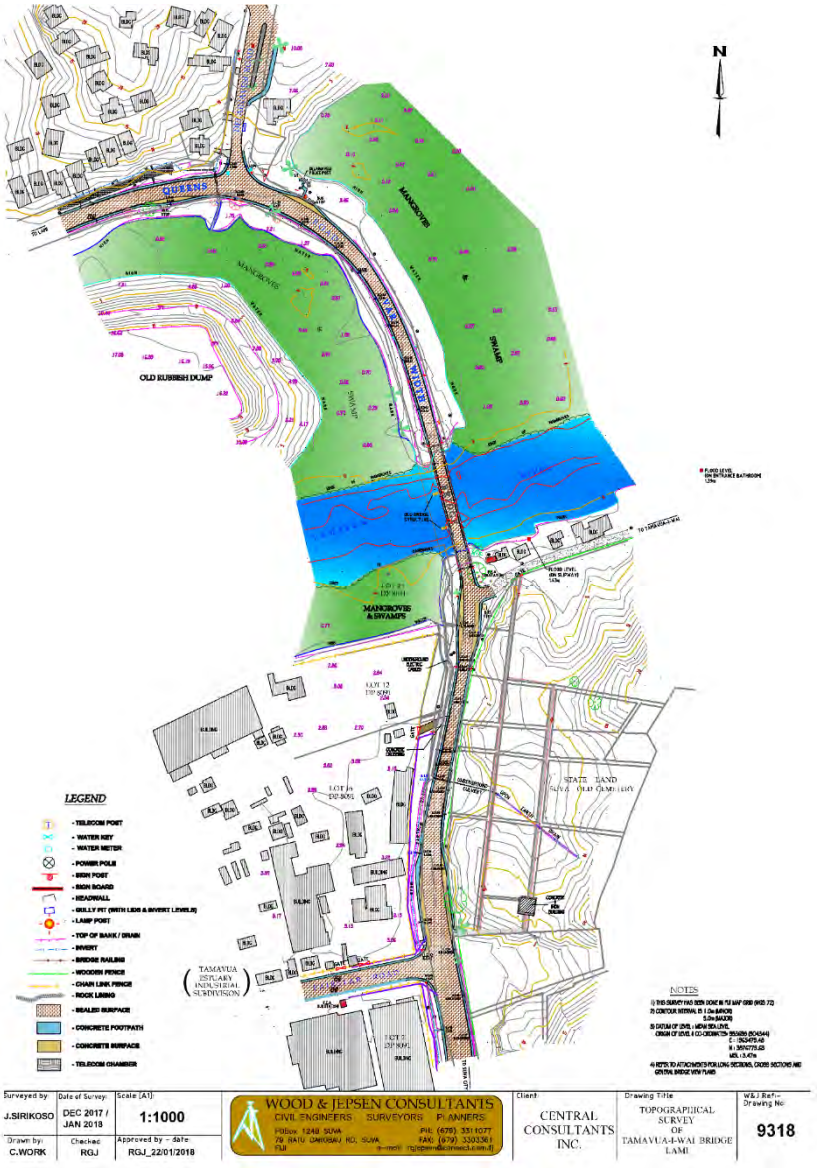



Figure 1-2-1 Survey map of Tamavua-i-waiBridge

## 1-2-2 Geological survey

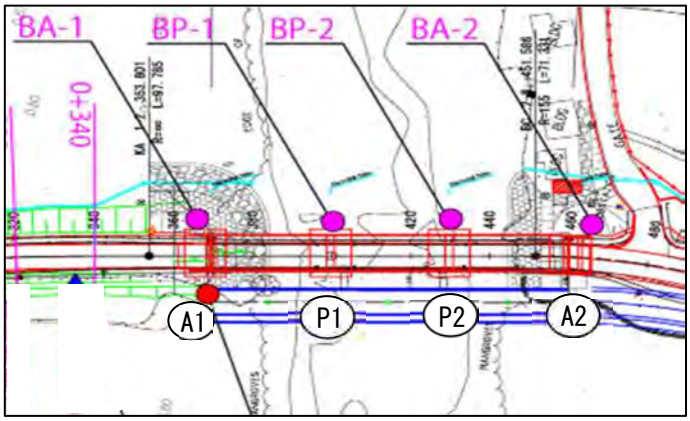
### (1) Geological Overview

According to a geological map with a scale 1:50,000 issued by the Fiji Geological Survey Department, there is a wide distribution of marlstone classified in the Suva group from the upper Miocene to early Pliocene in the survey region. This marlstone is inter-bedded with thin layers of tuff, has an overall thickness of at least 300m, and is sloped toward the sea side (south-southwest side) at a gentle slope of about 10 degrees. On the left bank of the Tamavua River, steep cliffs including some fault escarpments of thick marlstone layers are widely distributed, and a flat surface on top of a river terrace can been seen under the steep cliffs. Meanwhile, on the right side of the river, marlstone forms a terrain of gentle hills, and a low mangrove marsh area is located between these hills and the Tamavua River. Silty delta alluvial sediment is distributed in the low mangrove marsh area on both banks of the river and the current riverbed.

### (2) Boring position

The four boring positions are shown below.

← To Lami




To Suva →

Figure 1-2-2 Boring position

### (3) Results of boring

The results of boring are shown below.

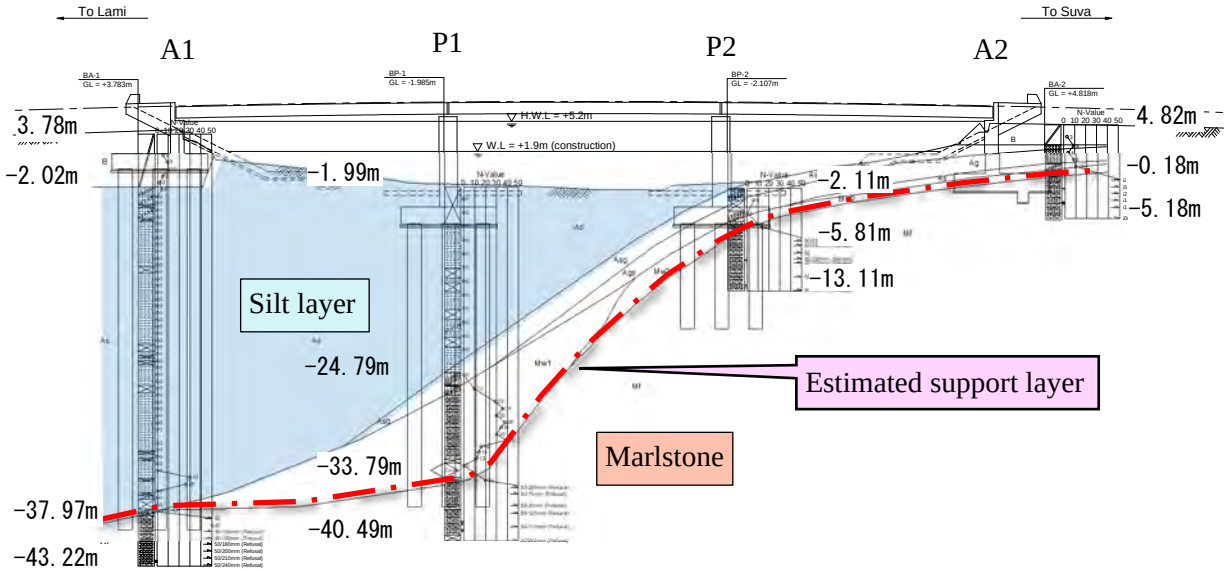



Figure 1-2-3 Selection of support layer

## 1-2-3 Meteorological, oceanographic and hydrological surveys

### (1) Temperature, humidity, and wind speed

For the average monthly temperature for the past five years observed by the Suva observing station, there is little fluctuation throughout the year for the maximum value and minimum value, and the difference between the maximum temperature and minimum temperature is approx. 11°C. The maximum temperature for the past five years was 32.7℃ (February 2016), and the minimum temperature was 20.3℃ (September 2014).

In addition, there is little fluctuation in humidity throughout the year. For the past five years, the maximum average monthly relative humidity was about 81% and the minimum was about 77%, so there is only a difference of about 4%. In light of this, it is necessary to determine the temperature changes for materials for design and the concrete casting and curing method for construction.

Wind speed is generally between 1.7m/s to 2.3m/s throughout the year, expect for when there is a cyclone, and as such it is not a region with particularly strong wind. However, because the location is near the mouth of the river, it can be assumed that there will a supply of salt, so measures to prevent salt damage will be necessary.

#### 1) Temperature

The monthly temperatures for the past 5 years at Suva Observatory are summarized as below.

Table 1-2-1 Monthly average maximum and minimum temperatures

℃

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max | 31.3 | 31.7 | 31.2 | 30.1 | 28.7 | 27.8 | 26.8 | 26.5 | 27.5 | 28.3 | 30.2 | 30.1 | 29.2 |
| Min | 25.0 | 25.0 | 25.1 | 24.2 | 23.3 | 22.4 | 21.2 | 21.6 | 24.2 | 23.2 | 24.0 | 24.1 | 23.6 |

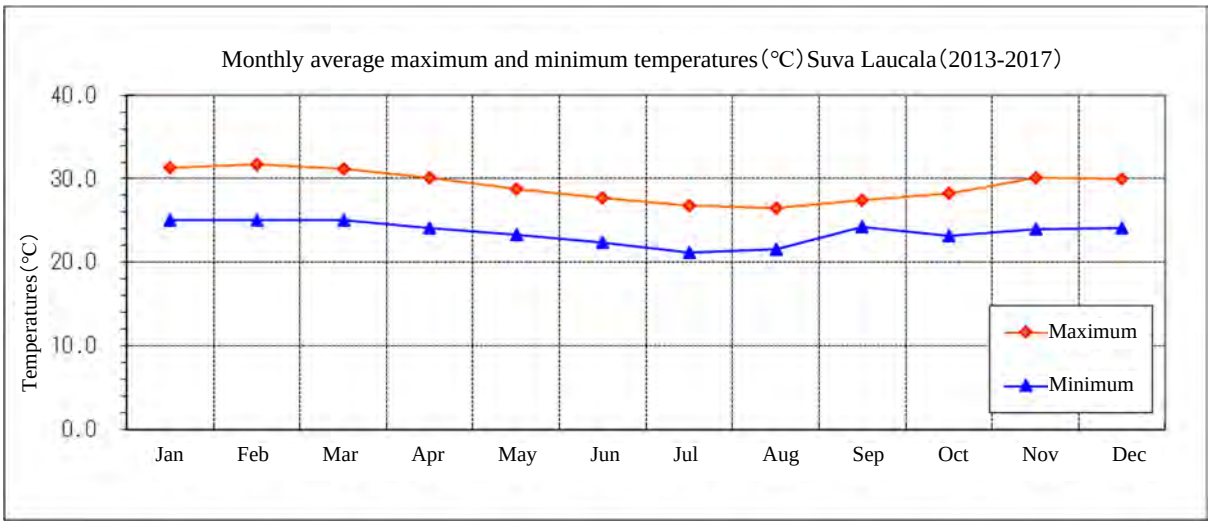



Figure 1-2-4 Monthly average maximum and minimum temperatures

### 2) Humidity

The humidities for the past 5 years at Suva Observatory are summarized as below.

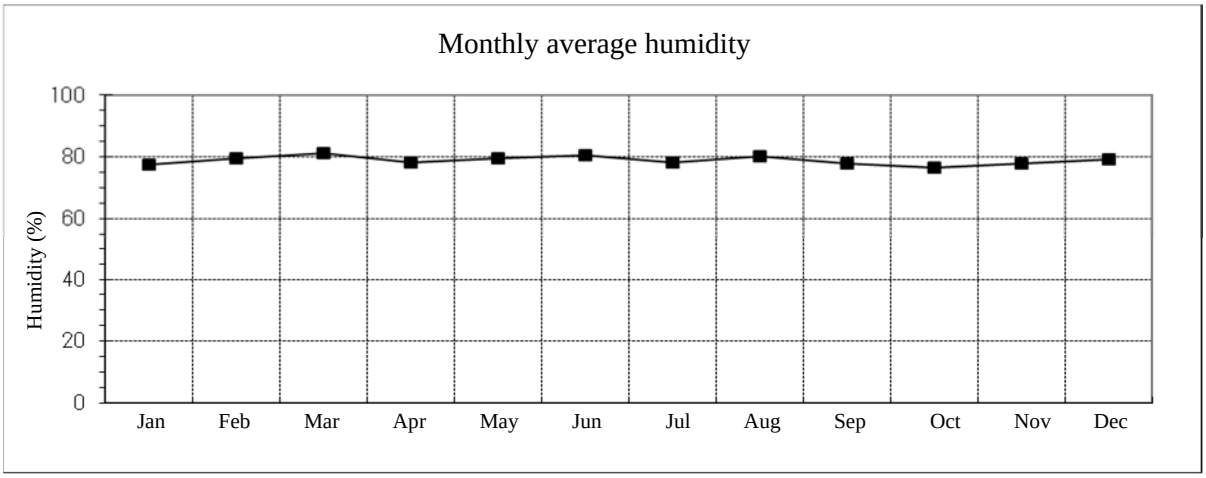



Figure 1-2-5 Monthly average humidity

### 3) Wind speed and Wind direction

The wind speed and wind direction for the past 5 years at Suva Observatory are summarized as below.

Table 1-2-2 Wind speed

m/s

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Yearly avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 1.5 | 1.0 | 1.2 | 1.7 | 1.9 | 1.5 | 2.3 | 1.7 | 2.7 | 2.3 | 2.0 | 2.0 | 1.8 |
| 2014 | 1.8 | 1.6 | 1.7 | 1.4 | 1.4 | 1.6 | 1.0 | 2.3 | 1.7 | 1.9 | 2.4 | 2.5 | 1.8 |
| 2015 | 1.5 | 1.8 | 2.0 | 2.5 | 2.0 | 1.7 | 2.0 | 2.6 | 1.9 | 3.0 | 3.1 | 2.4 | 2.2 |
| 2016 | 2.1 | 2.7 | 1.8 | 2.7 | 1.5 | 1.9 | 2.2 | 1.7 | 2.3 | 1.8 | 2.0 | 2.4 | 2.1 |
| 2017 | 1.4 | 1.6 | 1.4 | 1.1 | 2.1 | 1.6 | 1.6 | 1.9 | 2.1 | 2.4 | 2.6 | 2.1 | 1.8 |
| Average | 1.7 | 1.7 | 1.6 | 1.9 | 1.8 | 1.7 | 1.8 | 2.0 | 2.1 | 2.3 | 2.4 | 2.3 | 1.9 |

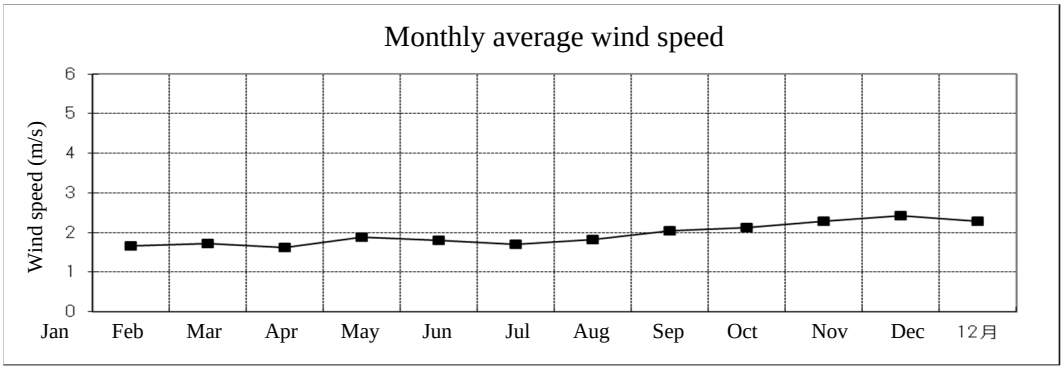



Figure 1-2-6 Monthly average wind speed

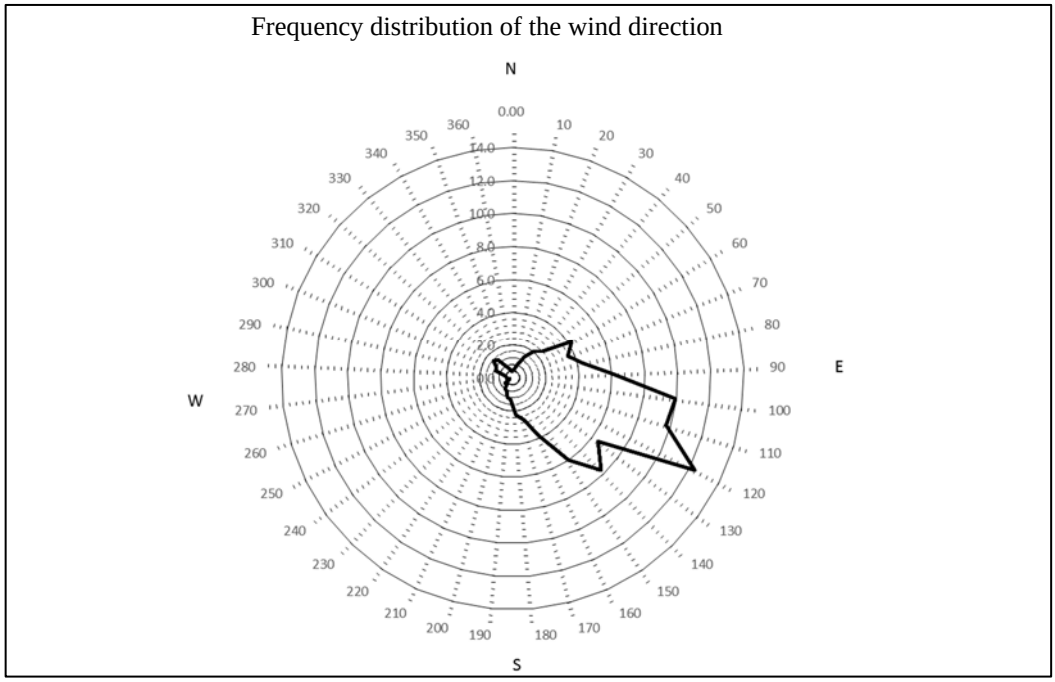



Figure 1-2-7 Frequency distribution of the wind direction

### (2) Precipitation

The average annual precipitation for the past 5 years observed by the Suva observing station was an average of 2870mm, and there is considerable variation because the range is 1809 to 3324mm. The dry season is from May to October, and the rainy season is from November to April, and Fiji also suffers from cyclones during the rainy season. In addition, maximum monthly rainfall was 762mm (December 2016) and maximum daily rainfall was 207mm (February 2014). As a result of a hydrological statistics analysis that was conducted using daily rainfall data for the past 76 years, the daily rainfall with a probability of once in 100 years was 399mm.

#### 1) Monthly precipitation

The monthly precipitations for the past 5 years at Suva Observatory are summarized as below.

Table 1-2-3 Monthly precipitation

mm

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Yearly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 189 | 435 | 444 | 240 | 144 | 141 | 238 | 155 | 174 | 248 | 155 | 449 | 3,013 |
| 2014 | 405 | 681 | 497 | 186 | 447 | 57 | 116 | 38 | 39 | 219 | 60 | 580 | 3,324 |
| 2015 | 292 | 273 | 189 | 86 | 93 | 55 | 53 | 133 | 128 | 98 | 45 | 364 | 1,809 |
| 2016 | 167 | 321 | 106 | 343 | 173 | 50 | 79 | 405 | 57 | 310 | 118 | 762 | 2,891 |
| 2017 | 307 | 352 | 383 | 309 | 285 | 110 | 86 | 150 | 111 | 150 | 662 | 410 | 3,314 |
| Average | 272 | 412 | 324 | 233 | 228 | 83 | 114 | 176 | 102 | 205 | 208 | 513 | 2,870 |

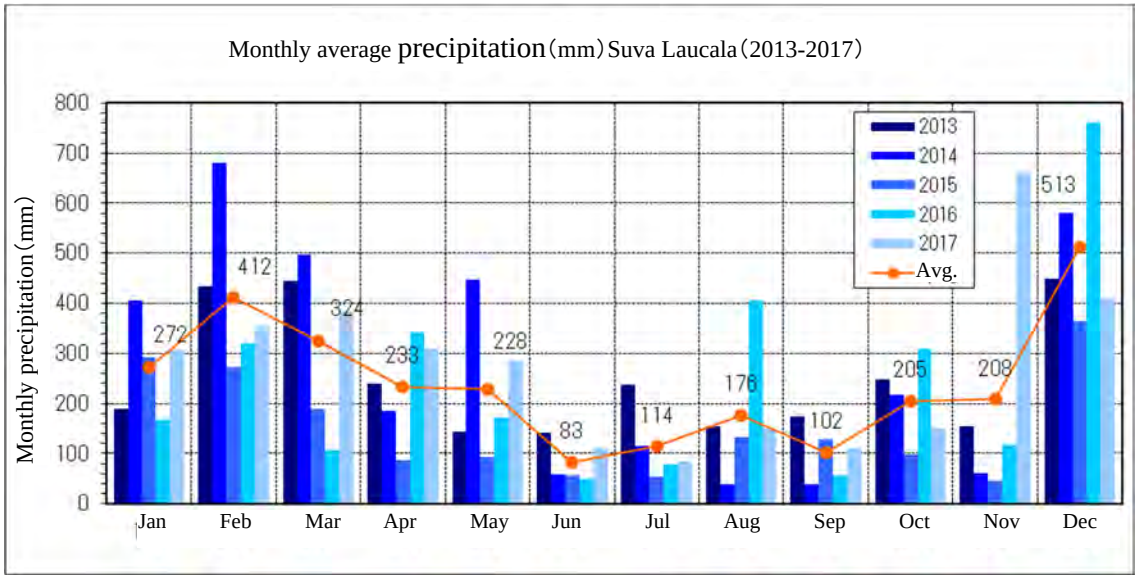



Figure 1-2-8 Monthly precipitation

### 2) Maximum daily precipitation

The monthly maximum daily precipitations for the past 5 years at Suva Observatory are summarized as below.

Table 1-2-4 Maximum daily precipitation

mm

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Yearly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 49.0 | 74.6 | 105.8 | 60.0 | 44.5 | 31.5 | 102.0 | 37.0 | 61.4 | 58.5 | 25.7 | 124.0 | 774 |
| 2014 | 130.1 | 206.6 | 103.2 | 42.2 | 168.5 | 13.9 | 37.7 | 7.3 | 13.8 | 38.0 | 26.6 | 197.6 | 986 |
| 2015 | 105.0 | 112.5 | 58.7 | 22.1 | 24.6 | 8.9 | 13.9 | 35.4 | 33.8 | 46.1 | 12.6 | 86.0 | 560 |
| 2016 | 42.2 | 158.9 | 23.4 | 67.3 | 58.7 | 18.7 | 16.4 | 88.2 | 34.1 | 96.3 | 50.0 | 185.6 | 840 |
| 2017 | 68.1 | 57.4 | 118.9 | 208.4 | 107.8 | 40.0 | 32.0 | 63.3 | 30.0 | 68.7 | 105.4 | 74.4 | 974 |
| Average | 79 | 122 | 82 | 80 | 81 | 23 | 40 | 46 | 35 | 62 | 44 | 134 | 827 |

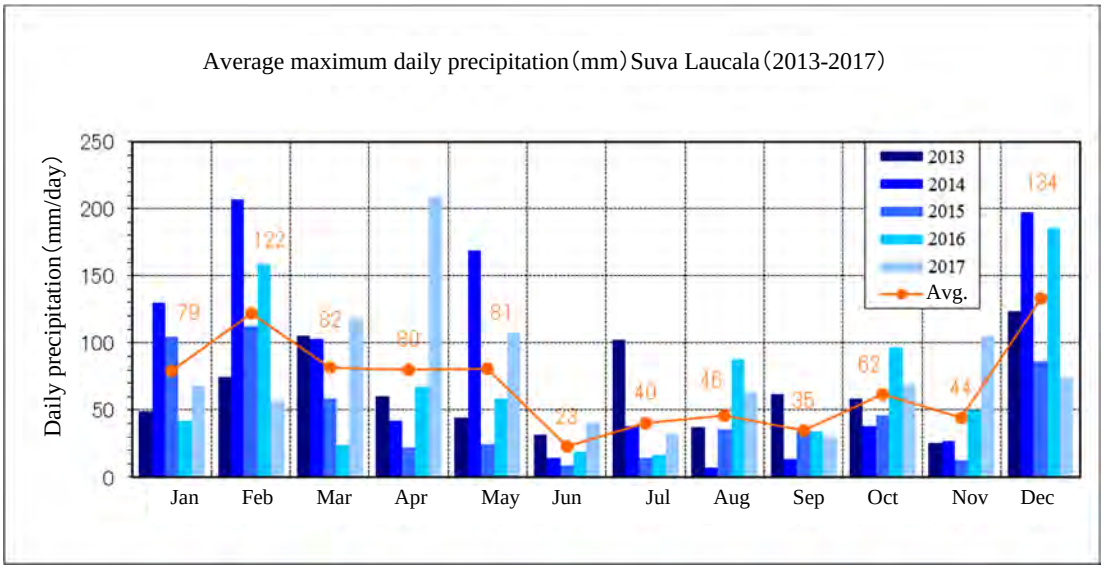



Figure 1-2-9 Average maximum daily precipitation

### 3) Days above 10mm/day precipitation

Days above 10mm/day precipitation for the past 5 years at Suva Observatory are summarized as below.

Table 1-2-5 Days above 10mm/day precipitation

day

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Yearly |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 6 | 14 | 8 | 7 | 5 | 5 | 7 | 5 | 7 | 11 | 6 | 9 | 90 |
| 2014 | 10 | 11 | 10 | 6 | 9 | 3 | 3 | 0 | 2 | 9 | 1 | 11 | 75 |
| 2015 | 8 | 7 | 7 | 3 | 3 | 0 | 2 | 4 | 3 | 3 | 1 | 9 | 50 |
| 2016 | 4 | 6 | 3 | 9 | 3 | 1 | 3 | 10 | 1 | 6 | 2 | 13 | 61 |
| 2017 | 11 | 13 | 7 | 5 | 6 | 3 | 2 | 4 | 4 | 3 | 11 | 12 | 81 |
| Average | 7.8 | 10.2 | 7.0 | 6.0 | 5.2 | 2.4 | 3.4 | 4.6 | 3.4 | 6.4 | 4.2 | 10.8 | 71.4 |

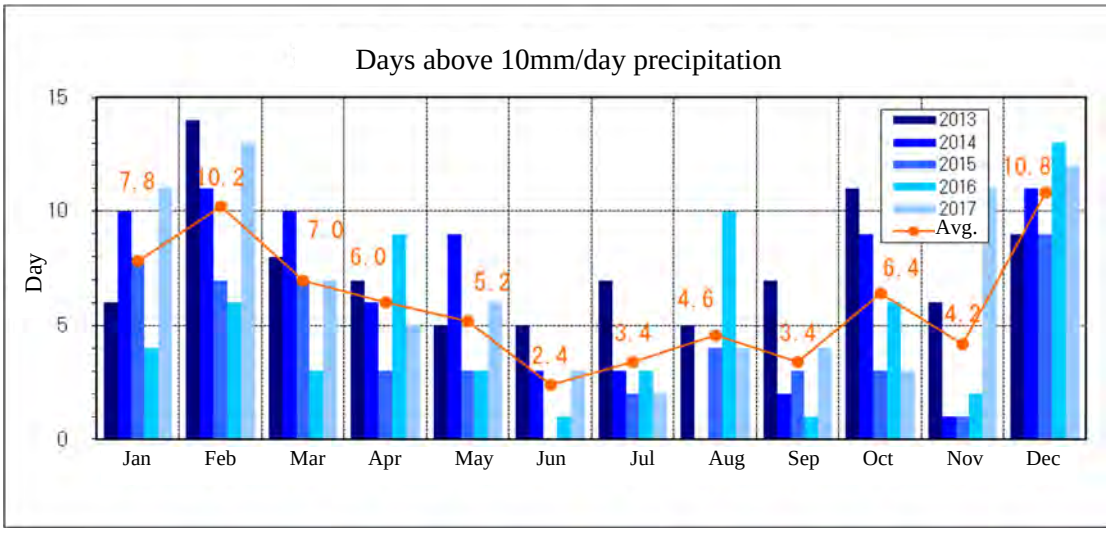



Figure 1-2-10 Days above 10mm/day precipitation

## (3) Climate change

According to a report from the IPCC, the amount of sea level rise for RCP2.6 and RCP8.5 is 0.4m and 0.7m, respectively, and this shall be considered when determining the clearance beneath the bridge.

## (4) Tide level

For the tide level, the value below that is the astronomical high tide level estimated by SOPAC plus deviation with a probability of once in 100 years shall be the plan tide level, and this shall be considered when determining the clearance beneath the bridge.

MSL+1.1m + 1.13m ≒ MSL+2.3m

Plan tide level taking into consideration climate change (RCP8.5) = MSL+2.3 + 0.7 = MSL+3.0m

**(5) Waves**

Because the water depth at the mouth of the Tamavua River is shallow, the waves are breaking waves and their height is only about 0.6 times that of the water depth. Accordingly, it shall be the value below, and this shall be considered when determining the clearance beneath the bridge.

Water depth at the mouth of the river = plan tide level -riverbed height at the river mouth + climate change (RCP8.5) = 2.3 - (-0.6) + 0.7 = 3.6m

Breaking wave height = 0.6 × 3.6 = 2.2m

Plan tide level taking into consideration climate change (RCP8.5) and waves

= MSL+3.0 + 2.2m = MSL+5.2m

**(6) Tsunami**

There was an earthquake in Fiji in 1953, and Suva suffered damage from the tsunami that was caused from a submarine landslide triggered by that earthquake. The tsunami was the largest recorded, and the wave height was 1.8m in Suva.

According to the standards in New Zealand, the plan tide level that takes tsunami into consideration (runup height) is the average tide level (MSL±0.0m) plus two times the height of the tsunami. Accordingly, it shall be the value below, and this shall be considered when determining the clearance beneath the bridge.

Plan tide level taking into consideration climate change (RCP8.5) and tsunami

= Average tide level + tsunami height × 2 + climate change (RCP8.5) = MSL±0.0 + 1.8×2 + 0.7

= MSL+4.3m

**(7) Discharge and tidal level during flood**

For the discharge volume when there is a flood, the bridge manual of the Fiji government prescribes the planned flood discharge as that from a flood with a probability of one in 100. It was assumed that the planned flood discharge is Q=500$m^3$/s for this survey as a result of an estimate based on the river cross-section, trace water level, and a rational formula.

In addition, the plan tide level taking into consideration floods was calculated as MSL+3.1m as a result of a water level calculation using the tide level that incorporates climate change (RCP8.5) in the plan tide level as the starting water level.

# 1-3 Environmental and Social Consideration

## 1-3-1 Overview of Project Components

### (1) Project Content and Objectives

The Project constitutes the reconstruction of Tamavua-i-wai Bridge across the Tamavua River in Suva District, in response to a request from the Government of Fiji. The objective of the Project is to improve the arterial road function so as to ensure an appropriate logistical route accessing the capital city of Suva City while withstanding natural disasters.

### (2) Project Site Location

The location of Tamavua-i-wai Bridge which is currently occupied by the old existing bridge constructed in 1975 and is located on the western edge of Suva District near the Lami Township, spanning the Tamavua River as part of the peripheral arterial road of southern circulation, named Queens Road, in the Viti Levs Island of Fiji. Queens Road is the only arterial road capable of accommodating heavy trailers and connecting to the northwestern area of Viti Levus, which is home to Nadi International Airport and the second-largest city, Lautoka. Despite the lack of any detour around the bridge, this southern peripheral arterial road and the 15 000 or so vehicles it handles daily to support national economic growth is one of the key lifelines for Fiji citizens. Conversely, there is conspicuous damage to the surface and other structures of the road due to over-laden trucks as well as to bridge structures like piers due to the large volume of floating objects after tropical cyclones. Regarding the current condition of Tamavua-i-wai Bridge, although damage has been urgently rectified whenever discovered, the current state of the bridge means emergency measures must be taken, since it could deteriorate at any moment.


Source: JICA Study Team

Figure 1-3-1 Location of Project Site

### (3) Other Relevant Projects

Apart from the project to reconstruct Tamavua-i-wai Bridge carried out under Japan's grant aid scheme (provisionally referred to as 'the New Tamavua-i-wai Bridge') on the Tamavua River, there is another project to construct a concrete bridge on the downstream side carried out by the FRA (provisionally referred to as the New FRA Bridge). Since the New FRA Bridge will be constructed before starting to construct the New Tamavua-i-wai Bridge, the New FRA Bridge will be able to secure

the transport function of Queen Road connecting Lami Town and Suva City during construction of the New Tamavua-i-wai Bridge.

### (4) JICA's Environmental Category

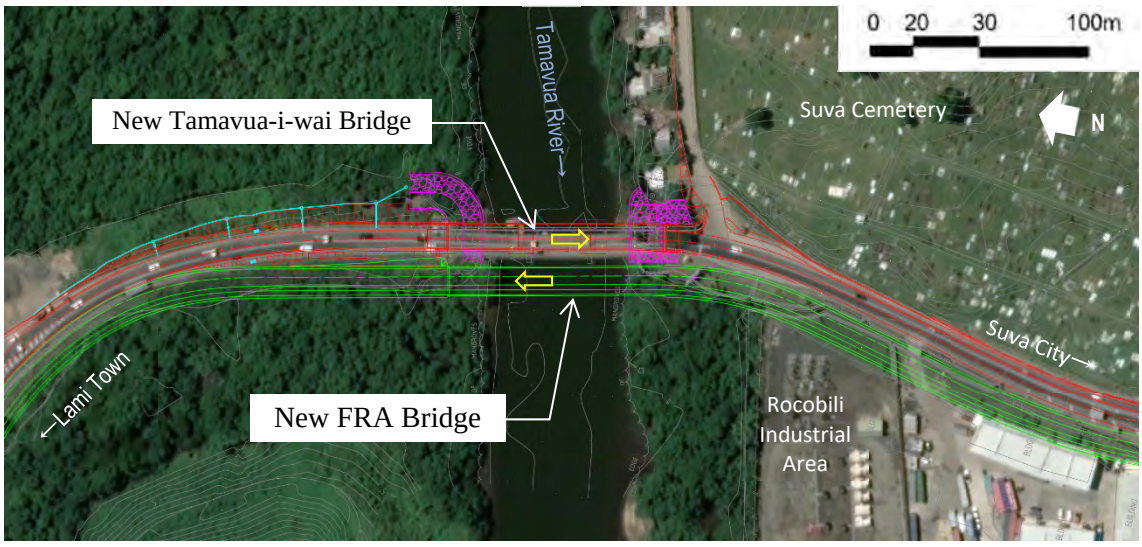
This Project has been categorized as 'category B' by JICA in the environmental and social consideration category based on JICA's Environmental and Social Consideration Guideline issued on April 2010, hereinafter referred to as 'JICA GL', because no significant adverse impact on the surrounding environment is caused by the Project and the Project does not have any affective characteristics or areas sensitive to impacts.

In terms of necessary protocols related to the Environmental Impact Assessment (EIA) in Fiji, the conditions and regulatory agency are prescribed in the Environmental Management Act (2005), plus specific procedures prescribed in the Environmental Management (EIA Process) Regulations (2007). However, there is no statement about environmental categorization in these documents, hence the need for an EIA for all development project in Fiji to be determined by the executive agency, the Ministry of the Environment, without categorization works during the screening stage.

### (5) Design Overview

#### 1) Overview plan

Figure 1-3-2 shows the preliminary design of both the New Tamavua-i-wai Bridge (red lines) and the New FRA Bridge (green lines) crossing the Tamavua River. Each has two carriageways carrying traffic in a single direction, meaning the section near the new bridges on Queen Road will have four-lane capacity to ease frequent traffic congestion in the area.



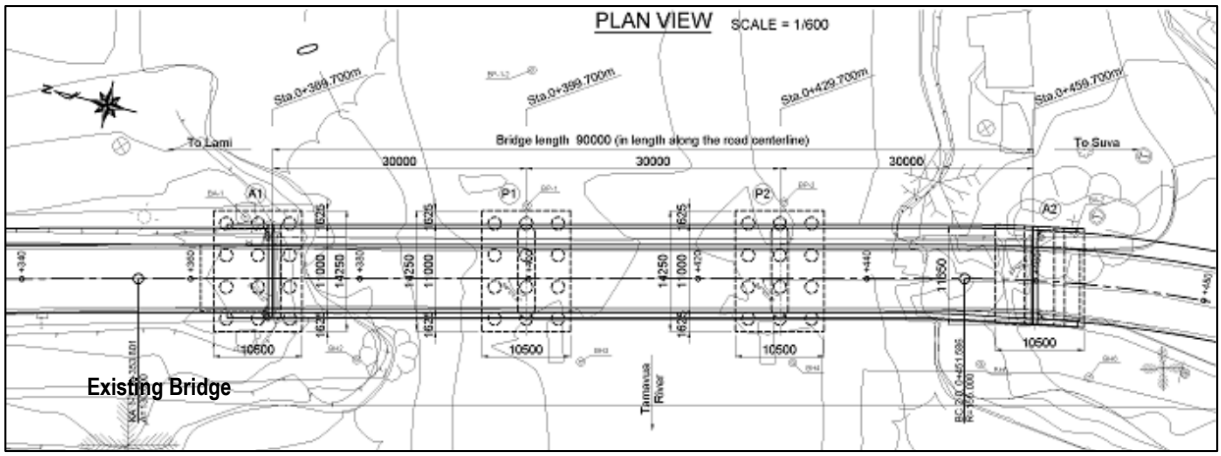

Source: JICA Study Team

Figure 1-3-1 Overall Plan View for the New Tamavua-i-wai Bridge

#### 2) Bridge Design

As shown in Figure 1-3-3, alignment of the New Tamavua-i-wai Bridge has an alignment over the existing bridge. Cost efficiency and workability are also taken into consideration for the alignment, given the benefits of utilizing the other 2-lane bridge on upstream side to be built under the other project

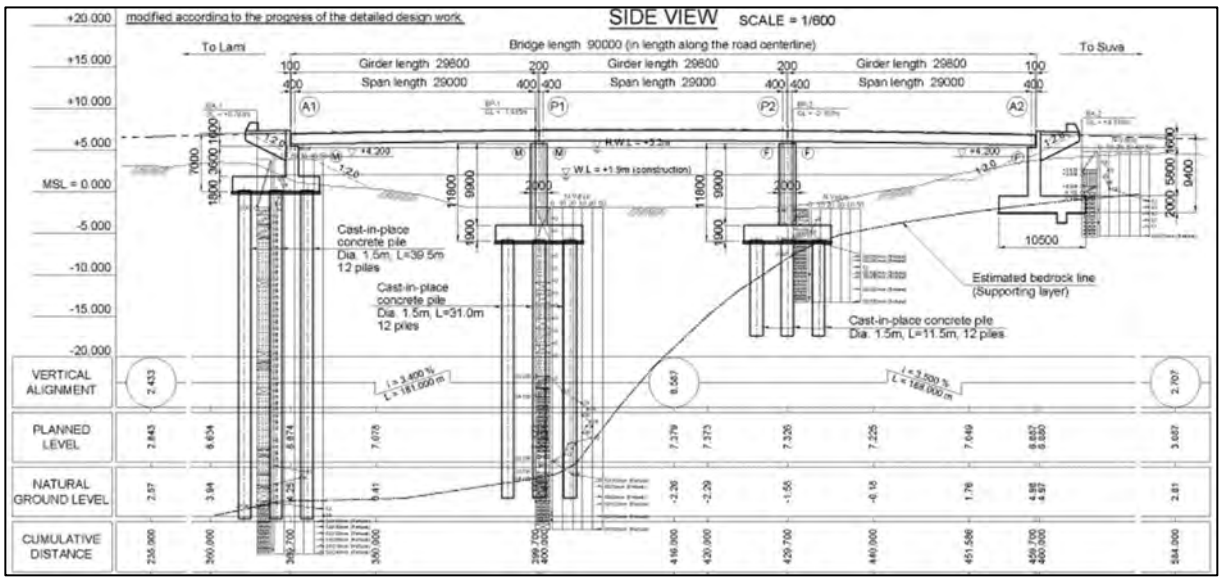
executed by FRA prior to the New Tamavua-i-wai bridge Construction, herein after referred as 'New FRA Bridge', as well as of demolishing old piers and foundations to be replaced.




Source: JICA Study Team

Figure 1-3-3 Bridge Plan View

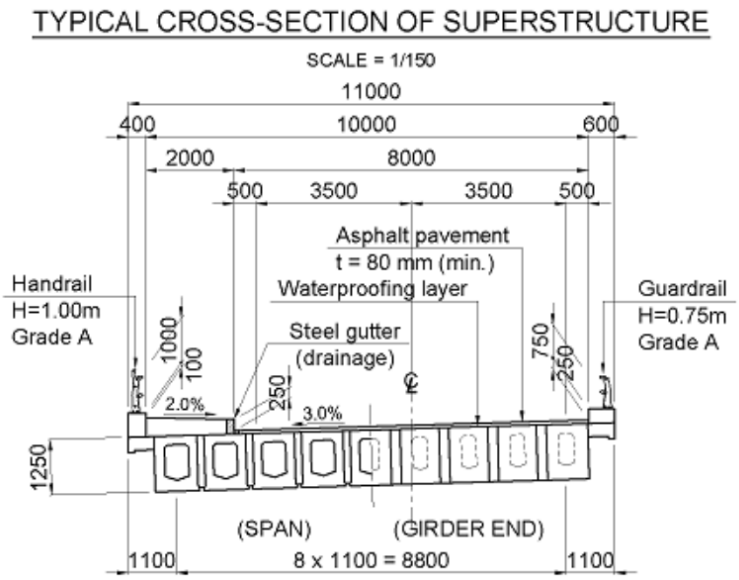
Given the soft geotechnical condition on the Lami Town side compared to Suva City, the foundations for Lami Town have to be deeper and reach to ground with bearing capacity. For the deep foundations, a concrete pile foundation will be applied and there is a risk of scattering raw concrete in the Tamavua River. Furthermore, applying inversed T-shaped concrete abutments with sufficient bearing capacity requires water shields, which then enlarges the excavation area. (Figure 1-3-4)




Source: JICA Study Team

Figure 1-3-4 Bridge Elevation View

As shown in Figure 1-3-5, pre-cast concrete with a three-span interconnected post-tension hollow slab will be applied for the superstructure. To ensure the safety of the bridge, a 2.0m wide sidewalk with a handrail and guardrail will be facilitated on both sides of the asphalt-paved carriageway.




Source: JICA Study Team

Figure 1-3-5 Typical Cross-Section of the Superstructure

### 3) Approach Road Design

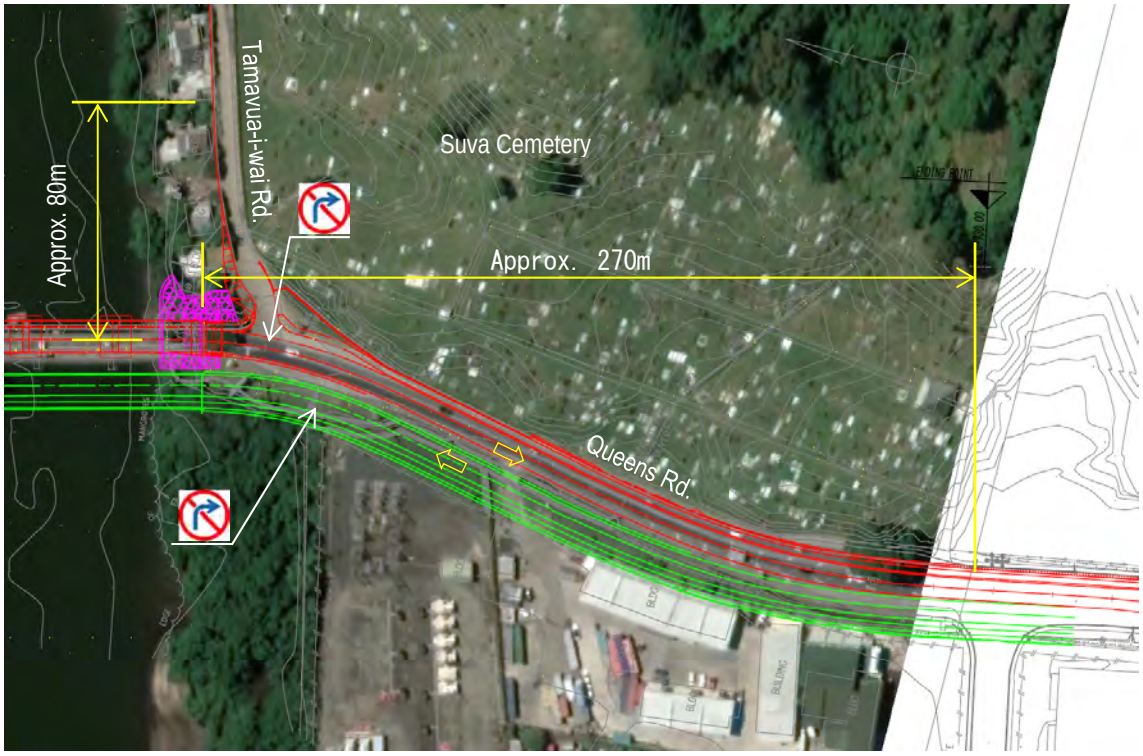
Since the elevation of the new bridge will exceed that of the existing bridge, new connecting approach roads higher than previously will be necessary, which will also require a large volume of fill soil to raise the road elevation with slope and ease the level difference between the new road and existing ground elevation. For other road design elements, an asphalt pavement for the surface finish as well as installing road facilities such as a drainage system, signboard and so on will be included. Conversely, since the construction site involves no geographical change, no cut soil to be disposed from the construction site would be expected.

As shown in Figure 1-3-6, for the approach road on the Suva side, a road approx. 280m long will be attached to the New Tamavua-i-wai Bridge. In terms of boundary, the approach road is designed not to interfere with the boundary of Suva Cemetery, but construction works involving careful and adequate caution and monitored by a competent maintenance agency will be recommended since the new road is very close to the cemetery boundary. (Figure 1-3-6)

In addition to the approach road, an 80m-long approach roads, part of the Tamavua-i-wai Road, between Suva Cemetery and the Tamavua River, will be rehabilitated to ensure appropriate accessibility to Queen Road, the longitude alignment of which is modified.

Furthermore, regarding the traffic network, after two bridges are constructed, there will be no right turns from either Queens Road to Tamavua-i-wai Road or vice versa, as illustrated in Figure 1-3-6, for traffic safety reasons. Moreover, private companies and those residing in the area alongside the Tamavua-i-wai Road have to take the existing roundabout on the Suva side when they need to go Lami Town from Tamavua-i-wai Road. Since there is no turning point on the Lami side, they have to find some place to turn when accessing Tamavua-i-wai Road from Queens Road. This deterioration of the traffic network is the reason why traffic capacity will be enhanced to ease congestion in this section and the mitigation measure will be carried out by the FRA by constructing a turning point close to the new

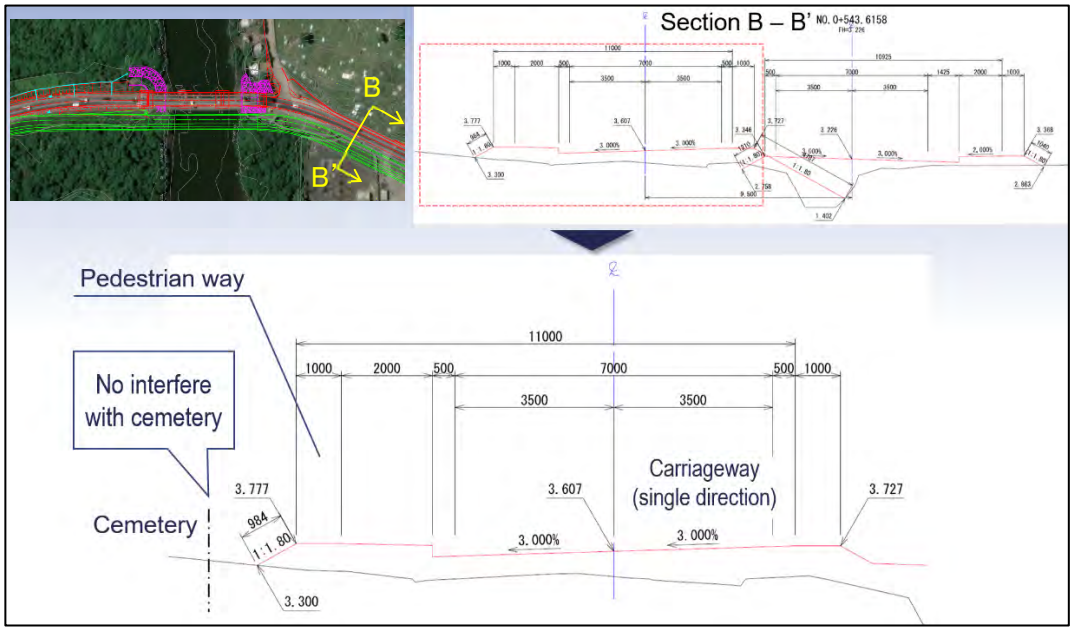
bridge on the Lami Town side. Signboards to prohibit right turns will be newly installed and the installation of soft cones separating road directions to avoid traffic accident is also recommended.




Source: JICA Study Team

Figure 1-3-6 Approach Road Plan View (Suva Side)

Basically, the existing road facility will be facilitated to the new approach roads, including a bus lane near the bridge, a pedestrian way and gutters as road drainage facilities, as shown in Figure 1-3-7.



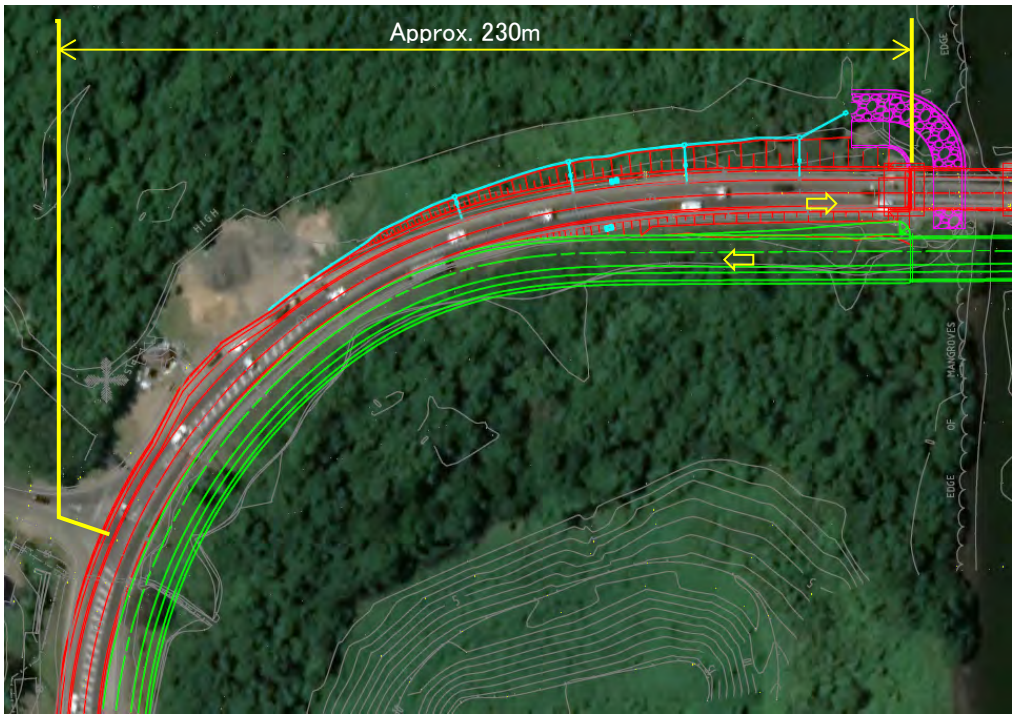

Source: JICA Study Team

Figure 1-3-7 Approach Road Section (Suva Side)

As shown in Figure 1-3-8, a 250m-long approach road will be attached to the New Tamavua-i-wai Bridge on the Lami Town side. The road boundary has to expand to the mangrove vegetation area, which

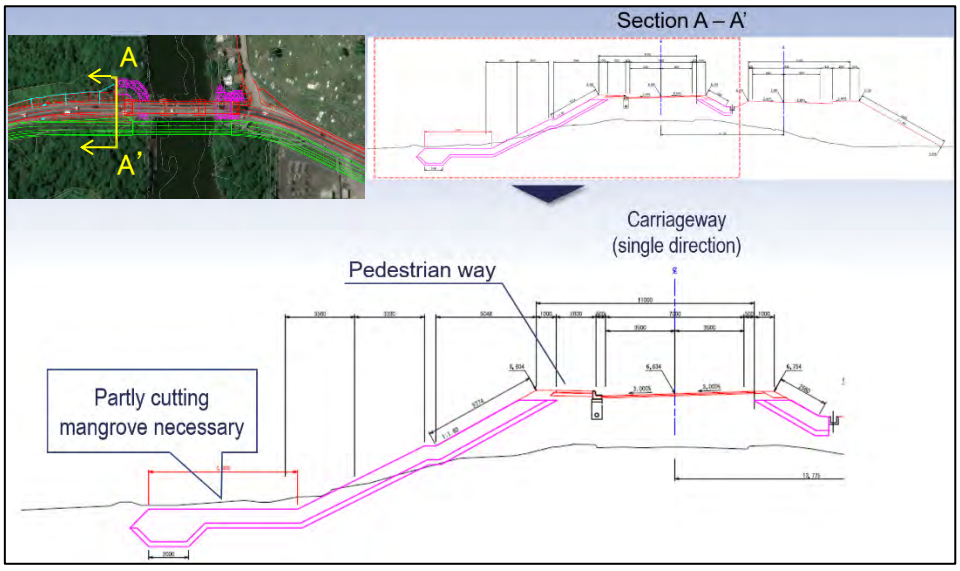
means some mangroves will have to be cut. However, the area where mangroves are to be cut is minimized thanks to a design that limits its size to approx. 2,000m² out of the total mangrove vegetation of 210,000m², comprising just 0.95%. Most of the area on the new approach road alignment is laid on arable land with the presence of a small agricultural field, including cassava and yams, which local residents are harvesting without the permission of the competent government agency.

Moreover, since the existing drinking water pipe is located on the new approach road alignment, the pipe shall be relocated before the construction starts. Apart from the mangrove and drinking water pipe, no other existing facility or structure is affected by the new approach road construction on the Lami Town side.




Source: JICA Study Team

Figure 1-3-8 Approach Road Plan View (Lami Side)

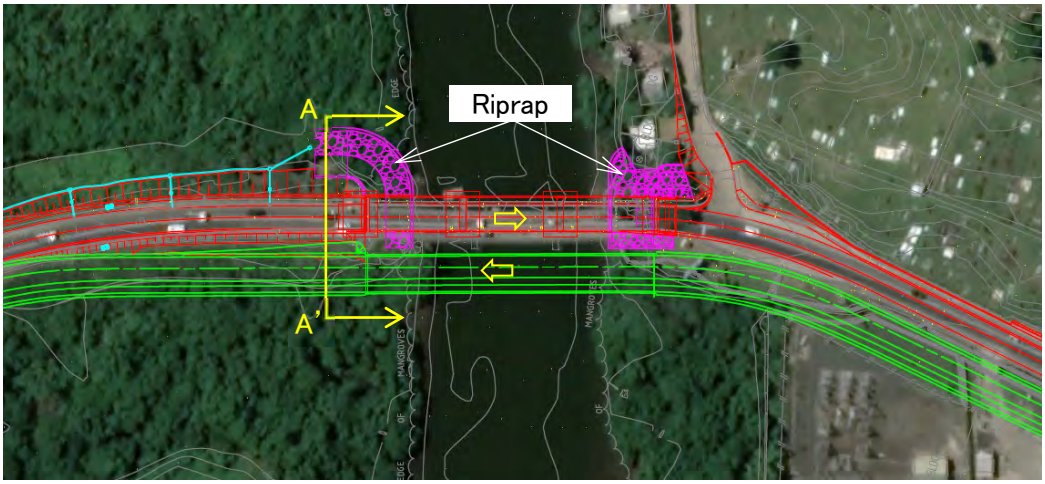


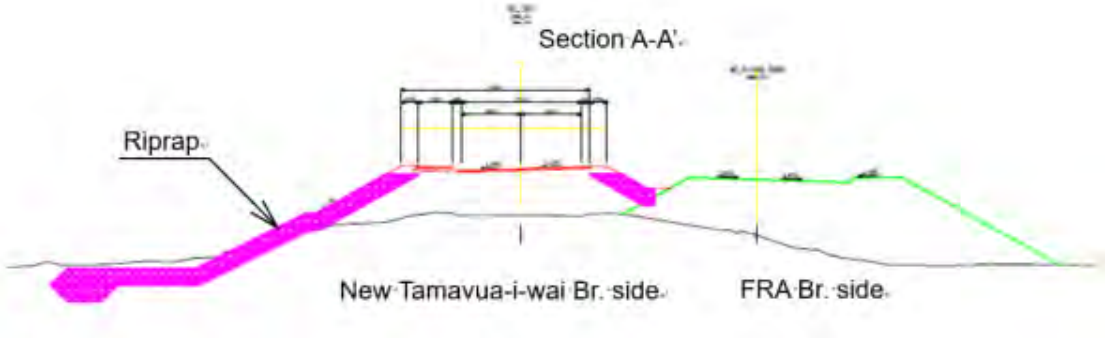

Source: JICA Study Team

Figure 1-3-9 Approach Road Plan Section (Lami Side)

### 4) Revetment Protection (Riprap)

Riprap to protect the abutment and road slope from river water surges caused by heavy rain will be applied. Their scope will be examined based on data indicating the likelihood of heavy rain, tidal records and the potential for sea-level rises caused by global warming.




Source: JICA Study Team

Figure 1-3-10 Revetment Plan & Section

### (6) Overview of Construction Works

Basically, five relevant components of construction works exist regarding environmental and social considerations as follows: The existing bridge (upper structure) will also be removed by the FRA. The work components are summarized in Table 1-3-1

Table 1-3-1 Summary of the Work Components

| New Tamavua-i-wai Bridge (2 lanes) |
|---|
| **Superstructure**<br>Pre-cast concrete (PC) 3-span interconnected post-tension hollow slab L=90.0m |
| **Substructure**<br>Main pier: Oval-shaped Cross-section Wall-Type Pier<br>Abutment: Reverse T-shaped concrete (Lami side), Reverse T-shaped concrete (Suva side) |
| **Foundation**<br>Main pier: Concrete pile foundation<br>Abutment: Concrete spread foundation (Suva), Concrete pile foundation (Lami side) |
| **Approach Road**<br>L=280m Suva side, L=250m Lami side, Raised by fill, Embankment with road slope,<br>Asphalt pavement, onside sidewalk etc. |

| New Tamavua-i-wai Bridge (2 lanes) |
|---|
| **Revetment Protection**<br>Riprap at the abutments and foot of the approach road slope |

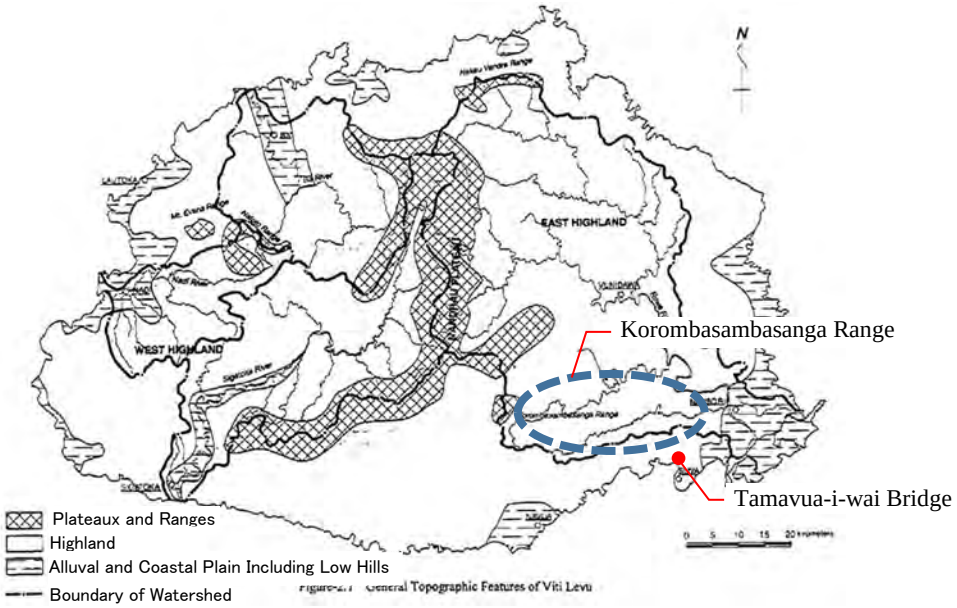
Source: JICA Study Team

In addition to the main bridge and approach roads, the area for the temporary construction yard (provisionally specified as 24,000m² or so) near the proposed bridge is required to assemble bridge parts and store construction materials and other equipment, including approach roadss from the existing road to the construction yards. Several possible areas for the construction yard have been proposed during the basic design. As one of the alternatives, the area reserved for future possible development adjacent to the Lami Landfill Premises at the corner of Queens Road and Nadonumai Road approx. 200m west of the existing Tamavua-i-wai Bridge can be a target land. The utilization scheme for the wide-open area will be clarified by the FRA before construction of the New Tamavua-i-wai Bridge gets underway.

## 1-3-2 Basic Environmental and Social Circumstances

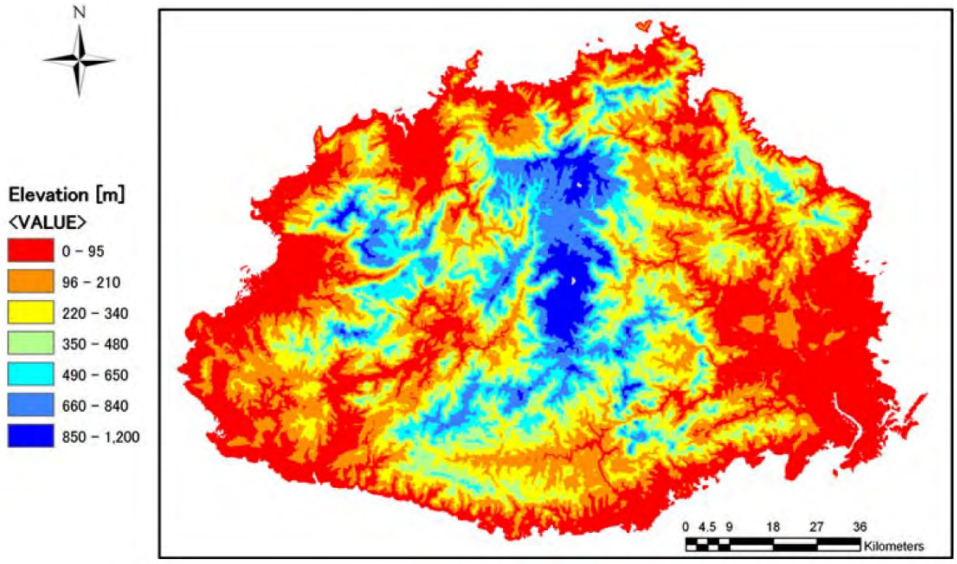
### (1) Geography

Viti Lev Island is one of the largest volcanic islands in Fiji, with an oval shape and measuring 146km from east to west and 106km from north to south. In terms of geography, east and west are separated by a mountain range vertically bisecting the island, including Mount Tomanivi (1,324m high). The eastern region is mostly blanketed in thick tropical rainforest, although dry and with relatively low precipitation spreading throughout the west. There are also vast alluvial plains stretching east and west, far from the mountain range, despite the narrow width of the coastal plain in the north and south regions. Figure 1-3-11 and Figure 1-3-12 show the general and digital topographical features of Viti Levu respectively.




Source: Study for Flood Control and River Basin Management in Fiji, JICA 1998

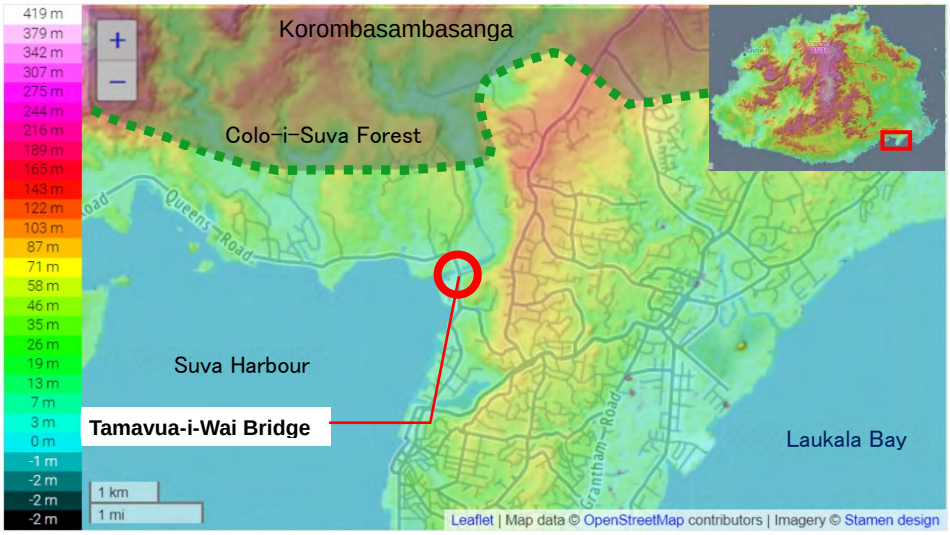
Figure 1-3-11 General Topographic Features of Viti Levu




Source: Study for Flood Control and River Basin Management in Fiji, JICA 1998

Figure 1-3-12 Topographic Features of Viti Levu

Tamavua-i-wai Bridge is located on the mouth of the Tamavua River and close to the outskirts of the Korombasambasanga range. The Tamavua-i-wai River starts from the Colo-i-Suva Forest Park and flows into the Suva Harbor (Figure 1-3-13).

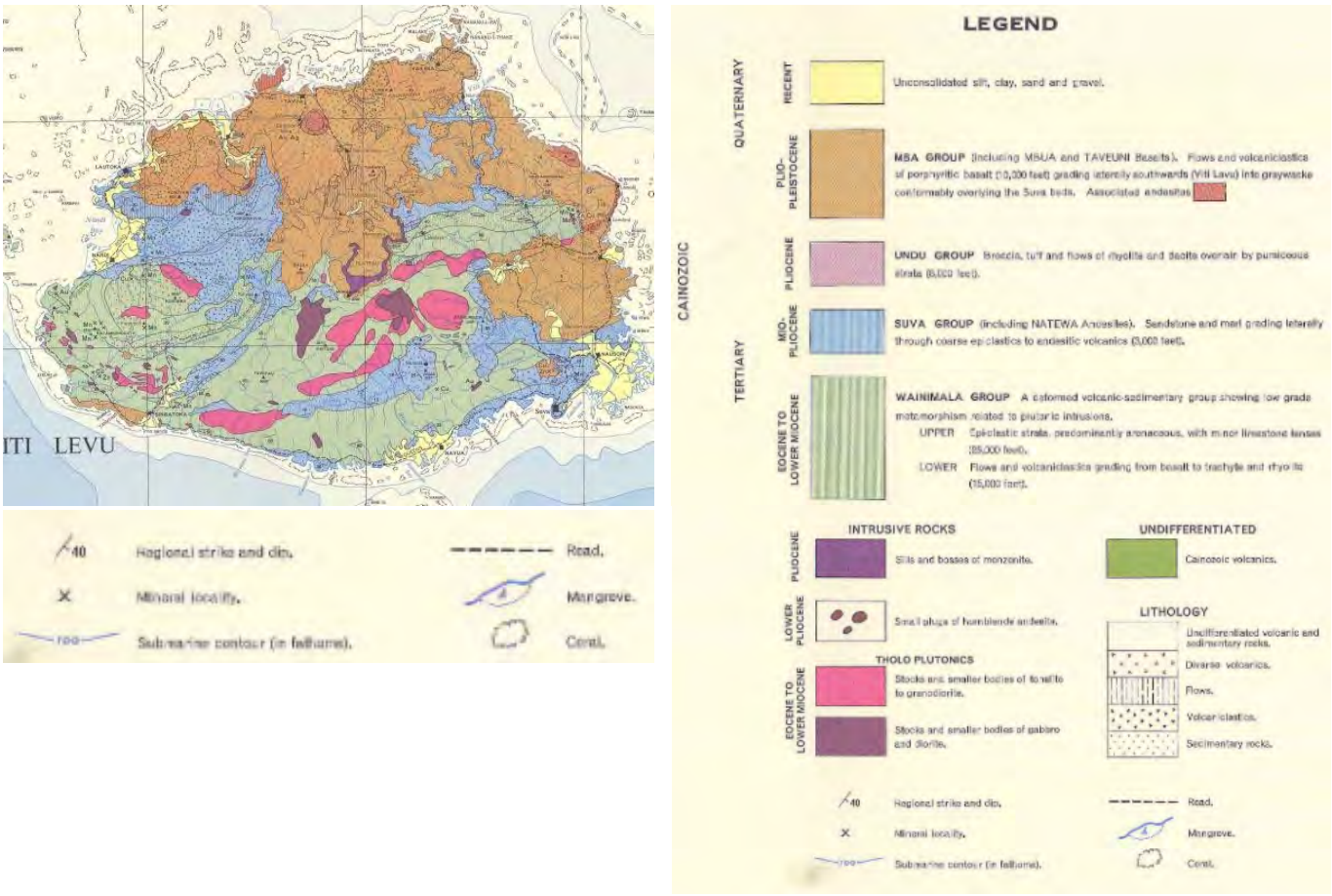



Source: Study: Open Street Map arranged by the JICA Study Team

Figure 1-3-13 Topography around Tamavua-i-wai Bridge

### (2) Geology

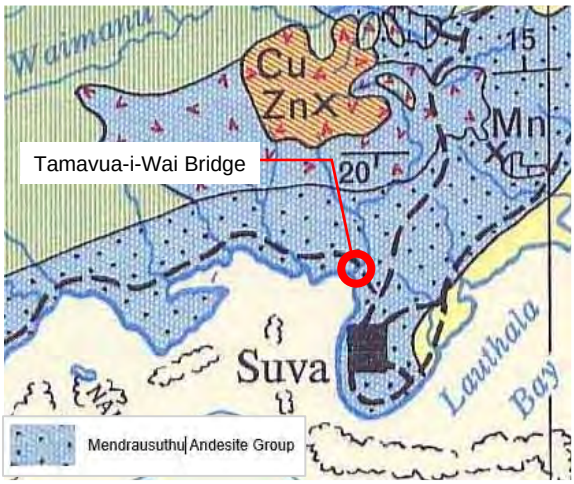
The geological history of Fiji is restricted to the Cainozoic era and its oldest known rocks are the Wainimala Group, formed between the Eocene and Lower Miocene eras and distributed in the central, southern and southwestern areas of Viti Levu Island. The rock mainly comprises pillow lava, but also sedimentary hard stones and limestones, while some of the Tholo plutonic rocks identified in the center of Viti Levu comprise tonalites and gabbros. The northern and eastern sides of the island are home to mottled basaltic rocks covered by the Mbua Group, formed between the Plio-Pliocene and Pleistocene eras. The geological features of the project site, the Suva area, are characterized by the Suva Group, comprising sandstone and marl stones formed in the Mio-Pliocene era.




Source: Geological Survey Department, Fiji (1965)

Figure 1-3-14 Topographic Features of Viti Levu

The wider geology of the area comprises the Mendrausuthu Andesite Group, including andesite lava, mud stone, sandstone andesitic volcanic conglomerate, marl and limestone1. This group is distributed across the southwestern area of the Island, with outcrops in narrow bands along the coastline between Suva City and Navua Town.




Source: Geological Survey Department, Fiji

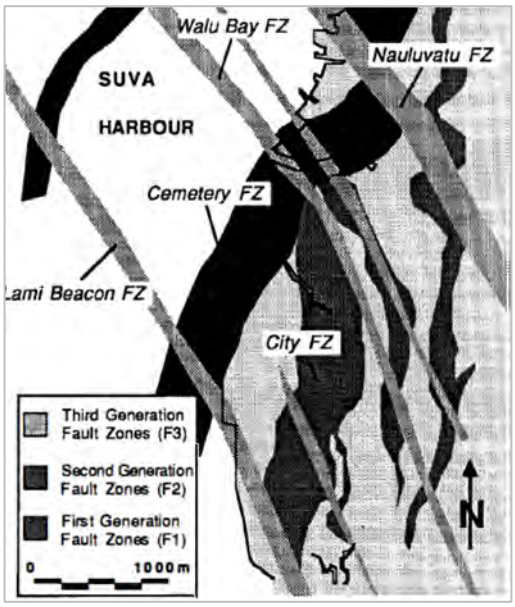
Figure 1-3-15 Wider Suva Geology

[1] JICA 1998. Study of watershed management and flood control for the four major Viti Levu Rivers in the Republic of Fiji Islands. Final Report. October 1998.

The three sedimentary formations of the Late Miocene-Pliocene era comprise the cover rocks of Suva Peninsula: the Veisari Sandstone, Lami Limestone and Suva Marl. The formations are either disconformable or show slight angular unconformity in places, while the lowermost formation, the Veisari Sandstone, is 400m thick and mainly comprises marine siltstone and fine-grained sandstone deposited at water depths of 300-500 m. (Figure 1-3-16)

The latter can be observed as an intense parallel jointing which developed early in the deformational history of the peninsula. The jointing is most obvious in the Suva Marl and is brittle in nature, with fold-like structures having formed as a result of progressive displacement across wide fault zones, giving an overall impression of monoclinal flexuring in the Suva Marl.

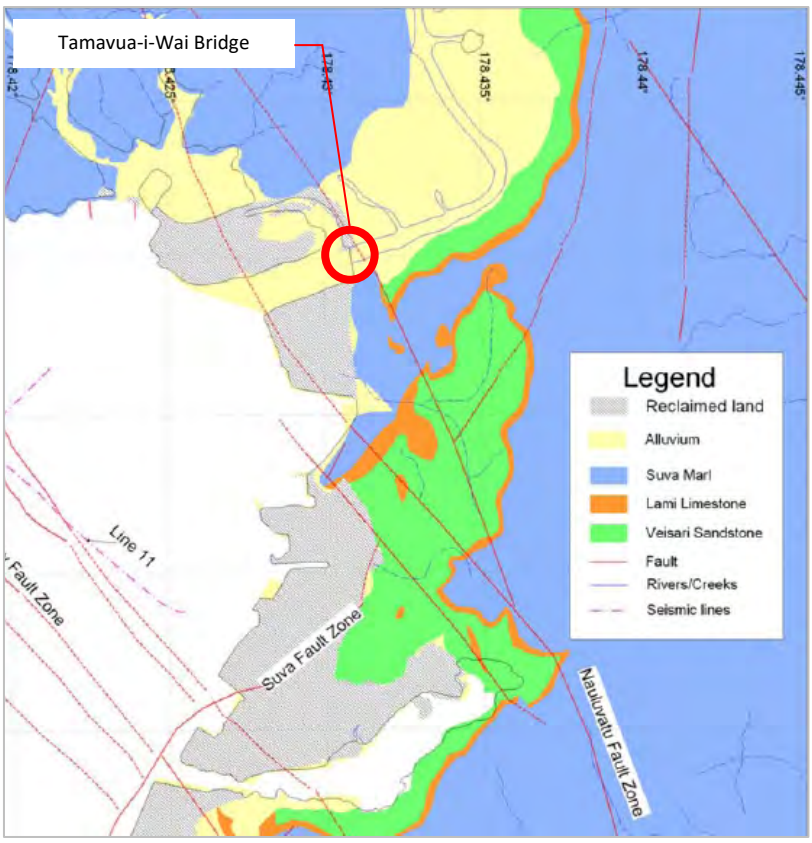
Either side of the Tamavua River lie heavily vegetated ridgelines, which are elevated above the River flats/floodplain. The river floodplain, meanwhile, is predominantly underlain by marine and alluvial deposits of the Holocene age[2] with elevated areas to the east of the site being underlain by Suva Marl of the Miocene age (Figure 1-3-17).




Source: New Zealand Journal of Geology and Geophysics

Figure 1-3-2 Geology of the western part of the Suva Peninsula

[2] Ibbotson, P. 1960. Geology of the Suva Area Viti Levu, Mineral Resources Department.




Source: Pacific Islands Applied Geoscience Commission

Figure 1-3-17 Geology of the vicinity of the Tamavua-i-Wai Bridge[3]

### (3) Climate

Historical climate data for the region has been sourced from the Fiji Meteorological Service (FMS). The most relevant meteorological station for the site is Laucala Bay Station in Suva, located approx. 2.5 km south of the bridge.

The general climate of the site is typical of the wetter seasonal climate on the eastern windward side of Viti Levu, with dominant southeast trade winds occurring all year round. Although the winds in general are light to moderate, they may, on occasion, intensify for brief spells during the period from May to October.

#### 1) Rainfall

Although annual rainfall varies, there are distinct 'wet' and 'dry' seasons. Rainfall occurs primarily on the southwestern and southeastern sides of Viti Levu, where Suva is located, on the wetter side of Viti Levu. The 'wet' season is approximately between November and May and the 'dry' between June and October.

The average monthly rainfall for the 'wet' season is 244-369 mm, compared with 143-213 mm during the 'dry' season (see Table 1-3-2). The highest and lowest recorded monthly rainfalls were in April and September (1,116 and 17 mm respectively).

Rainfall peaks during the months of December to April, when localized flash flooding due to prolonged heavy rainfall is common. Rainfall is lowest during the June to September period.

[3] SOPAC 2005. Literature and data review for Suva Harbour – Rokobili Project. SOPAC Miscellaneous Report 606. October 2005.

Table 1-3-2 Annual Rainfall (mm) for Laucala Bay, Suva (1942-2014)

| | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Total (Annual)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Total | 335 | 295 | 369 | 360 | 244 | 170 | 143 | 147 | 192 | 213 | 252 | 282 | 3,002 |
| Highest Recorded | 732 | 832 | 799 | 1,116 | 918 | 442 | 409 | 523 | 481 | 900 | 790 | 580 | 4,562 |
| Lowest Recorded | 43 | 79 | 83 | 51 | 50 | 19 | 24 | 20 | 17 | 27 | 24 | 52 | 1,581 |

Source: Fiji Meteorological Service

### 2) Temperature

Air temperature is relatively constant throughout the year (Table 1-3-3), while mean daily maximum temperatures range from 26.5°C in July to 30.8°C in February, with monthly variation typically peaking during the wet season (November to April) and at its lowest during the drier months (May to October).

Table 1-3-3 Mean monthly air temperature (°C) Laucala Bay, Suva (1942-2014)

| | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Total (Annual)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum | 30.6 | 30.8 | 30.6 | 29.7 | 28.4 | 27.5 | 26.5 | 26.6 | 27.0 | 27.9 | 28.9 | 29.9 | 28.7 |
| Mean Daily Minimum | 23.9 | 23.9 | 23.8 | 23.3 | 22.3 | 21.6 | 20.7 | 20.7 | 21.2 | 22.0 | 22.7 | 23.5 | 22.5 |
| Mean Daily Mean | 27.3 | 27.4 | 27.2 | 26.5 | 25.4 | 24.6 | 23.6 | 23.7 | 24.1 | 25.0 | 25.8 | 26.7 | 25.6 |

Source: Fiji Meteorological Service

### 3) Wind

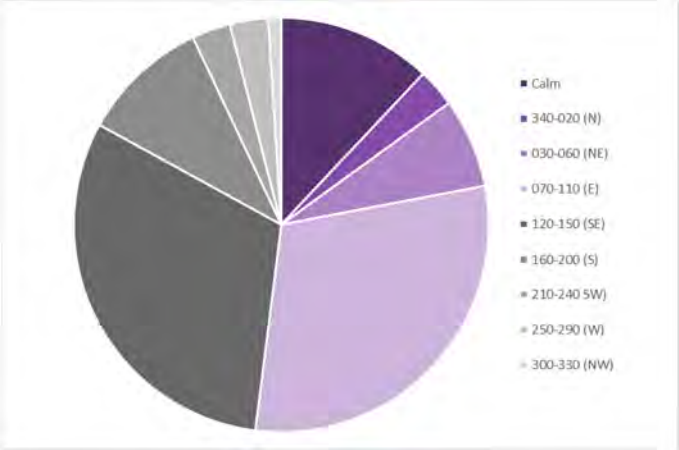
Wind speeds throughout Fiji are typical of the tropics, with little variation throughout the year (Table 1-3-4). However, the average wind speed is slightly stronger during the wet season due to the South Pacific Convergence Zone causing south-east trade winds to intensify in the latitudes where Fiji is located. Wind speeds tend to peak in the early afternoon when the land/sea temperature contrast is greatest and be lowest at night when the latter reaches its lowest point.

Winds from the east and southeast dominate the wind regime (Figure 1-3-18) and occur around 61% of the time. Winds from the south-west to north-west (between 210 to 330°) occur only 17% of the time, as opposed to periods of ‘calm’ or no wind about 12% of the time.

Table 1-3-4 Wind speed data (knots) for Laucala Bay, Suva (1979-1999)

| | **Jan.** | **Feb.** | **Mar.** | **Apr.** | **May** | **Jun.** | **Jul.** | **Aug.** | **Sep.** | **Oct.** | **Nov.** | **Dec.** | **Total (Annual)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean (at 1500) | 5.8 | 5.1 | 5.2 | 5.3 | 5.5 | 5.2 | 5.8 | 5.8 | 6.1 | 6.8 | 6.2 | 6.1 | 6 |
| Maximum | 91 | 47 | 66 | 44 | 41 | 42 | 49 | 43 | 31 | 36 | 56 | 52 | 91 |

Source: Fiji Meteorological Service




Source: Fiji Meteorological Service

Figure 1-3-18 Percentage distribution of wind direction during the day at Laucala Bay, Suva (1971-2014)

**(4) River Environment and Sediment**

The Tamavua-i-Wai Bridge in the lower reaches of the Tamavua River is positioned in the protected upper reaches of Suva Bay. The daily winds, waves and ocean currents affecting the lower river are small, with the river hydraulic regime likely to have a greater influence than typical coastal processes.

The lower Tamavui River, meanwhile, is influenced by the action of tides. Table 1-3-5 presents tide levels for Suva Harbor, which will be very similar for the lower River adjacent to the site.

Table 1-3-5 Tide levels in Suva Harbor

| Level | Height above Chart Datum (m) | Height above MSL (m) |
|---|---|---|
| Design Water Level (DWL) | 3.53 | 2.57 |
| Highest Astronomical Tide (HAT) | 1.90 | 0.94 |
| Mean High-Water Springs (MHWS) | 1.60 | 0.64 |
| Mean High-Water Neaps (MHWN) | 1.40 | 0.44 |
| Mean Sea Level (MSL) | 0.96 | .000 |
| Mean Low Water Neaps (MLWN) | 0.50 | (0.46) |
| Mean Low Water Springs (MLWS) | 0.30 | (0.66) |
| Lowest Astronomical Tide (LAT) | 0.00 | (0.96) |

Source: 'Climate and Oceans Support Program in the Pacific', Pacific Community, supported by the Australian Government Bureau of Meteorology

The substrate mangrove areas in the lower Tamavua River, including the river substrate beneath the Tamavua-i-Wai Bridge, are dominated by a range of alluvial materials, including fine silty clays, clay loams, occasional sands, gravel and pebble-type materials, which are considered typical of such estuarine environments.

Given that the mouth of the Tamavua River, which discharges into Suva Harbor, is approx. 400m downstream of the Bridge, the river bed sediments beneath the Bridge will be influenced by tidal and river mouth processes, which will affect the transport and deposition of silt and sediment from both the upstream river catchment and the river mouth, as well as accumulated river sediment in the mangrove ecosystem.

### (5) Vegetation

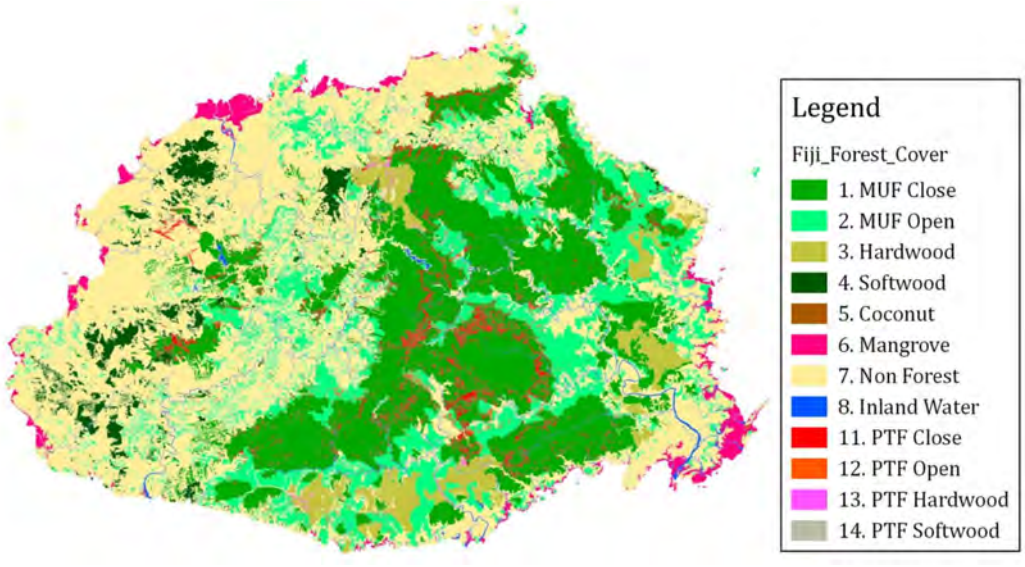
In terms of forest management in Fiji, the government categorizes the forest in Fiji as 'Class' for features and 'Function' for the forest to supervise the condition of national vegetation. The Class is subdivided to 'Close Forest', 'Open Forest' and 'Non-Forest' and determined by the vegetation rate out of canopy coverage as well as total land use. The Forest Function is basically subdivided into 'Protection Forest' (PTF), 'Multiple Use Forest' (MUF) and 'Timber Production Forest' (TPP) and Table 1-3-6 shows the forest criteria in Fiji divided by feature and function.

Table 1-3-6 Forest Criteria in Fiji

| | FOREST CLASS | | |
|---|---|---|---|
| | Close Forest | Open Forest | Non-Forest |
| | The area covered by tree canopy or ferns 41 to 100% with more than 20% ground coverage of bamboos or palms. | The area covered by tree canopy or ferns 10 to 40% with ground coverage of bamboos or palms between 50 and 80%. | The area covered by tree canopy or ferns less than 10% with ground coverage of grass, bamboos or palms between 50 and 80%. It includes agricultural farmland and pasture. |
| Protection Forest (PTF) | PTF is basically positioned as a native forest that is extremely sensitive determined by topography, climate, geology, or these elements combined. Cutting trees in PTF areas is strictly prohibited to protect the water cycle. | | - |
| Multiple Use Forest (MUF) | MUF is positioned as a native forest requiring proper management. The MUF is controlled by small-scale forestry activity and used for resources for recreational activity as well as wildlife habitat, also managed for rain catchment areas. | | - |
| Timber Production Plantation (TPP) | TPP is the area where vegetation listed blow is planted for commercial or industrial use.<br>(1) Hardwood, (2) Softwood, (3) Mangrove | | |

Source: JICA Study Team based on information from the Ministry of Forestry

Figure 1-3-19 shows a vegetation map in Viti Levu Island. A large volume of the Multiple Use Forest (MUF) is sprawling in the east region where rainfall is high throughout the year and the Close Forests are mainly distributed in the mountain range of central region and the Open Forests are located in fringe of the Close Forests. Furthermore, the Protection Forests are found in the area of high elevation. In the coastal range, despite many mangrove area in the east of Rewa state, the area is relatively small compared to the total mangrove areas in the west.




Source: Ministry of Forestry

Figure 1-3-19 Vegetation Map of Viti Levu

### (6) Conservation Area

Table 1-3-7 shows the conservation and biodiversity areas in Viti Levu Island. The Upper Navua Conservation Area, covering part of the Navua River in the Viti Levu Southern Highlands in Viti Levu Island, is the only site registered under the Ramsar Convention and the Viti Levu Southern Highlands is located nearby the project site and designated as one of the Key Biodiversity Areas and Important Bird Areas in Fiji. Figure 1-3-19, Figure 1-3-20 and Figure 1-3-21 illustrate the protected and biodiversity areas relevant to the project site.

Table 1-3-7 Conservation and Biodiversity Areas in Viti Levu

| # | Name | Category | Area (km²) | Region name | Execution organization |
|---|---|---|---|---|---|
| 1 | Colo-i-suva | Protected Forest | 4.97 | Rewa | MOF |
| 2 | Colo-i-suva | KBAs | 12.99 | Rewa | MOF |
| 3 | Savura | Protected Forest | 1.90 | Rewa | MOF |
| 4 | Nadarivatu | Protected Forest | 62.81 | Ba | MOF |
| 5 | Qaranibuluti | Protected Forest | 2.43 | Ra | MOF |
| 6 | Wabu | Protected Forest | 10.62 | Ra | MOF |
| 7 | Sovi Basin | Conservation Area | 20.00 | Naitasiri | NTF |
| 8 | Sovi Basin | KBAs, IBAs | 407.00 | Naitasiri | NTF |
| 9 | Garrick Memorial Park | Forest Park | 4.34 | Serua | NTF |
| 10 | Koroyanitu Heritage Park | Heritage Park, IBAs | 35.00 | Ba | Regional Community |
| 11 | Tomaniivi | Conservation Area | 11.04 | Ra | MOF |
| 12 | Greater Tomaniivi | KBAs, IBAs | 175.00 | Ra | MOF |
| 13 | Naqarabuluti | Conservation Area | 2.41 | Ra | N/A |
| 14 | Draunibota and Labiko | Conservation Area | 0.43 | Rewa | MOF |
| 15 | Sigatoka Sand dunes | National Park | 1.77 | Nadgroga-Navosa | NTF |
| 16 | Viti Levu Southern Highlands | KBAs, IBAs | 670.00 | Rewa, Namosi, Seura | MOF |
| 17 | Mount Korobaba and Waimanu Watershed | KBAs | 162.29 | Rewa | MOF |
| 18 | Nakauvadra Range | KBAs | 76.91 | Ra | MOF |
| 19 | Namosi Highlands | KBAs | 238.03 | Namosi | MOF |
| 20 | Nausori Highlands | KBAs | 170.00 | Ba | MOF |
| 21 | Serua Forest Wilderness | KBAs | 271.38 | Seura | MOF |
| 22 | Navua Gorge | KBAs | 404.69 | Seura | MOF |
| 23 | Upper Navua Conservation Area | Ramsar | 6.15 | Seura | MOF |

Source: JICA Study Team based on information from Birdlife International, Protected Plane and Ramsar Convention
Note: NTF (National Trust of Fiji), KBAs (Key Biodiversity Areas), IBAs (Important Bird Areas)

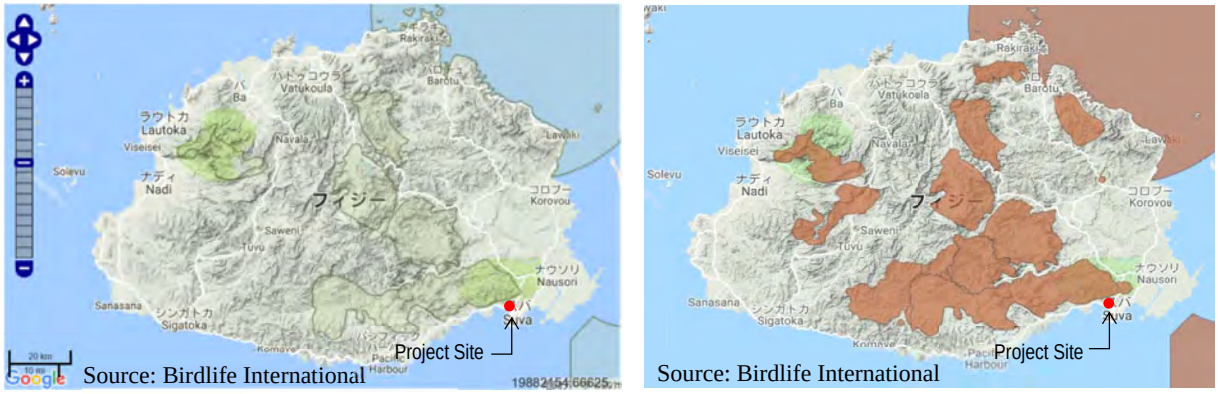
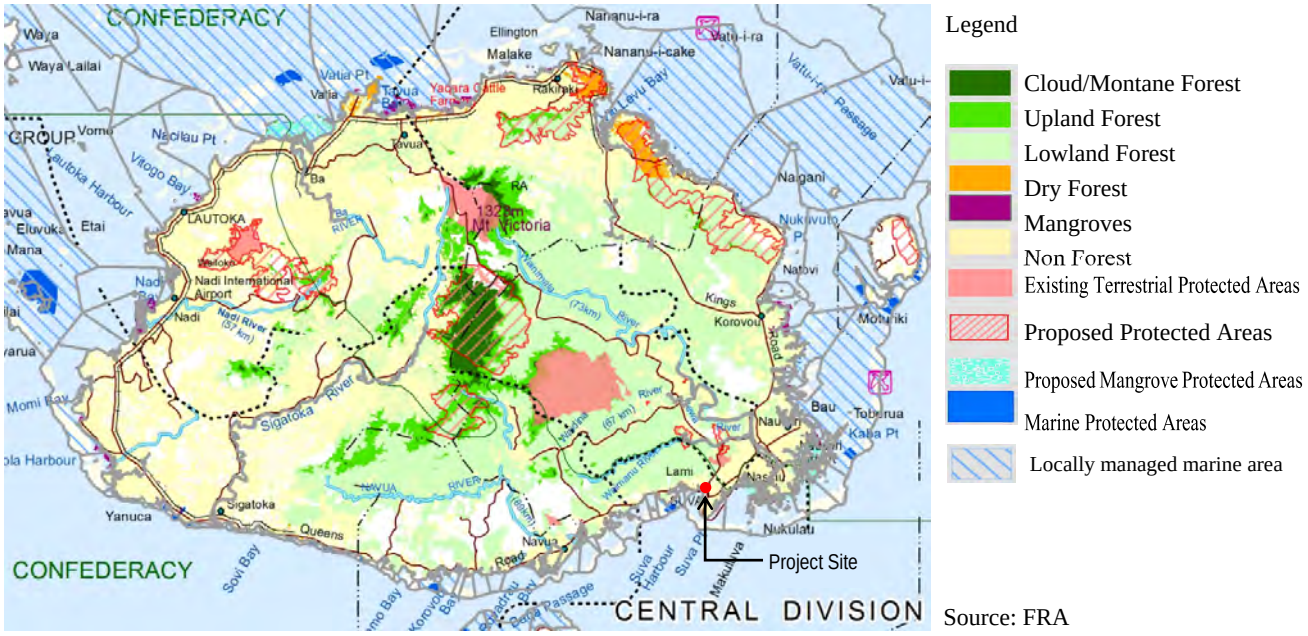


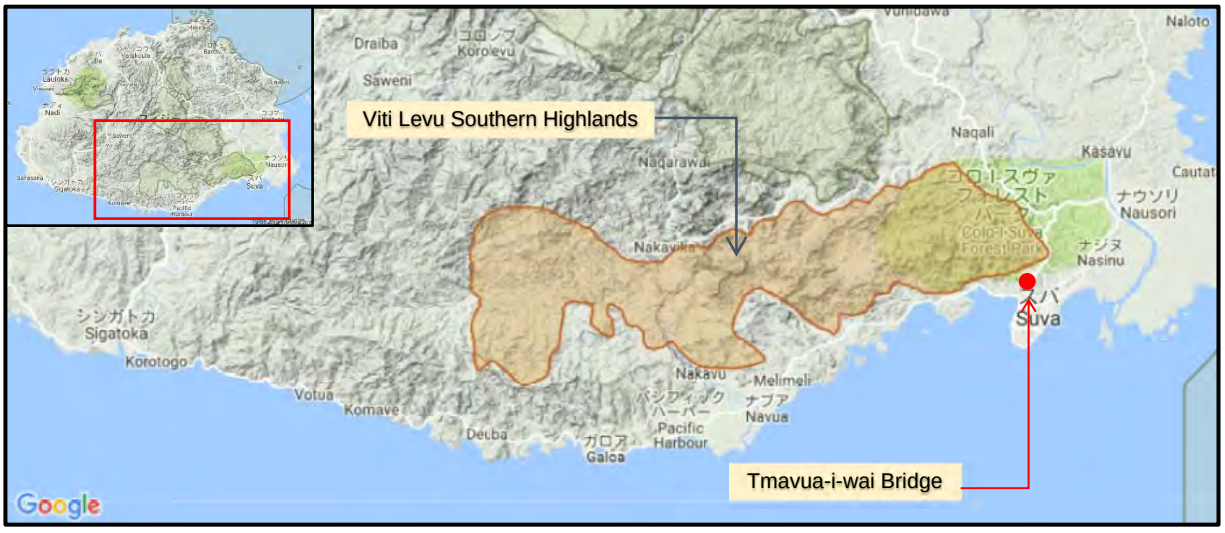

Figure 1-3-20 Location of IBAs (left) and KBAs (right)




Source: FRA

Figure 1-3-21 Location of Protected and Biodiversity Areas

The distance between the Tamavua-i-wai Bridge and the border nearest the Colo-i-suva Protected Forest is approx. 5.4km, while that between the bridge and nearest border of the Viti Levu Southern Highlands is approx. 2.0km. Both areas are located upstream of the Tamavua River. The Viti Levu Southern Highlands, the closest key biodiversity area, is an elongated mountain range to the southeast, about 62.0km long and comprising two western mountains known as Makuluva mountain (615m), Nakaboro mountain (860m) and two to the east known as Nakabalevu mountain (464m) and Nakaboro (860m). 24 of 25 in Fiji are identified in the Viti Levu Southern Highlands. Moreover, the Fijian Borrowing snake (*Ogmodon vitianus*) and Lauan ground skink (*Emoia Campbelli*), which are indigenous wildlife in Fiji, are identified in the western part of the highlands. Figure 1-3-22 shows the locational relationship between the Tamavua-i-wai Bridge and Viti Levu Southern Highland.




Source: Birdlife International

Figure 1-3-22 Locational Relationship between Tamavua-i-wai Bridge and Viti Levu Southern Highland

### (7) Cultural Heritage

In Fiji, Levuka Historical Port Town, which is located in the island of Ovalau, about 62km northeast of Suva City, was approved as National Heritage of Culture and Art by UNESCO in 2013. Additionally, Sigatoka Sand Dune National Park of Sovi Basin, which is registered as a Conservation Area located on the southwestern side of Viti Lavu Island and Yaduataba Crested Iguana Sanctuary in the remote island are tentatively listed as National Heritage Sites. However, since these sites are more than 35km from Tamavua-i-wai Bridge, they would not have an impact on the bridge construction project.

### (8) Natural Environment Condition

Fiji is a volcanic island country with abundant nature, including seashore coral reefs and rich marine and land biodiversity and the increase in alien species has been problematic in recent years. Table 1-3-8 shows wildlife species identified in Fiji:

Table 1-3-8 Important Wildlife Species for Biodiversity in Fiji

| Type | Native Species | Epidemic Species | Extinct Species | Threatened Species | Introduced Species |
|---|---|---|---|---|---|
| Terrestrial | | | | | |
| Birds | 56 | 27 (48%) | 7 | 13 (23%) | 11 |
| Mammals | 6 | 1 (17%) | 1 | 2 (33%) | 5 |
| Amphibians | 2 | 2 (100%) | 1 | 2 (100%) | 1 |
| Reptiles | 26 | 10 (38%) | 1 | 8 (31%) | 0 |
| Invertebrates | | | | | |
| Macrolepidoptera, Butterflies, Moths | 400 | 17 (4%) | 2 | N/A | N/A |
| Cicadas | 15 | 14 (93%) | N/A | N/A | 0 |
| Phasmids Stick Insects | 19 | 12 (63%) | N/A | 10 (52%) | 0 |
| Odonata Dragonflies, Damselflies | 33 | 22 (67%) | N/A | N/A | N/A |
| Plants, Flora | 1594 | 893 (56%) | 1 | 281 (18%) | 936 |
| Ferns | 303 | 90 (30%) | N/A | 58 (19%) | 7 |
| Palms | 24 | 24 (100%) | N/A | 12 (50%) | 6 |
| Psychotria spp. Rubiaceae | 76 | 72 (95%) | N/A | 21 (28%) | 0 |
| Aquatic | | | | | |
| Freshwater Bivalves, Gastropods and Crustacea | 61 | 7 (11%) | N/A | 1 (2%) | 3 |
| Fish and Brackish Water Fish | 91 | Few, if any | N/A | N/A | 10 |
| Fish (freshwater and marine combined) | 1930 | 1 | N/A | N/A | 10 |
| Marine Invertebrates | | | | | |
| Echinoderms | 240 | 0 | N/A | N/A | N/A |
| Crustacea | 262 | 1 (0.4%) | N/A | N/A | N/A |
| Gastropods-Cones | 99 | 0 | 29 | N/A | N/A |
| Gastropods-Cowries | 71 | 0 | 4 | N/A | N/A |
| Insects | 2 | 2 (100%) | N/A | N/A | N/A |
| Bivalves | 382 | 0 | 96 | N/A | N/A |

Source: Convention on Biological Diversity

Table 1-3-9 shows a list of endangered and critically endangered species in Fiji issued under the Endangered and Protected Species Act, 2002. (Marine wildlife excluded.)

Table 1-3-9 Endangered and Critically Endangered Species in Fiji

| Scientific Name | Common Name | Scientific Name | Common Name |
|---|---|---|---|
| Fish | | Birds | |
| *Bryanninops diannoea* | Diana's goby/Vo I daiana | *Falco peregrinus** | Peregrine falcon* |
| *Ecsenius fijiensis* | Fiji clown blenny/Beleni meketa | *Clytorhynchus nigrogularis* | Black-faced shrikebill |
| *Mesoprisles kneri* | Golden Crested Perch | *Dendrocygna arcuata* | Wandering whistling-duck |

| Scientific Name | Common Name | Scientific Name | Common Name |
|---|---|---|---|
| *Plagiotremus laudandus flavus* | Bicolor Fang-blenny/Beleni volai | *Erythrura kleinschmidti* | Pink-billed parrotfinch |
| *Plectranthias fijiensis* | Fiji anthia/Ecia selili | *Gallicolumba stairii* | Friendly ground-dove |
| *Rotuma lewisi* | Rotuna goby/Miqa kei rotuma | *Lamprolia Victoria* | Silktail |
| *Thamnaconus fijiensis* | Deepwater filefish/Ravi salili | *Mayrornis versicolor* | Ogea monarch |
| *Bolbometopon muricatum* | Bumphead Parrotfish/Kalia | *Myzomela chermesina* | Rotuma myzomela |
| *Brotula flaviviridis* | Brotula goby/Miqa I borotula | *Nesoclopeus poecilopterus* | Barred-wing rail |
| *Coris aygula* | Clown coris/Koli ni Wai/Drevulolo | *Poliolimnas cinereus* | White-browed crake |
| *Corythoichthys polynotatus* | Yellow-spotted pipefish/Ika se | *Porzana tabuensis* | Spotless crake |
| *Dermatopsis greenfieldi* | Greenfield's mudbrotula | Reptiles | |
| *Diancistrus fijiensis* | Fiji coral brotula/Miqa vunilase | *Brachylophus vitiensis** | Fiji crested iguana* |
| *Diancistrus robustus* | Robust coral brotula/Miqa ni namo | *Crocodylus porosus* | Saltwater crocodile |
| *Discotrema zonatum* | Clingfish/Ika saisai | *Hemiphyllodacrylus typus* | Indo Pacific tree gecko |
| *Ecsenius pardus* | Combtooth blenny/Bele ni tuinuku | *Lepidodactylus gardineri* | Rotuman forest gecko |
| *Epinephelus lanceolatus* | Giant Grouper/Kavu- loa | *Lepidodactylus manni* | Mann's forest gecko/moko kabi |
| *Epinephelus malabaricus* | Malabar Grouper/Kavu sevula | *Ogmodon vitianus* | Fiji burrowing snake/Bolo |
| *Eviota karaspila* | Pygmy goby/Vo/Miqa sewa | Amphibians | |
| *Gorgasia thamani* | Thaman's garden eel/Duna senilase | *Cornufer [Platymantis] vitiensis* | Fiji tree frog/Ula/Boto ni Viti |
| *Heteroconger tomberua* | Tomberua Conger eel/ Tunatuna | *Cornufer [Platymanthis] vitianua* | Fiji ground frog/Dreli/Boto ni Viti |
| *Heteroconger tomberua* | Tomberua Conger eel/Tunatuna | | |
| Reptiles (Lizards) | | Mammals | |
| *Emoia Campbelli* | Montane tree skink | *Emballonura semicaudata* | Polynesian sheath tailed bat/bekabeka |
| *Emoia mokosariniveikau* | Fiji forest skink | *Notopteris macdonaldi* | Fijian blossom bat/ikua |
| *Emoia nigra* | Pacific black skink | *Mirimiri/Pteralopex acrodonta* | Taveuni flying fox |
| *Leiolopisma alazon* | Lauan ground skink | Plants - Flora | |
| *Cryptoblepharus eximius* | Pygmy snake eyed skink | *Cyphosperma trichospadix* | |
| *Emoia oriva* | Rotuman barred tree skink/oriva | *Dacrydium nausoriense* | Yaka/Tagitagi |
| Plants - Flora | | *Elaeocarpus storckii* | Gaigai |
| *Polyalthia angustifolia* | | *Emmenosperma micropetalum* | Tomanu |
| *Agathis vitiensis* | Nda kua/dakua makadre | *Equisetum ramossisimum* | Ai masi |
| *Kingiodendron platycarpum* | Moivi | *Exocarpus vitiensis* | Tubu ni yasi |
| *Storckiella vitiensis* | Vesida | *Ficus storckii* | Ai masi |
| *Garcinia pseudoguttifera* | Bulu | *Freycinetia vitiensis* | Wame |
| *Garcinia myrtiflora* | laubu | *Geanthus cevuga* | Cevuga |
| *Terminalia vitiensis* | | *Heterospathe phillipsii* | Niuniu |
| *Geissois ternate var 2* | Vuga | *Hydriastele boumae* | Niuniu |
| *Vupaniopsis leptobotrys* | Malawaci | *Hydriastele vitiensis* | |
| *Weinmannia spiraeoides* | | *Lycopodium magnificum* | Blue tassel fern |
| *Weinmannia vitiensis* | | *Lycopodium serratum* | |
| *Debeneria vitiensis* | Masiratu | *Manilkara dissecta* | Bau sagali |
| *Gonystylus punctatus* | Mavota | Freshwater Snail | |
| *Hibiscus storckii* | | *Acochlidium fijiense* | Freshwater opisthobranch/Sici dabe |
| *Medinilla kandavuensis* | | *Fijidoma maculata* | Freshwater snail/Sici drodro |
| *Astronidium floribundum* | | *Fluviopupa daunivucu* | Daunivucu snail/Sici daunivucu |
| *Astronidium kasiense* | Rusila | *Fluviopupa derua* | Derua snail/Sici derua |
| *Mimosaceae spec.div* | Vavai-loa | *Fluviopupa irinimeke* | Irinimeke snail/Sici irinimeke |
| *Mimosaceae spec.div* | Vavai-vula | *Fluviopupa lali* | Lali snail/Sici lali |
| *Veitchia filifera* | | *Fluviopupa lalinimeke* | Lalinimeke snail/Sici lalinimeke |
| *Manilkara vitiensis* | Boca | *Fluviopupa mekewesi* | Mekewesi snail/Sici mekewesi |
| *Meryta tenuifolia* | Lutulutu | *Fluviopupa mekeniyaqona* | Mekeniyaqona snail |
| *Neoveitchia storckii* | Vuleito | *Fluviopupa pupoidea* | Stream rock snail/Sici vela |
| *Ophioglossum reticulatum* | | *Fluviopupa seasea* | Seasea snail/Sici seasea |
| *Parkia parrii* | Vaivai ni wai | *Fluviopupa vacamalolo* | Vakamalolo snail/Sici vakamalolo |
| *Pandanus joskei* | Voivoi | Terrestrial Snail | |
| *Pandanus levuensis* | | *Partula lanceolata* | Mago tree snail |
| *Pandanus taveuniensis* | | *Partula leefi* | Rotuman tree snail/Aniha hanua leefi |
| *Pandanus thurstonii* | Voivoi | *Partula lirata* | Lau tree snail/Sici vanua lirata |
| *Planchonella sessilis* | Yawe korobaba | *Samoana alabastrina* | Moala tree snail |
| *Pritchardia thurstonii* | Masei | *Callistocharis elobatus* | Vanua Levu sici vanua elobatus |
| *Psilotum complanatum* | | *Callistocharis fulguratus* | Sici vanua fulguratus |
| *Pterocymbium oceanicum* | Ma | *Callistocharis garretti* | Sici vanua garretti |
| *Symplocos leptophylla* | Ai susu | *Callistocharis graeffei* | Viti Levu sici vanua |
| *Tapeinosperma capitatum* | Dasia | *Callistocharis guanensis* | Gau sici vanua guanesis |
| *Tmesipteris truncata* | | *Callistocharis [Placostylus] hoyti* | Vanua Levu sici vanua hotyi |
| *Veitchia simulans* | Niusawa | *Callistocharis malleatus* | Sici vanua malleatus |
| *Acmopyle sahniana* | Drautabua | *Callistocharis morosus* | Sici vanua morosus |
| *Decusscicarpus vitiensis* | Dakua salusalu | *Callistocharis ochrostoma* | Sici vanua ochrostoma |
| *Podocarpus neriifolius* | Kuasi | *Callistocharis subroseus* | Sici vanua subroseus |
| *Dacrydium nidulum* | Yaka | *Euplacostylus kantavunsis* | Kadavu sici vanua kanatavunsis |
| *Turrillia ferruginea* | Kauceuti | *Euplacostylus koroensis* | Koro sici vanua |
| *Alphitonia zizyphoides* | Doi | *Euplacostylus mbengensis* | Beqa sici vanua |
| *Gardenia vitiensis* | Ndrenga, Ndrega, Meilango | *Euplacostylus seemanni* | Kadavu sici vanua seemani |
| *Mastixiodendron robustum* | Duvula | *Trochomorpha abrochroa* | Viti Levu trochomorphid snail |

| Scientific Name | Common Name | Scientific Name | Common Name |
|---|---|---|---|
| *Gardenia vitiensis* | Ndrega meilago | *Trochomorpha accurate* | Viti Levu trochomorphid snail |
| *Manikara spec.div* | Bausagali-damu | *Trochomorpha albostriata* | Lau trochomorphid snail |
| *Manikara spec.div.* | Bausagali-vula | *Trochomorpha coralline* | Lauan trochomorphid snail |
| *Planchonella garberi* | Sarosaro | *Trochomorpha depressostriata* | Viti Levu trochomorphid snail |
| *Planchonella umbonata* | Bauloa | *Trochomorpha fessonia* | Trochomorphid snail |
| *Alectryon grandifolius* | Masa B | *Trochomorpha kambarae* | Kabara trochomorphid snail |
| *Balaka diffusa* | Niuniu | *Trochomorpha kantavuensis* | Kadavu trochomorphid snail |
| *Balaka macrocarpa* | Niuniu/Balaka | *Trochomorpha latimarginata* | Ovalau trochomorphid snail |
| *Balaka microcarpa* | Balaka | *Trochomorpha luedersi* | Trochomorphid snail |
| *Balaka streptostacys* | | *Trochomorpha merzianoides* | Vanua Levu trochomorphid snail |
| *Balaka bulitavu* | Balaka | *Trochomorpha moalensis* | Moala trochomorphid snail |
| *Barringtonia seaturae* | Vutu dina | *Trochomorpha planoconus* | Ono trochomorphid snail |
| *Cordia subcordata* | Nawanawa | *Trochomorpha tavinniensis* | Taveuni trochomorphid snail |
| *Cupaniopsis vitiensis* | Vusavusa | *Trochomorpha transarata* | Mago trochomorphid snail |
| *Cyclophyllum barbatum* | Ola | *Trochomorpha tumulus* | Viti Levu trochomorphid snail |
| *Cyphosperma tanga* | Taqwa | *Trochomorpha tuvuthae* | Tuvuca trochomorphid snail |
| *Cyphosperma "naboutini"* | | Insects | |
| *Partula lanceolata* | Mago tree snail | *Xixuthrus heros* | Giant Fijian Long-horned beetle |
| *Partula leefi* | Rotuman tree snail/Aniha hanua leefi | *Xixuthrus ganglbaueri* | Giant Fijian Long-horned beetle |
| | | *Xixuthrus terribilis (syn. heyrovski)* | Giant Fijian Long-horned Beetle |
| Marine life (fish) | | Marine life (fish) | |
| *Lairdina hopletupus* | Hoofprint goby/ Miqa senuku | *Trimma anthrena* | Goby/ Miqa voladra/ Miqa I tirima |
| *Meiacanthus oualensis* | Yellow-fanged blenny/ Beleni sedromo | *Tryssogobius nigrolineatus* | Goby/ Miqa saivola |
| *Moringua (Basctanichthys)pusillus* | Moray eel/ Dabea seloa | *Vanderhorstia bella* | Shrimp goby/ Miqa vanuku |
| *Moringua fijiensis* | Fiji moray eel/ Dabea ni Uciwai | *Zoramia flebila* | Cardinal fish/ Ika ni toa |
| *Neoconger tuberculatus* | Swollen-gut worm eel/ Dunaduna saidra | *Synchiropus springeri* | Springer's mandarinfish/ Ika tuise |
| *Paracheilinus rubicaudalis* | Red-tailed flasher wrasse | Marine life (sharks) | |
| *Parioglossus triquetrus* | Dartfish/ Ika sailili | *Carcharhinus albimarginatus* | Silver-tip shark/ Qio seavula/ Qio dina |
| *Parmops echinatus* | Flashlight fish/ Ika tulase | *Carcharhinus amblyrhyncos* | Gray reef shark/ Qio saqa |
| *Petroscirtes pylei* | Twilight fang blenny/ Beleni seasea | *Carcharhinus falciformis* | Silky shark/ Qio sisi |
| *Plectorhinchus albovittatus* | Giant Sweet-lips | *Carcharhinus leucas* | Bull shark/ Qio Qa/ Qio ni uciwai |
| *Plesiops polydactylus* | Longfin | *Carcharhinus melanopterus* | Black-tip reef shark/ Qio tokiloa |
| *Pomacentrus microspilos* | Reef damsel/ Sisi sevola | *Carcharhinus plumbeus* | Sandbar shark/ Qio Vanuku |
| *Pseudoanthias flavicauda* | Yellow-tailed anthias/ Ecia buidromo | *Galeocerda cuvier* | Tiger shark/ Qio oria |
| *Redigobius lekutu* | Lekutu goby/ Vovo/ Miqa ni lekutu | *Isurus oxyrinchus* | Mako shark (SF)/ Qio mako |
| *Redigobius leveri* | Lever's grundel/ Lekutu red goby | *Isurus paucus* | Mako shark (LF)/ Qio mako |
| *Schismatogobius chrysonotus* | Orange-spotted scale-less goby/Vo – sisi | *Prionace glauca* | Blue shark/ Qio Tuiloa |
| *Schismatogobius vitiensis* | Fiji goby/ Vovo drili | *Pristis microdon* | Sawfish/ Qio uluvaro |
| *Siganus uspi* | Bi-colored, USP rabbitfish | *Triaenodon obesus* | White-tip reef shark/ Qio tukivula |
| *Solenostomus halimeda* | Halimeda ghost pipefish/ Volai I selumi | Marine life (whales) | |
| *Synchiropus springeri* | Springer's mandarinfish/ Ika tuise | *Mesoplodon longirostris* | Blainvilles Beaked whale |

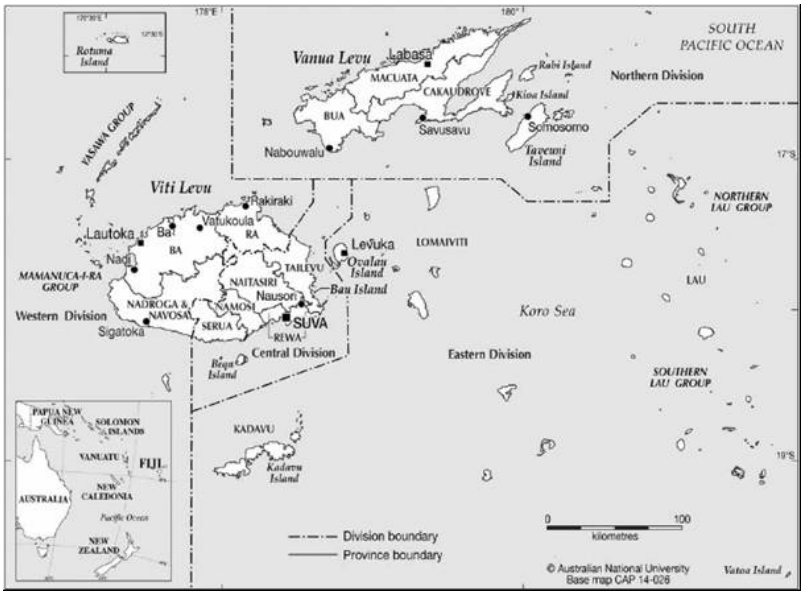
Source: Endangered and Protected Species Act, 2002 amended under Bill No. 6 of 2016

Note: '*'= the Convention on International Trade in Endangered Species (Fiji)

### (9) Administrative Demarcation

The Republic of Fiji is an archipelago located in Oceania and comprising 300 volcanic islands with coral reefs. Viti Levu Island (10,388km²) and Vanua Levu Island (5,587km²) are the two main islands, while the capital, Suva, is settled in the east of Viti Levu Island. Regarding administrative demarcations, there are four (4) divisions of top criteria known as the Central, Northern, Eastern and Western divisions. Under these, administrative subdivisions are categorized as provinces under the division, district under the province and village for the smallest subdivision. As of May 2018, there were four divisions, 15 provinces, 196 districts and 1,192 villages comprising republic country and a local autonomous administration is settled in each of the villages. Each village is basically referred to as a 'Town' or 'City' depending on its population.

The New Tamavua-i-wai Bridge is located in the east of Suva City of Rewa Province, Central Division near the border of Lami Town crossing the Tamavua River.




Source: Australian National University

Figure 1-3-23 Administrative Demarcation of the Republic of Fiji

**(10) Population Census**

Comparing volumes of population in the year 2007 and 2017, population of all provinces in Viti Levu Island has increasing trend, whereas population of other remoted islands has decreasing trend. The population of Rewa Province, site of the bridge reconstruction project, has increased by a fifth while that of adjacent provinces such as Tailevu, Naitasiri and Monasi on the northern and western sides, has risen by more than 10%. This fact was considered attributable to the increase in agricultural development utilizing riverside flat land and river water from Rewa and Navua rivers, two of the main water sources in Viti Levu for the surrounding provinces. Table 1-3-10 shows the population for the years 2007 and 2017 and the rate of increase between the two, while Figure 1-3-24 illustrates a distribution map of the population change in Viti Levu Island.

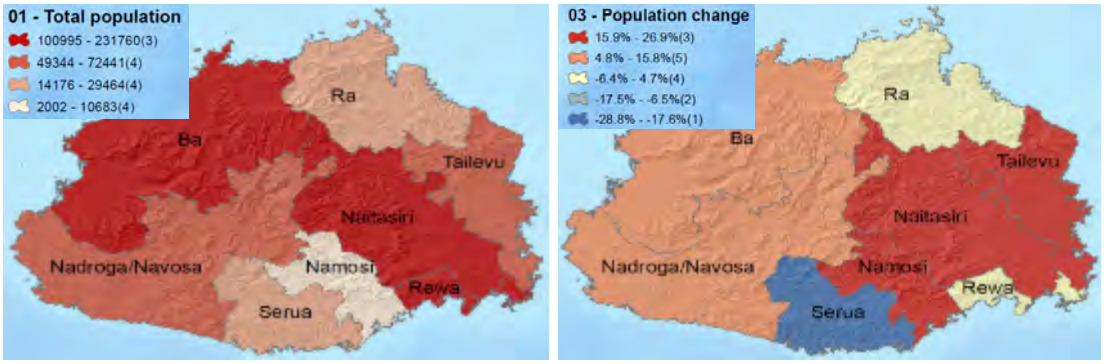
Table 1-3-10 Population, Area and Population Density in Fiji

| Province | Population | | Absolute Change Amount | Change Rate (%) | Area (km²) | Population Density (Person/km²) |
|---|---|---|---|---|---|---|
| | 2007 | 2017 | | | | |
| Ba* | 231,760 | 247,708 | 15,948 | 6.9 | 2,630 | 94.19 |
| Bua | 14,176 | 15,466 | 1,290 | 9.1 | 1,380 | 11.21 |
| Cakaudrove | 49,344 | 50,469 | 1,125 | 2.3 | 2,816 | 17.92 |
| Kadavu | 10,167 | 10,897 | 730 | 7.1 | 420 | 25.95 |
| Lau | 10,683 | 9,602 | -1,081 | -10.1 | 490 | 19.60 |
| Lomaiviti | 16,253 | 15,657 | -596 | -3.7 | 411 | 38.09 |
| Macuata | 72,441 | 65,983 | -6,458 | -8.9 | 2,004 | 32.93 |
| Nadroga/Navosa* | 58,387 | 58,931 | 544 | 0.9 | 2,385 | 24.71 |
| Naitasiri* | 160,760 | 177,678 | 16,918 | 10.5 | 1,700 | 104.52 |
| Namosi* | 6,898 | 7,871 | 973 | 14.1 | 570 | 13.81 |
| Ra* | 29,464 | 30,432 | 968 | 3.3 | 1,340 | 22.71 |
| Rewa* | 100,995 | 108,016 | 7,021 | 7.0 | 272 | 397.12 |
| Serua* | 18,249 | 20,031 | 1,782 | 9.8 | 830 | 24.13 |
| Tailevu* | 55,692 | 64,552 | 8,860 | 15.9 | 760 | 84.94 |
| Rotuma | 2,002 | 1,594 | -408 | -20.4 | 44 | 36.23 |

| Province | Population | | Absolute Change Amount | Change Rate (%) | Area (km²) | Population Density (Person/km²) |
|---|---|---|---|---|---|---|
| | 2007 | 2017 | | | | |
| Total | 837,271 | 884,887 | 47,616 | 5.7 | 18,052 | 49.02 |

Source: Fiji Bureau of Statistics

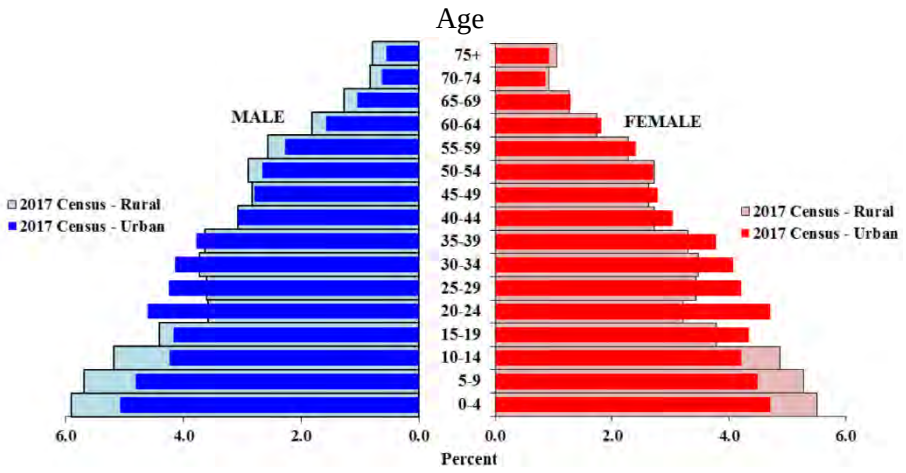
Note: '*' = Provinces located in the island of Viti Levu




Source: Fiji Bureau of Statistics

Figure 1-3-24 Distribution Map of Population Change in Viti Levu Island

Figure 1-3-25 shows the population pyramid in Fiji with rural and urban areas compared (2017). According to the figure, a large proportion of the population aged between 20 and 40 years, regardless of gender, is found in urban areas, despite a large proportion of the population aged between 0 and 15 years. This tendency would explain the trend for many of the younger generation to relocate to urban areas and the high birth rate in rural areas.




Source: Fiji Bureau of Statistics

Figure 1-3-25 Population Pyramid in Fiji

### (11) Economic Index

The economy of Fiji is mainly supported by tourism, despite its rich forestry, mining and fishery resources and the main source of foreign currency are remissions managed by labor income from overseas. In terms of industry, the service industry, including tourism, makes up 71.5%, manufacturing 17.9% and the agricultural industry 10.6%. (Source: CIA fact book)

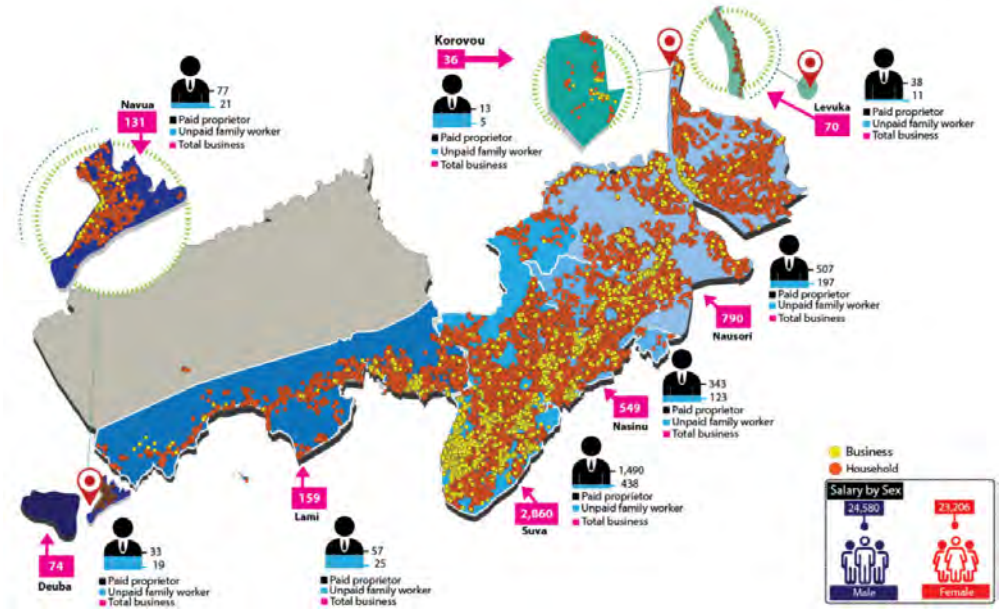
Conversely, more than 40% of industry in the Greater Suva Area comprises 'Wholesale and retail trade, repair of motor vehicles' whereas other industries comprised less than 10%. (Table 1-3-11)

Figure 1-3-26 shows the location of registered business and housing in the Greater Suva Area and shows how most of the registered business is concentrated on the center of Suva District, although households are spreading all over the Greater Suva Area, except for the forest area in the Lami district.

Table 1-3-1 Business by Industry in the Greater Suva Area

| Name of Industry | % |
|---|---|
| Wholesale and retail trade, repair of motor vehicles | 43.0 |
| Accommodation and food service activities | 9.8 |
| Manufacturing | 7.8 |
| Other service activities | 6.5 |
| Agriculture, forestry and fishing | 3.9 |
| Professional, scientific and technical activities | 3.8 |
| Transport and storage | 3.6 |
| Public administration and defence | 3.6 |
| Construction | 3.1 |
| Administration and support service activities | 2.9 |
| Financial and insurance activities | 2.3 |
| Information and communication | 2.1 |
| Education | 2.0 |
| Human health and social work activities | 1.7 |
| Arts, entertainment and recreation | 1.2 |
| Real estate activities | 0.8 |
| Water supply, sewage, waste management | 0.8 |
| Activities of extra-territorial organisations and bodies | 0.6 |
| Mining and quarrying | 0.3 |
| Electricity, gas, steam and air conditioning supply | 0.1 |
| Activities of household as employers | 0.0 |
| Total | 100.0 |

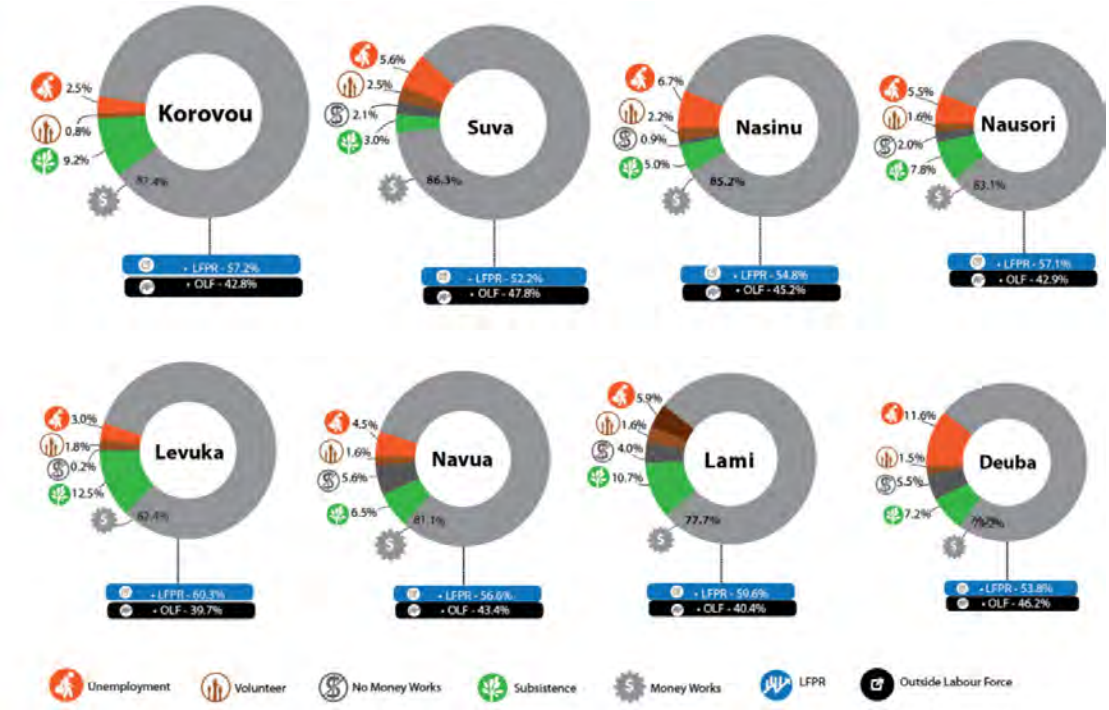
Source: Statistical News Release No. 63, 2018, Fiji Bureau of Statistics




Source: Statistical News Release No. 63, 2018, Fiji Bureau of Statistics

Figure 1-3-26 Business and Housing in the Greater Suva Area

Figure 1-3-27 shows that residents of the Suva and Lami districts are engaged in finance - not unemployed - and despite the two districts adjoining each other, the subsistence rate in Lami district, at 10.7%, exceeds that in Suva District, recorded at 3.0% - the lowest record in the Greater Suva Area.




Source: Statistical News Release No.63, 2018, Fiji Bureau of Statistics

Figure 1-3-27 Economic Activity in the Greater Suva Area (urban)[4]

### (12) Poverty

According to the census report for poverty in Fiji (2013-2014), over a third of poor people (33.9%) resided in the Central Division. However, rural dwellers were over-represented as far as the Rural and Urban distribution of Fiji's Poor in concerned, with 62.6% of the Poor population being rural dwellers. Table 1-3-12 shows estimates of population living in poverty by geography in Fiji.

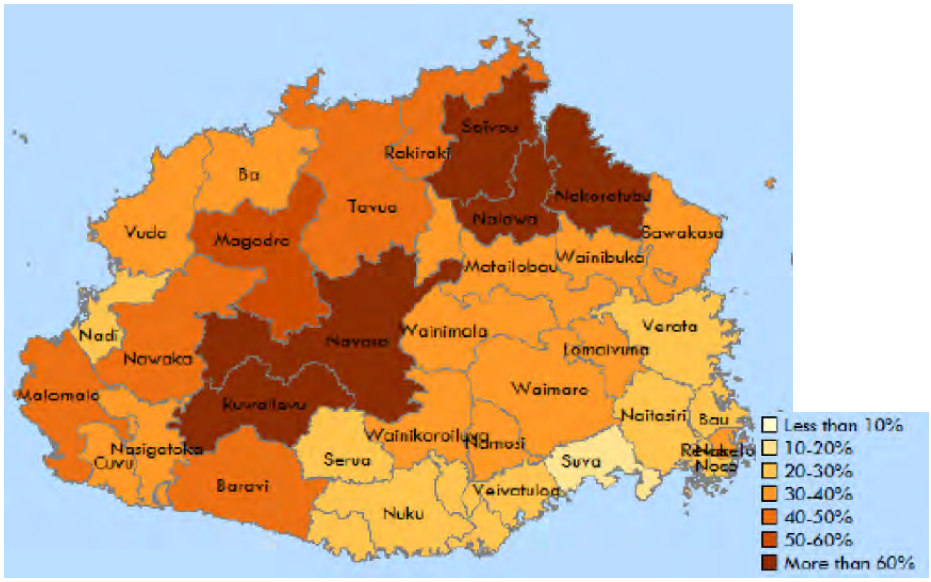
Table 1-3-12 Estimates of Population Living in Poverty by Geography (2013-2014)

| Division/Area | Rate of Population Living in Poverty | Estimated Population Living in Poverty | Estimated Total Population |
|---|---|---|---|
| **TOTAL** | | | |
| **Total** | **28.1%** | **237,107 (100%)** | **845,309 (100%)** |
| Urban | 19.8% | 84,939 (35.8%) | 429,759 (50.8%) |
| Rural | 36.7% | 152,466 (64.2%) | 415,550 (49.2%) |
| **URBAN** | | | |
| **Total** | 19.8% | 84,939 (35.8%) | 429,759 (50.8%) |
| Central | 16.9% | 44,220 (18.6%) | 261,070 (30.9%) |
| Eastern | 29.4% | 1,076 (0.5%) | 3,662 (0.4%) |
| Northern | 33.8% | 11,223 (4.7%) | 33,206 (3.9%) |
| Western | 21.6% | 28,420 (12.0%) | 131,821 (15.6%) |
| **RURAL** | | | |
| **Total** | **36.7%** | **152,466 (64.2%)** | **415,550 (49.2%)** |
| Central | 36.9% | 36,277 (15.3%) | 98,335 (11.6%) |
| Eastern | 42.1% | 15,088 (6.4%) | 35,797 (4.2%) |
| Northern | 52.6% | 53,184 (22.4%) | 101,116 (12.0%) |
| Western | 26.6% | 47,917 (20.2%) | 180,302 (21.3%) |

Source: Statistical News, 31 December, 2015 Fiji Bureau of Statistics

Figure 1-3-28 illustrates low poverty rates within Suva and the tourism-intensive southern coast of Viti Levu on a district level.

[4] LFPR: Labour force Participation Rate, OLF: Outside the Labour force




Source: World Bank

Figure 1-3-28 Poverty Headcount Ratio on a District Level

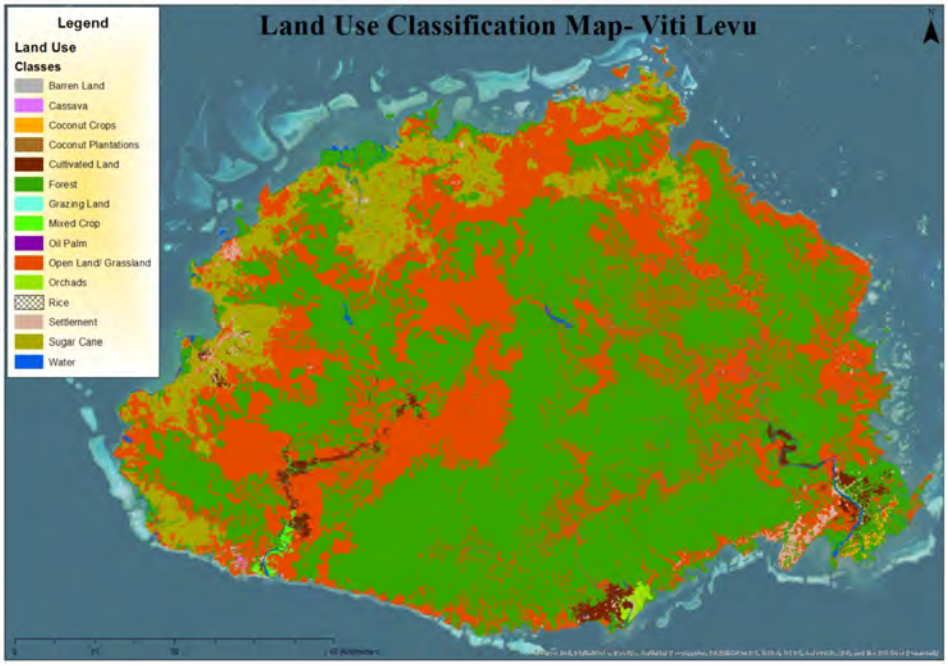
### (13) Land Use

Regarding land use in Viti Levu Island, 2018, more than 80% is covered by forest and grassland and approx. 10% is used for agricultural purposes. In particular, many flat fields in the western part of the island are developed for sugar cane fields, whereas numerous forests are conserved in the east. Furthermore, the settlement areas are limited to the Nadi District for west and the Suva District for the east. Table 1-3-13 shows the land-use status and rate and Figure 1-3-29 depicts the land-use classification in Viti Levu.

Table 1-3-13 Land-Use Status in Viti Levu Island

| Type | Area (ha) | Rate (%) | Type | Area (ha) | Rate (%) |
|---|---|---|---|---|---|
| Barren Land | 607 | 0.0565 | Mixed Crops | 1,546 | 0.1438 |
| Cassava Field | 269 | 0.0275 | Oil Palm Field | 23 | 0.0021 |
| Coconut Crop Field | 1,484 | 0.1380 | Open Land/Grassland | 373,364 | 34.7330 |
| Coconut Plantation | 698 | 0.0649 | Orchards | 1,914 | 0.1780 |
| Cultivated Land | 13,825 | 1.2861 | Rice Field | 1 | 0.0001 |
| Forest | 570,098 | 53.0346 | Settlement | 8,620 | 0.8019 |
| Grazing Land | 13 | 0.0012 | Sugar Cane Field | 93,822 | 8.7280 |
| | | | Water Surface | 8,646 | 0.8043 |
| | | | Total | 1,074,955 | 100.0000 |

Source: Lands Department, Fiji




Source: Fiji Bureau of Statistics

Figure 1-3-29 Land-Use Classification Map of Viti Levu Island

### (14) Natural Hazards and Extreme Events

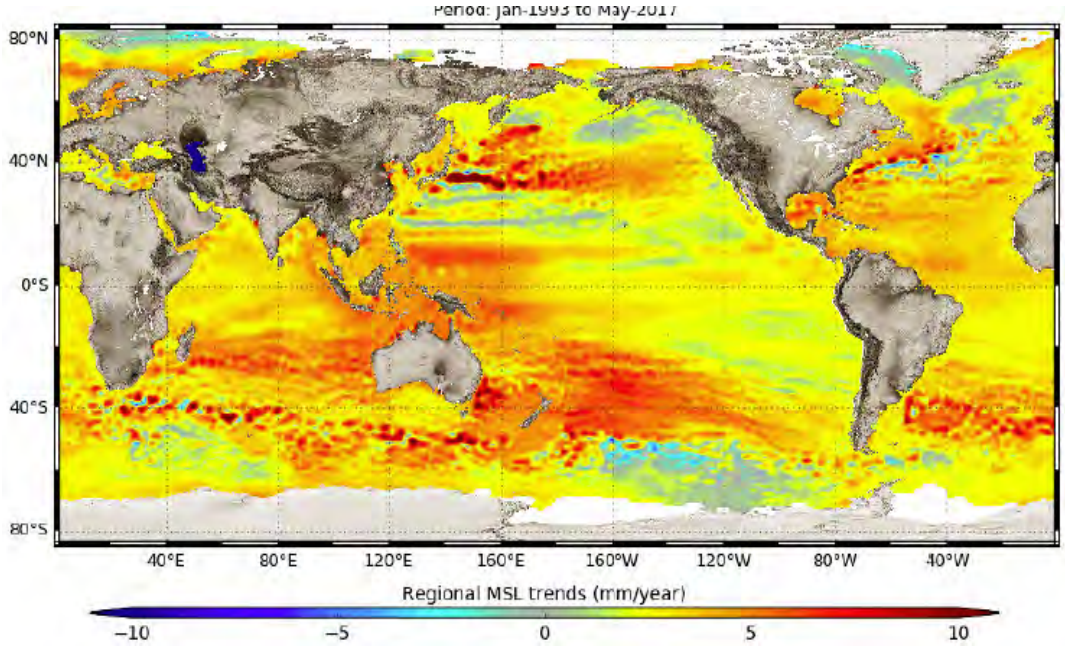
#### 1) Climate Change and Sea-Level Rise

The IPCC Fifth Assessment Report[5] provides broad-scale climate-change projections for the Pacific region. A more detailed assessment of past and potential future climate change was carried out for the region[6], the key points of which are as follows:

- Surface air and sea surface temperatures are projected to continue increasing (very likely). Annual mean surface temperatures are expected to be between 0.5 to 1°C higher by 2030 relative to 1990 and 1 to 2°C depending on the emission scenario by 2055.
- The intensity and frequency of days of extreme heat are projected to increase (very likely).
- Annual and seasonal mean rainfall is projected to increase (likely). Increases in annual mean rainfall are projected to be most prominent near the SPCZ, with widespread increases in the number of days of heavy rain (20-50 mm).

A number of projections, however, suggest that islands located near the eastern edge of the SPCZ, such as Fiji, may become drier in the wet season as trade winds in the south-east Pacific intensify. There is also some suggestion of a shift towards the equator of the SPCZ in the dry season (May to October), which could increase the mean rainfall during these months.

[5] IPCC, 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, Bex and P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.
[6] Australian Bureau of Meteorology & CSIRO, 2011. Climate change in the Pacific. Scientific assessment and new research. Volume One: Regional overview.

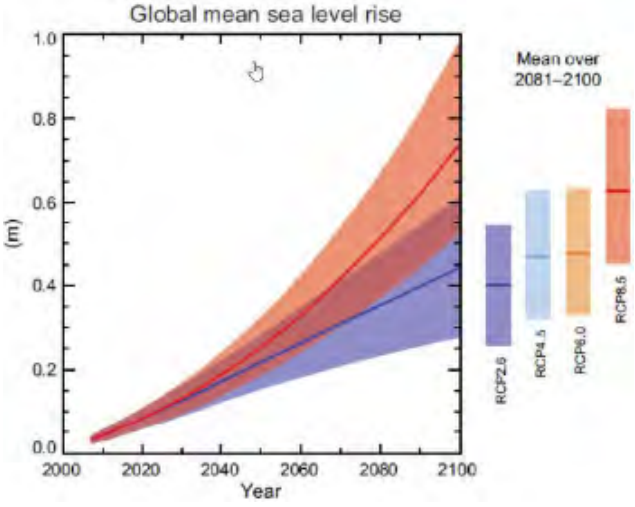



Source: EU Copernicus Marine Service, 2019

Figure 1-3-30 Global Distribution of the Rate of Absolute Sea-Level Rise between January 1993 and May 2017 from Satellite Altimeter Data[7]

Sea levels will continue rising, primarily due to thermal expansion within the oceans and loss of ice sheets and glaciers on land. Even if greenhouse gas emissions were to stabilize today, sea levels would continue rising.

For the period 2081-2100, compared to 1986-2005, the global mean sea level is likely to be between 0.26-0.54 m for the lowest emission scenario considered (Representative Concentration Pathway scenario, RCP2.6) to between 0.45-0.81 m for the highest emission scenario (RCP8.5).




Source: IPCC, Fifth Assessment Report 2013

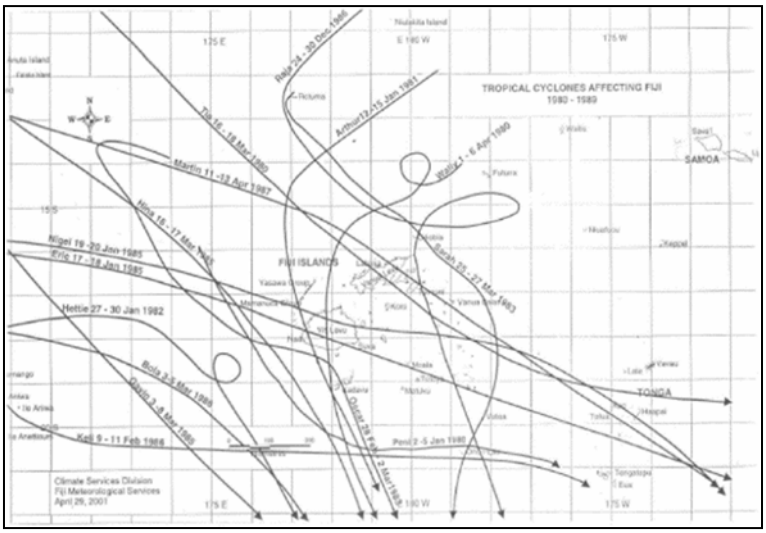
Figure 1-3-31 Projected Global Mean Sea-Level Rise to 2100 Relative to the Average Mean Sea Level between 1986 and 2005 for the Four Future Scenarios

### 2) Tropical Cyclone

A tropical cyclone is a relatively small, intense and often violent depression which forms over warm tropical seas. It is most often accompanied by hurricane conditions with destructive winds and torrential rain. Hurricane force winds (>64 knots) are common and winds may gust to 150 knots in extreme cases.

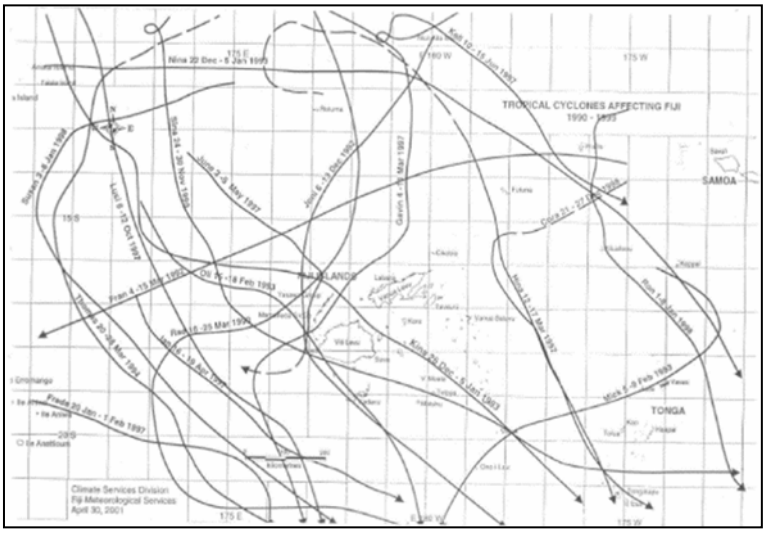
During the 63-year period between 1940 and 2003, ninety cyclones traversed Fiji, 14 of which were classed as severe by the Fiji Meteorological Service (FMS 1982, 2003). Figure 1-3-32 and Figure 1-3-33 show the hurricane tracks over Fiji in the two decades to 1999.

[7] https://www.aviso.altimetry.fr/en/data/products/ocean-indicators-products/mean-sea-level.html




Source: Fiji Meteorological Service

Figure 1-3-32 Cyclone pathways in the vicinity of Fiji (1980-1989)

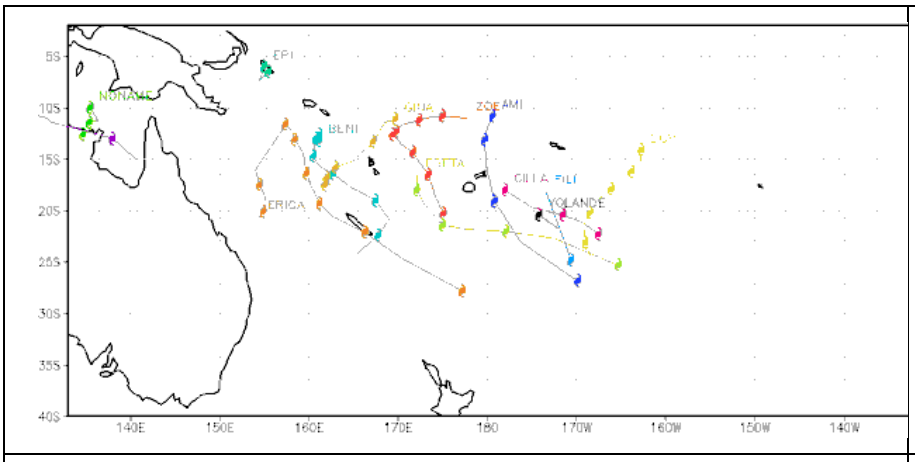



Source: Fiji Meteorological Service

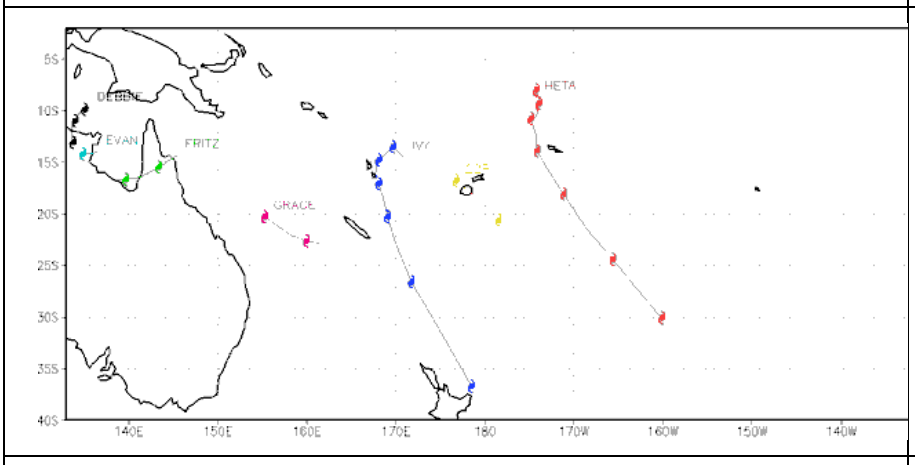
Figure 1-3-33 Cyclone pathways in the vicinity of Fiji (1990-1999)

Since 1999 Fiji has experienced a number of cyclones of varying severity, including Ami (2003), 22P (2004), 11P (2007), Gene (2008), Mick (2009), Evan (2012) and Winston (2016) (Figure 1-3-34 and Figure 1-3-35).

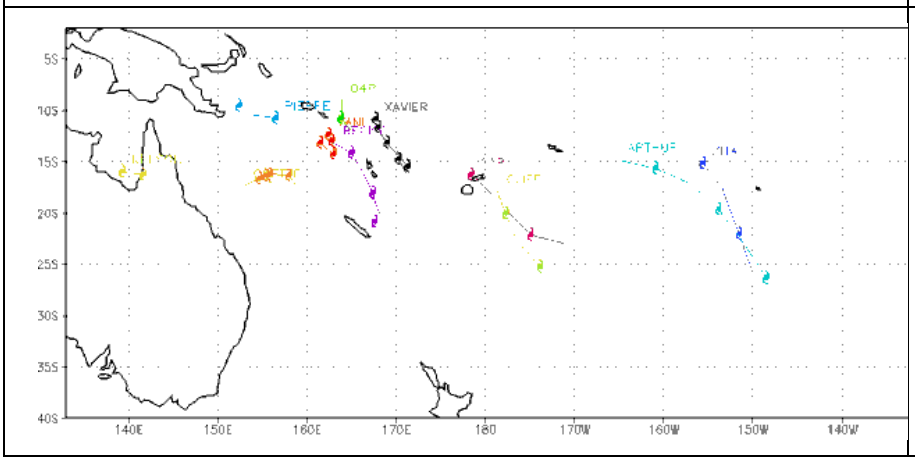
In most parts of Fiji, individual localities experience the nearby passage of a tropical cyclone (within 70 km) two to three times a decade. However, not all will have destructive intensity when passing, hence individual localities are likely to be exposed to moderate to severe damage about once every one to two decades.




| Name | Date |
|---|---|
| Yolande | 05 Dec., 2002 |
| Zoe | 26 Dec., 2002 |
| Noname | 04 Jan., 2003 |
| Ami | 12 Jan., 2003 |
| Beni | 25 Jan., 2003 |
| Cilla | 27 Jan., 2003 |
| Dovi | 06 Feb., 2003 |
| Erica | 05 Mar., 2003 |
| Craig | 09 Mar., 2003 |
| Eseta | 11 Mar., 2003 |
| Fili | 15 Apr., 2003 |
| Gina | 05 Jun., 2003 |
| Epi | 05 Jun., 2003 |



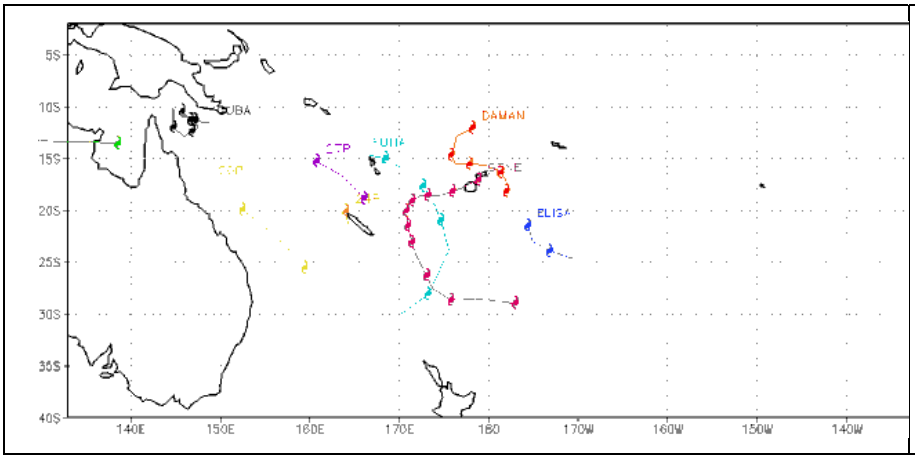

| Name | Date |
|---|---|
| | |
| Debbie | 19 Dec., 2003 |
| Heta | 02 Jan., 2004 |
| Fritz | 11 Feb., 2004 |
| Ivy | 24 Feb., 2004 |
| Evan | 02 Mar., 2004 |
| Grace | 22 Mar., 2004 |
| 22P | 08 Apr., 2004 |



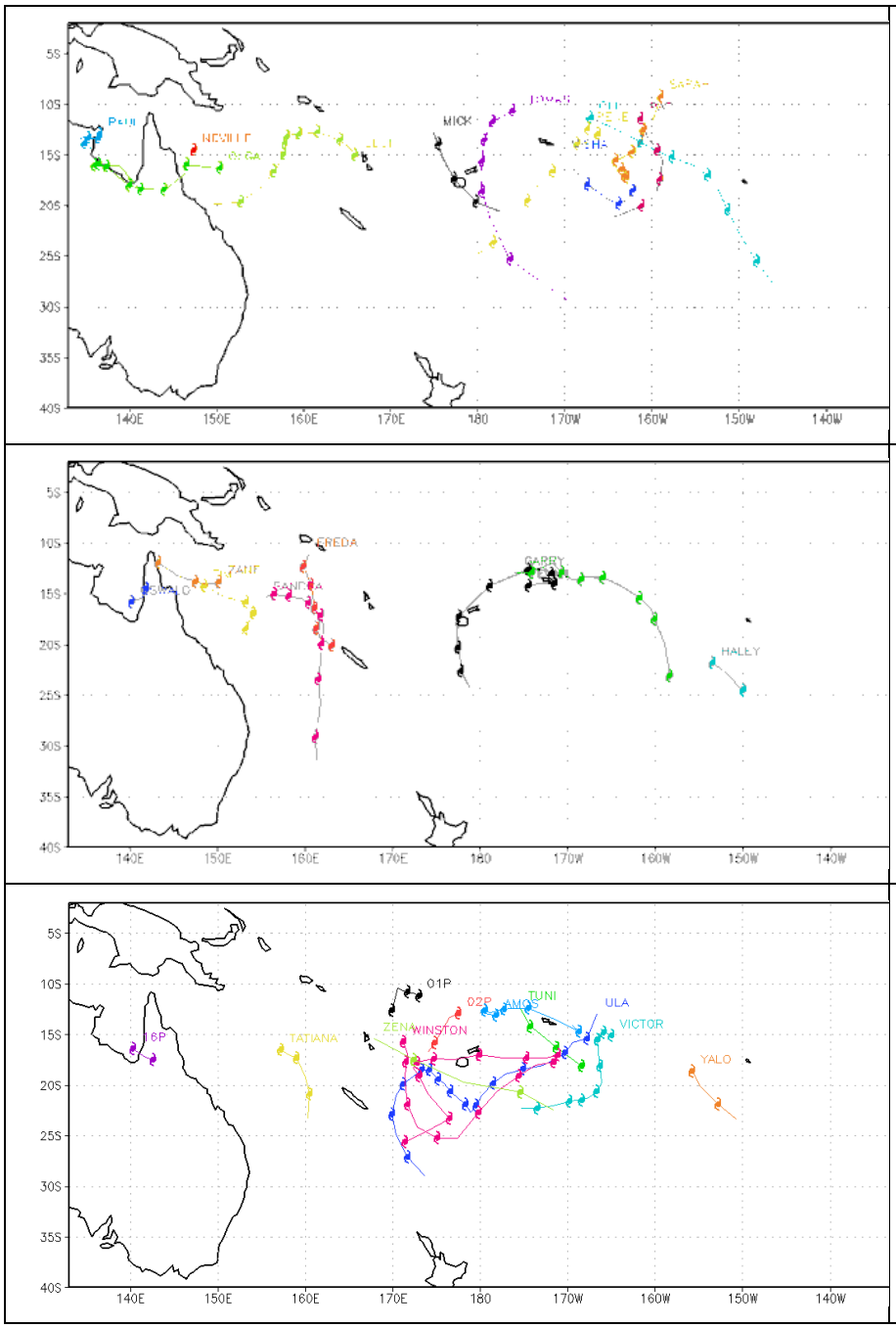

| Name | Date |
|---|---|
| Xavier | 22 Oct., 2006 |
| Yani | 22 Nov., 2006 |
| 04P | 01 Dec., 2006 |
| Zita | 23 Jan., 2007 |
| Arthur | 25 Jan., 2007 |
| 11P | 04 Feb., 2007 |
| Nelson | 06 Feb., 2007 |
| Odeite | 03 Mar., 2007 |
| Becky | 27 Mar., 2007 |
| Cliff | 05 Apr., 2007 |
| Pierre | 17 May, 2007 |

Source: Fiji Meteorological Service

Figure 1-3-34 Cyclone pathways in the vicinity of Fiji between 2003 and 2007




| Name | Date |
|---|---|
| Guba | 11 Nov., 2007 |
| Daman | 05 Dec., 2007 |
| Helen | 04 Jan., 2008 |
| Elisa | 10 Jan., 2008 |
| Funa | 17 Jan., 2008 |
| Gene | 28 Jan., 2008 |
| 20P | 29 Feb., 2008 |
| 24P | 21 Mar., 2008 |
| 27P | 18 Apr., 2008 |




| Name | Date |
|---|---|
| Mick | 13 Dec., 2009 |
| Neville | 21 Jan., 2010 |
| Olga | 23 Jan., 2010 |
| Nisha | 28 Jan., 2010 |
| Oli | 01 Feb., 2010 |
| Pat | 08 Feb., 2010 |
| Rene | 11 Feb., 2010 |
| Sarah | 22 Feb., 2010 |
| Tomas | 12 Mar., 2010 |
| Ului | 12 Mar., 2010 |
| Paul | 28 Mar., 2010 |

| Name | Date |
|---|---|
| Evan | 12 Dec., 2012 |
| Freda | 29 Dec., 2012 |
| Garry | 21 Jan., 2013 |
| Oswald | 21 Jan., 2013 |
| Haley | 10 Feb., 2013 |
| Sandra | 08 Mar., 2013 |
| Tim | 14 Mar., 2013 |
| Zane | 30 Apr., 2013 |

| Name | Date |
|---|---|
| 01P | 03 Aug., 2015 |
| 02P | 16 Oct., 2015 |
| Tuni | 28 Nov., 2015 |
| Ula | 31 Dec., 2015 |
| Victor | 15 Jan., 2016 |
| Winston | 11 Feb., 2016 |
| Tatiana | 11 Feb., 2016 |
| Yalo | 25 Feb., 2016 |
| 16P | 16 Mar., 2016 |
| Zana | 06 Apr., 2016 |
| Amos | 20 Apr., 2016 |

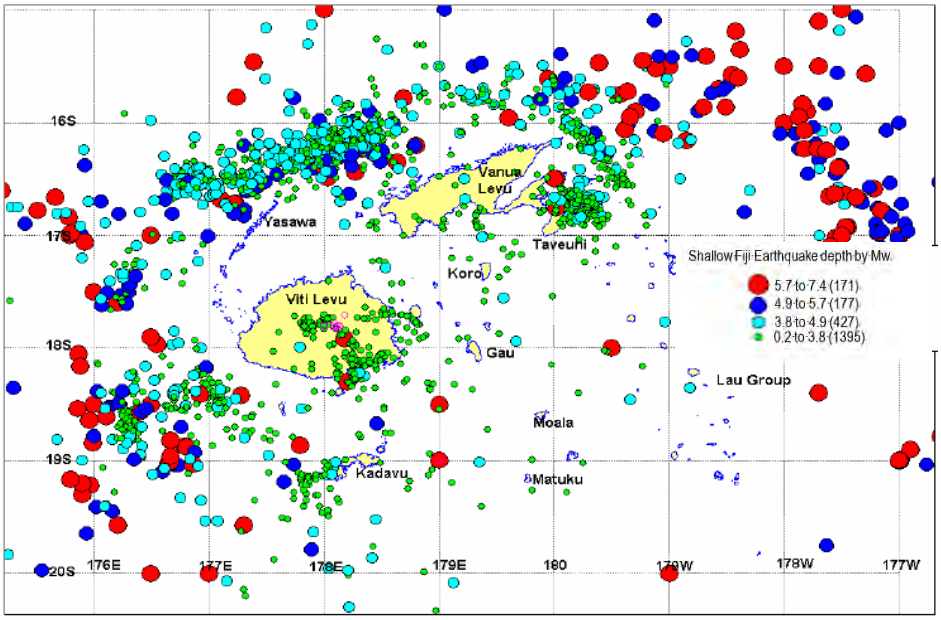
Source: Fiji Meteorological Service

Figure 1-3-35 Cyclone pathways in the vicinity of Fiji between 2008 and 2016

### 3) Seismicity

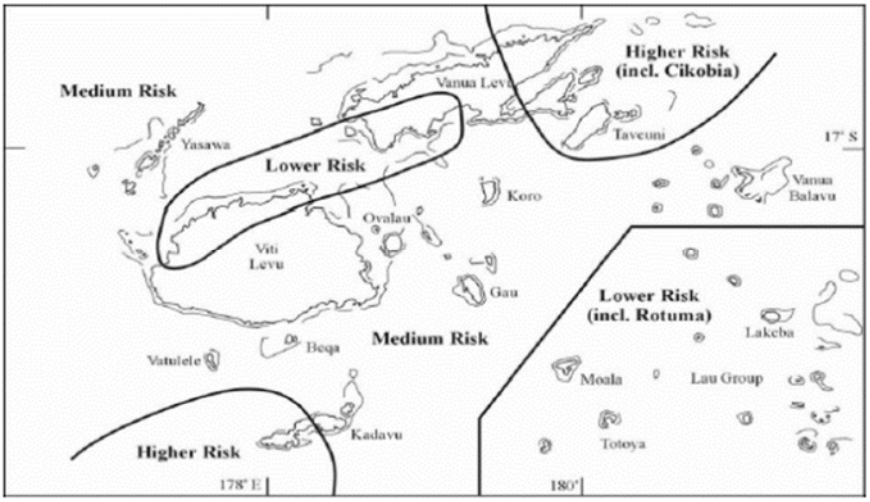
Fiji has a relatively complex tectonic history, with its islands primarily formed as volcanic arcs due to subduction processes. Fiji lies at the midpoint of the opposing Tonga Kermadec and New Hebrides convergence zones, from which it is currently separated by the two extensional back arc basins: the North Fiji Basin to the west and the Lau Basin to the east. Seismic activity is generally concentrated around the extremes of the Fiji Platform with the central parts of the platform less seismically active. The earthquake hazard in Fiji is acknowledged as ranging from moderately low to very high.

A review of seismic risk within the Fiji Island group[8] has been undertaken and shows the location of earthquake epicenters around the Fiji Group (Figure 1-3-36) and the seismic risk zoning map derived based on this data (Figure 1-3-37). The Nausori area is located within a low risk zone for seismic activity.




Source: University of the South Pacific

Figure 1-3-36 Location of earthquake epicenters around the Fiji.




Source: University of the South Pacific

Figure 1-3-37 Seismic Risk Zoning Map[4]

### (15) Education and Literacy Rate

Table 1-3-14 and Table 1-3-15 show the literacy rate of adults and the younger generation, aged over and under 15 years old respectively. They revealed a literacy rate exceeding 95% for the younger generation ensured for the past 30 years, but the literacy rate for adults from 2000 to 2004 showed a lower average of 93% with a gap between genders. Based on these results, the Government of Fiji (GoF) published a 'Roadmap for Democracy and Sustainable Socioeconomic Development, 2010-2014', as one of the primary policies in the education field in Fiji to reinforce educational measures to improve

[8] Baleivanualala, V. 2009. The Works' estate subdivision – Kulukulu, Nadroga. The physical environment Study (part of EIA study, by the Institute of Applied Sciences, USP 2009).

the literacy rate, including the gender gap. Additionally, the GoF has dramatically increased the budget for primary school education since 2008 and been increasing the number of teachers and training sessions. Thanks to these measures, despite the lack of a compulsory education system in Fiji, the enrolment rate for primary school education for children aged between 6 and 13 is as high as over 85%.

Table 1-3-14 Literacy Rate for Adults in Fiji (2000-2004)

| Items | Literacy Rate (%) |
|---|---|
| Adult Male | 94 |
| Adult Female | 91 |
| Total | 93 |

Source: Fiji Education for All Progress Report for 2000-2015, Ministry of Education

Table 1-3-15 Literacy Rate for the Younger Generation (under 15)

| Year | 1980 | 1985 | 1990 | 2004 |
|---|---|---|---|---|
| Literacy Rate of Young Generation (%) | 95.0 | 96.8 | 97.8 | 99.0 |

Source: Fiji Education for All Progress Report for 2000-2015, Ministry of Education

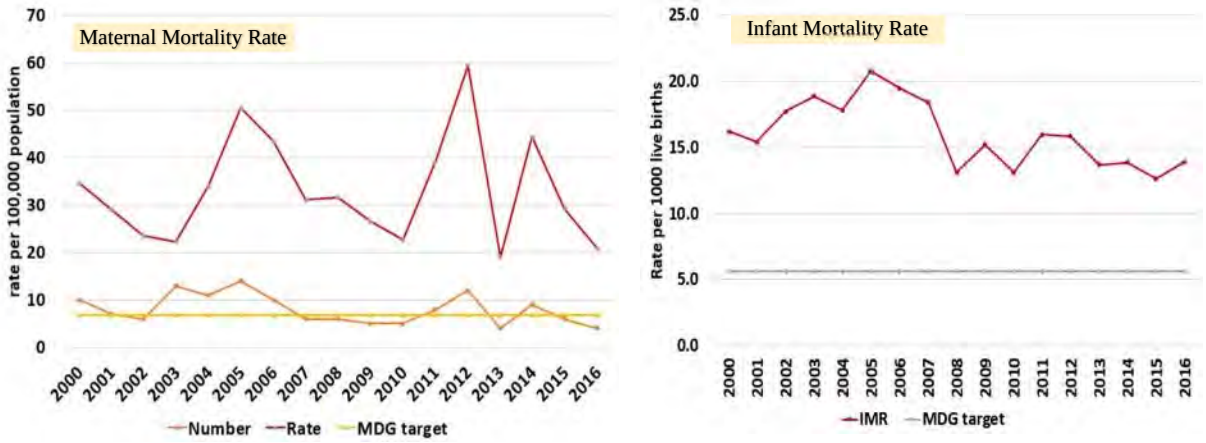
### (16) Hygiene Condition

The Ministry of Health and Medical Service articulates two Strategic Pillars: 'Preventive, curative and rehabilitative health services' and 'Health systems strengthening' as primary service priorities to provide every national citizen with quality health care to improve the quality of life. Table 1-3-16 shows life expectancy at birth in Fiji and shows how total life expectancy in years has improved by more than 4.0 years between 2008 and 2017. However, in terms of the Millennium Development Goal (MDG) prescribed by the United Nations, although the value of goals for the maternity mortality rate was satisfactorily achieved, that for the infant mortality rate of 14.0% remains high as it is targeted as 5.0% (Figure 1-3-38). Moreover, regarding the challenge of HIV cases spreading as one of the MDGs, there is an urgent need to establish countermeasures to control infectious diseases given the recent trend of increasing cases, as shown in Figure 1-3-39.

Table 1-3-2 Life Expectancy at Birth in Fiji

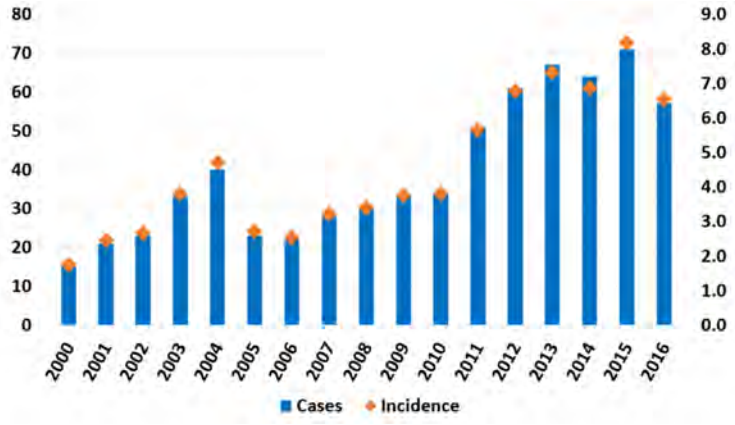
| | Female | Male | Total |
|---|---|---|---|
| 2017*1 | 75.80 | 70.30 | 73.00 |
| 2016 | 73.49 | 67.41 | 70.27 |
| 2015 | 73.32 | 67.28 | 70.12 |
| 2014 | 73.15 | 67.14 | 69.96 |
| 2013 | 72.98 | 66.99 | 69.80 |
| 2012 | 72.80 | 66.83 | 69.63 |
| 2011 | 72.61 | 66.67 | 69.45 |
| 2010 | 72.42 | 66.51 | 69.27 |
| 2009 | 72.22 | 66.34 | 69.09 |
| 2008 | 72.01 | 66.19 | 68.91 |

Source: '*' = CIA World Fact Book, other'countryeconomy.com'




Source: Health Status Report 2016, Ministry of Health and Medical Service

Figure 1-3-38 Maternal Mortality Rate and Infant Mortality Rate in Fiji



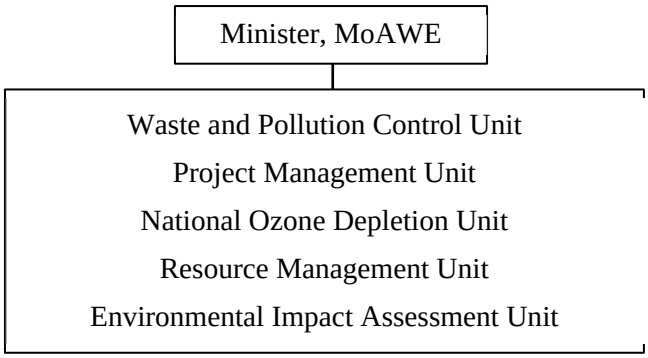

Source: Health Status Report 2016, Ministry of Health and Medical Service

Figure 1-3-39 HIV Cases in Fiji (2000-2016)

## 1-3-3 Environmental and Social Consideration Systems and Organizations

### (1) Organizational Framework

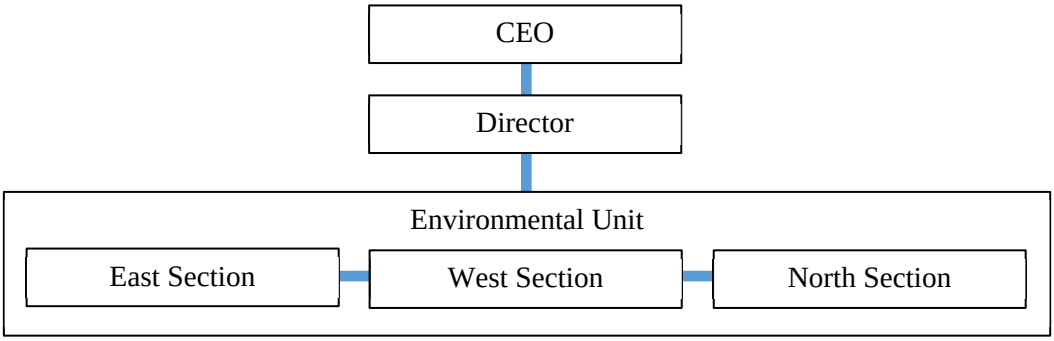
Governance related to the environment in Fiji is executed by the Ministry of Agriculture, Waterways and Environment (MoAWE), hereinafter referred as 'MoE'. (MoAWE has been restructured in 17th of April, 2020 from the Ministry of Waterways and Environment (MoWE)). Moreoverer, the MoE is in charge of issuing permission and supervision associated with an Environmental Impact Assessment (EIA) for any development project prescribed in the Environmental Management Act 2005. Actual works related to EIA are managed by the EIA Unit in the MoE. The organizational structure of the MoAWE is shown in the figure below.




Source: JICA Study Team based on the Interview with the MoE

Figure 1-3-40 Organizational Structure for the Ministry of Agriculture, Waterways and Environment

Regarding the unit relevant to environment and social consideration issues in FRA, as of May 2018, an Environmental Unit was established under the Director, comprising three sections divided by regional bases, to the west, east and north. The western and eastern sections cover each side of Viti Levu Island respectively, while the northern section covers all area of Vanua Levu Island. Each of the sections has one expert (for a total of three staff members) and it is expected that bringing more personnel on board in future will help in developing more road and bridge projects going forward.




Source: JICA Study Team based on the Interview with FRA

Figure 1-3-41 Organization Structure of the Environmental Unit for the Fiji Road Authority

**(2) Legal and System Framework**

Table 1-3-17 shows laws relevant to environmental issues with executive government agencies and general descriptions referred from the Environmental Management Act (EMA), 2005, while Table 1-3-18 summarizes the global and regional multilateral environmental agreements in Fiji.

Table 1-3-17 Law Relevant to Environment Issues

| Name | Executive Agency | Description |
|---|---|---|
| Factories Act (Cap. 99) | Ministry of Industry, Trade and Tourism | Specifies regulations on environmental and social considerations for factory development. |
| Fisheries Act (Cap. 158) | Ministry of Fishery | Specifies regulations on fishery rights for areas of development adjacent to river and oceans. |
| Forest Decree 1992 | Ministry of Forest | Specifies regulations on conserving forest resources for the conservation area and land owned by the MoL (mangroves excluded). |
| Ionizing Radiations Act (Cap. 102) | Ministry of Health and Medical Service | Specifies regulations on prevention of harm to health due to development activities with radioactive materials. |
| Litter Decree | Ministry of the Environment | Specifies regulations on waste management issues. |

| Name | Executive Agency | Description |
|---|---|---|
| Marine Spaces Act (Cap. 158A) | Ministry of Foreign Affairs | Specifies regulations for territory protection in marine areas. |
| Mining Act (Cap. 18) | Ministry of Land | Specifies conservation of natural resources for mining resource development. |
| Ozone Depleting Substances Act 1998 | Ministry of the Environment | Specifies regulations on activities related to ozone depletion associated with development projects. |
| Petroleum Act (Cap. 190) | Ministry of Industry, Trade and Tourism | Regulates activities which cause a negative environmental impact by management of crude oil and petroleum. |
| Public Health Act (Cap. 111) | Ministry of Health and Medical Service | Regulates activities threatening the health of people in the nation. |
| Rivers and Streams Act (Cap. 136) | Ministry of Land | Regulates activities which lead to the pollution of rivers and streams. |
| Quarries Act (Cap. 147) | Ministry of Land | Regulates activities which have adverse natural and social impacts by quarry development. |
| Sewerage Act (Cap. 128) | Ministry of Infrastructure and Meteorological Service | Regulates improper wastewater management leading to environmental pollution. |
| Town Planning Act (Cap. 139) | Ministry of Local Government | Regulates disorganized development actions leading to the deterioration of the social environment. |
| Employment Relations Act 2007 (No. 36 of 2007) and other relevant amendments | Ministry of Labor, Industrial Relations and Employment | Regulates employment matters to clarify employers and employee's right, including the working environment. |
| Water Supply Act (Cap. 144) | Ministry of Infrastructure and Meteorological Service | Regulates items for drinking water service to avoid confusion of the social environment and ensure people's health in the nation. |

Source: JICA Study Team based on the Environmental Management Act 2005

Table 1-3-18 Multilateral Agreements in Fiji

| # | Multilateral Environmental Agreement (MEA) | Ratified (R)/Approved (A) |
|---|---|---|
| I. Global Multilateral Environmental Agreements | | |
| A: Nature Conservation/Biodiversity related MEAs | | |
| 1 | Convention on Biological Diversity (CBD) | 25 February 1993 (R) |
| 2 | Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (UNCCD) | 26 August 1998 (A) |
| 3 | Convention on International Trade in Endangered Species of Wild Flora and Fauna 1973 (CITES) | 30 September 1997 (A) |
| 4 | The Convention on Wetlands | 11 September 2006 (R) |
| 5 | International Tropical Timber Agreement 2006 | 23 April 2010 |
| 6 | International Treaty on Plant Genetic Resources for Food and Agriculture | 9 July 2008 (A) |
| 7 | Convention Concerning the Protection of the World Cultural and Natural Heritage | 21 November 1990 |
| B: Hazardous Materials/Waste and Chemical related MEAs | | |
| 8 | Cartagena Protocol on Biosafety to the Convention on Biological Diversity | 5 June 2001 (R) |
| 9 | Stockholm Convention on Persistent Organic Pollutants | 20 June 2001 (R) |
| C: Climate Change/Atmosphere related MEAs | | |
| 10 | Vienna Convention for the Protection of the Ozone Layer 1985 | 23 October 1989 (A) |
| 11 | Montreal Protocol on Substances that Deplete the Ozone Layer 1987 | 3 October 1989 (A) |
| 12 | United Nations Framework Convention on Climate Change 1992 (UNFCCC) | 25 February 1993 (R) |
| 13 | Kyoto Protocol to the United Nations Framework Convention on Climate Change 1997 (Kyoto) | 17 September 1998 (R) |
| D: Marine and Freshwater related MEAs | | |
| 14 | United Nations Convention on The Law of The Sea 1982 (UNCLOS) | 10 December 1982 (R) |
| 15 | Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish stocks and Highly Migratory Fish stocks 1995 | 12 December 1996 (R) |
| II. Regional Multilateral Agreements | | |
| E: Ocean Governance and Fisheries | | |
| 16 | 1979 South Pacific Forum Fisheries Agency Convention | 10 July 1979 |
| 17 | 1990 Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific | 18 January 1994 |
| 18 | 1992 Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the | 5 March 1996 |

| # | Multilateral Environmental Agreement (MEA) | Ratified (R)/Approved (A) |
|---|---|---|
| | South Pacific Region | |
| 19 | 2000 Convention on the Conservation and Management of Highly Migratory Fish stocks in the Western and Central Pacific Ocean | 13 March 2001 |
| F: Chemicals, Hazardous Waste and Marine Pollution | | |
| 20 | 1985 South Pacific Nuclear Free Zone Treaty (Treaty of Raratonga) | 4 April 1985 |
| 21 | 1986 SPREP Protocol for the Prevention of Pollution of the South Pacific Region by Dumping (SPREP Dumping Protocol) | 18 September 1989 |
| 22 | 1990 SPREP Protocol Concerning Cooperation in Combating Pollution Emergencies in the South Pacific Region (SPREP Pollution Emergencies Protocol) | 18 September 1989 |
| 23 | Convention to Ban the Importation into Forum Island Countries of Hazardous and Radioactive Waste and to Control the Tran boundary Movements and Management of Hazardous Waste within the South Pacific Region 1995 (Waigani Convention) | 18 April 1996 |
| G: Biodiversity | | |
| 24 | 1976 Convention on the Conservation of Nature in the South Pacific (Apia Convention) | 8 September 1989 |
| H. Land and Marine Resources | | |
| 25 | 1986 SPREP (Noumea) Convention for the Protection of the Natural Resources and Environment of the South Pacific Region (SPREP Convention) | 18 September 1989 |

Source: University of the South Pacific

### (3) Gap Analysis between Fiji's Environmental System and JICA's Environmental Policy

Table 1-3-19 summarizes the results of gap analysis between Fiji's laws and systems related to environmental issues and JICA's environmental and social consideration policy.

Table 1-3-19 Gap between Fiji's Environmental System and JICA's Environmental Policy

| JICA guideline | Fiji's law and system | Gap between JICA's policy and Fiji's law and system | Basic Policy applied for the Project |
|---|---|---|---|
| **(Basic Policy)**<br>**Important Point 1:**<br>The types of impacts addressed by JICA cover a wide range of environmental and social issues.<br>**Important Point 2:**<br>JICA applies a Strategic Environmental Assessment (SEA) when conducting Master Plan Studies etc. and encourages project proponents etc. to ensure environmental and social considerations from an early stage to a monitoring stage.<br>**Important Point 3:**<br>JICA ensures accountability and transparency when implementing cooperation projects.<br>**Important Point 4:**<br>JICA incorporates stakeholder opinions into decision-making processes regarding environmental and social considerations by ensuring the meaningful participation of stakeholders to have consideration for environmental and social factors and to reach a consensus accordingly. JICA replies to stakeholders' questions. Stakeholders who participate in meetings are responsible for what they say.<br>**Important Point 5:**<br>JICA itself discloses information on environmental and social considerations in collaboration with project proponents etc., to ensure accountability and promote the participation of various stakeholders.<br>**Important Point 6:**<br>JICA strives to enhance the comprehensive capacity of organizations and operations in order for project proponents etc., to have consideration | **Important Point 1:**<br>'EMA' specifies that comprehensive analysis is required for impact analysis. Detailed environmental and social consideration items are prepared by the MoE with TOR based on the Environmental Management Regulation (EMR), 2007.<br>**Important Point 2:**<br>There is no rule on the application of SEA.<br>**Important Point 3:**<br>'EMA' specifies the provision of public participation during EIA preparation.<br>**Important Point 4:**<br>'EMA' regulates implementation of consultation to stakeholders by public hearing.<br>**Important Point 5:**<br>'EMR' requires public disclosure of EIA reports.<br>**Important Point 6:**<br>Reinforcement of capacity-building and structuring organization has progressed with the establishment of an environmental management unit by the FRA and it is expected to increase personnel | **Important Point 1:**<br>MoE will take the initiative on work to prepare TOR for detailed study items regarding environmental and social consideration for each project.<br>**Important Point 2:**<br>There is no rule on application of SEA for the stage of master plan.<br>**Important Point 3:**<br>There is no significant gap between the two.<br>**Important Point 4:**<br>There is no significant gap between the two.<br>**Important Point 5:**<br>There is no significant gap between the two.<br>**Important Point 6:**<br>There is no definite organization policy to prescribe reinforcement of organization structure and capacity-building for the issue of environmental and social considerations.<br>**Important Point 7:**<br>Acceleration for prompt project implementation and adequate environmental and | **Important Point 1:**<br>A survey is to be conducted in accordance with issues of environmental and social considerations in JICA GL and TOR prepared by the MoE.<br>**Important Point 2:**<br>No SEA is applied in the Project as it is in the design stage.<br>**Important Point 3:**<br>Accountability to local residents and transparency are ensured in accordance with JICA GL.<br>**Important Point 4:**<br>Environmental and social considerations study is carried out through stakeholder meetings in accordance with JICA GL.<br>**Important Point 5:**<br>Information on environmental and social considerations is actively disclosed in accordance with JICA GL.<br>**Important Point 6:**<br>Capacity-building of the environmental management unit involved in environmental and social considerations is promoted in accordance with JICA GL. |

| JICA guideline | Fiji's law and system | Gap between JICA's policy and Fiji's law and system | Basic Policy applied for the Project |
|---|---|---|---|
| for environmental and social factors, appropriately and effectively, at all times.<br>**Important Point 7:**<br>JICA addresses request of acceleration for the prompt implementation of projects while undertaking environmental and social considerations. | in charge of environmental and social issues.<br>**Important Point 7:**<br>Efforts for prompt project implementation are made within FRA. | social considerations are required. | **Important Point 7:**<br>Efforts are made to have the recognition of acceleration for the prompt project implementation and adequate environmental and social considerations within FRA. |

Source: JICA Study Team

### (4) Environmental Standards

Regarding environmental regulations in Fiji, the Environmental Management (Waste Disposal and Recycling regulations 2007) specifies regulatory values for air and water quality, but no regulations for noise and vibration exist. In the regulation regarding the methodology of monitoring, it is noted that the regulation requires the methodology to be applied in accordance with regulations in Australia for CO, NO2, OZONE and SO2 and in the USA for PM10. Table 1-3-20 compares environmental regulations among Fiji, Japan and other global organizations such as the IFC and WHO. With this comparison of environmental regulations in mind, basically the regulatory values in accordance with Fiji's and IFC/WHO's environmental regulation will be applied for this project supplemented by other organizations for those undefined. Table 1-3-21 clarifies the proposed environmental regulations to be applied for the project.

Table 1-3-20 Comparison of Environmental Regulations between Fiji, Japan and other Organizations

| Item | Unit | Standards | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fiji | | Japan | | IFC/WHO | |
| Air quality | | Residential, rural & other area | | - | | - | |
| $SO_2$ | ppm<br>µg/m³ | <350µg/m³ (1-hour of the 9-hour average)<br><570µg/m³ (anytime) | | <0.04ppm (daily average)<br><0.1ppm (per hour) | | <20µg/m³ (24-hour)<br><500µg/m³ (10 minute) | |
| $NO_2$ | ppm<br>µg/m³ | <200µg/m³ (1-hour of the 9-hour average) | | <0.04-0.06 ppm (daily average) | | <40µg/m³ (1-year)<br><200µg/m³ (1-hour) | |
| $PM_{10}$ (SPM) | mg/m³ | <0.05 (24-hour) | | <0.10 (daily average)<br><0.20 (per hour) | | <0.02 (1-year)<br><0.05 (24-hour) | |
| CO | ppm<br>mg/m³ | <10mg/m³ (1-hour of 8 hours average) | | <10mg/m³ (daily average)<br><20 (1-hour of 8 hours average) | | - | |
| Ozone (Ox) | ppm<br>µg/m³ | <150µg/m³ | | 0.06ppm (per hour)<br>(≒120µg/m³) | | <100µg/m³ | |
| Water quality | | Effluent Discharge | | Category B (agricultural use | Category C (industrial use) | Effluent Discharge | |
| pH | pH | 7-9 | | 6-8.5 | 6-8.5 | 6-9 | |
| SS | mg/l | <60 | | <25 | <50 | <50 | |
| BOD | mg/l | <40 | | <5 | <8 | <30 | |
| COD | mg/l | - | | - | - | <125 | |
| Coliform-Fecal | MPN/100ml | <400 | | <5,000 | | <400 | |
| Noise | | Residential zone | Industrial zone | Residential zone (B) | Industrial zone (C) | Residential zone | Industrial zone |
| dB (A) | dB (A) | - | | <55 (day)<br><45 (night) | <60 (day)<br><50 (night) | <55 (day)<br><45 (night) | <70 (day & night) |
| Vibrations | | | | | | | |
| dB | dB | - | | 55-65 | 75 | - | |

Source: JICA Study Team

Note: The Fijian environmental standard is referred from 'Environmental Management (Waste Disposal and Recycling regulations 2007)'

Table 1-3-21 Environmental Regulation to be Applied for the Project

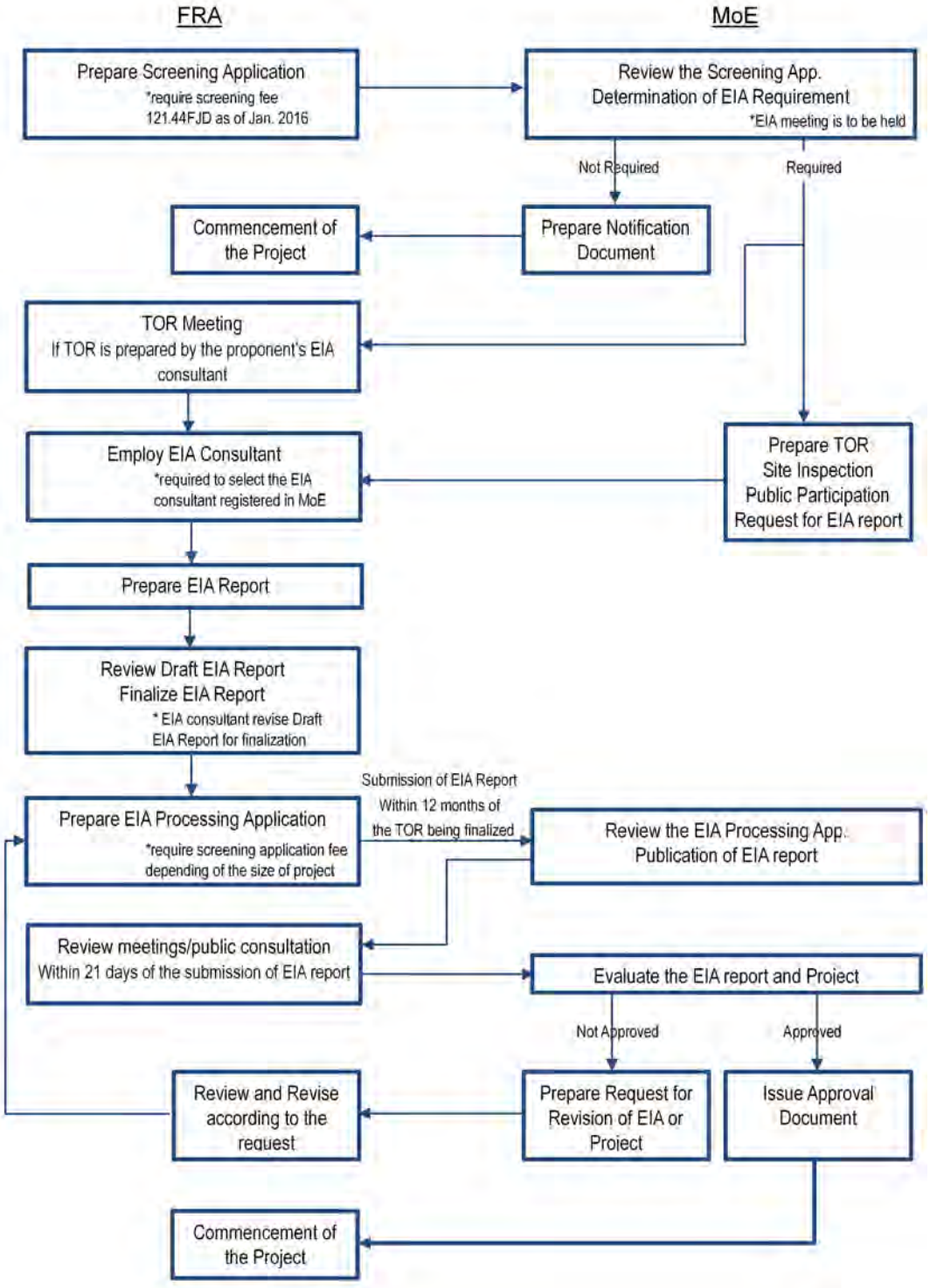
| Item | Unit | Standards to be Applied for the Project | | Referred from | Global Standard (IFC/WHO) | Remarks |
|---|---|---|---|---|---|---|
| Air quality | | Residential, rural & other area | | | | |
| $SO_2$ | ppm<br>µg/m³ | <350µg/m³ (1-hour of the 9-hour average)<br><570µg/m³ (anytime) | | Fiji | <20µg/$m^3$ (24-hour)<br><500µg/$m^3$ (10 minute) | |
| $NO_2$ | ppm<br>µg/m³ | <200µg/m³ (1-hour of the 9-hour average) | | Fiji | <40µg/$m^3$ (1-year)<br><200µg/$m^3$ (1-hour) | |
| $PM_{10}$ (SPM) | mg/m³ | <0.05 (24-hour) | | Fiji | <0.02(1-year)<br><0.05(24-hour) | |
| CO | µg/$m^3$ | <10mg/$m^3$ (1-hour of 8 hours average) | | Fiji | - | Only if equipment and laboratory are available |
| Ozone (Ox) | µg/$m^3$ | <150µm/$m^3$ | | Fiji | <100µm/$m^3$ | |
| Water quality | | Effluent Discharge | | | | |
| pH | pH | 7-9 | | Fiji | 6-9 | |
| SS | mg/l | <60 | | Fiji | <50 | |
| BOD | mg/l | <40 | | Fiji | <30 | |
| COD | mg/l | <125 | | IFC/WHO | <125 | |
| Coliform-Fecal | MPN/100ml | <400 | | Fiji | <400 | |
| Noise | | Residential zone | Industrial zone | | | |
| dB (A) | dB (A) | <55 (day) <45 (night) | <60 (day)<br><50 (night) | Japan | <70(day & night) | The industrial zone value will be applied |
| Vibrations | | Residential zone | Industrial zone | | | |
| dB | dB | 55-65 | 75 | Japan | - | The industrial zone value will be applied |

Source: JICA Study Team

### (5) Environmental Impact Assessment Procedure

#### 1) EIA Flow

The Environmental Impact Assessment procedure is clarified in the Environmental Management (EIA Procedure) Regulation 2007. All project proponents in Fiji must receive an EIA approval from the MoE. A project proponent involves submitting an EIA Screening Application (ESA) to the MoE in the early stage of the project, whereupon the MoE will prepare a TOR for environmental and social study for the project and request the proponent to prepare an EIA report based on the instructed TOR issued by the MoE. Once the proponent finalizes the EIA report with periodical internal reviews, the proponent submits the final EIA report with an EIA Processing Application (EPA) to the MoE. The MoE reviews the final EIA report and comments if any revision is required. There is no expiration period for the EIA approval defined in the regulation, however, any major modification of the project scope such as location or size must be documented and controlled on the project in question. Figure 1-3-42 summarizes the EIA procedural flow.




Source: JICA Study Team based on the Environmental Management Regulation 2007

Figure 1-3-42 EIA Procedure in Fiji

### 2) EIA and Other Procedures for the Project

Followed by the EIA procedure in Fiji, the project proponent, FRA for the project, must prepare the EIA report for the project and obtain EIA approval from the MoE before construction commences. In addition to the EIA approval, some other authorized documents such as permission and registration required to commence the construction works remain to be obtained by either FRA or the construction

contractor, including permission to infringe fishery rights, permission for soil dumpsite, registration for waste dump vehicles, permission to use a borrowed pit, permission to cut street trees, permission to enter the river area, permission to cut mangroves and permission to use the river surface water. Permission to use the quarry site would not be needed since the construction contractor would be capable of purchasing sufficient gravel and aggregates from licensed companies managing their quarry site in Fiji.

EIA approval for the New FRA Bridge spanning the Tamavua River to be conducted by the FRA was completed at the end of 2018. Conversely, since the bridge for this project differs from the modular bridge in terms of type and location, the need to prepare an EIA report for this project and obtain MoE approval was confirmed through discussion with FRA. Table 1-3-22 summarizes the types of permission to be obtained to commence construction works.

Table 1-3-22 Summary of Environmental Permission

| # | Name | Applied by/to | Requirements |
|---|---|---|---|
| 1 | EIA approval | FRA/MoE | A project proponent must receive an EIA approval for an EIA report for the project in question. The approved EIA report will be delivered to the relevant local governments, which then proceed to disclose information to the local residents. |
| 2 | Permission to infringe fishery rights | FRA/Fishing license owner | When a project is located adjacent to a river or marine area, the project proponent must obtain permission to infringe fishery rights from licensed fishermen of the river or marine area. The process of obtaining permission shall be managed based on a form waiving fishing rights and consensus-building with tradition fishing right owners. If mutual agreement cannot be reached with said owners, the proponent must prepare to provide monetary compensation with the coordination of the Ministry of Fishery. Compensation will be evaluated based on the size and quality of the fishing ground by the Ministry of Fishery. For the project of the Tamavua-i-wai bridge construction, permission can be adopted with the single agreement document, which has been managed by the FRA for the New FRA Bridge project in advance. The agreement document, including permission to infringe fishery rights, is supposed to form a set with a mutual agreement with both the fishermen groups as the family of Turatoga un Tui Suva (traditional fishing rights owners) and FRA before June 2018. |
| 3 | Permission for soil dumpsite | Contractor/Landowner (private or MoL) | Before commencing construction works, the project proponent shall obtain agreement and permission to use the soil dump site from the landowner thereof with a management report defining the methodology of dumping, volume and the type of dump soil involved. The management report shall be prepared by the construction contractor. For the Tamavua-i-wai Bridge Construction Project, agreement and permission need not be obtained since all the earthworks during the construction works are managed with a large fill volume and no cut soil is expected. |
| 4 | Registration for waste dump vehicle | Contractor/ MoE | Before commencing construction works, all the vehicles managed by the construction contractor involved with the waste dump must be registered to enter the designated dump site in Fiji. Registered waste dump vehicles will be able to carry construction waste to the Naboro Landfill located 15km west of the construction site. The construction waste can include general waste, concrete and asphalt debris. Dumping of any other industrial waste, such as oil or chemicals, at the Naboro Landfill is prohibited and the contractor has to entrust a licensed company capable of managing industrial waste to ensure it is treated properly. |
| 5 | Permission for borrowed pit use | Contractor/ Landowner (private or MoL) | When a project requires soil to be filled for earthworks during construction, the construction contractor must obtain agreement and permission to use the borrowed pit from the landowner of proposed borrowed pit. The construction contractor shall submit an application to use the borrowed pit with an earthwork plan clarifying the volume of soil required from the borrowed pit as well as the detailed location and methodology of the excavation. |
| 6 | Permission for cutting street trees | Project proponent (FRA)/Relevant local government (Suva City) | When a project requires street trees to be cut down, the project proponent must name the construction contractor and obtain permission to cut down street trees from the relevant district with a management report to define the areas of tree cutting, defining the areas, quantity and species of cut trees as well as feasibility. The permission only extends to cutting large-sized trees. For the Tamavua-i-wai Bridge Construction Project, several large-sized trees exist near the existing bridge along Queen Road and the FRA must name the construction contractor and obtain permission to cut street trees from the Suva City Council. |

| # | Name | Applied by/to | Requirements |
|---|---|---|---|
| 7 | Permission to enter river area | Contractor/MoL | Since it is necessary to enter the Tamavua River to construct approach roads and bridge piers as well as cut mangrove trees during the Tamavua-i-wai Bridge Construction Project, permission to enter the river area is required from the Ministry of Land managing the inland water area as Crown Land including a river in Fiji. |
| 8 | Permission for mangrove cutting | Contractor/ MOF | It is expected that mangrove cutting will be needed, partly in the Tamavua River, to construct the approach roads and bridge. Since the mangrove forests in Fiji are managed by the Ministry of Forestry, FRA with the name of construction contractor shall obtain permission to cut mangrove forests from the Director of Lands. A formatted application shall be submitted with a management plan in the EIA report specifying mitigation measures for vegetation recovery and a monitoring plan. |
| 9 | Permission for river surface water usage | Contractor/ MoL | When a project requires the extraction of water for construction use, the construction contractor must obtain a special water rights for the use of water to be applied to the Lands Director (LD). The construction contractor is to submit application letter for special use of water with an estimation clarifying volume of water required from the river/stream as well a detailed location and methodology of extraction. |

Source: JICA Study Team

#### 3) EIA approval for the new FRA Bridge

The construction of the New Tamavua-i-wai Bridge accompanying with construction of two carriageways in a single direction stands for a main objective of mitigating road safety against the existing condition of passing the damaged bridge as well as traffic congestion caused by future traffic increase, and this objective would be accomplished by a collaboration with the New FRA Bridge with two carriageways in a single direction to be constructed in parallel. Since both bridge construction projects will be carried out separately, and are not approved as one combined project, consequently it will be necessary to have an individual EIA approval for each bridge construction project. In addition, viability of the project will be confirmed with the accomplishment of project outcome even though without the New FRA Bridge. Besides, the EIA report for the New FRA Bridge was submitted to MoE on August 2019, and an approval document was issued on August, 2019.

### 1-3-4 Comparison of Alternatives (Including the Zero Option)

Under the National Development Plan, the Government of Fiji has defined national road transportation as one of the priority sectors to be developed and widening the projected section of Queens Road from two to four lanes could reduce periodic and chronic traffic congestion and has been desired by citizens of Suva City and Lami Town or other business sectors, either traffic safety or economic advantage.

Following all the related discussions about reconstructing the Tamavua-i-wai Bridge between FRA and JICA, it was agreed that widening the road section on the Tamavua-i-wai River could be fulfilled by constructing two new bridges functioning as a two-lane road and in a single direction respectively. Accordingly, the bridge construction project was adjusted to have two bridge constructions on the road section to be conducted in parallel. One is carried out by the FRA and the other is carried out under Japan's grant aid scheme referred to as the New Tamavua-i-wai Bridge.

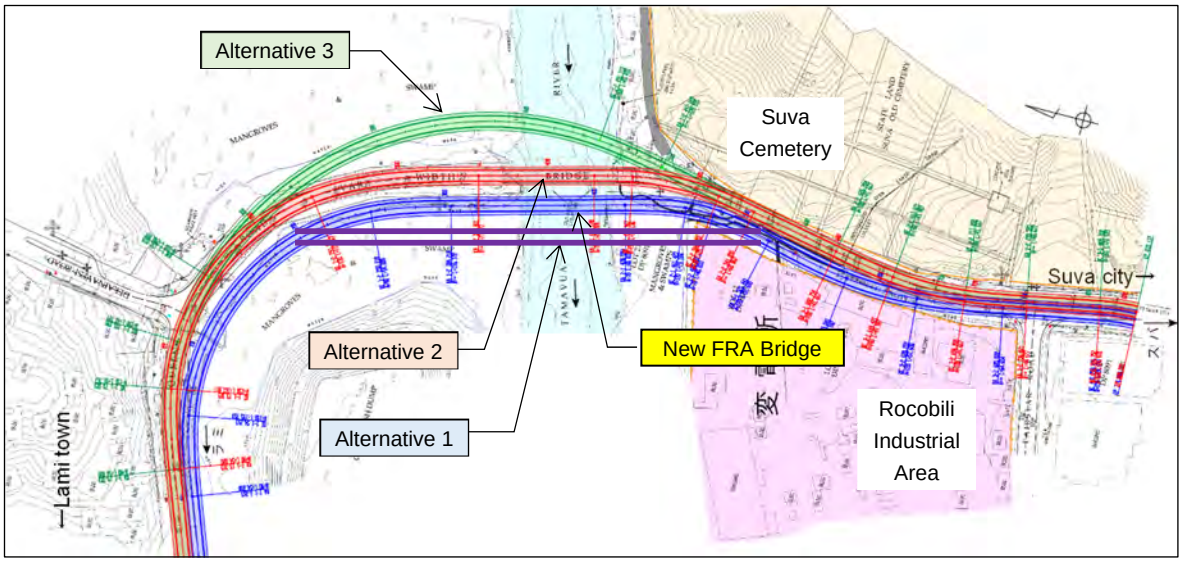
In the early stage of the survey, four cases were determined, including a zero option for the New Tamavua-i-wai Bridge construction project.

Table 1-3-23 shows the results of the alternative analysis corresponded with Figure 1-3-43, of which the alternative 3 was evaluated as the most appropriate solution for the project.

Table 1-3-23 Alternative Analysis for the New Tamavua-iwai Bridge Construction

| | | | | | |
|---|---|---|---|---|---|
| Alternative 1 | Overview: Bridge reconstruction on the downstream side of the existing bridge | | | | |
| | Economic efficiency | Need for an approach road | Need for detour | Workability | Environmental and social consideration |
| | - Bridge is approx. 90m long and there is no requirement to destroy substructures.<br>- Ratio of the construction cost: 1.08 compared to Alternative 3. | - An approach road will be needed.<br>- The alignment of the new approach roads will require complicated coordination with constructed one. | - No detour required during construction by operating the existing road. | - The availability of a construction yard near the projected site proved unworkable. | - Cutting part of the mangrove vegetation will be required.<br>- No involuntary resettlement is necessary.<br>- Land acquisition will be required for the land in the Power Plant. |
| | (Evaluation) △<br>- Access roads will be necessary, but since a temporary bridge and bypass route can be dispensed with, it is economically efficient.<br>- No involuntary resentment is needed, but land acquisition will be needed and part of the mangrove vegetation will have to be cut. | | | | |
| Alternative 2 | Overview: Reconstruction on the existing bridge location | | | | |
| | Economic efficiency | Need for an approach road | Need for detour | Workability | Environmental and social consideration |
| | - The bridge is approx. 90m long and substructures will have to be destroyed to construct the new bridge.<br>- No need a temporary bridge by utilizing the New FRA bridge.<br>- Ratio of the construction cost: 1.00 compared to Alternative 3. | - No new alignment of the approach roads will be necessary, but the roads will have to be elevated based on hydrological analysis.<br>- Existing alignment will be ensured. | - A temporary bridge and attached detour will not have to be constructed by utilizing the New FRA Bridge. | - A construction yard will be available by the existing road on Lami side.<br>- Workability will be ensured by utilizing the New FRA Bridge and approach roads. | - Mangroves will have to be cut down, however vegetation recovery after the construction works will be expected.<br>- No involuntary resettlement is necessary.<br>- The bus stop on both the Suva and Lami sides will have to be relocated. |
| | (Evaluation) ○<br>- The approach roads are not newly aligned, and a safety measure to elevate the road height following a natural disaster will be implemented.<br>- Unnecessary construction of a temporary bridge can be evaluated in high economic perspective.<br>- Although the required area is limited, part of the mangrove vegetation will have to be cut. | | | | |
| Alternative 3 | Overview: Bridge reconstruction on upstream side of the existing bridge | | | | |
| | Economic efficiency | Need for an approach road | Need for detour | Workability | Environmental and social consideration |
| | - The bridge is approx. 90m long and substructures will have to be destroyed to construct the new bridge.<br>-This accounts for base ratio of the construction cost, 1.00. | - An approach road will be necessary.<br>- No interference with the boundary of Suva Cemetery. | - No detour will be necessary during the construction by operating the existing road. | - A construction yard will be available by the existing road on Lami side.<br>- Workability will be ensured by utilizing the New FRA Bridge and approach roads. | - Part of the mangrove vegetation will have to be cut.<br>- No involuntary resettlement is necessary.<br>- The bus stop on both the Suva and Lami sides will have to be relocated. |
| | (Evaluation) ○-<br>- Since the existing bridge or New FRA Bridge will be operated, a temporary bridge and detour need not be constructed.<br>- Construction of new approach roads are required and no involuntary resettlement of one residential house will be necessary.<br>- Although the required area is limited, part of the mangrove vegetation will have to be cut. | | | | |
| Zero option | Overview: No bridge to be constructed | | | | |
| | Economic efficiency | Need for an approach road | Need for detour | Workability | Environmental and social considerations |
| | - The bridge will have to be constructed in the near future. | Not applicable | Not applicable | Not applicable | - Residents living near the bridge face ongoing threats of natural disaster and annoying traffic noise.<br>- Awareness of the damaged bridge for pedestrians crossing the existing bridge remains. |
| | (Evaluation) X<br>- People will suffer from ongoing daily congestion.<br>- Awareness of possible regional segregation, when natural disaster hits and destruction of the existing bridge occurs, will be sustained. | | | | |

Source: JICA Study Team




Source: JICA Study Team

Figure 1-3-43 Alternative Plans

## 1-3-5 Scoping Analysis and TOR for Environmental and Social Survey

### (1) Scoping Analysis

For this project, the scope will be determined based on JICA GL for Social Environmental Considerations (April 2010). The results of the scoping analysis associated with the environmental items referred from the road and bridge construction sector project are given in Table 1-3-24.

Table 1-3-24 Scoping Analysis (P: Planning, C: Construction, O: Operation)

| Category | # | Environmental items | Evaluation | | Reason for evaluation |
|---|---|---|---|---|---|
| | | | P/C Phase | O Phase | |
| Measures against pollution | 1 | Air pollution | D/B- | B- | P Phase: Before the work, there were no activities causing air pollution.<br>C Phase: Deterioration of air quality is expected if vehicular traffic congestion is generated. The operation of heavy machinery and construction equipment may result in a temporary deterioration in air quality (including dust).<br>O Phase: With the increase in vehicular traffic, the quality may decline due to emissions of gases and dust. The impact is limited since the new bridge is far from the area with a concentration of homes. |
| | 2 | Water pollution | D/B- | D | P Phase: There would be no activity polluting the river water.<br>C Phase: There is the possibility of contamination of the rivers resulting from the use of construction machines.<br>O Phase: There would be no activity resulting in contamination of the rivers. |
| | 3 | Waste | D/B- | D | P Phase: There would be no activity generating waste.<br>C Phase: Generation of construction waste as well as general waste from workers are expected.<br>O Phase: No waste will be generated. |
| | 4 | Soil pollution | D/B- | D | P Phase: There would be no activity causing contamination of soil.<br>C Phase: There is a possibility of soil being contaminated from the use of construction machines.<br>O Phase: There is no elements which may contaminate the soil. |
| | 5 | Noise and vibrations | D/B- | B- | P Phase: There would be no activity which may increase noise and vibrations.<br>C Phase: Noise will be generated due to the operation of heavy machinery and building equipment.<br>O Phase: The negative impact created by noise and vibrations with an increase in vehicular traffic will be involved. |
| | 6 | Subsidence of terrain | D | D | There are no activities (such as large-scale pumping of underground water) which may cause the terrain to subside. |
| | 7 | Odors | D/B- | D | P Phase: There would be no activity which may create an odor nuisance.<br>C Phase: An odor nuisance may be generated by waste from workers' camp if wastewater is not adequately treated.<br>O Phase: There would be no activity which may cause an odor nuisance. |
| | 8 | Sediments from riverbeds | D/B- | D | P Phase: There are no activities which may cause changes in the riverbed sediments.<br>C Phase: There may be an impact on riverbed sediments due to substructure construction works in the |

| Category | # | Environmental items | Evaluation | | Reason for evaluation |
|---|---|---|---|---|---|
| | | | P/C Phase | O Phase | |
| | | | | | river.<br>O Phase: There would be no elements which may cause changes in the riverbed sediments. |
| Natural environment | 9 | Protected areas | B-/B- | B- | P, C Phases: The location of the protected area near the project site shall be clarified.<br>O Phase: Some negative impacts would be involved depending on the location. |
| | 10 | Ecosystem | D/B- | B- | P Phase: There would be no activity which will generate an impact on the ecosystem of the area surrounding the construction site.<br>C Phase: Some negative impacts on the surrounding ecosystem are expected depending on the vulnerability of the natural environment.<br>O Phase: Some negative impacts would be involved depending on the condition of the natural environment around the project site. |
| | 11 | Hydrological conditions | D/B- | B- | P Phase: There would be no activity which will affect the hydrological systems of the river.<br>C Phase: Some impacts would be involved depending on the type of construction works.<br>O Phase: Some impacts would be involved depending on the bridge design. |
| | 12 | Topography of terrain, geology of soils | D/B- | D | P Phase: There would be no activity which may affect the topography of the land and soil.<br>C Phase: Some negative impacts would be involved depending on whether the design required cut and fills.<br>O Phase: Some negative impacts such as slope erosion would be involved if the new approach road were to include an embankment. |
| Social environment | 13 | Resettlement and land acquisition | B-/B- | D | P Phase: For the bridge construction project, residents affected by involuntary resettlement and land acquisition for approach roads construction must be considered.<br>C and O Phase: There are no activities which may require land acquisition and involuntary resettlement since displacement of involuntary resettlement shall be completed. |
| | 14 | Poverty | B-/B- | B+ | P Phase: Among the population to be relocated (PAPs), some people may belong to poverty groups.<br>C Phase: If adequate considerations are taken before starting to relocate poor people, a negative impact may be avoided.<br>O Phase: To construct the new bridges, a positive impact on the local economy contributed by structuring effective logistic environment after building the new bridge is projected. |
| | 15 | Ethnic minorities and indigenous peoples | D | D | In and around the project area are no ethnic minorities or indigenous peoples. |
| | 16 | Local economy such as employment and livelihood | D/B+ | B+ | P Phase: No impact on the local economy would be expected during the planning phase.<br>C Phase: Employment of locals or a new business opportunity could be ensured for the construction works.<br>O Phase: Some progress of the local economy could be expected based on the renewal of the existing bridge. |
| | 17 | Land use and local resources | B-/B- | D | P Phase: There would be some negative impacts if modification of land use is required for private land.<br>C Phase: Some negative impacts would be involved if significant local resources are located.<br>O Phase: No impact is expected after the construction. |
| | 18 | Water use/rights | D/B- | D | P Phase: There are no activities which may generate an impact on the use of water.<br>C Phase: Water from the river would be pumped for washing clothes and daily use. Some negative impact may be generated by the turbulence of water during implementation of the work.<br>O Phase: There are no activities which may generate an impact on the use of water. |
| | 19 | Existing social infrastructures and social services | B-/B- | B+ | P Phase: No social facilities such as educational, medical and religious facilities expected for the project are relocated. However, relocation of lifelines such as power, telecommunication and drinking water lines could affect the living conditions of residents.<br>C Phase: Since the road function will be retained during construction, accessibility to Suva Cemetery and the power station adjacent to the project site would be affected. Traffic congestion would be expected in case that diversion routes are required during the construction.<br>Bus stops at both sides of Tamavua-i-wai bridge will have to relocate, which could make public transport less convenient.<br>O Phase: The elevation of the new approach roads exceeds that of the present roads and access to the area near the roads may become difficult. Conversely, the construction of a new bridge will help ensure accessibility to the Suva District and regional safety. |
| | 20 | Social capital and social structure of regional decision-making organizations | D/D | D | P Phase: No negative impact on social capital in the region near the construction site is expected.<br>C and O Phase: No impact is foreseen regarding the social capital and social structure of regional decision-making organizations. |
| | 21 | Misdistribution of benefits and damage | B-/D | B+ | P Phase: If land acquisition and relocation are not managed correctly, this may lead to an unjust distribution of damages and benefits.<br>C Phase: Since the compensation activity is completed before commencing the construction works, a potentially unjust balance of damages and benefits in the surrounding areas is not projected.<br>O Phase: No misdistribution of benefits and damages in the region is expected. Otherwise transport accessibility and natural disease tolerance in the region will be improved. |

| Category | # | Environmental items | Evaluation | | Reason for evaluation |
|---|---|---|---|---|---|
| | | | P/C Phase | O Phase | |
| | 22 | Local conflict of interests | B-/D | D | P Phase: Depending on ownership of the land to be acquired, there could be some conflict with the community in the region near the project site.<br>C, O Phase: No negative impact is expected after commencing the construction works. |
| | 23 | Cultural Heritage | D/D | D | P, C and O Phase: Phase: No cultural heritage is found in the area around the project site. |
| | 24 | Landscape | D/B- | D | P Phase: There are no activities which may generate an impact on the landscape.<br>C Phase: The landscape around the project comprises the river near the river mouth and the mangrove vegetation along the river, plus the Suva Cemetery near the bridge on a slightly sloped field with scattered large trees. There would be some tree cutting activity along the road required for the project, which could cause the regional landscape to deteriorate.<br>O Phase: There are no activities which could generate an impact on the landscape. |
| | 25 | Gender | B-/B- | D | P Phase: Problems regarding equality in women's rights to compensate for land expropriation and the resettling process may arise.<br>C Phase: Potential negative impact on gender balance caused by neglect of job opportunity for the residence correlated with the construction operation.<br>O Phase: No negative impacts regarding gender issues are foreseen in the present project. |
| | 26 | Children rights | B-/B- | D | P Phase: Problems may arise regarding the rights of children with respect to compensation for land expropriation and the relocation process.<br>C Phase: Problems may arise with the rights of children when obtaining the necessary labor force to execute the works depending on the relevant measures carried out by the Fiji Government.<br>O Phase: The project would not be related to any issues concerning children's rights. |
| | 27 | Infectious diseases such as HIV/AIDS (including hygiene condition) | D/B- | D | P Phase: No impact is estimated for transmitted diseases such as HIV/AIDS in the present project.<br>C Phase: Infectious diseases may spread due to the influx of workers on site.<br>O Phase: No impact of infectious diseases such as HIV/AIDS is estimated in the present project. |
| | 28 | Working conditions (including work safety) | D/B- | D | P Phase: There is no element related to the working environment before commencing the works.<br>C Phase: Some negative impacts may be generated regarding safe labor conditions in case technically difficult tasks are carried out by local workers.<br>O Phase: There are no activities which may involve a deterioration of work conditions. |
| Others | 29 | Accidents | D/B- | B+ | P Phase: No works which could cause accidents will be carried out during the planning phase.<br>C Phase: There is an increased risk of workers or residents in the area having an accident due to the increase in work vehicles.<br>O Phase: Depending on the design, pedestrian safety will be ensured. |
| | 30 | Impact of crossing borders and climate change | D/D | B+ | P Phase: No negative impact would be expected during the planning phase.<br>C Phase: No negative impact would be expected given the modest size of project.<br>O Phase: By paving the bridge and making structural improvements, there may be scope to reduce greenhouse gas emissions to secure smooth running of vehicles by comparing current conditions. |

Note: A+/-: An important positive or negative impact is projected, B+/-: There may be some positive or negative impacts, C+/-: The occurrence of a positive or negative impact has not been determined (a more detailed study must clarify the impact). D: No impact is projected.
Source: JICA Study Team

### (2) TOR for Environmental and Social Survey

Study methods for each environmental and social criterion are selected based on the rating of scoping and summarized in the following table in relation to the TOR specified in Table 1-3-25.

Table 1-3-25 TOR for Environmental and Social Survey

| Environmental Impact Item | Item of Study | Study Method |
|---|---|---|
| Air quality | ① Verification of environmental standards in Fiji<br>② Study of existing air quality conditions<br>③ Estimate of the degree of traffic volume increase<br>④ Verification of the location of residences, schools and hospitals in the area near the project<br>⑤ Impact while implementing work | ① Review of existing materials<br>② Measurement survey at the site<br>③ Estimate of impact based on predictions of traffic demand<br>④ In-situ study, interviews<br>⑤ Verification of construction work content details. |
| Water quality | ① Verification of water quality norms and standards in Fiji<br>② River water quality<br>③ Status of the domestic use of river water<br>④ Verification of the scope and scale of the impact while implementing work | ① Review of existing materials<br>②, ③ In-situ studies, interviews in areas adjacent to the project<br>④ Verification of construction work content details. |
| Waste | ① Waste treatment method while implementing work (waste in general, construction waste, excavated soil) | ① Interviews with related organizations, compilation of past cases. |
| Soil pollution | ① Verification of the scope and scale of impacts while implementing work | ① Verification of construction work content details. |

| Environmental Impact Item | Item of Study | Study Method |
|---|---|---|
| Noise, vibrations and odors | ① Verification of environmental standards in Fiji<br>② Verification of the scope and scale of impact (distances from the place of origin up to residential areas, hospitals and schools)<br>③ Impact while implementing work | ① Review of existing materials<br>② In-situ studies (measurement survey at the site), interviews<br>③ Verification of construction work content details. |
| Sediments from riverbeds | ① Verification of the scope and scale of impact on the torrent | ① Checking of study results on the actual status of the torrent and verification of work content details. |
| Protected areas | ① Understanding of regulations on the development of projects in the buffer zone for protected areas | ① Review of existing materials. |
| Ecosystem | ① Verification of the impact on flora and fauna of the project zone and adjacent areas | ① Review of existing materials, interviews in project and adjacent areas and in-situ studies (especially identification of vegetation, aquatic species). |
| Hydrological conditions, topography of terrain and geology of soils | ① Verification of the river ecosystem of the present and past<br>② Impact while implementing work | ① Review of existing materials<br>② Verification of construction work content details. |
| Resettlement and land acquisition | ① Verification of the need for and scope of land acquisition and the relocation of residents<br>② Other subjects related to resident relocation plans | ① In-situ studies, measurements to indicate scope<br>② Interviews with the Project-Affected Persons (PAPs), related organizations and organize related existing resources. |
| Poverty | ① Verification of socioeconomic activities carried out in the project area and adjacent areas<br>② Verification of whether a poverty level exists | ① Study of social conditions based on interviews for the PAPs. |
| Land use and local resources | ① Verification of the present status of land use<br>② Verification of the status of the use of local resources in areas around the project<br>③ Knowledge of the impact, scope and scale | ① Review of existing materials, in-situ studies<br>② In-situ studies, interviews with local residents<br>③ Verification of construction work content details. |
| Water use/rights | ① Verification of the environment for use of water around the project zone | ① In-situ studies, interviews with related organizations and with the local. |
| Existing social infrastructure and social services | ① Verification of the existence or absence of residential areas, schools, health centers and approach roads | ① Review of existing materials, interviews with related organizations, in-situ studies. |
| Social capital and social structure of regional decision-making organizations | ① Verification of the surroundings of the existing social capital<br>② Understanding the impact on the social structure | ① Review of existing materials, interviews with related organizations<br>② In-situ studies, interviews with local residents. |
| Misdistribution of benefits and damage | ① Verification of social equity within communities in the project area | ① In-situ studies, interviews with local residents, interviews with related organizations. |
| Local conflict of interests | ① Confirmation of the existence of conflicts in the communities in the project area | ① In-situ studies, interviews with local residents, interviews with related organizations. |
| Landscape | ① Verification of the elements comprising the regional landscape | ① In-situ studies, interviews with local residents. |
| Rights according to gender and of children | ① Verification of social equality within communities in the project area | ① In-situ studies, interviews with local residents, interviews with related organizations. |
| Infectious diseases such as HIV/AIDS | ① Incidence of HIV/AIDS in areas near the project | ① Review of existing materials, interviews with related organizations. |
| Working conditions | ① Verification of labor standards in Fiji | ① Review of existing materials. |
| Accidents | ① Degree of increase in traffic accidents during service | ① Estimates based on the review of existing materials. |

Source: JICA Study Team

## 1-3-6 Environmental and Social Survey

### (1) Overview of Site Investigation

Table 1-3-26 shows an overview of the preliminary site investigation carried out by the JICA Study Team on May 7, 2018 to identify the current environmental and social condition of surrounding environment of Tamavua-i-wai Bridge.

Table 1-3-26 Overview of Site Investigation

| Surrounding Environment of Tamavaua-i-wai Bridge | |
|---|---|
| Natural Environment | · The current Tamavua-i-wai Bridge is located in the west of Suva City near the city border between Suva City and Lami Town and approx. 56.0m wide. The alignment of the river has an 'L' shape on the upstream side followed by the L-shaped hill range on the area north to east of the river streaming 500m straight up to the north and turning west along the hill scout.<br>· Mangrove vegetation approx. 50 to 250m wide spreads on the side west upstream of the bridge.<br>· Regarding the area downstream of the bridge, an open mangrove vegetation 12 to 42 m wide spreads out to the east and there are the Lami Landfill Premises with filled hills to the west. Although the landfill was developed by reclaiming part of the mangrove forest, vegetation of the landfill has been recovered by covering the topsoil layer since its capacity for filled waste was reached five years ago. However, no space is left for recovering mangrove vegetation.<br>· The river flow velocity is low and there is no significant turbidity found in the river water caused by the tide (1.2m)<br>· There is a large street tree located on the east side of the bridge end with a trunk 1.0m wide and more than 10m high and there is concern over the potential for a disaster to be caused if the tree falls during heavy rain with a high tide. |
| Social Environment | · There are 30 settlements identified in the area between the river and community road along the river on the upstream side, approx. 450m long from the Tamavua-i-wai Bridge and it is confirmed that all are illegal encroachers.<br>· Regarding the east hill upstream of the Tamavua River, there is Suva Cemetery developed on a gentle hill by cutting forests and part of the hill is used for a borrowed pit and privately managed logistic station.<br>· Across from the cemetery lies Rocobili power station (8,700m²); developed in the reclamation area and controlled by Fiji Electricity Authority.<br>· A heavy traffic volume of general vehicles and public buses is identified on the bridge since it is the only arterial road connecting the east area including Suva City and Lami Town and the west side of Viti Levu.<br>·There are bus stops near the bridge on both sides for daily transportation of citizens. A police box is located on the east side of the bridge. |

| | | |
|---|---|---|
|  |  |  |
| Photo 1 River mouth and Lami Landfills premises | Photo 2 Mangrove vegetation on the west upstream side | Photo 3 Large tree at the east bridge end |
|  |  |  |
| Photo 4 Adjacent to Suva Cemetery | Photo 5 Encroached settlement at the east bridge end | Photo 6 Narrow pedestrian walk and fishing activity in the river |

Source: JICA Study Team

### (2) Results of the Environmental and Social Survey

Results from the survey of pollution condition and natural environment around the project site are summarized below.

#### 1) Air Quality.

As described in the previous section, most of the wind comes from the south-east. Air quality in and around the project site will be influenced by a range of factors, including:

• Wind direction and strength.

• The vehicles that travel to and from Suva City along the Queens Road.

• Daily activities associated with adjacent residential and commercial properties, including burning of vegetation and domestic waste, etc.

Air quality monitoring was undertaken on 9 August, 2018 using an Air-Met Scientific MX6 meter equipped with NO2 (Nitrogen Dioxide) and SO2 (Sulfur Dioxide) sensors and an Aeroqual Series 500 meter for measuring PM10 concentrations from four locations along Queens Drive. The sites were located as follows:

- Residential properties located: on the Queens Road approx. 300m north of the existing Bridge; in Delanivisi Village on the corner of Kauvula and Kaudama Roads; and Kalili Settlement located directly adjacent to the eastern side of the bridge.
- The Delanivisi Police Post located in Delanivisi on the northern side of Queens Road and approx. 230m from the existing bridge.
- A commercial property (car wash) located adjacent to the Energy Fiji Limited (EFL) substation approx. 150m south of the existing bridge.

Table 1-3-27 and Figure 1-3-28 summarize the information relating to the sites used to collect environmental data. PM10 measurements were taken every minute for a minimum of 10 minutes between 1,000 and 1,125. The comparative standard is based on the Environment Management (Waste Disposal and Recycling) Regulations Fiji 2007 Dust and Gas Guidelines outlined in Schedule 5. The key points to note are as follows:

- For most sampling events at all four locations, mean $PM_{10}$ concentrations were below the guideline concentration of 50 mg/m³. However, on two occasions at Sites 3 (Delanivisi Police Post) and 4 (Kalili Settlement) with 68.8 ± 6.5 mg/m³ (9/8 am) and 82.5 ± 102.2 mg/m³ (8/8 pm) respectively, the guideline concentration was exceeded.
- $NO_2$ and $SO_2$ were below the detection limits (0.0 mg/m³) and below guideline concentrations (200 & 350 mg/m³ respectively for $NO_2$ and $SO_2$).

Overall, the air quality is consistent with that of urban areas, where predominant activities are typical of those undertaken in a city of Suva's size and extent.

Table 1-3-27 Summary of Site Locations and Environmental Monitoring

| Site # | Measurement Location | GPS Coordinates | Parameter | | | | |
|---|---|---|---|---|---|---|---|
| | | | $PM_{10}$ | $NO_2$ | $SO_2$ | Noise | Vibration |
| 1 | House on Queens Drive (Delanivisi Village) | S18°06'45.8" E178°25'46.4" | ✓ | ✓ | ✓ | ✓ | - |
| 2 | Delanivisi Village | S18°06'39.9" E178°25'46.4" | - | - | - | ✓ | - |
| 3 | Delanivisi Police Post | S18°06'46.6" E178°25'48.4" | ✓ | ✓ | ✓ | ✓ | ✓ |
| 4 | Kalili Settlement | S18°06'55.3" E178°25'52.9" | ✓ | ✓ | ✓ | ✓ | - |
| 5 | Car wash | S18°06'49.4" E178°25'51.1" | ✓ | ✓ | ✓ | ✓ | - |
| 6 | Lovonilase Cemetery | S18°06'46.8" E178°25'56.9" | - | - | - | ✓ | - |
| 7 | Hemraj Place | S18°06'26.7" E178°26'25.9" | - | - | - | ✓ | - |

Source: JICA Study Team

Table 1-3-28 Summary of Air Quality Monitoring Data (mean ± SD (range) median (n) presented)

| Parameter | Date | Site #1 | Site #2 | Site #3 | Site #4 | Fiji Guideline |
|---|---|---|---|---|---|---|
| | | House on Queens Drive | Delanivisi Village | Delanivisi Police Post | Kalili Settlement | |
| $PM_{10}$ | 8 Aug., pm | 28.5 ± 42.2 (8-159) 17.5 (12) | 12.1 ± 4.0 (4-12) 12.0 (27) | 35.8 ± 49.5 (10-179) 18.5 (12) | 41.4 ± 54.5 (10-212) 20 (18) | <50 |
| | 8 Aug., pm | 20.0 ± 6.0 (13-29) 20.5 (10) | 19.2 ± 3.9 (13-25) 18 (10) | 82.5 ± 102.2 (7-323) 34 (12) | 20.1 ± 6.8 (11-36) 18 (15) | |
| | 9 Aug., pm | 41.8 ± 16.8 (18-73) 37 (12) | 68.8 ± 6.5 (58-78) 69.5 (10) | 46.3 ± 38.6 (20-160) 35 (12) | 22.4 ± 10.2 (13-48) 19 (18) | |
| $NO_2$ | 8 Aug., am | 0.0 | 0.0 | 0.0 | 0.0 | <200 |
| | 8 Aug., am | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 9 Aug., am | 0.0 | 0.0 | 0.0 | 0.0 | |
| $SO_2$ | 8 Aug., am | 0.0 | 0.0 | 0.0 | 0.0 | <350 |
| | 8 Aug., pm | 0.0 | 0.0 | 0.0 | 0.0 | |
| | 9 Aug., am | 0.0 | 0.0 | 0.0 | 0.0 | |

Source: JICA Study Team

### 2) Water Quality

Water quality sampling was undertaken in August 2018, at one site (WQ1) within the main tidal channel of the Tamavua River, over which the Tamavua-i-wai Bridge traverses. In-situ field measurements were recorded at low tide using an Aqua DO2 (dissolved oxygen, temperature) and TPS WP-81 (pH, conductivity, salinity) water quality meters.

A water sample was also collected for laboratory analysis within the required timeframes and using standard analytical procedures as described in APHA9 (1995). The water sample was kept cool in a chilly bin (cooler box) and delivered to the IANZ-accredited Watercare Services Limited laboratory in Auckland (New Zealand) for analysis. The water sample was analyzed for a range of parameters including: turbidity, total suspended solids (TSS), ammonia, total oxidized nitrogen (TON), total kjeldahl nitrogen (TKN), total nitrogen (TN), dissolved reactive phosphorous (DRP), total phosphorous (TP), Escherichia coli (E.coli), total coliforms and fecal coliforms.

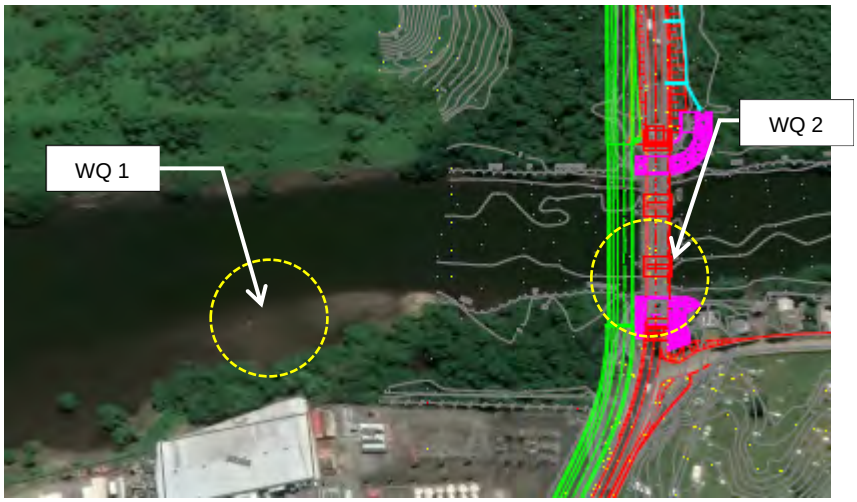
[9] APHA: American Public Health Association

A comparison of water quality data collected from the site visit was made against the values from the guideline in Fiji and the ANZECC (2000) trigger values for slightly to moderately disturbed estuarine ecosystems in tropical Australia, is provided in Table 1-3-29.

Table 1-3-29 A comparison of water quality data for samples collected at Site WQ1 with accepted guidelines

| Parameter | Unit | Site WQ1 | Site WQ2[10] | Guidelines[11] | Fiji Guideline |
|---|---|---|---|---|---|
| pH | pH units | 7.68 | 7.75 | 7.0 - 8.5 | 7-9 |
| Temperature | °C | 23.6 | 25.7 | - | <38 |
| Conductivity | µS/cm | 22.3 | 45.6 | - | - |
| TDS | ppk | 16.8 | 22.3 | - | - |
| Dissolved Oxygen (DO) | mg/L | 5.1 | 8.11 | - | - |
| Dissolved Oxygen (DO) | % | 78.8 | - | 80-120 | - |
| Biochemical Oxygen Demand (BOD) | mg/L | - | 1.22 | - | <40 |
| Turbidity | NTU | 3.5 | 2.17 | 1 - 20 | - |
| Total Suspended Solids (TSS) | mg/L | 9.6 | 12.7 | - | <60 |
| Ammonia | mg/L | 0.049 | - | 1.32/1.56[12] | <10 |
| Total Oxidized Nitrogen (TON) | mg/L | 0.041 | - | 0.03 | - |
| Total Kjeldahl Nitrogen (TKN) | mg/L | <0.1 | - | - | - |
| Total nitrogen (TN) | mg/L | 0.07 | 0.02 | 0.25 | <25 |
| Dissolved Reactive Phosphorous (DRP) | mg/L | 0.008 | - | 0.005 | - |
| Total Phosphorous (TP) | mg/L | 0.012 | - | 0.02 | <25 |
| E.coli | MPN/100mL | 1,300 | - | 35 & 230[13] | - |
| Total Coliforms | MPN/100mL | >2,400 | - | 150 & 1,000 | - |
| Fecal Coliforms | MPN/100mL | 4,400 | 235 | 400[14] | <400 |

Sampling Location




Source: JICA Study Team

Note: Fijian environmental standard is referred from 'Environmental Management (Waste Disposal and Recycling regulations 2007)'

The water quality assessment found that:

- The pH (7.7) was within the ANZECC (2000) default trigger value range of pH 7.0-8.5. The temperature data (23.6°C) reflects the time of day the samples were collected.
- The conductivity (22.3 µS/cm) and TDS (16.8 ppk) concentrations reflect the fact that samples were collected at low tide where freshwater inputs dominated.

[10] EIA report for Tamavua-i-wai Bridge, 2017 (FRA)
[11] ANZECC (2000) default trigger values for slightly to moderately disturbed estuarine ecosystems in tropical Australia
[12] Freshwater and marine trigger values at pH of 7.8.
[13] Primary and secondary contact
[14] Fiji Draft Sustainability Development Bill criteria for Class: swimming AA (coastal)/B (port) waters.

- The dissolved oxygen saturation (78.8%) was just below the ANZECC (2000) trigger range of 80-120%. Dissolved oxygen concentrations are typical for estuarine environments.
- Turbidity concentration (3.5 NTU) is within the ANZECC (2000) default trigger value range of 1-20 NTU. The TSS concentration (9.6 mg/L) is low.
- The total ammonia concentration (0.049 mg/L) is well below the ANZECC (2000) default trigger values of 1.32 and 1.56 mg/L for freshwater and marine ecosystems respectively.
- The total oxidized nitrogen concentration (0.041 mg/L) exceeds the ANZECC (2000) default trigger values of 0.03 mg/L for estuarine ecosystems.
- The total nitrogen concentration (0.007 mg/L) is below the ANZECC (2000) default trigger values of 0.25 mg/L for estuarine ecosystems.
- The dissolved reactive phosphorus concentration (0.008 mg/L) exceeds the ANZECC (2000) default trigger values of 0.005 mg/L for estuarine ecosystems.
- The total phosphorus concentration (0.012 mg/L) is below the ANZECC (2000) default trigger values of 0.02 mg/L for estuarine ecosystems.
- Escherichia coli concentrations indicate exceedance of ANZECC (2000) guideline values for primary contact (35 MPN/100mL) and secondary (230 MPN/100mL) contact.
- The total concentration of coliforms indicates non-compliance with ANZECC (2000) guidelines for primary contact i.e. swimming, etc. (150 MPN/100mL) and secondary contact i.e. line fishing, etc. (1000 MPN/100mL).
- Fecal coliform concentration data (4,400 MPN/100mL) indicates non-compliance with Fiji Draft Sustainability Development Bill criteria for Class: swimming AA (coastal)/B (port) waters of 400 MPN/100mL.

In summary, parameters tested in a water sample collected in the current survey are typically within the ANZECC (2000) default trigger value for estuarine systems in tropical Australia with the exception of total oxidized nitrogen dissolved reactive phosphorus concentrations and bacteria (E. coli, total coliforms and fecal coliform) which exceed limits. Despite the fact the value of fecal coliform was below the limit in 2017, water quality has deteriorated within a year.

**3) Noise**

Noise levels were measured using an IEC-compliant Rion NL-52EX-RT noise meter on 27 and 28 June 2018 at several locations in and around the Project site including: on the Queens Road approx. 300m north of the existing Tamavua-i-Wai Bridge; in Delanivisi Village on the corner of Kauvula and Kaudama Roads; and Kaleli Settlement located directly adjacent to the eastern side of the bridge; Delanivisi Police Post; Kaleli settlement on Tamavua Road; the Car Wash located adjacent to the EFL substation; Lovonilase Cemetery; and adjacent to residential properties in Hemraj Place off Princes Road.

Each measurement was conducted for 10-second intervals, with three measurements taken at each site for between one and three occasions depending on the site.

Table 1-3-30 presents the noise survey results, with the key points to note as follows:

- The quietest locations are adjacent to the residential properties located in Hemraj Place and within Delanivisi Village with levels of between 48.8-55.5 and 51.0-56.7 dB respectively recorded.
- The nosiest location was in the houses in the Kaleli Settlement located adjacent to Tamavua-i-wai Bridge and Delanivisi Police Post, where readings of between 64.4 - 77.5 and 65.3-74.0 dB were recorded.

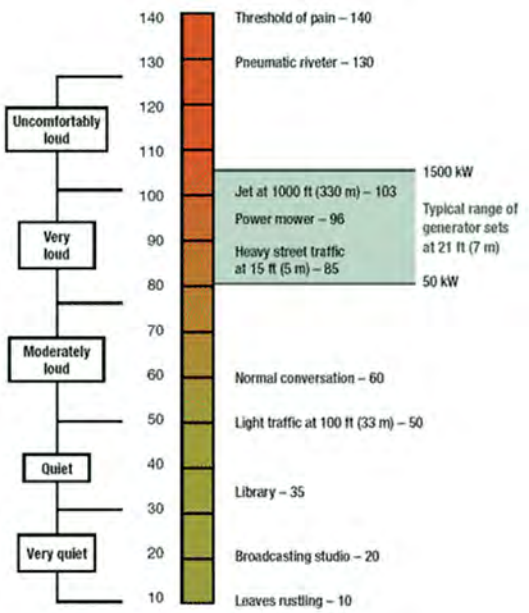
Figure 1-3-44 presents typical noise levels and sources. All the locations are at the low end of the typical 'moderately loud' noise environments. Overall, the noise survey results indicate 'moderately loud' current noise levels and are consistent with urban areas that have moderate to high vehicular traffic movements. This level of current noise at the Bridge is typical of other locations within and surrounding Suva City.

Traffic generated by vehicles travelling to and from Suva City along Queens Road was the main source of noise generated, with various car and truck movements observed during the site visit. Apart from traffic noise, the Project site has few activities considered significant in terms of noise generation. The residential properties located adjacent to the Bridge and along the western part of Queens Road are the nearest sensitive receptors, since they're located directly adjacent to the Road. The Government Institutions, Schools and Universities are considered less sensitive as they are generally set back from the Road.

Table 1-3-3 Noise Survey Results

| Site | Date / time | LAeq (dB) |
|---|---|---|
| 1 | 27-06-2018; 1:00 pm | 63.2 – 63.8 |
| | 27-06-2018; 4:57 pm | 63.8 – 67.6 |
| | 28-06-2018; 8:15 am | 65.4 – 69.0 |
| 2 | 27-06-2018; 2:31 pm | 51.5 – 56.7 |
| | 28-06-2018; 10:40 am | 51.0 – 51.6 |
| 3 | 27-06-2018; 10:56 am | 67.8 – 69.6 |
| | 27-06-2018; 4:23 pm | 65.3 – 71.5 |
| | 28-06-2018; 10:49 am | 67.0 – 74.0 |
| 4 | 27-06-2018; 1:16 pm | 66.8 – 69.1 |
| | 27-06-2018; 5:11 pm | 66.8 – 77.5 |
| | 28-06-2018; 10:06 am | 64.4 – 67.4 |
| 5 | 27-06-2018; 1:12 pm | 65.9 – 69.4 |
| | 27-06-2018; 5:06 pm | 61.6 – 65.0 |
| | 28-06-2018; 8:24 am | 59.3 – 62.5 |
| 6 | 27-06-2018; 1:33 pm | 58.0 – 59.8 |
| 7 | 27-06-2018; 1:44 pm | 48.8 – 52.1 |
| | 28-06-2018; 10:13 am | 52.8 – 55.5 |

Source: JICA StudyTeam




Source: Aaberg, A., 2018, 'Controlling unwanted noise from on-site power systems'

Figure 1-3-44 Typical noise levels and sources

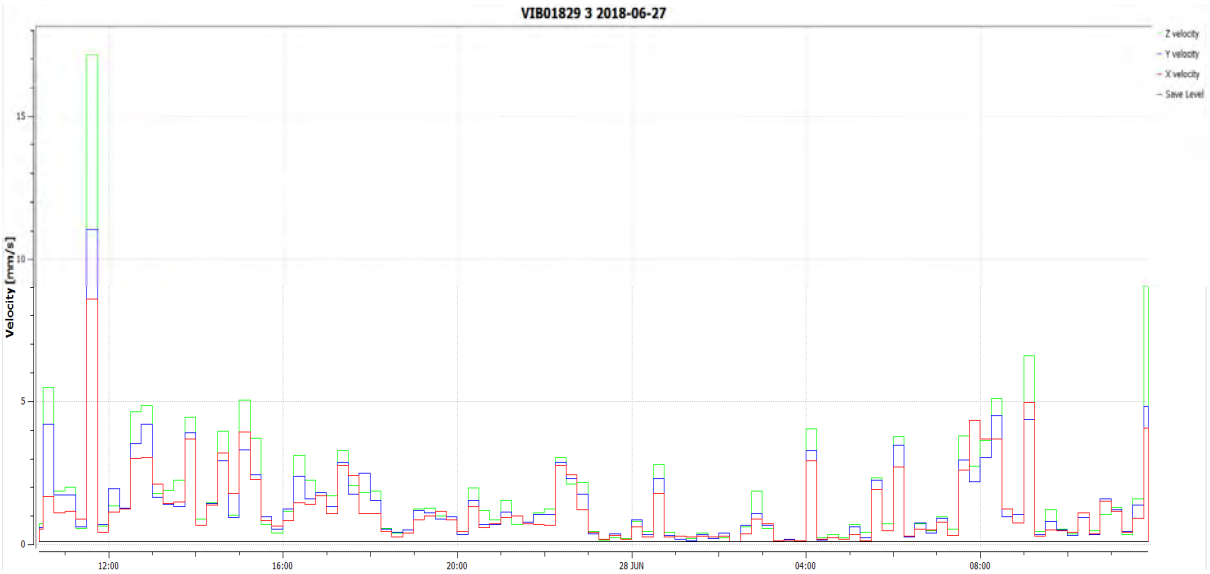
**4) Vibration**

Ambient vibration was measured for around a 24-hour period between 10:24 on 27 June, 2018 to 11:51 on 28 June, 2018 using a Profound Vibra ground vibration data logger. The sensor for the logger was placed on a pile of the Delanivisi Police Post (shown in Figure 1-3-45) located directly adjacent to Queens Road and approx. 220m from the west part of the proposed bridge location.

Source: JICA Study Team

Figure 1-3-45 Installed vibration sensor and logger at Delanivisi Police Box

Figure 1-3-46 presents the PPV (peak particle velocity) results for the monitoring undertaken. The key point to note is that PPV values were typically recorded at a level from 0.5 to 5 mm/s, peaking at 17 mm/s.




Source: JICA Study Team

Figure 1-3-46 PPV results for the vibration monitoring undertaken at Delanivisi Police Box

The British Standard BS 5228-2: 2009 outlines human response guidelines for vibration effects (see Table 1-3-31), which indicates that the current baseline vibration environment (typically <10 mm/s) adjacent to Queens Road already constitutes a level likely to bother and trigger complaints among residents of nearby residential properties.

Table 1-3-31 Human Response Guidelines for Vibration Effects

| Vibration level | Effect |
|---|---|
| 0.14 (mm/s) | Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration. |
| 0.3 (mm/s) | Vibration might be just perceptible in residential environments. |
| 1.0 (mm/s) | Vibration at this level in residential environments will trigger complaints. |
| 10 (mm/s) | Any more than a very brief exposure to this level of vibration is likely to be intolerable. |

Source: British Standard BS 5228-2: 2009

### 5) Solid Waste

General waste collected by a consigned company by local government is transported and treated at the Naboro Landfill, located approx. 15km west of the Tamavua-i-wai Bridge. The receiving areas are prepared by excavating earthworks from existing hill ranges, whereupon the waste is dumped and stacked on waterproof sheets stretched over the base of the planned fills to avoid soil pollution. There is no waste sorting policy required at the fills and any leachate collected from the waterproof sheet is treated in ponds located lower down the fills. When the dumped waste reaches a certain height, the top of the fill is covered in a layer of cap soil to help the vegetation recover. Concrete and asphalt debris from the construction site of the New Tamavua-i-wai Bridge will be dumped at the Naboro Landfill, but waste oils and other chemicals will have to be managed and treated by a specially registered company for detoxification or recycling, since such waste is not accepted by the Naboro Landfill. Figure 1-3-47 shows photos of the Naboro Landfill.

| | | |
|---|---|---|
|  |  |  |
| Photo 1 Waste Fill area (foreside) and Treatment Pond (backside) | Photo 2 Filled Waste (right) and Covered Topsoil (left) | Photo 3 Waterproof sheet on Base (before fill) |

Source: JICA Study Team

Figure 1-3-47 Current Condition of Naboro Landfill

### 6) Ecological Environment Baseline

A baseline assessment of the ecological resources (marine and freshwater habitats) and the water quality of the Tamavua River and adjacent coastal marine area potentially impacted on as a result of the Project works was undertaken as part of this EIA. The results of this survey are based on semi-quantitative site investigations undertaken in August 2018.

Following is a summary of the key findings of this ecological baseline assessment:

#### a) Aquatic/Estuarine Ecology

The coastal marine habitat flora (mangroves) and fauna present in and immediately adjacent to the site to the Tamavua-i-wai Bridge site were recorded during the site visit.

A qualitative assessment of the habitat adjacent to Queens Drive and Tamavua-i-wai Bridge was undertaken and key species identified and described. Mangroves, present in the Tamavua River and various locations across the upper intertidal zone adjacent to the Bridge, were also described.

#### i) Habitat Type

The habitat types directly adjacent to the Project site comprise the following:

- The area to the east of the northern approach to the new bridge dominated by mangroves; and
- The muddy sands and muds of the intertidal and subtidal channel area of Tamavua-i-wai.

Figure 1-3-48 shows images of the typical environment on and adjacent to the Project site. These habitat types are common in the coastal environment around Viti Levu.

Source: JICA Study Team

Figure 1-3-48 Typical coastal marine habitat present adjacent to the Tamavua-i-wai Bridge towards the channel (left) and mangrove areas (right)

### ii) Intertidal Flora and Fauna

The benthic communities adjacent to the Tamavua-i-wai Bridge are limited and mainly dominated by crustaceans including: fiddler crab Uca volcans, U. coarctata tetragonon and U. perplexa; rock crab Grapsus sp; and hermit crab Calcinus herbsti and C. perlatus; mangrove mud crab Scylla serrata in the adjacent mangroves (refer Table 1-3-31).

Bivalve mollusks attach to rocky surfaces, including the rock oyster Ostrea edibilis and occasional mussels Septifer bilocularis; and a range of species buried in the substrate, including Ark Shell Barbatia larceta, Sunset Shell Asaphis violacens, Cardita Clam Trachycardium orbita, Venus Shell Periglypta reticulata and Pen Shell Pinna bicolor.

Table 1-3-32 Marine fauna of the intertidal area adjacent to Tamavua-i-wai Bridge

| Type | Common Name | Scientific Name |
|---|---|---|
| Crustacea | Fiddler crabs | *Uca volcans* |
| | | *U. coarctata tetragonon* |
| | | *U. perplexa* |
| | Rock crab | *Grapsus sp* |
| | Hermit crab | *Calcinus herbsti* |
| | | *C. perlatus* |
| | Mangrove mud crab | *Scylla serrata* |
| Mollusk bivalve | Rock oyster | *Ostrea edibilis* |
| | Mussels | *Septifer bilocularis* |
| | Ark shell | *Barbatia lacerata* |
| | Sunset Shell | *Asaphis violascens* |
| | Cardita Clam | *Trachycardium orbita* |
| | Venus Shell | *Periglypta reticulata* |
| | Pen Shell | *Pinna bicolor* |

Source: Ecological Resource Assessment Report arranged by the JICA Study Team

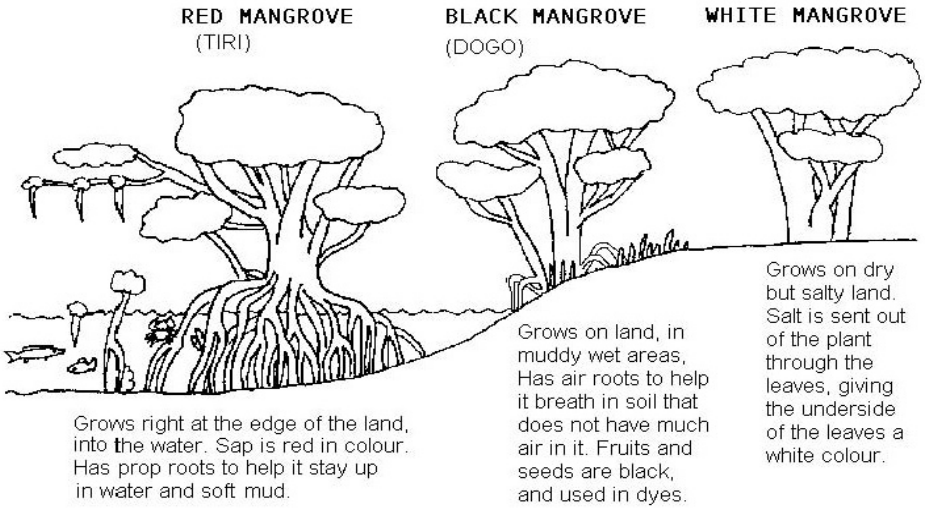
Overall, the benthic habitat in the new bridge abutment footprint, dominated by muddy sands, is characterized by a limited range of species found throughout Fiji which have no particular ecological conservation significance.

### iii) Mangrove

Mangroves in Fiji comprise seven main species of trees, which can be categorized into three functional groups depending on growth habit (see Figure 1-3-49):

- Red mangrove (‘Tiri’) which grow at the water’s edge, with “prop” roots that stabilize trees in soft mud and wave zones. There are two species of trees which live in this manner and one sterile hybrid when both species are present. Red Mangroves comprise: *Rhizophora stylosa* usually found directly fronting the sea; *R. samoensis* usually found closer to rivers; and the hybrid *R. selela* comprising taller trees found in mixed forest.
- Black mangrove (‘Dogo’) or *Bruguieria gymnorhiza* usually found behind red Mangroves in muddy areas that flood at high tide. They may have prop or elbow roots that protrude out of the mud and sometimes both.
- White mangroves, which are very salt-tolerant trees that grow on dry land immediately behind the wet mangrove areas and can survive occasional saltwater inundation and salty soil. The

four species comprise: *Lumnitzera littorea; Heritiera littoralis*; milky mangrove *Excoecaria agallocha*; and puzzlenut tree *Xylocarpus granatum.*




Source: Marine Ecology Consulting, 2007, 'Mangrove Management Plan for Resorts in the Fiji Islands'

Figure 1-3-49 Mangrove Zones based on Growth Habit

The Environment Management Act 2005 recognizes mangroves as "an ecosystem of national importance" requiring approval for projects from the Environment Impact Assessment Administrator for "a proposal that could damage or destroy … mangrove swamp …"

It was previously estimated that over 38,000 ha of mangrove forest existed in Fiji, most of which on Viti Levu and Vanua Levu and that more than 60% of Fiji's commercially important food fish use the mangrove at some stage of their life cycle.

The mangroves present adjacent to the Project site form part of the Suva Locale[15], which extends from Wailekutu Creek in Lami in the west to Samambula River in Suva to the east.

An investigation undertaken in 2007 and examining the mangrove resources present in the lower Tamavua River found that:

- The lower river is dominated by a range of native and introduced species common to mangrove communities, which tallies with that previously described. *Rhizophora samoensis* and *Bruguiera gymnorhiza*, common to the Suva Bay area, are the most dominant of the mangrove species. The mangrove species considered most highly threatened, *Limnocitrus littoralis*, *Xylocarpus granatum* and *Heritiera littoralis*, are scarcer and distributed evenly throughout, meanwhile there is no highly threatened species in the proposed tree-cutting area.
- There is evidence of anthropogenic impacts such as tree felling (cutting) and strip barking, particularly of *Bruguiera gymnorhiza*, which occurs throughout the lower River floodplain. There is, however, considerable regeneration through seedlings and sprouting from cut stems, for a range of species in both areas.
- Key mangrove species (red and black) in the upper part of the study reach show greater signs of environmental stress (leaf deformity and discoloration), which is likely due to the harsh conditions in which these trees prevail as opposed to anthropogenic influences.

[15] Watling, D., 1983. A mangrove management plan for Fiji. Phase II. A plan for the mangroves of the Nadi Bay and Suva-Navua locales. Report prepared for the Mangrove Management Committee.

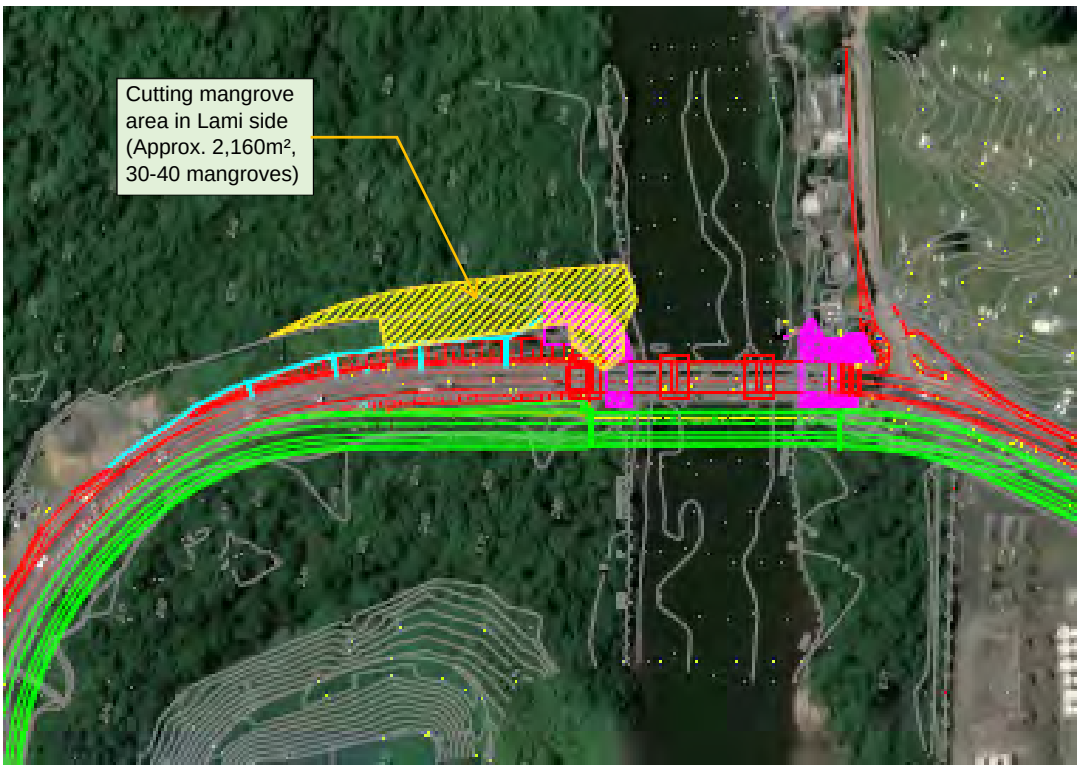
Site observations in August 2018 revealed mangroves present on both upstream and downstream sides of the Bridge. The mangroves in this location are dominated by Tiriwai (Rhizophora samoansis) with occasional Dogo (Bruiguiera gymnorhiza). Figure 1-3-50 shows images of the various mangroves stands present.

*Rhizophora samoensis* is described as a 'Near Threatened' species in the IUCN Red List and of *Bruguiera gymnorhiza* 'Of least concern'.

Source: JICA Study Team

Figure 1-3-50 Mangroves present adjacent to the Tamavua-i-wai Bridge, upstream (left) and downstream (right) of the Bridge, August 2018

Figure 1-3-51 illustrates the area where mangrove vegetation must be cut, calculated as a total of approx. 2,160 m²; comprising five multi-trunk mangroves on the Suva side and 1,000 m² equating to around 30-40 multi-trunk mangroves on the Lami side.




Source: JICA Study Team

Figure 1-3-51 Area of Cutting Mangrove

### iv) Fish Resources

A number of previous studies have also been undertaken on the fish populations of the Tamavua River and its surroundings.

An investigation of freshwater fish fauna, undertaken to inform the design of a representative forest reserve network in the Fiji Group of Islands (Jenkins, 2003), identified a total of seven Priority Ichthyofaunal Areas. The Tamavua River system (including Savura Creek) was ranked fifth out of seven sites in terms of conservation importance, namely due to:

- Relatively high overall diversity (53 species);
- Highly unusual fauna (e.g. the snake eel *Yirkala gjellerupi*); and
- High levels of endemism (approximately half of all endemic Fiji species).

The highest proportion of species present in the Tamavua River were either amphidromous or estuarine migrants (21% each), with the next most common type catadromous opportunists or freshwater stragglers (14% each).

An investigation of the fish resources present in the proposed Rokobili Port Area, close to where the Tamavua River joins the coast, was also undertaken by the Fijian Fisheries Department (see Whippy Morris et al., 2001) and fish populations at the mouth of the Tamavua River were investigated as part of the EIA associated with the proposed Rokobili Port (see Hughes & Movono, 2005). In summary both studies found that fish abundance and diversity were considered low with mostly small sizes present, likely due to over-fishing or disturbances from other human activities such as shipping, boating and pollution.

Other fish species reportedly present in the Suva Bay area include sergeant majors (Abedufduf sp.), puller (Chromis sp.), humbugs (Dascyllus sp.), garfish (Hemirhamphus sp.) blennies and common damsel fish (Pomacentrus sp.) along the shoreline adjacent to the Walu Bay wharf (Odense, 1992) and RSYC (Tamata & Odense, 1993; Wilson & Ram. 1998).

An investigation of the fish resources present in Tamavua River itself was undertaken in September 2007 (Argo, 2007) for an EIA prepared as part of the proposed Carpenters development approx. 600m upstream of the Tamavua-i-wai Bridge, which included monitoring sites directly upstream and downstream of the Bridge.

Gill nets were used to assess the types of fish resources present. Two 50m-long nets (with 1¾-inch mesh) were deployed by boat. Two types of locations were sampled: the main river channel; and the smaller side channels traversing the mangrove areas. Table 1-3-33 presents the species caught during the 2007 investigation. Photos of the fish caught at the sites directly upstream and downstream of the Tamavua-i-wai Bridge are shown in Figure 1-3-52.

Table 1-3-33 Summary of Fish Species in the Tamavua River

| Species | Common Name | Life History Pattern | IUCN Red List Classification |
|---|---|---|---|
| *Sphyraena barracuda* | Barracuda | Marine Migrant (MM) | Of least concern |
| *Leognathus equulus* | Ponyfish | Estuarine Migrant (EM) | - |
| *Sardinella fijiense* | Fiji sardine | Marine Migrant (MM) | Of least concern |
| *Mugil Cephalis* | Sea mullet | Catadromous Opportunist (COP) | - |
| *Caranx papuensis* | Trevally | Marine Migrant (MM) | Of least concern |

| Species | Common Name | Life History Pattern | IUCN Red List Classification |
|---|---|---|---|
| *Lutjanus argentimaculatus* | Mangrove red snapper | Catadromous Opportunist (COP) | Of least concern |
| *Eleotris melanosoma* | Broadhead sleeper | Amphidromous | Of least concern |
| *Trichiurus haumela* | Ribbonfish | Marine Migrant (MM) | Of least concern |
| *Upeneus arge* | Goat fish | Marine Migrant (MM) | Of least concern |

Source: Investigations of the Tamavua River and their Life History Patterns, 2007

Key outcomes of the survey are as follows:

- A total of 157 fish from nine different species were caught over two days of sampling.
- The most dominant species are the Fiji sardine *Sardinella fijiense* and the Ponyfish *Leognathus equulus* which collectively comprised almost three quarters of the total catch.
- Seven of the nine species identified were found in previous investigations at sites adjacent to the entrance to the River.
- The sampling site furthest upstream (approx. 5 km upstream from the coast) was the most abundant with 58 fish caught (representing a CPUE[16] of 14.5) from four species.
- Most of the species caught (five of the nine) utilizing the lower Tamavua River were marine migrants, two of which catadromous opportunists and one each of estuarine migrants and amphidromous varieties, the Ponyfish and Broadhead sleeper, respectively.

No species were identified as of conservation significance, with all species listed on the IUCN red list classified as 'Of least concern'.

Source: Investigations of the Tamavua River and their Life History Patterns, 2007

Figure 1-3-52 Fish caught in Tamavua River, upstream (left) and downstream (right) of the Tamavua-i-wai Bridge

[16] CPUE: Catch per Unit Effort

### b) Terrestrial Ecology

#### i) Terrestrial Vegetation

A total of 43 terrestrial plants species (16 tree species, 15 shrub species, 6 creeper and 6 grass species) were present in the footprint of the new bridge alignment; listed on the eastern side of the northern and southern bridge approaches in Table 1-3-34 with images of the typical vegetation. The key points to note are as follows:

- 16 tree species were present alongside the most common plant types, including Wild Tamarind (*Leucaena leucocephala*), African tulip (*Spathodea campanulata*) and Coconut tree (Cocos nucifera).
- 15 shrubs were present with the most common species being Ghuya (*Xanthosoma sagittifolium*), Cassava (*Manihot esculenta*) and Beefsteak plant species (*Acalypha insulana var. insulana*).
- Six creeper species were present, with the most common being the coarse climbing vine (*Merremia peltata*) and Morning glory (*Ipomea indica*).
- Six grass species were present, with the most common being Guinea grass (*Panicum maximum*) and Paragrass (*Brachiaria mutica*).

No rare or endangered vegetation species based on the Endangered and Protected Species Act of Fiji were identified. Even so, the presence of environmentally significant species, including a few specimen trees of the mangroves Tiri wai (Rhizophora samoensis) (eight individuals), Tiri tabua (Rhizophora stylosa) (two individuals) and Buttress root mangrove (Bruguiera gymnorrhiza) (one individual) was significant. Overall, the vegetation around the Tamavua-i-wai Bridge comprised a range of indigenous and naturalized or introduced species, with two highly invasive species identified: the African tulip (Spathodea campanulata) and Prickly solanum (Solanum torvum).

Table 1-3-34 Summery of Vegetation Present in the Development Area

| Common Name | Scientific Name | Status | IUCN Red List Classification |
|---|---|---|---|
| (Tree) | | | |
| Tiri wai (mangrove) | *Rhizophora samoensis* | Indigenous | Near Threatened |
| Tiri tabua (mangrove) | *Rhizophora stylosa* | Indigenous | Of least concern |
| Buttress root mangrove/Dogo | *Bruguiera gymnorhiza* | Indigenous | Of least concern |
| Blinding tree (mangrove)/Sinu | *Excoecaria agallocha* | Indigenous | Of least concern |
| Puzzlenut Tree (mangrove) | *Xylocarpus granatum* | Indigenous | Of least concern |
| Cannonball Tree | *Xylocarpus moluccensis* | Indigenous | Of least concern |
| African tulip | *Spathodea campanulata* | Introduced | Of least concern |
| Monkeypod Raintree | *Samanea saman* | Indigenous | Secure* |
| (Tree in horticultural or agricultural use) | | | |
| Wild tamarind | *Leucaena leucocephala* | Exotic | - |
| Coconut | *Cocos nucifera* | Indigenous | - |
| Pawpaw (Papaya) | *Carica papaya* | Introduced | - |
| Plantain | *Musa bulbisiana* | Indigenous | - |
| Mango | *Mangifera indica* | Exotic | - |
| Pommetia | *Pommetia pinnata* | Indigenous | - |
| Beach Almond | *Terminalia catappa* | Indigenous | - |
| Lemon | *Citrus lemon x medica* | Exotic | - |
| (Shrub) | | | |
| Giant Reed | *Arundo donax* | Exotic | Of least concern |
| Primrose willow | *Ludwigia octovalvis* | Introduced | Of least concern |

| Common Name | Scientific Name | Status | IUCN Red List Classification |
|---|---|---|---|
| Goat Weed | *Ageratum conyzoides* | Exotic | Of least concern |
| (Shrub in horticultural or agricultural use) | | | |
| Taro/Ghuya | *Xanthosoma sagittifolium* | Exotic | - |
| Cassava | *Manihot esculenta* | Exotic | - |
| Beefsteak plant | *Acalypha spp.* | Indigenous | - |
| Slender Mimosa | *Desmanthus virgatus* | Exotic | - |
| Ti | *Cordyline fruticosa* | Indigenous | - |
| Calyptocarpus | *Calyptocarpus vialis* | Indigenous | - |
| Sheena's Gold | *Duranta erecta* | Exotic | - |
| Gardenia | *Gardenia jasminoides* | Indigenous | - |
| Guava | *Psidium guajava* | Exotic | - |
| Phaleria | *Phaleria disperma* | Indigenous | - |
| Prickly solanum | *Solanum torvum* | Introduced | - |
| Piper | *Piper puberulum* | Indigenous | - |
| (Creeper) | | | |
| Coarse climbing vine | *Merremia peltata* | Indigenous | N/A |
| Blue Morning Glory | *Ipomea indica* | Exotic | N/A |
| Sensitive plant | *Mimosa pudica* | Exotic | Of least concern |
| Mile a Minute | *Mikania micrantha* | Exotic | N/A |
| Wood Rose | *Merremia tuberosa* | Exotic | N/A |
| Ivy-leaved Morning Glory | *Ipomea cairica* | Exotic | N/A |
| (Grass) | | | |
| Guinea grass | *Panicum maximum* | Exotic | N/A |
| Paragrass | *Brachiaria mutica* | Exotic | Of least concern |
| Broad leaved Carpet grass | *Axonopus compressus* | Exotic | N/A |
| Narrow leaved Carpet gras | *Axonopus affinis* | Exotic | N/A |
| Sudan Sorghum | *Sorghum sudanense* | Exotic | N/A |
| Golden Beardgrass | *Chrysopogon aciculatus* | Indigenous | N/A |

Source: Bill No. 6 of 2016, FOR AN ACT TO AMEND THE ENDANGERED AND PROTECTED SPECIES ACT 2002
Note: '*' are classified by NatureServe, Inc.

### ii) Birds

Bird species observed during the fieldwork were identified and observed with the assistance of the Fijian bird guide. The three bird species observed included the Red-Vented Bulbul Pycnonotus cafer, Common mynah Acridotheres tristis and Jungle mynah A. fuscus, all of which were introduced to Fiji and of no particular conservation concern according to the IUCN Red List of Threatened Species.

In addition to the field survey, the birds present in the lower Tamavua-i-wai mangrove area were investigated in detail in September 2007 as part of the previously proposed Carpenters development EIA[17]. Stationary (1-minute, 15- minutes and transect) and moving (5-minute and continuous moving) counts were made and identified with the assistance of the Fijian bird guide[18].

No species were identified with all the species listed on the IUCN red list classified as 'Of least concern'. The results of the previous and current surveys are presented in Table 1-3-35.

Table 1-3-35 Key Bird Species Identified Around the Tamavua-i-wai Bridge

| Common Name | Scientific Name | Status | IUCN Red List Classification |
|---|---|---|---|
| Common mynah | *Acridotheres tristis* | Introduced | Of least concern |

17 SES Ltd 2007. Carpenters Tamavua-i-Wai EIA. Report prepared by Sustainable Environmental Solutions for Carpenters Properties Ltd.

18 Watling, Dick. 2001. A Guide to the Birds of Fiji & Western Polynesia. Environment Consultants Fiji, Suva

| Common Name | Scientific Name | Status | IUCN Red List Classification |
|---|---|---|---|
| Jungle mynah | *Acridotheres fuscus* | Introduced | Of least concern |
| Wattled honeyeater | *Foulehaio carunculus* | Native | Of least concern |
| Red-vented bulbul | *Pycnonotus cafer* | Introduced | Of least concern |
| White-rumped swiftlet | *Aerodramus spodiopygius* | Native | Of least concern |
| Vanikoro broadbill | *Myiagra vanikorensis* | Native | Of least concern |
| Pacific swallow | *Hirundo tahitica* | Native | Of least concern |
| Fiji silvereye | *Zosterops lateralis* | Native | Of least concern |
| Black phase reef heron | *Egretta sacra* | Native | Of least concern |
| Orange-breasted honeyeater | *Myzomela jugularis* | Endemic | Of least concern |
| Spotted-necked dove | *Streptopelia chinensis* | Introduced | Of least concern |
| Pacific Harrier | *Circus approximans* | Native | Of least concern |
| Barking pigeon | *Ducula latrans* | Endemic | Of least concern |
| Collard Lory | *Phigys solitarius* | Endemic | Of least concern |
| Pacific Black Duck | *Anas superciliosa* | Native | Of least concern |
| White-collared kingfisher | *Halcyon chloris* | Native | Of least concern |
| Fiji Parrotfinch | *Erythrura pealii* | Endemic | Of least concern |
| Golden Whistler | *Pachycephala pectoralis* | Native | Of least concern |
| Golden Dove | *Ptilinopus luteovirens* | Endemic | Of least concern |
| Fiji Goshawk | *Accipiter rufitorques* | Endemic | Of least concern |

Source: EIA Report 2x2 Lane Bridge Development, FRA 2017, arraged by the JICA Study Team

### iii) Other Species

Three species of mammals listed in Table 1-3-36 were identified in either the field in 2017 for the previous EIA study or that in 2018

Table 1-3-36 Identified Species of Mammals

| Common Name | Scientific Name | Status | IUCN Red List Classification |
|---|---|---|---|
| Pacific flying fox | *Pteropus tonganus* | Native | Of least concern |
| Rat | *Rattus spp.* | Introduced | Of least concern |
| Mongoose | *Herpestes auropunctatus* | Introduced | Of least concern |

Source: EIA Report 2x2 Lane Bridge Development, FRA 2017, arranged by the JICA Study Team

Moreover, according to a survey in 2007, one of two species of fruit bat (Pteropus samoensis) commonly found in Fiji was seen returning to their inland colonies in the morning after night foraging in coastal locales or flying back towards the coast in late afternoon to resume their routine nocturnal foraging. At the time, a small colony may have been roosting on the well-wooded cliff face beyond the northern Tamavua-i-wai boundary.

It is possible that the Pacific flying fox (Pteropus tonganus) and Samoan flying fox (Pteropus samoensis) may be present, although no roosting habitat or other evidence of their presence was observed in the mangrove habitat surveyed. Although Samoan flying fox (Pteropus samoensis) is categorized in Near Threatened (NT) species under the red list category by IUCN, there is no this species found in the area near the existing Tamavua-i-wai Bridge including mangrove vegetation areas.

No herpetofauna was identified either during site visits and while it is possible that some habitat present supports herpetofauna, they are unlikely to be present in abundance in the Project area.

### (3) Social Environment Baseline

This section gives an overview of the existing socioeconomic status of community residents around the proposed development site. These residents, as well as other stakeholders, were identified through the social survey process.

#### 1) Overview of the Baseline Survey

A socioeconomic survey was carried out between 15-17 June, 2019 to analyze the social condition of the community from either demographic or economic perspectives adjacent to the construction site of the New Tamavua-i-wai Bridge. Survey samples were collected in Tamavua-i-wai and Kaleli settlements via interviews using a questionnaire sheet. The total sample count included 299 villagers from 46 households.

#### 2) Local Communities

The social environment immediately adjacent to the Tamavua-i-wai Bridge primarily comprises the residential properties in Delaninvisi Village north of the Bridge, Kaleli Settlement, located on the southern bank of the Tamavua River directly east of the Bridge and the commercial properties further to the south, including Electricity Fiji Limited's (EFL's) Rokobilli power station. All of the settlements are on the upstream side of the Bridge. The following descriptions give an overview of the two primary settlement near the projected site, while Figure 1-3-53 shows the location of the two settlements.

##### a) Kaleli Settlement

The Kaleli settlement is an informal (squatter) settlement, located on the true left bank of the Tamavua Riverbank along Tamavua Road and extending from the Tamavua-i-wai Bridge for approx. 450m upstream along the river bank. The settlement has been there for approx. 50 years and is occupied by people from around the Fiji region. Informal discussions with the Turaga-ni-Koro, named as coordinator of a village, confirmed that the pioneer settlers of the Kaleli settlement had moved from the outer islands to pursue employment and educational opportunities in Suva City.

In 2007 a total of 68 people lived in this settlement comprising 38 households and a church and a hall. The dwellings close to the water edge are flooded during high tides, during which time the occupants relocate.

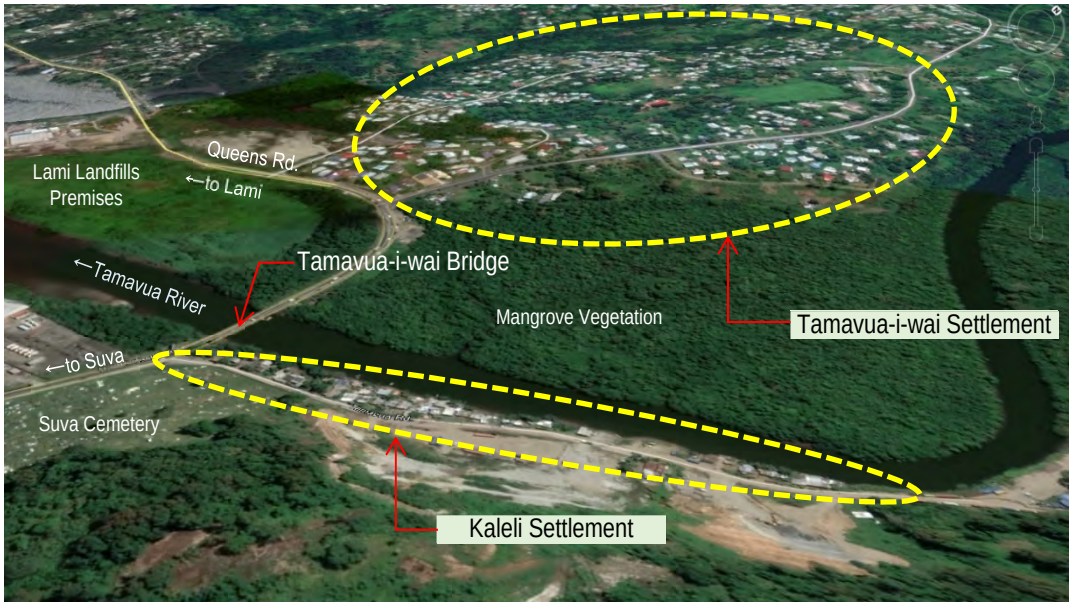
The settlement mainly comprises low-income earners, approx. 45% of whom are employed at nearby industrial areas as opposed to only a few in the city. The daily livelihood in terms of food source and infrastructure comes from the adjacent mangrove areas; a source of crabs, fish, eels and wood building materials. Daily root crop staples, meanwhile, are planted on the ridges along the Queen Road near the existing Tamavua-i-wai Road on the Lami side.

##### b) Tamavua-i-wai Settlement

The Tamavua-i-wai settlement, sometimes referred to as Tamavua village, is located on the true right bank of the Tamavua River to the north of the bridge and accessed via the Delainavesi Road off the Queens Road.

Technically, the Tamavua-i-wai settlement should not be described as a village due to the lack of traditional social structure and the varying origins of the people that call it home. It is divided based on

their religious beliefs: Anglicans and Methodists live in upper and lower parts respectively. Several private entities share ownership of different parts of the land the settlement is on. Those owning land in the upper part of the settlement have been identified as Tamavua village, Morescot, ANZ Bank, Seventh-Day Adventist Church, Ratu Mara and Sir Ragg, while the land of the lower part is owned by the Fijian Government. Information reviewed as part of this assessment tended to focus on the upper part only due to the presence of a Turaga-ni-Koro (the so-called 'village coordinator'), which implies a more organized social structure.




Source: JICA Study Team

Figure 1-3-53 Location of Related Settlements for the Project

### 3) Population Census of the Settlements

Table 1-3-37 shows that more than 60% of villagers in the two settlements are aged between 14 and 59, with more females than males except for the group of those aged 6 to 13. Regarding the dependent condition shown on Table 1-3-38 the total dependent ratio of the two settlements resembles that at a national level.

Table 1-3-37 Age and Gender Segregation of the Settlements

| | | | 0-5 | | 6-13 | | 14-29 | | 30-59 | | Over 60 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % | No. | % | No. | % |
| Male | 146 | 100% | 19 | 13% | 24 | 16% | 50 | 34% | 41 | 28% | 12 | 8% |
| Female | 153 | 100% | 17 | 11% | 19 | 12% | 54 | 35% | 47 | 31% | 16 | 10% |
| Total | 299 | 100% | 36 | 12% | 43 | 14% | 104 | 35% | 88 | 29% | 28 | 9% |

Source: JICA Study Team

Table 1-3-38 Dependents of the Settlements

| | | | under 15 | | 16-64 | | Over 65 | | Dependent Ratio | National Level |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. | % | No. | % | No. | % | | |
| Male | 146 | 100% | 47 | 32% | 94 | 64% | 5 | 3% | 55.32% | - |
| Female | 153 | 100% | 43 | 28% | 100 | 65% | 10 | 7% | 53.00% | - |
| Total | 299 | 100% | 90 | 30% | 194 | 65% | 15 | 5% | 54.12% | 52.2%* |

Source: JICA Study Team
Note: * World Bank, 2017

Regarding the household structure, as shown in Table 1-3-39, more than 45% of households had 7 to 10 people, with three households having more than 11 family members (the maximum size was 18).

According to the Bureau of Statistics, the average household size of poor households was 5.7 compared to 4.3 for the non-poor. Since the average household size of the two settlements was 6.78, the living conditions of the settlements were assumed to be harsher than average.

Table 1-3-39 Household Size of the Settlements

| Total | | 1-3 | | 4-6 | | 7-10 | | More than 11 | | Ave. | Ave. (National)* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | % | No. | % | No. | % | No. | % | No. | % | | |
| 46 | 100% | 6 | 13.04% | 16 | 34.78% | 21 | 45.65% | 3 | 6.52% | 6.78 | 5.7% (poor)<br>4.3% (non-poor) |

Source: JICA Study Team
Note: '*' referred from the 2013-2014 Household Income and Expenditure Survey

### 4) Ethnicity and Religion

The nationality of all the residents of the two settlements is Fijian, except for one from another Polynesian country, while the ethnicity of all the Fijians in the settlements is Itaukei, which comprises 56.8%*1of the entire Fiji ethnicity, except for that from Rabian (descendants who were forcibly relocated from Kiribati Banana Island in 1945) from Rabi Island, off the coast of Vanua Levu Island and residing in the Tamavua-i-wai settlement.

As shown in Table 1-3-40, almost 90% of residents belong to the Christian-based community, which indicate residents regularly attend their nearest church.

Table 1-3-40 Religion of the Settlements

| Religion name | | No. | Rate by category | Rate by type |
|---|---|---|---|---|
| Cristian based | | 41 | 89.13% | - |
| | Methodist | 25 | - | 54.35% |
| | Catholic | 4 | - | 8.70% |
| | Seventh-day Adventist | 3 | - | 6.52% |
| | Assembly of God | 3 | - | 6.52% |
| | Other*2 | 6 | - | 13.04% |
| Non-Christian | | 1 | 2.17% | - |
| | Muslim | 1 | - | 2.17% |
| Other | | 4 | 8.70% | - |
| | No religion | 1 | - | 2.17% |
| | N/A | 3 | - | 6.52% |
| Total | | 46 | 100.00% | 100.00% |

Source: JICA Study Team
*1 CIA world fact book
*2 Others include Anglican, Christian Medical Fellowship, Living Word Gospel, Latter Day Saints, Jehovah's Witness, Church of God for All Nations

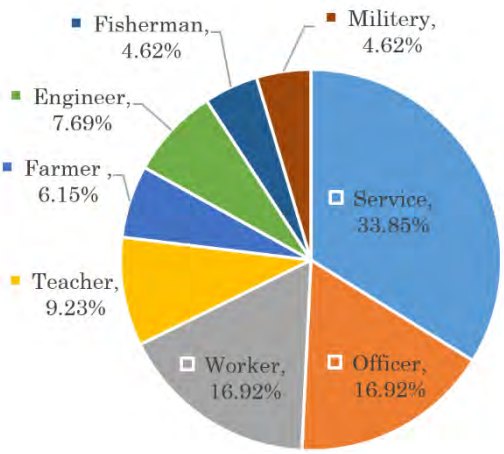
### 5) Livelihood Condition

In terms of livelihood condition, establishment of utility is one of the major elements needed to build a better life for the settlements. Regarding power utility, all households can receive electric power from Energy Fiji Limited (EFL), while sufficient drinking water is supplied by Lami Town and Suva City to all houses to cover needs, despite occasional water shortages during the dry season. Regarding sewage treatment, all households have septic tanks and the competent agency periodically collects from the sewers as one of the sanitary measures carried out by the local government. The local government also oversees the collection of general solid waste and settlements receiving the garbage collection service periodically.

In case villagers need medical care, those in the settlements commonly go to the Lami Health Center in Lami Town, located approx. 2.0km west of the settlements. Most of the households use public buses for their transportation to social facilities, while 11 households (24%) own cars for emergency access.

### 6) Economic Conditions

In terms of villagers' occupations, 65 samples were collected from villagers engaged in some economic activity for their daily life. Figure 1-3-54 shows a ratio of occupation types of the collected data. It explains that more than one third of people are engaged in some types of service industry such as a customer service of shop or restaurant, a taxi driver and medical service. And second-largest occupation types are officers and workers accounting for 16.92% respectively. Combined ratios for officers and workers comprised more than one third of the occupation ratio. The category of officer included administrative officers or clerks, while that of worker included construction and factory workers. Conversely, the occupation ratio in agricultural fields such as fishing and farming is less than 7% - comparatively low. It can be assumed that the location of these settlements, on the edge of urbanized Suva City, elicits various benefits to the villagers for working in the service industry and other vocations available there, rather than the agricultural field.




Source: JICA Study Team

Figure 1-3-54 Occupation Ratio in the Settlements

Table 1-3-41 shows the income range for families in the settlements. Despite the fact most of the villagers declined to provide income data during the survey, the data can partly explain the economic condition of households in the settlements. The table explains how more than half the households have a monthly income of less than 500 FJD. When this income is divided into the average family size of adults (4.9), the weekly income is calculated as 23.73 FJD*1. According to the national social survey19, a poverty line is defined as 55.12FJD per adult equivalent per week. Since the income required to exceed the poverty line is approx. 1,200 FJD, more than 69% of households could be categorized as below the poverty line and suffering from poor economic conditions.

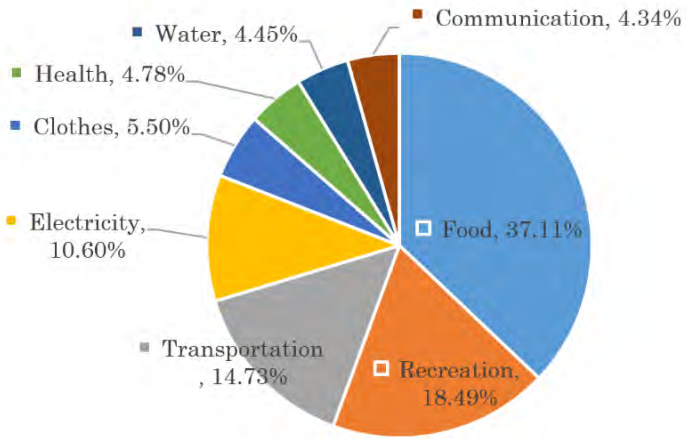
Furthermore, as shown in Figure 1-3-55, comparing the rate of expenditure type based on the average of all collated data, residents in the settlement need to spend more than one third of their expenditure on food.

Table 1-3-4 Family Income of the Settlements

| Amount of Monthly Income (FJD) | % |
|---|---|
| Less than 500 | 61.54 |
| 501 - 1000 | 7.69 |
| 1001 - 1500 | 15.38 |
| Over 1501 | 15.38 |
| Total | 100.00 |

Source: JICA Study Team

* 1 Note: 500 FJD÷4.3weeks÷4.9adults=23.73FJD




Source: JICA Study Team

Figure 1-3-55 Expenditure Ratio in the Settlements

19 2013-14 HOUSEHOLD INCOME AND EXPENDITURE SURVEY, Fiji Bureau of Statistics, Release No. 98, 2015

### 7) Land Use and Local Resource

The surrounding environment is semi-urban in nature. Downstream of the Bridge is the Rocobili Industrial Area and an EFL-managed power station lies to the south, while the closed Lami landfill is located to the north of the Bridge.

Suva (a.k.a. Lomanilase) Cemetery is located to the south of the Bridge, on the other side of Tamavua Road to Kaleli Settlement, while further along Tamavua Road lies the area for container storage facilities operated by Export Freight Services (EFS) and Carpenters.

Further afield, to the south, are port facilities of Suva, Rokobili Terminal and the Rokobili Port development. The Port is used for large vessel berthage, container stacking, stevedoring, truck handling and parking.

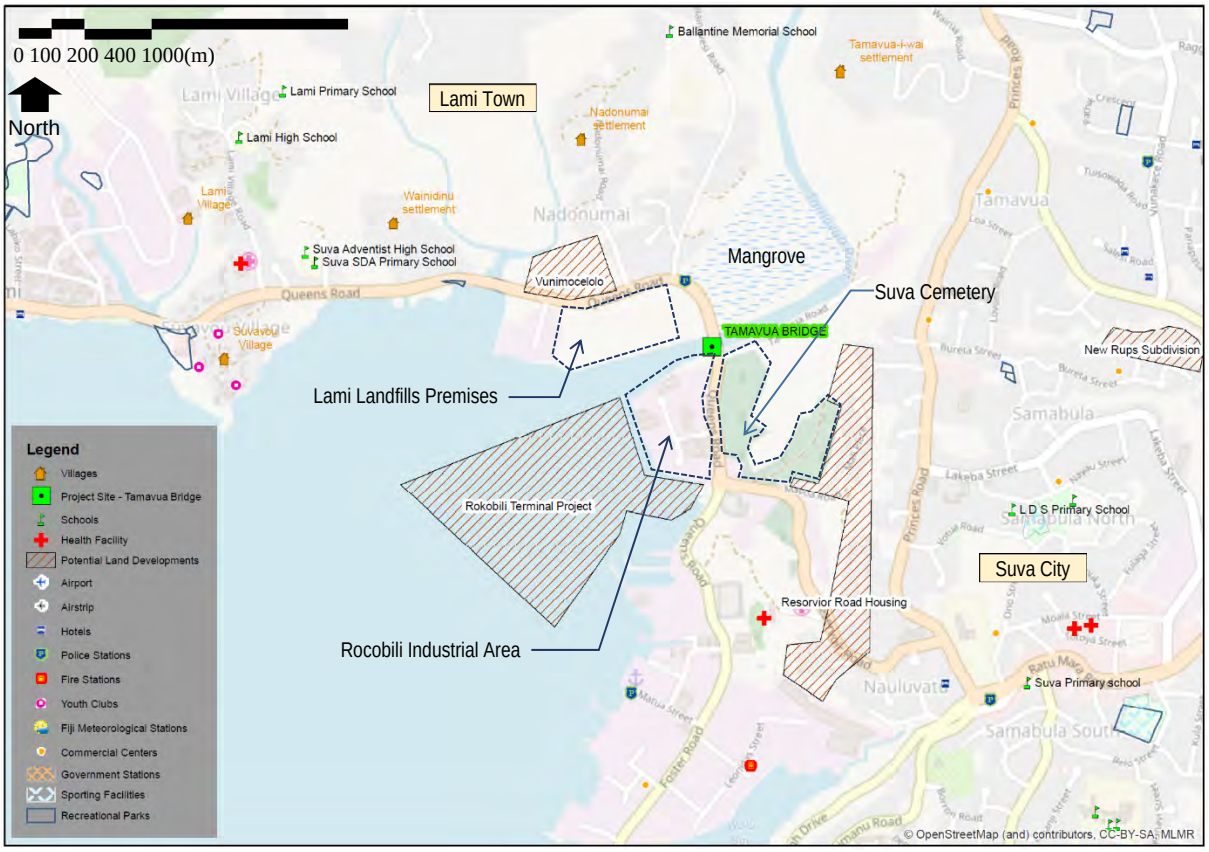
The existing Tamavua-i-wai Bridge is located on Crown Land and managed by the FRA. The Rocobili Industrial Area, EFL Power Station, Lami Landfill and Lomanilase Cemetery are also all on Crown Land and administered by the Ministry of Lands (MoL). A River Bank Reserve (RBR) is designated along the banks of the Tamavua River (within 6 m of the High-Water Mark) and also managed by the MoL (Figure 1-3-56).

The Native Land Commission has confirmed that the Vanua of Suva (Tokatoka Nos. 598 - 618A) excluding the Yavusa Nakurukuru (Tokatoka Nos. 590 - 596) are the traditional fishing right owners of the Tamavua-i-wai River.

The fishing grounds within the Suva Harbor and lower reaches of the Tamavua River belong to three traditional owners in Suvavou village, with most fishing activities conducted at the lower river mouth and estuarine areas, particularly at low tide. The most common type of fishing is with a fishing line and net while shellfish are gathered at low tide on the exposed mudflats and sand bars.

Within a 1.0km radius of the bridge, there are few residential areas and therefore no social facilities like hospitals and schools, although a few schools are settled at a distance of 1.5 to 2.0km away. Since these schools generally accept students living in the vicinity, it can be noted that the Tamavua-i-wai Bridge is not used for going to school. Conversely, the medical facilities in Suva City offer a better quality of service and a higher capacity than those in Lami Town, therefore, it is expected to be considerable demand from residents of Lami Town to attend hospitals in Suva City via the Tamavua-i-wai Bridge (Figure 1-3-56).

Additionally, there are several potential land development areas, including residential developments, adjacent to the Suva Cemetery and the terminal development next to the Rocobili Industrial Area in accordance with the land-use map shown in Figure 1-3-56. It can be envisaged that the traffic on the Queens Road in the Tamavua-i-wai Bridge section will soar after the development.




Source: FRA

Figure 1-3-56 Land Use around the Tamavua-i-wai Bridge

### 8) Archaeological/Cultural Site

The Fiji Museum GIS records of cultural heritage sites have been reviewed and no known sites of archaeological or cultural significance are known to be present within, or in the direct vicinity of, the proposed development site.

### 9) Landscape

The landscape around the existing Tamavua-iwai Bridge comprises three major elements, one of which is mangrove forest, with river water on the Lami side, Suva Cemetery, with undulating land skirting the hilly forest and Rokobili Industrial area on the Suva side. Since the projected area is located on the outskirts of Suva City, the urbanized landscape has been emerged into the original landscape where natural environment was remaining to create a mixture of natural and manmade landscape.

### 10) Transportation and Access

The Tamavua-i-wai Bridge is located on Queens Road, the main arterial route into central Suva from the west. This road services commuter traffic, peaking morning (0800-1000) and afternoon (1600-1800), through the Suva - Navua corridor and industrial/commercial traffic between Suva and Ba. A heavy traffic volume of general vehicles and public buses is identified on the bridge throughout the day, but particularly during these peak times. There are bus stops near the bridge on both sides for daily transportation of citizens.

Tamavua-i-wai Road, along the southern side of Tamavua River, is used to access the informal settlement (Kaleli) located on the true left bank of the River just upstream of the Tamavua-i-wai Bridge.

While settlements are located close to the Bridge, they do not contain any major social infrastructure, such as hospitals or schools. The closest schools are between 2 and 5 km from the bridge, while the nearest hospitals are in Lami and a similar distance from the nearby settlements, with most people in the vicinity of the Bridge (as well as movements from the west e.g. Lami towards Suva Hospital) likely to visit Suva Hospital due to its higher capacity and service scope.

The prevalence of traffic accidents on the bridge itself is relatively low, as it is located on a straight section of road, where speeds are reduced due to narrowing while crossing the road. Six traffic accidents were recorded on FRA's GIS system, between 2003 and 2012, in close proximity (within 50 m) to the Bridge, none of which were fatal.

Comparatively, the intersections to the north and south of the Bridge have a far greater incidence of crashes than the bridge itself (refer to Figure 1-3-57).


Source: FRA

Figure 1-3-57 Traffic Accident Records in the vicinity of Tamavua-i-wai Bridge

## 1-3-7 Environmental Impact Assessment

The evaluation of the impacts on the natural and social environment for the project based on the study results mentioned above is summarized in the following table, comparing it to that in the scoping stage.

Table 1-3-42 Summary of Environmental and Social Assessment

| Category | # | Environmental items | Evaluation | | | | Reason for evaluation |
|---|---|---|---|---|---|---|---|
| | | | Scoping | | EIA Study | | |
| | | | P/C Phase | O Phase | P/C Phase | O Phase | |
| Measures against pollution | 1 | Air pollution | D/B- | B-, B+ | D/B- | B-, B+ | P Phase: Before the work, there would be no activity causing air pollution.<br>C Phase: Deterioration of air quality is expected if vehicular traffic congestion is generated. The operation of heavy machinery and construction equipment may cause a temporary decline in air quality (including dust) exceeding regulatory levels.<br>O Phase: According to the comment that there is a traffic congestion chronically occurring in the subjected section from a stakeholder, air quality may improve due to a mitigation of traffic congestion after traffic control. Otherwise, air quality may be deteriorated due to future increase in traffic volume. |
| | 2 | Water pollution | D/B- | D | D/B- | D | P Phase: There would be no activity polluting the river water.<br>C Phase: There is the possibility of contamination of the rivers due to washing of heavy machinery and construction equipment, as well as wastewater from worksite housing. The water quality may be contaminated due to construction of piles in the river.<br>O Phase: There would be no activity resulting in contamination of the rivers. |
| | 3 | Waste | D/B- | D | D/B- | D | P Phase: There would be no activity generating waste.<br>C Phase: General waste will be generated by workers at the sites and soil excavated for road embankments and the dismantling of the present bridges will also generated as waste. For general waste, the contractor will follow the procedures required by the municipal jurisdiction, but no excessive volume of soil excavation is expected based on the current design. Industrial waste will be treated by construction contractors with the corresponding permit issued by the Ministry of the Environment. Possible pollution caused by malfunctioned waste management in surrounding natural and social environment would be concerned.<br>O Phase: No waste will be generated. |
| | 4 | Soil pollution | D/B- | D | D/B- | D | P Phase: There would be no activity causing contamination of soil.<br>C Phase: There is a possibility of soil contamination due to spillage of oil and similar products from heavy machinery and building equipment.<br>O Phase: There is no elements which may contaminate the soil. |
| | 5 | Noise and vibrations | D/B- | B- | D/B- | B- | P Phase: There would be no activity which may increase noise and vibrations.<br>C Phase: Noise will be generated due to the operation of heavy machinery and building equipment.<br>O Phase: Negative impacts created by noise and vibrations due to increase in vehicular traffic will be involved. |
| | 6 | Subsidence of terrain | D | D | D | D | There would be no activity (such as large-scale pumping of underground water) which may cause the terrain to subside. |
| | 7 | Odors | D/B- | D | D/B- | D | P Phase: There would be no activity which may create odor nuisances.<br>C Phase: An odor nuisance may be generated by waste from the workers' camp unless the wastewater is adequately treated.<br>O Phase: There would be no activity which may cause an odor nuisance. |
| | 8 | Sediments from riverbeds | D/B- | D | D/B- | D | P Phase: There would be no activity which may cause changes in the riverbed sediments.<br>C Phase: Construction of bridge pillars in the river would disturb the riverbed sediments.<br>O Phase: There would be no elements which may cause changes in the riverbed sediments. |

| Category | # | Environmental items | Evaluation | | | | Reason for evaluation |
|---|---|---|---|---|---|---|---|
| | | | Scoping | | EIA Study | | |
| | | | P/C Phase | O Phase | P/C Phase | O Phase | |
| Natural environment | 9 | Protected areas | B-/B- | B- | D | D | P Phase: There is no plan or area related to the natural conservation near the bridge.<br>C Phase: Viti Levu Southern Highland is the closest conservative area to the project site, but it would not exert any significant negative impact because the distance between the two exceeds 2km.<br>O Phase: There would be no elements to disturb protected areas near the project site. |
| | 10 | Ecosystem | D/B- | B- | D/B- | D | P Phase: There would be no activity which will generate an impact on the ecosystem of the area surrounding that of construction.<br>C Phase: Part of the mangrove area will be cut down for construction works. However, the scope of the impact on the river is limited compared to the whole mangrove area, thus the impacts can be mitigated by appropriate measures to be taken for cutting mangrove vegetation. Moreover, there is no endangered species near the project area. In areas adjacent to the road around the construction site, there is no important forest.<br>O Phase: There would be no activity which may generate an impact on the ecosystem. |
| | 11 | Hydrological conditions | D/B- | B- | D/B- | B+, B- | P Phase: There would be no activity which will affect the hydrological systems of the river.<br>C Phase: There may be changes in the stream due to the construction of substructures and other activities to be conducted in the river.<br>O Phase: Newly built bridge pillars in the river may result in changes to the torrent of the rivers but reducing the number of pillars of the new bridge can reduce the risk of inundation and floods in the region. |
| | 12 | Topography of terrain, geology of soils | D/B- | D | D/B- | B- | P Phase: There would be no activity which may impact on the topography of the land and the geology of the soil.<br>C Phase: Since the new approach roads will be built with filled embankment, soil erosion from the embankment would occur and indirect negative impacts at the borrowed pit area would be one of the concerns. However, the possible negative impacts of taking aggregates from the quarry site would be mitigated, since these construction materials will be procured from a registered company specialized in taking quarries.<br>O Phase: Although the area is very limited, there would be some concern over embankment erosion if the embankment protection were inappropriately maintained. |
| Social environment | 13 | Resettlement and land acquisition | B-/B- | D | B-/D | D | P Phase: There is a leased land found in the projected site and a through explanation of items in the Abbreviated Resettlement Action Plan (ARAP) to the Project-Affected Persons (PAPs) will be required. Additionally, implementation of the ARAP shall be ensured by the relevant institutions before commencing the construction works. No area for land acquisition has been identified based on the preparatory survey.<br>C and O Phase: No resettlement and land acquisition are required during the operational phase. |
| | 14 | Poverty | B-/B- | B+ | B-/D | B+ | P Phase: Displacement of the PAPs would affect their economic status unless the ARAP is properly implemented.<br>C Phase: There would be no element of correspondence with poverty in the region near the project site.<br>O Phase: There would be a positive impact on the local economy as a result of forming a better bridge condition. |
| | 15 | Ethnic minorities and indigenous people | D | D | D/D | D | In and around the project area, there are no ethnic minorities or indigenous people. |
| | 16 | Local economy such as employment and livelihood | D/B+ | B+ | D/B+ | B+ | P Phase: No impact on the local economy would be expected during the planning phase.<br>C Phase: Employment of locals or new business opportunities could be ensured for the construction work.<br>O Phase: Some progress of the local economy could be expected to result from the renewal of the existing bridge. |
| | 17 | Land use and local resources | B-/B- | D | B-/B- | D | P Phase: Land-use modification from Freehold Land to Common Land as road property will be proceeded through an inter-ministerial meeting.<br>C Phase: The fishing ground in the Tamavua River near the bridge is a major local resource, which could be affected by water pollution.<br>O Phase: No impact is expected after the construction. |

| Category | # | Environmental items | Evaluation | | | | Reason for evaluation |
|---|---|---|---|---|---|---|---|
| | | | Scoping | | EIA Study | | |
| | | | P/C Phase | O Phase | P/C Phase | O Phase | |
| Social environment | 18 | Water use/rights | D/B- | D | D/B- | D | P Phase: There are no activities which may generate an impact on the use of water.<br>C Phase: The community along the river using river water for their daily lives would be affected due to possible water turbulence.<br>O Phase: There would be no activities which may generate an impact on the use of water. |
| | 19 | Existing social infrastructures and social services | B-/B- | B+ | B-/B- | B+ | P Phase: No social infrastructure requiring relocation, such as any educational, medical and religious facility, is found. However, relocation of lifelines such as power, telecommunication and drinking water lines could affect the living conditions of residents.<br>C Phase: Regarding the accessibility of the Suva Cemetery, no negative impact would be expected since the cemetery entrance is not close to the project site. Furthermore, no major disturbance of traffic flow on the project site would be expected since adequate traffic can be controlled by the new FRA and existing bridge during construction.<br>There would be significant deterioration of accessibility for the residence along the Tamavua-i-wai Road since turning right from and to the Queens Road will be prohibited.<br>Bus stops on both sides of Tamavua-i-wai bridge will have to be relocated, which could make public transportation less convenient.<br>O Phase: Elevation of the new access road will exceed that of present roads, thus ensuring a safe level of disaster protection against regional flooding. |
| | 20 | Social capital and social structure of regional decision-making organizations | D-/D | D | D/D | D | P Phase: No complicated social communities or capital found in the region near the project site, thus no negative impact is expected.<br>C and O Phase: No impact is foreseen regarding the social capital and social structure of regional decision-making organizations. |
| | 21 | Misdistribution of benefits and damage | B-/D | B+ | D/D | A+ | P Phase: No significant negative impact is expected, since the magnitudes of land acquisition and resettlement are minimal.<br>C, O Phase: Misdistribution of benefit and damage in the region is not expected. Otherwise transport accessibility and natural disease tolerance in the region will be improved after the project. |
| | 22 | Local conflict of interests | B-/D | D | D/D | D | P Phase: There is no element which could trigger local conflict according to feedback from the local authority.<br>C, O Phase: No negative impact is expected after commencing the construction works. |
| | 23 | Cultural Heritage | D/D | D | D/D | D | P, C and O Phase: Suva Cemetery is adjacent to the project site, however, no disturbance in the area of Suva Cemetery is expected based on the design on the preparatory study. |
| | 24 | Landscape | D/B- | D | D/D | D | P Phase: No negative impact is expected on the landscape near the project site.<br>C Phase: No significant negative impact is expected since the size of the development is small and there would not be a large volume of cutting trees or mangroves comprising regional landscape in the region.<br>O Phase: No negative impact is expected on the landscape near the project site. |
| | 25 | Gender | B-/B- | D | D/D | D | P Phase: No significant negative impact is expected since the volume of involuntary resettlement is minimal.<br>C and O Phase: No negative impact on gender issues is foreseen. |
| | 26 | Children rights | B-/B- | D | D/D | D | P Phase: No significant negative impact is expected since the volume of involuntary resettlement is minimal.<br>C Phase: Fiji Government has established a national 24-hour toll-free helpline for children to seek counselling, advice and referrals for support services, as well as to report cases of child neglect and abuse, thus no negative impact associated with children rights such as child labor issues is expected.<br>O Phase: No negative impact on gender issues is foreseen. |
| | 27 | Infectious diseases such as HIV/AIDS (including hygiene condition) | D/B- | D | D/B- | D | P Phase: No impact is expected on infectious diseases such as HIV/AIDS.<br>C Phase: Infectious diseases may be spread due to the influx of construction workers depending on management of hygiene condition.<br>O Phase: No negative impact on gender issues is foreseen. |
| | 28 | Working conditions | D/B- | D | D/B- | D | P Phase: No negative impact related to the working environment is expected.<br>C Phase: Some negative impacts may be generated regarding labor conditions, |

| Category | # | Environmental items | Evaluation | | | | Reason for evaluation |
|---|---|---|---|---|---|---|---|
| | | | Scoping | | EIA Study | | |
| | | | P/C Phase | O Phase | P/C Phase | O Phase | |
| | | (including work safety) | | | | | if the work environment is not appropriately managed.<br>O Phase: There are no activities which may imply the deterioration of work conditions. |
| Others | 29 | Accidents | D/B- | B+ | D/B- | B+ | P Phase: There would be no activity which could trigger some accidents.<br>C Phase: The increase in construction machines could cause accidents.<br>O Phase: Since a pedestrian walkway with rails will be constructed along both sides of the bridge, the safety of pedestrians is assured. |
| | 30 | Impact of crossing borders and climate change | D/D | B+ | D/D | D | P Phase: There is no major clearing of trees or greenhouse gas emissions.<br>C Phase: No major impact of crossing borders or climate change is expected.<br>O Phase: No major impact is expected since the project is modest in size. |

Note: A+/-: An important positive or negative impact is projected, B+/-: There may be some positive or negative impacts, C+/-: The occurrence of a positive or negative impact has not been determined (a more detailed study must clarify the impact). D: No impact is projected.

### 1-3-8 Mitigation Measures and Implementation Costs

The following table presents mitigation measures for environmental items evaluated with respect to the negative impact in the previous clause. Similarly, cost estimates for mitigation measures are given in the following table.

Table 1-3-43 Summary of Mitigation Measures

| Category | # | Items | Mitigation Measure | Implementation Agency | Responsible Agency | Cost to be Shouldered by |
|---|---|---|---|---|---|---|
| Planning and Construction Stage | | | | | | |
| Pollution | 1 | Air pollution | [Dust]<br>- Sprinkle water for dust nuisance<br>[Exhaust gas]<br>- Use low emission construction machinery to avoid high exhaust gas emissions.<br>- Thorough management of construction machines to avoid inappropriate gas emissions. | Contractor | FRA | Contractor |
| | 2 | Water pollution | [Turbid water and other items]<br>- Discharge turbid water through a sedimentation pond and silt fence.<br>- Install a portable toilet for workers.<br>- Appropriate management of waste and construction machines to prevent oil spillage/discharge of untreated wastewater from the work site.<br>- Provide an appropriate explanation and response to the community and fishermen residing along the river, if necessary. | Contractor | FRA | Contractor |
| | 3 | Soil pollution | - Ensure appropriate waste and facility management in the construction yard and working camp.<br>- Prepare a treatment method in the case of some soil pollution. | Contractor | FRA | Contractor |
| | 4 | Waste | [Construction waste]<br>- Waste shall not be dumped into the river and a temporary dump area shall be prepared.<br>- After considering scope for reuse, construction waste, including concrete debris, shall be disposed of at the designated disposal site.<br>- Hazardous waste material shall be stored properly until final treatment.<br>[Garbage from base camp]<br>- Garbage at the workers' camp and waste oil shall be brought to a disposal site or treatment facility.<br>[Night soil]<br>- Temporary sanitation facilities such as septic tanks shall be introduced to the workers' camp. | Contractor | FRA | Contractor |
| | 5 | Noise and | [Construction noise and vibrations] | Contractor | FRA | Contractor |

| Category | # | Items | Mitigation Measure | Implementation Agency | Responsible Agency | Cost to be Shouldered by |
|---|---|---|---|---|---|---|
| | | vibrations | - Install a noise barrier; select low-noise equipment if necessary.<br>- Avoid works involving heavy equipment at night.<br>- Inform the surrounding communities of the construction schedule. | | | |
| | 7 | Odors | [Garbage from base camp]<br>- Garbage at the workers' camp shall be collected by the local authority.<br>[Night soil]<br>- Temporary sanitation facilities such as septic tanks shall be introduced to the workers' camp.<br>[Other]<br>- Proper maintenance and control of odorous construction materials in the construction yard. | Contractor | FRA | Contractor |
| | 8 | Sediments from riverbeds | - Applying a particular construction method to minimize disturbance of the riverbed sedimentation. | Contractor | FRA | Contractor |
| Natural Environment (N.E.) | 10 | Ecosystem | - The construction development area shall be roped or fenced off and remain undisturbed.<br>- Planting of mangroves shall be carried out for cutting mangrove. Replanting of ten seedlings per one cutting mature mangrove is introduced. The area for replanting is designated following discussion with the relevant authorities. | (Rope or fence) Contractor<br>(Seedling) FRA | FRA | (Rope or fence) Contractor<br>(Seedling) FRA |
| | 11 | Hydrology | - Avoid applying materials that may block the river flow and prepare an engineering analysis for the river flow movement based on the actual construction method if needed.<br>- Periodically monitor the movement of water flow. | Contractor | FRA | Contractor |
| | 12 | Topography of terrain, geology of soils | - Apply road embankment protection technology such as ground cover plants to protect against soil erosion.<br>- Confirm the erosion control condition at the planned quarry site. | Contractor | FRA | Contractor |
| Social Environment (S.E.) | 13 | Resettlement and land acquisition | - Hold a consultation meeting to convey the compensation policy.<br>- Offer appropriate compensation and social assistance in accordance with the RAP. | FRA | FRA | FRA |
| | 14 | Poverty | - Apply economic assistance to boost the livelihood for PAPs under the poverty line and PAHs with the socially vulnerable. | FRA | FRA | FRA |
| | 17 | Land use and utilization of local resources | - Hold an inter-ministerial meeting for land-use modification issues.<br>- Apply mitigation measures for water pollution.<br>- Obtain permission for fishery rights before commencing construction.<br>- Carry out proper management, including monitoring works near the cemetery border. | (Cemetery) Contractor<br>(Other) FRA | FRA | (Cemetery) Contractor<br>(Other) FRA |
| | 18 | Water usage | - Apply mitigation measures for 'Water pollution'. | Contractor | FRA | Contractor |
| | 19 | Existing social infrastructures and services | - Hold a stakeholder meeting with the authorities relevant with service lines.<br>- Hold a stakeholder meeting with the relevant authorities as well as residents to discuss about relocation of bus stops near the bridge for public consent.<br>- Construct diverted roads for vehicles and pedestrians appropriately to ensure accessibility.<br>- Construct a roundabout on the Lami side to ease traffic flow for residents and businesses located around or at the end of Tamavua-i-wai Road. | (Stakeholder MTG & round about) FRA<br>(Accessibility) Contractor | FRA | (Stakeholder MTG & round about) FRA<br>(Accessibility) Contractor |
| | 27 | Infectious diseases such as dengue and HIV/AIDS | - Install sufficient drainage facilities to discourage breeding of vector mosquitos<br>- Reinforce medical screening and periodic medical check-ups<br>- Promote awareness of infectious diseases such as HIV/AIDS among laborers to prevent such diseases spreading. | Contractor | FRA | Contractor |
| | 28 | Working conditions (including work safety) | - Periodical guidance and supervision of safety during construction works shall be ensured.<br>- Proper occupational safety management and records of the same are recommended. | Contractor | FRA | Contractor |

| Category | # | Items | Mitigation Measure | Implementation Agency | Responsible Agency | Cost to be Shouldered by |
|---|---|---|---|---|---|---|
| Others | 29 | Accidents | - Deploy flagmen at the gate and crossing points of the construction vehicles.<br>- Install safety signboards.<br>- Install fences around the construction site to keep out local people such as children.<br>- Install lighting for nighttime traffic control near the construction area.<br>- Install adequate parking areas for idling construction machines.<br>- Restrict mobilization speed in the construction site.<br>- Safety training for workers.<br>- Safety patrol at the construction site by supervisors. | Contractor | FRA | Contractor |
| Operation Stage | | | | | | |
| Pollution | 1 | Air pollution | - Vehicle maintenance regulations for gas emission control from vehicles shall be enforced.<br>- A monitoring or surveillance system for ambient air quality on the road shall be structured to quickly respond in the event of any deterioration in air quality, such as a dust nuisance in the region. | FRA | FRA | FRA |
| N.E | 5 | Noise and vibrations | - Vehicle speed shall be controlled by periodically installed barricades. | FRA | FRA | FRA |
| | 12 | Topography of terrain, geology of soils | - Establish a surveillance system for embankment erosion and a procedure to maintain reinforcement of road embankments. | FRA | FRA | FRA |
| O | 13 | Resettlement and land acquisition | - Evaluating the implementation of resettlement activities, particularly for restoring livelihood in accordance with the RAP. | FRA | FRA | FRA |

Source: JICA Study Team

Table 1-3-44 Cost Estimation of Mitigation Measures

| Stage | Item | Cost (FJD) | Cost (USD) | Responsible | Remarks |
|---|---|---|---|---|---|
| Planning | Coordination with stakeholders | 5,895 | 2,800 | FRA | Coordination with local government and resident.<br>Coordination with organizations related to infrastructure, such as telecommunication, power and drinking water lines. |
| | Land acquisition | 0 | 0 | - | No land acquisition required |
| | Lease right compensation | 50,000 | 23,750 | FRA | 1 PAHs (no need resettlement) |
| | Compensation for crops | 517 | 246 | FRA | 1 PAH for Cassava and yam field |
| | Land lease cost | - | - | FRA | Used for construction yard during construction period.<br>Assume that the old Lami Waste Depot site will be used for the cinstruction yard. (existing construction yard for the new FRA construction operation) If not 24,000FJD can be estimated. |
| Construction | Mitigation measures for vegetation recovery | 15,000 | 8,100 | FRA | Mangrove seedlings |
| | Environmental monitoring | - | - | Contractor | Estimated in the monitoring plan |
| | Implementation of mitigation measures for | 76,421 | 36,300 | Contractor | Installation of silt fence, etc. |
| | Safety measures | 114,737 | 54,500 | Contractor | Installation of fence, signboards, etc. |
| Operation | Environmental monitoring | - | - | FRA | Estimated in the monitoring plan |
| Total | | 289,570 | 125,696 | - | |

Source: JICA Study Team

## 1-3-9 Environmental Management Study

### (1) Environmental Management Plan

The preliminary items of the Environmental Management Plan (EMP) during the construction and operation phases are listed below, with impacted items selected based on the assessment analysis in the previous section. The final EMP to be prepared by the construction contractor shall be reviewed and revised based on actual construction planning before commencing the construction works. Management records shall be kept by the contractor and reported to FRA each month as an indicator of environmental management activity.

Table 1-3-45 Items of the Environmental Management Plan

| Category | # | Impacted Item on JICA GL | Major Mitigation Measures | | Responsibility | |
|---|---|---|---|---|---|---|
| | | | Pre and During Construction phase | Operation phase | Implementation Agency | Responsible Agency |
| Pollution Control | 1 | Air pollution | [Dust]<br>-Sprinkle water for dust nuisance<br>[Exhaust gas]<br>-Use low emission construction machinery to avid high exhaust gas emissions<br>-Thorough management of construction machines to avoid inappropriate gas emission. | - Vehicle maintenance regulations for gas emission control from vehicles shall be enforced.<br>- A monitoring or surveillance system for ambient air quality on the road shall be structured to quickly respond in the event of any deterioration in air quality, such as a dust nuisance in the region. | [Construction] Contractor<br>[Operation] FRA | [Construction] FRA<br>[Operation] FRA |
| | 2 | Water pollution | [Turbid water and other items]<br>- Discharge turbid water through sedimentation pond and silt fence<br>- Install a portable toilet for workers<br>- Appropriate management of waste and construction machines<br>- Explain and respond appropriately to the community and fishermen residing along the river, if necessary. | Not required | [Construction] Contractor | [Construction] FRA |
| | 3 | Soil pollution | - Appropriate waste and facility management in the construction yard and working camp.<br>- Preparation of a treatment method in the case of some soil pollution. | Not required | [Construction] Contractor | [Construction] FRA |
| | 4 | Waste | [Construction waste]<br>- Waste shall not be dumped into the river and a temporary dump area shall be prepared.<br>- After considering its potential for reuse, construction waste, including concrete debris, shall be disposed of at the designated disposal site.<br>- Hazardous waste material shall be stored properly pending final treatment.<br>[Garbage from base camp]<br>- Garbage at workers' camp and waste oil shall be brought to a disposal site or treatment facility.<br>[Night soil]<br>- A temporary sanitation facility such as septic tank shall be introduced to the workers' camp. | Not required | [Construction] Contractor | [Construction] FRA |
| | 5 | Noise and vibrations | [Construction noise and vibrations]<br>- Install a noise barrier; select low-noise equipment if necessary.<br>-Avoid works involving heavy equipment at night. | - The vehicle travel speed shall be controlled | [Construction] Contractor<br>[Operation] Local Police | [Construction] FRA<br>[Operation] Local Police |

| Category | # | Impacted Item on JICA GL | Major Mitigation Measures | | Responsibility | |
|---|---|---|---|---|---|---|
| | | | Pre and During Construction phase | Operation phase | Implementation Agency | Responsible Agency |
| | | | -Inform the surrounding communities of the construction schedule. | | | |
| | 7 | Odors | [Garbage from base camp]<br>- Garbage at the workers' camp shall be collected by the local authority<br>[Night soil]<br>- A temporary sanitation facility, such as a septic tank, shall be introduced to the workers' camp.<br>[Other]<br>- Proper maintenance and control of odorous construction materials in the construction yard. | Not required | [Construction] Contractor | [Construction] FRA |
| | 8 | Sediments from riverbeds | - Applying a specific construction method to minimize disturbance of riverbed sedimentation. | Not required | [Construction] Contractor | [Construction] FRA |
| Natural Environment | 10 | Ecosystem | - The construction development area shall be roped or fenced off and remain undisturbed.<br>- Planting of mangroves shall be carried out for cutting mangrove. Replanting of ten seedlings per one cutting mature mangrove is introduced. The area for replanting is designated following discussion with the relevant authorities. | Not required | [Construction] Contractor (bordering), FRA (replanting)/other supporting organization | [Construction] FRA |
| | 11 | Hydrology | - Avoid applying materials that may block the river flow and prepare an engineering analysis for the river flow movement based on the actual construction method if needed.<br>- Periodically monitor the movement of water flow. | Not required | [Construction] Contractor | [Construction] FRA |
| | 12 | Topography of terrain, geology of soils | -Applying road embankment protection technology such as ground cover plants to protect against soil erosion.<br>- Confirm the condition of erosion control at the planned quarry site. | - Establish a surveillance system for embankment erosion and reinforce the maintenance procedure for road embankments | [Construction] Contractor<br>[Operation] FRA | [Construction] FRA<br>[Operation] FRA |
| Social Environment | 13 | Resettlement and land acquisition | - Hold a consultation meeting to convey compensation policy.<br>- Appropriate compensation and social assistance in accordance with the RAP. | - Evaluating the implementation of resettlement activities, particularly for livelihood restoration in accordance with the RAP | [Planning Phase] FRA<br>[Operation] FRA | [Planning Phase] FRA<br>[Operation] FRA |
| | 14 | Poverty | - Applying economic assistance as reconstruction of livelihood for PAPs under the poverty line and PAHs including the socially vulnerable. | Not required | [Planning Phase] FRA | [Planning Phase] FRA |
| | 17 | Land use and utilization of local resources | - Hold an inter-ministerial meeting for land-use modification issues.<br>- Apply measures to mitigate water pollution.<br>- Obtain permission for fishery rights before commencing construction.<br>- Information circulation for the cautious works near the cemetery border. | Not required | [Planning Phase] FRA (land use)<br>[Construction] Contractor (water pollution and permission) | [Planning Phase] FRA (land use)<br>[Construction] FRA |
| | 18 | Water usage | - Apply measures to mitigate water pollution. | Not required | [Construction] Contractor | [Construction] FRA |
| | 19 | Existing social infrastructures and services | - Hold a stakeholder meeting with the authorities with relevant service lines<br>- Hold a stakeholder meeting with the relevant authorities as well as residents to discuss the relocation of bus stops near the bridge for public consent.<br>- Construct diverted roads for vehicles and pedestrians appropriately to ensure accessibility. | Not required | [Planning Phase] FRA (service line and bus stops)<br>[Construction] Contractor (accessibility) | [Planning Phase] FRA (service line and bus stops)<br>[Construction] FRA |

| Category | # | Impacted Item on JICA GL | Major Mitigation Measures | | Responsibility | |
|---|---|---|---|---|---|---|
| | | | Pre and During Construction phase | Operation phase | Implementation Agency | Responsible Agency |
| | 27 | Infectious diseases such as dengue and HIV/AIDS | - Install sufficient drainage facilities to discourage breeding of vector mosquitos<br>-Reinforce medical screening and periodic medical check-ups<br>-Promote awareness of infectious diseases such as HIV/AIDS among laborers to prevent such diseases spreading. | Not required | [Construction] Contractor | [Construction] FRA |
| | 28 | Working conditions (including work safety) | - Periodical guidance and supervision of safety during construction works shall be ensured.<br>- Proper occupational safety management and records of the same are recommended. | Not required | [Construction] Contractor | [Construction] FRA |
| Others | 29 | Accidents | - Deploy flagmen at the gate and crossing points of the construction vehicles.<br>- Install safety signboards.<br>- Install fences around the construction site to keep out local people such as children.<br>- Install lighting for overnight traffic control near the construction area.<br>- Install adequate parking areas for idling construction machines.<br>- Restrict mobilization speed in the construction site.<br>- Safety training for workers.<br>- Safety patrol at the construction site by supervisors. | Not required | [Construction] Contractor | [Construction] FRA |

Source: JICA Study Team

### (2) Environmental Monitoring Plan

#### 1) Construction Phase

Environmental monitoring will be carried out to assess whether mitigation measures are being correctly applied against negative environmental impacts during the construction stage. The monitoring activity associated with pollution control during the construction will be initiated mainly by the contractor at its own expense, with monitoring reports submitted periodically to the FRA. The monitoring activities to be carried out during the construction phase and cost estimates are proposed in the following table:

Table 1-3-46 Summary of Monitoring Activity during the Construction Phase

| Category | No | Items | Parameter | Method | Location | Frequency per year | Cost (USD)/ Construction period (27.7months) | Implementation Agency | Standard |
|---|---|---|---|---|---|---|---|---|---|
| Pollution Control | 1 | Air pollution | SO2, NO2, PM10 | Same method as the baseline survey | 1 site (adjacent to the construction site) | Twice | 5,200 | Contractor | SO2: <350μg/m³ (1hr.)<br>NO2: 200μg/m³ (1hr.)<br>PM10: 0.05mg/m³ (24hrs) |
| | 2 | Water pollution | pH, BOD, COD, SS, Coliform | Same method as the baseline survey | 1 site (Tamavua river near the construction site) | Twice | 5,200 | Contractor | pH 7.0 - 9.0<br>BOD <40 mg/l<br>COD <125 mg/l<br>SS <60 mg/l<br>COL <400 (MPN)/100ml |
| | 3 | Waste | Volume of waste soil, cutting tree and domestic garbage.<br>Waste from demolition works | Record volume of generated waste<br>Record of disposal method | Construction yard and camp site | Monthly | 2,900 | Contractor | Generated waste shall be disposed of at a designated site.<br>The method shall be followed by the final EMP |
| | 4 | Soil pollution | Surveillance of polluted soil | Ocular inspection | Construction yard and camp site | Monthly | Counted in 'Waste' | Contractor | Soil polluted by oil or another chemical can be found |

| Category | No | Items | Parameter | Method | Location | Frequency per year | Cost (USD)/ Construction period (27.7months) | Implementation Agency | Standard |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | Noise | Ambient and roadside noise (LAeq (dB (A)) | Same method as the baseline survey | 2 sites (adjacent to the construction site) | Twice | 2,000 | Contractor | Daytime: 60 dB (A)<br>Nighttime: 50 dB (A) |
| | | Vibration | Vibration (dB L10) | Same method as the baseline survey | 2 sites (adjacent to the construction site) | Twice | 2,000 | Contractor | 75 dB |
| | 7 | Odors | Condition pf garbage and septic tank maintenance | Record of odor condition | Construction yard and base camp | Monthly | Counted in 'Waste' | Contractor | No perception of annoyance. It can be estimated in the item 'Waste'. |
| Natural Env. | 10 | Ecosystem | Status of cutting and replanting mangrove area | Ocular inspection | Mangrove field | 6 times | 3,900 | FRA | Can be reported to the MOE or local authority |
| | 12 | Topography of terrain, geology of soils | Status of road embankment | Ocular inspection | Constructed road embankment | Monthly | - | FRA | Can be counted for regular supervision activity |
| Social Environment | 13 | Involuntary resettlement | Economic status of relocated PAHs and records of complain (if involuntary resettlement finally confirmed) | Interview with PAPs about their economic condition after relocation | Displaced PAHs | Twice | 700 | FRA | Shall be completed during the construction stage |
| | 14 | The poor | | | | | | | |
| | 16 | Local economy such as employment | | | | | | | |
| | 17 | Land use and utilization of local resources | Condition of fishing ground (Tamavua river) | Interview with fisherman | Tamavua river near the construction site | 6 times | 2,000 | FRA | |
| | 18 | Water usage | pH, Coliform | Same method as the baseline survey | Same locations as the baseline survey | 4 times | - | Contractor | Can be inclusively estimated in the item 'water quality' |
| | 19 | Existing social infrastructure and services | Status of accessibility and construction of approach roads | Ocular inspection<br>Interview with residents and companies along the Tamavua-i-wai Road | All the access road | Monthly | - | FRA | Can be counted as regular supervision activity |
| | 27 | Infectious diseases such as HIV/AIDS | Number of infected patients | Periodical health check list | All construction workers | Monthly | - | FRA | Monitoring shall be done based on management record<br>Can be counted for regular supervision activity |
| | 28 | Labor environment (including work safety) | Record of work environment Implementation record of safety instruction | Recording working condition | Construction site, yard and worker's base camp | Monthly | - | FRA | No complaints shall be generated from workers<br>No accident shall occur as a result of the works<br>Can be counted for regular supervision activity |
| Others | 29 | Accident | Number of accidents | Recording accidents related to construction activity | Construction site, yard and worker's base camp | Monthly | Can be counted for regular supervision activity | FRA | Monitoring will be done based on the management records<br>Can be counted for regular supervision activity |
| TOTAL | | | | | | | 23,900 | | FRA: 6,600<br>Contractor: 17,300 |

Source: JICA Study Team

### 2) Operational Phase

The monitoring activity during the operation period will be carried out mostly by the FRA, with appropriate collaboration with the relevant institution such as the MoE in accordance with the fields of the environmental items for two years on an ongoing basis after completion of construction. It is preferable to obtain basic information on the FRA road environment to determine environmental

changes in local communities once all inhabitants have been displaced. The monitoring activities are proposed with estimated cost in the following table:

Table 1-3-47 Summary of Monitoring Activity during the Operation Phase

| Category | No | Items | Parameter | Method | Location | Frequency per year | Cost (USD)/ Construction period (2.0 years) | Implementation Agency | Standard |
|---|---|---|---|---|---|---|---|---|---|
| Pollution | 1 | Air pollution | SO2, NO2, PM10 | Same method as the baseline survey | 1 site (adjacent to the construction site) | Twice | 3,300 | FRA | SO2: <350μg/m³ (1hr.) NO2: 200μg/m³ (1hr.) PM10: 0.05mg/m³ (24hrs) |
| | 5 | Noise | Ambient and roadside noise (dB (A)) | Same method as the baseline survey | 1 site (adjacent to the construction site) | Twice | 3,300 | FRA | Daytime: 60 dB (A) Nighttime: 50 dB (A) |
| Natural | 10 | Ecosystem | Status of cutting and replanting mangrove area | Ocular inspection | Mangrove field | 2 time | 2,500 | FRA | Can be reported to the MOE or local authority |
| | 12 | Topography of terrain, geology of soils | Status of road embankment | Ocular inspection | Constructed road embankment | Twice | - | FRA | Can be counted for regular maintenance activity |
| Others | 29 | Accident | Number of accidents | Recording accidents related to construction activity | Construction site, yard and worker's base camp | Monthly | - | FRA | Monitoring system has been established in FRA's internet site |
| TOTAL | | | | | | | 9,100 | | |

Source: JICA Study Team

## 1-3-10 Stakeholder Meetings (SHM)

### (1) Implementation Policy

A stakeholder meeting is held to share information about the project and reflect stakeholder comments in the environmental and social consideration study through dialog with stakeholders. Information to be explained to the stakeholders includes an overview of the project and expected working components during the construction work. The expected negative and positive impacts on the natural and social environment around the projected site as well as proposed mitigation measures for the negative impacts are also shared during the SHM to extract other comments from the aspects of belonging organization or residents. SHMs are held during both scoping and draft final report stages as part of the environmental and social consideration study. The projected site covers part of both Lami Town and Suva City and settlements are clustered on the Lami Town side (approx. 300m from the bridge) whereas there are no residents living on the Suva City side. Therefore, the SHM for the residents could be collectively held at a single location.

### (2) SHM in the Scoping Stage

Stakeholder meetings were held during the scoping stage to discuss the expected negative impacts and concerns about the natural and social environment possibly triggered by the bridge construction project in the area of Tamavua-i-wai Bridge. The Suva City Council and Lami Town Council were selected as stakeholders correlating closely with residents and other workers near the bridge and MarenqetiViti was selected as the Non-Governmental Organization (NGO) carrying out comprehensive

activities to conserve the natural environment in Fiji. Table 1-3-48 summarizes the discussions and comments in the meetings.

Table 1-3-48 Comments from the SHM during the Scoping Stage

| | |
|---|---|
| Name of Organization | MareqetiViti (NGO) |
| Date/Venue | May 16, 2018/MareqetiViti office |
| In attendance | Nunia Thomas-Moko (Director), Dick Watling, Bindiya |
| ➢As development activities are implemented, it seems that strong regulations on environmental protection are inadequate in Fiji and the mangrove forest in particular tends to be destroyed, despite wide awareness of its environmental benefits such as water purification and countermeasures have yet to be implemented. While allowing this development activity, it is crucial to have mitigation measures, such as replantation of mangrove seedlings, when the destruction of the mangrove forest is necessary. | |
| Name of Organization | Lami Town Council |
| Date/Venue | May 22, 2018/Lami Town Council Office |
| In attendance | Mr. Jasper Singh (Administrate Director) |
| ➢ One of the concerns for the Tamavua-i-wai Bridge construction project from an environmental perspective is the deterioration of vegetation and water quality, as occurred with the previous bridge construction project at the Suva port carried out by a Chinese contractor.<br>➢ The project site on the Suva side includes no residence in the area except for squatters along the river. It seems the bus stop on the Suva side is used mostly by the squatters.<br>➢ They say there would be significant leachate from the landfill premises.<br>➢ Lami Town Council plan to construct a sports complex stadium whereas the MoL plan to transfer the land to the Port Authority to develop a new port. It seems that no progress has yet been made.<br>➢ Last year, 2017, tremendous traffic congestion occurred when the rehabilitation of Tamavua-i-wai Bridge was carried out. During this rehabilitation, a single carriageway was closed, which meant the journey from Lami Town to Suva City took about two hours at 16: 30. Following the rehabilitation of the double carriageway, although traffic flow improved slightly, most of the residents knew the bridge condition was unsafe, which would be a major concern for all parties.<br>➢ It would be good policy to replant mangrove seedlings for vegetation recovery as one of the measures to mitigate the New Tamavua-i-wai Bridge construction project.<br>➢ Lami Town Council has carried out a project of replanting mangrove seedlings as one of its educational programs as well as nursing and selling mangrove seedling pots. A JICA volunteer has also been supporting the program.<br>➢ It would be very meaningful to integrate mangrove seedling activities as one of the measures to mitigate the project and educational programs to reinforce environmental concerns. Lami Town Council agrees with the policy of maintaining a close relationship with the project. | |
| Name of Organization | Suva City Council |
| Date/Venue | May 23, 2018/Suva City Council Office |
| In attendance | Mr. Bijay Chand (CEO) |
| ➢ Reconstructing Tamavua-i-wai Bridge was the main priority for public interest, which would spawn new business opportunities in Suva City.<br>➢ The negative environmental impact of cutting mangrove forests is of major concern. However, cutting a large street tree would not have any negative impact on the surrounding natural and social environment and Suva City will be able to give permission to cut the street tree in Suva City without delay.<br>➢ The bus stop at bridge end on the Suva City side is mostly used by squatters. FRA would have to coordinate relocation of the bus stop.<br>➢ Regarding accessibility of Suva Cemetery, it would not be a problem since the entrance to the cemetery is not located on the bridge side, but the opposite side of bridge between the Rokobili area and Reservoir road, namely far from the project site. However, a meeting with the Commissioner of Correction Service, Mr. Franciskin, who oversees maintenance of the cemetery, would be needed.<br>➢ Serious traffic congestion would be involved if the carriageways of the existing bridge were controlled during construction. FRA would have to disclose information about the construction to the public through media such as newspapers as one of the measures to mitigate traffic safety.<br>➢ Overweight trucks passing on the bridge are serious problem and there is no current monitoring activity to co correspond to the problem.<br>➢ No evacuation warning has yet been announced, even during heavy rain with high tide at the project site. | |

Source: JICA Study Team

### (3) SHM in the Draft Final Report Stage

The draft final stage of the stakeholder meeting was held on 5 June, 2019 under the preparation of FRA. Since its main objective involved sharing information about an overview of the New Tamavua-i-wai Bridge construction project and other environmental and social consideration issues, the scope of those invited to attend was limited to residents, representatives of the related village and local government. Moreover, additional stakeholder meetings initiated by the FRA will be held for individual issues, such as relocation of infrastructure line and traffic control during the construction works, with the relevant government agencies and private sectors. Table 1-3-49 shows an outline, while Table 1-3-50 summarizes the discussions and comments in the meetings.

Table 1-3-49 Outline of the SHM in the Draft Final Report Stage

| | |
|---|---|
| Name of Meeting | Stakeholder Meeting for the Project to Reconstruct Tamavua-i-wai Bridge in the Republic of Fiji |
| Date | Wed. 5 June, 2019 from 17:00 to 19:00 |
| Venue | Suvavou Village Community Hall |
| In attendance | Village Chief (1), Village Spokesman (1), Residents (19) including PAPs , Local government (1) |
| Purpose | A stakeholder consultation meeting to share both the proposed bridge construction design and methodology for the Government of Japan funded Tamavua-i-wai Bridge Replacement Project and the associated Environmental Impact Assessment (EIA), which is currently underway, with key stakeholders.<br>Key interested parties are invited to the public consultation meeting and their views and comments on the Project were sought. At this stage limited stakeholder consultation was considered appropriate, on the recommendation of the Fiji Roads Authority (FRA), with nearby residents and key government stakeholders also invited. |
| (1. Opening Remark)<br>➢Mr. Filipe Coreregа (FRA) thanked and welcomed attendees, providing a brief introduction to why the consultation was taking place and provided an opportunity for key facilitators from Argo Environmental Ltd (Mr. Daniel Gulliver), JICA Study Team (JST) (Mr. Tomomi Fujita) and FRA (Mr. Filipe Coreregа) to introduce persons from each organization present. | |
| (2. Project overview, design and methodology)<br>➢ Mr. Tomomi Fujita (JICA Study Team) presented the Project as part of a PowerPoint presentation, outlining key aspects, including the context/background, high-level design and methodology.<br>➢ Mr. Fujita discussed how two bridges were to be built via separate funding and approval avenues, but that these would ultimately function as a single piece of infrastructure once completed. Construction of the first bridge downstream of the existing bridge (funded by the FRA) had already been approved by DOE, with construction activities imminent.<br>➢ The second bridge project (to be funded by JICA) was the specific topic to be discussed in this consultation meeting.<br>➢ Mr. Fujita also outlined:<br>- A preloading design technique to reassure the stability of the land towards Delainavesi, due to the variable geological environment on each side of the bridge<br>- Elements considered during the construction of the bridge, such as Natural Disasters causing a Rise in Sea Level.<br>- FRA to ensure Project-Affected People (PAPs) are appropriately compensated and any resettlement addressed accordingly. | |
| (3. EIA Study Outline)<br>➢ Mr. Daniel Gulliver (Argo) presented the Environmental Impact Assessment (EIA) Study, as part of a PowerPoint presentation, including the objectives of the meeting, introduction to the EIA consultant, EIA methodology, summary of key environmental and social baseline information, preliminary impact assessment outcomes and proposed corresponding mitigation measures.<br>➢ Specific baseline survey work undertaken was summarized, including:<br>-Water quality sampling, -Air quality, noise and vibration sampling, -Aquatic and terrestrial ecological surveys | |
| (4. Project Timing and Schedule)<br>➢ Mr. Fujita (JICA Study Team) outlined the project schedule in terms of design and construction phases, as well EIA duration, in the context of the FRA Bridge, construction of which is about to start. | |
| (5. Discussion Session)<br>➢ Stakeholders attending were invited to comment and ask any questions they had regarding the project. These are summarized in the section in<br>➢Table 1-3-50. | |

Source: JICA Study Team

Table 1-3-50 Comments of the SHM in Draft Final Report Stage

| Question | Answer |
|---|---|
| ➢ What will happen to the old bridge? (Village Chief) | ➢ The old bridge will be dismantled. (Mr. Fujita, JST)<br>➢ Reiterates to the villagers the issue concerning the geotechnical stability of land towards the Delainavesi side, which is currently unstable. (Mr. Samuela Tawakedrau, FRA) |
| ➢ How will be the current traffic control or circulation change? (Village Spokesman) | ➢ After the construction, in the section around the new bridge, Queens Road will be four lanes wide and the safety measure will mean no way of turning right from Queens Rd. to Tamavua-i-wai Rd. and vice versa. (Mr. Fujita, JST)<br>➢ Additionally, temporary relocation of bus stops on both sides will be necessary during the construction work. The timing of the relocation will be announced to the Village beforehand. (Mr. Fujita, JST)<br>➢ As a measure to counter this issue, FRA is discussing means to facilitate a turning point on the Lami side, such as a roundabout to ease the deterioration of traffic circulation. (Mr. Fujita, JST) |
| ➢What will happen to the residences that directly upstream of the bridge? (Village Chief)<br>➢Will we (Suvavou) be responsible for resettling the three residential homes? (Village Chief) | ➢ Three households have been identified within the footprint of the proposed bridge. These will be resettled in accordance with FRA and MoL standard policy. (Mr. Daniel Gulliver, ARGO).<br>➢ Consultation has begun with these households; which FRA will continue. Resettlement of these households will be the responsibility of the proponent (Mr. Samuela Tawakedrau, FRA).<br>➢ He added that it was unsafe for the three houses to remain in their current location during construction as they were directly within the footprint, or very close to it. (Mr. Fujita, JST).<br>➢ We will be discussing with the Lands Department and the three residential homes along with the FRA regarding the resettlement policy. (Mr. Samuela Tawakedrau, FRA). |
| ➢ Why did the new bridge not follow the alignment of the existing bridge once demolished? (Village Chief) | ➢ It is impossible to use the existing bridge alignment as the substructure of the existing bridge is considerably damaged and the design would include a risk of construction cost and workability. (Mr. Fujita, JST)<br>➢ Approval from the Department of Environment to commence works on the FRA Bridge is awaited. Once the FRA Bridge is constructed, the existing bridge will be demolished and work on the JICA bridge can begin (pending approval) (Mr. Samuela Tawakedrau, FRA) |
| (Photos of the meeting)  | |

Source: JICA Study Team

## 1-3-11 Land Acquisition and Resettlement

### (1) Need for Land Acquisition and Resettlement

Before constructing the new bridge on the existing bridge alighnment under Japan's grant aid scheme (hereinafter referred to as the New Tamavua-i-wai Bridge,) construction of another new bridge on the downstream side carried out by the FRA (hereinafter referred to as the FRA Bridge) will be completed. Moreover, it has been confirmed that construction work of the FRA Bridge will be carried out without acquiring any private land and involuntary resettlement according to the EIA report for the FRA Bridge.

Since the existing bridge structures, including the superstructure, piers and foundation, are severely damaged, the superstructure of the existing bridge will be dismantled soon after completing the FRA Bridge construction and before commencing the New Tamavua-i-wai Bridge construction.

Utilization of existing bridge alignment will correspond to the issues of construction workability, time schedule and cost, traffic safety with familiar driving environment, as well as expectation of cut mangrove vegetation recovery at the area of temporaly use for the construction operation.

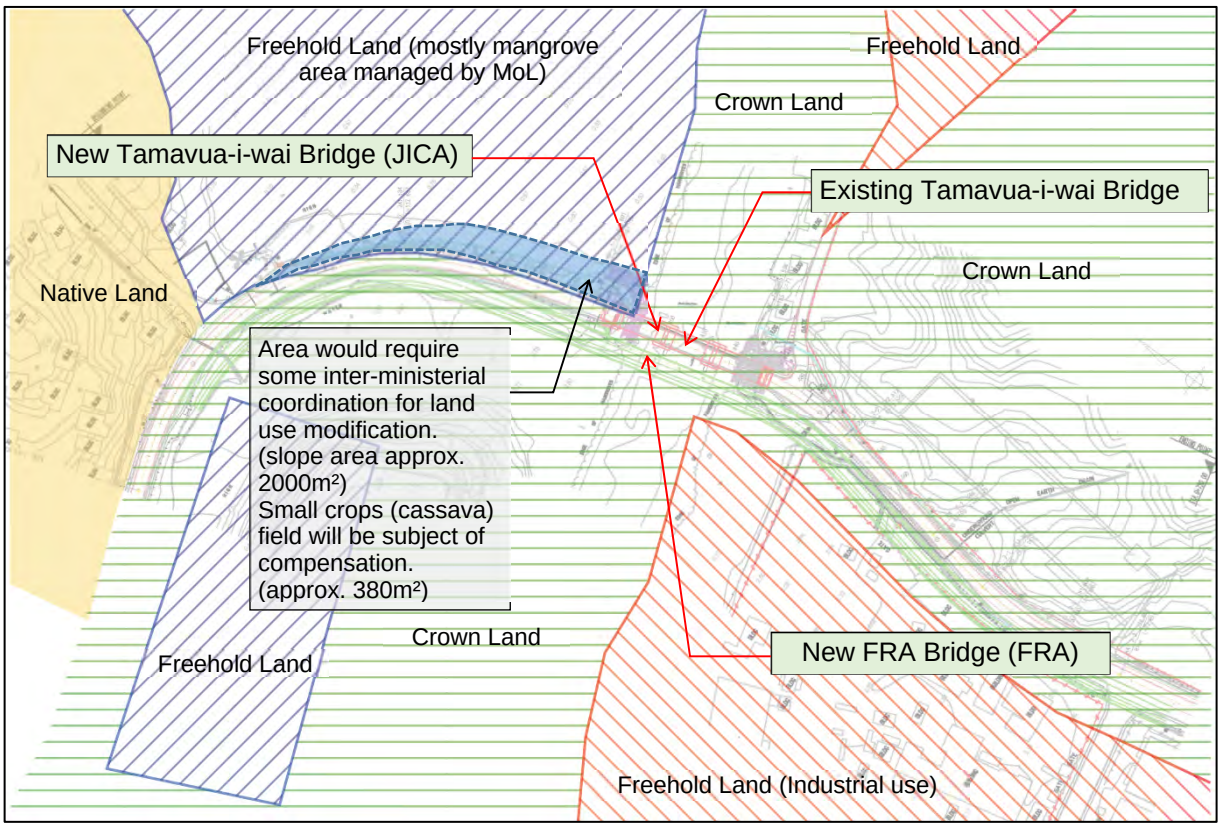
In terms of landownership related to the land acquisition for the Project, there is no private land in the area around the existing Tamavua-i-wai Bridge and the area is confirmed as Crown Land managed by the Fiji Government (Figure 1-3-58). Conversely, an area of privately leased land (2,264m²) was confirmed through the interview survey on Crown Land in the gap between the Tamavua-i-wai River and Tamavua-i-wai Drive near the existing bridge on the Suva side, part of which (approx. 55m²) will be required for land acquisition or termination of the lease agreement for construction and future bridge maintenance (Figure 1-3-59). Although a single title holder living in the leased land was identified for the subject leased land, the eligibility of the lease title will be verified by the Land Department.

Additionally, there are illegal settlements within a range of about 450m along the river on the upstream side, known as Kaleli settlement and the left bank of the existing bridge.

Regarding the Right of Way (ROW) in Fiji, despite the lack of any definite legal statement concerning specific ROW, the following definition is included in the LAW of FIJI Cap 139 Town Planning:

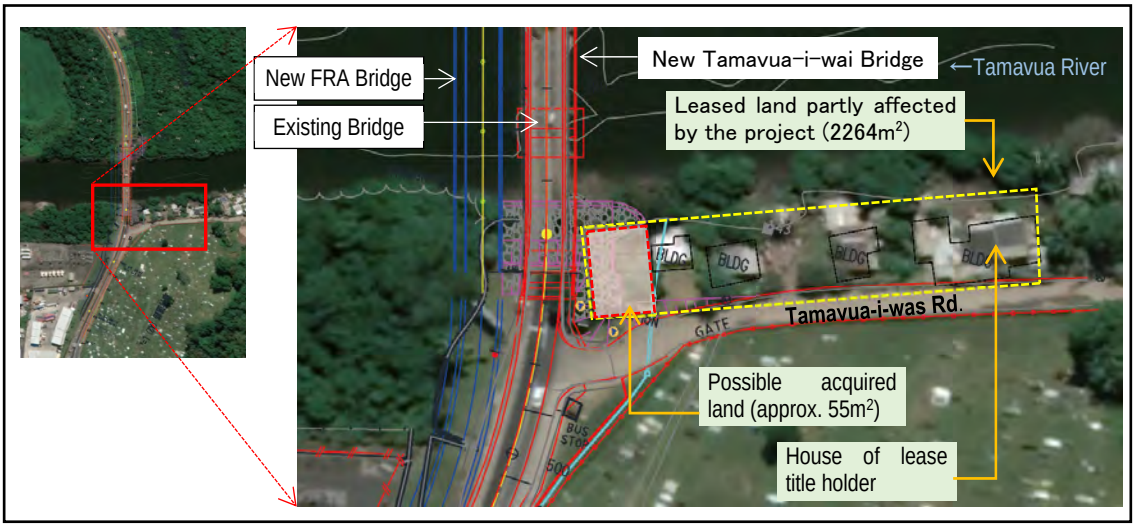
*"street" includes any road, square, footway or passage, whether a thoroughfare or not, over which the public has a right of way and also the way over any public bridge and also includes any road, footway or passage, open court or open alley, used or intended to be used as a means of access to two or more houses whether the public has a right of way thereover or not and all channels, drains and ditches at the side of any street shall be deemed to be part of such street;*

Based on the reference of land tenure overlapped on the new alignment of the New Tamavua-i-wai Bridge and approach road shown as in Figure 1-3-58, no land can be acquired from either a private sector or indigenous clan. However, regarding the issue of changing the boundary of Queens Road in the section near the new bridges, there would be a need to coordinate and discuss with authorized government institutions since the area of the new approach road on the Lami Town side (approx. 2,000m²) would need inter-ministerial coordination associated with land-use modification from Freehold Land to Crown Land as part of road property.




Source: JICA Study Team

Figure 1-3-58 Land Status around the Existing Tamavua-i-wai Bridge



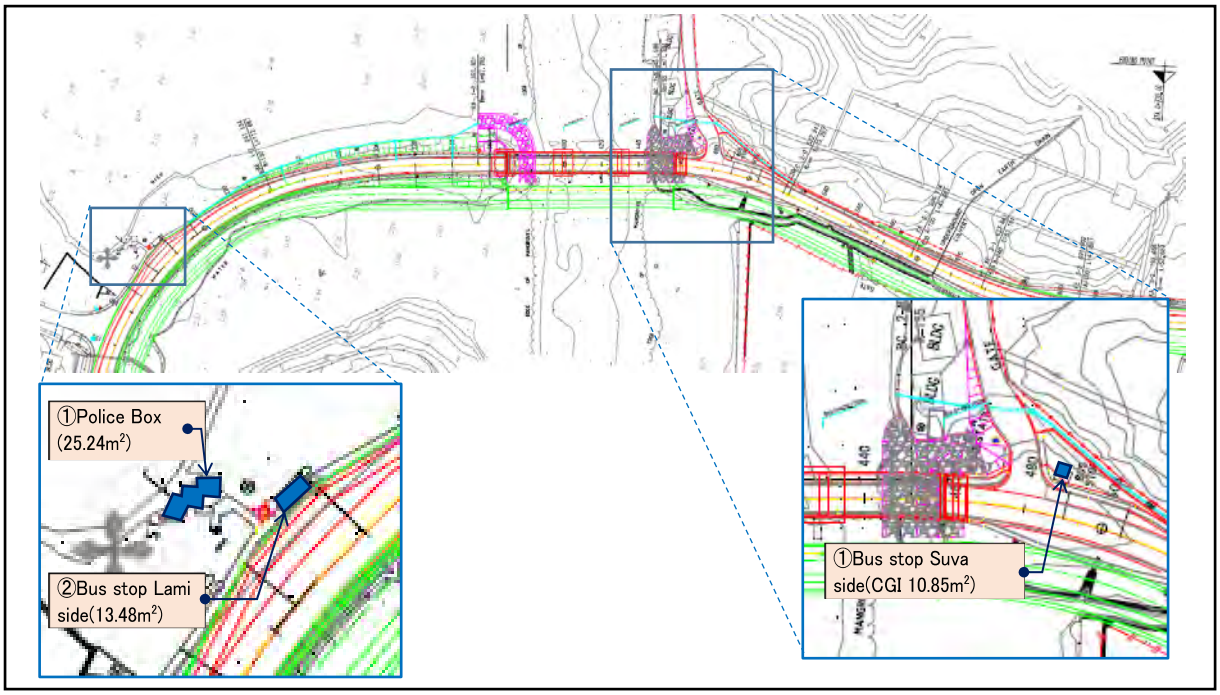

Source: JICA Study Team

Figure 1-3-59 Area for Possible Land Acquisition

Regarding structures potentially affected by the construction works of the New Tamavua-i-wai Bridge, three (3) public structures, including two (2) bus stops on both Suva and Lami sides and one (1) police box on the Lami side are identified. On the other hand, there is no involuntary resettlement confirmed on this project.

Regarding other public structures, prior to commencing the construction works, the project proponent (FRA) must coordinate the relocation issue with competent agencies, Ministry of Commerce, Trade, Tourism and Transport (MCTTT) for the bus stops and Fiji Police Force (FPF) for the police box.

The location of the affected structures and photos are shown on Figure 1-3-60 and Figure 1-3-61 respectively.




Source: JICA Study Team

Figure 1-3-60 Structures Potentially Affected

| | |
|---|---|
|  |  |
| Photo 1 Bus Stop (Suva side) | Photo 2 Bus stop (Lami side) |
|  | |
| Photo 3 Police box (Lami side) | |

Source: JICA Study Team

Figure 1-3-61 Photos of Affected Structures

### (2) Legal Framework for Land Acquisition and Resettlement

#### 1) Overview of the Law and Policy of Land Acquisition and Resettlement in Fiji

The laws and acts listed below comprise the legal framework for issues associated with land acquisition and involuntary resettlement in Fiji.

- The Constitution of Fiji
- The Itaukei Land Trust Act [Cap. 134], 1985 (originated from The Native Land Trust Board Act)
- The Land Transfer Act [Cap 139], 1978
- The Land Sales Act [Cap 137], 1978
- The Agricultural Landlord and Tenant Act, 1997 (supplemented by the Land-Use Decree No. 36 (2010))
- The State Acquisition of Land (amended) Act, 1998 (originated from The Crown Acquisition of Land Act, 1940)
- Town Planning Act [Cap 139], 1978
- Rivers and Streams Act [Cap 139], 1985
- Acquisition Guideline (prepared by the Valuation Division, November 2019)

(Other relevant policy applied for the previous development project by the FRA)

- The Land Acquisition and Resettlement Framework (updated 2017)

#### 2) Land Classification

The land classification in Fiji is summarized as shown below.

##### a) Native Land

The Native Land, comprising approx. 83% of Fiji land, is mostly owned by a clan unit and maintained by the Native Land Trust Board (NLTB). Its position and policy are specified in the Itaukei Land Trust Act and trading thereof is basically prohibited to secure the landownership rights of Fiji's indigenous people. Development in the Native Land requires land lease agreements on some lease payments to the NLTB with a clan and development proponents. The payment will be returned to the owner such as the chief of a clan and delivered to clan members. The lease period varies and is defined between 30 and 99 years. No land trading is prohibited when the land is sold or handed over to the Fiji Government for public use.

##### b) Freehold Land

Freehold Land, comprising approx. 10% of the land of Fiji, is the registered under the Torrens Title System of the Land Transfer Act and which was purchased by European colonists before the colonial period. It is known as modern land adapted to the current status of economic activities that can be sold and leased according to the Land Sales Act. In recent years, to avoid disorder, trading in the land is prohibited to foreigners holding residence permission.

##### c) Crown Land

Crown Land, comprising approx. 7% of the land of Fiji, is land retained by the British Royal Family but without any definite attribution as of 1875. It is commonly known as 'State Land' since it is managed by the MoL as public land. Regarding the river area, the area below the high-water mark (HWM) is

defined as Crown Land. Trading of Crown Land is prohibited, but it may be utilized under a lease agreement supervised by the MoL.

Table 1-3-51 Summary of Fiji Land Classification

| Name | Landowner | Ownership Procedure |
|---|---|---|
| Native Land | Clan | Since trading in the land is not prohibited, the land must be leased according to the Itaukei Land Trust Act.<br>Land acquisition and compensation issues for public use are specified in the Land Transfer Act. |
| Freehold Land | Tenure Holder | The land can be traded according to the Land Sales Act and the trading rights are managed by the Torrens Title System. |
| Crown Land | Government | The land can be leased based on the State Acquisition of Land (amended) Act. |

Source: JICA Study Team

### 3) JICA's Policy for Involuntary Resettlement

The key principles of JICA's policies on involuntary resettlement are summarized below.

Table 1-3-52 JICA's Policy for Involuntary Resettlement

| # | Description |
|---|---|
| 1 | Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. |
| 2 | When, population displacement is unavoidable, effective measures to minimize the impact and compensate for losses should be taken. |
| 3 | People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated for and supported, so that they can improve or at least restore their living standards, income opportunities and production levels to pre-project levels. |
| 4 | Compensation must be based on the full replacement cost[20] as much as possible. |
| 5 | Compensation and other forms of assistance must be provided prior to displacement. |
| 6 | For projects entailing large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A. |
| 7 | In preparing a resettlement action plan, those affected and their communities must be consulted based on sufficient information made available to them in advance. When such consultation is held, explanations must be given in a form, manner and language understandable to those affected. |
| 8 | Appropriate participation of those affected must be promoted when planning, implementing and monitoring resettlement action plans. |
| 9 | Appropriate and accessible grievance mechanisms must be established for those affected and their communities. |
| The above principles are complemented by World Bank OP 4.12, since it is stated in JICA GL that "JICA confirms that projects do not deviate significantly from the World Bank's Safeguard Policies". One additional key principle based on World Bank OP 4.12 is as follows: | |
| 10 | The affected people are to be identified and recorded as early as possible to establish their eligibility through an initial baseline survey (including a population census that serves as an eligibility cut-off date, asset inventory and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of those encroaching others who wish to take advantage of such benefits. |
| 11 | Eligibility of Benefits includes PAPs with formal legal rights to land (including customary and traditional land rights recognized under law), PAPs without formal legal rights to land at the time of census eligible to claim such land or assets and PAPs without any recognizable legal right to the land they are occupying. |
| 12 | Preference should be given to land-based resettlement strategies for displaced persons with land-based livelihoods. |
| 13 | Support the transition period (between displacement and livelihood restoration.) |

[20] Description of "replacement cost" is as follows.

| | | |
|---|---|---|
| Land | Agricultural Land | The pre-project or pre-displacement, whichever is higher, the market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels on a par with those of the affected land, plus the cost of any registration and transfer taxes. |
| | Land in Urban Areas | The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes. |
| Structure | Houses and Other Structures | The market cost of the materials to build a replacement structure with equivalent or superior area and quality than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees and any registration and transfer taxes. |

| # | Description |
|---|---|
| 14 | Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children and ethnic minorities etc. |
| 15 | For projects entailing land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. |
| In addition to the above core principles on the JICA policy, it also emphasized a detailed resettlement policy including all the above points; a project-specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed Financial Plan etc. | |

Source: Reporting instruction of environmental and social considerations for Category B (June 2011)

### (3) Comparative Analysis between JICA's and Fiji's Policy

A comparison between the Government's laws/regulations and JICA GL is shown in Table 1-3-53. The overall policy for assistance package is considered based on measures to fill the gaps in the following table.

Table 1-3-53 Gap Analysis in Land Acquisition and Resettlement between Fiji's Laws[21] and JICA GL

| # | JICA guidelines | Laws in Fiji | Gap between Laws in Fiji and JICA GL | Measures to fill the gap |
|---|---|---|---|---|
| 1 | Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives. (JICA GL) | Compulsory possession of land for public use is stated under the Constitution of Fiji and the State Acquisition of Land Act (SALA).<br>Conversely, in the basic LARF policy, it is stated that involuntary resettlement and loss of means of livelihood have to be avoided or minimized.<br>Additionally, as measures to be taken when avoidance is not possible, the need to compensate for acquired land and loss of assets is defined in the SALA. | There is no definite gap about avoidance from resettlement and loss of means.<br>The requirement for measures to be taken to restore livelihood, restructure the production level and help boost living standards is not defined under Fiji law. | In compliance with LARF and JICA GL, ways must be studied to avoid or minimize land acquisition, involuntary resettlement as well as loss of livelihood during the design stage. This must be followed by JICA GL and measures to reconstruct livelihood for PAPs after relocation are implemented. |
| 2 | When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken. (JICA GL) | | | |
| 3 | People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels. (JICA GL) | | | |
| 4 | Compensation must be based on the full replacement cost as much as possible. (JICA GL) | In the basic LARF policy, it is stated that compensation has to be evaluated based on market price without taking depreciation into consideration.<br>According to SALA, compensation for loss of assets except for land such as structure will be evaluated at book/depreciated value. | Although details of the compensation is not specified under the Fiji's law, similar description specified in LARF. | In compliance with LARF and JICA GL, any compensation is based on the market value of replacement cost without taking depreciation into consideration. |
| 5 | Compensation and other kinds of assistance must be provided prior to displacement. (JICA GL) | The date of compensation payment is defined within 30 days of public announcement in SALA. | It is not specified whether the compensation payment is carried out before physical relocation.<br>Regarding the policy of the MoL, the procedure of compensation payment provides for 75% before construction and 25% after construction. | In compliance with JICA GL, compensation and other forms of assistance are basically provided prior to displacement as much as possible. |
| 6 | For projects entailing large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. (JICA GL) | Need to prepare RAP report, information sharing to PAPs and public disclosure is defined as basic policy in LARF. | There is no legal requirement for an RAP report and public disclosure of the RAP.<br>There is no definite gap between LARF and JICA GL. | In compliance with LARF and JICA GL, the RAP report is prepared and disclosed. |

[21] Including the relevant framework applied for the previous road development project carried out by the FRA

| # | JICA guidelines | Laws in Fiji | Gap between Laws in Fiji and JICA GL | Measures to fill the gap |
|---|---|---|---|---|
| 7 | In preparing a resettlement action plan, consultations must be held with those affected and their communities based on sufficient information made available to them in advance. (JICA GL) | During land acquisition and resettlement procedures, periodical announcements to the landowner are required.<br>The requirement to provide information to the PAPs and disclose the RAP report to the public is defined in the basic LARF policy. | There is no legal requirement for an RAP report and public disclosure of the RAP.<br>There is no definite gap between LARF and JICA GL. | In compliance with JICA GL, the RAP report is public disclosed and prepared through public consultation with PAPs and the community. |
| 8 | When consultations are held, explanations must be given in a form, manner and language understandable to those affected. (JICA GL) | The requirement to consult affected landowners at each phase of RAP preparation activity is stated in SALA. | There is no legal requirement for explanations to be given in a form, manner and language understandable to the PAPs. | Followed by JICA GL, explanations are provided in a form, manner and language understandable to the PAPs. |
| 9 | Appropriate participation of affected people must be promoted in planning, implementing and monitoring resettlement action plans. (JICA GL) | The requirement to consult affected landowners at each phase of RAP preparation activity is stated in SALA. | Participation of RAP preparation is limited to landowners and not clarified to all the affected persons and community. | Followed by JICA GL, participation of all the affected persons and community is assured during RAP preparation. |
| 10 | Appropriate and accessible grievance mechanisms must be established for those affected and their communities. (JICA GL) | Applying grievance by the PAPs is ensured in SALA. A grievance mechanism is clarified in LARF. | There is no detailed grievance mechanism in Fiji's law.<br>There is no definite gap found between LARF and JICA GL. | A grievance mechanism is clarified for actual implementation in accordance with LARF and JICA GL. |
| 11 | Affected people are to be identified and recorded as early as possible to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory and socioeconomic survey), preferably at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP4.12 Para.6) | The requirement for an inventory survey for loss of assets is stated in the resettlement procedure in SALA.<br>LARF defines that identification of entitlement and eligibility for compensation shall be examined through a baseline survey on the initial stage. | There is no legal requirement of detailed baseline survey in Fiji, setting out cut-off-date as well as measures to avoid influx of illegal settlements after displacement.<br>There is no definite gap found between LARF and JICA GL. | In compliance with LARF and JICA GL, a baseline survey, including a socioeconomic survey for the PAPs, is carried out in the initial stage of RAP preparation. Set out the cut-off-date as the starting date of the baseline survey for the PAPs in the initial stage and plan and implement measures against the influx of illegal settlements. |
| 12 | Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP4.12 Para.15) | Protective measures for indigenous persons and persons with no legal possession of land are provided under customary law in Fiji.<br>Implementation of compensation for loss of assets and livelihood reconstruction for squatters is defined in the basic LARF policy. | There is no legal statement defining the right of receiving compensation for the person who has no legal possession of land.<br>There is no definite gap found between LARF and JICA GL. | In compliance with LARF and JICA GL, compensation for loss of assets and assistance of livelihood reconstruction for the person who has no legal possession are provided. |
| 13 | Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP4.12 Para.11) | There is no legal statement about land-based resettlement.<br>In the basic LARF policy, it is stated that land-based resettlement can be provided under coordination with the relevant agency. | There is no legal statement about land-based resettlement.<br>There is no definite gap found between LARF and JICA GL. | Followed by JICA GL, a compensation scheme will be decided through discussion with the PAPs considering their preference. |
| 14 | Provide support for the transition period (between displacement and livelihood restoration). (WB OP4.12 Para. 6) | No legal statement about provision of support for the transition period is found in the laws in Fiji.<br>In the basic LARF policy, the need for support to cover the cost during the transition period is clarified. | There is no legal statement about support for the transition period.<br>There is no definite gap found between LARF and JICA GL. | In compliance with LARF and JICA GL, support to cover the transitional cost required for the displacement is provided. |
| 15 | Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, | There is no legal statement about consideration of social vulnerability in Fiji. | There is no legal statement about consideration of social vulnerability in Fiji.<br>There is no definite gap found between LARF and JICA GL. | In compliance with LARF and JICA GL, mitigation measures such as a livelihood restoration |

| # | JICA guidelines | Laws in Fiji | Gap between Laws in Fiji and JICA GL | Measures to fill the gap |
|---|---|---|---|---|
| | elderly, women and children, ethnic minorities etc. (WB OP4.12 Para. 8) | In the LARF policy, particular consideration of social vulnerability is required. | | program for the socially vulnerable are provided. |
| 16 | For projects entailing land acquisition or involuntary resettlement of fewer than 200 people, an abbreviated resettlement plan is to be prepared. (WB OP4.12 Para. 25) | No legal requirement to prepare an Abbreviated Resettlement Action Plan exists in Fiji. Preparation of an RAP report is required in the LARF policy, regardless of the resettlement volume. | There is no law defining the requirement of Abbreviated Resettlement Action Plan in Fiji. There is no definite gap found between LARF and JICA GL. | An Abbreviated Resettlement Action Plan will be prepared based on the JICA GL when the volume of PAPs is under 200. |

Source: JICA Study Team

### (4) Scale and Scope of Land Acquisition and Resettlement

#### 1) Basic Policy for the Project

Regarding land acquisition, when land use has to be modified due to alignment change of the new approach road, the land between the current and new boundary line is acquired based on a land ownership map which clarifies each of the classifications: Native Land, Freehold Land and Crown Land. Location of the borders is followed by inventory data managed by the Lands Department and a new boundary defined at the edge of the designated road facility.

Regarding involuntary resettlement, all the residential structures located on planned road alignment as well as those which would prove hindrances during the construction works will be categorized as affected structures. During this determination, the intensity of disruption will be taken into consideration for partly affected structures through public consultation with the Project-Affected Persons (PAPs).

The cut-off date, which is related to entitlement of compensation for land acquisition and resettlement, is established based on the start date of the socioeconomic survey dated 15 June, 2019. Since providing any entitlement to compensate for the assets in the projected site after the cut-off date is prohibited, work to install a signboard and disclose information about the project and monitoring/surveillance activity at the projected site will be appropriately carried out by the FRA as countermeasures to avoid problems associated with involuntary resettlement, including the influx of new settlements and structures.

Furthermore, the scope of land acquisition and involuntary resettlement will be updated based on the detailed design and additional consultations to the PAPs will be required if the scale of impacts changes to reflect comments on the updated resettlement action plan.

#### 2) Scale of Involuntary Resettlement and Affected Structures

As shown in Figure 1-3-60 and Figure 1-3-61, there is no involuntary resettlement identified for constructing the New Tamavua-i-wai Bridge and approach road. Conversely, there are three (3) public structures found to be relocated on both sides of the existing bridge. On the Lami Town side, one (1) bus stop is located on the new approach road alignment and one (1) police box would hinder construction operations, while one (1) bus stop is also located on the new approach road on the Suva City side. To proceed to relocate these public structures, some coordination between FRA and the relevant authorities such as police or MCTTT is required. Table 1-3-54 summarizes the scale of impact for resettlement with/without involuntary relocation.

### 3) Scale of Land Acquisition

As shown in Figure 1-3-58, there is no privately owned land on the new alignment of bridge and approach road for the New Tamavua-i-wai Bridge construction project. However, a leased land exists in the Crown Land near the existing bridge. This leased land is solely used for boat-building purposes and part of this land (approx. 55m$^2$) will be the subject of land acquisition or termination of the lease agreement. Additionally, part of the land (approx. 2,000m$^2$) on the new alignment on the Lami Town side is overlapped on Freehold Land which is controlled by the MoL, thus, the use of the land would need to be modified on completion of the project from Freehold Land to Crown Land as road property. Table 1-3-54 summarizes the impact of land acquisition for the project.

### 4) Scale of Affected Crop

An area of cultivated land covering approx. 380m² at the bridge end was found on the Lami side. As shown in Figure 1-3-58, since the land is categorized as Freehold Land managed by the Lands Department, the farmer cultivating crops is illegally engaged in agricultural activity. Major crops include cassava and yam. According to the consultation individually carried out for the farmer, he knows that agricultural activity on the land is not legal and harvests cassava and yam for his family consumption. The farmer also mentioned that it is difficult to record harvests periodically since he only harvests on an as-required basis. The family consumes 1.5 heaps of cassava per week and one bundle of yam potatoes per week from that farm and this consumption volume is used as the basis to evaluate crop compensation.

### 5) Summary of the Impact Scale

Table 1-3-54 summarizes the impact of constructing the New Tamavua-i-wai Bridge on affected land, structures and crops.

Table 1-3-54 Summary of Impacts

| Impact Category | Impact Magnitude | Remarks |
|---|---|---|
| Affected persons requiring involuntary resettlement | | |
| Residence to be displaced | 0 PAPs | |
| Affected persons without resettlement | | |
| Lease title holder | 1 PAPs | Land for houseboat purpose |
| Crop owner | 1 PAPs | Cultivates a cassava and yam field |
| | | |
| Affected assets | | |
| (Private structures) | | |
| Not required | - | |
| (Public structures) | | |
| Police box | 1 (25.24m²) | Controlled by the Fiji Police Force |
| Bus stop | 2 (13.48m², 10.85m²) | Controlled by the MoIT |
| (Leased government land) | | |
| Land requires lease tile modification | 55 m² | Part of the land of total leased land (2,264m²) |
| (Land for public use) | | |
| Land requires land-use modification | 2,000 m² | Land to be modified from Freehold Land to the Crown Land as road property |
| (Cultivated land) | | |
| Land with crops | 380 m² | The land is categorized as Freehold Land managed by the MoL; thus no compensation will be provided. |

Source: JICA Study Team

### (5) Socioeconomic Survey of PAPs

There is no PAPs categorized as involuntary resettlement on this project.

### (6) Measures for Compensation and Assistance

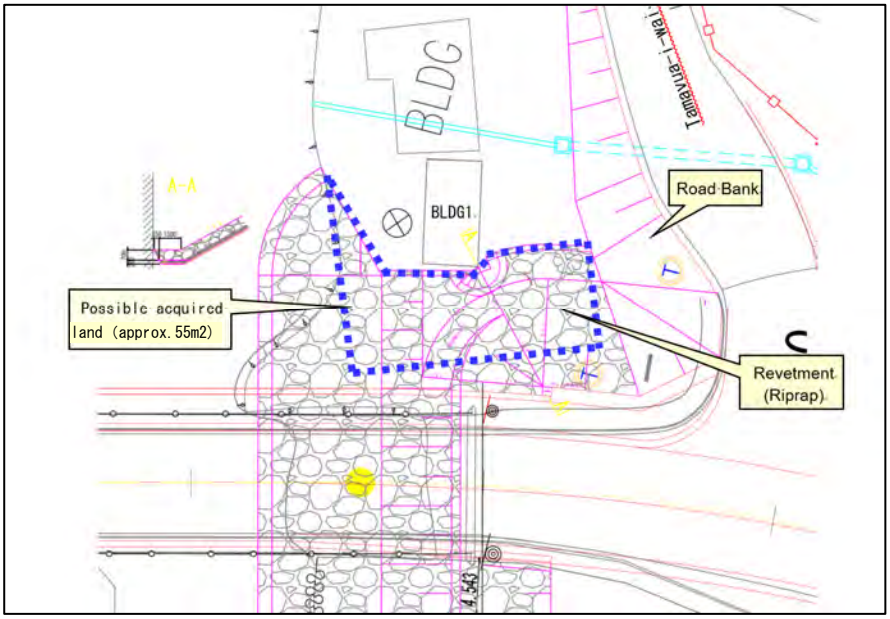
#### 1) Compensation for Loss of Assets

##### a) Loss of Land or Land-Use Rights

Since there is no land owned by the private sector in accordance with the land tenure map organized by the Lands Department and the settlement area overlapping with the new bridge and road alignment is categorized as Crown Land, no compensation for loss of land will be provided to unauthorized occupants along the river bank adjacent to the project area. Conversely, there is a leased land (approx. 55m$^2$), which will be affected by the construction of new road embankment and river revetment associated with the new bridge construction (the following figure shows the location of the affected leased land), and before commencement of the construction operation the lease agreement will have to be terminated with fair compensation to the title holder. More accurate area shall be determined at detailed design stage.

One of the conditions of the lease title prescribes that the leased land shall be solely used for boat-building purposes and one third of the leased land will be utilized for this purpose by the title holder living in the leased land, while the remaining area, which will be affected by the project, is occupied by illegal settlers. In this regard, part of the leased land will be subject to the loss of land-use rights, such as modification or termination of the lease agreement, which shall be mitigated by compensation.

As well as compensating for loss of land lease rights, there would be only inter-ministerial coordination left to take a particular administrative protocol for land-use modification from Freehold Land to Crown Land as road property, since some land on the Lami Town side currently controlled by the Lands Department overlaps the new alignment of the approach road.




Source: JICA Study Team

Figure 1-3-62 Location of the Affected Leased Land

### b) Loss of Structures

There is no privately owned structure affected by this project.

### c) Loss of Crops/Other

Regardless of legal and unauthorized land users, representatives of farmland users will have the right to receive cash compensation for lost consumption for three months at the wholesale price for crops before harvest on the affected farmland. In the case of animal husbandry, no loss of livestock is applicable since livestock is not immovable.

## 2) Entitlement Matrix

The Entitlement Matrix below shows the following fields: i) type of loss, ii) eligible persons, iii) entitlement, iv) implementation issues and v) implementation institution, in accordance with the nature of loss to restore the economic and social livelihood of the PAPs.

Table 1-3-55 Entitlement Matrix of Land Acquisition and Resettlement (Draft)

| Type of Loss | Eligible Persons | Entitlement | Implementation Issues | Implementation Institution |
|---|---|---|---|---|
| A. Loss of Land | | | | |
| Loss of Land/Loss of Land-Use Right | Legal landowner of residential, agricultural or commercial land (Private Freehold Land and Native Land) | · Cash compensation equivalent to the full replacement cost to purchase new land in a similar condition to lost land is provided.<br>· Land-to-land compensation in similar condition will be provided on request. | · In the case of land-to-land compensation, infrastructure such as power, gas, water, approach roads etc. shall be facilitated before actual relocation. | (Evaluation) DL<br>(Payment) FRA<br>(Alternative land) DL |
| | Illegal land occupants for residential, agricultural or commercial use | · No compensation for loss of land is provided to illegal occupants.<br>· Provision of a formal settlement with a new lease agreement can be carried out depending on PAPs' preference. | · Assistance to restore their livelihood will be provided to illegal occupants.<br>· In the case of formal settlement compensation, infrastructure such as power, gas, water, approach roads etc. shall be facilitated before the actual relocation.<br>· In the case of formal settlement compensation, location will be limited depending on availability. | (Alternative land) DL |
| Loss of Land-Use Right | Land lessee of residential, agricultural or commercial land (Lease holder) | · Cash compensation at the replacement cost of leased land or provision of new lease for alternative land at no cost to PAPs for relinquishing the original lease and processing an alternative. | · The eligibility of the certificate holder is determined by the competent authority. | (Evaluation) DL<br>(Payment) FRA<br>(Preparation of compensation money) FRA |
| B. Loss of Structure | | | | |
| Loss of structures including residential houses, commercial office or structures attached to original building such as retaining walls | Owner of structures in ROW | · Cash compensation equivalent to the full replacement cost to purchase new structures is applied.<br>· Reconstruction of lost structures in similar condition will be provided on request. | · Depreciation or price deduction against remaining materials cannot be considered when deciding on compensation for structures.<br>· Shifting allowance for relocating household or business goods.[22]<br>· No compensation will be provided when a formal settlement with a new house is received. | (Evaluation) DL<br>(Payment) FRA<br>(Removal and reconstruction of structure) FRA |

[22] The shifting/relocation allowance will be agreed between the FRA and the household of PAPs on a case-by case basis. The shifting allowance will be adequate to cover (i) dismantling of the structure; (ii) transport of structure/housing materials salvaged and all household effects/commercial goods; and (iii) costs of alternative accommodation, if required, while the structure is being rebuilt.

| Type of Loss | Eligible Persons | Entitlement | Implementation Issues | Implementation Institution |
|---|---|---|---|---|
| Loss of community structures | Community representatives | · Replacement as agreed with community or cash compensation replacement cost without deductions for any materials salvaged. | · Details of compensation shall be determined through discussion with community representatives. | (Evaluation Reconstruction) FRA |
| C. Other Loss (Crops, Trees Etc.) | | | | |
| Loss of crops | Owner (s) of crops or trees irrespective of legal status | · Cash compensation based on a wholesale price in the regional market for agricultural products of single season before harvest on the affected agricultural land is applied. | · Compensation will be paid regardless of legal or illegal landowners and users.<br>· The compensation cost will be determined by the Ministry of Agriculture for crops or productive plants/trees and the Ministry of Forestry for timber trees. | (Evaluation) MOA, MOF (Payment) FRA |
| D. Assistance for Restoration Livelihood | | | | |
| Assistance for moving cost | Household heads of PAPs who need to move | · Cash assistance for estimated moving costs based on required moving expenses is applied. | · Cash assistance for single moving activity will be applied.<br>· Estimation arrangement will be required at an early stage with PAPs since the assistance amount relies on the distance of the new relocation site. | (Evaluation Payment) FRA |
| Assistance for income loss associated with loss of land or land-use rights | Household head of PAPs who loses agricultural income | · Cash assistance equivalent to the price of yearly crop yields on the affected agricultural farm at wholesale prices will be provided. | · Compensation will be paid regardless of legal or illegal landowners and users.<br>· Consultation support in finding a new destination for agricultural farms will be provided.<br>· Livelihood restoration assistance will be implemented through income restoration/improvement programs, including vocational training if needed. | (Evaluation Payment) FRA |
| Assistance for the socially vulnerable | Household head of family with disabled persons | · Cash assistance equivalent to 3 months (20 working days) of minimum wage is applied. | · Assistance amount would be estimated from the minimum wage of Fiji in 2017. (2.68FJD/hr. x 7hrs x 20days x 3.6adults x 3months =4,052FJD). | (Evaluation Payment) FRA |
| | Woman household head or head of household in poverty | · Cash assistance equivalent to 3 months (20 working days) of minimum wage is applied.<br>· Provision of consultation support from finding a new relocation destination is applied.<br>· Implementation of income recovery and restoration program, including career training, will be carried out as livelihood restoration assistance. | · Assistance amount would be estimated from the minimum wage of Fiji in 2017. (2.68FJD/hr. x 7hrs x 20days x 3.6adults x 3months =4,052FJD)<br>· A household in poverty can be defined as a household below the poverty line for average adult individual income. (55.12FJD/adult/wk.)[23] | (Evaluation Consultation, Payment) FRA |

Source: JICA Study Team

[23] 2013-14 HOUSEHOLD INCOME AND EXPENDITURE SURVEY, Fiji Bureau of Statistics, Release No: 98, 2015

### (7) Grievance Redress Mechanism (GRM)

#### 1) General

Regarding the GRM, the Land Acquisition and Resettlement Framework (LARF) can be referred since there is no policy specifying about the GRM in Fiji. According to the LARF for the Transport Infrastructure Investment Sector Project in Fiji, key functions of the GRM are defined as i) recording, categorizing and prioritizing the grievance, ii) settling the grievance in consultation with complainants and other stakeholders, iii) informing the aggrieved parties about the solutions and iv) forwarding any unsolved cases to a higher authority. Moreover, the GRM for the Project, FRA, will be the execution agency to take responsibility to deal with all issues related to land acquisition and involuntary resettlement.

The Project-Affected Persons (PAPs) have the right to access FRA for grievances concerning issues of land acquisition and resettlement to find solutions and ease their difficulties before/after relocation free of charge. Their grievances will be heard by the FRA's social impact manager/social safeguard specialist and the means of contact will be clarified in writing when an agreement on land acquisition or resettlement is concluded. All the relevant authorities such as the MoL and TLTB will be available to review the public complaint and advice on the FRA's performance of the GRM.

#### 2) Procedure

The basic GRM procedure comprises six steps as follows in Table 1-3-56. For step 1, FRA's social impact manager duplicates the record of grievance and hands it over to the complainant after receiving the grievance and clarifying the GRM procedure to be taken for the complaint. Once agreement on the solution is reached between the complainant and FRA through consultation and discussion concerning the solution managed by the social impact manager, all the records of discussion and agreement with the complainant will be archived in a specifically formatted document and promptly reported to JICA.

Table 1-3-56 Grievance Redress Procedure

| Stage | Process | Duration |
|---|---|---|
| 1 | The displaced person/village head or traditional chief takes the grievance to FRA's social impact manager. | Anytime |
| 2 | FRA's social impact manager reviews and finds a solution to the problem in consultation with the village head or traditional chief and relevant agencies. | 2 weeks |
| 3 | FRA's social impact manager reports back the outcome to the village head/traditional chief/displaced person. | 1 week |
| If issue unresolved or party dissatisfied with the outcome obtained by the FRA's social impact manager: | | |
| 4 | The displaced person/village head or traditional chief takes the grievance to the FRA Chief Executive Officer. | Within two weeks of receipt of decision in step 3 |
| 5 | The FRA Chief Executive Officer reviews and finds a solution, in coordination with relevant agencies (such as Lands Deartment). | 4 weeks |
| 6 | The FRA Chief Executive Officer reports back the solution/decision to the displaced person/village head or traditional chief. | 1 week |
| If unresolved or at any stage if the displaced person is dissatisfied: | | |
| The displaced person/village head or chief can take the matter to the appropriate court. | | As per the judicial system |

Source: Land Acquisition and Resettlement Framework, Nov. 2017

### (8) Institutional Framework for Implementation

For the Tamavua-i-wai Bridge Construction Project, the FRA will be responsible for overseeing and managing project execution, including compliance with project requirements and issues of land acquisition and involuntary resettlement in accordance with the Abbreviated Resettlement Action Plan (ARAP) report to be prepared by the FRA; based on both Fiji and JICA safeguard policies. Social Safeguard Personnel (SSP) in FRA will ensure that the procedures and processes established in the ARAP are followed for the project and shall oversee the required Detailed Measurement Survey (DMS) for the affected structures and socioeconomic status of the Project-Affected Persons (PAPs) to complete procedures for compensation and physical resettlement prior to commencing the construction. Moreover, the SSP will be responsible for evaluating lost assets and monetary assistance to reconstruct livelihood to PAPs in poor economic condition and the socially vulnerable in their families. The FRA will be able to outsource a Design and Supervision Consultant (DSC) to share the relevant works as well as reinforce SSP's management capacity for resettlement issues. The entire budget for outsourcing DSC and other recruits for additional SSP shall be prepared by the FRA.

No compensation for land acquisition will be needed for the project since no land need be acquired for road property from private sources. In case the project requires modification of land use from private to public during the detailed design stage, the Lands Department (LD) will be responsible for the following table.

Table 1-3-57 Summary of institutional roles for ARAP implementation

| Institution | Role | Remarks |
|---|---|---|
| FRA | | |
| Social Safeguard Section | (Finalization of ARAP report)<br>・ Verify compliance with applicable laws and standards.<br>・ Verify the scope of impacts regarding land acquisition and involuntary resettlement through a site investigation based on the final detailed design.<br>・ Carry out DMS for the acquired land and structures as well as the socioeconomic status of PAPs.<br>・ Evaluate the unit cost of affected assets, including structures and crops.<br>・ Finalize the compensation and assistance cost estimates followed by compensation policy in RAP.<br>・ Coordinate consultation meetings for explanations to PAPs.<br>・ Study all the relevant activities for the grievance mechanism.<br>・ Discuss and coordinate with the relevant institutions or authorities regarding involuntary resettlement and land acquisition.<br>・ Prepare to disclose project outline, including resettlement issues.<br>(Implementation of RAP)<br>・ Supervise the implementation of ARAP in collaboration with the DSC.<br>・ Negotiate with PAPs for the compensation cost of affected structures and crops as well as the assistance cost.<br>・ Prepare and finalize a document for the compensation agreement with PAPs.<br>・ Manage the grievance redress mechanism, including receiving and recording complaints from PAPs.<br>・ Report and request the total compensation amount to the MOF.<br>・ Coordinate and record receipts of payment for compensation and assistance.<br>・ Coordinate and supervise displacement activity by PAPs.<br>・ Control the area of the project site after displacement to avoid illegal settlement until commencing the construction.<br>・ Monitor the economic status of PAPs after displacement. | A social safeguard specialist will be in charge.<br>DSC can be outsourced for support. |

| | | |
|---|---|---|
| Other Ministry (if necessary) | | |
| Ministry of Land,<br>Lands Department | ・ Attending village consultation meetings regarding land acquisition.<br>・ Carry out initial valuations for the affected land.<br>・ Identify owners and leaseholders.<br>・ Negotiate with landowners for land acquisition or modification/termination of lease agreements.<br>・ Prepare Sale and Purchase Agreements and send them to the TLTB for Board endorsement if needed.<br>・ Approve final land surveys on completion of the project and adjust land compensation as required.<br>・ Prepare land transfer, lease surrender, or freehold dedication documents.<br>・ Administrative works for registration of titles. | Land acquisition of the leased land will be carried out under the MoL's policy |
| Ministry of Forestry | ・ Attend village consultation meetings regarding affected trees.<br>・ Carry out initial valuations for affected trees. | |
| Ministry of Agriculture | ・ Attend village consultation meetings regarding affected crops.<br>・ Carry out initial valuations for affected crops. | |
| Others (if necessary) | | |
| TLTB | ・ Negotiate land acquisitions on behalf of mataqali landowners.<br>・ Sign agreements.<br>・ Secure the consent of mataqali members prior to making such agreements.<br>・ Request the TLTB Board to endorse and approve the Sales and Purchase Agreements and transfer document. | |
| NGO | ・ Review and advise for management of resettlement activity<br>・ Consult PAPs when identifying any particularly vulnerable people | Except for *mataqali* issue |

Source: JICA Study Team

### (9) Implementation Schedule

This ARAP will be updated based on a detailed design of the New Tamavua-i-wai Bridge construction project and will require a Detailed Measurement Survey in the area to be affected by the construction works. An indicative implementation schedule for land acquisition and resettlement activities to (i) update the ARAP; (ii) implement the ARAP; and (iii) monitor resettlement activities, comes as follows (to be updated with detailed and specific target dates during implementation):

Table 1-3-58 Preparation and Implementation Schedule of ARAP

| # | Activities | Responsibility | Schedule |
|---|---|---|---|
| | Update of ARAP | | |
| 1 | Confirm land requirements based on detailed engineering design of the bridges. Determine areas of land, which will fall outside the existing road reserve (ROW). | Consulting engineers, FRA | Month 1 |
| 2 | Provide plans identifying areas to be acquired to LD and TLBT. | FRA | Month 1 |
| 3 | Determine the type of affected land tenure (Itaukei, leased, or freehold) | LD and TLTB | Month 1 |
| 4 | Determine numbers in mataqali group, landowners and users affected (APs) and identify any other vulnerable households not yet noted. | LD, TLTB and FRA | Month 2 |
| 5 | Engage affected communities in consultation and agree on land acquisition. | LD, TLTB and FRA | Month 2; ongoing |
| 6 | Obtain written consent from PAPs, including each landowning unit, during consultation meeting. | LD, FRA | Month 3-4 |
| 7 | Conduct a cadastral survey (Detailed Measurement Survey (DMS)) of the affected assets, determine socioeconomic status if needed and submission for land registration. | LD, FRA | Month 2 |
| 8 | Conduct titles/leases search in the Government titles registration office for affected landownership. | LD, FRA | Month 2 |
| 9 | Determine and mark areas for each land unit required. | LD, FRA | Month 2 |
| 10 | Conduct an inventory of losses - land, trees, crops - and provide valuation for compensation. | FRA, Valuation Division LD & MAFF | Month 4-5 |
| 11 | Negotiate compensation with landowners (mataqali) or holders of Native Leases or | FRA, LD and TLTB | Month 5 |

| # | Activities | Responsibility | Schedule |
|---|---|---|---|
| | freehold landowners as well as owners of lost assets. | | |
| 12 | FRA to submit the updated ARAP for JICA approval. | FRA and JCIA | Month 6 |
| | ARAP Implementation | | |
| 13 | Prepare relevant agreement document for compensation, including Sale and Purchase Agreement endorsed by TLTB Board. | FRA, LD and TLTB | Month 5 |
| 14 | Pay compensation and allowances. | LD, FRA and TLTB | Month 6 |
| 15 | LD to complete land transfers & registration. | LD | Month 7 |
| 16 | FRA to submit the Land Acquisition Completion Report to JICA. | FRA | Month 7 |
| 17 | Award of civil works contract, clearance of land and briefing of contractor on safeguards. | FRA | Month 8 |
| 18 | Commencement of civil works<br>(contingent on payment of compensation and allowances). | FRA | Month 9 |
| 19 | Final survey plan on completion of work; payment of adjusted compensation as required. | FRA and LD | Month 15 |
| | Monitoring Plan | | |
| 20 | FRA starts PAPs socioeconomic monitoring. | FRA | Month 12 |
| 21 | FRA submits a progress report to JICA on ARAP implementation. | FRA | Monthly |
| 22 | FRA conducts a post-project survey and final monitoring report. | FRA | Biannual for 2year-period |

Source: JICA Study Team based on the LARF

### (10) Estimation Cost and Budget

An approximate estimation of compensation items for the construction project of the New Tamavua-i-wai Bridge is shown in Table 1-3-59. The compensation unit prices for land acquisition were estimated based on the market price referred to under the recent project conducted by the FRA with a similar case and all costs related to the land acquisition and resettlement, including compensation money, shall be prepared and shouldered by the FRA.

Table 1-3-59 Cost Estimation for Resettlement

| Items | Quantity | Unit | Unit Price (FJD) | Total Amount (FJD) | Remarks |
|---|---|---|---|---|---|
| 【Land acquisition (acquisition of lease right)】 | | | | | |
| Lease Area | 1 | Blocks | 50,000 | 50,000 | |
| Sub total | | | | 50,000 | |
| 【Compensation for Structure】 | | | | | |
| Not required | - | - | - | 0 | |
| Sub total | - | - | - | 0 | |
| 【Compensation for Crops】 | | | | | |
| Cassava | 1 | laps | 194 | 194 | |
| Yam | 1 | laps | 323 | 323 | |
| Sub total | | | | 517 | |
| 【Moving Cost Assistant】 | | | | | |
| Not required | - | - | - | 0 | |
| Sub total | - | - | - | 0 | |
| 【Livelihood Restoration Support】 | | | | | |
| Not required | - | - | - | 0 | |
| Sub total | - | - | - | 0 | |
| Total | | | | 50,517 | |
| 【Other】 | | | | | |
| Lease land for construction yard | 24,000 | m² | 10 | 240,000 | Assume that the old Lami Waste Depot site will be used for the construction yard. (Existing construction yard for Fletcher). If not $240,000 should be used. |
| Sub total | | | | 240,000 | |
| Grand Total | | | | 290,517 | FJD |
| | | | | 137,996 | USD |

Source: JICA Study Team

### (11) Monitoring Plan

In relation to the compensation based on the Abbreviated Resettlement Action Plan (ARAP), the FRA will ensure evaluation of the compensation details is adequate during the ARAP implementation plan and revise it as needed. The compensation process will be also monitored to ensure it is performed appropriately.

Monitoring activities will be conducted to focus on the following:

✓Whether compensation is given to PAPs appropriately with correct payment amounts.

✓Whether there are any significant complaints because they determine insufficient paid compensation.

✓Number of complaints collected and processed for compensation and other matters

Monitoring activities will be conducted based on information through interviews with the PAPs and the socioeconomic condition after relocation shall be taken into consideration.

Monitoring activities will be conducted by the FRA for approximately two years after completion of compensation payment and shall include recording living conditions data of PAPs. The monitoring activity will preferably be conducted on a quarterly basis.

### (12) Public Consultation

Discussions with residents who would possibly be the PAPs categorized as involuntary resettlement near the Tamavua-iwai Bridge were held on 3 and 4 June, 2019. During the public consultation to the possible PAPs, these discussions are summarized as follows:

Table 1-3-60 Summary of Public Consultation

| | |
|---|---|
| Status of Interviewee | Resident (informal settler) |
| Date/Venue | June 4, 2019/ Possible PAP's house |
| (PAPs' comments)<br>➢ This house was inherited by my wife's sister, who passed away about five years ago and we sometimes suffer from traffic noise and natural disasters.<br>➢ We know that we do not own this land and it is not comfortable to live or safe here. My sister has been living here for more than 20 years and moved from her own village without permission.<br>➢ Although we understand that new bridge construction will be of significant public benefit and agree with the project, we are concerned about our future settlement status.<br>➢ It is very difficult to be a formal settler without enough money, so we would be grateful if the government of Fiji could provide us with a formal settlement. |  |
| Status of Interviewee | Land lease title holder |
| Date/Venue | June 4, 2019/ Possible PAP's house |
| (PAPs' comments)<br>➢ The lease title was issued by the Lands Department and my chief was also involved at that time.<br>➢ I am currently using my house and concrete yard in front for boat-building purposes and three families started to reside there without permission because the area was not in use for the stated purpose.<br>➢ I agree with the new bridge construction project since the existing bridge is in poor condition and would like to discuss the issue of affected leased land with the government of Fiji. |  |
| Status of Interviewee | Farmer (informal settler) |
| Date/Venue | June 3, 2019/Possible PAP's house |
| (PAPs' comments)<br>➢ The types of harvest in the area along the Queen Road near the Tamavua-i-wai Bridge are mainly yam and cassava.<br>➢ The yields are only used for our home consumption.<br>➢ Our family consumes 1.5 heaps of cassava per week and one bundle of yam potatoes per week from that farm.<br>➢ We know that we are cultivating the land illegally.<br>➢ I understand the importance of the project and I would say it is not very difficult to find another place to cultivate illegally if the area is used for the new bridge. |  |

Source: JICA Study Team

## 1-3-12 Others

### (1) Environmental Checklist

| Category | Environmental Items | Main Check Items | Yes: Y No: N | Specific environmental and social considerations (Reason for 'yes' or 'no', grounds, mitigation measures, etc.) |
|---|---|---|---|---|
| 1 Permits and Explanation | (1) EIA and Environmental Permits | (a) Have EIA reports already been prepared in the official process?<br>(b) Have EIA reports been approved by the authorities of the host country's government?<br>(c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, have they been satisfied?<br>(d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government? | (a)N<br>(b)N<br>(c)N<br>(d)Y | (a) An EIA report will be finalized by the FRA based on the preparatory study report prepared by the JICA Study Team.<br>(b) The FRA is to follow the procedure for EIA approval speculated in the Environmental Management Regulation (2007) after finalization of the EIA report. The MoE will be the executive authority for EIA approval.<br>(c) The EIA report will be finalized by the FRA and submitted to the MoE for EIA approval.<br>(d) Several permissions are required to proceed with construction works, all of which are summarized in the preparatory study report. |
| | (2) Explanation to the Local Stakeholders | (a) Have the contents of the project and the potential impacts been adequately explained to the local stakeholders based on appropriate procedures, including information disclosure? Has the understanding of local stakeholders been obtained?<br>(b) Have the comment from stakeholders (such as local residents) been reflected in the project design? | (a)Y<br>(b)Y | (a) Stakeholder meetings with the relevant institutions, including local governments, NGOs and residents, were held to share project information.<br>(b) Stakeholder meetings with residents were also held in the draft final stage and all the comments from residents will be reflected in the final EIA report. |
| | (3) Examination of Alternatives | (a) Have alternative plans for the project been examined with social and environmental considerations? | (a)Y | (a) An alternative analysis was carried out during the basic design stage with a thorough social and environmental consideration study. |
| 2 Pollution Control | (1) Air Quality | (a) Is there a possibility that air pollutants emitted from project-related sources, such as vehicle traffic, will affect ambient air quality? Does ambient air quality comply with the country's air quality standards? Will any mitigating measures be taken?<br>(b) Where industrial areas already exist near the route, is there a possibility of the project exacerbating air pollution? | (a)Y<br>(b)Y | (a) Some negative impacts on ambient air quality due to the construction works are expected, but countermeasures, including spraying water and managing construction machines effectively, will be implemented.<br>(b) Since the project is relatively modest in scope and there is no facility potentially worsening ambient air quality, there is no secondary negative impact triggered by the project. |
| | (2) Water Quality | (a) Is there a possibility that soil runoff from bare land resulting from earthmoving activities, such as cutting and filling, will cause water quality to decline in downstream areas?<br>(b) Is there a possibility that surface runoff from roads will contaminate water sources, such as groundwater? | (a)Y<br>(b)Y<br>(c)Y<br>(d)N | (a) Erosion of the approach road embankment during either construction or operational phases would result in a decline in river water quality.<br>(b) Inappropriate runoff treatment of the planned approach roads attached to the newly built bridge would contaminate the river water of the Tamavua River. |
| | (3) Waste | (a) Is waste generated from the project facilities, such as parking areas/service areas, properly treated and disposed of in accordance with the country's regulations? | (a)Y | (a) Regular waste generated from the project facilities is to be transported to Naboro Landfill and disposed of in accordance with Fiji's disposal regulation. Other industrial waste which might contain hazardous substances is to be treated by the licensed company. |
| | (4) Noise and Vibration | (a) Do noise and vibrations from vehicles and train traffic comply with the country's standards?<br>(b) Is low-frequency noise from passing vehicles and railways consistent with the country's standard? | (a)Y<br>(b)Y | (a) & (b) An EIA report sets noise and vibration standards based on the standards of IFC and Japan since no such standards exist in Fiji. |
| 3 Natural Env. | (1) Protected Areas | (a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas? | (a)N | (a) There is no protected area or area designated by international treaties and conventions near the construction site. |
| | (2) Ecosystem | (a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g. coral reefs, mangroves, or tidal flats)?<br>(b) Does the project site encompass the protected habitats of endangered species as designated by the country's laws or international treaties and conventions?<br>(c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? | (a)Y<br>(b)N<br>(c)Y<br>(d)Y<br>(e)N | (a) Part of the mangrove vegetation will have to be cut for the project, but this environmental impact is insignificant since the scope is comparatively low.<br>(b) No endangered species near the project site has been found, through either a field survey or researching existing references.<br>(c) Replanting of mangrove seedlings will be carried out as a mitigation measure for cutting part of the |

| Category | Environmental Items | Main Check Items | Yes: Y No: N | Specific environmental and social considerations (Reason for 'yes' or 'no', grounds, mitigation measures, etc.) |
|---|---|---|---|---|
| | | (d) Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation and traffic accidents of wildlife and livestock?<br>(e) Is there a possibility that installation of roads will have an impact, such as destruction of forests, poaching, desertification, reduction of wetland areas and disturbance of ecosystems due to the introduction of exotic (non-native invasive) species and pests? Have adequate measures to prevent such impacts been considered? | | mangrove vegetation. (ten seedlings for one cut mangrove)<br>(d) Installation of a barrier fence between vegetation near the river and construction site will be implemented to prevent traffic accidents during the construction phase.<br>(e) Since the construction site is located in an industrial zone, there would be neither an ecologically significant ecosystem nor scope for the new development to cause extensive loss of the natural environment. |
| | (3) Hydrology | (a) Is there a possibility that alteration of topographic features and installation of structures like tunnels will adversely affect surface water and groundwater flows? | (a)N | (a) The bridge construction project will not comprise the installation of structures which could change topographic features or affect surface and ground water flows. |
| | (4) Topography and Geology | (a) Is there any soft ground on the route that may cause slope failures or landslides? Have adequate measures been considered to prevent slope failures or landslides, where needed?<br>(b) Is there a possibility that civil works, such as cutting and filling, will cause slope failures or landslides? Have adequate measures been considered to prevent slope failures or landslides?<br>(c) Is there a possibility that soil runoff will result from cut-and-fill areas, waste soil disposal sites and borrow sites? Have adequate measures been taken to prevent soil runoff? | (a)N<br>(b)N<br>(c)N /Y | (a) There is no area prone to landslides on the project site.<br>(b) No work component is expected to result in any landslides.<br>(c) There are no concerns for landslides at the project site and borrowed pit given the minor volume of the required cut-and-fill. However, the need to monitor the embankment condition shall be taken into consideration.<br>Soil erosion of the embankment of new road would be expected. |
| 4 Social Environment | (1) Resettlement | (a) Does implementing the project involve any involuntary resettlement? If so, have efforts been made to minimize the impacts caused?<br>(b) Has adequate explanation on compensation and resettlement assistance been given to affected people prior to resettlement?<br>(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic resettlement studies?<br>(d) Is the compensation going to be paid prior to the resettlement?<br>(e) Are the compensation policies prepared in a document?<br>(f) Does the resettlement plan focus particularly on vulnerable groups or people, including women, children, the elderly and people below the poverty line, ethnic minorities and indigenous peoples?<br>(g) Are agreements with those affected obtained prior to resettlement?<br>(h) Is an organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?<br>(i) Are any plans developed to monitor the impacts of resettlement?<br>(j) Is a grievance redress mechanism established? | (a)N<br>(b)Y<br>(c)Y<br>(d)Y<br>(e)Y<br>(f)Y<br>(g)Y<br>(h)Y<br>(i)Y<br>(j)Y | (a) No involuntary resettlements will be required for the project. Alternative analysis to minimize the social impact was carried out during the design stage.<br>(b) Public consultation with the possible PAPs was held to share information about the project and items relevant with further resettlement activity during the design stage and will be held when the details of compensation are fixed.<br>(c) A socioeconomic survey of the possible PAPs was conducted to prepare the Abbreviated Resettlement Action Plan (ARAP) and all the compensation policy in the ARAP is prepared based on the survey results. The ARAP will be finalized during the detailed design stage.<br>(d) The ARAP report specifies that compensation payment shall be completed prior to actual displacement.<br>(e) The ARAP report specifies compensation policy.<br>(f) An entitlement matrix in the ARAP report was prepared based on particular consideration for the socially vulnerable, including the poor and indigenous peoples.<br>(g) Agreement with PAPs will be obtained based on the implementation flow and schedule in the ARAP report.<br>(h) The ARAP report clarifies the organization framework relevant with resettlement activity, as well as a budget source for the compensation.<br>(i) The ARAP report specifies a monitoring plan to the PAPs after displacement.<br>(j) The ARAP report specifies a grievance redress mechanism and clarifies the responsible institution. |

| Category | Environmental Items | Main Check Items | Yes: Y No: N | Specific environmental and social considerations (Reason for 'yes' or 'no', grounds, mitigation measures, etc.) |
|---|---|---|---|---|
| | (2) Living and Livelihood | (a) Where roads are newly installed, is there a possibility that the project will affect the existing means of transportation and the associated workers? Is there a possibility that the project will cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unemployment? Have adequate measures been considered to prevent these impacts?<br>(b) Is there a possibility that the project will adversely affect the living conditions of the inhabitants other than the target population? Have adequate measures been considered to reduce the impacts, if necessary?<br>(c) Is there a possibility that diseases, including infectious diseases, such as HIV will be brought due to the influx of workers associated with the project? Have adequate considerations been given to public health, if necessary?<br>(d) Is there a possibility that the project will adversely affect road traffic in the surrounding areas (e.g. increase in traffic congestion and traffic accidents)?<br>(e) Is there a possibility that roads will hinder the mobility of inhabitants?<br>(f) Is there a possibility that structures associated with roads (such as bridges) will cause sun shading and radio interference? | (a)N<br>(b)N<br>(c)Y<br>(d)N<br>(e)N<br>(f)N | (a) There will be no major traffic control on the main road during the construction period since the new bridge will be built next to the existing bridge. However, the construction of new approach road will require a diversion road accessing to main road for the relevant residents.<br>(b) The road access to and from the Tamavua-i-wai Road will decline, but construction of a roundabout will mitigate the impact.<br>(c) The influx of workers would have some negative impact on infectious diseases. Establishment of a health check system for construction workers was specified in the prepared EIA report.<br>(d) No negative impact on the road environment is concerned since there is no complex traffic control during the construction phase.<br>(e) Since the new bridge will be constructed by the existing bridge and the bridge can be in operation during construction, accessibility for residents would not be significantly disturbed.<br>(f) No structure associated with sunshade and radio disturbance will be built for the project. |
| | (3) Heritage | (a) Is there a possibility that the project will damage the local archaeological, historical, cultural and religious heritage? Have adequate measures been considered to protect these sites in accordance with the country's laws? | (a)N | (a) Although Suva Cemetery is located near the project site, particular concerns not to disturb the cemetery were taken into consideration during the design phase. |
| | (4) Landscape | (a) Is there a possibility that the project will adversely affect the local landscape? Have the necessary measures been taken? | (a)N | (a) No significant negative impact on landscape is concerned since the project site is located adjacent to an industrial zone. |
| | (5) Ethnic Minorities and Indigenous Peoples | (a) Are considerations given to reduce the impacts on the culture and lifestyle of ethnic minorities and indigenous peoples?<br>(b) Are all the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected? | (a)N<br>(b)N | (a) and (b) Neither ethnic minorities nor indigenous people are found in the PAPs. |
| | (6) Working Conditions | (a) Is the project proponent violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project?<br>(b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents and management of hazardous materials?<br>(c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health programme and safety training (including traffic safety and public health) for workers etc.?<br>(d) Are appropriate measures being taken to ensure that security guards involved in the project do not threaten the safety of other individuals involved, or local residents? | (a)Y<br>(b)Y<br>(c)Y<br>(d)Y | (a) The proponent and construction contractor shall comply with the Employment Relations Act 2007 and other relevant acts to protect employees' rights and monitoring by construction supervision to check working environment is established on the EIA report.<br>(b) and (c) All measures, regardless of whether tangible or intangible, for a safe working environment will be implemented by the construction contractor and specified in the Environmental Management Plan (EMP) finalized by the contractor.<br>(d) The construction contractor will oversee security of construction materials and other equipment, which will be clarified in the finalized EMP. |
| 5 Others | (1) Impacts during Construction | (a) Have adequate measures been considered to reduce impacts during construction (e.g. noise, vibrations, turbid water, dust, exhaust gases and waste)?<br>(b) If construction activities adversely affect the natural environment (ecosystem), have adequate measures been considered to reduce impacts?<br>(c) If construction activities adversely affect the social environment, have adequate measures been considered to reduce impacts? | (a)Y<br>(b)Y<br>(c)Y | (a) Adequate mitigation measures related to pollution control will be implemented by the construction contractor during the construction period.<br>(b) Mangrove seedlings will be replanted as a mitigation measure for cutting part of mangrove vegetation. (ten seedlings for one cut mangrove)<br>(c) Although an increase in heavy construction vehicles and complexity of the diversion route would trigger some disturbance, this can be minimized by prompt internal information sharing by the contractor. |
| | (2) Monitoring | (a) Will the proponent develop and implement a monitoring programme for the environmental items considered to have potential impacts?<br>(b) What are the items, methods and frequencies of the monitoring programme?<br>(c) Will the proponent establish an adequate monitoring | (a)Y<br>(b)Y<br>(c)Y<br>(d)Y | (a) The EIA and ARAP specify a monitoring plan with the responsible institutions to check for any adverse impact during the construction and operation phases.<br>(b) Monitoring for pollution control will be carried out by a periodical site measurement survey |

| Category | Environmental Items | Main Check Items | Yes: Y No: N | Specific environmental and social considerations (Reason for 'yes' or 'no', grounds, mitigation measures, etc.) |
|---|---|---|---|---|
| | | framework (organization, personnel, equipment and adequate budget to sustain the monitoring framework)?<br>(d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities? | | conducted by the construction contractor. (basically biannual). The FRA will oversee monitoring of the social environment and conduct such monitoring based on a periodical interview survey.<br>(c) The FRA owns an Environmental Unit and is eligible to outsource environmental and social experts from a local consultant.<br>(d) A monitoring sheet is prepared on the EIA report and will be finalized by the construction contractor based on the actual work component. The EIA specifies the submission of the monitoring report to the FRA as well as JICA. |
| 6 Note | (1) Reference to Checklist of Other Sectors | (a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g. projects including large areas of deforestation).<br>(b) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g. projects including installation of power transmission lines and/or electric distribution facilities). | (a) -<br>(b) - | (a) and (b): There are no items to be verified in another environmental revision list. |
| | (2) Notes on Using Environmental Checklist | (a) If necessary, the impacts on transboundary or global issues should be confirmed, if necessary (e.g. the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming). | (a) - | (a) No specific impacts are expected on a global scale or trans-border problems. |

Source: JICA Study Team

## (2) Monitoring Form for Planning Phase (Tentative)

### Preparation of Resettlement Sites (where necessary)

| No. | Explanation of the site (e.g. Area, no. of resettlement HH, etc.) | Status (Completed (date) / not complete) | Details (e.g. Site selection, identification of candidate sites, discussion with PAPs, development of site, etc.) | Expected Date of Completion |
|---|---|---|---|---|
| 1 | | | | |
| 2 | | | | |

Public Consultation

| No. | Date | Place | Attendants | Language | Contents of the consultation / main comments and answers |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |

Finalizations of PAPs List

| Criteria (based on the Entitlement Matrix) | No. of PAPs | Remarks |
|---|---|---|
| 1. Loss of land | | |
| 2. Loss of land use rights | | |
| 3. Loss of structures | | |
| 4. Loss of social structures | | |
| 5. Loss of crops | | |
| 6. Eligibles for moving cost support | | |
| 7. Eligibles for social vulnerability support (PAHs having physical disability) | | |
| 8. Eligibles for social vulnerability support (PAHs under poverty line) | | |

Progress of Activities

| Resettlement Activities | Planned Total | Unit | Progress in Quantity | | | Progress in % | | Expected Date of Completion | Responsible Organisation |
|---|---|---|---|---|---|---|---|---|---|
| | | | During the Quarter | Till the Last Quarter | Up to the Quarter | Till the Last Quarter | Up to the Quarter | | |
| Preparation of RAP | | | | | | | | | |
| Employment of Consultants | | Man-month | | | | | | | |
| Implementation of Census Survey (including Socioeconomic Survey) | | - | | | | | | | |
| Approval of RAP | | - | | | | | | | |
| Progress of Compensation Payment | | | | | | | | | |
| 1. Loss of land | | No. of HHs | | | | | | | |
| 2. Loss of land use rights | | No. of HHs | | | | | | | |
| 3. Loss of structures | | No. of HHs | | | | | | | |
| 4. Loss of social structures | | No. of HHs | | | | | | | |
| 5. Loss of crops | | No. of HHs | | | | | | | |
| 6. Eligibles for moving cost support | | No. of HHs | | | | | | | |
| 7. Eligibles for social vulnerability support (PAHs having physical disability) | | No. of HHs | | | | | | | |
| 8. Eligibles for social vulnerability support (PAHs under poverty line) | | No. of HHs | | | | | | | |
| Progress of Land Acquisition (All Lots) | | ha | | | | | | | |
| Lot 1 | | ha | | | | | | | |
| Lot 2 | | ha | | | | | | | |
| Lot 3 | | ha | | | | | | | |
| Progress of Asset Replacement (All Lots) | | No. of HHs | | | | | | | |
| Lot 1 | | No. of HHs | | | | | | | |
| Lot 2 | | No. of HHs | | | | | | | |
| Lot 3 | | No. of HHs | | | | | | | |
| Progress of Relocation of People (All Lots) | | No. of HHs | | | | | | | |
| Lot 1 | | No. of HHs | | | | | | | |
| Lot 2 | | No. of HHs | | | | | | | |
| Lot 3 | | No. of HHs | | | | | | | |

### (3) Monitoring Form for Construction Phase (Tentative)

The latest results of the following monitoring items shall be submitted to the lenders as part of the Monthly Progress Report throughout the construction phase.

Construction Phase

1. Response/Actions to Comments and Guidance from Government Authorities and the Public

*Main response from the local residence, relevant business persons and government agency is expected.

| Monitoring Item | Monitoring Results during Report Period |
|---|---|
| Number and contents of formal comments made by the public | |
| Number and contents of responses from Government agencies | |

2. Pollution

- Air Quality (Ambient Air Quality)

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| SO2 | µg/m3 (24h) | | | <350µg/m3 (1-hour of 9 hours average) <570µg/m3 (anytime) | To be clarified by engineer | Same as applied value | <20µg/m3 (24-hour), <500µg/m3 (10 minute) | Biannual |
| NO2 | µg /m3 (1h) | | | <200µg/m3 (1-hour of 9 hours average) | S/A | Same as applied value | <40µg/m3 (1-year) <200µg/m3 (1-hour) | Biannual |
| PM10 | µg /m3 (24h) | | | <0.05 mg/m3 (24-hour) | S/A | Same as applied value | <0.02(1-year) <0.05(24-hour) | Biannual |

- Water Quality

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| pH | - | | | 7-9 | To be clarified by engineer | 7-9 | 6-9 | Biannual |
| BOD | mg/l | | | <40 | S/A | <40 | <30 | Biannual |
| COD | mg/l | | | <125 | S/A | N/A | <125 | Biannual |
| SS | mg/l | | | <60 | S/A | <60 | <50 | Biannual |
| Coliform bacteria | MPN /100ml | | | <400 | S/A | <400 | <400 | Biannual |

- Noise

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| Noise Level Leq. | dB A | | | <60(day) <50(night) *Japan's standard | To be clarified by engineer | N/A | <70(day & night) | Biannual |

- Vibration

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| Vibration Level Leq. | dB | | | 75 *Japan's standard | To be clarified by engineer | N/A | N/A | Biannual |

- Waste and Odour

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Inventory record of waste disposal (volume, methodology ) | | To be clarified by engineer | Monthly |
| Inventory record of odour nuissance | | S/A | Monthly |

- Soil Pollution *management of liquid wastes containing oil / chemical substances will be mainly addressed.

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Inventory record of waste disposal (volume, methodology ) and surveillance by visual inspection | | | Monthly |

## 3. Natural Environment

- Condition of cut and re-planted mangrove

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Condition of cut mangrove field | | | Once every two months |
| Condition of re-planted mangrove seedlings | | | Once every two months |

- Condition of constructed road embankment

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Existence of erosion | Details of survey results, such as findings | | Monthly |

## 4. Social Environment

- Condition of fishing ground

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Volume of production | Details of survey results, such as findings | | Once every two months |

- Condition of accessibility

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Status of accessibility | Details of survey results, such as findings | | Once every two months |

- Infectious disease such as HIV/AIDS and other STDs

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Infectious diseases such as HIV/AIDS and other STDs (Incidences per 1000 inhabitants ) | | | Monthly |

- Labour environment

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Record of work environment Implementation record of safety instruction | Details of survey results, such as findings | | Monthly |

## 5. Other

- Traffic Accidents

| Monitoring Item | Monitoring Results during Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Inventory record of traffic accident | Details of survey results, such as findings | | Monthly |

### (4) Monitoring Form for Operational Phase (Tentative)

The latest results of the following monitoring items shall be submitted to the lenders on a biannual basis for the first two years of operation:

Operation Phase

1. Response/Actions to Comments and Guidance from Government Authorities and the Public

| Monitoring Item | Monitoring Results during the Report Period | Frequency |
|---|---|---|
| Number and contents of formal comments made by the public | | Upon receipt of comments/complaints |
| Number and contents of responses from Government agencies | | |

2. Pollution

- Air Quality (Ambient Air Quality)

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| SO2 | µg/m3 (24h) | | | <350µg/m3 (1-hour of 9 hours average) <570µg/m3 (anytime) | To be clarified by engineer | Same as applied value | <20µg/m3 (24-hour), <500µg/m3 (10 minute) | Biannual |
| NO2 | µg /m3 (1h) | | | <200µg/m3 (1-hour of 9 hours average) | S/A | Same as applied value | <40µg/m3 (1-year) <200µg/m3 (1-hour) | Biannual |
| PM10 | µg /m3 (24h) | | | <0.05 mg/m3 (24-hour) | S/A | Same as applied value | <0.02(1-year) <0.05(24-hour) | Biannual |

- Noise

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| Noise Level Leq. | dB A | | | <60(day) <50(night) *Japan's standard | To be clarified by engineer | N/A | <70(day & night) | Biannual |

- Vibration

| Item | Unit | Measured Value (Mean) | Measured Value (Max) | Applied Standards | Measurement Point | Fiji's Standard | IFC's Standard | Frequency |
|---|---|---|---|---|---|---|---|---|
| Vibration Level Leq. | dB | | | 75 *Japan's standard | To be clarified by engineer | N/A | N/A | Biannual |

3. Other

- Traffic Accidents

| Monitoring Item | Monitoring Results during the Report Period | Measures to be Taken | Frequency |
|---|---|---|---|
| Inventory record of traffic accident | Details of survey results, such as findings | | Monthly |

# Chapter 2
# Contents of the Project

# Chapter 2 Contents of the Project

## 2-1 Basic Concept of the Project

This project will reconstruct the Tamavua-i-wai Bridge (bridge length 90m) on Queens Road, which is the most important arterial road in the suburbs of Suva, the capital of Fiji in Viti Levu Island. This project aims to strengthen the resilience of the trunk road against natural disasters by implementing it with the development of approach roads of approx. 500 m. This will contribute to securing safe and stable traffic, strengthening transportation capacity, and traffic safety. This project will contribute to pursue the prosperity of Fiji by strengthening the connectivity of the land transportation network through this robust and sustainable development with the resilient infrastructure.

## 2-2 Outline Design of the Japanese Assistance

### 2-2-1 Design Policy

This Project is for implementing general design on the Tamavua-i-wai Bridge on the Queens Road in response to concern about the risk of the bridge collapsing due to aging, damage, and insufficient load bearing ability.

The plan is to rebuild the Tamavua-i-wai Bridge in an effort to increase load bearing, improve traveling speed and resolve traffic congestion and also improve the convenience of residents along the road based on the policy below in light of the requests of the government of Fiji, field surveys, and discussions.

#### 2-2-1-1 Basic Policy

The design policy for general design is as follows.

**(1) Scope of Cooperation**

The official request for grant aid the Project was submitted to the Japanese embassy from Fiji in May 2014. The request document states that the Tamavua-i-wai Bridge built where the Queens Road crosses the Tamavua River is at risk of collapsing due to aging and frequent damage by the tropical cyclone, and proposes the reconstruction of this bridge.

The preparation survey was conducted for the purpose of reconfirming the details of the request and to confirm factors such as the bridge location and structure plan, cross section configuration, the construction plan/integration, environmental and social considerations, and natural conditions. As a result of consultations with the Fiji government, the main contents of the request for Japanese grant aid that was ultimately confirmed is as follows.

- Construction of PC concrete bridge (two inbound lanes and one side sidewalk)
- Construction of approach road (including T-type intersection)
- River revetment work (including scour countermeasure work)
- Demolition of the A1 bridge abutment and A2 bridge abutment from the existing bridge (however, the superstructure, bridge pier, and former bridge pier will be removed by Fiji)

### (2) Bridge Location

It has been proposed to replace the Tamavua-i-wai Bridge due to deterioration and lack of load bearing capacity. Regarding the following three proposals as the location of the bridge, a comparative study will be conducted on the alignment and structural form of the new Tamavua-i-wai Bridge, the need for temporary bridge and detours, environmental and social considerations, economic efficiency, etc., and the optimal proposal will be determined.

The new FRA bridge construction plan by FRA will also be considered in the comparative study of bridge locations.

- Proposal-1 : The new Tamavua-i-wai Bridge will be constructed downstream of the existing bridge.
- Proposal-2 : The new Tamavua-i-wai Bridge will be constructed at the location of the existing bridge.
- Proposal-3 : The new Tamavua-i-wai Bridge will be constructed upstream of the existing bridge.

### (3) Longitudinal Section Plan

As for the longitudinal section plan of the bridge, the following three proposals will be compared to determine the optimal proposal by raising the height, the effect of waves, the vertical alignment of the road, environmental and social considerations, and economic efficiency.

- Proposal 1: 1/100-year recurrence interval tides + 1/100-year recurrence interval flood water level + climate change with RCP 8.5 scenario
- Proposal 2: 1/100-year recurrence interval tides + 1/100-year recurrence interval waves + climate change with RCP 2.6 scenario
- Proposal 3: 1/100-year recurrence interval tides + 1/100-year recurrence interval waves + climate change with RCP 8.5 scenario

### (4) Traffic Safety

Since the bridge is close to the urban area, the basic policy is to make a plan with due consideration to traffic safety. The specific measures are as follows.

- Separate the sidewalk from the roadway and widen the sidewalk width in order to ensure the safety of pedestrians.
- A bus bay will be installed in order to get on and off the bus safely.
- By separating the new Tamavua-i-wai Bridge from the new FRA bridge, the inbound and outbound lanes will be separated.
- Ensure a longitudinal viewing distance to improve the driver's visibility.

### (5) Scale, etc.

#### 1) Standard Span Length

The planned flood discharge (Q) for the Tamavua River at the position of the Tamavua-i-wai Bridge is 500m3/s, the span length based on the span length settings procedures (Figure 2-2-10) is L≧20m.

#### 2) Scope of Cooperation for the Approach Road

Based on the bridge and road structure plan, it is necessary to raise the existing bridge surface by approx. 2.55m at the A1 bridge abutment position and approx. 1.76m at the A2 bridge abutment position, and an approach road is required in the connecting section at the current road height of Queens Road from the new bridge. While this mounting road will be constructed through Japanese grant aid, the scope of cooperation will be approx.230m on the Lami side and approx.270m on the Suva side.

### (6) Details of the Request and Matters for Consultation and Confirmation

General design will be implemented under the terms mutually confirmed by both countries and the survey team, and the details of the request and matters for consultation and confirmation as of the time of the preparation survey are as follows.

Table 2-2-1 Details of Request and Matters for Consultation and Confirmation

| Item | | Details of request | Matters for consultation and confirmation |
|---|---|---|---|
| Number of lanes | | Two lanes | Two lanes for each side (inbound) |
| Bridge Location | | Existing bridge location | Existing bridge location |
| Bridge length | | 75m | 3@30.0m=90m |
| Bridge form | | 7-span H-steel plate girder bridge | 3-span PC post-tension type slab girder bridge |
| Width | | Roadway 7.315 + sidewalk 1.067m × 2 = 9.449m (existing bridge) | Roadway 7.0m + shoulder 0.5m × 2 + single-sided sidewalk 2.0m = 10.0m |
| Design Speed | | - | 50km/h |
| Design Live Load | | HN-H0-72 (existing bridge) | B live load |
| Approach road | | | Lami side approx.230m, Suva side approx.270m, total approx.500m |
| Revetments | Right bank | | Rubble (upper layer D50-450mm,lower layer D50-150mm) 70m |
| | Left bank | | Rubble (upper layer D50-450mm,lower layer D50-150mm) 60m |
| Bed protection | P1 | | Foundation consolidation mat, covering type 3t-type 303m2 |
| | P2 | | Foundation consolidation mat, covering type 3t-type 310m2 |

### 2-2-1-2 Seismic design policy

#### (1) Summary of the earthquake

The area near the boundary between the Pacific Plate and Indo-Australian Plate is one of the most active seismic activity areas in the world, and some of the main earthquakes that have occurred in Fiji are shown in the table below.

Table 2-2-2 Earthquakes in Fiji (M6.5 or above, depth of less than 30km)

| Date of occurrence | M | Date of occurrence | M | Date of occurrence | M |
|---|---|---|---|---|---|
| 1919.01.01 | 7.8 | 1994.03.09 | 7.6 | 2013.05.24 | 7.4 |
| 1928.06.21 | 6.7 | 1998.03.29 | 7.2 | 2014.11.02 | 7.1 |
| 1949.12.26 | 6.9 | 2004.07.15 | 7.1 | 2016.05.28 | 6.6 |
| 1952.06.10 | 6.5 | 2007.12.09 | 7.8 | 2017.01.04 | 6.9 |
| 1960.11.24 | 7.2 | 2009.11.09 | 7.3 | 2018.08.19 | 8.2 |
| 1990.06.23 | 6.9 | 2011.09.16 | 7.3 | 2018.09.07 | 8.1 |

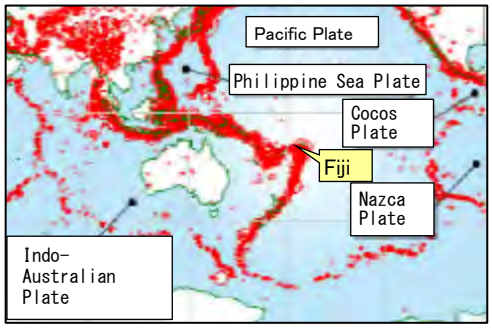



Figure 2-2-1 Distribution Map of Earthquakes with a Shallow Epicenter (0 to 100km) of M5 or Above

In this manner, many large earthquakes have occurred in Fiji in the past, and sufficient earthquake-resistant design is required for the design of the bridge being surveyed.

#### (2) Earthquake-resistant Design Policy

The Queens Road where the bridge is positioned is an important main highway that loops around south to link the capital Suva, the second largest city Lautoka, and Nadi International Airport. If the bridge were to collapse due to an earthquake, it would have a significant negative impact on not only regional logistics, but also on rescue, medical, and firefighting activities. In this manner, because the bridge plays an extremely important role, it is important to ensure earthquake-resistance and the basic policy is to aim to improve earthquake-resistance in design.

### 2-2-1-3 Policy for Traffic Volume

A traffic volume survey shall be conducted at the Tamavua-i-wai Bridge to gain an understanding of current traffic volume near the target bridge. The results of the survey shall be used for estimates of future traffic volume and pavement design for the Tamavua-i-wai Bridge.

#### (1) Survey on Current Traffic Volume

##### 1) Purpose of the Survey

A traffic volume survey by vehicle type including pedestrians and two-wheeled vehicles was conducted to gain an understanding of current traffic volume (2018) and set future traffic volume for Tamavua-i-wai Bridge.

##### 2) Contents of the Survey

A survey on traffic volume near the target bridge was conducted for a total of three days as follows. In terms of the survey method, manual measurements were conducted at predetermined measurement points by multiple surveyors.

Table2-2-3 Contents of the Traffic Volume Survey

| Survey site | Survey date | Survey time | Contents of the Survey |
|---|---|---|---|
| Tamavua-i-wai Bridge | May 29 (Tuesday) | 7:00 to 19:00 (12 hours) | • By direction (both directions)<br>• All vehicles including pedestrians and two-wheeled vehicles (by vehicle type) |
| | May 31 (Thursday) | 7:00 to 7:00 on the following day (24 hours) | |
| | June 3 (Sunday) | 7:00 to 19:00 (12 hours) | |


Figure 2-2-2 Traffic Volume Survey Sites

### 3) Survey Results

The results of the traffic volume survey conducted for this survey are shown below. Note that the value from 19:00 to 7:00 of the following day that for the 12-hour survey conducted on May 29 and June 3 was calculated based on the day and night ratio (78%) gained from the results of the 24-hour survey conducted on May 31.

Table 2-2-4 Traffic Volume Survey Results

| Date | Direction | Time | Passenger Cars | Taxies | Pickups/ Vans | Mini-Buses (14 seats < ) | Buses | Light Trucks | Heavy Truck | Trailer | Multi Trailer | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 29th May Tuesday | SUVA - LAMI | 7:00 - 19:00 | 4,601 | 1,946 | 1,252 | 68 | 295 | 52 | 743 | 104 | 43 | 9,104 |
| | | 19:00 - 7:00 | 1,299 | 550 | 354 | 19 | 83 | 15 | 210 | 29 | 12 | 2,571 |
| | | Sub Total | 5,900 | 2,496 | 1,606 | 87 | 378 | 67 | 953 | 133 | 55 | 11,675 |
| | LAMI - SUVA | 7:00 - 19:00 | 4,168 | 1,798 | 1,805 | 68 | 272 | 73 | 767 | 107 | 17 | 9,075 |
| | | 19:00 - 7:00 | 1,177 | 508 | 510 | 19 | 77 | 21 | 217 | 30 | 5 | 2,563 |
| | | Sub Total | 5,345 | 2,306 | 2,315 | 87 | 349 | 94 | 984 | 137 | 22 | 11,638 |
| | Both Direction | Total | 11,246 | 4,801 | 3,920 | 174 | 727 | 160 | 1,936 | 271 | 77 | 23,313 |
| 31st May Thursday | SUVA - LAMI | 7:00 - 19:00 | 3,967 | 2,099 | 1,920 | 70 | 299 | 56 | 707 | 142 | 39 | 9,299 |
| | | 19:00 - 7:00 | 1,104 | 836 | 515 | 38 | 53 | 8 | 134 | 43 | 7 | 2,738 |
| | | Sub Total | 5,071 | 2,935 | 2,435 | 108 | 352 | 64 | 841 | 185 | 46 | 12,037 |
| | LAMI - SUVA | 7:00 - 19:00 | 4,425 | 2,182 | 1,994 | 72 | 298 | 102 | 813 | 184 | 9 | 10,079 |
| | | 19:00 - 7:00 | 1,133 | 936 | 432 | 22 | 58 | 9 | 114 | 29 | 2 | 2,735 |
| | | Sub Total | 5,558 | 3,118 | 2,426 | 94 | 356 | 111 | 927 | 213 | 11 | 12,814 |
| | Both Direction | Total | 10,629 | 6,053 | 4,861 | 202 | 708 | 175 | 1,768 | 398 | 57 | 24,851 |
| 3rd June Sunday | SUVA - LAMI | 7:00 - 19:00 | 2,534 | 1,425 | 1,067 | 50 | 131 | 13 | 278 | 9 | 0 | 5,507 |
| | | 19:00 - 7:00 | 716 | 402 | 301 | 14 | 37 | 4 | 79 | 3 | 0 | 1,555 |
| | | Sub Total | 3,250 | 1,827 | 1,368 | 64 | 168 | 17 | 357 | 12 | 0 | 7,062 |
| | LAMI - SUVA | 7:00 - 19:00 | 2,684 | 1,436 | 946 | 48 | 120 | 14 | 297 | 14 | 0 | 5,559 |
| | | 19:00 - 7:00 | 758 | 406 | 267 | 14 | 34 | 4 | 84 | 4 | 0 | 1,570 |
| | | Sub Total | 3,442 | 1,842 | 1,213 | 62 | 154 | 18 | 381 | 18 | 0 | 7,129 |
| | Both Direction | Total | 6,692 | 3,669 | 2,582 | 126 | 322 | 35 | 737 | 29 | 0 | 14,191 |
| Average | Both Direction | Total | 9,522 | 4,841 | 3,788 | 167 | 586 | 123 | 1,481 | 233 | 45 | 20,785 |

Characteristics of current traffic on the Tamavua-i-wai Bridge (Results of weekday 24-hour survey)

- Daily traffic (2018): 24,851 vehicles (excluding two-wheeled vehicles)
- Vehicle type composition: passenger vehicles 86.7%, large vehicles 9.6%,
  buses 3.7%
- Peak rate: 8% (17:00 to 18:00)

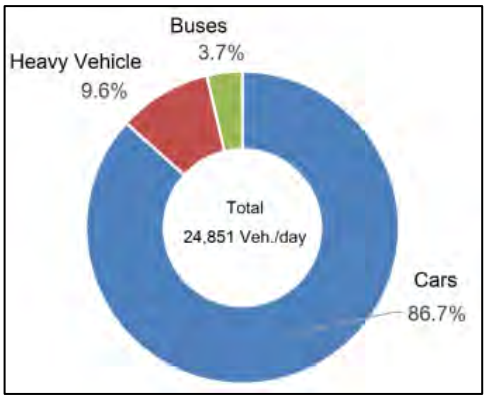



Figure2-2-3 Traffic Volume Survey Results

### 4) Annual Average Daily Traffic

Although information on day of week variation and monthly variation was collected in Fiji in order to calculate the annual average daily traffic (AADT), there was not any past data that could be used. For this reason, day of week variation and monthly variation coefficients were set based on information from local subcontractors.

For day of week variation, there was little variation in the traffic volume on weekdays depending on the day of the week throughout the year, and there was a significant reduction on Sundays. A similar trend has been seen in the survey results for this survey. The traffic volume on Saturday was set at a level between weekdays and holidays based on the results of the interviews.

For monthly variation, because there is a decrease in cars going between homes and schools during school holidays during the two months of January and December and a period of two weeks each in April and August, traffic volume was set 10% lower than normal traffic volume during these months.

The annual average daily traffic (AADT) that was calculated from the monthly variation and daily variation set is shown in the following table.

Table2-2-5 Annual Average Daily Traffic (2018)

Vehicle/day

| No. | Day | Passenger Cars | Taxies | Mini-Buses (14 seats < ) | Buses | Pickups/ Vans | Light Trucks | Heavy Truck | Trailer | Multi Trailer | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | Weekday | 10,937 | 5,427 | 188 | 718 | 4,391 | 168 | 1,852 | 334 | 67 | 24,082 |
| (2) | Saturday | 8,815 | 4,548 | 1,385 | 520 | 2,258 | 101 | 1,295 | 182 | 33 | 19,137 |
| (3) | Sunday | 6,692 | 3,669 | 2,582 | 322 | 126 | 35 | 737 | 29 | 0 | 14,191 |
| (4) | Average | 10,028 | 5,050 | 701 | 633 | 3,477 | 139 | 1,613 | 269 | 53 | 21,963 |
| (5) | AADT | 9,777 | 4,924 | 684 | 617 | 3,390 | 136 | 1,573 | 262 | 51 | 21,414 |

Note: (4) =( (1)*5days+((1)+(3))/2+(3))/7days
(5) =(4)*Monthly variation coefficient(0.975)

### 5) Two-wheeled Vehicles and Pedestrians

The 24-hour traffic volume for two-wheeled vehicles on the Tamavua-i-wai Bridge that was confirmed in the traffic volume survey was 13 vehicles on weekdays and 18 vehicles on holidays. In addition, the traffic volume for pedestrians including bicycles was 72 people on weekdays (of which, 7 bicycles) and 48 people on holidays (of which, 4 bicycles). For two-wheeled vehicles, because the number of users within the city of Suva overall is low, the traffic volume was also low on the Tamavua-i-wai Bridge. For pedestrians, the traffic volume of approx. 75% was based on use between 7:00 to

19:00. In addition, pedestrian and two-wheeled vehicle traffic volume was nearly zero between 21:00 and 5:00 of the following day. However, it was observed that while there were few users from early morning to the even hours, constant use was observed.

### (2) Estimated Future Traffic Volume

#### 1) Estimation Method

The annual average daily traffic (AADT) for 2018 calculated based on the results of the traffic volume survey conducted for this survey was used as the traffic volume for the base year. Future traffic volume was estimated from the future traffic volume growth rate based on the traffic volume for the base year. The traffic volume growth rate was set from the elasticity value calculated from the registered number of automobiles and the GDP growth rate and the projected GDP growth rate. The projection period for future traffic volume is 20 years from the start of use.

#### 2) Future Traffic Volume Growth Rate

##### a) Registered Number of Automobiles

The registered number of automobiles increased from 60,071 vehicles in 2001 to 110,763 vehicles in 2016 when looking at the total for all vehicle types, so there was an annual average growth rate (CAR) of 4.2%. A growth trend has continued in the registered number of automobiles, and it is expected that it will increase in the future as well.

Passenger vehicles more than doubled from 37,546 vehicles in 2001 to 79,815 vehicles in 2016. In addition, the ratio of passenger vehicles to all vehicles was over 70% and they account for the majority of vehicles.

The registered number of automobiles by vehicle type is shown in the following table.

Table 2-2-6 Registered Number of Automobiles (Vehicles/Year)

| Year | Private Car | Taxis | Heavy Vehicles | Buses | All Other Vehicles | Total |
|---|---|---|---|---|---|---|
| 2001 | 37,546 | 4,027 | 15,980 | 1,277 | 1,241 | 60,071 |
| 2002 | 40,938 | 4,196 | 16,688 | 1,339 | 1,491 | 64,743 |
| 2003 | 45,012 | 4,653 | 16,710 | 1,417 | 1,829 | 69,730 |
| 2004 | 48,607 | 5,029 | 17,783 | 1,468 | 2,337 | 75,384 |
| 2005 | 51,233 | 5,154 | 17,833 | 1,511 | 2,781 | 78,753 |
| 2006 | 53,565 | 5,463 | 18,569 | 1,607 | 3,264 | 82,754 |
| 2007 | 53,515 | 5,390 | 18,262 | 1,635 | 3,250 | 82,351 |
| 2008 | 54,167 | 5,137 | 18,375 | 1,567 | 3,217 | 82,756 |
| 2009 | 53,023 | 5,427 | 16,879 | 1,595 | 3,312 | 80,522 |
| 2010 | 53,819 | 5,687 | 16,757 | 1,763 | 3,627 | 81,926 |
| 2011 | 53,714 | 5,974 | 17,072 | 1,839 | 3,923 | 82,781 |
| 2012 | 54,919 | 6,079 | 16,646 | 1,890 | 3,832 | 83,655 |
| 2013 | 59,415 | 6,459 | 17,077 | 1,971 | 3,961 | 89,190 |
| 2014 | 64,988 | 6,572 | 17,616 | 2,034 | 4,411 | 95,940 |
| 2015 | 69,968 | 6,475 | 18,170 | 2,006 | 4,478 | 101,425 |
| 2016 | 79,815 | 6,045 | 17,485 | 2,403 | 4,690 | 110,763 |
| CAGR | 5.2% | 2.7% | 0.6% | 4.3% | 9.3% | 4.2% |

Source: Fiji Bureau of Statistics

### b) GDP Growth Rate

Although both positive GDP growth and negative GDP growth were experienced up to 2009, positive growth has been maintained since 2010 and the economy has been generally stable. GDP growth rate trends are shown in the following table.

Table2-2-7 GDP Growth Rate

| Year | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 3.2% | 0.8% | 5.4% | -1.3% | 1.9% | -0.9% | 1.0% | -1.4% | 3.0% | 2.7% | 1.4% | 4.7% | 5.6% | 3.8% | 0.4% |

### c) Elasticity Value

The elasticity value was calculated by dividing the growth rate in the registered number of automobiles by vehicle type from 2002 to 2016 by the GDP growth rate for the same period.

Table 2-2-6 Elasticity Value

| Vehicle Type | Private Car | Taxis | Heavy Vehicles | Buses |
|---|---|---|---|---|
| Elasticity | 1.6 | 0.9 | 0.2 | 1.4 |

### d) Growth Rate

The future traffic volume growth rate was calculated based on the projected GDP growth rate and the elasticity value calculated above. Because the International Monetary Fund (IMF) projects that Fiji's GDP growth rate will continue to be around 3.2% in the future, a projected GDP growth rate of 3.2% was used for this survey.

Table2-2-7 Future Traffic Volume Growth Rate

| Vehicle Type | Private Car | Taxis | Heavy Vehicles | Buses |
|---|---|---|---|---|
| Growth Rate | 5.3% | 2.8% | 0.7% | 4.4% |

### 3) Future Traffic Volume

Future traffic volume was calculated from the annual average daily traffic for 2018 and the future traffic volume growth rate. A New FRA Bridge is being constructed by FRA next to the Tamavua-i-wai Bridge that is the target bridge for the Work. For this reason, half of the original traffic volume was allocated to Tamavua-i-wai Bridge traffic volume and the remaining half was allocated to the New FRA Bridge. The future traffic volume for the Tamavua-i-wai Bridge is shown below.

Table2-2-8 Future Traffic Volume (Tamavua-i-wai Bridge)

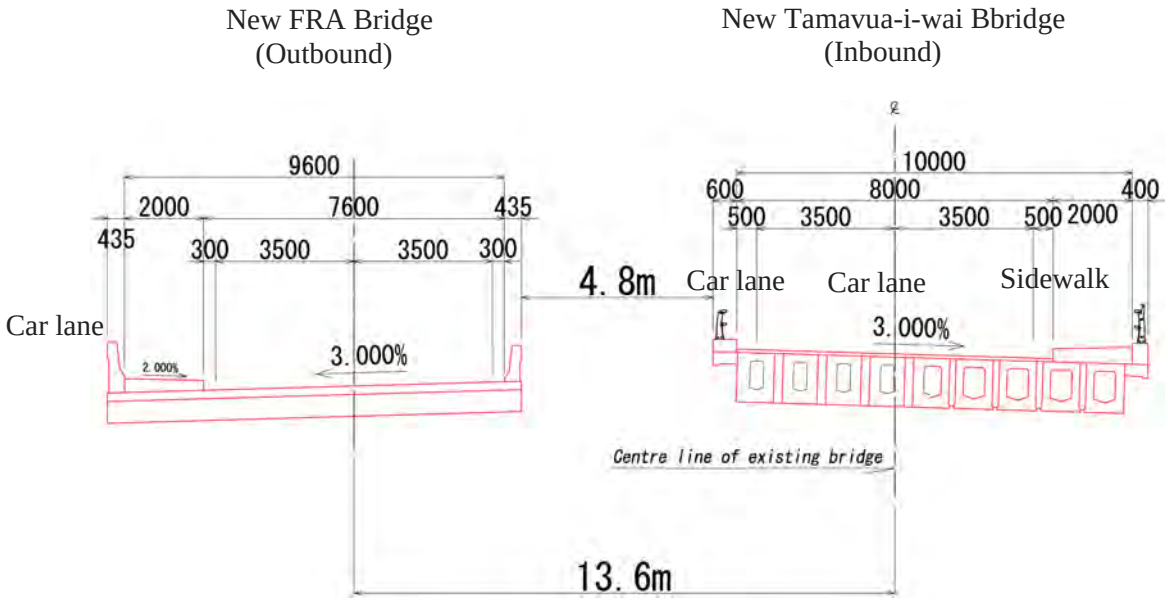
(vehicle/day)

| Year | Passenger Cars | Taxies | Mini-Buses (14 <) | Pickups /Vans | Buses | Light Trucks | Heavy Truck | Trailer | Multi Trailer | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | 4,888 | 2,462 | 342 | 1,695 | 308 | 68 | 787 | 131 | 26 | 10,707 |
| 2019 | 5,145 | 2,532 | 357 | 1,706 | 322 | 68 | 792 | 132 | 26 | 11,081 |
| 2020 | 5,415 | 2,604 | 373 | 1,718 | 336 | 69 | 797 | 133 | 26 | 11,471 |
| 2021 | 5,700 | 2,679 | 389 | 1,729 | 351 | 69 | 802 | 134 | 26 | 11,880 |
| 2022 | 5,999 | 2,755 | 406 | 1,741 | 367 | 70 | 808 | 135 | 26 | 12,307 |
| 2023 | 6,314 | 2,833 | 424 | 1,752 | 383 | 70 | 813 | 136 | 27 | 12,753 |
| 2024 | 6,646 | 2,914 | 443 | 1,764 | 400 | 71 | 818 | 136 | 27 | 13,220 |
| 2025 | 6,995 | 2,997 | 463 | 1,776 | 418 | 71 | 824 | 137 | 27 | 13,708 |
| 2026 | 7,363 | 3,083 | 483 | 1,787 | 436 | 72 | 829 | 138 | 27 | 14,219 |
| 2027 | 7,750 | 3,171 | 505 | 1,799 | 456 | 72 | 835 | 139 | 27 | 14,753 |
| 2028 | 8,157 | 3,261 | 527 | 1,811 | 476 | 72 | 841 | 140 | 27 | 15,312 |
| 2029 | 8,585 | 3,354 | 551 | 1,823 | 497 | 73 | 846 | 141 | 28 | 15,897 |
| 2030 | 9,036 | 3,449 | 575 | 1,836 | 519 | 73 | 852 | 142 | 28 | 16,510 |
| 2031 | 9,511 | 3,548 | 600 | 1,848 | 542 | 74 | 857 | 143 | 28 | 17,151 |
| 2032 | 10,010 | 3,649 | 627 | 1,860 | 566 | 74 | 863 | 144 | 28 | 17,822 |
| 2033 | 10,536 | 3,753 | 655 | 1,873 | 591 | 75 | 869 | 145 | 28 | 18,524 |
| 2034 | 11,089 | 3,860 | 684 | 1,885 | 617 | 75 | 875 | 146 | 29 | 19,260 |
| 2035 | 11,672 | 3,970 | 714 | 1,898 | 645 | 76 | 881 | 147 | 29 | 20,030 |
| 2036 | 12,285 | 4,083 | 746 | 1,910 | 673 | 76 | 886 | 148 | 29 | 20,836 |
| 2037 | 12,930 | 4,199 | 779 | 1,923 | 703 | 77 | 892 | 149 | 29 | 21,681 |
| 2038 | 13,610 | 4,319 | 813 | 1,936 | 734 | 77 | 898 | 150 | 29 | 22,566 |
| 2039 | 14,324 | 4,442 | 849 | 1,949 | 767 | 78 | 904 | 151 | 29 | 23,493 |
| 2040 | 15,077 | 4,568 | 887 | 1,962 | 800 | 79 | 910 | 152 | 30 | 24,465 |
| 2041 | 15,869 | 4,699 | 926 | 1,975 | 836 | 79 | 916 | 153 | 30 | 25,482 |
| 2042 | 16,702 | 4,832 | 967 | 1,988 | 873 | 80 | 922 | 154 | 30 | 26,549 |

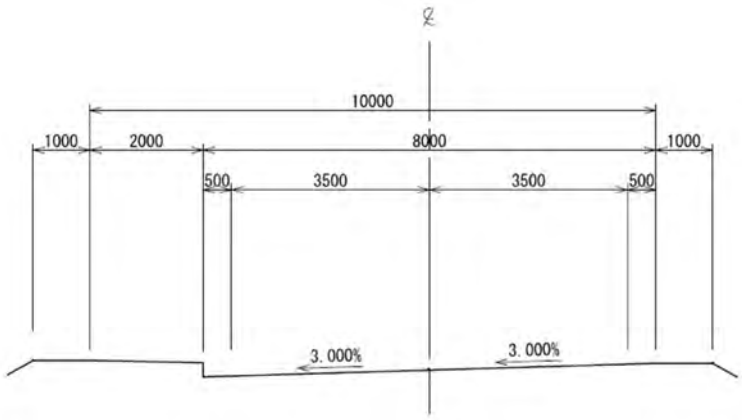
### 2-2-1-4 Policy for Width

The width of the bridge and approach road shall comply with standards in Fiji (FRA Design Guide), standards in New Zealand (NZTA Bridge Manual), and standards in Japan (Road Structure Ordinance), and the width is shown in the figure below while also taking into consideration current conditions and reflecting the results of discussions with Fiji.

Moreover, because FRA will ultimately newly construct an outbound two-lane bridge on the downstream side of the existing bridge, the new Tamavua-i-wai Bridge will be an inbound bridge.




Bridge portion




Road portion

Figure2-2-4 Cross Section Configuration of Bridge and Road Portion

### 2-2-1-5 Policy for Design Live Load

Although there is a Design Guide (FRA) for Fiji, design will generally be in accordance with New Zealand standards (Bridge-manual-3rd-edition). The B live load prescribed in Japan's Specifications for Highway Bridges and Commentary will be adopted as the live load used in the design of the Tamavua-i-wai Bridge for the following reasons (see Technical Notes 7. Design live load).

① The bending moment that occurs for the B live load prescribed in Japan's Specifications for Highway Bridges and Commentary is large than the design live load under the New Zealand standards.

② The Project is Japanese grant aid, and an agreement has been reached with FRA to apply Japanese standards (Specifications for Highway Bridges and Commentary).

### 2-2-1-6 Policy for Revetment Design

The policy below will be implemented for revetment design in an effort for bridge safety.

- The revetment normal line and structural form will be made to fit with the upstream embankment revetment that has already been planned to ensure the smooth flow of water during floods.
- Because a scour depth of about 5m is assumed from changes in flow velocity for the bridge cross section, foundation consolidation work will be conducted as a scour countermeasure.
- Take into consideration flow velocity at the bridge location for the stability of revetments.

### 2-2-1-7 Policy for Social and Economic Conditions

The matters that should be considered and countermeasures in the planning, design, and construction of the target bridge are as follows.

① Occurrence of particulates during construction: Implement measures to prevent particulates such as sprinkling with water

② Occurrence or noises and vibrations during construction: Adopt construction methods to minimize noises and vibrations

③ Runoff of pollutants (including the runoff of oil): Implement measures to prevent the runoff of pollutant

④ Soil runoff and river pollution: Implement measures to prevent soil and river contamination

⑤ Interference with general transportation: Implement safety education for industrial vehicles.

⑥ Borrow pit and stone pit measures: Select locations with a low environmental burden in the selection of borrow pits. In addition, use existing stone pits as much as possible, and avoid extracting rubble from new locations.

⑦ Occurrence of accidents: Prevent the occurrence of accidents by thoroughly implementing safety and hygiene education for people involved in construction.

⑧ Resettlement of residents: Implement the resettlement of residents appropriately in accordance with an abbreviated resettlement action plan (ARAP).

### 2-2-1-8 Policy on the Construction Situation

#### (1) Labor Situation

① Because major construction companies conduct structure and road construction, they can be used to secure labor in terms of organizers and ordinary workers. However, according to an interview with a Chinese company that recently constructed a bridge, most skilled workers are brought from the home country in the case of bridge work, and locally-hired workers conduct work after guidance has been provided by skilled workers from their own company. For this work, it is necessary to provide guidance to and develop workers under the supervision of a SV from Japan or an SV from a third country.

② For small-scale bridge (20m to 30m) construction by local construction companies in Fiji, I-girders are procured from Hume and cranes are used for erection. However, because it does not have a track record for a post-tension type PC slab girder bridge like this bridge, it will be difficult to secure bridge technicians.

③ For road paving, Fulton Hogan Hiways is conducting repair work on existing roads within Suva, and it has an asphalt plant. It also has the paving machinery required for asphalt paving, and it will be possible to secure paving technicians.

#### (2) Status of Materials Procurement

##### 1) Cement

In Fiji, cement is manufactured by Pacific Cement and the Chinese company Tengy Cement. However, the product manufactured by Pacific Cement is generally used by most companies, and its quality is stable. Chinese companies have also used the product manufactured by Pacific Cement in the construction of bridges.

##### 2) Rebar, Steel, and PC Steel

In Fiji, one domestic company, Blue Scope, manufactures deformed rebar and round steel with diameters ranging from 10mm to 32mm. Most local construction companies use the rebar made by Blue Scope. Another factor is that domestic procurement from Blue Scope is conducted due to the fact that tariffs of 32% are levied on imports from overseas. Small quantities are also sold at hardware shops.

On the other hand, materials such as steel and PC steel are not produced in Fiji, and they are procured from areas such as Southeast Asia, China, and New Zealand as necessary. Accordingly, procurement from Japan should also be considered for these materials that include rebar in consideration of the possibility of timely procurement without tariffs, ensuring quality, and consolidated transportation with other materials.

##### 3) Bridges Accessories

Although some bridge accessories can be procured from neighboring countries, because there are

frequently problem related to quality, it would be preferable to procure them from Japan.

#### 4) Concrete Plants and Aggregate Plants

In terms of concrete plants and aggregate plants, ready-mixed concrete companies have their own plants in Suva and the suburbs of Suva, and they supply ready-mixed concrete to construction companies. Moreover, they supply concrete with a strength of 50MPa.

#### 5) Asphalt Plants

In terms of asphalt plants, one local construction company owns an asphalt plant, and the others are owned by Chinese companies.

#### 6) Aggregate

In terms of aggregate, a construction company that was covered by this survey owns its own aggregate extraction pit. Because other ready-mixed concrete companies also have their own aggregate extraction pits, procurement from ready-mixed concrete companies is also possible.

In terms of crushed stone for roadbeds, most construction companies that were surveyed in this survey either buy from Standard Concrete, or in the case of small quantities, produce it with their own mobile crushing plants.

#### 7) Embankment Material and Backfilling Material

For embankment material and backfilling material, construction companies makes purchases from borrow pit developers that have acquired development permission from the government, and procurement is possible from these developers. Currently, local materials are being extracted from the borrow pits of one company and soil tests are being conducted.

### (3) Status of Construction Machinery Procurement

①In Fiji, construction machinery used in construction is owned by construction companies, and it was not possible to confirm any lease companies specializing in construction machinery besides cranes.

②Major construction companies own the general earthwork and construction machinery that is frequently used (dump trucks, backhoes, bulldozers, etc.). On the other hand, large cranes that are not used frequently are leased from leasing companies at the time of construction as necessary. In addition, concrete pump cars are mostly owned by ready-mixed concrete companies, and pump cars are ordered along with orders for ready-mixed concrete.

③Although there are truck crane leasing companies, it was not possible to confirm any companies in Fiji with special construction machinery such as girder installation or gantry cranes used when conducting work on bridge superstructures.

④For pile foundation work that was been conducted in Fiji up until now, although there is a track

record for H steel piles using a vibrohammer, a track record could not be confirmed for site piling (casing rotary drilling methods, etc.) or all-around rotation excavator, etc.

### (4) Standards for the Design and Construction of Roads, Bridges, etc.

In Fiji, only limited standards regarding things such as street lighting, road signs, and road markings and a few design guides have been developed, and international standards such as those of standards of Australia, New Zealand, and AASHTO are used for each project for everything else. The standards already in place also generally use the standards of New Zealand and Australia as a reference.

For this reason, the budget of the FTIISP:Fiji Transport Infrastructure Investment Sector Project that is being jointly funded by ADB and WB is being used to procure consultants for the purpose of developing design standards and construction standards. The purpose is to develop appropriate standards for Fiji in the future based on the standards of New Zealand, Australia, and other international standards.

Because there are currently no clear rules on the applicable standards as described above and the Project is a Japanese grant aid project, Japanese standards will be applied for design as a general rule, along with the application of standards of Australia, New Zealand, AASHTO, etc. as necessary.

#### 1) Bridge Design

- Specifications for Highway Bridges and Commentary
- Bridge Manual (Third edition)(New Zealand)
- Design Guide (Version A) (FRA)

#### 2) Road Design and Pavement Design

- Road Structure Ordinance (Japan)
- AustRoads (Australia)
- AASHTO (American Association of State Highway Transportation Officials)

#### 3) River Design

- Cabinet Order Concerning Structural Standards for River Administration Facilities, etc. (Japan)

### 2-2-1-9 Policy for the Use of Local Companies

① Although there are bridge construction projects that were completed by a Chinese company in 2017 (Stinson Parade Bridge and Vatuwaqa Bridge), there have not been any bridges constructed in the suburbs of Suva since then. Currently (2018), there are many companies interested in the New FRA Bridge ordered by FRE that the bidding was closed for.
In terms of the past track record of PC bridge construction by local companies, Hume produces simple I-girders, and girder are either purchased from Hume for installation or girder installation is undertaken by Hume and construction is conducted. In addition, there are cases of longer bridges being constructed by foreign companies such as those from New Zealand or China. Therefore, the supply of bridge technicians in Fiji is limited.

② For road construction, local construction companies have an abundant track record that includes

earthworks and paving work. For this reason, it is possible to secure road technicians.

③ Although there is a number of local consultant companies in Suva, there are few technicians. In most cases bids for bridge construction consist of design and construction.

### 2-2-1-10 Policy for Responding to the Operations, Maintenance, and Management Capabilities of the Implementing Agency

#### (1) Organization

The implementing agency for the Project is the Fiji Roads Authority (FRA) that is a part of the Minister for Infrastructure and Transport.

The FRA is a body that was established in January 2012 for the purpose of road maintenance and management, modifications, and development, and it is responsible for roads, bridges, and piers.

The Capital Projects Department is the department responsible for the Project, and it is in charge of areas including planning, design, procurement, and construction. Maintenance and management after construction will be conducted by the Maintenance Department.

Two bridge engineers work full time at FRA, and these two engineers are responsible for the building and reconstruction of bridges and reinforcement design during the maintenance and management phase. Because a limited number of engineers are responsible for this work, in many cases worked is ordered up to the stage of design and construction. In addition, technology advisor contracts have been entered with consulting companies from New Zealand and Australia to reinforce area that lack related to technology.

#### (2) Maintenance and Management Structure

The FRA created an Asset Management Plan in September 2013, and it conducts maintenance and management in accordance with this plan.

Of the four administrative regions (central, eastern, western, and northern), the FRA has integrated the central and eastern region to establish three administrative regions, and it has set up a branch in each of these administrative regions. The Tamavua-i-wai Bridge is located in the central region.

For these three regions, a comprehensive maintenance and management contract has been entered with a private sector company based on a 4 to 6-year contract. The current central/eastern region of the maintenance and management contract is until December 2018, and a new maintenance and management contract will be renewed based on a bidding process. However, large-scale work (such as bridge repairs) that costs a lot of money is separately ordered and is not included in the comprehensive maintenance and management contract for each region.

Table2-2-9 Maintenance and Management Structure

| Region | Office | Maintenance and management company (private sector) |
|---|---|---|
| Central/Eastern Division | Suva | Fulton Hogan Hiway JV |
| Northern Division | Labasa | Fulton Hogan Hiway JV |
| Western Division | Nadi | Higgins Group |

The office of the maintenance and management department of the Central/Eastern Division that is responsible for the Tamavua-i-wai Bridge is located in Suva. There are 26 staff members (6 engineers, 18 technicians, and 2 office staff) working at this office.

Regular inspections and emergency inspections after emergencies are conducted by FRA technicians, and FRA engineers formulate repair plans in light of those results.

### 2-2-1-11 Policy for Setting the Facility Grade

Queens Road is the most important arterial road in Fiji with the capital Suva with the second largest city Lautoka and Nadi International Airport, and an increasing role for Queens Road, growth in the domestic flow of goods, and development of the region are expected in the future.

Because the Tamavua-i-wai Bridge that is the cooperation target is an extremely important bridge that is located where the Queens Road crosses the Tamavua River.

#### (1) Design Standards

- Specifications for Highway Bridges and Commentary (Japan: 2017)
- Bridge manual (New Zealand: 2014)
- Design Guide (FRA)
- Road Structure Ordinance (Japan: 2015)
- AustRoads (Australia: 2015)
- AASHTO (American Association of State Highway Transportation Officials)
- Cabinet Order Concerning Structural Standards for River Administration Facilities, etc. (Japan: 2015)

#### (2) Design Live Load

The B live load prescribed in Japan's Specifications for Highway Bridges and Commentary will be adopted.

Note that the B live load can sufficiently withstand the current state of traffic in Fiji.

#### (3) Width

- Bridge portion: Roadway width 3.5m×2=7.0m, shoulder 0.5m×2=1.0m, sidewalk 2.0m Total 10.0m
- Approach road portion: Roadway width 3.5m×2=7.0m, shoulder 0.5m×2=1.0m, sidewalk 2.0m Total 10.0m

#### (4) Road Type

- Urban arterial road (Australian standard)

#### (5) Design Speed

- 50km/h

### 2-2-1-12 Policy for the Construction Method and Construction Period

#### (1) Policy for the Construction Method

In Fiji, the rainy season is generally from November to April, the dry season is generally from May to October, and it is affected by tropical low pressure from November to April. The maximum monthly rainfall is in December, when 762mm/month was recorded, and the maximum average by month (2013-2017) is 513mm/month (December).

The Tamavua-i-wai Bridge is located at the mouth of the Tamavua River and it is more affected by fluctuations in water level from the tide level than rain, and the water level can be up to 4m during high tide two times a day. Accordingly, when conducting foundation work and substructure on the river, extremely close attention is needed in particular for work such as coffering work, stake driving work, and drilling work.

#### (2) Policy for the Construction Period

As described above, the location where the new bridge is being conducted is affected by the tide level year-round, and the maximum water depth every day is 4m. Therefore, because this is equivalent to it being rainy season year-round, no constraints are imposed by the rainy season and dry season. However, because it is difficult to conduct paving during the rainy season, it is necessary to form the work schedule plan so that paving is finished during the dry season.

## 2-2-2 Basic Plan

### 2-2-2-1 Basic Plan Work Flow

For the basic plan, the studies required to implement the Work will be conducted including the implementation of a survey of existing conditions, the selection of the bridge location, a study of the longitudinal section plan, setting of the bridge size, a study of the bridge form, and a study of environmental and social considerations, and the bridge form will then be decided on. The work flow for the basic plan is shown in the figure below.

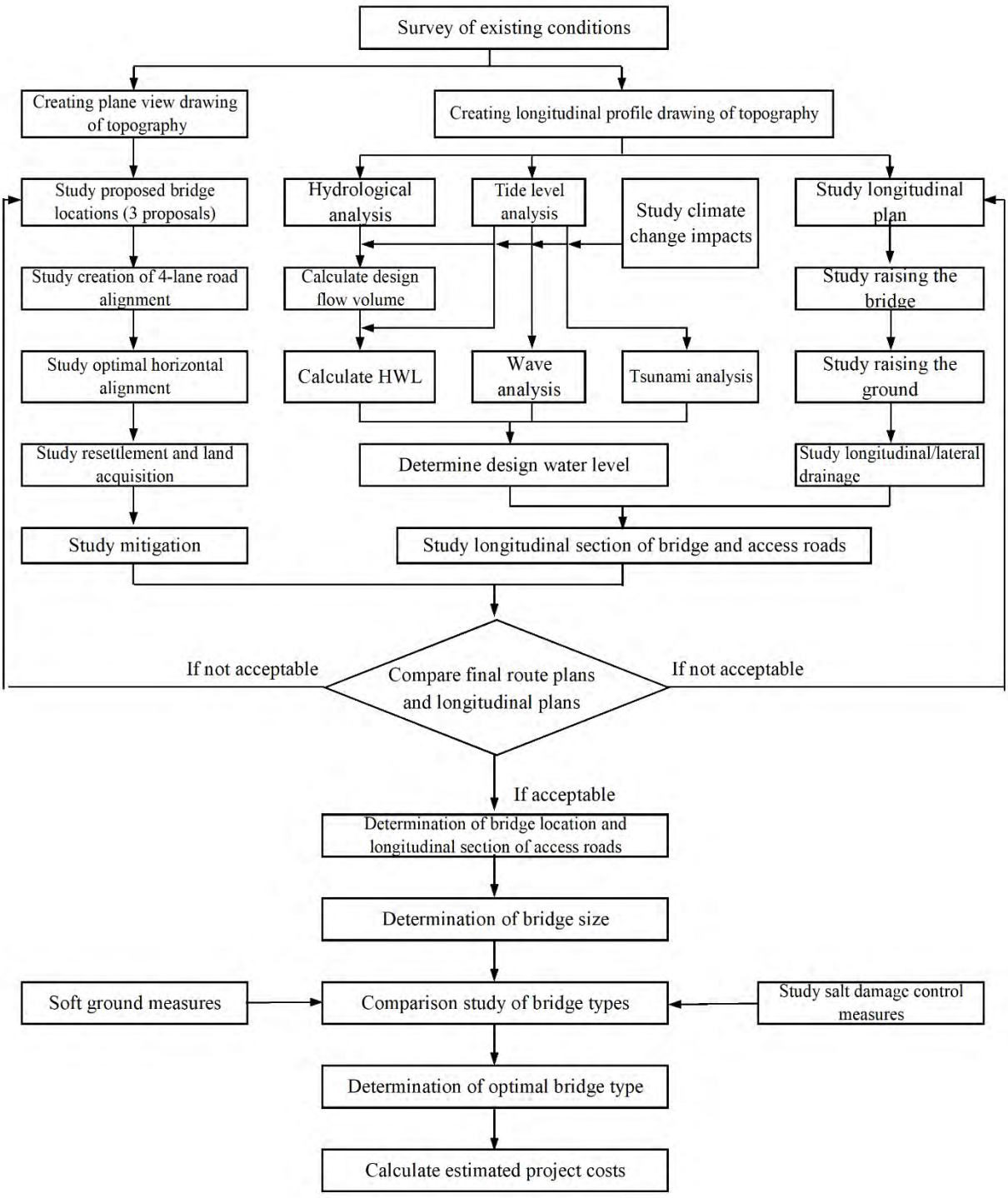



Figure 2-2-5 Study work flowchart

### 2-2-2-2 Survey of Site Conditions

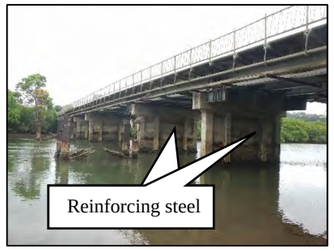
A survey of site conditions was conducted at the target bridge site. The results of the survey of site conditions are shown in Figure 2-2-6 on the next page.

### 2-2-2-3 Status of Degradation and Damage to the Existing Bridge

The Tamavua-i-wai Bridge (7-span H-steel plate girder bridge, bridge length: 83.110m, width: roadway width 7.315 + sidewalk width 1.067m × 2 = 9.449m) was constructed in 1975, and it has been pointed out that there is a risk of the bridge collapsing due to degradation and significant damage from repeated cyclones. Accordingly, a survey on the current status of the bridge shall be conducted to access the degree of damage to the Tamavua-i-wai Bridge and verify the appropriateness of reconstruction, and to then reflect this survey in the facility and construction plan as necessary.

The results of the survey on the current status of the Tamavua-i-wai Bridge are shown in Table 2-2-12

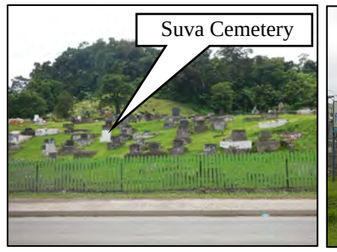

①Full view of Tamavua-i-Wai Bridge (front)



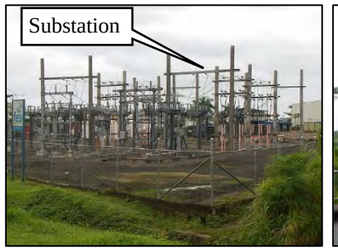

②Full view of Tamavua-i-wai Bridge (side)

③Looking toward Suva from Tamavua-i-wai Bridge

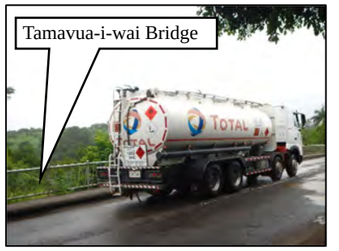

④Traffic speed is restricted to 30 km/h on the bridge.



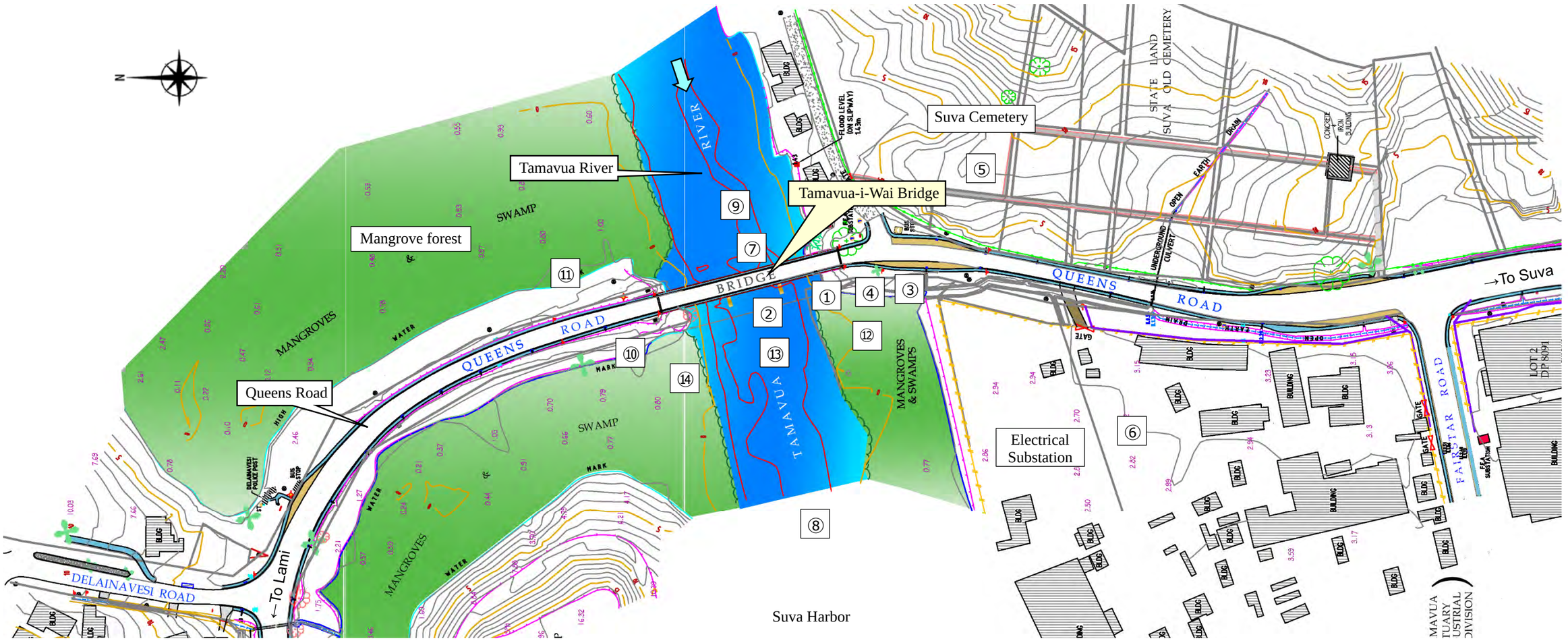

⑤Suva Cemetery, on the right side before the bridge (Suva side)

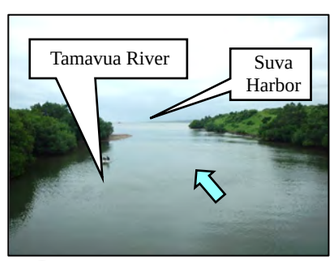



⑥Substation, on the right side before the bridge (Suva side)

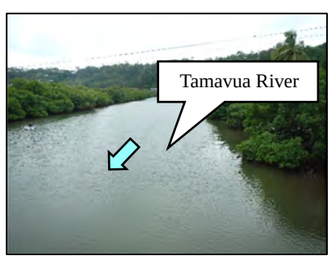



⑦Large vehicle passing over the Tamavua-i-Wai Bridge

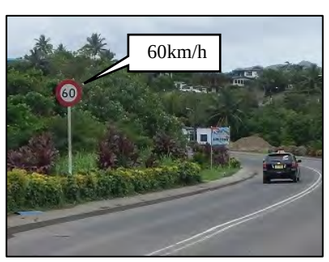



⑧Looking downstream toward Suva from bridge

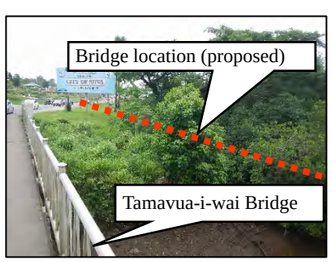



⑨Looking upstream from the bridge

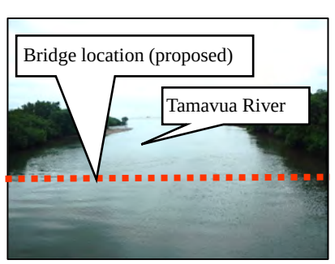



⑩Speed limit on the road from bridge to suburbs is 60 km/h.

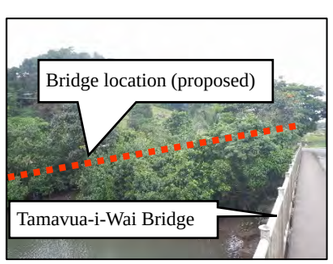

⑪Overhead power lines installed parallel to road




⑫State of left bank if bridge location is shifted downstream




⑬State of river if bridge location is shifted downstream




⑭State of right bank if bridge location is shifted downstream

Figure 2-2-6 Results of the survey of site conditions

Table 2-2-10 Results of Current Bridge Conditions Survey

| | | | | | |
|---|---|---|---|---|---|
| Bridge name | | | Tamavua-i-wai Bridge | | |
| Parameters | Year of construction | | 1975 | Location | longitude 178°25'52.88" E.; latitude 18°06'53.70" N. |
| | Annual average daily traffic (2017) | | 18,000 (vehicles/day) | Elevation: 5 m | Distance: approx. 3 km from Suva |
| | Vehicle types | | Standard automobiles: 26,300; Large vehicles: 5,300 (17% large-vehicle mix rate) | | |
| | Width | | Roadway width 7.315 m + Walkway width 1.067 m × 2=9.449 m | | |
| | Design live load | | HN-HO-72 | | |
| | Superstructure | Type | 7-span H-steel plate girder bridge | | |
| | | Length | 9.246+13.716+9.449+18.288+9.449+13.716+9.246＝83.110m | | |
| | Substructure | | Abutment: RC structure | | Piers: Wall-type RC structure |
| | Foundation | | Abutment: pile foundation | | Piers: pile foundation |
| Survey Results | Traffic functionality (role) | | ・Queens Road, on which the Tamavua-i-bridge is situated, is an important southbound arterial road connecting the capital of Suva with the second largest city (Lautoka) and Nadi International Airport. Its functionality (role) for traffic is extremely high.<br>・Annual average daily traffic is 18,000 vehicles, making its functionality (role) for traffic extremely high. | | |
| | Structural soundness (damage) | | ・With a considerable amount of flaking concrete, rebar has been exposed (Photos 1-2).<br>・Deterioration/discoloration of concrete, as well as deterioration of steel plate girders is pronounced (Photos 3-5).<br>・Pavement wear and the damage to joints and walkways is pronounced (Photos 8-10). | | |
| | Structural properties (stability) | | ・The absence of a cross section makes reinforcement effects questionable (Photo 6).<br>・The significant amount of chipped concrete (Photos 1-2) has caused rebar to become exposed and fractured (Photos 1-2). | | |
| Observations | | | ・The absence of a concrete cross-section is prominent; steel reinforcements are used, but their effect is questionable (Photo 6). Rebar is also fractured (Photo 2), making the possibility of bridge collapse very high.<br>・With the significant amount of deterioration and damage suffered by the bride, its load bearing capacity is near its limit. Since there is a risk of bridge collapse, the bridge should be rebuilt at the earliest possible stage. | | |

Photo 1 Exposed rebar

Photo 2 Exposed and fractured rebar

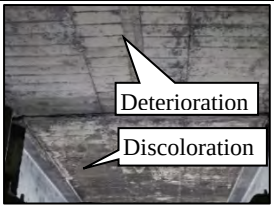


Photo 3 Deteriorated and discolored deck slab

Photo-4 Significantly deteriorated deck slab

Photo-5 Significantly deteriorated plate girders

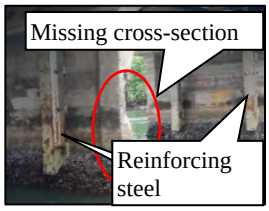


Photo-6 Effect of reinforcing steel is questionable

Photo 7 Cracking in piers

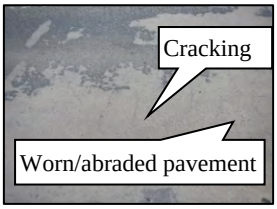


Photo 8 Pavement wear

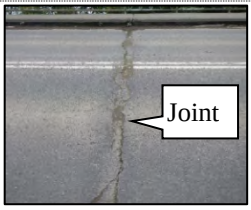


Photo-9 Damaged joint


Photo-10 Significantly damaged walkway


Photo-11 Bent road surface


Photo-12 Old bridge pier corroded by salt

### 2-2-2-4 Bridge Location Study

#### 2-2-2-4-1 Primary Comparative Study

As the bridge location of the New Tamavua-i-wai Bridge, the following 3 alternatives will be compared and determined the optimal one (see Table 2-2-13).

**(1) Proposal 1: Downstream shift proposal**

The following matters can be given as a basis (reason) for reconstruction the bridge downstream from the existing bridge.

① Although there is a substation on the left bank downstream on the Tamavua River, there is sufficient space between the land border of this substation and the existing bridge, so the bridge location can be shifted downstream. However, there could be problems with land acquisition.

② Although there is a mangrove forest on the right bank downstream on the Tamavua River, because it would not be an obstruction, the bridge location can be shifted downstream. However, there could be problems with land acquisition.

③ By shifting the bridge location downstream, the construction of a temporary bridge and detour road would be unnecessary because the existing bridge and road could be used while the new bridge is being constructed.

**(2) Proposal 2: Existing bridge location proposal**

The following matters can be given as a basis (reason) for reconstruction at the existing bridge location.

① Because reconstruction will be conducted at the existing bridge location, this proposal would present the lease problems in terms of environmental and social considerations including the resettlement of residents and land acquisition.

② The horizontal alignment of the existing bridge is a straight line and the horizontal alignment for the approach road to the back and front is nearly a straight line, so reconstruction at the existing bridge location would make it possible to maintain the current good horizontal alignment.

③ Because reconstruction will be conducted at the existing bridge location, it would not be necessary to construct a new approach road and it would be possible to maintain and use the current approach roads to its full potential.

④ However, because the existing bridge will have to be removed for reconstruction at the existing bridge location, it will be necessary to build a temporary bridge and detour road during the construction of the new bridge.

However, if the FRA constructs a New FRA Bridge, it would not be necessary to build a temporary bridge and detour road because this New FRA Bridge could be used for traffic.

### (3) Proposal 3: Upstream shift proposal

The following matters can be given as a basis (reason) for reconstruction the bridge upstream from the existing bridge.

① Although there is a mangrove forest on the right bank upstream on the Tamavua River, because it would not be an obstruction, the bridge location can be shifted upstream. However, there could be problems with land acquisition.

② Although there is a cemetery on the left bank upstream on the Tamavua River, it would be possible to shift the alignment upstream in a manner that would not conflict with the cemetery. However, the demolition of several buildings and resettlement of residents would be necessary.

③ By connecting the pull alignment from the approach road to the back and front of the bridge, it would be possible to form a large, smooth horizontal alignment. However, the bridge would be a curved bridge.

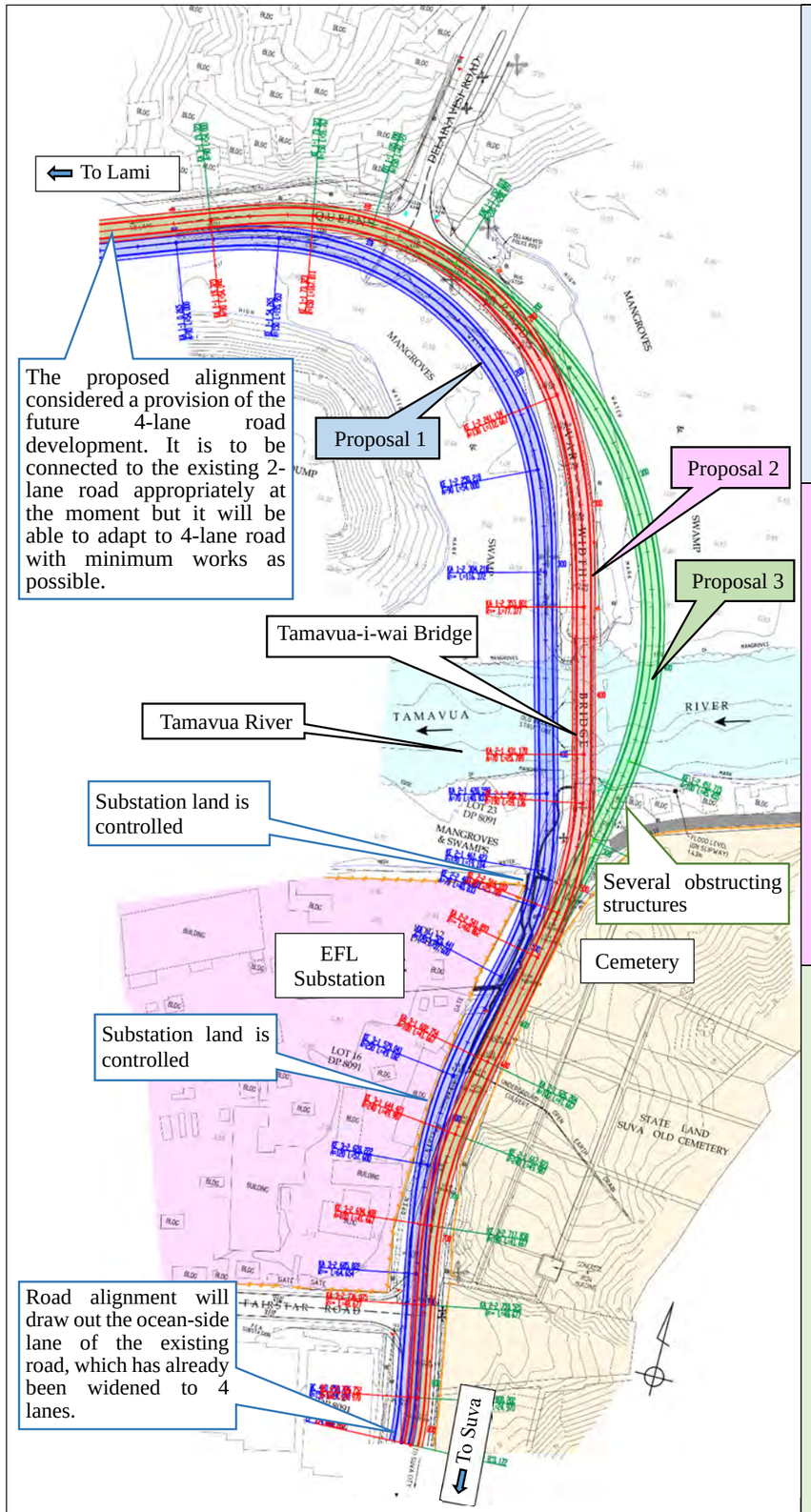
As a result of explaining the outline and advantages and disadvantages of each comparative plan to the FRA and discussing them, the second plan (proposed existing bridge position) was adopted as the most desirable plan and the FRA agreed.

① The construction of the New FRA Bridge by FRA would enable reconstruction at the current position.

② The construction of the New FRA Bridge would make the construction of a temporary bridge and detour road unnecessary, so this would be the most favorable plan economically.

③ This is the most desirable in consideration of environmental and social issues, since land acquisition and resettlement will not occur due to replacement at the existing bridge position.

Table 2-2-13 Comparison table of bridge location




| | | | |
|---|---|---|---|
| Proposal 1 | Alternative plan overview | | • It is a plan to shift the bridge location to the existing bridge downstream. | |
| | Evaluation of the Proposal | Bridge length and economic efficiency | • The length of the bridge is about 90m, and the economic efficiency of the bridge is the same as the Proposal 2. | |
| | | Necessity and alignment of approach roads | • Since the bridge position is shifted to the downstream side, the new approach roads to the both ends of the bridge are required, and its extension is the longest of all the proposals.<br>• The alignment of the new approach road will be slightly improved from the existing as its straight section becomes longer. | |
| | | Effects of river on bridge | • The new bridge receives lesser impact from the Tamavua River as its number of piers is reduced than the existing bridge. | |
| | | Revetment development plan | • In order to reduce the effects of river floods, revetments are constructed in front of and around the abutments. The arrangement of the revetment development is the same for all proposals. | |
| | | Necessity of detours | • Since the existing bridge can be used, no temporary bridge nor detour is required. | |
| | | Environmental and social considerations | • Since the bridge position is shifted to the downstream side, the land acquisition for the installation of the approach road is necessary, which is the largest of the three proposals. However, resettlement of residents and removal of buildings will not occur. | |
| | | Target construction (construction cost ratio) | • Bridge (90m), approach roads (720m), revetment (2,200m2) (1.14) | |
| | | Overall evaluation | • New approach roads are required as the bridge position is shifted, and its extension is the longest of all the proposals.<br>• The new bridge receives lesser impact from the Tamavua River as its number of piers is reduced than the existing bridge.<br>• The approach roads are required, but no temporary bridge nor detour is required. | △ |
| Proposal 2 | Alternative plan overview | | • It is a plan to construct a new bridge at the existing bridge position. | |
| | Evaluation of the Proposal | Bridge length and economic efficiency | • The length of the bridge is about 90m, and the economical efficiency of the bridge is the same as the Proposal 1. | |
| | | Necessity and alignment of access roads | • New approach roads are not required because the bridge is replaced at the existing bridge position. Also, as the alignment of the existing bridge is straight, and no problematic point is found. | |
| | | Effects of river on bridge | • The impact from the Tamavua River to the new bridge is significantly reduced as its wider span (3 spans) provides less number of bridge pier (2 piers) than the existing bridge which has 7 spans with 6 piers. | |
| | | Revetment development plan | • Same as the Proposal 1. | |
| | | Necessity of detours | • Since the FRA is planning a new bridge, temporary bridges and detours will not be required. | |
| | | Environmental and social considerations | • There are several residences in the riverbank area on the left upstream side of the river, but no resident relocation nor building removal will occur. | |
| | | Target construction (construction cost ratio) | • Bridge (90m), revetment (2,200m$^2$) (1.00) | |
| | | Overall evaluation | • New approach roads are not required because the bridge is replaced at the existing bridge position.<br>• As the number of bridge piers in the river is reduced and the span length is increased, the impact of the Tamavua River on the bridge is significantly reduced.<br>• Relocation of residents and removal of buildings will not occur.<br>• It is the most economical of all the proposals because it does not require the new approach roads nor a temporary bridge and detour. | ◎ |
| Proposal 3 | Alternative plan overview | | • It is a plan to shift upstream from the existing bridge. | |
| | Evaluation of the Proposal | Bridge length and economic efficiency | • The length of the bridge is about 90m, but it is a curved bridge, therefore the economic efficiency is the highest among all the proposals. | |
| | | Necessity and alignment of approach roads | • Since the bridge position is shifted to the upstream side, the new approach roads to the both ends of the bridge are required.<br>• The alignments at the both ends of the bridge are oblique direction to the river in accordance with the existing road alignment and adjustment with the boundary of the cemetery, and it forms a curved bridge. | |
| | | Effects of river on bridge | • Same as the Proposal 2. | |
| | | Revetment development plan | • Same as the Proposal 1. | |
| | | Necessity of detours | • Since the existing bridge can be used, no temporary bridge nor detour is required. | |
| | | Environmental and social considerations | • As the position of the bridge is shifted to the upstream side, relocation of some residents and removal of existing buildings will occur at the left upstream side of riverbank area for the installation of the approach road. | |
| | | Target construction (construction cost ratio) | • Bridge (90m), approach road (330m), revetment (2,200m$^2$) (1.06) | |
| | | Overall evaluation | • The new approach roads are required as the bridge position is shifted, and relocation of several residents and removal of the existing buildings will be necessary.<br>• As the alignments at the both ends of the bridge are oblique direction into the river, the bridge becomes curved.<br>• As the number of bridge piers in the river is reduced and the span length is increased, the impact of the Tamavua River on the bridge is significantly reduced.<br>• Since a temporary bridge and detour are not required and the approach road is shorter than the Proposal 1, economic efficiency is moderate. | ○ |

### 2-2-2-4-2 Secondary Comparative Study

Because FRA has decided to construct a New FRA Bridge downstream of the existing bridge, the new Tamavua-i-wai Bridge will be constructed at the existing bridge location. It meant that the two bridges will be constructed adjacently, and therefore a secondary comparative study shall be conducted on the bridge location. In addition, a study shall be conducted on a case in which two two-lane bridges are constructed and another in which one four-lane bridge is constructed.

#### (1) Study of Four-lane Carriageway

Although it is still in the study stage, the Fiji Government has plans to convert Queens Road into a 4-lane road between Suva and Lami (Novotel Suva Lami Bay), and a 4-lane road has already been provided from Suva City to 300m before the Tamavua-i-wai Bridge that is the target bridge of this project. Furthermore, it is also one of the bottlenecks of the other on-going road improvement project namely: SARUP2 (Suva Arterial Road Upgrade Project Stage 2), which is including widening the existing 4-lane sections.

Moreover, as the emergency countermeasure to the deterioration of the existing Tamavua-i-wai Bridge, the Fiji government has been implementing the New FRA Bridge downstream of the existing bridge (design and construction contract; in process of selecting a contractor as of May 2018).

As it described above, the New FRA Bridge was initially handled as a temporary bridge as an emergency measure however, as of the start of this project preparatory survey, FRA has determined to develop it as a permanent bridge and intend to form a 4-lane carriageway by the two 2-lane bridges along with this project target bridge so called the New Tamavua-i-wai Bridge.

In light of this situation, an alignment study around the bridge was conducted with an assumption of 4-lane road arrangement, which will minimize the works adapting its actual development in the future. As a result of this 4-lane road alignment study, the findings were shared with FRA as the reference information which would be preferable to take into consideration for their alignment study and relocation of utility for the New FRA Bridge.

However, because this future 4-lane road development is something that should be implemented independently by Fiji, the current design configuration (scope of project through grant aid) will be set for the road alignment connected to the existing road and within the minimum required scope while taking into consideration the New FRA Bridge design and the future 4-lane road alignment described above.

An alignment study figure of the integrated 4-lane road is shown in Figure 2-2-7. In addition, an alignment study figure in the case of gradual development is shown in Figure 2-2-8.

.

#### (2) Final Bridge Location

As a result of a study on the proposals shown on the Figure 2-2-7 Integrated 4-lane Road Alignment Study and Figure 2-2-8 Gradual 4-lane Road Alignment Studyfor a 4-lane road development above, because FRA is independently constructing a 2-lane bridge in advance and there is no plan for

immediately converting the approach roads at the both ends of the bridge into a 4-lane road, the two 2-lane bridges proposal was selected. The final bridge location of this project target bridge, so called the New Tamavua-i-wai Bridge and the New FRA Bridge are shown in Figure 2-2-9.

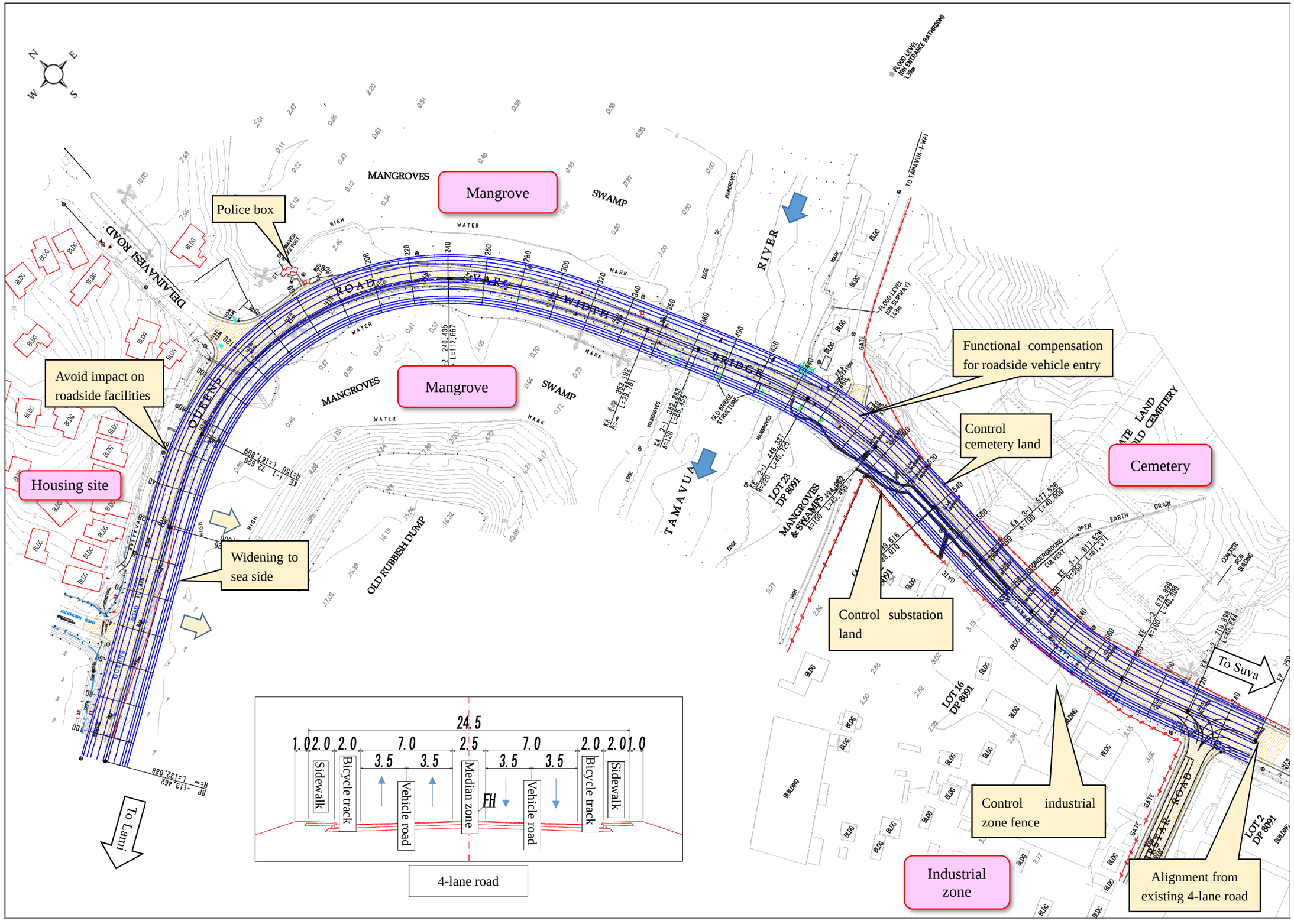



Figure 2-2-7 Integrated 4-lane Road Alignment Study

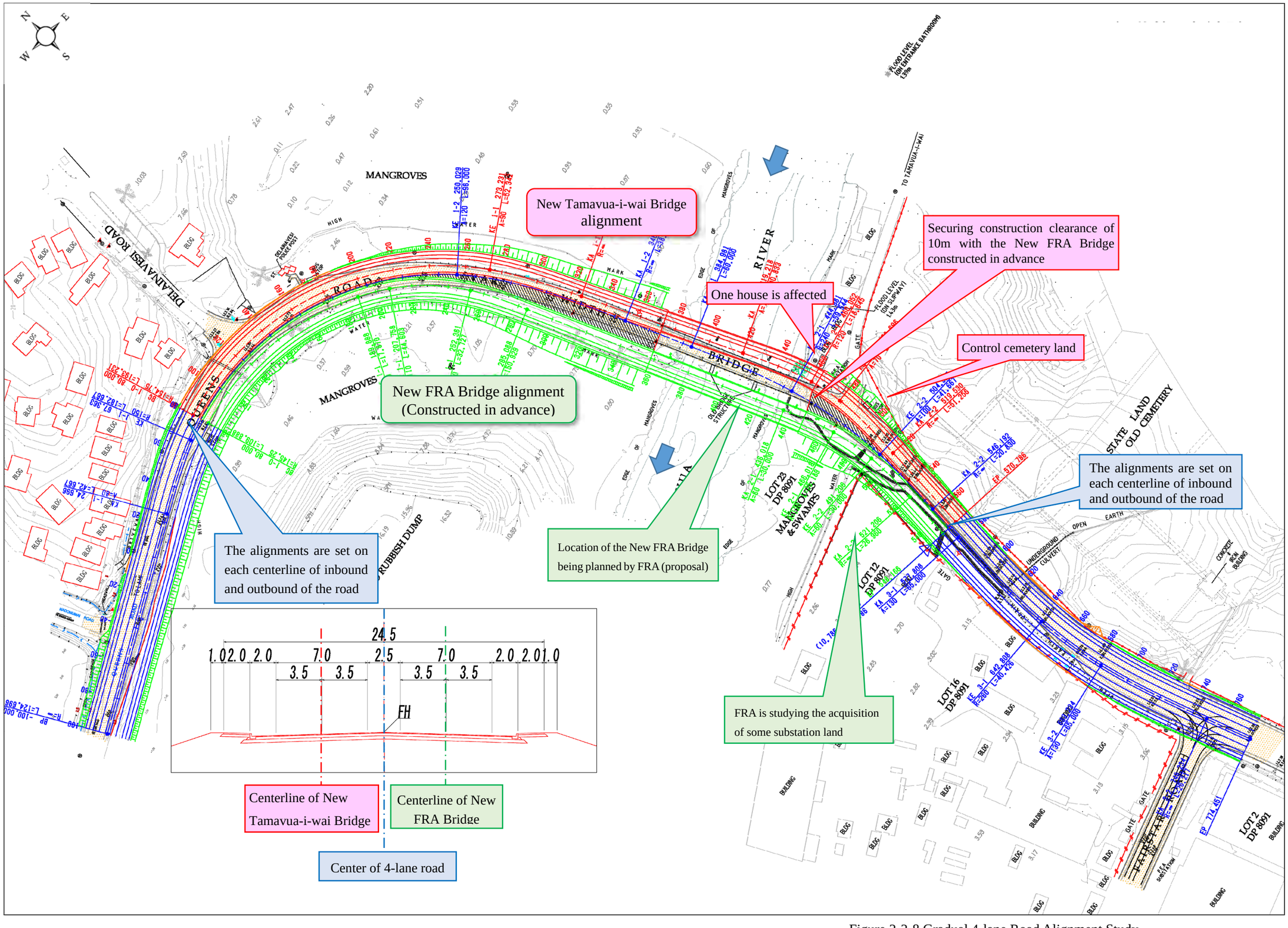



Figure 2-2-8 Gradual 4-lane Road Alignment Study

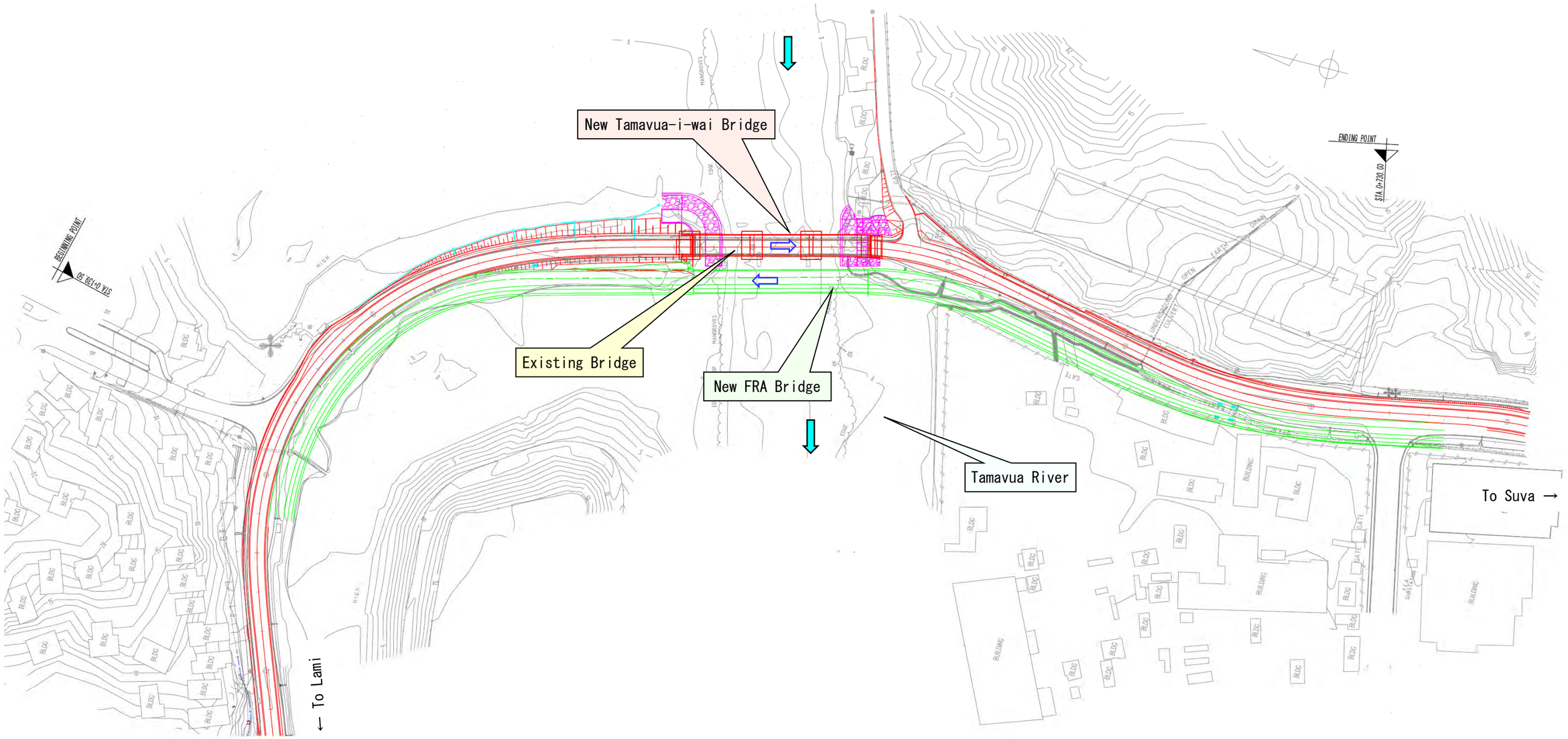



Figure 2-2-9 Final bridge location

### 2-2-2-5 Longitudinal Section Plan

The bridge longitudinal section plan shall be developed that takes some factors into consideration such as astronomical tide levels, floods from tropical cyclones, etc., waves, and a future rise in sea level caused by climate change.

A comparative study shall be conducted on the impact of the water level, road and bridge longitudinal alignment, the impact of the embankment, environmental and social considerations, and economic factors for the following three proposals (refer to Table 2-2-15).

- Proposal 1: 1/100-year recurrence interval tides + 1/100-year recurrence interval flood water level + climate change with RCP 8.5 scenario
- Proposal 2: 1/100-year recurrence interval tides + 1/100-year recurrence interval waves + climate change with RCP 2.6 scenario
- Proposal 3: 1/100-year recurrence interval tides + 1/100-year recurrence interval waves + climate change with RCP 8.5 scenario

The results of calculations on water levels, etc. in the three proposals described above are shown in the table below.

Table2-2-11 Maximum Water Level

Unit (m)

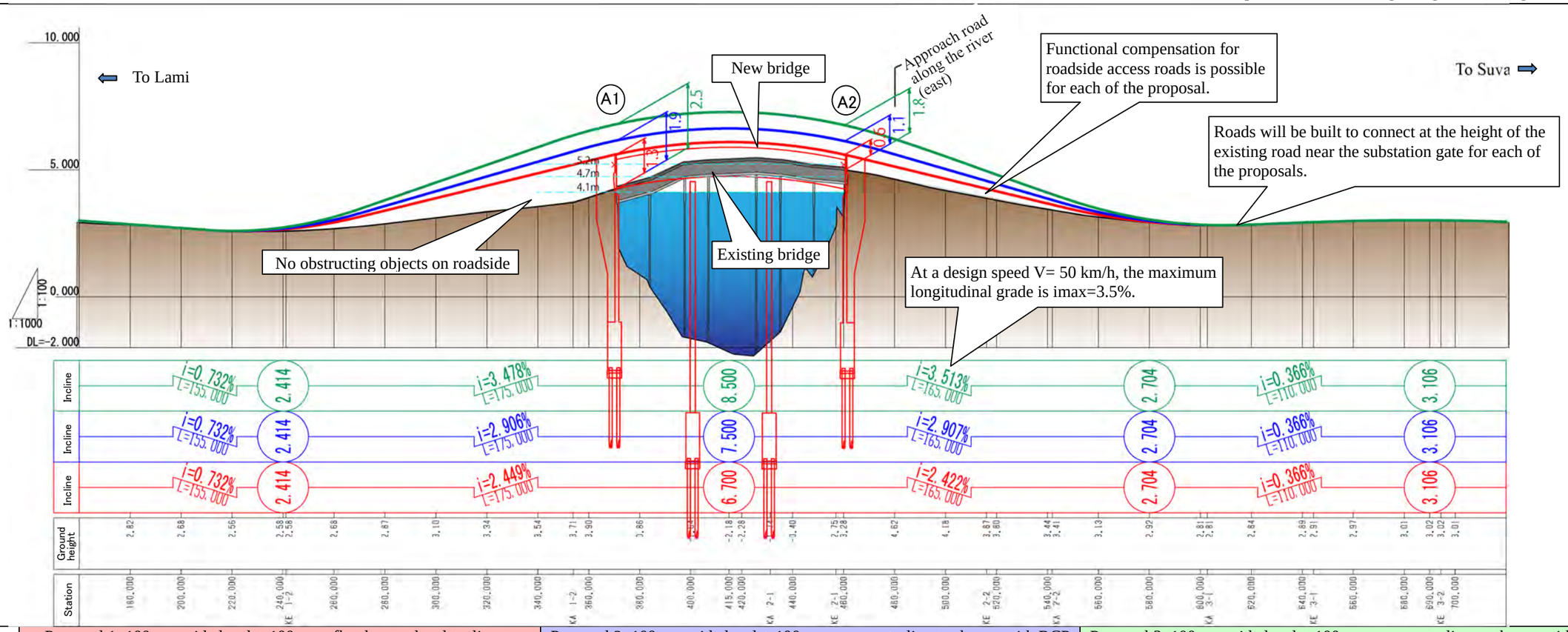
| Proposal | Astronomical high tide level | | Floods | | Climate change | Waves | Maximum water level |
|---|---|---|---|---|---|---|---|
| | Tide level | Deviation | Water level rise due to flooding | Clearance | Sea level rise | Wave-height | |
| Proposal 1 | 1.1 | 1.2 | 0.1 | 1.0 | 0.7 | - | 4.1 |
| Proposal 2 | 1.1 | 1.2 | - | - | 0.4 | 2.0 | 4.7 |
| Proposal 3 | 1.1 | 1.2 | - | - | 0.7 | 2.2 | 5.2 |

As a result of explanation of the outline with advantages and disadvantages of the above three proposals, and further discussion with FRA, the Proposal 3 was adopted and agreed by FRA as the most desirable plan for the following reasons.

① Although the bridge road surface raising height was 0.5m as of the submission of the request document (May 2014), significant damage was suffered from Cyclone Winston in February 2016. Accordingly, for a raising height to ensure the bridge would not be damaged from a natural disaster such as an extremely large cyclone in the future, it would be preferable to adopt proposal 3 that has the maximum water level.

② Superstructure girders would not be affected by waves even at the maximum water level (proposal 3) in the event of a sea level rise for 1/100-year recurrence interval tides + 1/100-year recurrence interval waves + climate change with RCP 8.5 scenario.

③ The recurrence interval for flood in the Fiji Design Guide (based on the New Zealand Bridge Manual) is 1/100-year for a serviceability limit state and 1/500-year for an extreme limit state, and it is believed that the probability of three natural phenomena occurring at the same time (proposal 3) is reasonable.




| | | Proposal 1: 100-year tide level + 100-year flood water level + climate change with RCP 8.5 scenario | | Proposal 2: 100-year tide level + 100-year waves + climate change with RCP 2.6 scenario | | Proposal 3: 100-year tide level + 100-year waves + climate change with RCP 8.5 scenario | |
|---|---|---|---|---|---|---|---|
| Alternative Plan | | | | | | | |
| Alternative plan overview | | This proposal adds a tide level with a 1/100-year recurrence interval, a flood water level with a 1/100-year recurrence interval, and sea level rise due to climate change with RCP of 8.5 to the design water level, further adding a 1m clearance height beneath the girders for the girder height of the new bridge. | | This proposal adds a tide level with a 1/100-year recurrence interval, waves with a 1/100-year recurrence interval, and sea level rise due to climate change with RCP of 2.6 to the design water level for the girder height of the new bridge. | | This proposal adds a tide level with a 1/100-year recurrence interval, waves with a 1/100-year recurrence interval, and sea level rise due to climate change with RCP of 8.5 to the design water level for the girder height of the new bridge. | |
| Evaluation of alternative plans | Raised height (At A1 abutment and A2 abutment) | unit / A1 abutment / A2 abutment<br>New bridge girder height: m / 4.100<br>New bridge road surface height: m / 5.599 / 5.586<br>Current bridge road surface height: m / 4.255 / 4.984<br>Raised amount: m / 1.344 / 0.602 | | unit / A1 abutment / A2 abutment<br>New bridge girder height: m / 4.700<br>New bridge road surface height: m / 6.155 / 6.120<br>Current bridge road surface height: m / 4.255 / 4.984<br>Raised amount: m / 1.900 / 1.136 | | unit / A1 abutment / A2 abutment<br>New bridge girder height: m / 5.200<br>New bridge road surface height: m / 6.800 / 6.745<br>Current bridge road surface height: m / 4.255 / 4.984<br>Raised amount: m / 2.545 / 1.761 | |
| | Effects of waves | • If 100-year waves occur, these waves will reach halfway up the height of the girder of the superstructure. Therefore, the superstructure girder design must be able to withstand this wave pressure. | | • If there is a rise in sea level due to climate change with RCP of 8.5, waves will reach nearly halfway up the height of the girder of the superstructure. Therefore, the superstructure girder design must be able to withstand this wave pressure. | | • Superstructure girders will not be affected by waves. | |
| | Road longitudinal alignment | • By raising the A1 abutment 1.3 m over the existing road height, and the A2 abutment 0.6 m higher, the longitudinal gradient of the new approach roads will be 2.4%, causing no problems for the longitudinal alignment. | | • By raising the A1 abutment 1.9 m over the existing road height, and the A2 abutment 1.1 m higher, the longitudinal gradient of the new approach roads will be 2.9%, which is steeper than the longitudinal gradient of Proposal 1. | | • By raising the A1 abutment 2.5 m over the existing road height, and the A2 abutment 1.8 m higher, the longitudinal gradient of the new approach roads will be 3.5%, which is much steeper than the longitudinal gradient of Proposal 1. | |
| | Environmental and social considerations | • The height will be raised to a maximum of 1.3 m higher than the existing road surface (at the A1 abutment), but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations. | | • The height will be raised to a maximum of 1.9 m higher than the existing road surface (at the A1 abutment), but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations. | | • The height will be raised to a maximum of 2.5 m higher than the existing road surface (at the A1 abutment), but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations. | |
| | Economic efficiency | • This proposal is the most economically efficient of the three because it has the shortest longitudinal section. | | • This proposal has a medium level of economic efficiency because it has the second highest longitudinal section height of the three proposals. | | • This proposal is the least economically efficient of the three because it has the tallest longitudinal section. | |
| | Overall evaluation | • If 100-year waves occur, these waves may reach halfway up the height of the girder of the superstructure.<br>• The height will be raised to a maximum of 1.3 m higher than the existing road surface, but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations.<br>• This proposal is also the most economically efficient because the longitudinal section has the lowest height. | △ | • If there is a rise in sea level due to climate change with RCP of 8.5, these waves may reach halfway up the height of the superstructure.<br>• The height will be raised to a maximum of 1.9 m higher than the existing road surface, but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations.<br>• This proposal has a medium level of economic efficiency because it has a longitudinal section height that is between the other proposals. | ○ | • Superstructure girders will not be affected by waves.<br>• The height will be raised to a maximum of 2.5 m higher than the existing road surface, but since there are no residences near the approach roads, there are no particular problems in terms of environment and social considerations.<br>• This proposal is the least economically efficient of the three because it has the tallest longitudinal section. | ◎ |

### 2-2-2-6 Overall Plan

#### 2-2-2-6-1 Applied Design Standards Conditions

##### (1) Bridge Design Conditions

###### 1) Hydraulic Conditions

###### a) Plan Scale

Because the bridge is located on an estuary, the plan tide level (water level) was determined in consideration of floods, the tide level, waves and tsunami, as well as a sea level rise from climate change. As a result, as shown in the table below, the impact of waves is rather dominant over floods, and the required clearance beneath the bridge gets higher as adding the value of the 1/100-year recurrence high waves and a sea level rise from climate change (RCP8.5) on the value for the 1/100-year recurrence high tide level, which its height becomes MSL+5.2m.

Table2-2-16 Plan Tide Level and Required Clearance

| Impact factors | Tide level (water level) | | Required Clearance |
|---|---|---|---|
| High tide | Astronomical high tide level + 1/100-year recurrence deviation + climate change (RCP8.5) | MSL+3.0m | MSL+3.0m |
| Waves | High tide + 1/100-year recurrence high waves | MSL+5.2m | MSL+5.2m |
| Tsunami | Average tide level + tsunami height × 2 + climate change (RCP8.5) | MSL+4.3m | MSL+4.3m |
| Flood | High tide + increase in water level during inflow of planned water flow | MSL+3.1m | MSL+4.1m* |

*: Tide level (water level) + consider a clearance of 1m

The basis for the tide level (water level) in the table is shown in 1-2-3Meteorological, oceanographic and hydrological surveys

###### b) Depth of Footing

For the depth of footing for the bridge pier, (1) securing a minimum earth covering of 2.0m from the deepest riverbed height to the footing upper surface and (2) the installation of foundation consolidation to the column base as a measure in response to local scouring were set as conditions. Meanwhile, the depth of footing for the bridge abutments was determined with the condition of fixing the footing lower surface to the existing ground surface or estimated support layer line (bedrock).

###### 2) Design Live Load

Because the B live load prescribed in Japan's Specifications for Highway Bridges and Commentary (2012) is greater than the live load (HN-HO-72) prescribed in the New Zealand standards (Bridge Manual), the B live load will be adopted.

### 3) Seismic Load

#### a) Concept of seismic load

The design horizontal seismic intensity used for the calculation of horizontal force in an earthquake is calculated based on the Fiji standards and New Zealand standards as follows.

- Design-Guide-Version-A-June-2015-1 (FRA)
- Bridge Manual Third Edition (New Zealand Transport Agency)
- NZS1170.5-2004 (New Zealand)
- NZ-Building-Code (New Zealand)

In addition, according to the Fiji standard and the New Zealand standard, the seismic load is calculated from the following concept.

① Immediately after the earthquake, the bridge should be usable for emergency vehicles.
② Allow damage to the extent that temporary restoration may be required.
③ Consider plastic hinges as a ductile structure or a partially ductile structure.
④ Consider the influence of active faults as the Near-Fault Factor.
⑤ Select the Hazard Factor from Seismic Hazard Map for Fiji.
⑥ Consider the Structural Ductility Factor and the Inelastic Spectrum Scaling Factor because the response acceleration becomes large when the elastic design is used.

**i)** The Elastic Site Hazard Spectrum for Horizontal loading (C(T))

The Elastic Site Hazard Spectrum for Horizontal loading (C(T)) is calculated by the following equation.

$C(T)=Ch(T)\cdot Z\cdot R\cdot N(T,D)$

where

Each element and coefficient are as follows.

① Importance Level 4 (High)

Tamavua i Wai Bridge is located on the most important road in Fiji. If the bridge is destroyed by an earthquake, important traffic functions will be paralyzed. In addition, the Tamavua i wai Bridge plays a major role in supporting the affected areas. Therefore, it was judged that the Importance Level was high, and 4 was selected.

② Design Working Life 100 (years)

Considering the importance and life of the bridge, the Design Working Life was set at 100 years.

③ Period T1=0.216 (sec)

The Period of vibration of the bridge was calculated to be 0.216 seconds.

④ Site Subsoil Class E (Very soft soil)

Since the geology of the site is extremely soft ground, E was selected as the Site Subsoil Class.

⑤ The Spectral Shape Factor Ch(T1)=3.00

From the period of vibration of the bridge T1=0.216 (sec) and the Site Subsoil Class (Very soft soil) E, the Spectral Shape Factor Ch(T1) is 3.00 from NZS 1170.5, 3.1.2, TABLE 3.1.

⑥ The Hazard Factor Z=0.16

From the Seismic Hazard Map for Fiji in the FRA Design Guide (BRIDGE), the Hazard Factor Z=0.16 at the location of Tamavua i wai Bridge was selected.

⑦ The Return Period Factor Rs(SLS1)=0.5 (1/100)

The Return Period Factor Rs for the return period (100 years) in the Serviceability Limit State (SLS1) is 0.5.

⑧ The Return Period Factor Rs(SLS2)=1.0 (1/500)

The Return Period Factor Rs for the return period (500 years) in the Serviceability Limit State (SLS2) is 1.0.

⑨ The Return Period Factor Ru=1.8 (1/2500)

The Return Period Factor Ru for the return period (2500 years) in the Ultimate Limit State (ULS) is 1.8.

⑩ The Near-Fault Factor N(T,D)=1.00

Since the Period is less than 1.5, the Near-Fault Factor N(T,D) is 1.00.

**ii)** The Horizontal Design Action Coefficient (Cd(T1))

The Horizontal Design Action Coefficient (Cd(T1)) is calculated by the following formula.

$$Cd(T1)=C(T1)\cdot Sp/k\mu$$

① μ :Structural Ductility Factor

The Structural Ductility Factor (μ) has the following values in the Serviceability Limit State ( SLS1, SLS2 ) and the Ultimate Limit State ( ULS ).

for SLS1: $1.00 \leqq \mu \leqq 1.25$

for SLS2: $1.00 \leqq \mu \leqq 2.00$

for ULS : $1.00 \leqq \mu \leqq 6.00$

② Sp :The Structural Performance Factor

The Structural Performance Factor (Sp) is 0.7 in each limit state.

③ kμ :The Inelastic Spectrum Scaling Factor

The Inelastic Spectrum Scaling Factor (kμ) was 1.00, 1.70 and 2.50 for SLS1, SLS2 and ULS, respectively.

The Horizontal Design Action Coefficient (Cd(T1)) obtained from each coefficient is shown in the table below.

| State | C(T1) | μ | Sp | kμ | Cd(T1) |
|---|---|---|---|---|---|
| SLS1 | 0.240 | 1.00 | 0.7 | 1.00 | 0.168 |
| SLS2 | 0.480 | 2.00 | 0.7 | 1.70 | 0.198 |
| ULS | 0.864 | 4.00 | 0.7 | 2.50 | 0.242 |

Therefore, the Horizontal Design Action Coefficient used in earthquake-resistant design for this bridge shall be C = 0.25.

**b) Concept of seismic design**

The applicable design standard for this bridge is the Japanese Specifications for Highway Bridges. The Horizontal Design Action Coefficient Cd (T1) = 0.25 obtained by the concept of seismic load in the previous section a) is equivalent to the design horizontal seismic coefficient Kh in the Japanese Specifications for Highway Bridges, and Kh = 0.25.

This design horizontal seismic coefficient Kh = 0.25 corresponds to the level 1 seismic motion in the Japanese Specifications for Highway Bridges. Therefore, the seismic design shall be designed in consideration of the level 1 seismic motion in the Japanese Specifications for Highway Bridges.

**4) Material Strength**

The strength of materials used in the Project is as follows.

① Prestressed concrete

The design criteria strength for concrete used in main girder work (post-tension slab girder) is σck ＝50N/mm$^2$.

The design criteria strength for concrete used in horizontal setting work (filling, connection crossbeams) is σck＝30N/mm$^2$.

② Reinforced concrete

The design criteria strength for concrete used in substructure building frames (bridge abutments and bridge piers) and bridge face work (wheel guard) is σck＝24N/ mm$^2$.

The design criteria strength for underwater concrete used in pile foundation work (site piling) is σck＝24N/ mm$^2$ (nominal strength of 30N/ mm$^2$).

③ Plain concrete

The design criteria strength for concrete used in sidewalk and adjustment concrete (bridge surface work) and leveling concrete (substructure) is σck＝18N/ mm$^2$.

④ Rebar

Rebar used in superstructures, substructures, and pile foundation work (total structure materials) is equivalent to SD345 (JIS G 3112).

⑤ PC steel

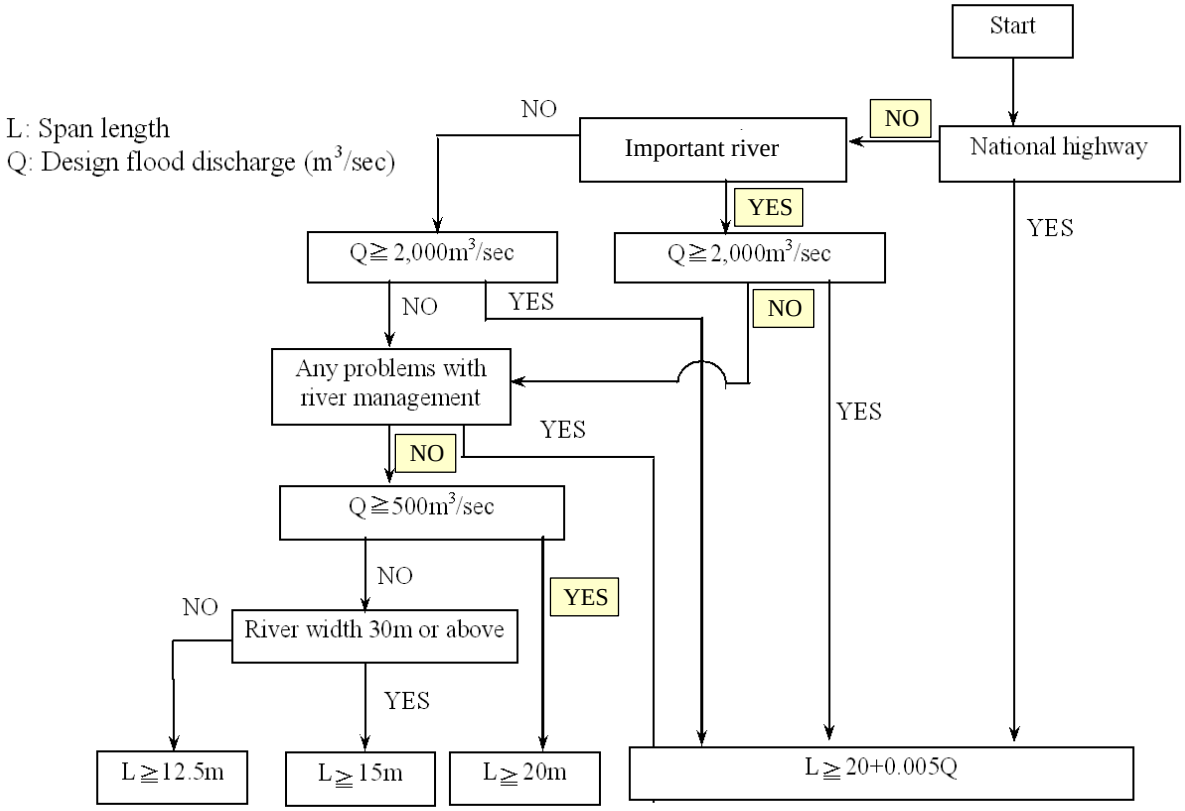
PC steel used in main cables is equivalent to 7S12.7

SWPR7BL (JIS G 3536).

PC steel used in tightening cables is equivalent to 1S21.8 SWPR19L (JIS G 3536).

**5) Span Length Setting Procedures**

The span length setting procedures are shown in the figure below. As a result of calculation based on span length setting procedures, the span length of the target bridge for the Project is L≧20m if planned flood discharge is Q=500m³/s.




Source: Structural Regulations for River Management Facilities, 1976 Japan

Figure 2-2-10 Setting procedure of span length

### (2) Road Design Conditions

Road design shall be based on Australian standards in general. Furthermore, Japanese and US standards have been used as complementary reference point as necessary.

The road geometric design standards are shown in the table below.

Table 2-2-12 Road geometric standards (applicable design speed of 50 km/h)

| Road classification | | | | Urban arterial roads | | | Adopted value | Remarks |
|---|---|---|---|---|---|---|---|---|
| Design speed | | | km/h | 40 | 50 | 60 | 50 | |
| Plane Alignment | Minimum radii of horizontal curves based | Desirable | m | 36 | 56 | 98 | 150 | Urban roads |
| | | Absolute | m | 31 | 49 | 75 | | |
| | Minimum horizontal curve lengths | Minimum | m | 45 | 70 | 100 | 71.3 | |
| | Transition curves | Maximum radius requiring | | Design speed 60km/h or less ommited | | | Ommited | |
| Profile Alignment | General maximum grades | Flat | % | na | na | 6 - 8 | 3.5 | na:not applicable |
| | | Rolling | % | na | na | 7- 9 | | |
| | | Mountainous | % | na | na | 9 - 10 | | |
| | Minimum grades | Desirable | % | 1.0 | | | 0.3 | Road with kerb and / or channel |
| | | Absolute | % | 0.3 | | | | |
| | Minimum length of crest vertical curve | Minimum | m | 20 -30 | 30 - 40 | 40 - 50 | 140 | |
| | | Min. grade change requiring a crest curve | % | 1.0 | 0.9 | 0.8 | na | |
| | Minimum size crest vertical curve | Desirable | K value | 3.5 | 6.8 | 11.8 | 20.3 | General (Rt=2.0s) |
| | | Absolute | | 2.9 | 5.4 | 9.2 | | |
| | Minimum size sag vertical curve | Desirable Urban roads and rural roads with street lighting | K value | 4.0 | 7.0 | 10.0 | 19.5 | |
| | | Desirable Urban roads and rural roads without street lighting | | 7.0 | 11.0 | 16.0 | | |
| | Typical minimum vertical clearance | Main and arterial roads | m | 5.4 | | | 5.4 | Include future provision of 0.1m |
| | | Other roads | m | 4.6 | | | | |

### 2-2-2-6-2 Width Plan

As mentioned in 2-2-1-4 Policy for Width, the width plan is as follows.

The cross-sectional configuration of the bridge portion shall be a roadway width of 3.5m×2=7.0m, shoulder width of 0.5m×2=1.0m, and single sidewalk width of 2.0m, for a total of 10.0m (effective width).

The standard cross-sectional configuration of the approach road portion shall be a roadway width of 3.5m×2=7.0m, shoulder width of 0.5m×2=1.0m, single sidewalk width of 2.0m, and protection shoulder of 1.0m×2=2.0m, for a total of 12.0m (total width).

**2-2-2-6-3 Study of Bridge Length**

The bridge length was determined as shown in the table below under the conditions: (1) it does not fall below the bridge length of the existing bridge (approx. 89.5m), (2) the new bridge abutments will be installed at the position of existing bridge abutments, and (3) the installation direction for bridge abutment shall match the river flow direction.

Table2-2-13 Bridge

| | Measuring point | Skew angle | Bridge length |
|---|---|---|---|
| A1 abutment | Sta.0+369.700m | 90° 0’ 0.0” | L=90.000m |
| A2 abutment | Sta.0+459.700m | 87° 0’ 2.2” | (Road centerline) |

Source: JICA survey team

Span ratio selection was determined as shown in the table below under the conditions: (1) an intermediate bridge pier shall be installed at a position that is an isodiametric span and (2) the installation direction for the bridge pier shall match the river flow direction that was determined as shown in the table below.

Table2-2-14 Bridge Pier

| | Measuring point | Skew angle | Span ratio |
|---|---|---|---|
| P1 bridge pier | Sta.0+399.700m | 90° 0’ 0.0” | 3 x 30.000m |
| P2 bridge pier | Sta.0+429.700m | 90° 0’ 0.0” | (Road centerline) |

Source: JICA survey team

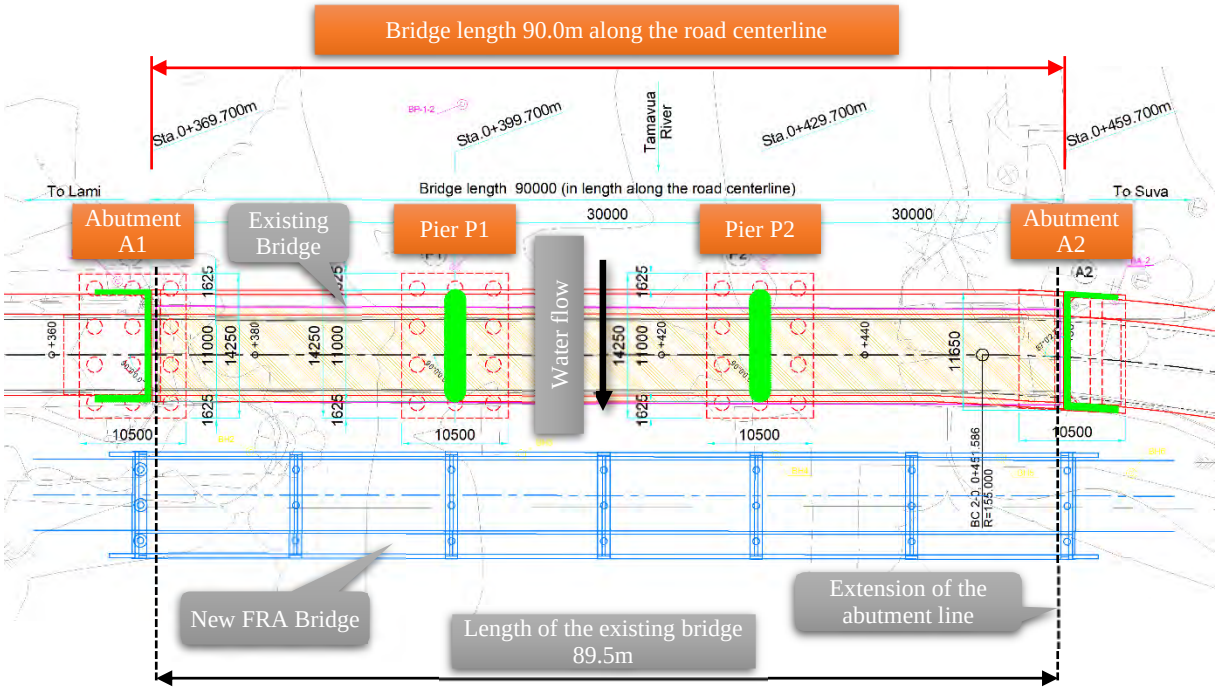



Figure 2-2-11 Bridge length and pier arrangement

### 2-2-2-6-4 Study of Bridge Type

#### (1) Countermeasure for Driftwood, etc.

As the drainage basin of the Tamavua River is mostly a mountainous area, driftwood may be generated during floods. Although the photograph at right is not the Tamavua River, but another river in Fiji, this situation is quite possible on the Tamavua River.

Photo 2-2-1 Driftwood accumulated by flooding caused by Cyclone Winston

The size (length) of driftwood that reaches at the bridge is determined by the width of channel and the form of the flow path of the river, and accumulation at the bridge depends on the span and the space under the bridge, these point shall be confirmed and plan the countermeasure to prevent the accumulation of driftwood.

Specifically, the maximum length of driftwood is said generally to be 20m, therefore the span length shall be set at least 20m and so driftwood does not accumulate.

#### (2) Study of Salt Damage Control Measures

##### 1) Salt Damage Environment

If the general weather conditions for steel exposed to the natural environment are a temperature of 20℃ or above and humidity of 70% of above, it is generally said that the steel is in a corrosive environment. Figure2-2-12 shows the relationship between the monthly average temperature and relative humidity in Sapporo, Tokyo, and Naha in Okinawa prefecture the Southern island of Japan.

. You can see that Okinawa has a harsh environment in which corrosion of steel is likely to occur for 8 months of the year. According to measurement data from 1971 to 2000, Fiji's capital of Suva has a minimum temperature of 20℃ or above and a maximum temperature of 26℃ or above throughout the year, and variation in temperature every day is small because it is tropical rainforest climate. In addition, as shown in Figure2-2-12, a relative humidity of 70% or above and an average temperature of 25℃ or above have been observed in Suva throughout the year, therefore Fiji can be considered to have an environment in which steel corrosion is likely to occur or advance.

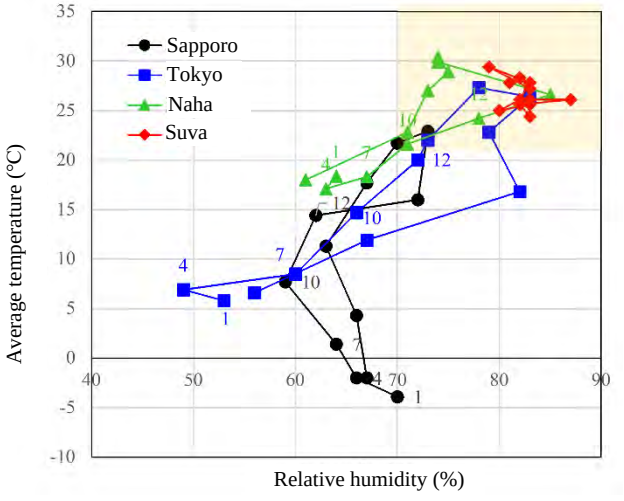
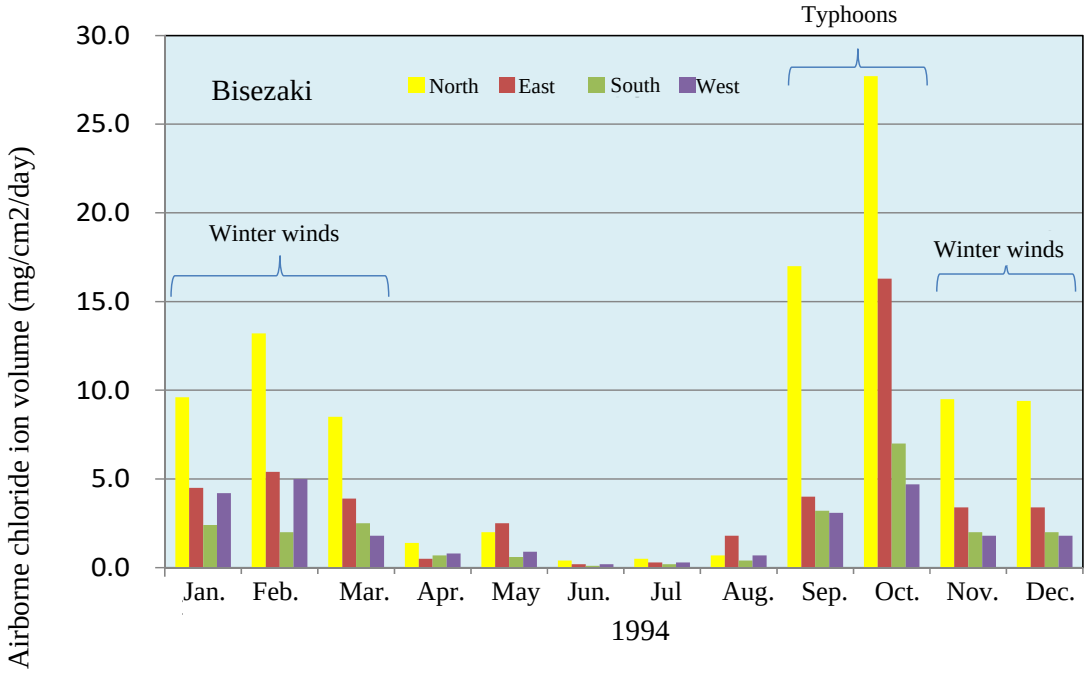



Figure2-2-12 Climograph Monthly Averages

The salt damage environment is also significantly influenced by the wind direction, wind speed, and structure (type) of the coastline. Figure 2-2-13 shows the windborne salt observation data for each month in Okinawa Prefecture. As it is known that much of the supply of windborne salt in Okinawa is winter wind and waves accompanying the seasonal winds (strong winds from the north) that blow in from the Asian continent in winter and typhoons that come from the summer to the fall. In addition, Figure 2-2-14 shows the relationship between the coastline structure and the windborne salt. Even on coastlines where the salt damage environment is said to be severe, the windborne salt amount significantly varies depending on the coastline structure.

In terms of the wind conditions in Fiji, on Viti Levu Island where the capital Suva is located, there is much wind from the east to the southeast throughout the year due to the trade winds, and there are generally mild and moderate winds. The Tamavua-i-wai Bridge is located on the south coastline about 380m inland from the coast however, as the Tamavua River, the Tamavua-i-wai Bridge is across, continues to the sea, the salt damage environment is rated as equivalent to 0m away from the coast. Because the area near the bridge has been covered with trees, and these trees serve as a barrier for salt that blows in from the seas, it can be assumed that the windborne salt to the bridge is brought in along the river. Although the salt damage environment is expected to be mild based on the location of the Bridge and wind conditions in Fiji, during the period from November to April, Fiji suffers tropical cyclones and, there is the possibility of large volumes of windborne salt.

In light of this surrounding environment and weather condition, an exposure test was conducted the windborne salt on the plate mortar was observed for each exposure period (1 month, 3 months, 6 months, and 9 months).




Tanigawa, et. Research on durability of reinforced concrete structures when exposed to severe salt damage (Effects of acrylic rubber waterproofing film): Japan Journal of Structural Systems, Vol. 487, pp. 11-19, Sept. 1996

Source: Hiroshi Kazama, R&A

Figure 2-2-13 Monthly climograph averages in Okinawa

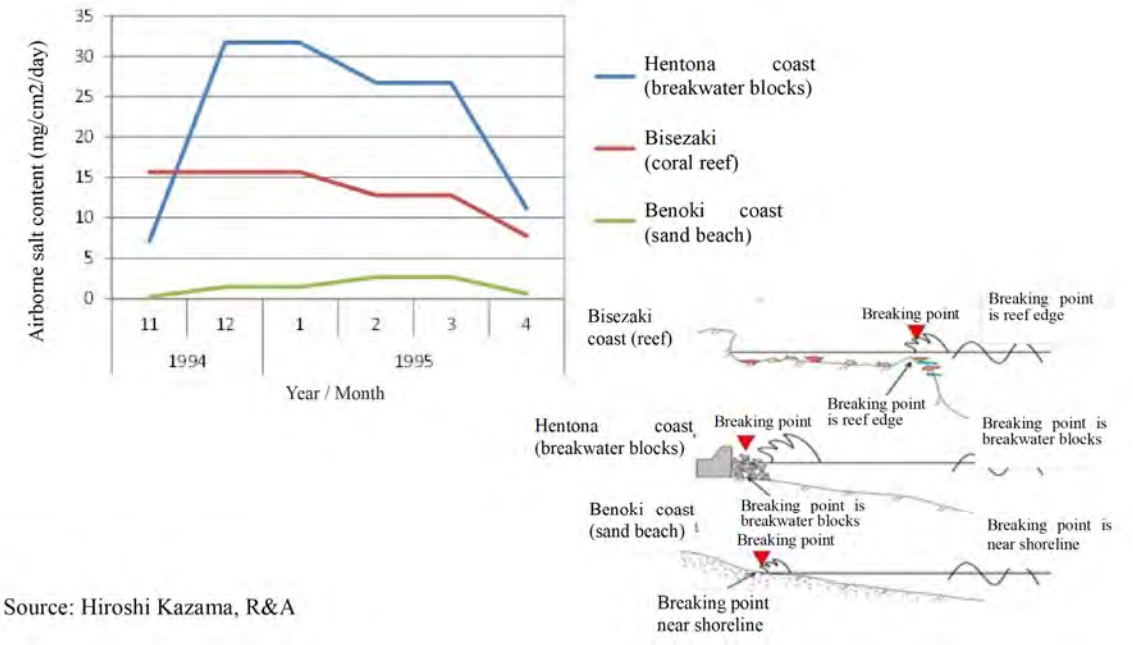



Figure 2-2-14 Relation between coastline type and airborne salt content

Because Okinawa Prefecture is a region within Japan with a severe salt damage environment, the measures indicated in Figure 2-2-15 have been implemented to ensure durability from salt damage on the coastline in Okinawa Prefecture. In addition to the current salt damage control measures (securing coverings), concrete structures have been made more durable through the use of coated PC steel, corrosion-resistant sheath, coated rebar, and high durability concrete (fly ash concrete(FAC), etc.).

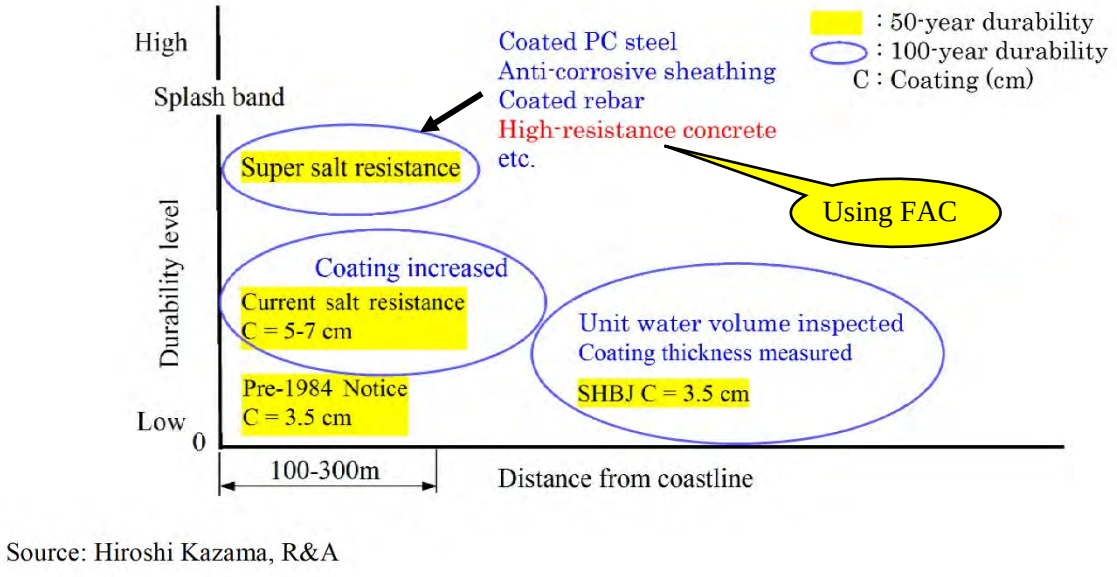



Figure 2-2-15 Image of Durability levels

The status of windborne salt in Fiji related to the reconstruction of the Tamavua-i-wai Bridge has been summarized based on the results of the survey on windborne salt on the thin plate mortar specimens for the existing bridge which is shown in Photo 2-2-2, and additional factors are included namely,

the condition of the existing bridge and bridges near the surrounding coastline, the characteristics in usable materials, and construction costs. The amount of salt on specimens were measured after the collection of these which were attached to the flank of the bridge facing to the both upstream and downstream side, and its end points (Suva side and Lami sade) and the center, with varied exposure periods such as 27, 87, 184, and 352 days.

Photo 2-2-2 Summary of study on airborne salt content

Figure2-2-16 shows the changes in the adhering salt volume on the thin plate mortar specimens during the exposure period. As it is seen in the figure, the overall trend is that the adhering salt volume increased along with the passing days of exposure. It is believed that this is because windborne salt was supplied from the sea. In terms of differences in exposure sites, while the adhering salt volume was the highest for the central portion of the bridge and lowest for the its end point at Suva side, and no significant differences in the overall trend were seen. Figure2-2-17 shows the adhering salt volume on the thin plate mortar specimens exposed in Okinawa Prefecture. The exposure period was 90 days for the Bridge J and from 120 days to 125 days for other locations, and the direction of each exposure site indicates the position of the coast. As it is seen in the figure, the highest adhering salt volume during exposure in Okinawa Prefecture was 26kg/m$^3$ at Hentona and the lowest amount was 0.50kg/m$^3$ at Bridge I. In addition, as can be seen in Figure2-2-16 and Figure2-2-17, even if a comparison is made with the results of 352 days of exposure with the highest adhering salt volume at the Tamavua-i-wai Bridge, the adhering salt volume is lower than each location within Okinawa Prefecture.

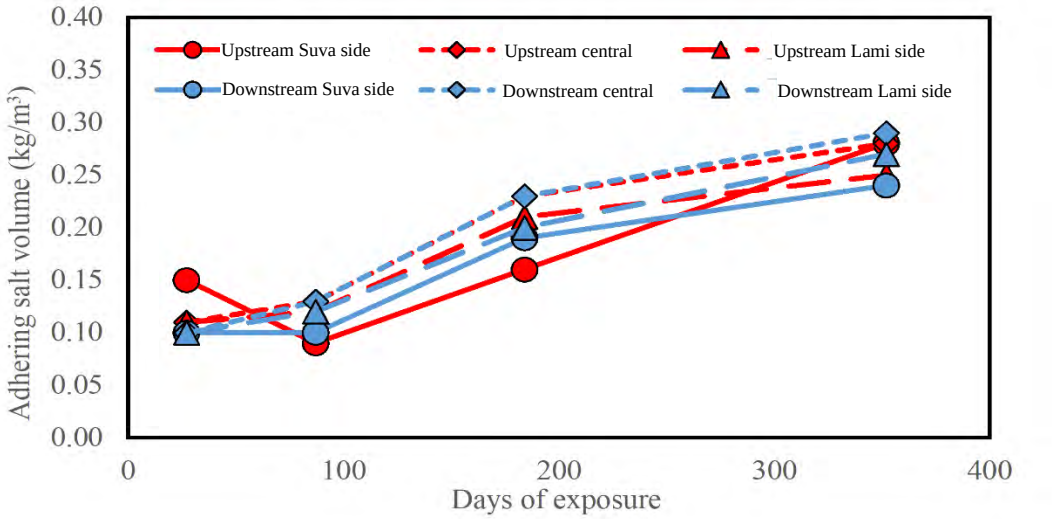



Figure2-2-16 Changes in Adhering Salt Volume on the Thin Plate Mortar Specimens Over Time (Tamavua-i-wai Bridge)

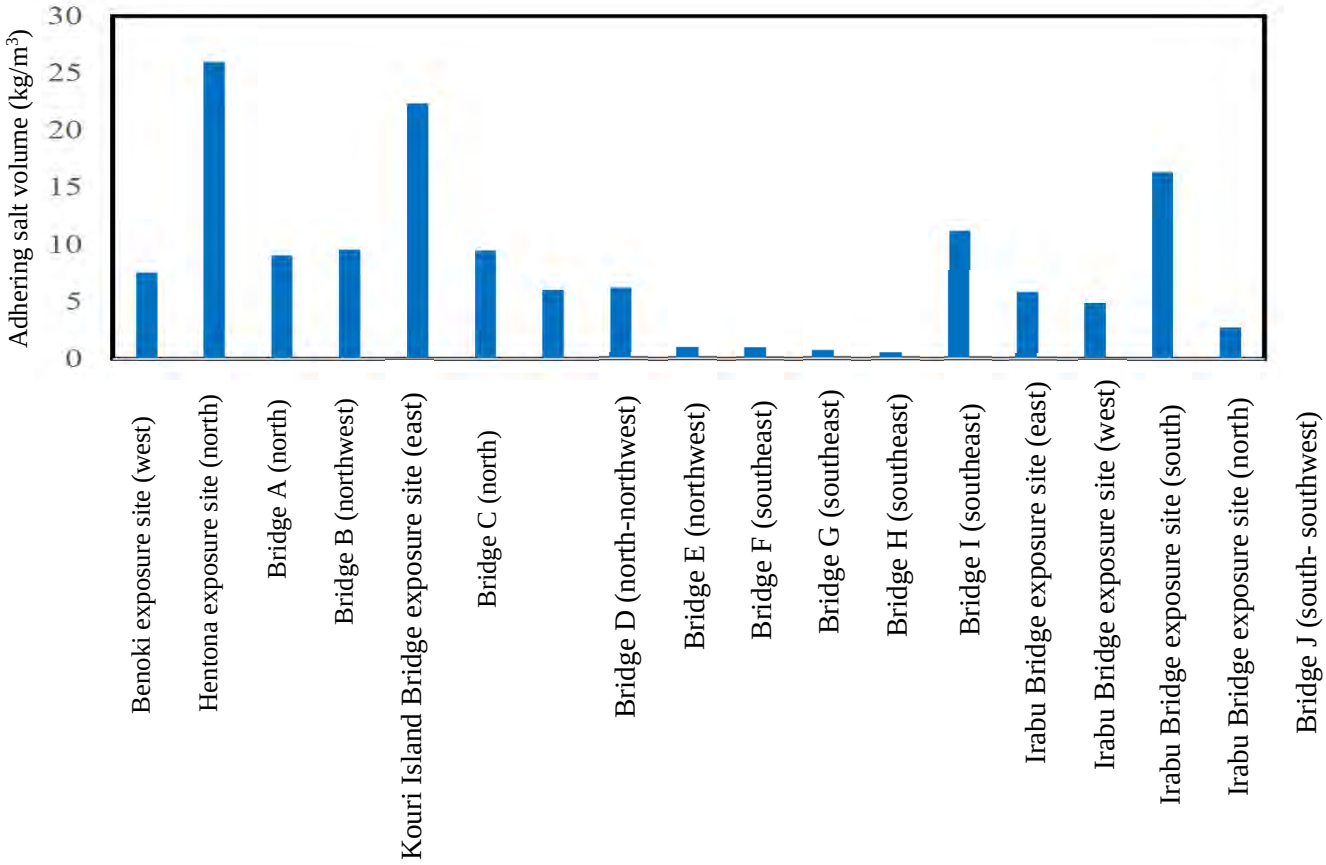



Figure2-2-17 Adhering Salt Volume on the Thin Plate Mortar Specimens in Okinawa Prefecture

**2) Status of Salt Damage on the Existing Bridge**

Table2-2-20 shows the status of salt damage on the existing bridge. On the road portion, kinks can be seen on the central portion of the road surface, and there are significant vibrations on the entire bridge when a vehicle drives over the bridge. On the sidewalk portion, although some parts of the concrete are damaged, it is sound overall. On the bridge railing, although bolt corrosion can be seen, it is believed to be painted regularly, and it is sound overall.

For the superstructure, although concrete cracks and discoloration were seen on the lower surface of the concrete floor slab, the areas which were peeling or stripping were not confirmed in the field survey. Meanwhile, on the overhanging portion of the floor slab, corrosion of rebar from salt damage along with concrete flaking and peeling and stripping as the result were identified on both the upstream and downstream side. Table2-2-20 shows that the field survey found the areas with extremely little rebar covering and the areas with poor construction works including honeycombs and construction joints were found, and these are believed to be factors that promoted degradation by the salt damage. For the steel girders, although paint peeling and corrosion were confirmed, the little cross section damage to the steel girders was little. Because damage was significant to parts with a low clearance that windborne salt is likely to adhere to, it is believed that salt damage was the main cause of concrete damage.

For substructures, there was significant corrosion accompanies by concrete peeling and stripping at the bridge piers, and this is believed to be degradation from salt damage. Because these bridge piers are in an environment of being wet in the sea water and then dry repeatedly due to the tide, this promoted salt adherence on concrete portions and it can be inferred that they are in a much more severe deterioration environment compared to the floor slab portion.

In addition, a field survey was conducted on other bridges nearby to the Tamavua-i-wai Bridge. Figure2-2-18 shows the location of these bridges. In the same manner as the Tamavua-i-wai Bridge, these bridges are positioned on the coastline and they are exposed to the windborne salt. As it is seen in Photo 2-2-3, in the same manner as the Tamavua-i-wai Bridge, significant cracks on bridge piers and cracks from floor slab rebar corrosion were seen on these bridges. If the degree of deterioration is compared between Tamavua-i-wai Bridge and these bridges, the same degree of deterioration can be seen on the bridge piers, and it is believed the effect of wetting and drying has had a significant impact of the depredation on these bridges in the same manner as for the Tamavua-i-wai Bridge. For the floor slab portion, the degree of degradation is rather low compared with the Tamavua-i-wai Bridge, and it is believed that initial defects from the time of construction of the Tamavua-i-wai Bridge have promoted degradation. Note that turtleback cracks from an alkali-aggregate reaction or structural cracks from fatigue were not confirmed for either the Tamavua-i-wai Bridge or these bridges. However, because pavement bending and joint damage were also confirmed and there are significant vibrations when a car passes over the Tamavua-i-wai Bridge, it is possible that concrete residual strain from fatigue has accumulated and when this is considered along with the joint interaction with steel degradation from salt damage and concrete cross section damage, it is believed that reconstruction is needed without delay.

Table2-2-15 Status of Salt Damage on the Existing Bridge

| Part checked | | | Status of damage | Cause of damage |
|---|---|---|---|---|
| Bridge surface | Road portion |  | Kinks can be seen on the central portion of the road surface. | |
| | Sidewalk portion |  | Although some damages were confirmed, no serious problem was found. It can be said sound overall. | |
| | Bridge railing | | It is believed that regular painting is conducted based on the external appearance, and although some bolts were corroded, it is sound overall. | Deterioration from aging |
| Superstructures | Floor slab steel girders |  | For the floor slab at central portion, although concrete cracks and discoloration were seen in some floor slab steel girders, no major damage was seen compared to the floor slab overhanging portion. For the steel girders, although some corrosion was confirmed, no major damages such as cross section damage was confirmed. | Salt damage |
| | Floor slab overhanging portion |  | There is scattered concrete peeling and stripping on the downstream side (sea side). | Salt damage |
| | |  | There is also scattered concrete peeling and stripping on the downstream side (sea side). | Salt damage |
| Substructure | Pillar part |  | There is significant rebar corrosion accompanied by concrete peeling and stripping. | Salt damage |

Photo 2-2-3 Areas with poor construction work including honeycombs and construction joints and areas with insufficient covering


Figure2-2-18 Location of Nearby Bridges

Photo 2-2-4 Concrete flaking from rebar corrosion (Bridge A)

Photo 2-2-5 Concrete cracks in bridge piers (Bridge B)

### 3) Salt Damage Control Measures

#### a) Bridge Plan to Reduce the Amount of Airborne Salt Adherence

According to the survey on the other bridges near the Tamavua-i-wai Bridge constructed on the coast, the structure of the girder bridge, which most of them are applied, makes airborne salt adherence relatively difficult. No major damage was seen in the central portion of the floor slab, and there was not any significant steel corrosion. In addition, there was a little damage to the supports around supporting points and/or the bridge seat surface that normally vulnerable to the salt damage, and it is believed that the salt damage to the superstructures has been comparatively mild. Therefore the bridge type should be considered avoiding a structure susceptible to salt adherence (such as T girder bridge that is susceptible to significant salt damage) and adopting a structure that minimizes the salt adherence surface (such as suspended girder slab bridge) which would be effective salt damage control measures. For bridge piers, similar degradation from salt damage was seen on the Tamavua-i-wai Bridge as well as others. It can be inferred that the bridge pier degradation was the result of an environmental aspect that became wet and then dry due to the repeated difference in the seas level from the tidal encouraging salt adherence. Therefore, because it is not possible to control the amount of salt adherence through structural measures alone, it is necessary to control the influence of the salt adherence through the use of thick covering and the concrete materials and its composition used.

#### b) Selection of Materials to Ensure Durability

Since the durability of concrete is greatly impacted by the water-cement ratio, aggregate, and slump, etc., the properties of local materials must be assessed and concrete should be selected while taking its composition, etc. into account. As a result of the field survey, it was found that there was no supply of blended cement that have salt-blocking properties (fly ash cement and blast-furnace cement), and that it would need to be supplied from a neighboring country (such as New Zealand) if used. Therefore, composition ingenuity such as reduction of the water-cement ratio would be necessary if not using blended cement for economic reasons, and composition selection will be studied after confirming strength and salt-blocking properties using composition samples. In addition, the type of aggregate rock is basalt, and although there have been no reports of degradation from an alkali-aggregate reaction in actual concrete structures that used basalt in Japan, it is necessary to check for internal chlorides in aggregate, etc. and the alkali-aggregate reaction response for aggregate, and keep in the aggregate quality in mind by.

Moreover, in detailed design it is necessary to conduct appropriate composition design while taking into consideration factors such as the result of surveys on the surrounding environment including airborne salt and the characteristics of the rebar, aggregate, and cement used.

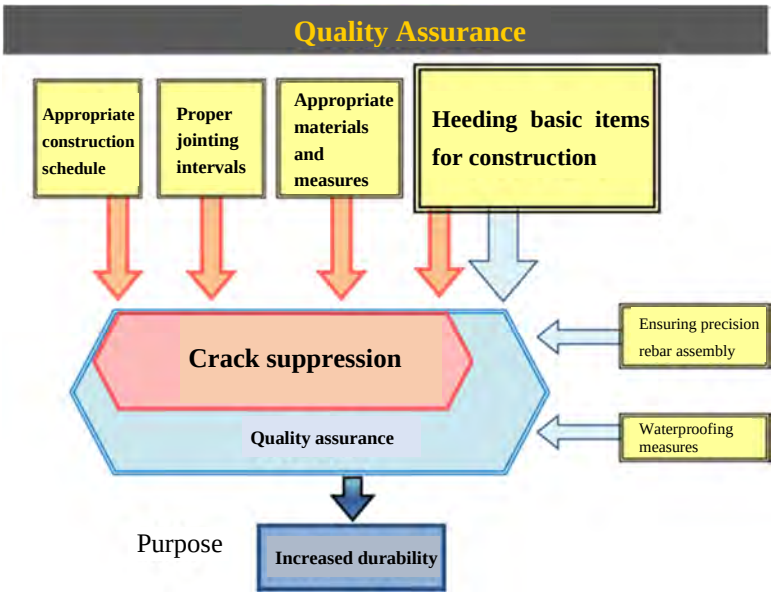
#### c) Detailed Design to Ensure Durability

As indicated above, the salt damage environment in Fiji is expected to be equivalent to that in Okinawa Prefecture. Therefore, the super salt damage control measures shown in Figure 2-2-15 should be taken for the materials used for the reconstruction of the Tamavua-i-wai Bridge. However, if it is difficult to take the super salt damage control measures described above from the perspective of reducing costs, effective salt damage control measures would include making the clearance high, avoiding a

structure susceptible to salt adherence (such as T girder bridge that is susceptible to significant salt damage), and adopting the structure that minimizes the salt adherence surface as described above.

**d) Construction Supervision to Ensure Durability**

To ensure the durability of a concrete structure, in addition to considerations such as the selection of materials and the structural form, it is essential to ensure the quality of concrete at the first stage. In other words, construction and curing must be conducted appropriately. The six considerations (within the yellow section) shown in Figure 2-2-19 are necessary to ensure the quality of concrete structures.




Source: Yamaguchi Pref. Construction Dept.

Figure 2-2-19 Conceptual diagram on ensuring concrete structure quality

① Appropriate construction period

Select an appropriate construction period to avoid concrete placement during periods with high temperatures as much as possible.

*While this is not possible in a region like Fiji that has high temperatures year round, a period with a relatively low temperature during the dry season would be an appropriate construction period.

② Appropriate construction joint intervals

Because the maximum crack width tends to be smaller the shorter the construction joint interval is, set an appropriate construction joint interval so that the construction joint interval is as short as possible. Here a construction joint interval in the case of something like a bridge abutment would refer to the number of days from the day footing is poured and the day of pouring the vertical wall that is the next lift.

③ Appropriate measures through materials, etc.

Study and implement appropriate measures through materials, etc. such as materials (reinforced rebar, glass fiber, hydration suppression-type expanding materials, etc.), the use of induced joints, and curing methods.

④ Compliance with basic construction matters

A consultant should use a check sheet to assess the status of construction and support the contractor so that the contractor can construct a quality concrete structure.

⑤ Ensure the accuracy of rebar assembly

To prevent insufficient covering, the detailed covering diagrams, which are easy-to-understand by the contractors and avoiding their misunderstanding, should be provided. It will be an assurance that the contractor can assemble rebar accurately and securely at the prescribed location indicated by design.

⑥ Waterproofing measures

Water can have an impact on the degradation of concrete structures. For this reason, possible countermeasures, such as the way preventing water inflow to the structures or the structures either reducing water inflow or prompt draining water, were considered through the variety of standards and manuals etc. In addition to the consideration of the quality assurance described above, it is necessary to consider the construction schedule, such as delaying the timing of mold removal for fly ash concrete which its strength generation can be low. As well as appropriate curing treatment like using curing sheets after mold removal is necessary.

Like Fiji, the regions inhere the salt damage environment, the construction management with consideration of quality assurance for the concrete structures as described above is preferable.

**e) Creation of a Maintenance Management System**

**i) Implementation of Surveys Over Time as Required for Maintenance Management**

The use of sealant materials that allow for visual inspection of exterior surfaces will be studied to create a structure with easy maintenance. In addition, for the appropriate maintenance management of concrete structures, it is necessary to gain understanding the environmental effects (such as airborne salt, temperature, and wind direction and wind speed) and concrete response (such as salt adherence and internal rebar corrosion speed). Accordingly, it would be appropriate to set up exposure test specimens with the same concrete composition as the new bridge and measure factors such as the adhering salt volume and internal rebar corrosion speed in order to collect data for future maintenance management.

**ii) Human Resources Development**

The development of local human resources will be important for the creation of an appropriate maintenance management system. For the establishment of such the creation of an educational program in cooperation with Japanese municipalities and/or private sector is considerable. For example, Okinawa prefecture and the University of the Ryukyus, and private sector companies that have specific knowledge of salt damage control measures as its region has the most harsh salt damage environment in Japan.

### (3) Study of Bridge Type

#### 1) Cross-section Configuration

The bridge cross-section configuration is as indicated in 2-2-1-4Policy for Width.

#### 2) Bridge Type Comparison Proposal

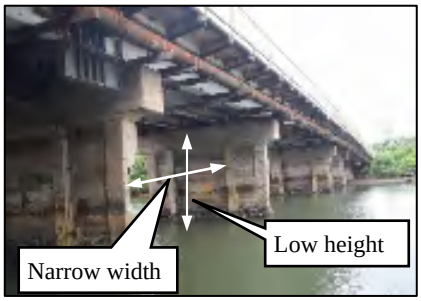


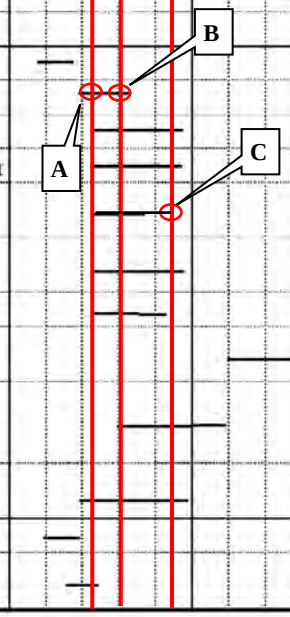
Photo 2-2-6 Current bride has a narrow width and low height

The existing bridge is a 7-span steel girder bridge, and the lengths of the spans are very short at approx. 9-18 meters. Additionally, the longitudinal section of the bridge does not have an adequate height. Therefore, a comparative study of multiple alternatives plans will beconducted for the bridge type, focusing on the effects of flood water levels, tide levels, and driftwood, executability, economic efficiency, and ease of maintenance. Based on this, the most appropriate proposal will be selected. Since the Tamavua-i-wai Bridge faces the shoreline, a steel bridge is not desirable, taking corrosion due to salt into consideration. Thus, the main body of the bridge will be prestressed concrete. Additionally, as a measure to combat driftwood, the number of piers will be reduced, and the spans will be lengthened to prevent driftwood accumulation. Furthermore, to keep the longitudinal section height of the bridge as low as possible, it is necessary to study bridge types in which the height of the main girder is low. Therefore, the basic policy will be to study types of bridges that meet these conditions, and a comparative study will be conducted on the following bridge types selected under Table 2-2-21 regarding factors such as structural properties (salt damage resistance), executability, impact on the surrounding environment, river characteristics and driftwood measures, and economic efficiency. Based on this, the most appropriate proposal will be selected.

- Proposal 1: 4-span PC interconnected pre-tensioned slab girder bridge (l=4@22.5m=90.0m) (A in the table below)
- Proposal 2: 3-span PC interconnected post-tensioned slab girder bridge (L=3@30.0m=90.0m) (B in the table below)
- Proposal 3: 2-span PC interconnected post-tensioned T-girder bridge (L=2@45.0m=90.0m) (C in the table below))

Table 2-2-16 Superstructure format and recommended applicable spans

| | Superstructure type | Recommended span (50 m / 100 m / 150 m) | Curve applicable: Main structure | Curve applicable: Bridge deck | Girder height Span ratio |
|---|---|---|---|---|---|
| Steel bridge | Simple composite plate girder | | ○ | ○ | 1/18 |
| | Simple plate girder | | ○ | ○ | 1/17 |
| | Continuous plate girder | | ○ | ○ | 1/18 |
| | Simple box girder | | ○ | ○ | 1/22 |
| | Continuous box girder | | ○ | ○ | 1/23 |
| | Simple truss | | × | ○ | 1/ 9 |
| | Continuous truss | | × | ○ | 1/10 |
| | Reverse Langer girder | | × | ○ | 1/6,5 |
| | Reverse Lohse girder | | × | ○ | 1/6,5 |
| | Arch | | × | ○ | 1/6,5 |
| PC bridge | Pretentioned girder | | × | ○ | 1/15 |
| | Hollow slab | | ○ | ○ | 1/22 |
| | Simple T girder | | × | ○ | 1/17,5 |
| | Simple composite girder | | × | ○ | 1/15 |
| | Continuous T girder, composite girder | | × | ○ | 1/15 |
| | Continuous composite girder | | × | ○ | 1/16 |
| | Simple box girder | | ○ | ○ | 1/20 |
| | Continuous box girder (cantilever method) | | ○ | ○ | 1/18 |
| | Continuous box girder (Push-out or support method) | | ○ | ○ | 1/18 |
| | π shaped rigid frame ridge | | × | ○ | 1/32 |
| RC Bridge | Hollow slab | | ○ | ○ | 1/20 |
| | Continuous spandrel-filled arch | | ○ | ○ | 1/ 2 |




### 3) Results of Comparative Study

The results of a comparison study of the three proposals above are shown in Table 2-2-22. An overview of the three proposals and their advantage and disadvantage points were explained to FRA, and as a result of discussions, an agreement was reached with FRA that proposal 2 (3-span PC interconnected pre-tensioned suspended slab bridge) proposal would be the best.

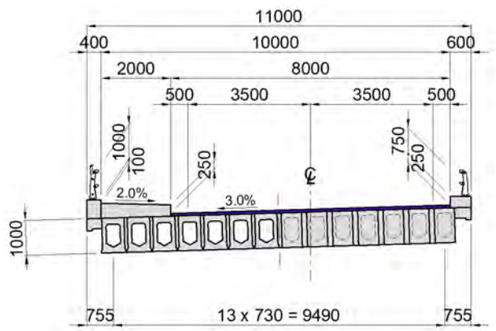
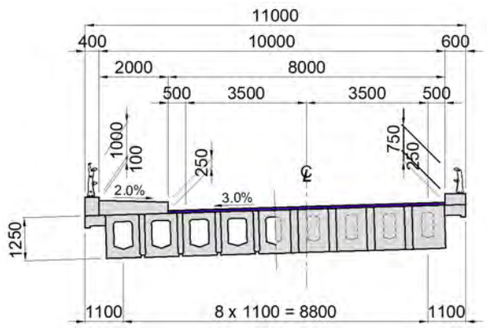
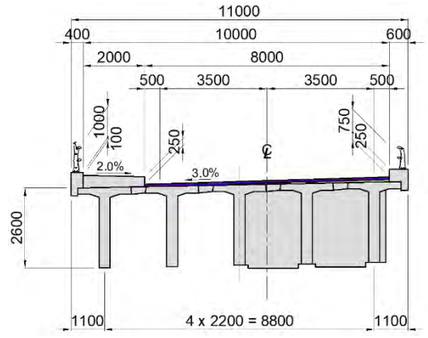
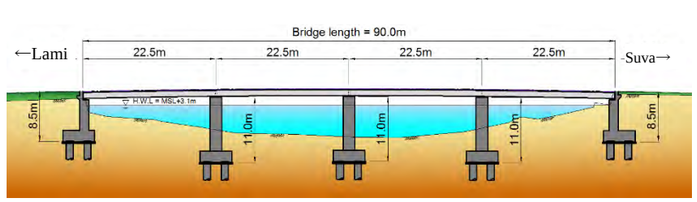
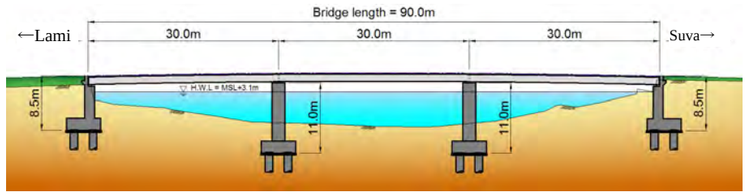
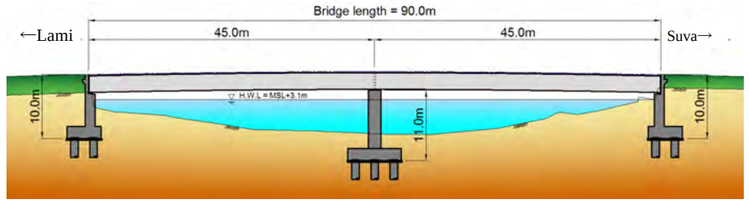
① It would be possible to keep the girder height low, and as a result, keep the raising height of the bridge surface at 1.5m.

② Because the span length is 30, it sufficiently satisfies the required width (20m) for the avoidance of driftwood accumulation.

③ It has a shape that is not susceptible to salt adherence and excels in salt damage resistance.

④ It is the best in terms of economic efficiency.

Table 2-2-22 Bridge Type Comparison Table

| | Proposal 1: 4-span PC interconnected pre-tensioned slab girder bridge | Proposal 2: 3-span PC interconnected post-tensioned slab girder bridge | Proposal 3: 2-span PC interconnected post-tensioned T-girder bridge |
|---|---|---|---|
| Superstructure cross-section view |  |  |  |
| Side view |  |  |  |
| Structural properties | • Pre-tensioned PC slab girder bridge<br>• This structure is suitable for technology transfer because little capital investment is required for equipment for fabrication and erection.<br>• Compared to the other proposals, this allows for the lowest structural height.<br>• Since girders are linked above the piers, it has superior drivability, maintenance management, and seismic resistance. | • Post-tensioned PC slab girder bridge<br>• Concrete is poured in between girders to form a structure that is integrated in a transverse direction.<br>• Due to the low girder height, this type is advantageous if restrictions are imposed on structural height.<br>• Since girders are linked above the piers, it has superior drivability, maintenance management, and seismic resistance. | • Post-tensioned PC slab girder bridge<br>• As the typical format for PC bridges, there are many cases of its use in grant aid projects.<br>• The girder height-effective span ratio is 1:17, and its structural height is higher than the other proposals.<br>• Since girders are linked above the piers, it has superior drivability, maintenance management, and seismic resistance. |
| Executability | • Simplified pretensioning facilities will be set up near the site for girder fabrication.<br>• If crane erection is performed, construction can be done quickly, but work is easily impacted by the river.<br>• Since there are many piers in the river, the total construction period is longer than other proposals.<br>(Estimated construction period: approx. 27.5 months) | • Box section slab girders can be fabricated in a temporary yard near the site.<br>• A precast block construction method can be used if necessary.<br>• Since erected girders will be used, girder erection work is possible during flood season.<br>(Estimated construction period: approx. 25 months) | • T-girders can be fabricated in a temporary yard near the site.<br>• The number of main girders to be fabricated is fewer than the other proposals, making the proposal advantageous in terms of the construction schedule.<br>• Girder height is very high, making it necessary to consider toppling prevention measures during fabrication and erection.<br>(Estimated construction period: approx. 24 months) |
| Maintenance | • Since high-strength concrete is used, it has superior durability.<br>• Compared to cast-in-place girders, quality is stable, which is advantageous for maintenance.<br>• Since it is a concrete bridge, ordinary maintenance is easy. | • Compared to cast-in-place girders, quality is stable, which is advantageous for maintenance.<br>• Salt adherence is easy to prevent because the surface area of the bridge is small.<br>• Since it is a concrete bridge, ordinary maintenance is easy. | • Compared to cast-in-place girders, quality is stable, which is advantageous for maintenance.<br>• With many corners on girder cross sections, this bridge is more easily impacted by salt damage than the other proposals.<br>• Since it is a concrete bridge, ordinary maintenance is easy. |
| Surrounding environment | • In order to secure clearance under the girders, it will be necessary to elevate the road surface at the center of the road: approximately 0.45 m on the Suva side and approximately 1.20 m on the Lami side. The impact of the raised road surface will have a small impact on roadside usage. | • In order to secure the clearance under the girders, it will be necessary to elevate the road surface at the center of the road: approximately 0.60 m on the Suva side and approximately 1.35 m on the Lami side.<br>• The impact of the raised road surface will have a small impact on roadside usage; it is about the same as Proposal 1. | • In order to secure clearance under the girders, it will be necessary to elevate the road surface at the center of the road: approximately 2.05 m on the Suva side and approximately 2.80 m on the Lami side.<br>• With a high amount of road surface elevation, this has a large negative impact on roadside usage. |
| River properties | • Bridge span length (22.5 m) is not problematic, but the river area blockage percentage is in high (approx. 6.8%).<br>• Piers must be constructed near the center of the river, where the water is deepest. | • Bridge span length (30 m) and river area blockage (approx. 4.5%) both meet standard values.<br>• Bridge pier placement will avoid the center of the river. | • This proposal has the longest bridge span (45 m) and the least amount of river area blockage (approx. 2.3%).<br>• Piers must be constructed near the center of the river, where the water is deepest. |
| Economic efficiency | • Construction costs for the substructure are high, making it less economically efficient compared to Proposal 2.<br>(Estimated construction cost ratio: 1.01) | • This is the most economically efficient compared to the other proposals.<br>(Estimated construction cost ratio: 1.00) | • Construction costs for the superstructure are high, making it the least economically efficient compared to the other proposals.<br>(Estimated construction cost ratio: 1.11) |
| Overall evaluation | • With low girder heights and superior durability, there are no problems in terms of the structure type. However, the construction period is longer and it is less economically efficient than the other proposals. In order to lower the river area blockage percentage to the target value or less (5.0% or less), the structure of piers in the river remains an issue. | • With the best economic efficiency, this proposal is very well balanced in terms of structural properties, executability, and river properties. It is resistant to salt damage, with no problems in durability and maintenance. There is little difference between Proposal 1 in the amount of road surface elevation, and since this proposal is deemed superior overall, it is the recommended proposal. | • The effective span is large (nearly to the upper limit of standard applicable effective spans), and the structural height is very high. Therefore, safety measures must be adequately considered during construction. The impact on the roadside area due to raising the road surface is large, and this proposal is the least economically efficient. |
| | △ | ◎ | ○ |

### (4) Study on Substructure and Foundation Type

#### 1) Selection of Support Layer

There is a wide distribution of marlstone classified in the Suva group from the upper Miocene to early Pliocene near the location of the bridge. According to the result of a boring survey, the surface portion of the marlstone layer that is the bedrock has weathered and locally there are also some areas that have hollowed out. However, a fresh marlstone layer with an N value of at least is distributed below this and serves as the support layer for the bridge foundations. Although it is approx. 5 to 6m from the ground to the support layer on the Suva side (A2 abutment side), it becomes extremely deep up to the support layer on the Lami side (A1 abutment side) at around 40m, where a weak alluvial silt layer with an N value of 0 is thickly deposited on the bedrock.

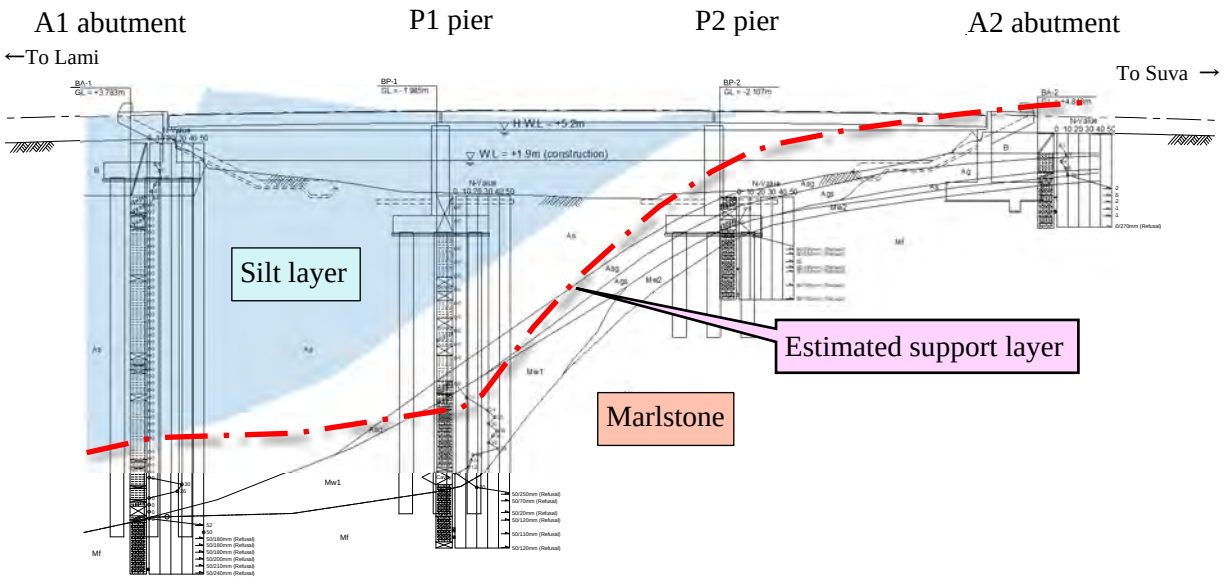


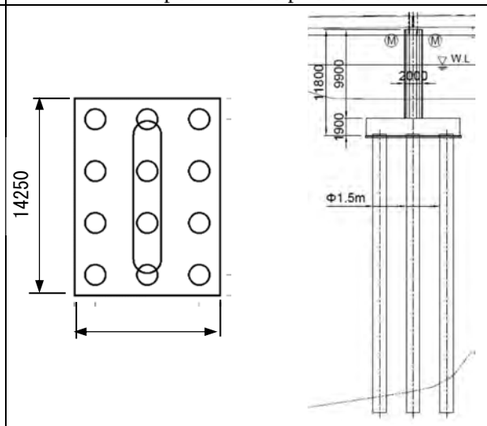
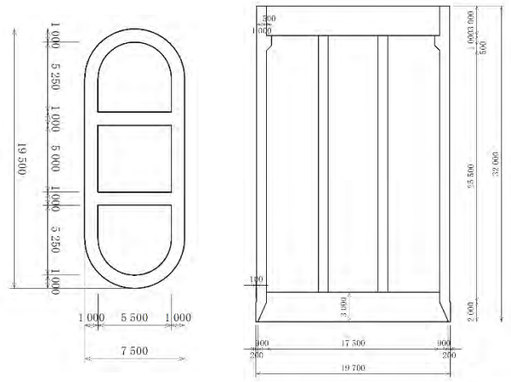
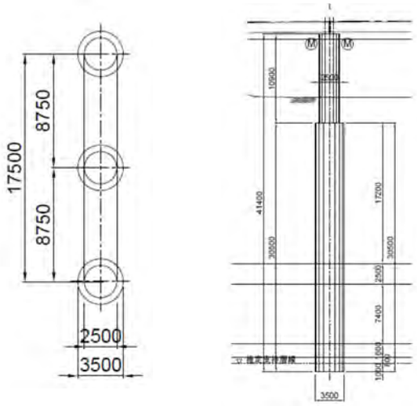
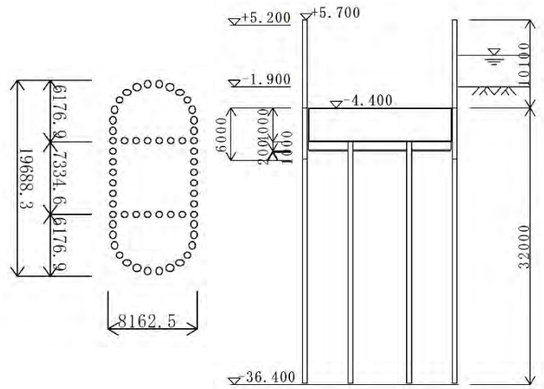

Figure 2-2-20 Selection of support layer

#### 2) Selection of the Foundation Type

Because the support layer is at a depth of about 40m from the ground, it is also soft ground, and the water depth is deep at 4.0m, a comparative study will be conducted on the following four types regarding factors such as the necessity of temporary coffering, the impact on the river, executability, and economic efficiency. Based on this, the most appropriate proposal will be selected. The results of the comparative study on the four proposals below are shown in the table below. As a result of this study, a site pile foundation was selected（see Table2-2-23）.

- Proposal 1: Site pile foundation
- Proposal 2: Caisson foundation
- Proposal 3: PC well foundation
- Proposal 4: Steel pipe sheet pile

Table 2-2-23 Foundation type Comparison Table

| Proposal | | Proposal 1: Site pile foundation | Proposal 2: Caisson foundation | Proposal 3: PC well foundation | Proposal 4: Steel pipe sheet pile foundation |
|---|---|---|---|---|---|
| Foundation form | |  |  |  |  |
| Characteristic | Coffering | • Coffering with sheet pile is necessary because the water depth is deep at 4m. | • Coffering with sheet pile is necessary because the water depth is deep at 4m and an island will be made. | • Temporary coffering is not needed because the coffering can also be used by the PC well. | • Temporary coffering is not needed because the coffering can also be used by the steel pipe sheet pile. |
| | Impact on the river | • Because the bridge form can be made oblong, flowing water turbulence is smaller and the impact on scouring is also smaller at the time of flooding compared to the PC well type.<br>• The percentage inhibition of the cross-sectional area of the river is smaller compared to the PC well type. | • Same as left | • Because the bridge form is pile bent type, flowing water turbulence is bigger and so scouring impact at the time of flooding compared to the other proposals.<br>• The percentage inhibition of the cross-sectional area of the river would be the highest. | • The same as Proposal 1. |
| | Impact of flowing objects | • Because the bridge form is oblong, the risk of flowing objects such as driftwood and refuse getting caught is low compared to the PC well type. | • Same as left | • Because the bridge form is pile bent, the risk of flowing objects such as driftwood and refuse getting caught and colliding with the bridge is higher compared to the other proposals. | • The same as Proposal 1. |
| | Bridge frame height | • Because a bridge frame beam is not required, the bridge frame height could be kept low compared to the PC well type. | • Same as left | • Because a bridge frame beam is necessary and the under-beam surface must be more than the planned high water level (HWL), the bridge frame height would be higher compared to the other projects (the longitudinal section height is 2 to 3m higher compared to Proposal 1 and Proposal 3). | • The same as Proposal 1. |
| | Workability | • It is a site pile foundation, and this method has the most track record overseas.<br>• Because it is necessary to construct coffering, it is disadvantageous compared to Proposal 3 and Proposal 4 from that perspective.<br>• Although it would be site pile work within coffering, there would be no particular problems.<br>• Because a bridge frame beam is not required, the bridge frame construction and its duration would be rather simple and quick compared to the PC well type. | • Although there is an abundant track record in Japan, there is not much of a track record overseas.<br>• Because it is necessary to construct coffering, it is disadvantageous compared to Proposal 3 and Proposal 4 from that perspective.<br>• Because a bridge frame beam is not required, the bridge frame construction and its duration would be rather simple and quick compared to the PC well type. | • It would be the pile bent type, which is being adopted less in Japan, and it does not have much of a track record overseas.<br>• Because it is not necessary to construct coffering, it is advantageous compared to Proposal 1 from that perspective.<br>• Time would be required to produce the PC well on-site.<br>• A considerably large pier would be required for the installation and press fitting of the PC well.<br>• Because a bridge frame beam is necessary, timbering work would be required for beam construction, which would mean that the construction steps would be more complex, and the construction period would be longer compared to Proposal 1 and Proposal 3. | • There is not much of a track record of adoption for small to medium-sized bridges, and it does not have much of a track record overseas.<br>• Because it is not necessary to construct temporary coffering, it is advantageous compared to Proposal 1 from that perspective.<br>• There are no particular problems with steel pipe pile laying.<br>• Because a bridge frame beam is not required, the bridge frame construction and its duration would be rather simple and quick compared to the PC well type. |
| | Economic factors | • Although coffering is necessary and it would be more expensive than the other proposals for this process, because it is a site pile foundation and the bridge frame height is the lowest, this would be the most favorable proposal economically. | • Because coffering is necessary, it would be more expensive than other proposals for this process. In addition, because the Caisson size is large, it would be less expensive than proposal 4, but more expensive than proposal 1. | • Although temporary coffering is not necessary, because the PC well construction costs are considerably high and materials costs and transport costs for molds, etc. would be required for local production, the construction costs would be quite high.<br>• Furthermore, because a bridge frame beam is also required and the longitudinal section would be higher, it is inferior economically to Proposal 1. | • Although temporary coffering is not necessary, because the construction costs for the steel pipe sheet pile are extremely high and transportation expenses are required for the steel pipe sheet pile foundation, this proposal is the least favorable economically. |
| | Overall assessment | • It has the most track record overseas.<br>• The impact on the river and the impact of flowing objects is the lowest.<br>• It is the most favorable economically. ◎ | • Although it has more of a track record overseas than proposal 3 and proposal 4, it has much less of a track record than proposal 1.<br>• It is medium in terms of economic factors. △ | • It does not have much of a track record overseas (only a few cases).<br>• The impact on the river and the impact of flowing objects is the highest.<br>• It is medium in terms of economic factors. △ | • It does not have much of a track record overseas (only a few cases).<br>• The impact on the river and the impact of flowing objects is the lowest.<br>• It is the least favorable economically. △ |

(Source: JICA survey team)

### 3) Selection of Substructure Type

A site pile foundation was selected under 2) Selection of the Foundation Work Type above, so the selection of the substructure type in this case will be studied.

The height of abutments and bridge piers (from the crest to the lower surface of the footing) is determined according to the road plan height and the depth of the footing. The height of the A1 abutment and A2 abutment will be 7.0m and 9.4m, respectively, and the height of the P1 pier and P2 pier will be 11.8m. The type of the abutments and bridge piers shall be selected in reference to the substructure type selection table shown in the table below in accordance with that height. For the abutments type, an inverted T abutment (A in the table below) was adopted for both the A1 abutment and A2 abutment, and for the bridge pier type, an oblong bridge pier (B in the table below) was adopted for both the P1 pier and P2 pier.

Table 2-2-19 Substructure format selection

| Substructure | Structure type | Applicable height (m) | Characteristics |
|---|---|---|---|
| | | 10 20 30<br>7m 9.4m | |
| Abutment | 1.Gravity type | A | With shallow support ground, the gravity type is suitable for direct foundation. |
| | 2.Reverse T-style | | Used in many bridges. Suitable for direct foundation/ pile foundation. |
| | 3.Buttressed type | | Suitable for tall abutments. Few materials are used for this type, but the lead time is long. |
| | 4.Box type | | Designed for tall abutments. The lead time is slightly long. |
| Pier | 1.Column type | | Low piers. Suitable for stringent intersection conditions and installation in a river. |
| | 2.Rigid frame type | | Relatively tall piers. Suitable for wide bridges. Their installation in a river may hinder water flow in time of flooding. |
| | 3.Pile bent type | B | While they are the most cost efficient piers, they are not suitable for bridges with high horizontal force. Their installation in a river may hinder water flow in times of flooding. |
| | 4.Elliptical type | | Tall bridge piers. Suitable for bridges with high external force. |

### 4) Selection of Site Pile Construction Method

A site pile foundation was selected under 2) Selection of the Foundation Work Type above, so the selection of the site pile construction method in this case will be studied.

The site pile construction method shall be selected in reference to the substructure type selection table shown in the table below in consideration of factors including the depth of the support layer, executability, and economic efficiency. The site pile foundation type (full rotation all casing method construction method) was adopted in consideration of the fact that the A1 abutment through the P2 pier have a depth of approx. 40m to 12m from the support layer to the ground, it excels in executability and economic efficiency compared to other construction methods, and there is also an abundant construction track record with the other similar projects.

Note that a direct foundation type was adopted for the A2 abutment because the support layer is shallow (approx. 6m).

| Selection requirements \ Foundation types | | | | Direct foundation | Cast pile foundation | | | Inner excavation pile foundation | | | | | | Cast in-situ pile foundation | | | | Caisson foundation | | Steel pipe sheet pile foundation | **underground continuous wall foundation** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | PHC pile | | | Steel pipe pile | | | | | | | | | | |
| | | | | | RC pile | PHC pile | Steel pipe pile | Final impact driving method | Blast agitation | Concrete impact | Final impact driving method | Blast agitation | Concrete impact | All casing | Reverse | Earth drill | Chicago board | Pneumatic | Open | | |
| Ground requirements | Below support layer | Soft ground in the interlayer | | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | × | ○ | ○ | ○ | ○ |
| | | An extremely hard layer inside the inter layer | | ○ | × | △ | △ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | △ | ○ | ○ | △ | △ | ○ |
| | | Gravel in the interlayer | Gravel size 5 cm or below | ○ | △ | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | | | Gravel size 5 cm～10 cm | ○ | × | △ | △ | △ | △ | △ | △ | △ | △ | ○ | ○ | △ | ○ | ○ | ○ | △ | ○ |
| | | | Gravel size 10 cm～50 cm | ○ | × | × | × | × | × | × | × | × | × | △ | × | × | ○ | ○ | △ | × | △ |
| | | The layer has liquefiable ground | | △ | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Conditions of the support layer | Support layer depth | Below 5 m | ○ | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × | × |
| | | | 5～15 m | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | ○ | △ | △ |
| | | | 15～25 m | × | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | | | 25～40 m | × | × | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | ○ | ○ | ○ | ○ |
| | | | 40～60 m | × | × | △ | ○ | △ | △ | △ | ○ | ○ | ○ | △ | ○ | × | × | △ | ○ | ○ | ○ |
| | | | 60 m or above | × | × | × | △ | × | × | × | × | × | × | × | △ | × | × | × | △ | △ | △ |
| | | Soil properties of the support layer | Cohesivvve soil (20 N) | ○ | ○ | ○ | ○ | ○ | × | △ | ○ | × | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | | | Sand/ gravel (30 N) | ○ | ○ | ○ | ○ | ○ | ○ | × | ○ | ○ | × | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | | High gradient (30° or above) | | ○ | × | △ | ○ | △ | △ | △ | ○ | ○ | ○ | ○ | △ | △ | ○ | ○ | △ | △ | △ |
| | | The surface of the support layer is severely uneven | | ○ | △ | △ | ○ | △ | △ | △ | ○ | △ | △ | ○ | ○ | ○ | ○ | ○ | △ | △ | ○ |
| | Groundwater | Groundwater level is close to the ground surface | | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | ○ | ○ | ○ | ○ |
| | | Significant amount of spring water | | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | × | ○ | ○ | ○ | △ |
| | | Artesian groundwater 2 m above the ground surface | | × | ○ | ○ | ○ | × | × | × | × | × | × | × | × | × | × | △ | △ | ○ | × |
| | | Groundwater velocity is 3m/ min or above | | × | ○ | ○ | ○ | ○ | × | × | ○ | × | × | × | × | × | × | ○ | △ | ○ | × |
| Structural properties | Load size | Low vertical load (span length 20m or below) | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | × | △ | × | × |
| | | Moderate vertical load (span length 20m to 50m) | | ○ | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | | High vertical load (span length 50m) | | ○ | × | △ | ○ | △ | △ | △ | ○ | ○ | ○ | ○ | ○ | △ | ○ | ○ | ○ | ○ | ○ |
| | | Horizontal load is lower than vertical load | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | △ | △ | △ | △ |
| | | Horizontal load is higher than vertical load | | ○ | × | △ | ○ | △ | △ | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ |
| | Support type | | Support pile | | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | | | | |
| | | | Friction pile | | ○ | ○ | | | | | | | | ○ | ○ | ○ | | | | | |
| **Construction requirements** | Construction on water | | Water depth below 5m | ○ | ○ | ○ | ○ | △ | △ | △ | △ | △ | △ | × | ○ | △ | × | △ | △ | ○ | × |
| | | | Water depth 5m or above | × | △ | △ | ○ | △ | △ | △ | △ | △ | △ | × | △ | × | × | △ | △ | ○ | × |
| | Limited work space | | | ○ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | △ | ○ | △ | △ | × | △ |
| | Batter pile construction | | | | △ | ○ | ○ | × | × | × | △ | △ | △ | △ | × | × | × | | | | |
| | Effects of toxic gas | | | △ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | ○ | × | × | ○ | ○ | ○ |
| | Surrounding environment | Oscillation noise measures | | ○ | × | × | × | △ | ○ | ○ | △ | ○ | ○ | △ | ○ | ○ | ○ | ○ | ○ | △ | ○ |
| | | Effects on adjacent structures | | ○ | × | × | △ | △ | ○ | ○ | △ | ○ | ○ | ○ | ○ | ○ | △ | △ | △ | △ | ○ |

### 2-2-2-6-5 Study of the Revetment

#### (1) Structural Form

Rubble was used as the structural form of the revetment in order to achieve integrity with the revetment in front of the New FRA Bridge downstream that has already been planned.

As a result of a stability calculation on the rubble diameter for the flow velocity, it was confirmed that there would be no problems with the same specification on the downstream side (see table below).

Table2-2-26 Rubble Specifications

| Item | Value | Remarks |
|---|---|---|
| Rubble diameter | Upper layer 0.45m, lower layer 0.15m | |
| Upper layer thickness | Minimum 0.7m | 2 layers |
| Lower thickness | Minimum 0.25m | |
| Slope gradient | 1: 2.0 | |
| Slope foot completely flat width | 7.5m | |
| Slope gradient | 1: 2.0 | |

#### (2) Bridge Pier Foot Protection Structure

The bridge pier portion is subject to riverbed scouring from the bridge pier. In addition, because the coffering sheet pile is buried and there is a possibility that sheet pile is exposed from the riverbed and promotes scouring, foot protection shall be installed.

As a result of comparison with rubble, cage mat that excels in economic efficiency was adopted for the structure.

Table2-2-27 Cage Mat Specifications

| Item | Value | Remarks |
|---|---|---|
| Form | 3t-type | |
| Average grain size of filling material | 0.175m | 0.15m to 0.2m |
| Planar shape | 2.1m×2.1m | After laying |
| Thickness | 0.5m | After laying |
| Crest height | MSL-2.1m | Deepest riverbed height at the bridge location |

### 2-2-2-6-6 Study of Close Construction

Because the New Tamavua-i-wai Bridge will be constructed at the same position of the existing bridge that is currently in service, it will be construction at a location close to the NewFRA Bridge (for which service is planned to start before the removal of the existing bridge) that is being constructed downstream from the existing bridge by the Fiji government. Because the coffering (temporary steel pile) pulling work during substructure construction could have an detrimental effect on the New FRA Bridge, the

sheet pile on the side adjacent to the New FRA Bridge will be cut near the current ground (near the riverbed) and removed, and the underground portion will be left as is.

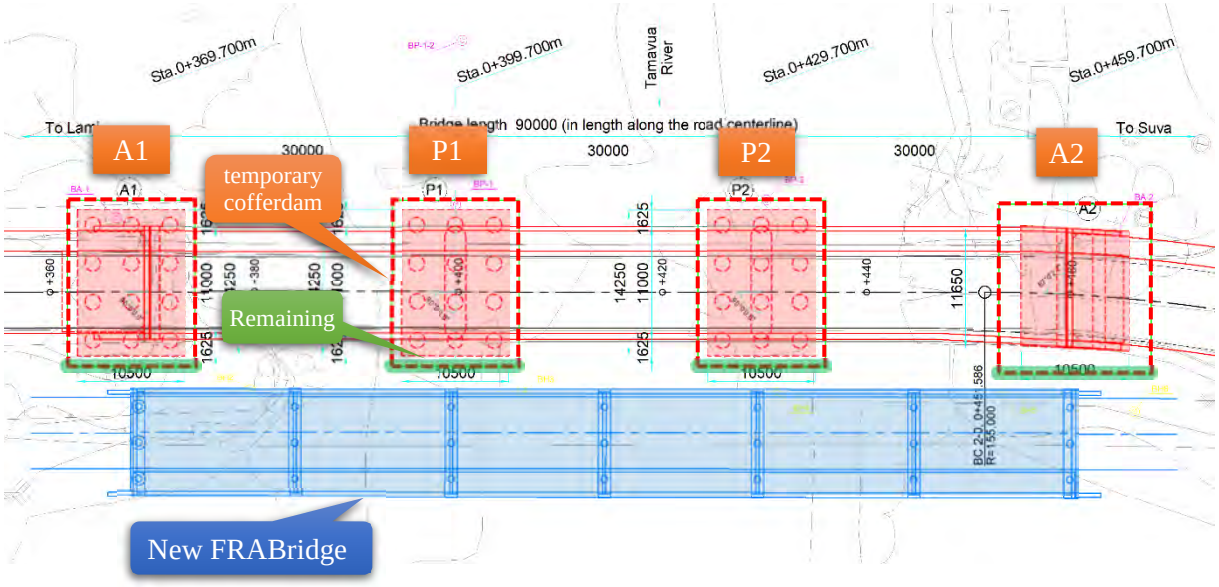


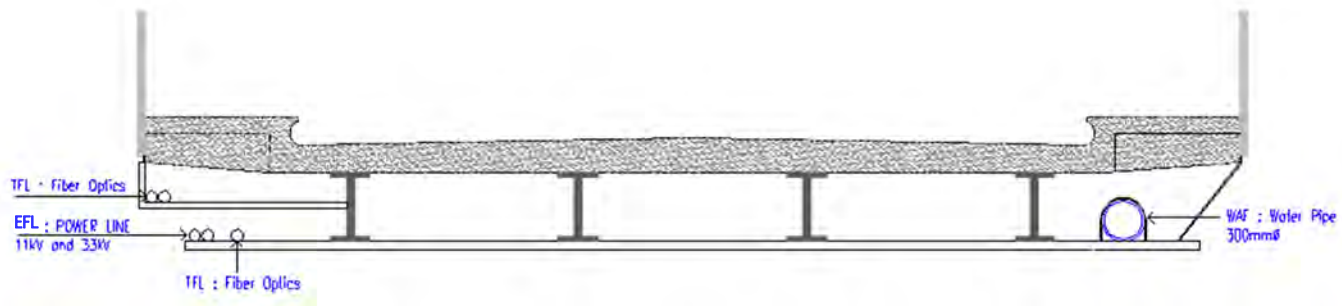

Figure 2-2-20 Study of Close Construction

### 2-2-2-6-7 Study of Responsibilities of the Recipient Country

#### (1) Survey on Existing Utilities

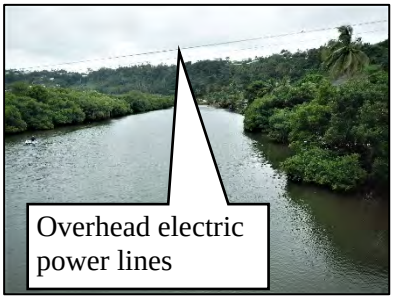
##### 1) Types and Locations of Utilities

Currently, there are water pipes, communication tubes, and high voltage electric power lines are attached to the existing Tamavua-i-wai Bridge. In addition, there are overhead electric power lines in the proximity.




High voltage electric power lines and communication tubes

Water pipes




Overhead electric power lines

The details and owners of water pipes, communication tubes, and high voltage electric power lines are as follows.

| | Owner | Number of attached lines | Details |
|---|---|---|---|
| Water pipes | WAF: Water Authority of Fiji | 1 | Diameter 300mm |
| High voltage electric power lines | EFL: Energy Fiji Limited | 2 | 11Kv (overhead power lines) and 33Kv (in the pipes attached to the existing bridge) |
| Communication tubes | TFL: Telecom Fiji Ltd | 3 | Optical fiber cable |

##### 2) Relocation Policy

It was confirmed that there are plans to relocate the utilities installed at the existing bridge to the New FRA Bridge that is being constructed by FRA on the downstream side. When the New Tamavua-i-wai Bridge is being constructed, removal or relocation of the utilities at the existing bridge will not occur. If there are wishes to attach new utilities to the New Tamavua-i-wai Bridge in the future, the contents of

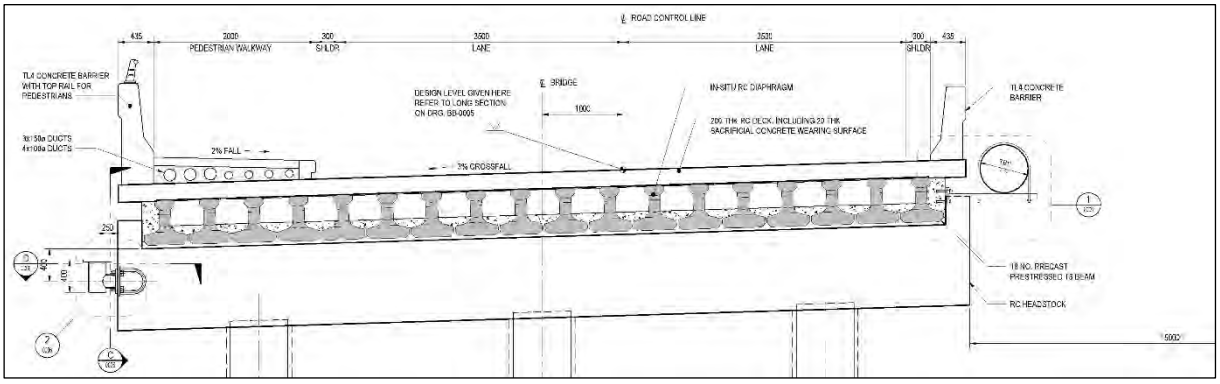
these attached utilities will be confirmed and consideration will be given to the design dead load at the time of detailed design as necessary. FRA will temporarily relocate overhead electric power lines and electricity poles about 10 m upstream of the road outside the construction area during the construction period, and restore them after the construction is completed.

It was confirmed that an order has been placed for both the design and build of the New FRA Bridge and that the tender documents have the following statements regarding utility relocation.

> Conduits shall be provided for utility services with provision of ducts and/or hangers for the following:
>
> - WAF services 3 x 300mmØ ducts including draw cords.
> - EFL services 3 x 150mmØ ducts including draw cords.
> - TFL services 4 x 100mmØ ducts including draw cords.
>
> Utility services (WAF, EFL, TFL) shall be relocated from the old bridge access road to the new bridge.

In addition, it was confirmed that the Design Report (2019-08-16) and design drawings prepared by the contractor for the New FRA Bridge contained the following statements.

> **3.1.8 Services**
>
> The following services will be accommodated in the bridge cross section, as per Principal's requirements:
>
> - 3 no. 150mm diameter and 4 no. 100mm diameter ducts – these will be provided below the footpath ~~in the gap between the T3 bridge beams underneath the pedestrian walkway.~~
> - 1 no. 600mm diameter watermain – this will be supported on the upstream side of the bridge, ~~potentially~~ by steel brackets fixed to the outside of the bridge ~~barriers~~.




**(2) Study on the Temporary Yard**

The area of the temporary yard shall be about 170m × 140m (including a main girder production yard with an area of about 120m × 10m and a stock yard with an area of about 105m × 25m). If this area

cannot be secured at one location, the area shall be secured through division into two locations. The site proposed for the temporary yard is shown in the figure below.

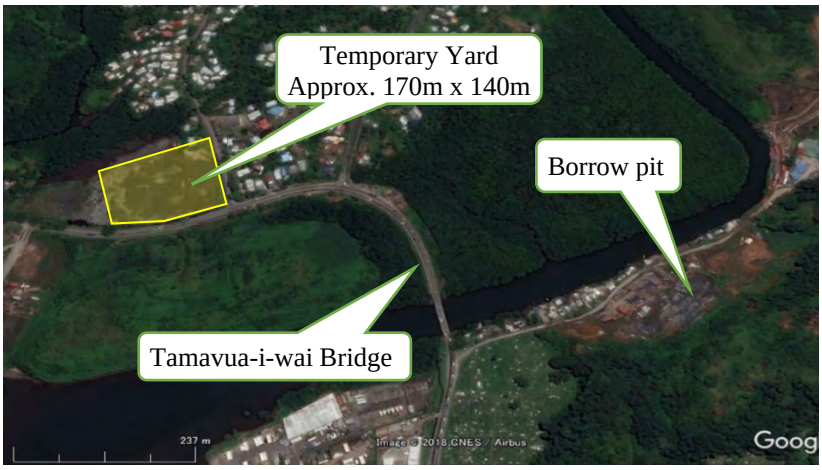



Figure2-2-21 Site Proposed for Temporary Yard and Borrow Pit

### (3) Study on Waste Disposal Site

The location of the Naboro Landfill that is the site proposed for the disposal of waste (including surplus soil) that is generated from construction is shown in the figure below.

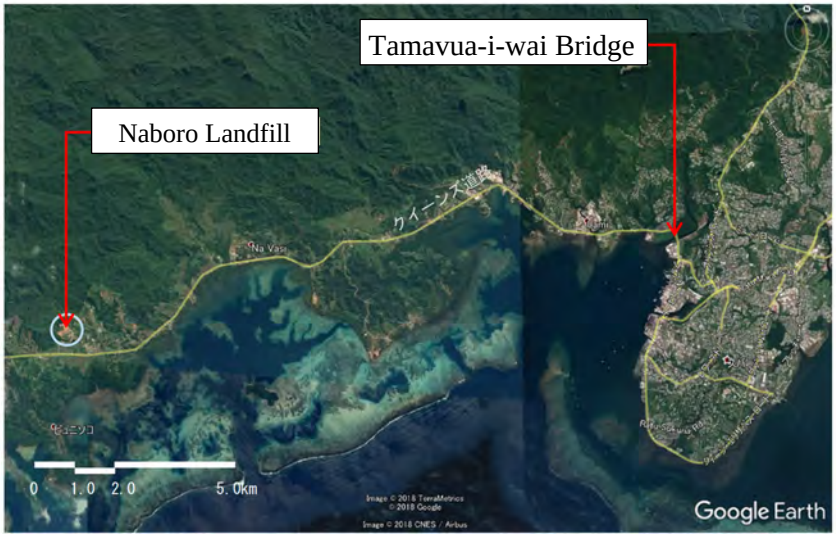



Figure2-2-22 Naboro Landfill

### (4) Tax Exemption Treatment

The taxes related to project implementation in Fiji are tariffs, value-added tax, corporate tax, and personal income tax. In the case of a grant aid project, these taxes are exempted through tax exemption procedures in advance.

The information pertaining to tax exemption is as follows. The Fiji Revenue & Customs Service (FRCS) shall conduct the tax exemption procedures with the endorsement by the Ministry of Economy.

#### 1) Customs Duties

It is necessary to pay customs duties when equipment and materials procured from outside Fiji are imported. However, customs duties will be exempted when tax exemption procedures are conducted.

When the project is started, the master list of equipment and materials will be endorsed for its exemption by the Ministry of Economy through FRA, and submitted to the Fiji Revenue & Customs Service (FRCS) for the further approval. Approved equipment and materials can be imported tax-free.

#### 2) Value-added tax (VAT)

There is a value-added tax of 9% on products and services purchased in Fiji.

Value-added tax that includes purchases of equipment and materials and payments to subcontractors in Fiji can be exempted through the receipt of a refund after conducting the refund process with the Fiji Revenue & Customs Service (FRCS). Because a TIN (tax identification number) is necessary for the refund procedures, prior registration of TIN is required.

Refund applications are conducted on a monthly basis for VAT paid for the project. Typically, the refund is paid in about two to three weeks after an application.

#### 3) Corporate Tax

Corporate tax is exempt.

#### 4) Personal Income Tax

The personal income tax of people from Japan and third countries is exempt.

### (5) Acquisition of Construction Permits

FRA will obtain construction permits. Other permits that are required during the construction period will be acquired by FRA or the construction company under the cooperation of FRA.

### (6) Details and Implementation Deadlines for the Responsibilities

The details and implementation deadlines for the responsibilities of Fiji are shown in the table below.

Table2-2-21 Details and Implementation Deadlines for the Responsibilities of Fiji

| Responsibility | | Details | Implementation deadline |
|---|---|---|---|
| 1 | Provision and clearing of a temporary yard and land grading | • FRA shall specify the most appropriate location from the site proposed in Figure2-2-22 or an available location proposed by FRA by the time of the DF/R explanation (late March 2020).<br>• The area of the temporary yard shall be about 170m × 140m (including a main girder production yard with an area of about 120m × 10m and a stock yard with an area of about 105m × 25m). If this area cannot be secured at one location, the area shall be secured through division into two locations. | By P/Q public notice |
| 2 | Selection of borrow pits | • FRA shall specify the most appropriate location from the site proposed in Figure2-2-22 or an available location proposed by FRA by the time of the DF/R explanation (late March 2020).<br>• If the proposed site is limited land owned by a private company, FRA will provide appropriate support so that it can be used in construction. | By P/Q public notice |
| 3 | Provision of soil dumping ground | • Because the surplus soil generated from construction will be limited, it will be disposed in the same manner as the waste below. | By P/Q public notice |
| 4 | Provision of waste disposal site | • Based on the assumption that the waste (including surplus soil) that is generated from construction will be disposed at the Naboro Landfill (Figure2-2-23) that it located approx. 15km from the Tamavua-i-wai Bridge, support will be provided to the construction company for the submission of the required registration and application documents to the Ministry of Environment.<br>• For the disposal of liquid industrial waste such as waste oil that cannot be accepted at the Naboro Landfill, FRA will provide support for appropriate disposal, including the introduction of a registered disposal vendor. | Immediately after start of construction |
| 5 | Land acquisition and resettlement of residents | • FRA shall reliably implement the acquisition of land, the resettlement of residents, and the removal of buildings and structures after resettlement required for the bridge reconstruction work and the work to convert the approach road into a 4-lane road.<br>• FRA shall take the necessary measures to prevent illegal use including the inflow of residents after land acquisition and the resettlement of residents. | Land acquisition and resettlement of residents: By P/Q public notice<br>Removal of structures: Before start of construction |
| 6 | Utility relocation | • The water pipes, communication tubes, and high voltage electric power lines attached to the existing bridge shall all be relocated to the New FRA Bridge during construction by FRA. | After the completion of the FRA bridge, by the start of existing bridge removal |
| | | • FRA shall relocate the existing utility poles and high voltage electric power lines (overhead electric power lines) that would interfere with construction outside of the construction area. | By P/Q public notice |

| Responsibility | | Details | Implementation deadline |
|---|---|---|---|
| 7 | Removal of existing bridge | • FRA shall remove the existing bridge by the start of construction. However, the abutments on both sides (2 units) shall be removed by Japan, and FRA will only leave the abutments in place. | By P/Q public notice (after the completion of the FRA bridge) |
| 8 | Conversion of the approach roads into a 4-lane road | • FRA shall convert the approach roads into a 4-lane road by the start of construction. | By P/Q public notice (by FRA bridge construction or after completion of FRA bridge) |
| 9 | Procedures related to environmental and social considerations | • FRA shall submit the screening application and EIA processing application required for procedures related to environmental and social considerations, and received approval of the environmental impact assessment (EIA) report on the business from the Ministry of Environment. Note that FRA shall be responsible for the costs related to these applications. | Screening application: Initial stage of the survey<br>EIA processing application and EIA report approval: By P/Q public notice |
| 10 | Tax exemption | • Tariffs: The FRA shall submit the master list of equipment and materials to be imported created by the construction contractor to the FRCS (Fiji Revenue & Customs Service) for approval with its endorsement by the Ministry of Economy. | Start of project |
| | | • VAT (value added tax): FRA and the Ministry of Infrastructure and Meteorological Services shall support for submission of the refund application to the FRCS (Fiji Revenue & Customs Service) and provide appropriate support so that the refund payment by FRCS is reliably received. | Application once per month |
| 11 | Acquisition of various permits | • FRA shall provide appropriate support so that the following procedures are reliably implemented.<br>1) Acquisition of the TIN (tax identification number) (Fiji Revenue and Custom Service)<br>2) Acquisition of work permits (Department of Immigration) | Immediately after start of construction |
| | | • FRA shall acquire the required construction permits before the start of construction. | By P/Q public notice |
| | | • The construction contractor shall acquire the required construction permits during the construction period. FRA shall provide appropriate support for the acquisition of various construction permits by the construction contractor. | During the construction period |
| 12 | Maintenance and management | • Conduct maintenance management for the bridge and approach roads after completion based on the survey team's maintenance management plan. | After the end of construction |

### 2-2-2-6-8 Study on the approach road

#### (1) Study policy

During the study on the approach roads, an alignment study was conducted in anticipation of the 4-lane road vision in FRA's future plan, including consideration to the alignment on the FRA side so that there would be no reworks on the bridge portion at the time of future widening, while communicating the concept to FRA, providing the alignment (proposal), and holding discussions on the current necessity of converting the road section on the Suva side into to a 4-lane road.

There is a cemetery on the hillside upstream on the Suva side of the target bridge. Because the current boundary is right next to the cemetery, the policy is to control the boundary with the cemetery and ensure that there is no impact when it is converted into a 4-lane road in the future.

In addition, for construction, an alignment study was conducted under assuming the condition that the bridge developed by FRA was already in service, and also assuming the condition that the substructure of the existing bridge was removed.

Although the river crossing section will be a 4-lane road at the time of completion (2-lanes for 1 direction x 2) along with the New FRA Bridge, because there is the possibility of a 2-lane road being used on the Lami side for the time being, an alignment and width plan was made while taking into consideration an appropriate runoff section (1/40×3.5m) for the change in the number of lanes (from 2 lanes to 1 lane).

For intersections, although no large-scale has been planned, a right-hand turn lane will be established and partial modifications to winding sections in consideration of smooth intersection management.

For existing bus stops, sufficient width will be secured so that they can be set in the same locations as much as possible, based on the general rule of compensation function.

Table2-2-22 Facility Size Study Policy

| Road structures and attached facilities | Facility size |
|---|---|
| Drainage facilities | • Standard rainfall recurrence: Channels and gutters (5 years), road crossing pipe culvert (10 years)<br>• Design rainfall intensity: 200mm/h (continuous rainfall duration of less than 15 minutes)<br>• In light of the fact that the target road is an important arterial road, the road crossing pipe culvert shall have a minimum diameter of 0.8m in consideration of maintenance and management. |
| Traffic safety facilities | • Guard fences will be installed on sections with a difference in height from the current ground.<br>• Road signs and road marking based on standards in Fiji and Australia will be installed. |
| Bus bay | The shape of the existing bus bay in the bus stop lane and the acceleration and deceleration lane (15m+15m+15m, W=3.0m) will be followed as a general rule. |
| Disability measures | • Secure a width of 2.0 m for the bridge and approach roads so that wheelchairs (occupied width 1.0 m) can pass each other.<br>• The sidewalk of the approach roads has a mount-up structure to eliminate the level difference with the sidewalk of the bridge.<br>• A fall prevention fence (height: 1.1 m) will be installed on the embankment.<br>• The slope of the approach roads should be 1/12 or less. |

### (2) Pavement design

#### 1) Basic policy for pavement design

The basic matters related to pavement design are shown in the table below.

Table 2-2-23 Basic Matters Related to Pavement Design

| Item | Application | Remarks |
|---|---|---|
| Standards followed | Austroads | Pavement Structural Design 2012 |
| Type of pavement | Flexible pavement | Standard specifications for major arterial roads in Fiji |
| Design period | 20 years | Asphalt concrete pavement |
| Reliability | 90% | Major roads in urban areas with high traffic volume |
| Roadbed design CBR | 8 | The CBR test values sampled from 3 locations were 13% (Lami side), 8% (Suva side), and 9% (borrow pits). As the design target CBR, the CBR was set at 8% to be on the safe side. |
| Design target vehicles | Heavy vehicles (including medium-sized freight vehicles) | For pavement design, large and medium-sized freight vehicles that pass over the target bridge were selected as the design target vehicles.<br>*Reason: Because trailers also pass over the Tamavua-i-wai Bridge between the Suva Harbor and container yard. |
| Modified asphalt | DS value (dynamic stability) | The target DS calculated from future traffic volume and weather conditions at the design location was 850 times/mm. Since the DS value of straight asphalt is generally set to about 800 times/mm, the modified asphalt will not be used this time, and the plan will be conducted using straight asphalt. |

Source: JICA Study Team

**2) Calculation of dynamic stability**

DS=0.679（Y･T･W･V･Ct / D）

where

DS : Target dynamic stability（times/mm）

Y : Service period（day）=7,300（Pavement design period:20 years）

T : Large vehicle traffic (vehicle/day/direction)=1,143（20-year average）

W : Wheel load correction coefficient（Table 1）=1.0（Large vehicle mixture rate）

V : Travel speed correction coefficient（Table 2）=0.4（General part）

Ct : Temperature correction coefficient（Figure 1）=1.5E-02（Fiji's monthly average maximum temperature (31.7℃, February ; Preparatory Survey Report) is the same as Tokyo（31.0℃, August ; JMA observation data））

D : Rut amount（mm）=40（Ministry of Land, Infrastructure, Transport and Tourism control level）

Table 1 Wheel load correction coefficient

| Classification | Correction coefficient W |
|---|---|
| Few heavy vehicles | 1.0 |
| Many heavy vehicles | 2.0 |
| Very many heavy vehicles | 3.0 |

Table 2 Travel speed correction coefficient

| Category | Correction coefficient V |
|---|---|
| General part | 0.4 |
| Intersection | 0.9 |

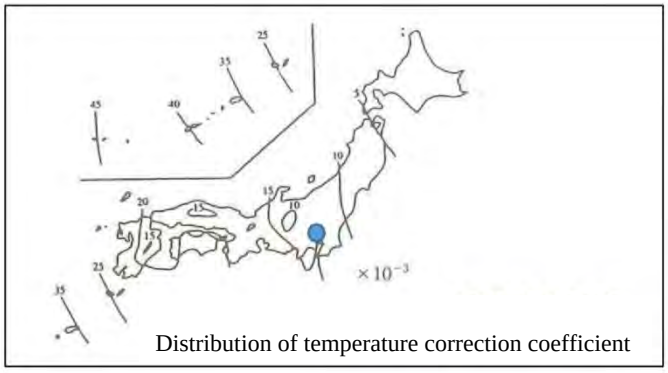



Figure 1 Temperature correction coefficient (Japan)

DS=0.679（Y･T･W･V･Ct / D）=850（times/mm）

（The dynamic stability of straight asphalt is about 800 times/mm. Therefore, 850 times/mm is the target dynamic stability that can be handled with straight asphalt.）

### 3) Pavement structure

As a result of a study including the pavement structure and traffic volume survey results for the road plan by FRA, the pavement structure in the table below shall be the standard.

Table 2-2-31 Pavement Configuration

| Layer configuration | Pavement thickness | Specifications |
|---|---|---|
| Surface layer | 5 cm | Heated asphalt concrete |
| Base layer | 6 cm | Heated asphalt concrete |
| Upper subbase | 25 cm | Cement stabilization roadbed |
| Lower subbase | 25 cm | Crusher-run |

Source: JICA Study Team

### 1) Cumulative number of heavy vehicles axles

The estimate for the cumulative number of heavy vehicles axles ($N_{DT}$) that pass over the design target bridge during the design period was calculated using the formula below.

The traffic volume estimation results for the cumulative traffic volume in the pavement design period of 20 years is shown in the table below.

$$N_{DT} = 8.3 \times 10^6 \times N_{HVAG}$$

$$N_{DT} = 40.7 \times 10^6$$

Table2-2-24 Estimated Future Traffic Volume

(Vehicle/Year)

| | Year | Passenger Cars | Taxies | Mini-Buses (14 seats <) | Pickups/Panels/Vans | Buses | Light Trucks | Heavy Truck | Trailer | Multi Trailer | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 1,962,707 | 988,534 | 137,220 | 680,512 | 123,855 | 27,235 | 315,782 | 52,648 | 10,300 | 3,907,993 |
| OD | 2019 | 2,065,805 | 1,016,703 | 143,298 | 685,048 | 129,342 | 27,417 | 317,887 | 52,999 | 10,368 | 4,044,423 |
| DD | 2020 | 2,174,318 | 1,045,674 | 149,646 | 689,614 | 135,071 | 27,600 | 320,005 | 53,352 | 10,437 | 4,187,016 |
| CS | 2021 | 2,288,531 | 1,075,472 | 156,275 | 694,210 | 141,054 | 27,784 | 322,138 | 53,708 | 10,507 | 4,336,072 |
| CS | 2022 | 2,408,743 | 1,106,118 | 163,197 | 698,838 | 147,302 | 27,969 | 324,286 | 54,066 | 10,577 | 4,491,906 |
| 1 | 2023 | 2,535,270 | 1,137,638 | 170,426 | 703,496 | 153,828 | 28,155 | 326,447 | 54,426 | 10,648 | 4,654,849 |
| 2 | 2024 | 2,668,443 | 1,170,056 | 177,976 | 708,185 | 160,642 | 28,343 | 328,623 | 54,789 | 10,719 | 4,825,250 |
| 3 | 2025 | 2,808,612 | 1,203,397 | 185,860 | 712,905 | 167,758 | 28,532 | 330,813 | 55,154 | 10,790 | 5,003,474 |
| 4 | 2026 | 2,956,143 | 1,237,689 | 194,093 | 717,657 | 175,189 | 28,722 | 333,018 | 55,522 | 10,862 | 5,189,904 |
| 5 | 2027 | 3,111,424 | 1,272,958 | 202,690 | 722,440 | 182,949 | 28,913 | 335,238 | 55,892 | 10,934 | 5,384,945 |
| 6 | 2028 | 3,274,862 | 1,309,232 | 211,669 | 727,256 | 191,053 | 29,106 | 337,473 | 56,265 | 11,007 | 5,589,020 |
| 7 | 2029 | 3,446,885 | 1,346,539 | 221,045 | 732,103 | 199,516 | 29,300 | 339,722 | 56,640 | 11,081 | 5,802,574 |
| 8 | 2030 | 3,627,944 | 1,384,910 | 230,837 | 736,983 | 208,354 | 29,495 | 341,986 | 57,017 | 11,154 | 6,026,073 |
| 9 | 2031 | 3,818,513 | 1,424,374 | 241,062 | 741,895 | 217,584 | 29,692 | 344,266 | 57,397 | 11,229 | 6,260,011 |
| 10 | 2032 | 4,019,093 | 1,464,963 | 251,740 | 746,840 | 227,222 | 29,890 | 346,561 | 57,780 | 11,304 | 6,504,902 |
| 11 | 2033 | 4,230,209 | 1,506,708 | 262,892 | 751,818 | 237,287 | 30,089 | 348,871 | 58,165 | 11,379 | 6,761,288 |
| 12 | 2034 | 4,452,414 | 1,549,642 | 274,537 | 756,830 | 247,798 | 30,290 | 351,196 | 58,553 | 11,455 | 7,029,740 |
| 13 | 2035 | 4,686,291 | 1,593,801 | 286,698 | 761,874 | 258,775 | 30,492 | 353,537 | 58,943 | 11,531 | 7,310,856 |
| 14 | 2036 | 4,932,454 | 1,639,217 | 299,398 | 766,952 | 270,238 | 30,695 | 355,893 | 59,336 | 11,608 | 7,605,265 |
| 15 | 2037 | 5,191,547 | 1,685,928 | 312,660 | 772,064 | 282,208 | 30,899 | 358,265 | 59,731 | 11,685 | 7,913,627 |
| 16 | 2038 | 5,464,250 | 1,733,970 | 326,510 | 777,211 | 294,709 | 31,105 | 360,653 | 60,129 | 11,763 | 8,236,638 |
| 17 | 2039 | 5,751,277 | 1,783,381 | 340,974 | 782,391 | 307,764 | 31,313 | 363,057 | 60,530 | 11,842 | 8,575,026 |
| 18 | 2040 | 6,053,382 | 1,834,199 | 356,078 | 787,606 | 321,397 | 31,521 | 365,477 | 60,934 | 11,921 | 8,929,559 |
| 19 | 2041 | 6,371,355 | 1,886,466 | 371,851 | 792,856 | 335,634 | 31,732 | 367,913 | 61,340 | 12,000 | 9,301,043 |
| 20 | 2042 | 6,706,031 | 1,940,222 | 388,323 | 798,140 | 350,502 | 31,943 | 370,366 | 61,749 | 12,080 | 9,690,324 |
| | | | | | | | 20-year total | 6,959,376 | 1,160,292 | 226,991 | |
| | | | | | | | | 8.3.E+06 | | | |

Source: JICA Study Team

For the average number of axles per heavy vehicles, all of the heavy vehicles axles sampled were classified into five axle groups, and the ratio of the total number of axle group types (single axle with single tires (SAST) and tandem axle with single tires (TAST)) that could be steering axles to all axles was calculated. Looking at the results of the axle load survey (30 vehicles, 148 axles) conducted for this survey, the ratio of the total number of SAST and TAST to all axles is 0.2027. Therefore, the number of axles per heavy vehicle can be calculated as 1/0.2027=4.9.

**2) Heavy vehicle traffic load distribution**

The traffic load distribution by axle group and axle load based on the results of the axle load survey conducted for this survey.

Note that the five types of axle groups are as follows.

- SAST: Single axle with single tyres
- SADT: Single axle with dual tyres
- TAST: Tandem axle with single tyres
- TADT: Tandem axle with dual tyres
- TRDT: Triaxle with dual tyres

Table2-2-33 Traffic Load Distribution by Axle Group and Axle Load

| Axle group / Axle load (KN) | SAST | SADT | TAST | TADT | TRDT |
|---|---|---|---|---|---|
| 30 | | | | | 0.027586 |
| 40 | 0.013793 | | | 0.041379 | 0.013793 |
| 50 | 0.096552 | 0.006897 | | 0.034483 | 0.006897 |
| 60 | 0.082759 | 0.013793 | | 0.062069 | 0.000000 |
| 70 | 0.020690 | | | 0.075862 | 0.013793 |
| 80 | | | | 0.082759 | 0.041379 |
| 90 | | | | 0.089655 | 0.034483 |
| 100 | | | | 0.068966 | 0.041379 |
| 110 | | | | 0.041379 | 0.013793 |
| 120 | | | | 0.027586 | 0.013793 |
| 130 | | | | 0.020690 | 0.006897 |
| 140 | | | | | |
| 150 | | | | | |
| 160 | | | | | |
| 170 | | | | | 0.006897 |
| Vehicle group composition | 0.2138 | 0.0207 | 0.0000 | 0.5448 | 0.2207 |

Source: JICA Study Team

### 3) Number of standard axle repetitions per equivalent standard axle

The number of standard axle repetitions (number of times standard axles have passed) is calculated through the following formula.

$$SARm_{ij} = \left(\frac{L_{ij}}{SL_i}\right)^m$$

Here:

$SARm_{ij}$: Number of standard axle repetitions that cause equivalent damage as when a load ($L_{ij}$) for the number (j) of axle group types (i) in the damage index (m) s (number of times standard axles have passed)

$Sl_i$: Standard load for axle group type i

$L_{ij}$: Load for j number of axle group type i

m: Damage index corresponding to damage type

Table2-2-34 Standard Load for Each Axle Group Type

| Axle group type | Tire width | Load (kN) |
|---|---|---|
| SADT | No provisions | 80 |
| TADT | No provisions | 135 |
| TRDT | No provisions | 181 |
| SAST | Less than 375mmm<br>375mm or more, less than 450mm<br>450mm or more | 53<br>58<br>71 |
| TAST | Less than 375mmm<br>375mm or more, less than 450mm<br>450mm or more | 90<br>98<br>120 |

Source: Austroads

The damage index for each damage type calculated by multiplying the heavy vehicle traffic load distribution based on the results of the axle load survey (see Table2-2-33 Traffic Load Distribution by Axle Group and Axle Load) by $SARm_{ij}$ (see Austroads) is shown in the table below.

Table2-2-25 Pavement Damage Index from Number of Standard Axle Repetitions Per Equivalent Standard Axle

| Damage type | Damage index (m) | Damage indicator | Damage indicator calculated value |
|---|---|---|---|
| Overall pavement damage (thin layer pavement | 4 | ESA/HVAG | 0.43 |
| Asphalt fatigue | 5 | SAR5/HVAG | 0.41 |
| Rut or road surface damage (permanent deformation) | 7 | SAR7/HVAG | 0.47 |
| Cement stabilization material fatigue | 12 | SAR12/HVAG | 1.03 |

Note: Equivalent Standard Axle (ESA), Standard Axle Repetitions (SAR), Heavy Vehicle Axle Group (HVAG)
Source: JICA Study Team

Based on the table above, the average number of standard axle repetitions (SAR) per equivalent standard axle (ESA) is as follows.

- Asphalt fatigue: SAR5/ESA=0.41/0.43=0.95
- Permanent deformation: SAR7/ESA=0.47/0.43=1.09

### 4) Number of design standard axle repetitions

The number of design equivalent standard axles (DESA) and the number of design standard axle repetitions (DSAR5 and DSAR7) are as follows.

- $DESA=ESA/HVAG\times N_{DT} = 0.43\times 40.7\times 10^6 = 17.5\times 10^6$
- $DSAR5 \text{ (asphalt fatigue)} = SAR5/ESA\times DESA = 0.95\times 17.5\times 10^6 = 16.6\times 10^6$
- $DSAR7 \text{ (permanent deformation)} = SAR7/ESA\times DESA = 1.09\times 17.5\times 10^6 = 19.1\times 10^6$

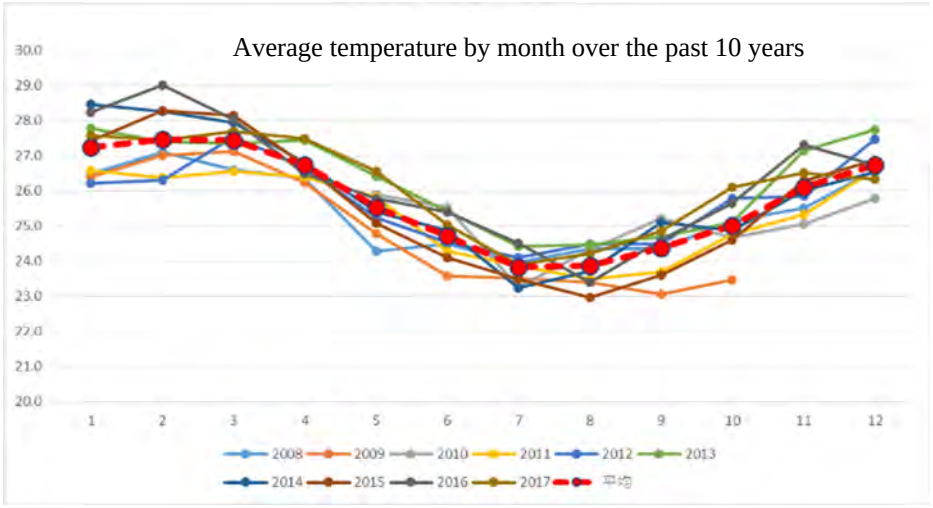
### 5) Study on fatigue fractures

The pavement temperature for each month near the target bridge was set based on an estimation formula based on the average temperature for each month for the past 10 years, and the elastic coefficient was calculated as follows.

Table2-2-26 Average Temperature for Each Month Observed by the Suva Weather Station (2008-2017)

| Month | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 26.5 | 26.4 | | 26.6 | 26.2 | 27.8 | 28.5 | 27.4 | 28.2 | 27.6 | 27.2 |
| 2 | 27.1 | 27.0 | | 26.4 | 26.3 | 27.4 | 28.3 | 28.3 | 29.0 | 27.5 | 27.5 |
| 3 | 26.6 | 27.1 | | 26.6 | 27.5 | 27.4 | 27.9 | 28.2 | 28.0 | 27.7 | 27.4 |
| 4 | 26.3 | 26.3 | | 26.4 | 26.7 | 27.4 | 26.8 | 26.8 | 26.5 | 27.5 | 26.7 |
| 5 | 24.3 | 24.8 | 25.9 | 25.8 | 25.2 | 26.4 | 25.4 | 25.1 | 25.8 | 26.6 | 25.5 |
| 6 | 24.5 | 23.6 | 25.5 | 24.3 | 24.5 | 25.4 | 24.9 | 24.1 | 25.4 | 25.0 | 24.7 |
| 7 | 24.0 | 23.5 | 23.3 | 23.9 | 24.1 | 24.4 | 23.2 | 23.5 | 24.5 | 23.9 | 23.8 |
| 8 | 24.3 | 23.4 | 24.3 | 23.5 | 24.5 | 24.5 | 23.7 | 23.0 | 23.4 | 24.2 | 23.9 |
| 9 | 24.4 | 23.1 | 25.2 | 23.7 | 24.5 | 24.7 | 25.1 | 23.6 | 24.6 | 24.9 | 24.4 |
| 10 | 25.1 | 23.5 | 24.7 | 24.8 | 25.8 | 25.1 | 24.9 | 24.6 | 25.7 | 26.1 | 25.0 |
| 11 | 25.5 | | 25.1 | 25.3 | 25.9 | 27.1 | 26.0 | 26.3 | 27.3 | 26.5 | 26.1 |
| 12 | 26.6 | | 25.8 | 26.6 | 27.5 | 27.7 | 26.5 | 26.9 | 26.7 | 26.3 | 26.7 |

Source: Calculated by survey team based on meteorological data from the Suva Weather Station




Source: JICA Study Team

Figure 2-2-23 Average Temperature for Each Month Observed by the Suva Weather Observation

## Table2-2-37 Pavement Materials Elastic Coefficient for Each Month

Calculation of elastic coefficient by month

| | Average temperature | Pavement average temperature Mp | | Elastic coefficient | | | | | Poisson's ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Asphalt mixture | Asphalt stabilization | Asphalt mixture | Asphalt mixture | Upper subbase (cement stabilization) | Lower subbase (crusher-run) | Subgrade | Each layer of pavement | Roadbed (cement stabilization) | Subgrade |
| | Ma | z= 3.67 | z= 19.33 | MPa | MPa | MPa | MPa | MPa | | | |
| Jan | 27.2 | 35 | 33 | 1,595 | 1,900 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Feb | 27.5 | 36 | 33 | 1,480 | 1,900 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Mar | 27.4 | 36 | 33 | 1,480 | 1,900 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Apr | 26.7 | 35 | 32 | 1,595 | 2,005 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| May | 25.5 | 33 | 31 | 1,900 | 2,230 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Jun | 24.7 | 32 | 30 | 2,005 | 2,300 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Jul | 23.8 | 31 | 29 | 2,230 | 2,560 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Aug | 23.9 | 31 | 29 | 2,230 | 2,560 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Sep | 24.4 | 32 | 30 | 2,005 | 2,300 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Oct | 25.0 | 33 | 30 | 1,900 | 2,300 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Nov | 26.1 | 34 | 32 | 1,710 | 2,005 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Dec | 26.7 | 35 | 32 | 1,595 | 2,005 | 1000 | 200 | 80 | 0.35 | 0.20 | 0.40 |
| Suva observation data (2008-2017) | | | | | | | | 10*CBR | | | |
| | | From the following formula | From the following formula | Average in the table below | | | From (5.3.1) | CBR=8% | | | |
| Pavement thickness | | 11 | 25 | | | | | Suva side | | | |

General formula for temperature relationship between the temperature and asphalt mixture layer

$$Mp=Ma(1+2.54/(z+10.16)) - 25.4/(9(z+10.16)) + 10/3$$

| Pavement average temperature Dav | Elastic modulus min | Elastic modulus max | Average MPa |
|---|---|---|---|
| 28 | 700 | 5000 | 2850 |
| 29 | 620 | 4500 | 2560 |
| 30 | 600 | 4000 | 2300 |
| 31 | 560 | 3900 | 2230 |
| 32 | 510 | 3500 | 2005 |
| 33 | 500 | 3300 | 1900 |
| 34 | 420 | 3000 | 1710 |
| 35 | 390 | 2800 | 1595 |
| 36 | 360 | 2600 | 1480 |
| 37 | 320 | 2500 | 1410 |
| 38 | 300 | 2200 | 1250 |
| 39 | 290 | 2000 | 1145 |
| 40 | 280 | 1900 | 1090 |

Read from Pavement Design Handbook p.118, Figure 5.3.5 Asphalt Mixture Elastic Coefficient Graph

Source: JICA Study Team

The appropriateness of the pavement structure was studied by using the pavement materials elastic coefficient calculated for each month to calculate the allowable fatigue fracture axle count for the asphalt mixture and the allowable fatigue fracture axle count for the road surface using a games analysis, and comparing that with the number of design standard axle repetitions applied to the pavement by vehicles passing over the target road section.

The results of this study indicate that, as shown on the next page, the number of design standard axle repetitions for the asphalt mixture and the road surface both fall below the allowable value, so the pavement structure has durability to fatigue fractures.

Table2-2-38 Study on Fatigue Fractures

| Month | Damage count of asphalt mixture | | | | Damage count of subgrade | | | | Mechanical assessment of pavement cross section |
|---|---|---|---|---|---|---|---|---|---|
| | Tensile strain $\varepsilon_t(*10^{-6})$ | Allowable number of 9kip axles $N_{fa}$ | Damage from one passage by a 9kip wheel load Da | Damage count $N_{fad}$ | Compression strain $\varepsilon_s(*10^{-6})$ | Allowable number of 9kip axles $N_{fs}$ | Damage from one passage by a 9kip wheel load Ds | Damage count Nfsd | |
| Jan | 54.9 | 7,118,810,737 | 2.688.E−10 | 3.720.E+09 | 214.0 | 83,073,615 | 1.135.E−08 | 8.808.E+07 | $(N_{fad}/\gamma_R) > N$<br>$(N_{fsd}/\gamma_R) > N$<br>$N=63.5\times10^6$<br>$\gamma_R=4$<br>$(N_{fad}/\gamma_R)=929.98\times10^6$<br>$(N_{fsd}/\gamma_R)=22.02\times10^6$ |
| Feb | 52.7 | 8,496,025,494 | | | 216.0 | 80,287,858 | | | |
| Mar | 52.7 | 8,496,025,494 | | | 216.0 | 80,287,858 | | | |
| Apr | 54.9 | 6,197,236,025 | | | 214.0 | 83,073,615 | | | |
| May | 59.2 | 3,400,380,215 | | | 209.0 | 90,596,313 | | | |
| Jun | 60.3 | 2,899,716,219 | | | 207.0 | 93,847,410 | | | |
| Jul | 62.2 | 1,924,038,834 | | | 204.0 | 99,007,840 | | | |
| Aug | 62.2 | 1,924,038,834 | | | 204.0 | 99,007,840 | | | |
| Sep | 60.3 | 2,899,716,219 | | | 207.0 | 93,847,410 | | | |
| Oct | 59.2 | 3,140,013,288 | | | 209.0 | 90,596,313 | | | |
| Nov | 56.7 | 5,390,269,354 | | | 212.0 | 85,983,563 | | | |
| Dec | 54.9 | 6,197,236,025 | | | 214.0 | 83,073,615 | | | |

| | |
|---|---|
| Reliability | 90% |
| Coefficient | 4 |

Coefficient for damage count/reliability

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 3.720.E+09 / 4 | | | | 8.808.E+07 / 4 | | | |
| = | 9.300.E+08 | | | | 2.202.E+07 | | | |
| = | $929.98\times10^6$ | > | $16.6\times10^6$ | OK | $22.02\times10^6$ | > | $19.1\times10^6$ | OK |
| | | | Design axle count | | | | Design axle count | |

Input conditions table

| | | | | | |
|---|---|---|---|---|---|
| $N_{fa}$ | | Allowable number of 9kip axles | $N_{fs}$ | | Allowable number of 9kip axles |
| C | 0.235 | Parameters for the volumetric properties of mixture used in lowest layer of asphalt mixture layer | $\varepsilon_s$ | Table above | Compression strain of surface of subgrade (calculated through GAMES) |
| M | −0.6292 | | $\beta_{s1}$ | 2134 | |
| VFA | 56.0 | Degree of saturation (%) | $\beta_{s2}$ | 0.819 | |
| $\varepsilon_t$ | Table above | Tensile strain in asphalt mixture layer lower surface (calculated through GAMES) | | | |
| E | From the previous page | Elastic coefficient of mixture used in lowest layer of asphalt mixture layer (Mpa) | | | |
| $\beta_{a1}$ | 52,290 | Correction factor for AI destruction standard | | | |
| $K_a$ | 1.000 | Appended figure 5.4.4 | | | |
| $\beta_{a1}'$ | 52,290 | | | | |
| $\beta_{a2}$ | 1.314 | | | | |
| $\beta_{a3}$ | 3.018 | | | | |

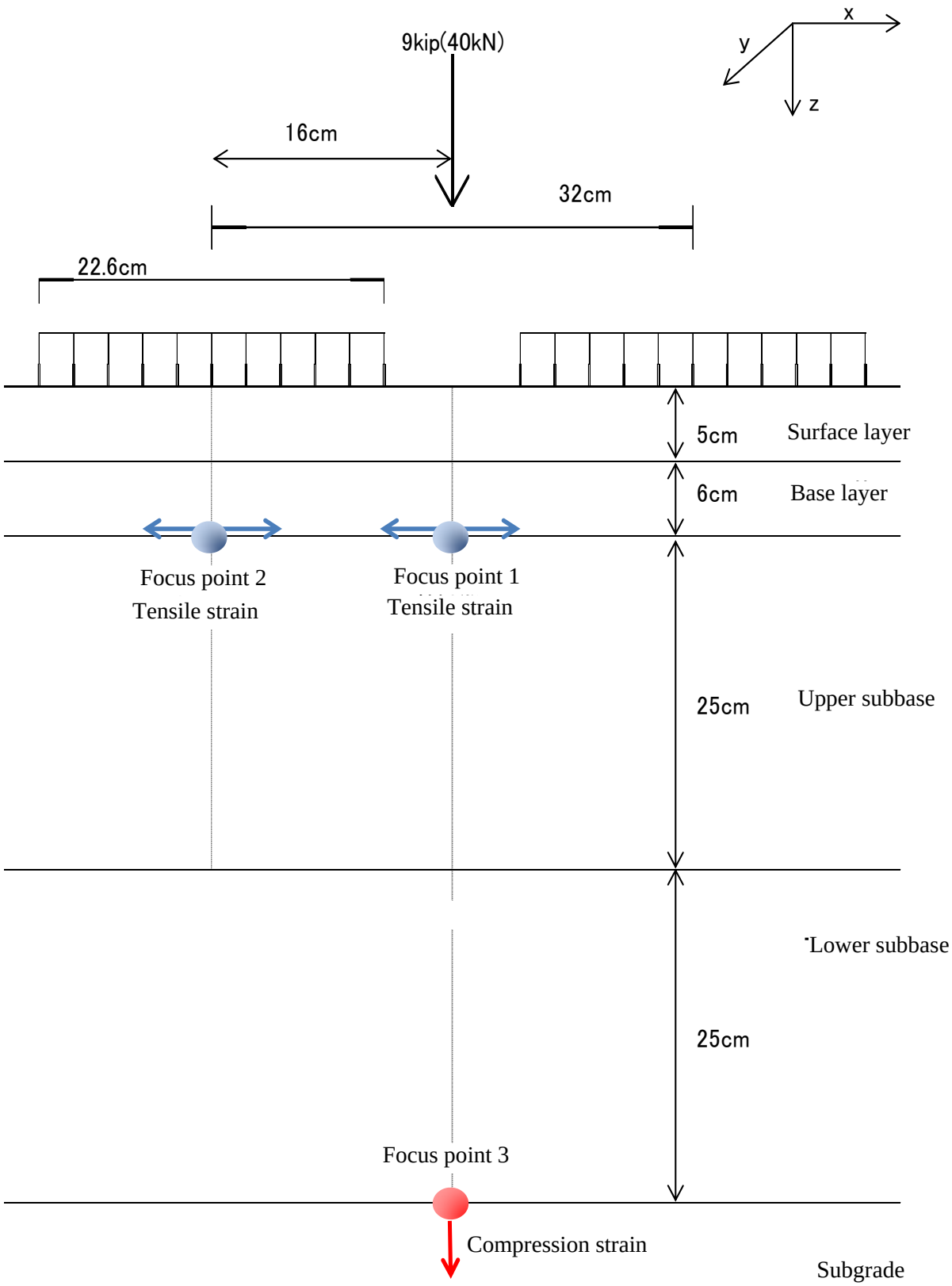



Figure 2-2-25 Pavement Fatigue Fracture Study Model

### 2-2-2-6-9 Study on soft ground measures

#### (1) Basic study conditions

##### 1) Contents of the Survey

The matters in this survey, the soil survey conducted by FRA (mechanical boring and cone penetration test), and soil tests for the target section are shown below.

- The design range is the road construction section from the originating side 0+80.000 (BC1-0) to the ending side 0+374.200 (A1 bridge abutment).
- The ground layer section and ground physical property values were set in reference to the cone penetration test results (CPT01 to CPT03: 2018 to 2019 survey) as a ground layer thickness settings material based on Bor.No.BH01 (FY 2019 survey) and No.BA-1, No.BH01 (2018 survey).
- The consolidation characteristics of the weak layer was set as the ground layer section corresponding to ground physical property values, based on BH01 (FY 2019 survey).

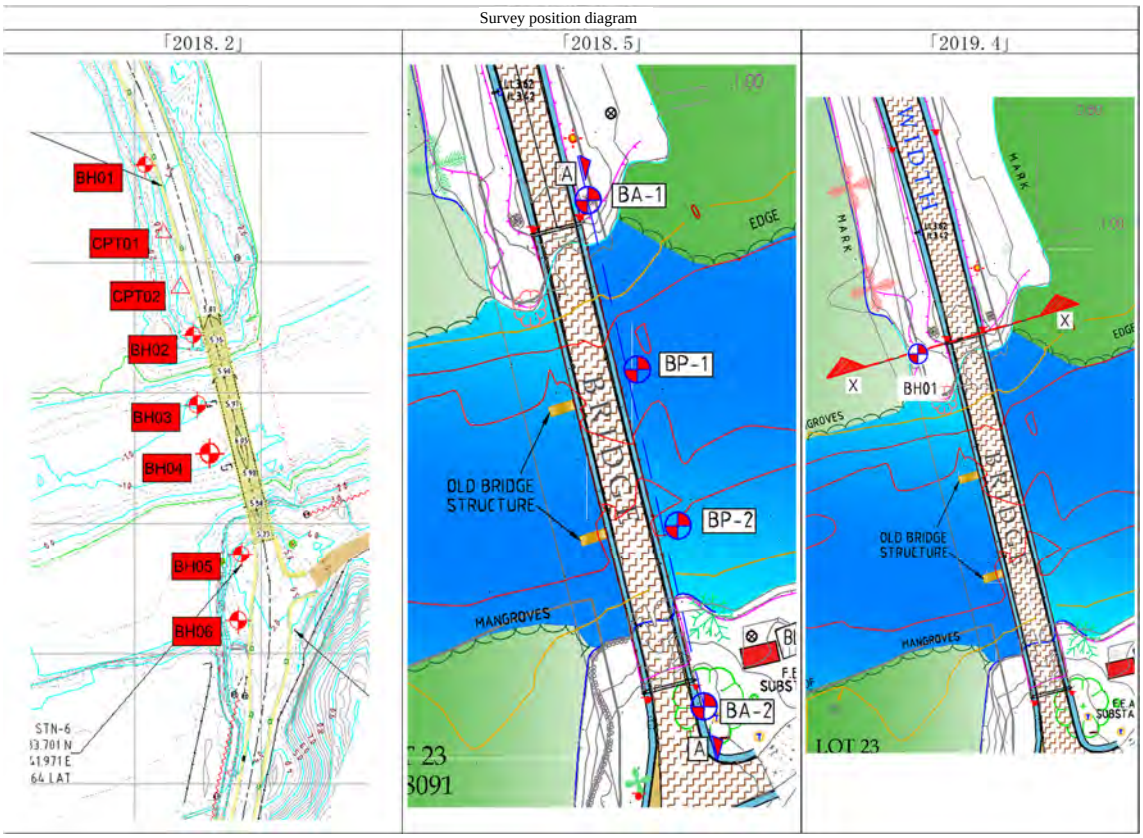



Figure2-2-26 Geological Survey Position

## 2) Geological Survey Position and Assumed Geological Cross Section

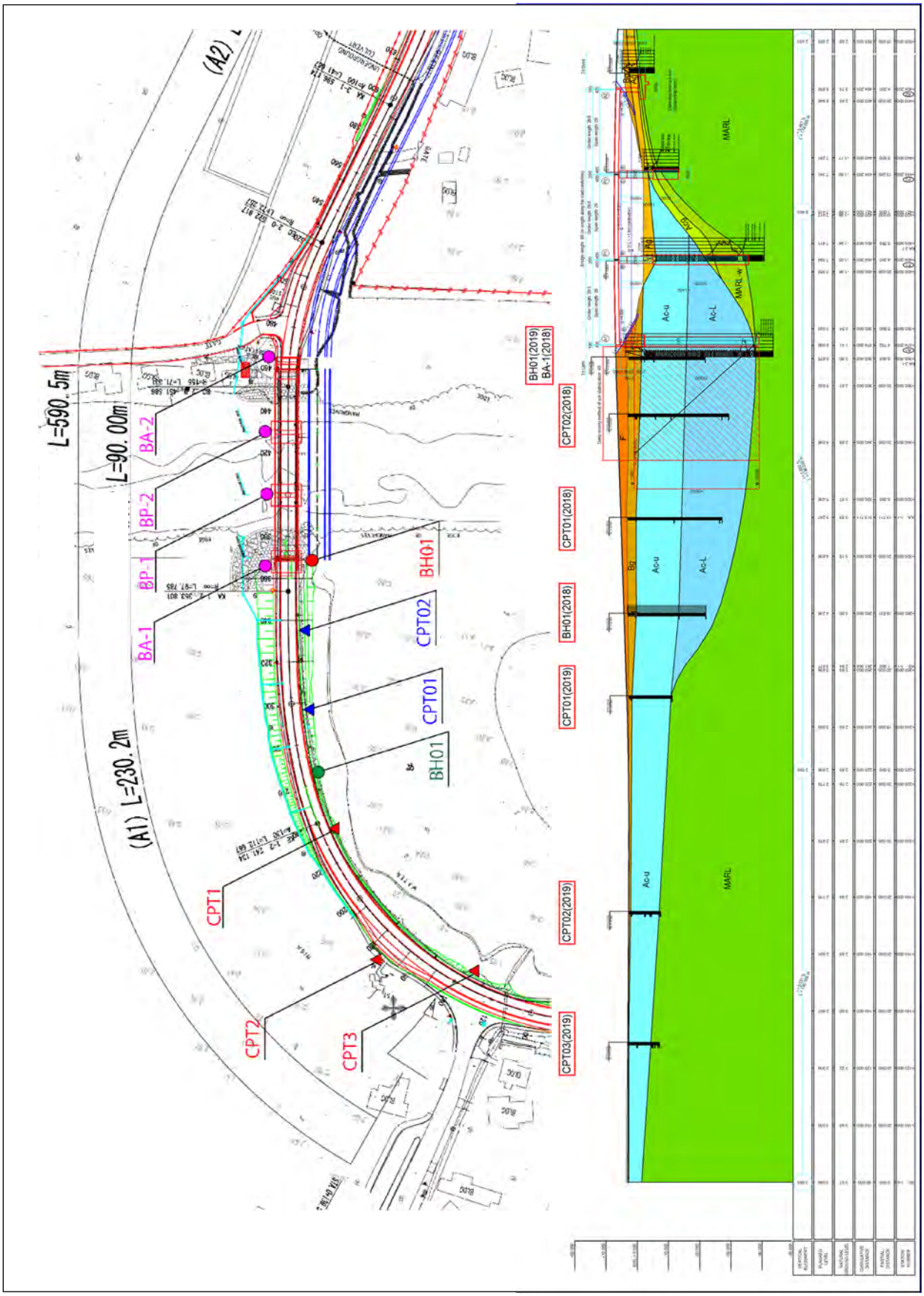



Figure2-2-24 Geological Survey Location and Assumed Geological Cross Section

### 3) Study cross section

#### a) Study cross section location

・For the study cross section, 6 cross sections from the originating side were selected based on the sidewise movement measures (ground improvement work) planned for the back of the bridge abutment for the purpose of gaining an understanding of the subsidence and stability characteristics of the road embankment constructed on soft ground.

・For this site, it seems that the soft layer is sloping from the originating side in the ground layer longitudinal drawing, so a check was conducted at an observation interval of L=20m to decide on the specifications of the L=20m verification measures for measures based on the relationship between (1) the embankment thickness from the plan embankment form and (2) the soft layer thickness directly below the road.

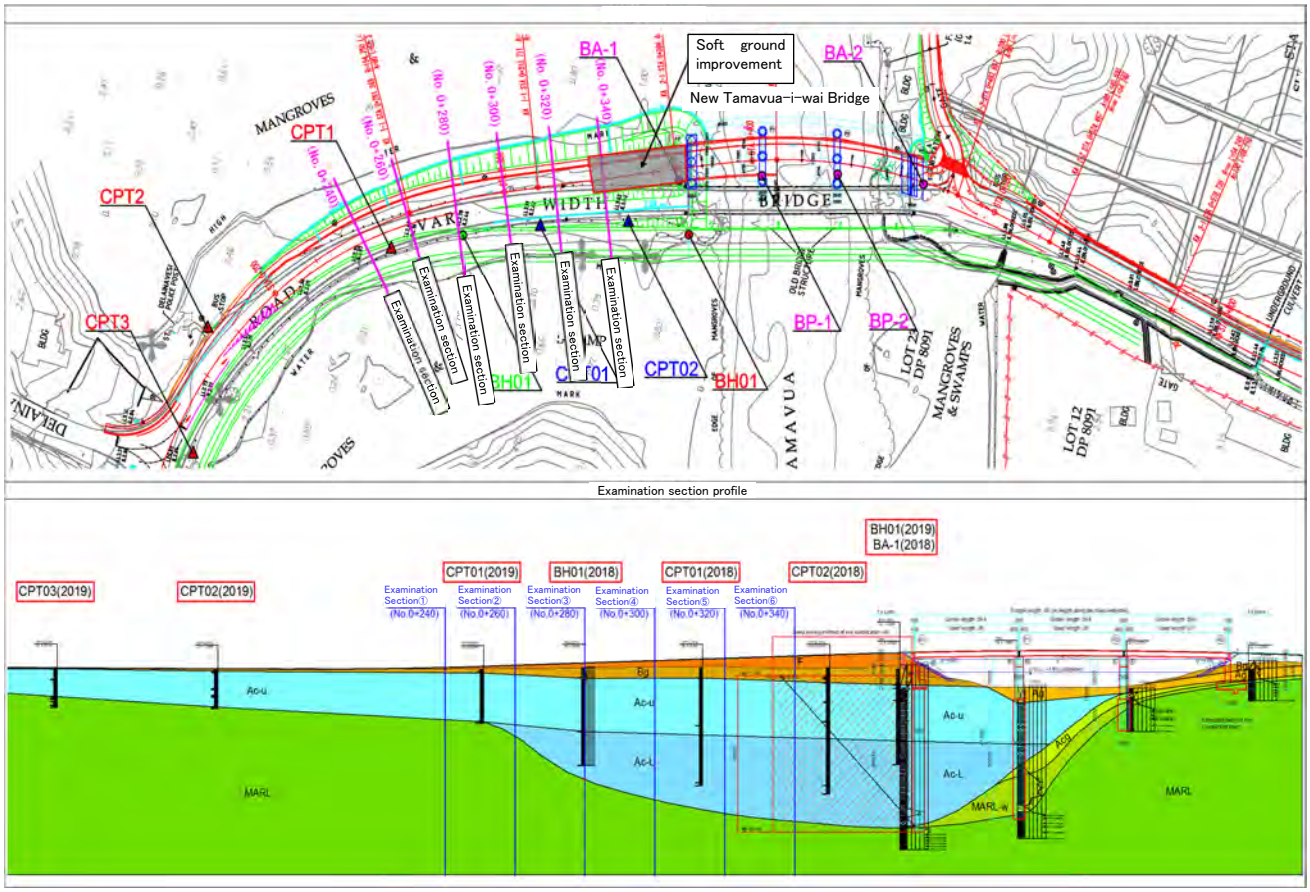



Figure2-2-25 Study Cross Section Location

**b) Road embankment plan and traffic load**

・For the loaded weight, the embankment slope shall be unloaded in consideration of the traffic load for the road portion and sidewalk portion.

・For the road portion, the traffic road according to the plan embankment thickness shall follow the road earthworks standard.

・The sidewalk load was set according to the crowd load (q=3.5(kN/m2) in the Specifications for Highway Bridges and Commentary below.

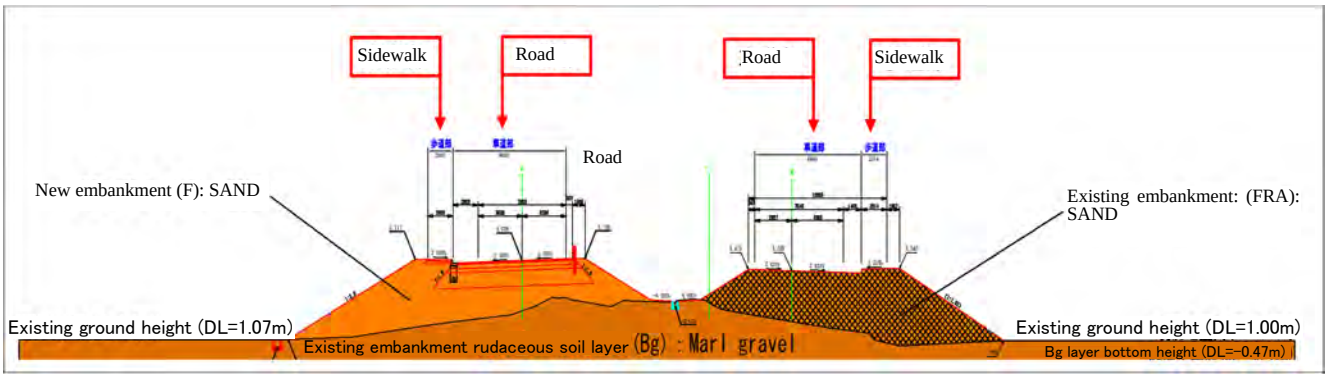



Figure2-2-26 Study Cross Section Overview Drawing

**(2) Summary of results of study**

**1) Results of subsidence study**

- For the extra-banking shape focus points, the consolidation subsidence quantity was calculated for (1) top of slope L, (2) vehicle road CL, and (3) top of slope R through the plan form, and the maximum subsidence quantity point was used as the standard.
- Subsidence remains without it being possible to satisfy the required standing period for a residual subsidence quantity of within Sr=10cm for the total cross section or the allowable standing period (t=180 days, 365 days). (For study cross section (1), can be secured if the allowable standing period is t=365 days.)
- The vertical drain (cardboard drain) method was considered as a measure during periods of consolidation settlement, and the relationship between the placement interval and thickness of the measures layer ((1) Ac-u all layers, (2) layer thickness D=20m, (3) layer thickness D=25m, and (4) layer thickness D=30m) that satisfies the required standing period was calculated.
- The drain measures specifications shall be a placement interval of d=1.50m (average measures thickness of D=11.8 to 12.8m) for the starting point to No.0+260, a standardized placement interval of d=1.00m in consideration of workability, and the average measures thickness shall be 20.0 to 31.0m.

Table 2-2-39 List of Required Time for Subsidence Without Measures

| Study cross section | | Study location | Plan embankment form | | | | | | | | Construction extra-banking form (without measures) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Plan embankment height FH1 (m) | Current ground height GH(m) | Plan embankment thickness H1 (m) | Low embankment traffic load q (kN/m$^2$) | Embankment period t1 (days) 10cm/day | Consolidation subsidence quantity S1 (cm) | | | Maximum subsidence quantity point | Subsidence quantity equivalent thickness surcharge H2 (m) | Loaded weight equivalent thickness preload H3 (m) | Extra-banking thickness H2+H3 (m) | Construction embankment thickness H4 (m) | Construction embankment height FH2 (m) | Embankment period t1 (days) 10cm/day | Consolidation subsidence quantity S1 (cm) | | | JICA embankment start date t (days) | Verification period (embankment period + standing period) | | Residual subsidence 10cm required amount of time t (days) | Judgment |
| | | | | | | | | Upper viscous soil | Lower viscous soil | Total subsidence quantity | | | | | | | | Upper viscous soil | Lower viscous soil | Total subsidence quantity | | Standing period t (days) | | | |
| | | | | | | | | Ac-u | Ac-L | | | | | | | | | Ac-u | Ac-L | | | 180 | 365 | | |
| (1) | No.0 +240 | Top of slope L | 3.180 | 1.590 | 1.59 | 31.0 | 17 | 21.14 | - | 21.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 days (NG) 365 days (OK) |
| | | Vehicle road CL | 3.099 | 1.489 | 1.61 | | | 35.40 | - | 35.4 | ○ | 0.44 | 1.63 | 2.07 | 3.68 | 5.17 | 37 | 43.26 | - | **43.3** | 195 | 412 | 597 | 470 | |
| | | Top of slope R | 3.199 | 2.578 | 0.62 | | | 26.76 | - | 26.8 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| (2) | No.0 +260 | Top of slope L | 3.717 | 1.704 | 2.01 | 31.0 | 21 | 28.10 | 6.90 | 35.0 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 days (NG) 365 days (NG |
| | | Vehicle road CL | 3.636 | 2.026 | 1.61 | | | 38.14 | 8.44 | 46.6 | ○ | 0.60 | 1.63 | 2.23 | 3.84 | 5.87 | 39 | 48.99 | 10.44 | **59.4** | 200 | 419 | 604 | 1,374 | |
| | | Top of slope R | 3.751 | 2.654 | 1.10 | | | 28.35 | 7.40 | 35.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| (3) | No.0 +280 | Top of slope L | 4.317 | 1.355 | 2.96 | 31.0 | 30 | 37.20 | 24.10 | 61.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 180 days (NG) 365 days (NG) |
| | | Vehicle road CL | 4.236 | 2.626 | 1.61 | | | 38.60 | 24.52 | 63.1 | ○ | 0.82 | 1.63 | 2.45 | 4.06 | 6.69 | 41 | 50.44 | 30.82 | **81.3** | 202 | 423 | 608 | 11,352 | |
| | | Top of slope R | 4.367 | 2.787 | 1.58 | | | 31.89 | 24.24 | 56.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| (4) | No.0 +300 | Top of slope L | 4.917 | 1.560 | 3.36 | 31.0 | 34 | 42.51 | 30.24 | 72.8 | ○ | 1.09 | 1.63 | 2.72 | 6.08 | 7.64 | 61 | 65.53 | 42.73 | **108.3** | 209 | 450 | 635 | 21,245 | 180 days (NG) 365 days (NG) |
| | | Vehicle road CL | 4.836 | 3.182 | 1.65 | | | 40.30 | 29.41 | 69.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| | | Top of slope R | 4.960 | 3.089 | 1.87 | | | 31.64 | 30.08 | 61.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| (5) | No.0 +320 | Top of slope L | 5.517 | 1.796 | 3.72 | 26.0 | 38 | 45.85 | 34.06 | 79.9 | ○ | 1.13 | 1.37 | 2.50 | 6.22 | 8.02 | 63 | 66.18 | 46.43 | **112.6** | 214 | 457 | 642 | 31,579 | 180 days (NG) 365 days (NG) |
| | | Vehicle road CL | 5.436 | 3.371 | 2.07 | | | 42.06 | 33.09 | 75.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| | | Top of slope R | 5.556 | 3.167 | 2.39 | | | 34.40 | 34.17 | 68.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| (6) | No.0 +340 | Top of slope L | 6.117 | 1.836 | 4.28 | 13.0 | 43 | 48.88 | 37.06 | 85.9 | ○ | 1.09 | 0.68 | 1.77 | 6.06 | 7.89 | 61 | 62.31 | 46.26 | **108.6** | 216 | 457 | 642 | 38,777 | 180 days (NG) 365 days (NG) |
| | | Vehicle road CL | 6.036 | 2.875 | 3.16 | | | 43.80 | 36.91 | 80.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |
| | | Top of slope R | 6.156 | 3.423 | 2.73 | | | 32.57 | 35.52 | 68.1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | |

Table 2-2-40 List of Consolidation Settlement Promotion Method Specifications and Required Standing Period

| Study cross section | | Study location | Construction extra-banking form (cardboard drain measures) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Drain measures specifications | | | | | Verification period | Relationship with the verification period | Residual subsidence 10cm required amount of time t (days) | Judgment | Applied laying interval |
| | | | Laying interval d(m) | Laying layout | Measures bottom depth DL(m) | Average measures depth D(m) | Measures width B(m) | Embankment period + standing period 180 days | | | | |
| (1) | No.0+240 | Vehicle road CL | 1.50 | square | -10.29 | 11.8 | 15.8 | 412 | > | 234 | **OK** | ○ d=1.50m |
| (2) | No.0+260 | Vehicle road CL | 1.50 | square | -11.60 | 12.8 | 17.6 | 419 | > | 261 | **OK** | ○ d=1.50m |
| (3) | No.0+280 | Vehicle road CL | 1.00 | square | -19.70 | 20.0 | 20.0 | 423 | > | 397 | **OK** | ○ d=1.00m |
| (4) | No.0+300 | Top of slope L | 1.00 | square | -24.64 | 25.0 | 21.0 | 450 | > | 429 | **OK** | ○ d=1.00m |
| (5) | No.0+320 | Top of slope L | 1.10 | square | -29.81 | 30.0 | 22.6 | 457 | > | 441 | **OK** | ○ d=1.00m |
| (6) | No.0+340 | Top of slope L | 0.90 | Square | -30.47 | 30.0 | 23.6 | 457 | > | 418 | **OK** | × |
| | | | 1.00 | Square | -31.47 | 31.0 | 23.6 | 457 | > | 434 | **OK** | ○ d=1.00m |

*For (5), although the square layout for the laying interval 1.1m fulfills the requirement of the standing period of a half year and residual subsidence of 10cm, the square layout was made 1.0m in consideration of the workability with other sections.

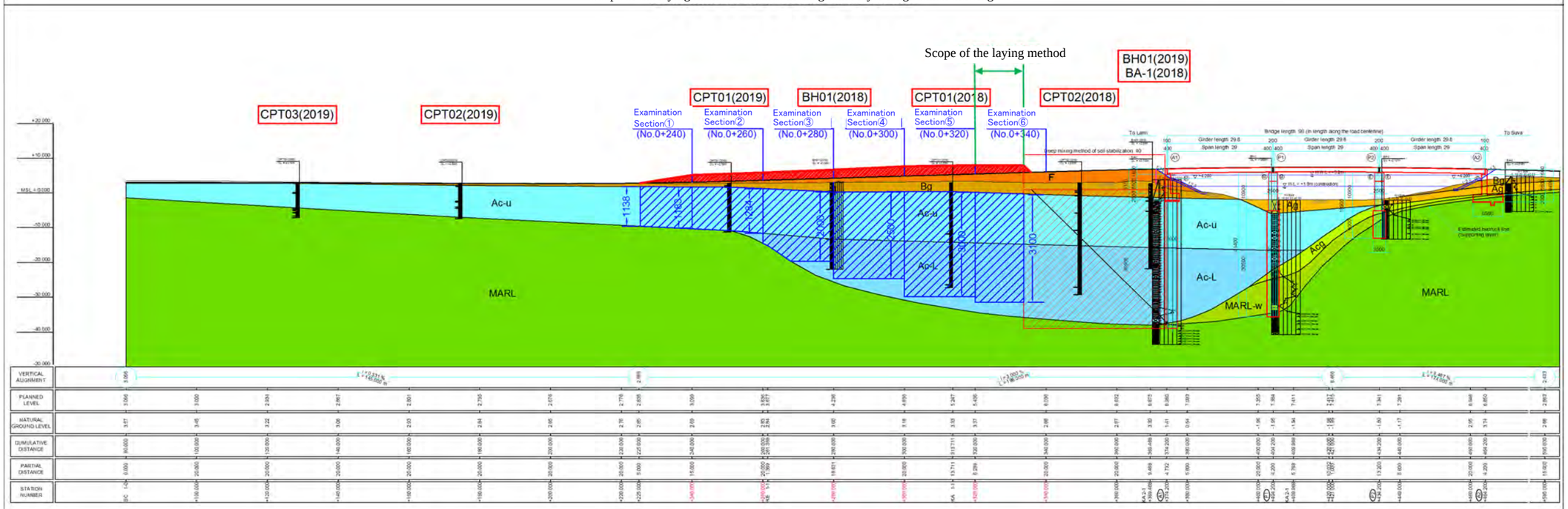
**2) Stability study results**

- For the embankment slope stability study, calculations were conducted for the construction time to extra-banking form (embankment launching time) and the kh method (level 1: kh=0.12) during normal times and during an earthquake for the plan form.
- As a result of the calculation of construction time, it was found that the compaction index was increased from drain work that is the subsidence measure and that the target safety factor (Fs≧1.10) was mostly satisfied. Of these, although it fell below the target safety factor for study cross section (4) and (5), the arc scope is from the new embankment (F) to the current embankment (Bg), and because the adhesive strength C factor cannot be expected, it would be an arc that cuts through the embankment slope surface layer. As for the evaluation, measures will not be conducted at the time of construction because it is not an arc that cuts through the soft ground (Ac-u).
- As a result of calculation for normal times, if consideration is given to the increase in strength from a compaction index of U=90% and the traffic load of the road crown and sidewalk portion, it would be possible to satisfy the target safety factor (Fs≧1.25).
- As a result of calculation for the kh method during an earthquake and verification through the limited arc method, because the target safety factor (Fs≧1.00) can be satisfied only for study cross section (6) for seismic movement level 1, stabilization work (laying method) shall be considered for this cross section.
- The laying position for laying work was set at DL=2.87m (laying width L=22.0m) near the center of the new embankment to avoid excavation of the existing embankment as much as possible.
- As a result of calculation, stability was secured with a design strength of TAE=124 (kN/m) using geotextile (geogrid) as a laying material.

Table 2-2-41 List of Stability Study Results

| Study cross section | | Study case | Subsidence measures | Study form | Road CL embankment height FH(m) | Study seismic movement | Design water Average seismic intensity kh | Loaded weight (traffic load) q(kN/m²) | Results of stability calculation with no measures | | | | Laying work measures specifications | | Results of stability calculation with measures | | Target safety factor Fs | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Embankment left slope | | Embankment right slope | | Design strength (during and earthquakes) $T_{AE}$(kN/m) | Installation width L(m) | Embankment left slope | | | |
| | | | | | | | | | Minimum Safety factor Fsmin | Judgment | Minimum Safety factor Fsmin | Judgment | | | Minimum safety factor Fsmin | Judgment | | |
| (1) | No.0+240 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 5.17 | - | - | - | 1.448 | ○ | No slope face | - | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 1.679 | ○ | | | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 3.10 | - | - | 31.0 | 2.100 | ○ | | - | | | | | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 3.10 | seismic movement level 1 | 0.12 | - | 1.648 | ○ | | - | | | | | 1.00 | Limited arc method |
| (2) | No.0+260 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 5.87 | - | - | - | 1.133 | ○ | No slope face | - | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 1.252 | ○ | | | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 3.64 | - | - | 31.0 | 1.810 | ○ | | - | | | | | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 3.64 | seismic movement level 1 | 0.12 | - | 1.456 | ○ | | - | | | | | 1.00 | Limited arc method |
| (3) | No.0+280 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 6.69 | - | - | - | 0.915 | × | No slope face | - | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 1.209 | ○ | | | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 4.24 | - | - | 31.0 | 1.546 | ○ | | - | | | | | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 4.24 | seismic movement level 1 | 0.12 | - | 1.250 | ○ | | - | | | | | 1.00 | Limited arc method |
| (4) | No.0+300 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 7.64 | - | - | - | 0.782 | × | 1.060 | × | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 0.901 | △ | 1.193 | ○ | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 4.84 | - | - | 31.0 | 1.368 | ○ | 1.742 | ○ | | | | | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 4.84 | seismic movement level 1 | 0.12 | - | 1.101 | ○ | 1.723 | ○ | | | | | 1.00 | Limited arc method |
| (5) | No.0+320 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 8.02 | - | - | - | 0.739 | × | 1.059 | × | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 0.888 | △ | 1.225 | ○ | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 5.44 | - | - | 26.0 | 1.307 | ○ | 1.741 | ○ | | | | | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 5.44 | seismic movement level 1 | 0.12 | - | 1.014 | ○ | 1.575 | ○ | | | | | 1.00 | Limited arc method |
| (6) | No.0+340 | Time of construction (time of extra-banking) | When there are no measures | Extra-banking height | 7.89 | - | - | - | 0.765 | × | 1.175 | ○ | - | - | - | - | 1.10 | - |
| | | | Measures implemented | | | | | | 1.116 | ○ | 1.336 | ○ | | | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | Plan height | 6.04 | - | - | 13.0 | 1.335 | ○ | 1.886 | ○ | 124 | 22.0 | 1.387 | ○ | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | Plan height | 6.04 | seismic movement level 1 | 0.12 | - | 0.939 | × | 1.466 | ○ | | | 1.006 | ○ | 1.00 | Limited arc method |

Scope of the laying method measures in the ground layer longitudinal drawing




【Study cross section⑥(No.0+340) : Laying net method countermeasure diagram】

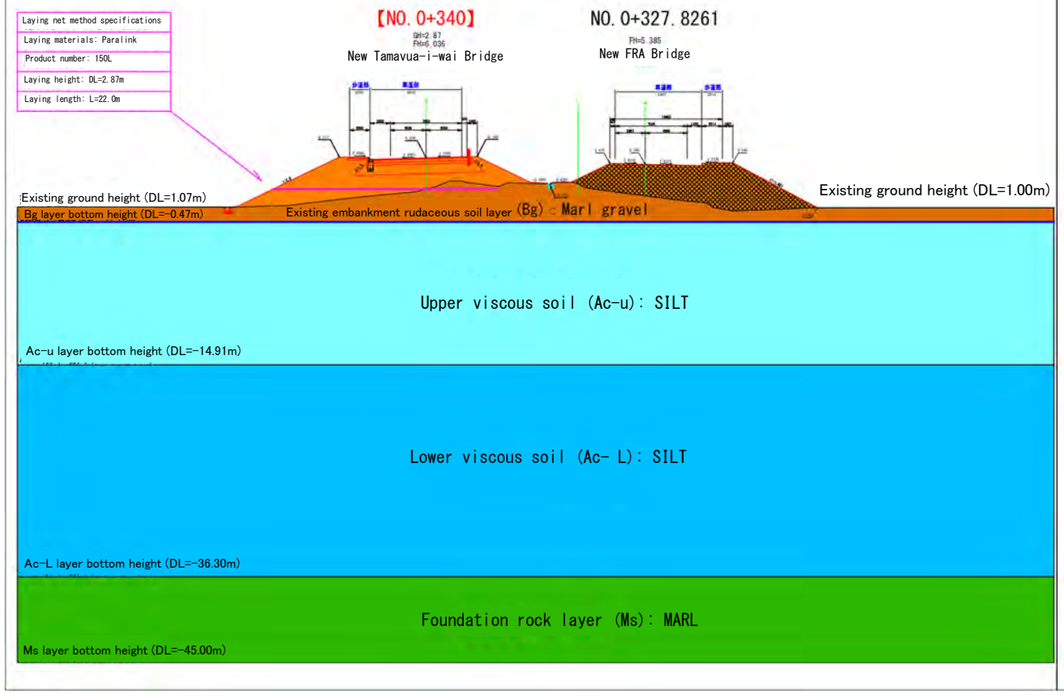



Figure 2-2-30 Soft Ground Prevention Work Study Overview Drawing

### (3) Subsidence prevention work

#### 1) Surplus-banking construction method

- The construction embankment (extra-banking) height is calculated from the 3 points of (1) top of embankment slope L, (2) road CL and (3) top of embankment slope R, and the subsidence amount shall be studied from the biggest point.
- The extra-banking shape shall be a trapezoid added to the extra-banking thickness, based on the traffic load loaded edges for both of the embankment crest edges.
- Construction embankment thickness (H4) = planned embankment thickness (H1) + subsidence volume equivalent surcharge thickness (H2)
  + loaded weight equivalent pre-load thickness (H3)

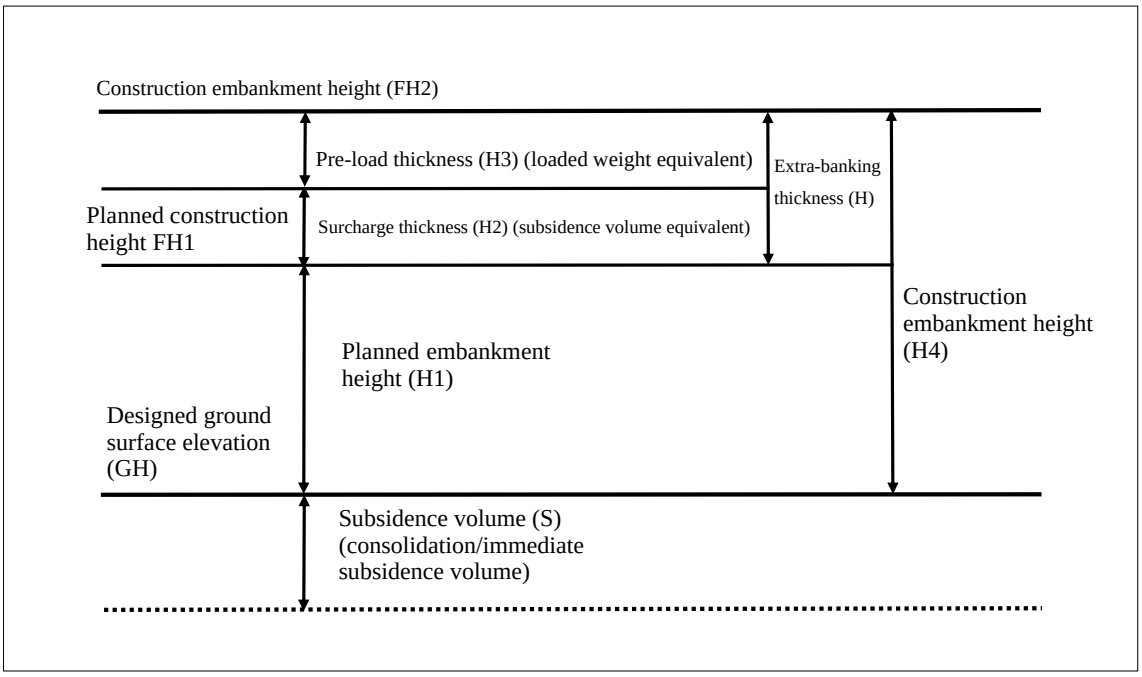



Figure 2-2-28 Approach to Construction Embankment Thickness

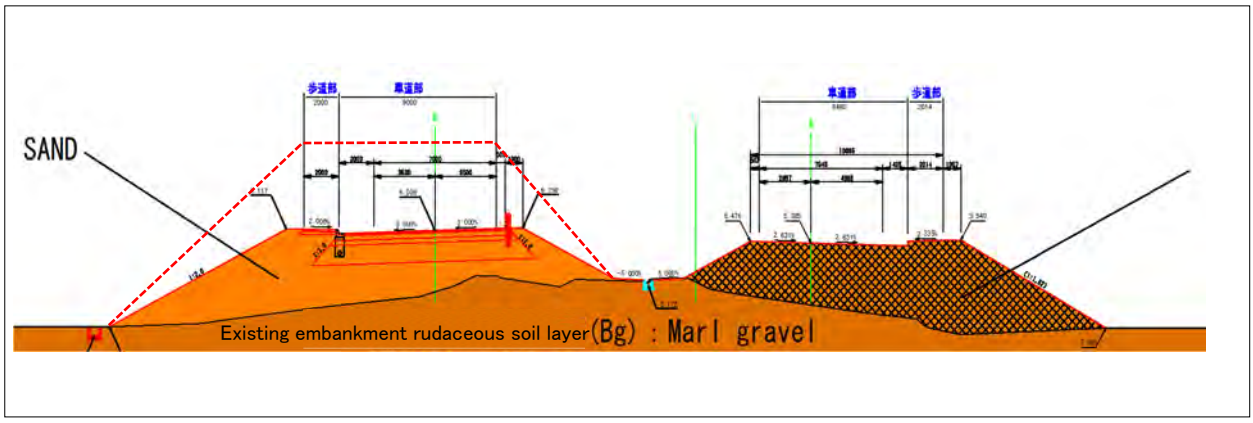



Figure2-2-29 Extra-banking Shape Schematic Diagram

### 2) Vertical drain method

- For the drain placement range, from the foot of the left side embankment slope the top of the right side embankment slope was studies as the scope.
- A drain will be place on the left side because it can be expected to enhance the strength of the ground surface directly below the embankment surface where the plan embankment is the thickest.
- There shall be no measures on the right edge because it will be sunk to be uniform with the road and there is an existing road directly under the right-side slope face.
- For the calculation cases, the drain placement interval was decided so that the verification period (embankment period + standing period) can be satisfied for the four cases of (1) all upper viscous soil layers (Ac-u) covered, (2) drain placement length (D=20.0m), (3) drain placement length (D=25.0m), and (4) drain placement length (D=30.0m).

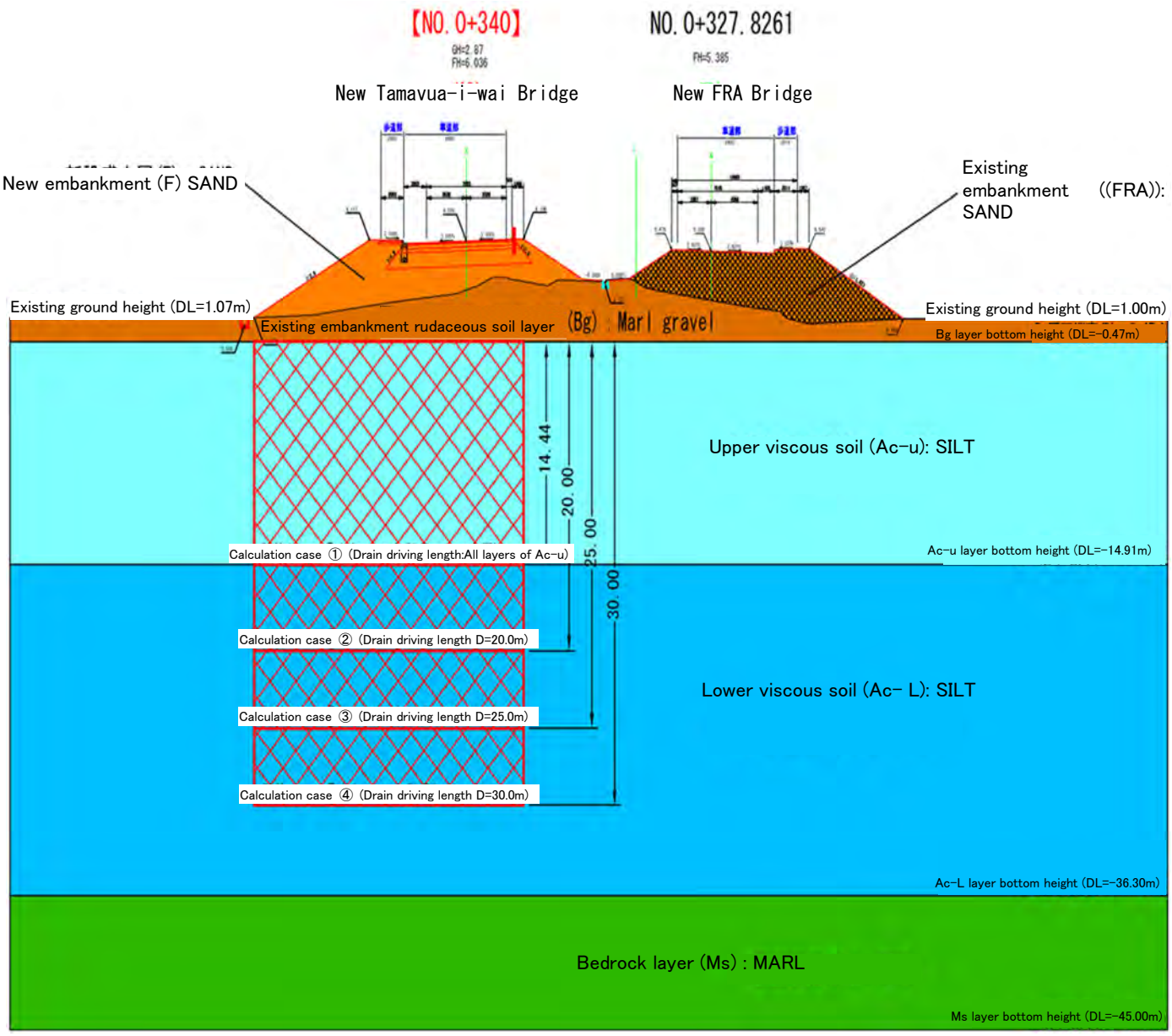



Figure2-2-30 Cardboard Drain Placement Calculation Case Schematic Diagram

Table 2-2-42 Soft Ground Prevention Work Placement Length and Placement Interval Study Table

| Study cross section | | Road CL soft layer thickness H (m) | | | Standing period (180 days) Verification period (days) | | | | Maximum placement length D(m) | | | | Calculation case | | Required standing period for residual subsidence of Sr=10cm for the placement interval | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Upper layer | Lower layer | Soft layer thickness | | | | | | | | | | | Cardboard drain method study placement interval d (m) | | | | | | | | | |
| | | Ac-u | Ac-L | | Embankment start | Embankment period | Standing period | Verification period | Left side embankment slope foot L | Vehicle road CL | Right side embankment top of slope R | Average placement length | | | 1.50 | 1.40 | 1.30 | 1.20 | 1.10 | 1.00 | 0.90 | 0.80 | 0.70 | 0.60 |
| (1) | No.0+240 | 10.29 | - | 10.29 | 195 | 37 | 180 | 412 | 11.81 | 11.78 | 11.90 | 11.83 | (1) | D= Ac-u all layers | 234 | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | ○ | - | - | - | - | - | - | - | - | - |
| (2) | No.0+260 | 12.84 | 2.89 | 15.73 | 200 | 39 | 180 | 419 | 12.46 | 12.84 | 12.96 | 12.75 | (1) | D= Ac-u all layers | 261 | - | - | - | - | - | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | ○ | - | - | - | - | - | - | - | - | - |
| (3) | No.0+280 | 13.60 | 12.28 | 25.88 | 202 | 41 | 180 | 423 | 20.00 | 20.00 | 20.00 | 20.00 | (1) | D= Ac-u all layers | 3290 | 3290 | 3290 | 3290 | 3290 | 3290 | 3290 | 3290 | 3290 | 3290 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (2) | D= 20.00 | 553 | 519 | 486 | 455 | 425 | 397 | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | ○ | - | - | - | - |
| (4) | No.0+300 | 14.20 | 16.96 | 31.16 | 209 | 61 | 180 | 450 | 25.00 | 25.00 | 25.00 | 25.00 | (1) | D= Ac-u all layers | 7832 | 7832 | 7832 | 7832 | 7832 | 7832 | 7832 | 7832 | 7832 | 7832 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (2) | D= 20.00 | 2247 | 2247 | 2247 | 2247 | 2247 | 2247 | 2247 | 2247 | 2247 | 2247 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (3) | D= 25.00 | 626 | 582 | 540 | 500 | 463 | 429 | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | ○ | - | - | - | - |
| (5) | No.0+320 | 14.56 | 19.92 | 34.48 | 214 | 63 | 180 | 457 | 30.00 | 30.00 | 30.00 | 30.00 | (1) | D= Ac-u all layers | 13208 | 13208 | 13208 | 13208 | 13208 | 13208 | 13208 | 13208 | 13208 | 13208 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (2) | D= 20.00 | 5269 | 5269 | 5269 | 5269 | 5269 | 5269 | 5269 | 5269 | 5269 | 5269 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (3) | D= 25.00 | 1262 | 1241 | 1229 | 1225 | 1223 | 1223 | 1223 | 1223 | 1223 | 1223 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (4) | D= 30.00 | 621 | 571 | 524 | 481 | 441 | - | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | ○ | - | - | - | - | - |
| (6) | No.0+340 | 14.44 | 21.40 | 35.84 | 216 | 61 | 180 | 457 | 30.00 | 30.00 | 30.00 | 30.00 | (1) | D= Ac-u all layers | 17501 | 17501 | 17501 | 17501 | 17501 | 17501 | 17501 | 17501 | 17501 | 17501 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (2) | D= 20.00 | 7284 | 7284 | 7284 | 7284 | 7284 | 7284 | 7284 | 7284 | 7284 | 7284 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (3) | D= 25.00 | 1975 | 1972 | 1971 | 1971 | 1971 | 1971 | 1971 | 1971 | 1971 | 1971 |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | × | × | × | × |
| | | | | | | | | | | | | | (4) | D= 30.00 | 734 | 672 | 613 | 558 | 507 | 460 | 418 | - | - | - |
| | | | | | | | | | | | | | | Judgment | × | × | × | × | × | × | ○ | - | - | - |
| | | | | | | | | | 31.00 | 31.00 | 31.00 | 31.00 | Reference | D= 31.00 | - | - | - | - | - | 434 | - | - | - | - |
| | | | | | | | | | | | | | | Judgment | - | - | - | - | - | ○ | - | - | - | - |

### (4) Slope stability study

#### 1) Measures to enhance ground strength

- Measures to enhance ground strength will cover the alluvial upper viscous soil layer (Ac-u), and will not consider the alluvial lower viscous soil layer (Ac-L) because the distribution deepness is deep and it is outside the scope of the embankment arc.
- The scope of measures to enhance the ground strength for (1) embankment surface portion and (2) portion below the embankment shall be considered.
- The study on measures to enhance the ground strength is by calculation of two cases (1) no measures and (2) with drain measures.
- The compaction index during construction refers its extra-banking completion value from the subsidence calculation results.
- The compaction index at the start of service (during normal times/during earthquakes) is calculated as U=90% (upper limit).

| Calculation position | Compaction index (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Study cross section (1) | | Study cross section (2) | | Study cross section (3) | | Study cross section (4) | |
| | Extra-banking completion t = 232 days | | Extra-banking completion t = 239 days | | Extra-banking completion t = 243 days | | Extra-banking completion t = 270 days | |
| | No measures | Measures implemented PBD (d=1.5m) | No measures | Measures implemented PBD (d=1.5m) | No measures | Measures implemented PBD (d=1.0m) | No measures | Measures implemented PBD (d=1.0m) |
| Slope face Left side | 24.3 | 80.2 | 12.8 | 71.3 | 4.9 | 90.0 | 4.2 | 90.0 |
| Road CL | 22.4 | 72.4 | 11.9 | 66.4 | 4.4 | 90.0 | 3.8 | 90.0 |
| Slope face Right side | - | - | - | - | - | - | 4.3 | 4.3 |

| Calculation position | Compaction index (%) | | | | | |
|---|---|---|---|---|---|---|
| | Study cross section (5) | | Study cross section (6) | | Study cross section (1) to (6) | |
| | Extra-banking completion t = 277 days | | Extra-banking completion t = 277 days | | Service start timing (when there are no measures and measures implemented) | |
| | No measures | Measures implemented PBD (d=1.1m) | No measures | Measures implemented *PBD (d=1.0m) | Normal times | At the time of earthquake |
| Slope face L side | 3.6 | 90.0 | 3.2 | 90.0 | 90.0 | 90.0 |
| Road CL | 3.3 | 90.0 | 3.0 | 90.0 | 90.0 | 90.0 |
| Slope face R side | 3.8 | 3.8 | 3.6 | 3.6 | 90.0 | 90.0 |
| | | | *d = @1.00m study | | | |

2) Stability study results

- The results of the stability study when there are no measures is shown in the table below. Note that a safety factor through the limited arc method is applied because the inertial force is high and the area greater the embankment scope is within the scope of the slip circle during an earthquake.
- For the stability of the right slope of the embankment, there is no problem with securing stability (study cross section (4) to (6)) from the pushing effect from a form in which there is not embankment slope (study cross section (1) to (3)) as a result of the balance with the FRA side embankment.
- For the stability at the time of construction, although it cannot be secured when there are no subsidence measures, there is a tendency for the target safety factor to be satisfied by increase of the compaction index U as implementation of subsidence measures (cardboard drain).
- The slip circle state for study cross section (4) and (5) when stability cannot be secure through subsidence measures during construction on the left slope of the embankment is an arc that passes through the surface layer of the new embankment (F) to current embankment (Bg). This is a phenomenon that occurs because there is a sand/gravel soil base and the adhesive strength C cannot be expected, and because the arc does not cut through the lower soft layer (Ac-u), it has been deemed that the possibility of this actually occurring is low. A low-gradient construction through coarse formations will be used at the time of construction, and not stability measures will be implemented at the time of construction.
- For during normal times and during earthquakes, the minimum safety factor when the compaction index is U=90% will be used. During normal time, it is possible to secure stability and during earthquakes, it is possible to satisfy the target safety factor only for study cross section (6).

Table 2-2-43 Stability Study Results Table

| Study cross section | | Study case | Subsidence measures | Strength enhancement | | | | | Study form | Road CL embankment height FH(m) | Study seismic movement | Design horizontal seismic intensity kh | Loaded weight (traffic load) q(kN/m²) | Results of stability calculation | | | | Target safety factor Fs | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Subsidence measures | Laying interval d(m) | Upper viscous soil (Ac-u) | | | | | | | | Embankment left slope | | Embankment right slope | | | |
| | | | | | | Compaction index (%) | | | | | | | | Minimum safety factor Fsmin | Judgment | Minimum safety factor Fsmin | Judgment | | |
| | | | | | | Slope face CL | Vehicle road CL | Slope face R | | | | | | | | | | | |
| (1) | No.0+240 | Time of construction (time of extra-banking) | When there are no measures | - | - | 24.3 | 22.4 | - | Extra-banking height | 5.17 | - | - | - | 1.448 | ○ | No slope face | - | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.50 | 80.2 | 72.4 | - | | | | | | 1.679 | ○ | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 3.10 | - | - | 31.0 | 2.100 | ○ | | - | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 3.10 | seismic movement level 1 | 0.12 | - | 1.648 | ○ | | - | 1.00 | Limited arc method |
| (2) | No.0+260 | Time of construction (time of extra-banking) | When there are no measures | - | - | 12.8 | 11.9 | - | Extra-banking height | 5.87 | - | - | - | 1.133 | ○ | No slope face | - | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.50 | 71.3 | 66.4 | - | | | | | | 1.252 | ○ | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 3.64 | - | - | 31.0 | 1.810 | ○ | | - | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 3.64 | seismic movement level 1 | 0.12 | - | 1.456 | ○ | | - | 1.00 | Limited arc method |
| (3) | No.0+280 | Time of construction (time of extra-banking) | When there are no measures | - | - | 4.9 | 4.4 | - | Extra-banking height | 6.69 | - | - | - | 0.915 | × | No slope face | - | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.00 | 90.0 | 90.0 | - | | | | | | 1.209 | ○ | | | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 4.24 | - | - | 31.0 | 1.546 | ○ | | - | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | - | Plan height | 4.24 | seismic movement level 1 | 0.12 | - | 1.250 | ○ | | - | 1.00 | Limited arc method |
| (4) | No.0+300 | Time of construction (time of extra-banking) | When there are no measures | - | - | 4.2 | 3.8 | 4.3 | Extra-banking height | 7.64 | - | - | - | 0.782 | × | 1.060 | × | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.00 | 90.0 | 90.0 | 4.3 | | | | | | 0.901 | △ | 1.193 | ○ | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 4.84 | - | - | 31.0 | 1.368 | ○ | 1.742 | ○ | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 4.84 | seismic movement level 1 | 0.12 | - | 1.101 | ○ | 1.723 | ○ | 1.00 | Limited arc method |
| (5) | No.0+320 | Time of construction (time of extra-banking) | When there are no measures | - | - | 3.6 | 3.3 | 3.8 | Extra-banking height | 8.02 | - | - | - | 0.739 | × | 1.059 | × | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.10 | 90.0 | 90.0 | 3.8 | | | | | | 0.888 | △ | 1.225 | ○ | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 5.44 | - | - | 26.0 | 1.307 | ○ | 1.741 | ○ | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 5.44 | seismic movement level 1 | 0.12 | - | 1.014 | ○ | 1.575 | ○ | 1.00 | Limited arc method |
| (6) | No.0+340 | Time of construction (time of extra-banking) | When there are no measures | - | - | 3.2 | 3.0 | 3.6 | Extra-banking height | 7.89 | - | - | - | 0.765 | × | 1.175 | ○ | 1.10 | - |
| | | | Measures implemented | P.B.D | 1.00 | 90.0 | 90.0 | 3.6 | | | | | | 1.116 | ○ | 1.336 | ○ | | |
| | | Time of service (normal times) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 6.04 | - | - | 13.0 | 1.335 | ○ | 1.886 | ○ | 1.25 | - |
| | | Time of service (kh method at time of earthquake) | When there are no measures/when there are measures | | | 90.0 | 90.0 | 90.0 | Plan height | 6.04 | seismic movement level 1 | 0.12 | - | 0.939 | × | 1.466 | ○ | 1.00 | Limited arc method |

### 3) Study on stabilization work

#### a) Conditions for study on stabilization work

##### i) Reinforcement materials installation method (laying)

① Study cross section: Study cross section (6) (No.0+340)

② Installation construction type: high-strength band geosynthetic (paralink)

③ Installation position: DL=2.87m

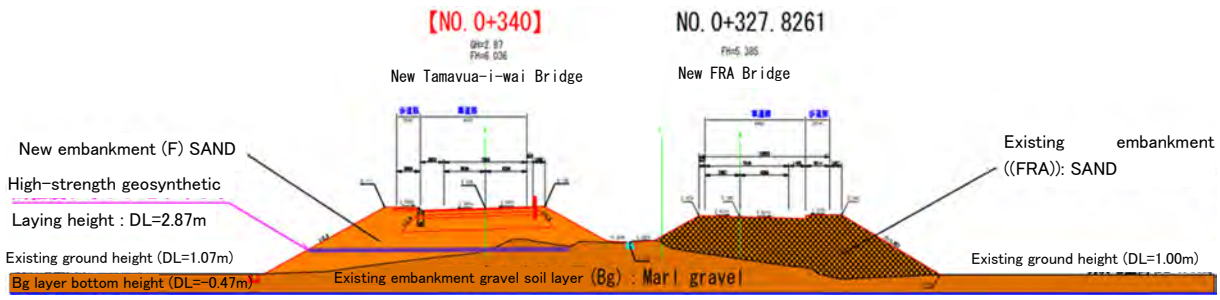
The installation position: The laying height shall be the current ground elevation of the road CL (GH=2.87m). Because the arc at the time of an earthquake will be a large act that cuts through the entire embankment, it will be necessary to do slight excavation on the current embankment (Bg).

④ Number of layers installed: n=1 layer or more

For the number of layers installed, because the scope is the embankment left slope during an earthquake when there are no measures, 1 layer for the entire width shall be general arrangement as economically efficient. However, 1 layer of more will be considered again if stability cannot be secured using the maximum tensile strength.

⑤ Reinforcement materials standard: maximum deterrent force ÷ number of layers installed < design strength

Reinforcement materials shall be adopted with a design strength that satisfy the maximum required deterrent force when there are no measures.




##### ii) Target safety factor

When studying the installation method, the safety factor shown below should be targeted for the calculation based on the arc slip using the geotextile and pull force of the geotextile.

| Calculation case | Normal times | At the time of earthquake |
|---|---|---|
| (1) Safety factor for the arc slip Fs | 1.25 or more | 1.00 or more |
| (2) Safety factor for pull force Fs | 2.00 or more | 1.20 or more |

### b) Results of stability study after measures

#### i) Results of calculation of geotextile required fixation length and pull force

If the maximum required pull forced per number of steps installed n=1 step is TA=119.9 (kN/m), paralink 150L is necessary for the applied reinforcement materials.

| Study cross section | Stabilization work | Reinforcement material | Study case | Specifications for measures | | | Slip study slope |
|---|---|---|---|---|---|---|---|
| | | | | Number of steps installed n | Installation width L(m) | Installation position DL(m) | |
| (6) (No.0+340) | Laying work | Paralink | Time of service (kh method at time of earthquake) | 1.0 | 22.0 | 2.87 | Embankment Left side |

| Results of calculation of fixation length and required pull force | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Study installation steps | Required fixation length (m) | | Required deterrent force $T_A$(kN/m) | Arc and formed angle α (degrees) | Pull force Σcosα+sinα*tanφ | Pull force per step $T_A$(kN/m) (deterrent force/pull force) | Applied reinforcement materials | |
| | Length in the arc | 17.18 | | | | | Product number | Design strength (during and earthquakes) $T_{AE}$(kN/m) |
| | Fixation length | 4.13 | | | | | | |
| Step 1 | 21.31 | < Installation width (OK) | 99.7 | 66.14 | 0.831 | 119.9 | 150L | 124 |

(Unit: kN/m)

| Item number | 50L | 100L | 150L | 200L | 250L | 300L | 400L | 500L | 600L | 700L | 800L | 900L | 1000L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quality standard strength $T_{max}$ | 50 | 100 | 150 | 200 | 250 | 300 | 400 | 500 | 600 | 700 | 800 | 900 | 1000 |
| Design strength (2 years durability) $T_A$ | 35 | 71 | 106 | 142 | 177 | 213 | 284 | 359 | 431 | 503 | 575 | 647 | 718 |
| Design strength (120 years durability) $T_A$ | 33 | 66 | 99 | 133 | 166 | 199 | 266 | 336 | 403 | 470 | 537 | 605 | 672 |
| Design strength (during an earthquake) $T_{AE}$ | 41 | 83 | 124 | 166 | 208 | 249 | 332 | 420 | 504 | 588 | 672 | 756 | 840 |

### ii) Results of stability calculation using geotextile

Based on the results of stability calculation after measures, stability can be ensured through the effects of laying during an earthquake.

| Study cross section | Study case | Study seismic movement | Design horizontal Seismic intensity kh | Loaded weight (traffic load) q(kN/m$^2$) | Results of stability calculation with no measures | | Target safety factor Fs |
|---|---|---|---|---|---|---|---|
| | | | | | Embankment left slope | | |
| | | | | | Minimum safety factor Fsmin | Judgment | |
| (6) (No.0+340) | Time of service (normal times) | - | - | 13.0 | 1.335 | ○ | 1.25 |
| | Time of service (kh method at time of earthquake) | Seismic movement level 1 | 0.12 | - | 0.939 | × | 1.00 |

| Laying work (paralink) measures specifications | | | Results of stability calculation with measures | | Target safety factor Fs | Remarks |
|---|---|---|---|---|---|---|
| Item number | Design strength (during and earthquakes) $T_{AE}$(kN/m) | Installation width L(m) | Embankment left slope | | | |
| | | | Minimum safety factor Fsmin | Judgment | | |
| 150L | 124 | 22.0 | 1.387 | ○ | 1.25 | - |
| | | | 1.006 | ○ | 1.00 | Limited arc method |

### 2-2-2-6-10 Facility overview

An overview of the facility in the plan determined on based on the studies above is summarized in the table below.

Table 2-2-32 Facility Overview

| Item | | | Type/specifications |
|---|---|---|---|
| Bridge location | | | Existing bridge location |
| Width | Bridge portion | | Roadway 3.5m×2=7.0m, shoulder 0.5m×2=1.0m,<br>single-sided sidewalk 2.0m Total 10.0m (effective width)<br>Wheel guards at road side 0.6m, at sidewalk side 0.4m<br>Total 11.0m (total width) |
| | Approach roads | | Roadway 3.5m×2=7.0m, shoulder 0.5m×2=1.0m,<br>single-sided sidewalk 2.0m Total 10.0m (effective width)<br>Protection shoulder 1.0m×2=2.0m Total 12.0m (total width) |
| Bridge type | | | PC 3-span post-tension type slab girder bridge |
| Span ratio selection, bridge length | | | 3@30.0m=90.0m (road centerline) |
| Bridge surface pavement | | | Asphalt pavement (road portion 80mm) |
| A1 abutment (Lami side) | | Type | Inverted T abutment |
| | | Structure height | H=7.0m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=39.5m, n=12 units) |
| A2 abutment (Suva side) | | Type | Inverted T abutment |
| | | Structure height | H=9.4m |
| | | Foundation work | Spread foundation |
| P1 pier | | Type | Oblong pier |
| | | Structure height | H=11.8m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=31.0m, n=12 units) |
| P2 pier | | Type | Oblong pier |
| | | Structure height | H=11.8m |
| | | Foundation work | Cast-in-place pile foundation (φ1.5m, L=11.5m, n=12 units) |
| Approach roads | | Length | Lami side: approx. 230m<br>Suva side: approx. 270m Total approx.500m |
| | | Pavement | Asphalt pavement (surface layer 50mm + base layer 50mm=100mm） |
| Revetments | Right bank | Type (length) | Rubble (upper layer D50-450mm,lower layer D50-150mm) 70m |
| | Left bank | Type (length) | Rubble (upper layer D50-450mm,lower layer D50-150mm) 60m |
| Bed protection | P1 bridge pier | Type (area) | Foundation consolidation mat, covering type 3t-type 303$m^2$ |
| | P2 bridge pier | Type (area) | Foundation consolidation mat, covering type 3t-type 310$m^2$ |

### 2-2-3 General design diagram

The general design diagram created based on the basic plan above is stored on the next page.

- Figure 2-2-34 General view of Tamavua-i-wai Bridge
- Figure2-2-35 General view of substructure
- Figure2-2-36 Plan and profile view of approach road
- Figure2-2-37 Typical cross section view of approach road
- Figure2-2-38 Typical cross section view of revetment
- Figure2-2-39 Soft ground prevention work

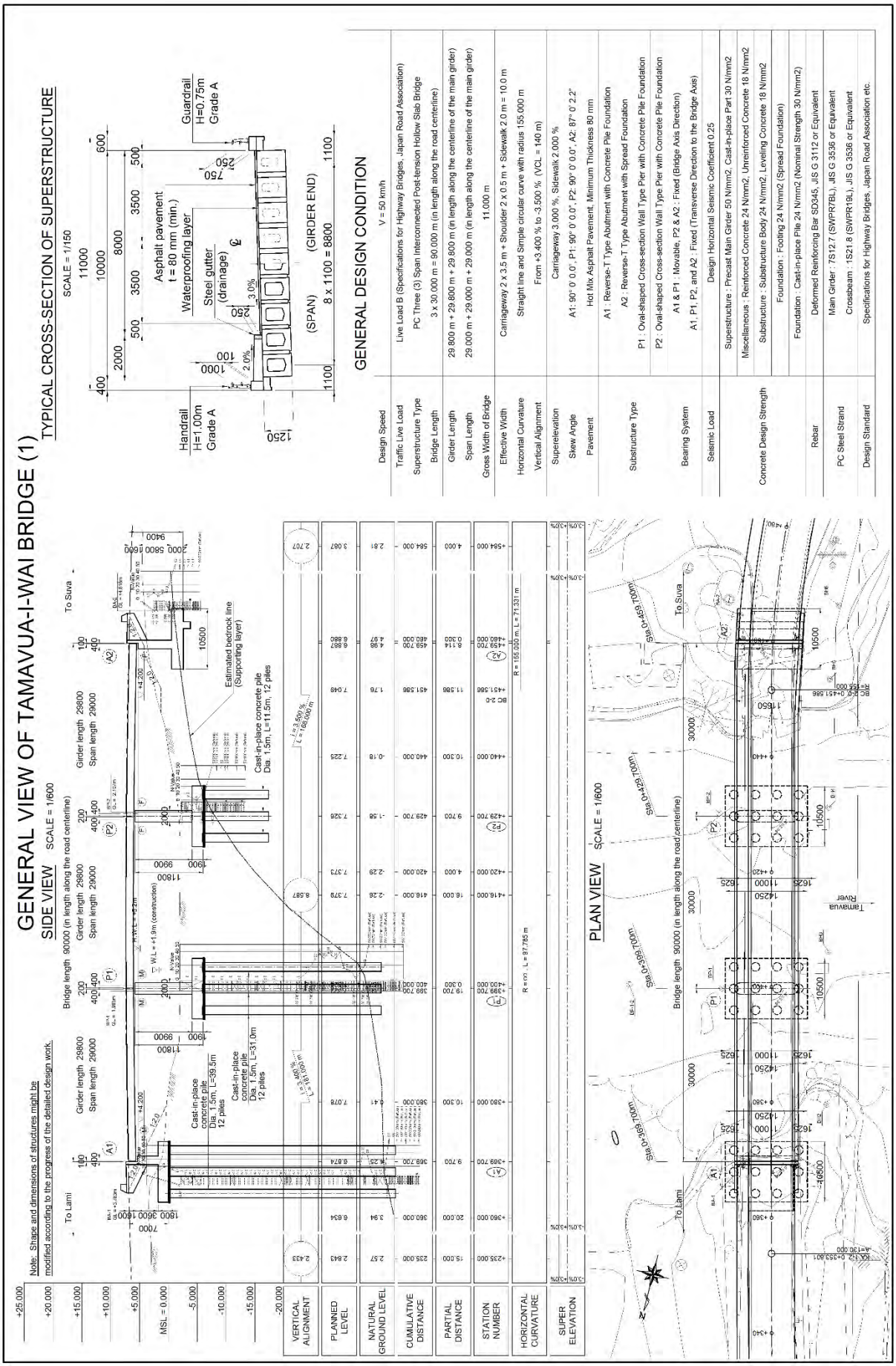



Figure 2-2-31 General view of Tamavua-i-wai Bridge

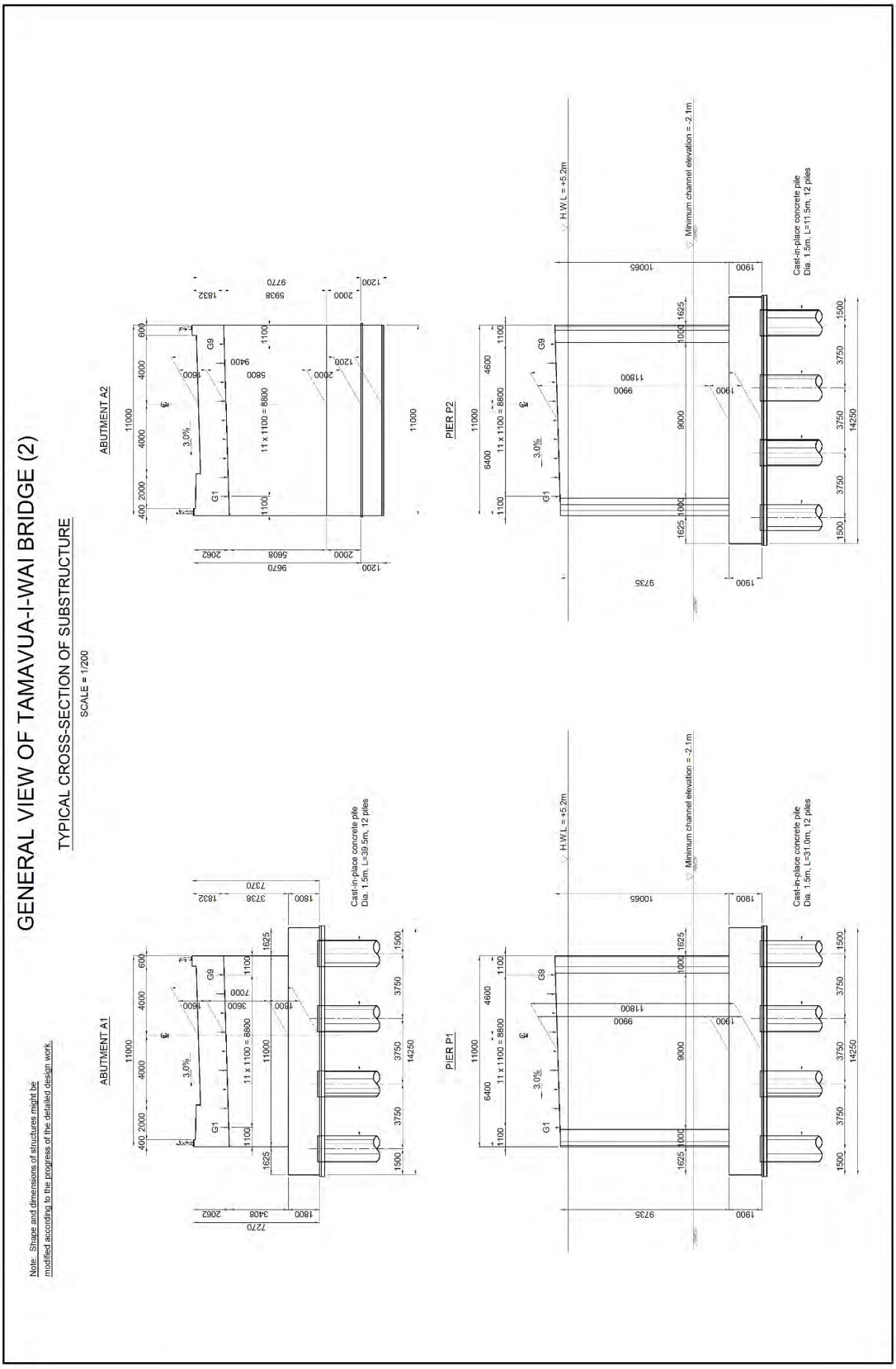



Figure2-2-32 General view of substructure

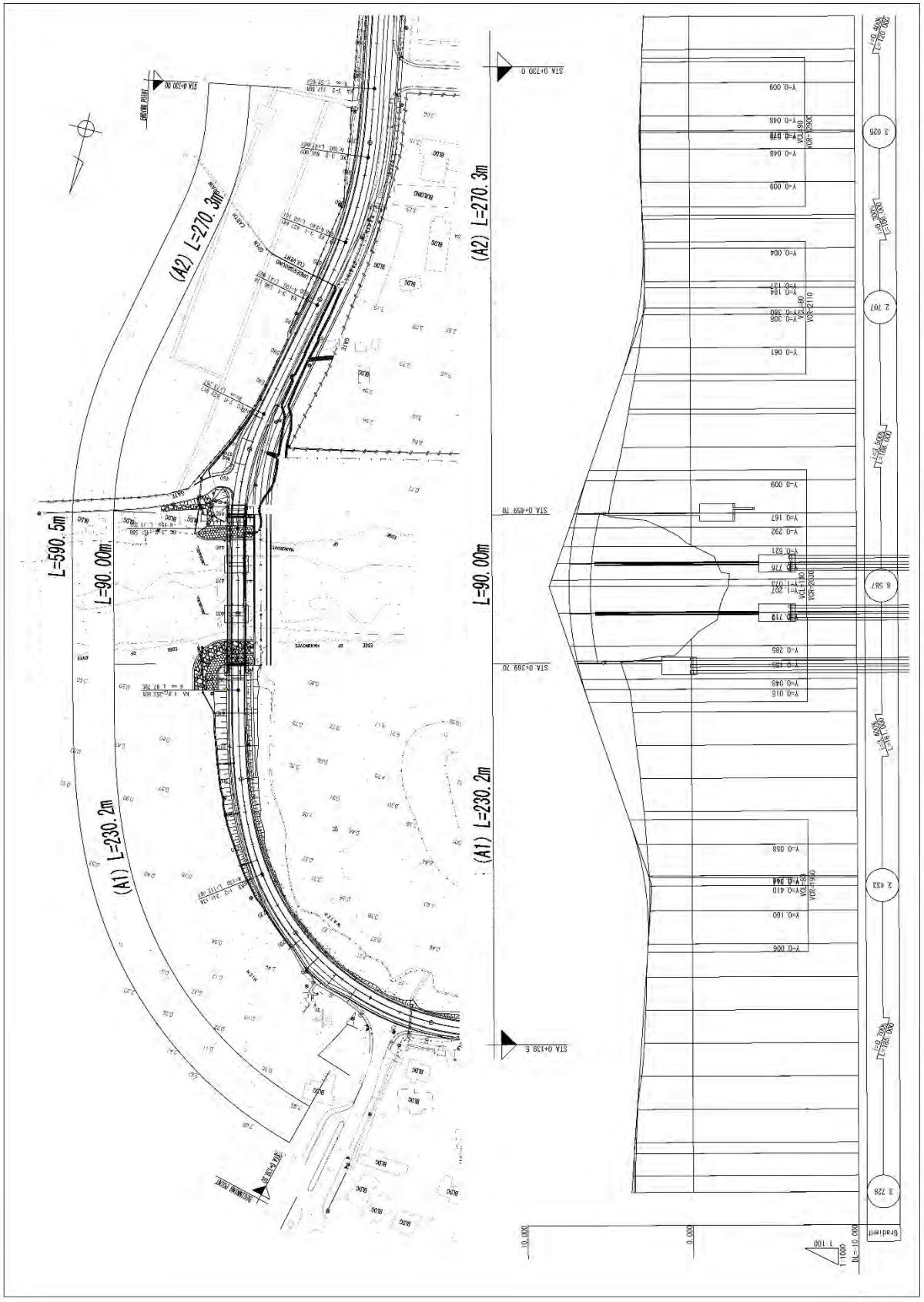



Figure2-2-33 Plan and profile view of approach road

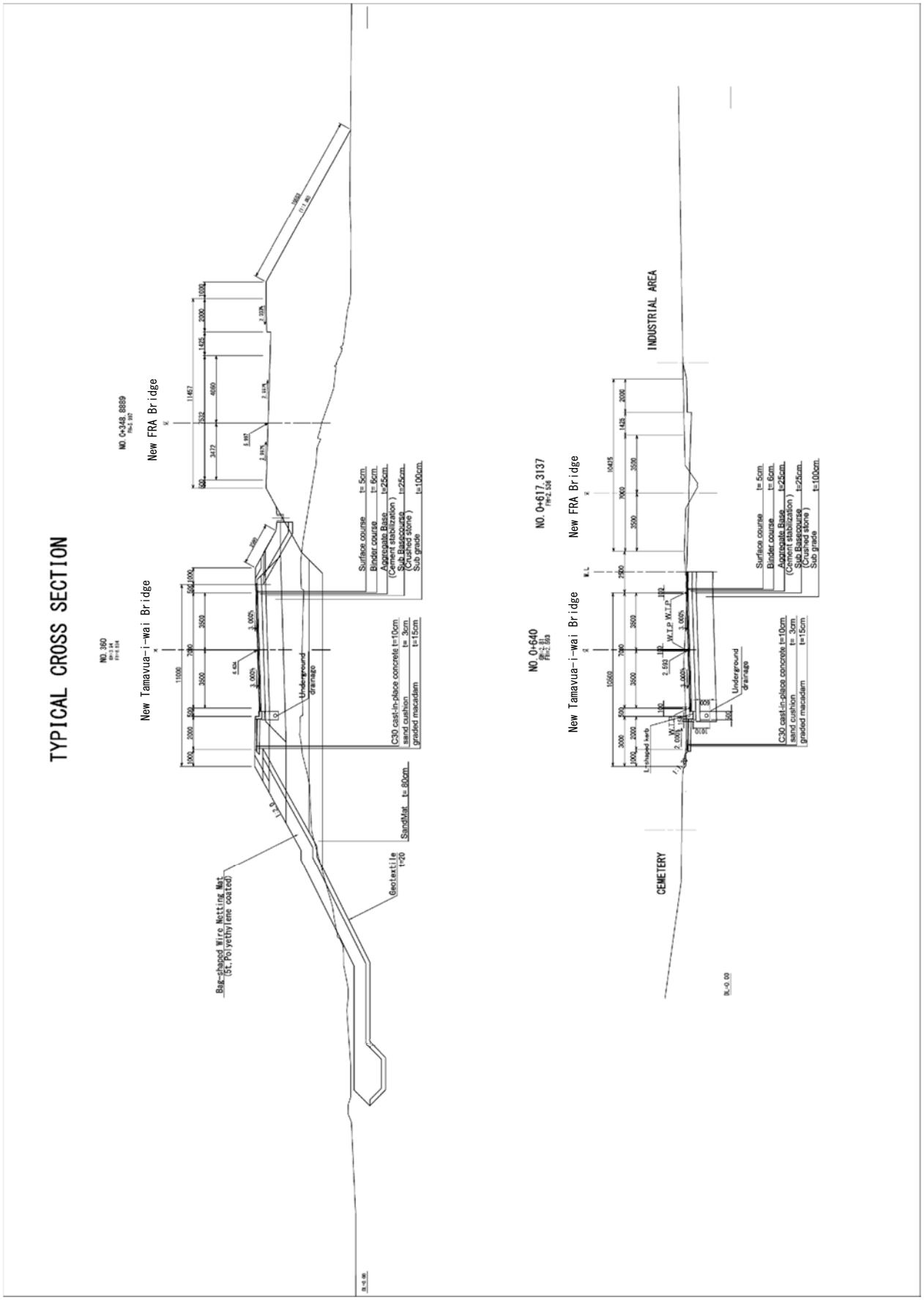



Figure2-2-34 Typical cross section view of approach road

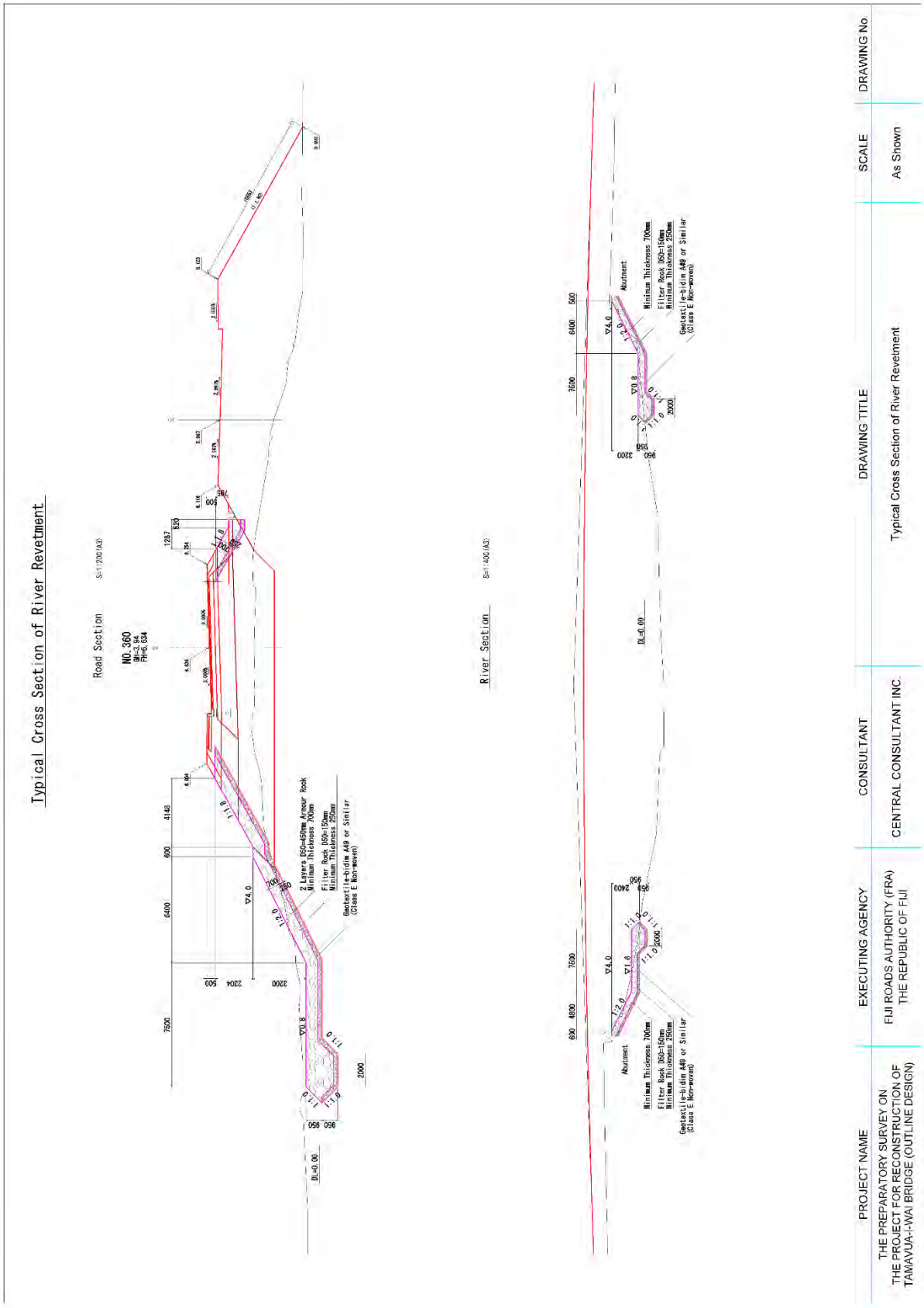



Figure2-2-35 Typical cross section view of revetment

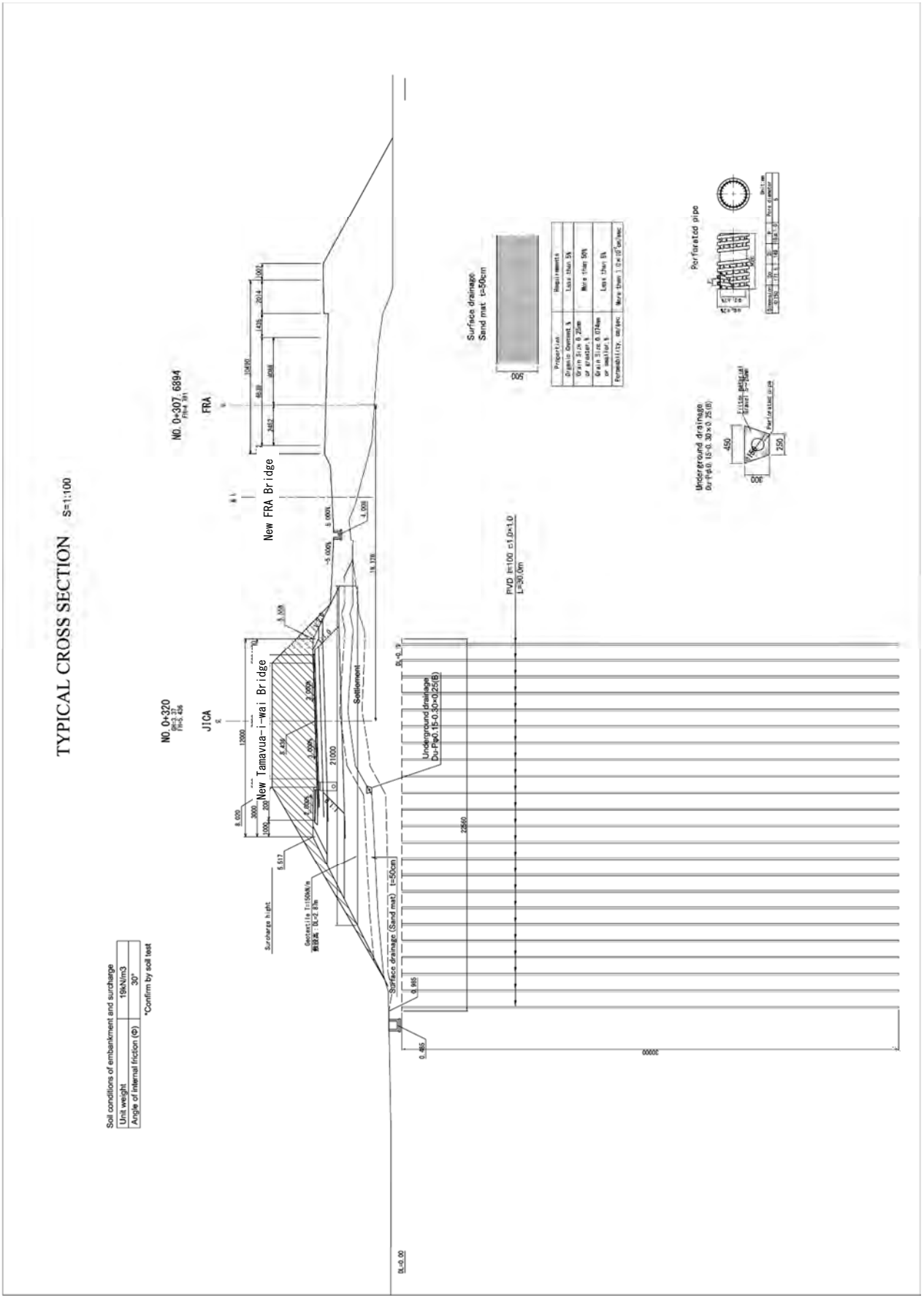



Figure2-2-36 Soft ground prevention work

## 2-2-4 Construction plan

### 2-2-4-1 Construction policy

Assuming this plan is implemented under the framework of Japanese grant aid, the following matters shall be considered as the construction policy.

① Local technicians, laborers, and materials shall be used as much as possible for this plan to contribute to the revitalization of the regional economy, the creation of employment opportunities, and promotion of the transfer of technology.

② Fiji is requested to secure the land (approach roads, construction yard, etc.) required for implementation of the plan by PQ (pre-qualification) public notice in Japan as a responsibility of the recipient country.

③ Fiji is requested to implement tax exemption measures for tariffs, domestic taxes, and value-added tax levied in Fiji related to the project, including the procurement and import of equipment and materials, and locally provided services related to the construction.

④ Fiji is requested to provide assistance related to entering and leaving the country for people involved in the implementation of the project.

⑤ Careful supervision shall be conducted in an aim to enhance the reliability of construction, including precise management for the confirmation of the actual geological conditions and to ensure the support layer for the pile foundation etc. at the time of foundation work.

⑥ A construction method that is appropriate and feasible in light of rainfall morphology and water level fluctuations shall be adopted, and a realistic and assuring construction plan shall be formed.

⑦ For the maintenance and repair after the completion of construction, a proposal of its method, timing and operational policies shall be made, and OJT for local technicians who will be responsible for future maintenance management shall be included in the plan as part of this.

### 2-2-4-2 Items of note related to construction

#### (1) Ensuring safety during the construction period

During the construction period, the consideration shall be given to the following matters in particular to ensure the safety referring the JICA's safety management guideline for ODA construction works (September 2014).

- The entrance for construction vehicles will be from Queens Road, and because this road has heavy vehicle traffic, security personnel will be stationed at this entrance in an effort to prevent traffic accidents.
- Since there are residents in and around the existing building in the riverbank on the left bank upstream of the river, it is necessary to pay sufficient attention to ensuring safety during the construction period.
- Because work will be conducted in a river, an effort shall be made to prevent accidents from a rise in the water level through the establishment of a sufficient monitoring system and contact system for responding to rising water levels.

**(2) Environmental preservation during the construction period**

Consideration shall be given to the following matters in particular for environmental preservation during the construction period.

- Particulates from the running of construction vehicles shall be controlled through measures including sprinkling and controls on speed.
- Work in the early morning and late night shall be avoided to noises and vibrations from construction machinery during those times.
- Measures shall be taken including securing silt fence, spare tanks and pumps in response to water quality degradation from the runoff of muddy water during work in the river on the substructure, etc.
- Measures for removed turf, etc. shall be taken for embankment slopes.

**(3) Compliance with labor standards laws**

The construction contractor shall comply with the current construction related laws in Fiji, follow appropriate working conditions and practices related to employment, and prevent conflicts with workers and ensure their safety.

**(4) Focusing on concrete quality management**

The main construction work for this project includes the A1 abutment, P1 pier, P2 pier, and A2 abutment as substructures, and concrete girders and PC cables as superstructures, and the main construction work can be considered concrete construction work. It is necessary to conduct construction with concrete quality control as a priority items, including the materials management of aggregate, sand, water, cement, etc., specification standards for concrete mixing plants, concrete transport standards, concrete laying management, and curing management.

**2-2-4-3 Construction classifications**

An overview of the respective responsibilities of the governments of Japan and Fiji when implementing the grant aid project is shown below.

Table 2-2-45 Respective Responsibilities of the Governments of Japan and Fiji

| Responsibilities of Japan | Responsibilities of Fiji |
|---|---|
| ・ Reconstruction of the Tamavua-i-wai Bridge (bridge length of 90m) and construction of an approach roads (Approx.500m) and revetments, etc.<br>・ Removal of existing abutments.<br>・ Safety measures for construction work during the construction period and general traffic that passes through the construction section.<br>・ Environmental pollution prevention measures for construction work during the construction period. | ・ Acquisition of the land required for the plan and removal of facilities affected.<br>・ Free provision of the temporary facilities and land required for the project.<br>・ Removal and relocation work for high voltage electric power lines, water pipes, communication cables, and overhead electric power lines impacted by the implementation of the project.<br>・ Provision of electricity, telephones, a water supply, etc. for the site office, housing, etc.<br>・ Supply of IDs to the people involved in construction. |

| | |
|---|---|
| • Procurement, import, and transport of the construction equipment and materials indicated in the equipment and materials procurement plan. Re-export of the imported equipment and materials to the procurement country.<br>• Implementation design indicated in the construction supervision plan, creation of bidding documents and contracts, and bidding assistance and work construction supervision. Includes supervision of environmental management plan. | • Provision of a waste disposal site as required for the project.<br>• Monitoring of the entire construction area during the construction period.<br>• Exemption from tariffs, domestic taxes, and other taxes charged by the government of Fiji.<br>• Supervision by members of the government of Fiji during the construction period.<br>• Provision of assistance to Japanese people and the people from third countries involved in the project with entering and staying in the country.<br>• Covering bank fees (for bank account opening, authority to pay procedures)<br>• Monitoring related to environmental and social considerations during the construction period and after service provision. |

### 2-2-4-4 Construction supervision plan

#### (1) Basic policy for construction supervision work

Assuming this project is implemented under the framework of Japanese grant aid, the following matters shall be considered as the basic policy for construction supervision work.

- Because the quality of construction has a significant impact on the life and durability of the completed facility, construction supervision work shall be performed with quality control as the foremost priority. In particular, concrete work, foundation work, and revetment work which river work involves should be focused on.
- Following the quality control above, the management items such as progress management, safety management, and payment management should be focused.
- In order to respond to the above issues, joint site inspections and regular meetings by construction contractor and consultant shall be held once a week to confirm issues and discuss response policies.
- In addition, a regular meeting shall be held once a month with a representative from FRA that is the client, construction contractor, and consultant to confirm issues and discuss response policies.
- A local technician shall be hired as an inspector, and efforts shall be made to transfer technologies including quality control, progress management, and safety management methods that are related to the construction supervision technologies.
- Instructions to the construction contractor, all meeting minutes, and reports to the client, etc. shall be documented and reported through documents.

### (2) Construction supervision work of the consultant

The main work included in the consultant contract is as follows.

#### 1) Bidding documents drafting stage

Implementation design shall be conducted for each facility in accordance with the results of the general design survey report. Next, the consultant shall draft the construction contract and gain the approval of the Fiji government through FRA the following deliverables.

- Design report
- Design drawing
- Bidding documents

#### 2) Construction bidding stage

FRA shall select a construction contractor with a Japanese nationality through an open bid under the assistance of the consultant. A representative selected by the government of Fiji that participates in this open bid and the subsequent construction contract shall have all approval authority related to the construction contract. The consultant shall assist FRA with the following duties.

- Bid announcement
- Advance eligibility screening
- Bidding and bid evaluation

#### 3) Construction supervision stage

After the signing of the construction contract between the construction contractor that was selected as a result of the bid and FRA that is the representative for the government of Fiji, the consultant shall issue a construction start order to the construction contractor and start construction supervision work. The construction supervision work consists of direct reports on construction progress to FRA, the Japanese Embassy in Fiji, and JICA, and the sending of monthly reports to other stakeholders as necessary. The construction supervisor shall conduct supervision work that includes administration related to work progress, quality, safety, and payments and technical improvement measures and proposals related to construction work. In addition, a defect inspection shall be conducted one year after the completion of construction supervision. This shall complete the consultant service.

### (3) Personnel plan

The personnel and roles required for the detailed design, construction bidding, and construction supervision stage are as follows.

#### 1) Detailed design stage

- Operations chief: Main person responsible for technical aspects in detailed design, supervision of overall operations coordination, and responding to the client.

- Bridge technician (superstructure): Conducts field surveys, structural calculations, design diagram drafting, and quantity calculations related to superstructure design.
- Bridge technician (substructure): Conducts field surveys, structural calculations, design diagram drafting, and quantity calculations related to substructure design.
- Bridge technician (foundation): Conducts structural calculation, stability calculations, design diagram drafting, and quantity calculations related to foundation design.
- Road technician: Conducts alignment finalization calculation, standard cross-section finalization, slope work studies, road drainage design, design diagram drafting, and quantity calculation for road design.
- River technician: Conducts field surveys, structural calculations, stability calculations, design diagram drafting, and quantity calculations related to river structure design.
- Environmental and social considerations supervisor: Conducts field surveys, site coordination, etc. related to environmental and social considerations overall.
- Design verifier: Verifies the design.
- Construction plan and integration supervisor: Conducts construction plan drafting and integration work using the design quantity and construction work unit price from the detailed design results.

**2) Construction bidding stage**

Finalize advance eligibility screening and bidding documents, implement advance eligibility screening, and assist FRA in the construction bid evaluation.

- Operations chief: Supervises the consultant service described above throughout the bid creation work.
- Bridge technician: Approves bidding documents and assists bid evaluation.
- Bidding documents supervisor: Drafts bidding documents.
- Technician for project applying preliminary expenses: Conducts supplemental work related to unit price agreement and unit price monitoring after the bid.

**3) Work supervision stage**

- Operations chief: Supervises the consultant service overall in work supervision.
- Resident supervision technician: In charge of work supervision on site and makes reports and coordinates with the related organizations in Fiji on work progress.
- Construction supervision technician (foundation): Conducts construction supervision related to foundation work.
- Construction supervision technician (girder production and installation): Conducts construction supervision related to girder production and installation.
- Construction supervision technician (soft ground prevention work): Conducts construction supervision related to soft ground prevention work.
- Defect inspector: Conducts completion inspection.

### 2-2-4-5 Quality control plan

The quality control plan for the project is shown in the table below.

Table 2-2-33 List of quality control items (draft)

| Item | | | Test Method | Frequency of Test |
|---|---|---|---|---|
| Subgrade (macadam) | Blended material | | Liquid limit, plasticity index (<sieve No. 4) | For each blend |
| | | | Particle-size distribution (blending) | 〃 |
| | | | Aggregate abrasion loss test | 〃 |
| | | | Aggregate density test | 〃 |
| | | | Maximum dry density (compaction test) | 〃 |
| | Laying | | Density test (compaction rate) | Once/day |
| Prime coat / tack coat | Material | Bituminous material | Quality certificate | For each material |
| | | | Application amount | Per 500 $m^2$ |
| Asphalt | Material | Bituminous material | Quality certificate, ingredient analysis table | For each material |
| | | Aggregates | Particle-size distribution (blending) | For each blend, once/month |
| | | | Water absorption | For each material |
| | | | Aggregate abrasion loss test | 〃 |
| | Blending test | | Stability | For each blend |
| | | | Flow value | 〃 |
| | | | Porosity | 〃 |
| | | | Aggregate porosity | 〃 |
| | | | Tensile strength (indirect) | 〃 |
| | | | Residual stability | 〃 |
| | | | Design asphalt amount | 〃 |
| | Laying | | Mixing temperature | As needed |
| | | | Rolling temperature | For each transport |
| | | | Marshall test | About once/day |
| Concrete | Material | Cement | Quality certificate, chemical & physical test results | For each material |
| | | Water | Ingredient test result | For each material |
| | | Admixture | Quality certificate, ingredient analysis table | For each material |
| | | Fine aggregates | Oven dry density | For each material |
| | | | Grain size distribution, fineness modulus | 〃 |
| | | | Percentages of clay lumps and soft particles | 〃 |
| | | Coarse aggregates | Oven dry density | For each material |
| | | | Flake content | 〃 |
| | | | Particle-size distribution (mix) | 〃 |
| | | | Sodium sulfide diagnosis (missing mass) | 〃 |
| | At the time of blend test | | Compressive strength test | For each blend |
| | At the time of laying | | Slump | Once/batch |
| | | | Temperature | Once/day |
| | Strength | | Compressive strength test (7 days, 28 days) | Once/day or $50m^3$ above |
| Steel bars | Material | | Quality certificate, tensile test result | For each lot |
| Structural steel | Material | | Mill sheet | For each lot |
| Coating | Material | | Quality certificate, ingredient table | For each lot |
| Bearing | Material | | Quality certificate, strength test result | For each lot |
| Lighting equipment | Material | | Quality certificate, strength test result | For each lot |

Note): Basically, the test is performed once before the start of use. However, if the material is changed, the test should be performed each time.

### 2-2-4-6 Equipment and materials procurement plan

#### (1) Construction equipment and materials procurement

The materials that can be procured locally are earth and sand, rubble, concrete, wood, formwork plywood, rebar, etc., and other materials will be imported. The equipment and materials procurement policy is as follows.

- If there are imports that are constantly supplied to the market that are of a sufficient quality, these will be procured.
- Products that cannot be procured locally will be procured from Japan or a third country. Suppliers shall be decided on by comparing factors such as prices, quality, and time required for customs clearance.

The possible suppliers for the main construction equipment and materials are shown in the table below.

Table2-2-47 Suppliers of Main Construction Equipment and Materials

| Item | Supplier | | | Reason for procuring from Japan |
|---|---|---|---|---|
| | Fiji | Japan | Third country | |
| PC steel | | ○ | | It is not distributed in the target country. Although procurement from a neighboring third country would be possible, it is not clear that the specs would be satisfied. |
| Bridge railing | | ○ | | It is not distributed in the target country. Bridge railing is a material that is noticeable to people passing by. There is variation in the quality of products from neighboring third countries, and there would be a possibility of defects in the finish if such products were used. |
| Temporary steel materials | | ○ | | They are not distributed in the target country. Although procurement from a neighboring third country would be possible, it is not clear that the specs would be satisfied. |
| Rubber bearing | | ○ | | It is not distributed in the target country. Although procurement from a neighboring third country, there is variation in the quality of the materials (rubber), and it is not clear whether they would satisfy the specifications for this project. |
| Aggregate | ○ | | | |
| Portland cement | ○ | | | |
| Expansion device | | ○ | | It is not distributed in the target country. Although procurement from a neighboring third country, there is variation in the quality, and it is not clear whether they would satisfy the specifications for this project. |
| Rebar | ○ | | | |
| Wood for mold forms | ○ | | | |
| Steel forms for main girders | | ○ | | The materials shall be procured from Japan because precision is required. |
| Diesel | ○ | | | |
| Gasoline | ○ | | | |
| Bridge surface waterproofing material | | ○ | | It is not distributed in the target country. Although procurement from a neighboring third country would be possible, it is not clear that the specifications would be satisfied. |
| Materials for soft ground countermeasure | | | | Geotextile and plastic board drain materials are not distributed in Fiji. Although procurement from a neighboring third country would be possible, it is not clear that the specifications would be satisfied. |

### (2) Construction machinery

Construction machinery for road construction can be procured in Fiji. However, bridge production and installation machinery cannot be procured in Fiji, and therefore it shall be procured from Japan or a third country.

In terms of concrete plants and aggregate plants, ready-mixed concrete companies have their own plants in Suva and the suburbs of Suva, and they supply ready-mixed concrete to construction companies. The suppliers for the main construction machinery and the reason for procuring from Japan are shown in the table below.

Table2-2-48 Suppliers of Main Construction Machinery

| Model | Supplier | | | Reason for procuring from Japan |
|---|---|---|---|---|
| | Fiji | Japan | Third country | |
| Dump trucks (2t, 4t, 10t) | ○ | | | |
| Bulldozers (15t, 20t, 32t) | ○ | | | |
| Backhoes (0.45m$^3$ (piling up), 0.80m$^3$ (piling up)) | ○ | | | |
| Tractor shovels (wheel loaders)1.2m$^3$ | ○ | | | |
| Large breakers 1300kg | ○ | | | |
| Trailers (35t) | ○ | | | |
| Motor graders | ○ | | | |
| Sprinkler vehicles | ○ | | | |
| Tire rollers | ○ | | | |
| Vibration rollers | ○ | | | |
| Asphalt finishers | ○ | | | |
| Agitator trucks | ○ | | | |
| Concrete pump vehicles | ○ | | | |
| Production equipment for PC segment girder | | ○ | | Difficult to procure locally |
| PC girder installation equipment | | ○ | | Difficult to procure locally |
| Soft ground measures equipment | | ○ | | Difficult to procure locally |
| Truck cranes (25t) | ○ | | | |
| Truck cranes (50t) | | ○ | | Difficult to procure locally |
| Crawler cranes (80t) | | | | |
| Vibratory hammers | | ○ | | Difficult to procure locally |
| Full circle pile drivers | | ○ | | Difficult to procure locally |

### 2-2-4-7 Implementation Schedule

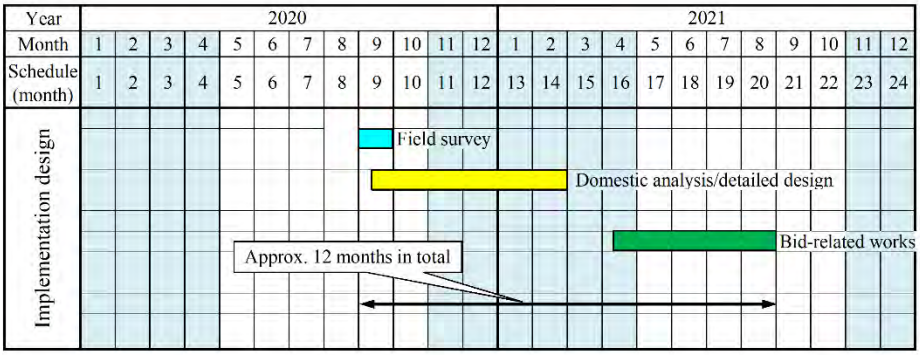
After executing an exchange of notes (E/N) related to the implementation design for this project, the consultant shall enter a consulting service contract and start the implementation design for the project as a grant aid project. After the service is started, the consultant shall conduct a field survey for implementation design for a period of about 2 weeks in Fiji followed by the production of detailed design and bidding document drafting in Japan.

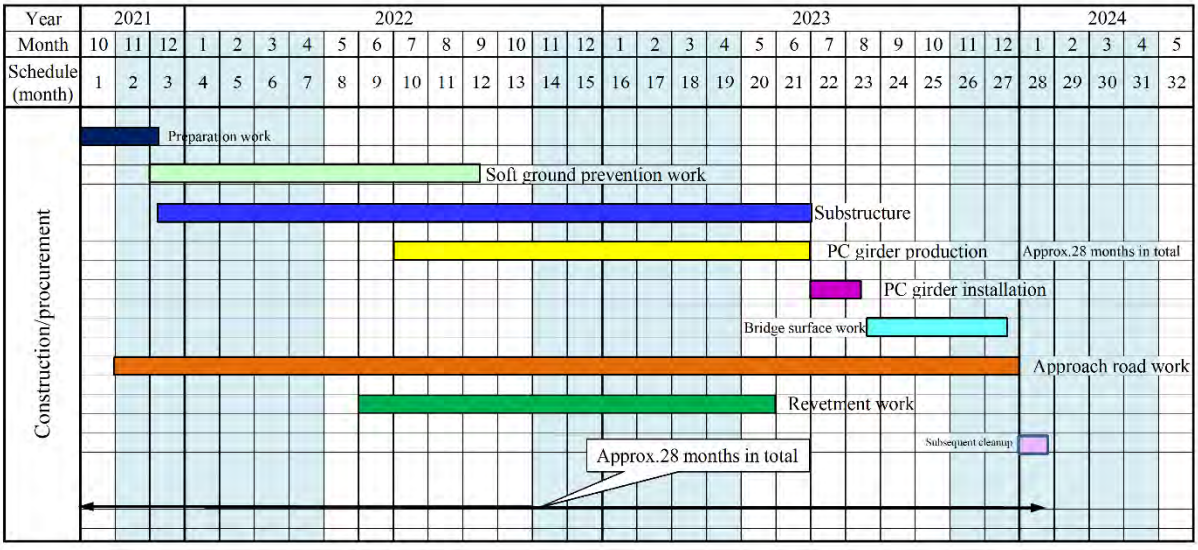
After that, another exchange of notes (E/N) related to bidding assistance work, construction supervision work, and bridge construction work will be executed, and then, the consultant shall conduct the work related to bidding procedure namely, bidding document preparation, vendor eligibility screening, bidding, vendor selection, and construction contracts, as the assistance for the Fiji government which implements the bidding.

Through the bidding process above, the selected construction contractor shall enter a construction contract with the Fiji government, followed by receiving certification from the government of Japan for the construction contract, and then start construction upon receiving construction start order from the consultant.

The implementation schedule above is shown in the table below.

Table2-2-34 Work Implementation Schedule Table



## 2-3 Obligations of Recipient Country

The responsibilities of the Fiji government in the implementation of the project plan are as follows.

### 2-3-1 General matters related to grant aid from Japan

① Provide the data and information necessary for the implementation of the project plan.
② Secure the lands (for the road, works and accommodations for the project contractor, storage for the materials and equipment) required for the implementation of the project plan.
③ Clear each construction site before the start of construction.
④ Open an account with a bank in Japan under the name of Fiji government, and issue authority to pay.
⑤ Conduct prompt unloading work at the cargo handling point in Fiji, and to ensure the implementation of tax exemption and duty-free concession procedures at customs.
⑥ For the provision of products or services under authorized contracts, Japanese corporations and Japanese people involved in this project shall be exempt from tariffs, domestic taxes, and other taxes levied in Fiji.
⑦ People involved with the project shall be permitted to enter and stay in Fiji for its implementation and/or provision of services under the approved contracts.
⑧ Permits and other authorizations will be granted for implementation of the project as necessary.
⑨ The facilities constructed through this project shall be properly and effectively maintained, managed, and preserved.
⑩ The host country shall be responsible for all costs within the scope of project besides the costs covered by Japanese grant aid.

### 2-3-2 Specific considerations for this program

① Removal of facilities impacted by construction
② Acquisition of EIA approval from the Ministry of Environment (MOE)
③ Securing additional land required for the project besides the existing road land
④ Temporary relocation or relocation of water pipes, communication cables, high voltage electric power lines, electricity poles and overhead electric power lines
⑤ Provision and clearing of a temporary yard and its land grading

(Complete by PQ public notice.)

⑥ Provision of soil dumping ground and waste disposal site
⑦ Provision of IDs to people involved in construction
⑧ Monitoring of the entire construction area during the construction period
⑨ Supervision by members of the government of Fiji during the construction period

## 2-4 Project operations, maintenance management plan

The government of Fiji shall supervise the implementation and maintenance management of the project. In addition, the Fiji Roads Authority (FRA) that is a part of the Minister for Infrastructure and Meteorological Services shall be responsible for the maintenance management of the bridge, approach roads, and revetments newly constructed in this project.

A proposal on maintenance plan after the completion of the construction shall be made by the resident supervisor with its repair method, timing and operational policies, and OJT for the local technicians who will be responsible for future maintenance management shall be included in this proposal.

The maintenance management work after the completion of the project can be roughly divided into work regularly conducted annually and its conducted in units of several years. The necessary for this project are shown below.

### 2-4-1 Maintenance management method

#### (1) Inspections, maintenance management required annually

The annually required inspection and maintenance management are as follows.

① Removal and cleaning of sand and garbage that gets stuck in drainage pipes and drainage ditches on the bridge surface

② Removal and cleaning of garbage near expansion joints and bearings

③ Maintenance management of traffic safety work including the repainting of road marking

④ Inspections and repairs to revetment work after floods

⑤ Removal of boulders, driftwood, etc. after floods

⑥ Weeding of road shoulders and slope surface

⑦ Pavement patching

#### (2) Maintenance management conducted in units of several years

The maintenance management that shall be conducted roughly once every five years is as follows.

- Bridge surface and approach roads pavement overlaying
- Inspections and repairs to revetments
- Inspection, repainting, and repairs to bridge railing

### 2-4-2 Maintenance management structure

The following matters will be implemented to ensures the maintenance and management method in 2-4-1 above.

① Establish a maintenance management team in FRA. The team shall be configured as follows.
- Engineers: 1
- Inspection personnel: 2
- Records personnel: 1

② Establish a structure capable of responding promptly if small repairs are required in light of the regular inspections.

③ Develop a databased for the results of regular inspections and use it to help with developing accurate estimates for the required maintenance management costs.

④ Store the drawings and documents for the project (completion drawing, bridge inventory, etc.), and create a system to facilitate repairs in the future.

# 2-5 Estimated Costs for the Project

## 2-5-1 Estimated Grant Aid Project Costs

### 2-5-1-1 Cost born by the Government of Japan

The project will be implemented in accordance with the Japan's grant aid scheme and the cost will be determined before concluding the Exchange of Note for the project.

### 2-5-1-2 Cost born by the Government of Fiji

Table2-5-1 Cost born by the Government of Fiji

(Unit: FJD 1 = JPY 53.28)

| Responsibility | Cost (FJD) | Yen conversion (thousand yen) |
|---|---|---|
| (1) Land acquisition cost | 50,517 | 2,692 |
| (2) Land compensation | 362,895 | 19,335 |
| (3) Logging / Rooting | 15,000 | 799 |
| (4) Demolition of the existing bridge | 1,922,730 | 102,443 |
| (5) Relocation of utilities attached on the existing bridge | 1,388,500 | 73,979 |
| (6) Relocation of electric poles and wires | 60,000 | 3,197 |
| (7) Bus shelter relocation (replace with new shelter) | 90,000 | 4,795 |
| (8) Bank charges | 95,000 | 5,062 |
| (9) EIA | 20,000 | 1,066 |
| (10) EMP and EMoP | 52,000 | 2,771 |
| (11) PMR and Completion report | 67,000 | 3,570 |
| (12) Facilities (electricity, water supply and drainage) | 65,000 | 3,463 |
| (13) Safety measures | 180,000 | 9,590 |
| (14) Supervision and Contract management | 640,000 | 34,099 |
| (15) Operation and Maintenance | 123,510 | 6,581 |
| (16) VAT of expenses borne by the Fiji side | 461,894 | 24,610 |
| (17) VAT of expenses borne by the Japan side (to be refunded) | 805,000 | 42,890 |
| Total | 6,399,046 | 340,941 |

### 2-5-1-3 Estimate conditions

① Time of estimate: June 2018
② USD exchange rate: USD 1.00 = JPY 108.75 (average for past three months from May 31, 2018)
③ FJD exchange rate: FJD 1.00 = JPY 53.28(average for past three months from May 31, 2018
④ Construction period: 28 months
⑤ Other: This project will be implemented based on the grant aid guidelines of the Japanese government.

### 2-5-2 Operations and maintenance management costs

The Fiji Roads Authority (FRA) shall be responsible for maintenance management of the bridge, approach roads, and revetments developed in this project. The main maintenance management work after the construction of the Tamavua-i-wai Bridge are the daily inspections, cleaning, and repairs indicated in the table below, and the maintenance management costs are estimated to be FJD 61.7 thousand. These maintenance management costs are equivalent to 0.01% of the FRA's road maintenance management budget of FJD 500.8 million (FY2017/2018), and it has been deemed that maintenance management is manageable by them sufficiently.

Table 2-5-2 Main O&M items and expenses

| Category | Frequency | Area Inspected | Work Details | Est. Cost (FJD) | | Notes |
|---|---|---|---|---|---|---|
| | | | | Per Inspection | Per Annum (Annual Avg.) | |
| Drainage O&M | 2 times/year | Bridge surface drains and gutters | Sediment removal | 2,140 | 4,279 | |
| Traffic safety work O&M | Annually | Road markings | Repaint | 4,448 | 4,448 | 10% of direct cost anticipated |
| Road maintenance | 2 times/year | Road shoulders and slopes | Weeding | 5,274 | 10,548 | |
| Inspection and repair for revetments and bed protection | When flooded (expected every 2 years) | Revetments and bed protection | Repair damaged areas | 15,240 | 7,620 | 2% of direct cost anticipated |
| Pavement maintenance and repair | Once/5 years. | Paved surfaces | Overlay and repair cracks, potholes, etc. | 39,640 | 7,928 | 10% of direct cost anticipated |
| Replacement of expansion joint and bearing | Once/10 years | Expansion joint and bearing | Replacement of expansion joint and bearing | 92,868 | 9,287 | |
| Direct construction cost | | | | | 44,110 | |
| Overhead (40%) | | | | | 17,644 | |
| Annual O&M costs (yearly average) | | | | | 61,755 | |