**THE REPUBLIC OF FIJI**

**MINISTRY OF AGRICULTURE, RURAL AND MARITIME DEVELOPMENT AND NATIONAL DISASTER MANAGEMENT**

# THE PROJECT FOR THE PLANNING OF THE NADI RIVER FLOOD CONTROL STRUCTURES

## VOLUME Ⅱ MAIN REPORT

## PART Ⅰ: MASTER PLAN STUDY

**JULY 2016**

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**YACHIYO ENGINEERING CO., LTD.**
**CTI ENGINEERING INTERNATIONAL CO., LTD.**

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# THE REPUBLIC OF FIJI
# THE PROJECT FOR THE PLANNING OF THE NADI RIVER FLOOD CONTROL STRUCTURES

## COMPOSITION OF FINAL REPORT

**VOLUME I** **SUMMARY**

**VOLUME II** **MAIN REPORT**

**Part Ⅰ** **MASTER PLAN STUDY**
**Part Ⅱ** **FEASIBILITY STUDY**

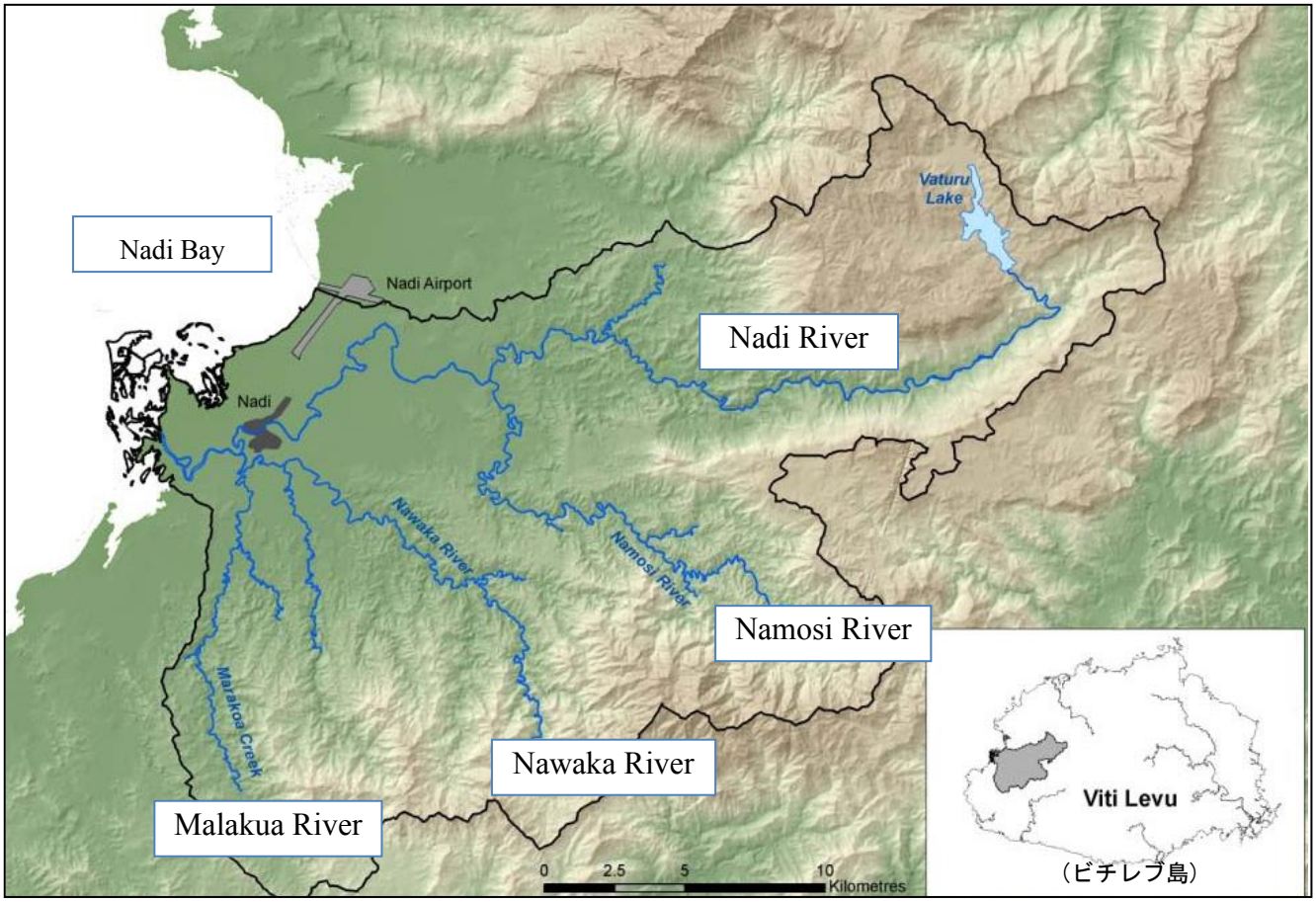
**VOLUME Ⅰ Ⅲ** **DATA BOOK**

**Part Ⅰ** **DATA BOOK (1)**
**Part Ⅱ** **DATA BOOK (2)**

Exchange Rate: FJD 1 = JPY 54.5, 1 USD=FJD 2.17

(As of April, 2016)

# <Map of Project Area>




（出典）Integrated Water Resource Management Demonstration Project

Photo

Photo-1 Inception Report Meeting

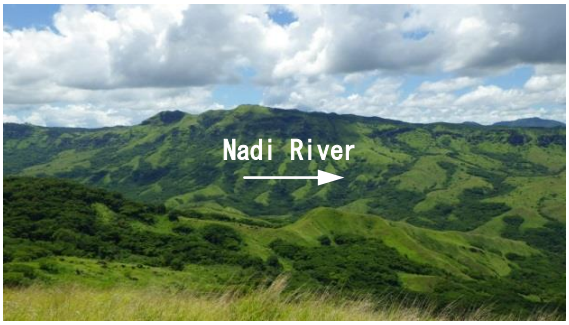



Photo-2 Nadi River Basin (Upstream)

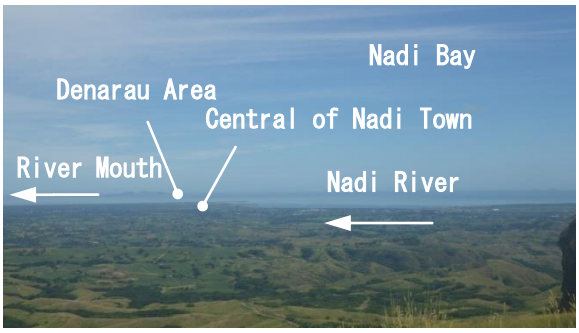



Photo-3 Nadi River Basin（Panoramic view）

Photo-4 Nadi River (River Mouth)

Photo-5 Central of Nadi Town

Photo-6 Nadi River (Middle Stream)

Photo-7 Nadi River (Upstream)

Photo-8 Vaturu Dam (Nadi River Upstream)


Photo-9　Nadi River（Nadi Town Bridge）


Photo-10 Nadi River（Nadi Town Bridge）during Flood


Photo-11　Nadi River（Old Queens Road Bridge）


Photo-12 Nadi River（Old Queens Road Bridge）during Flood

Photo-13 Nawaka River

Photo-14　Retention Dam（Nawaka River）

Photo-15　Counterpart Training in Japan

Photo-16 Seminar in Fiji

# Executive Summary of Flood Control Master Plan and Priority Project in Nadi River Basin

## 1. Master Plan

【Basic Concept of Master Plan】

- In the Master Plan, based on the flood and river basin characteristics as well as properties in the upstream, midstream and downstream of the Nadi River, taking into account measures in an entire basin, comprehensive flood control plan consisting of dam, river improvement, retarding basins and ring dikes are proposed.
- Taking into account a long term and the large budget to complete the structural measures, and also taking into account the risk due to flood exceeding design scale, perfect protection measures for flood inundation are not feasible. Therefore, structural measures and non-structural measures such are proposed in the Master Plan..
- In the formulation of the Master Plan, it is an important to clarify priority protected areas from the view point of clarification on the contents of flood control plan and addressing a road map for the integration of short, middle and long term flood control plan. Therefore, Important Protected Area is set and it is prioritized to be mitigated from damage by flood.
- The Master Plan is formulated considering Environmental and Social Considerations and Social Acceptance for flood control

【Target Area of Master Plan】

Target area of Master Plan is Nadi River Basin with catchment area of 516 $km^2$.

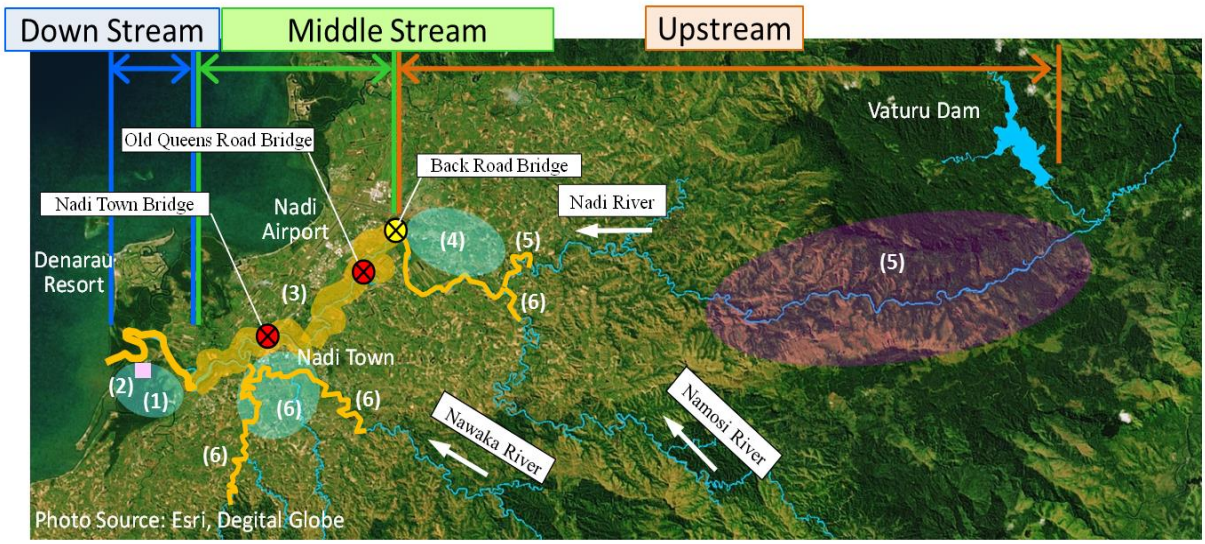
【Target Scale of Master Plan】

Design flood scale for Master Plan is set as 1/50 with regard to previous maximum flood event occurred in March 2012.

【Components of Master Plan】

(1) Structural Measures

Structural Measures as shown in Figure1 and Table1 are proposed in order to mitigate flood damage by targeted flood in Nadi River Basin.




| | |
|---|---|
| (1) | : Retarding Basin in downstream incl. surrounding dike of retarding basin in downstream<br>: River Improvement in downstream |
| (2) | : Ring Dike |
| (3) | : River Widening incl. Rebuilding of 2(two) bridges |
| (4) | : Retarding Basin A,B in upstream |
| (5) | : Dam<br>: River improvement in upstream |
| (6) | : Retarding Basins in Tributaries incl. surrounding dike<br>: River Improvement in Tributaries incl. Rebuilding of 4(four) bridges |

**Figure 1 Components of Master Plan (Structural Measures)**

**Table 1 Components of Master Plan (Structural Measures)**

| | River, Location | | Component of the Master Plan | | Quantities | Remarks |
|---|---|---|---|---|---|---|
| Structural Measures | 1. Nadi River | Downstream | (1) | Retarding Basin and River Improvement in downstream | A=725 ha<br>V=9,715 千m3 | — |
| | | | (2) | Ring Dike | L=1.8 km | — |
| | | Middlestream | (3) | River Widening[2)] | L=13 km | Including rebuilding of 2 (two) bridges |
| | | | (4) | Retarding Basin A | A=35 ha<br>V=795 千m3 | |
| | | | | Retarding Basin B | A=178 ha<br>V=6,920 千m3 | — |
| | | Upstream | (5) | Dam and River improvement in upstream | 1 | |
| | 2. Tributaries | Nawaka<br>Maralua<br>Namosi<br>River | (6) | River Improvement | L=21 km | Including rebuilding of 4 (four) bridges in tributaries |
| | | | | Retarding Basins (13 sites) | A=340 ha<br>V=11,600 千m3 | |

(2) Non-Structural Measures

Non-Structural Measures as shown in Table2 are proposed in order to corroborate and complement structural measures and mitigate damage by targeted flood.

**Table 2 Components of Master Plan (Non-Structural Measures)**

| | Effect of Measure (Large Classification) | Major components |
|---|---|---|
| Non-Structural Measures | (1) Understanding disaster risk and risk avoidance | 1-1) Strengthening of understanding flood risk with flood hazard map<br>1-2) Strengthening flood forecasting technology |
| | (2) Enhancing disaster preparedness for effective response | 2-1) Strengthening disaster management system |
| | (3) Disaster risk management, risk avoidance | 3-1) Technical assistant for land-use regulation<br>3-2) Strengthening river basin management |
| | (4) Economic disaster risk management | 4-1) Strengthening economic disaster risk management by regional BCP |
| | (5) Evaluation and feedback | 5-1) Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback |

【Implementation Schedule of Master Plan】

Proposed entire implementation schedule of the Master Plan projects is shown in Table3. Target implementation period of Master Plan is proposed as 30 years from the project commencement.

# Table 3 Components of Master Plan and Implementation Schedule (Proposed)

| | Work Item | 20XX-20XX | 20XX-20XX | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | Study on M/P | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Detailed Design | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **I. Structural Measures** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **I-A. Priority Project (Short Term Measures)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **1** | **River channel widening works in midstream section** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | River channel widening works in midstream section, L=13km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2** | **Retarding basin works in upstream section** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Retarding basin (A) works in right bank side in Nadi River, A=35ha | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2) | Retarding basin (B) works in left bank side in Nadi River, A=178ha | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **3** | **Ring dike** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Ring dike, L=1.8km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **4** | **Shortcut in tributaries / Surrounding dike works in Nadi River** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Shortcut in tributaries, A=0.5km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2) | Surrounding dike, L=4.5km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **I-B. Middle Term Measures** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **1** | **Retarding Basin in downstream section (A=km2)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Retarding Basin in downstream section, A=725ha | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2** | River improvement in tributaries | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Nawaka River, L=8.5km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2) | Malakua River , L=8.5km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3) | Namosi River , L=4.0km | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **I-C. Long Term Measures** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **1** | **Dam construction in upstream in Nadi River (H= m)** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1) | Dam construction in upstream in Nadi River | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **II. Non-structural Measures** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **1** | **Understanding disaster risk and risk avoidance** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-1) | Strengthening of understanding flood risk with flood hazard map | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1-2) | Strengthening flood forecasting technology | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **2** | **Enhancing disaster preparedness for effective response** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-1) | Strengthening disaster management system | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2-2) | Strengthening emergency assistance system | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **3** | **Disaster risk management, risk avoidance** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3-1) | Land use regulations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3-2) | Strengthening river basin management | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **4** | **Economic disaster risk management** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4-1) | Strengthening economic disaster risk management by regional BCP | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **5** | **Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5-1) | Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Note: *including loan agreement, EIA, land acquisition, procurement of consultant (D/D, C/S), detailed design, preparation of PQ and tender document and so on.

## 2. Priority Project

【Basic Concept for selection of Priority Project】

- Taking into account a long term and the large budget to complete the structural measures, and also taking into account the risk due to flood exceeding design scale, perfect protection measures for flood inundation are not feasible. Therefore, Priority Project is selected in order to protect important area and mitigate flood damage.
- Regarding structural measures of Priority Project, components which mitigate flood damage in Important Protected Area is selected after setting Important Protected Area.
- Regarding non-structural measures of Priority Project, protection of human lives, understanding of disaster risks and evacuation are considered as a top priority. Based on this concept, components for understanding of disaster risks and evacuation are selected as Priority Project.

【Components of Priority Project】

(1) Structural Measures

Structural Measures as shown in Figure 3 and Table 4 are proposed in order to mitigate flood damage in Important Protected Area (Figure 2).

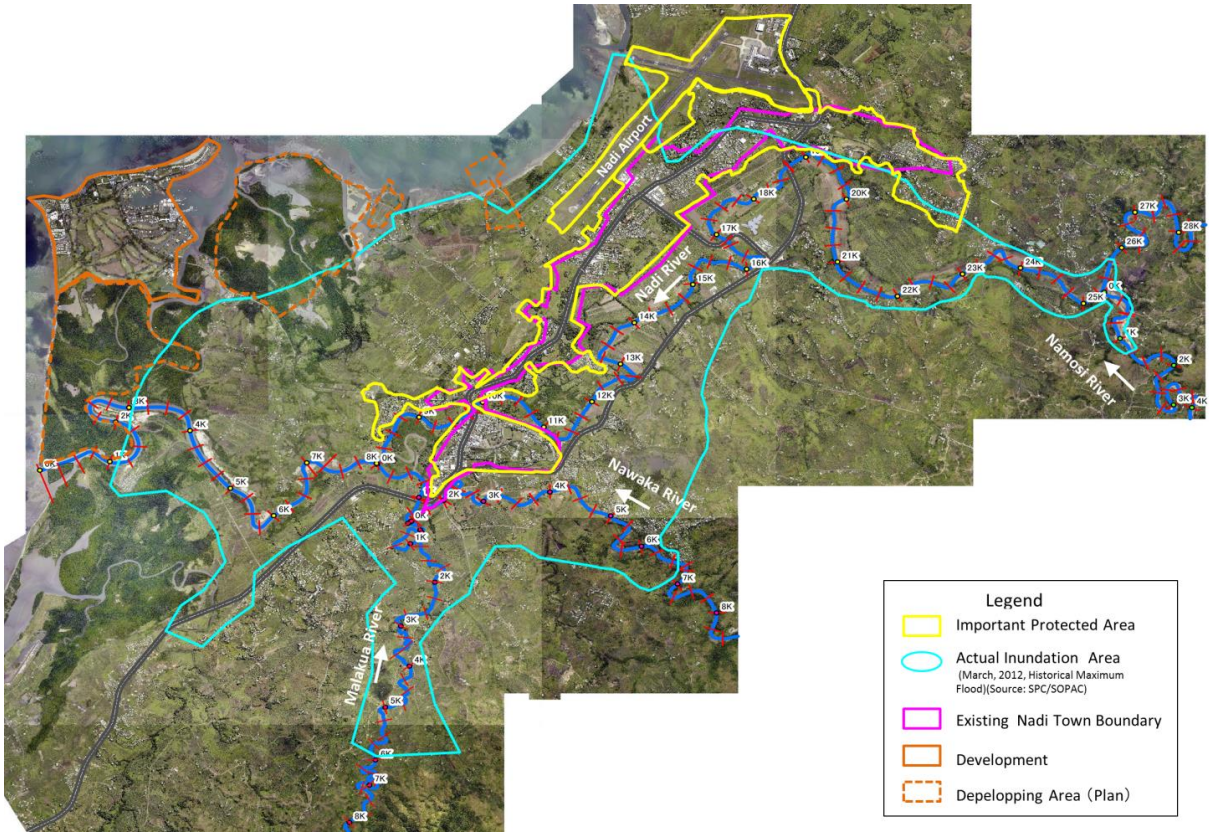



**Figure 2　Important Protected Area**

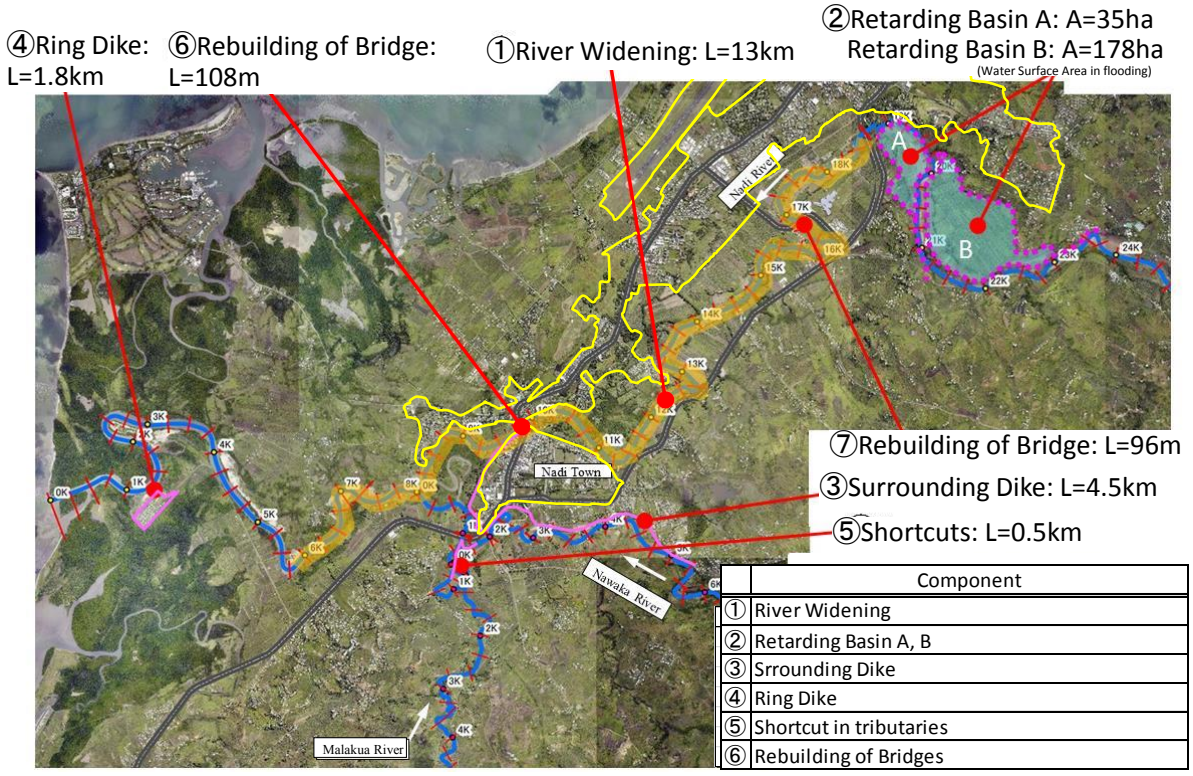



**Figure 3 Components of Priority Project (Structural Measures)**

**Table 4 Components of Priority Project (Structural Measures)**

| | River, Location | | Component of the Master Plan | Component of the Priority Project | | Remarks |
|---|---|---|---|---|---|---|
| | | | | Main Component | Quantities | |
| Structural Measures | 1. Nadi River | Downstream | (1) Retarding Basin and River Improvement in downstream | — | — | — |
| | | | (2) Ring Dike | ④ Ring Dike | L=1.8 km | — |
| | | Middlestream | (3) River Widening[2)] | ① River Widening<br>Rebuilding of Nadi TOwn Bridge<br>Rebuilding of Old Queens Road Bridge | L=13 km<br>L=108 m<br>L= 96 m | — |
| | | | (4) Retarding Basin A | ② Retarding Basin A | A=35 ha<br>V=795 千m3 | |
| | | | Retarding Basin B | ② Retarding Basin B | A=178 ha<br>V=6,920 千m3 | |
| | | Upstream | (5) Dam and River improvement in upstream | — | — | — |
| | 2. Tributaries | Nawaka<br>Maralua<br>Namosi<br>River | (6) River Improvement | ⑤ Shortsut of Tributaries<br>③-2 Surrounding Dike of Nadi Town | L=0.5 km<br>L=4.5 km | Shortcut and Surrounding dike in tributaries are preceded to construction as part of the master plan |
| | | | Retarding Basins (13 sites) | — | — | |

(2) Non-Structural Measures

Protection of human lives, understanding of disaster risks and evacuation are considered as a top priority, under condition that the progress of structural measures project will be at initial phase. Therefore, activities accompanied with development and disclosure of hazard maps and development of hydrological devices for awareness of flood risks are proposed as Priority project. In addition, in order to evaluate the effect of non-structural measures in the past or priority projects, and in order to connect to “Better disaster prevention”, evaluation and feedback system on the past projects is also proposed as Priority Project.

**Table 5 Components of Priority Project (Non-Structural Measures)**

| | Category | Measures |
|---|---|---|
| Non-structural Measures | Understanding disaster risk and risk avoidance | ・ Strengthening of understanding flood risk with flood hazard map<br>・ Strengthening flood forecasting technology, such as expansion of rainfall gauge, water level gauge and introduction of real-time monitoring camera |
| | **B**etter Disaster Prevention | ・ Establishing a system of evaluation of Pre-disaster activity / existing measures and feedback |

【Selection of Implementation Project】

Integrated flood control facilities considering whole river basin have not been installed yet in spite of effectiveness of structural measures and implementation of structural measures such as dam, retarding basin, and river are required urgently. Therefore, structural measures of Priority Project are selected as Implementation Project.

【Objective of Implementation Project】

Objective of Implementation Project is to improve of vulnerability to flood in Nadi River Basin, mitigate flood damage specially in Important Protected Area and contribute to improve living environment of residents by developing flood control facilities such as river widening and retarding basin in Nadi River Basin, which has been damaged by severe flood.

【Components of Implementation Project】

Components of Implementation Project is as shown in Figure 4 and Table 6, which are as same as structural measures of Priority Project.

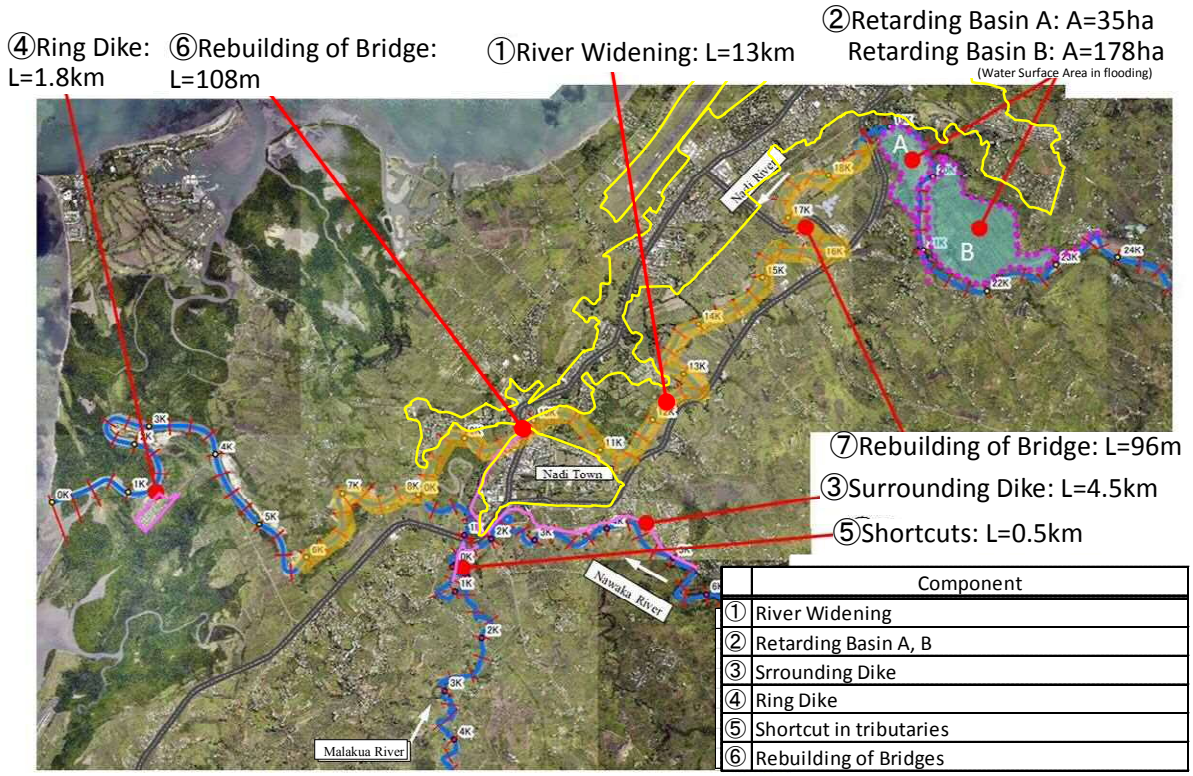



**Figure 4 Components of Implementation Project (Structural Measures)**

**Table 6 Components of Implementation Project (Structural Measures)**

| | River, Location | | Component of the Master Plan | Component of the Priority Project | | Remarks |
|---|---|---|---|---|---|---|
| | | | | Main Component | Quantities | |
| Structural Measures | 1. Nadi River | Downstream | (1) Retarding Basin and River Improvement in downstream | — | — | — |
| | | | (2) Ring Dike | ④ Ring Dike | L=1.8 km | — |
| | | Middlestream | (3) River Widening[2)] | ① River Widening<br>Rebuilding of Nadi TOwn Bridge<br>Rebuilding of Old Queens Road Bridge | L=13 km<br>L=108 m<br>L= 96 m | — |
| | | | (4) Retarding Basin A | ② Retarding Basin A | A=35 ha<br>V=795 千m3 | |
| | | | Retarding Basin B | ② Retarding Basin B | A=178 ha<br>V=6,920 千m3 | — |
| | | Upstream | (5) Dam and River improvement in upstream | — | — | |
| | 2. Tributaries | Nawaka<br>Maralua<br>Namosi<br>River | (6) River Improvement | ⑤ Shortsut of Tributaries<br>③-2 Surrounding Dike of Nadi Town | L=0.5 km<br>L=4.5 km | Shortcut and Surrounding dike in tributaries are preceded to construction as part of the master plan |
| | | | Retarding Basins (13 sites) | — | — | |

【Implementation Schedule of Implementation Project】

Implementation Schedule of Implementation Project is as shown in Table 8.

【Implementation Project 】

Implementation Project Cost is as shown in Table 9.

【Economic Feasibility of Implementation Project】

Total cost of the priority project is JPY21.0 billion (F$385million) and the average annual benefit is JPY 1.88billion (F$34.5million). These figures lead to EIRR 12.0%, B/C=1.2 and NPV JPY1.8billion (F$33million) respectively. This economic valuation is beyond the target investment rate of 10% in Fiji and show the adequate economic effect.

**Table 7 Result of Economic Evaluation**

| Economic indicator | Result | Evaluation |
|---|---|---|
| Economic internal rate of return (EIRR) | 12.0% | Since EIRR is well over 10% which is applied to the development assistance project in Fiji, the economic effectiveness is high. |
| Benefit-cost (B/C) ratio | 1.20 | Since the B/C ratio is over 1.0, the cost-effectiveness is high. |
| Net present value (NPV) | JPY 1.8 billion (FJD33 million) | Since the value is plus, the cost-effectiveness is high. |

Source: JICA study team

【Conclusion and Recommendation】

Implementation Project proposed as one of the Priority Project is evaluate appropriate since it could mitigate severe flood damage and it is feasible technically, economically, socially and environmentally. Therefore, next steps such as securing budget and request for technical assistance as follows are recommended to be conducted by Fiji Government as soon.

(1) Implementation of the Priority Project and establishment of Implementation Structure

(2) Formulation consensus of Government and residents for the Implementation

(3) Commencement of loan procedure for project fund

(4) Commencement of negotiation for land acquisition and compensation

(5) Commencement of consultant procurement and environmental monitoring

(6) Establishment of legislation of flood control

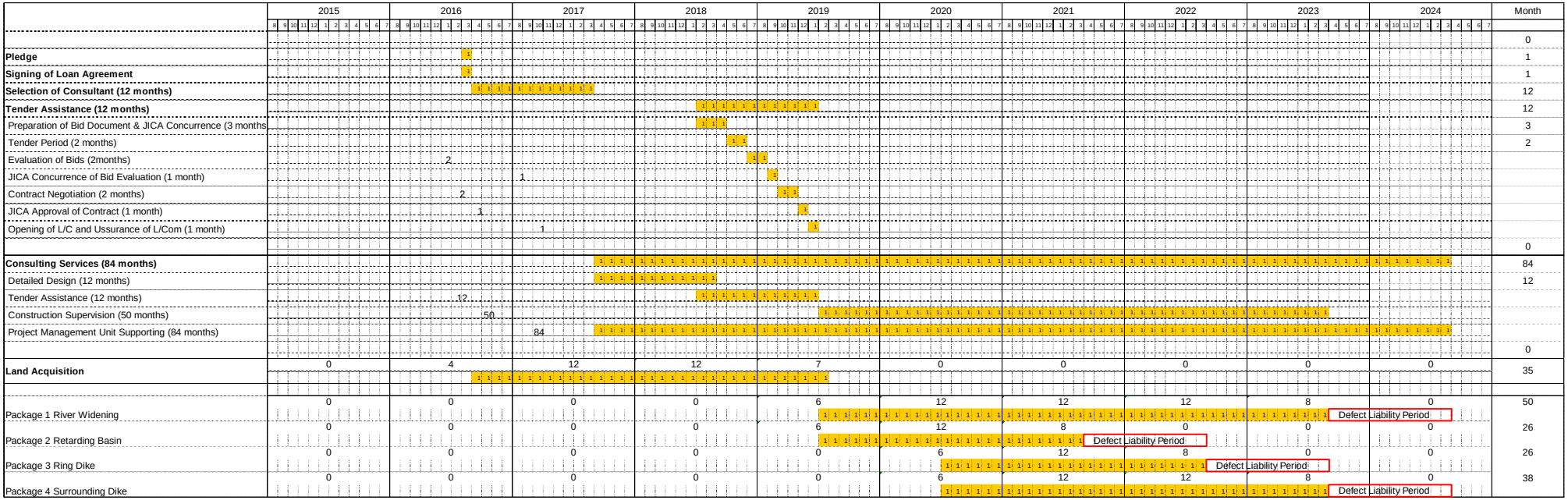
(7) Preparation and consolidation of organization responsible for flood control and capacity building

(8) Preparation of criteria and standard

(9) Permanent securement of maintenance budget for flood control

# Table 8 Implementation Schedule of Implementation Project (Proposed)

Implementation Schedule




*Year in above table shows the fiscal year of Fiji (August 1st to July 31th of following year)

## Table 9 Project Cost of Implementation Project

(FC&Total: Million JPY, LC: Million FJD)

| Item | | Total | | | |
|---|---|---|---|---|---|
| | | FC | LC | Total | |
| | | million (Yen) | million (F$) | million (Yen) | million (F$) |
| **A. ELIGIBLE PORTION** | | | | | |
| Ⅰ) | Procurement / Construction | 6,778 | 134 | 14,074 | 258 |
| | Package 1 River Widening, Rebuilding of Bridge | 4,213 | 77 | 8,432 | 155 |
| | Package 2 Retarding Basin | 1,281 | 19 | 2,299 | 42 |
| | Package 3 Ring Dike | 40 | 1 | 76 | 1 |
| | Package 4 Surrounding Dike | 392 | 5 | 657 | 12 |
| | Base cost for JICA financing | 5,926 | 102 | 11,464 | 210 |
| | Price escalation | 529 | 26 | 1,940 | 36 |
| | Physical contingency | 323 | 6 | 670 | 12 |
| Ⅱ) | Consulting services | 933 | 18 | 1,893 | 35 |
| | Base cost | 828 | 14 | 1,579 | 29 |
| | Price escalation | 60 | 3 | 223 | 4 |
| | Physical contingency | 44 | 1 | 90 | 2 |
| Total (Ⅰ+Ⅱ) | | 7,711 | 151 | 15,967 | 293 |
| **B. NON ELIGIBLE PORTION** | | | | | |
| a | Procurement / Construction | 0 | 0 | 0 | 0 |
| | | | | | |
| | Base cost for JICA financing | 0 | 0 | 0 | 0 |
| | Price escalation | 0 | 0 | 0 | 0 |
| | Physical contingency | 0 | 0 | 0 | 0 |
| b | Land Acquisition | 0 | 38 | 2,093 | 38 |
| | Base cost | 0 | 34 | 1,845 | 34 |
| | Price escalation | 0 | 3 | 148 | 3 |
| | Physical contingency | 0 | 2 | 100 | 2 |
| c | Administration cost | 0 | 17 | 903 | 17 |
| d | VAT | 0 | 30 | 1,625 | 30 |
| e | Import Tax | 0 | 0 | 0 | 0 |
| Total (a+b+c+d+e) | | 0 | 85 | 4,621 | 85 |
| **TOTAL (A+B)** | | 7,711 | 236 | 20,588 | 378 |
| | | | | | 0 |
| **C. Interest during Construction** | | 351 | 0 | 351 | 6 |
| | Interest during Construction(Const.) | 350 | 0 | 350 | 6 |
| | Interest during Construction (Consul.) | 1 | 0 | 1 | 0 |
| **D. Front End Fee** | | 32 | 0 | 32 | 1 |
| **GRAND TOTAL (A+B+C+D)** | | 8,094 | 236 | 20,971 | 385 |
| | | | | | |
| **E. JICA finance portion (A)** | | 7,711 | 151 | 15,967 | 293 |

US$1=2.17 F$, 1F$= JPY 54.5

## Abbreviation

| | | |
|---|---|---|
| ADB | Asian Development Bank | アジア開発銀行 |
| ADRA | Adventist Development and Relief Agency | アドベンチスト開発救助機関 |
| AusAID | Australian Agency for International Development | オーストラリア国際開発庁 |
| BCP | Business Continuity Plan | 事業継続計画 |
| BOM | Bureau Of Meteorology | オーストラリア気象局 |
| CBD | Convention on Biological Diversity | 生物多様性条約 |
| CCA | Climate Change Adaptation | 気候変動適応 |
| CCL | Climate Change Loan | 気候変動対策円借款 |
| CCM | Climate Change Mitigation | 気候変動緩和 |
| CHARM | Comprehensive Hazard And Risk Management | 統合的ハザード・リスク管理 |
| C/P | Counterpart | カウンターパート |
| CRED | Centre for the Research on the Epidemiology of Disaster | 災害の疫学に関する研究センター |
| CWO | Commissioner Western Office | 西部地域長官室 |
| DEM | Digital Elevation Model | デジタル標高モデル |
| DF/R | Draft Final Report | ドラフトファイナルレポート |
| DIS | Drainage & Irrigation Section | 排水・灌漑部門 |
| DISMAC | Disaster Management Centre | 災害管理センター |
| DMP | Disaster Management Plan | 防災計画書 |
| DOE | Department of Environment | 環境局 |
| DOFi | Department of Fishery | 漁業局 |
| DOF0 | Department of Forest | 森林局 |
| DOL | Department of Lands | 土地局 |
| DO-N / DO | District Nadi Office / District Office | ナンディ地区事務所／地区事務所 |
| DOW | Department of Works | 公共事業局 |
| DRCC | Disaster Ready Community Committee | 災害自立型コミュニティ委員会 |
| DRR | Disaster Risk Reduction | 災害リスク軽減 |
| DRRDM | Disaster Risk Reduction & Disaster Management | 災害リスク軽減・災害管理 |
| DTCP | Department of Town & Country Planning | 都市／地方計画局 |
| EDF | European Development Fund | ヨーロッパ開発基金 |
| EIA | Environmental Impact Assessment | 環境影響評価 |
| EiE | Education in Emergencies | 緊急時の教育 |
| EOC | Emergency Operation Center | 緊急対策室 |
| EPGA | Environmental Programme Grant Aids | 環境プログラム無償資金協力 |
| EU | European Union | 欧州連合 |
| EWS | Early Warning System | 早期警報システム |
| FBS | Fiji Bureau of Statistics | フィジー統計局 |
| FMS | Fiji Meteorological Service | フィジー気象局 |
| F/R | Final Report | ファイナルレポート |

| | | |
|---|---|---|
| FRA | Fiji Road Authority | フィジー道路公社 |
| F/S | Feasibility Study | フィジビリティ調査 |
| FSC | Fiji Sugar Corporation | フィジー砂糖会社 |
| GDP | Gross National Product | 国民総生産 |
| GEF | Global Environmental Facility | 地球環境ファシリティ |
| GGP | Grant Assistance for Grassroots Human Security Projects | 草根の無償／草の根・人間の安全保障無償資金協力 |
| GIS | Geographical Information System | 地理情報システム |
| GNI | Gross National Income | 国民総所得 |
| HFA | Hyogo Framework for Action | 兵庫行動枠組み |
| IC/R | Inception Report | インセプションレポート |
| IDA | Initial Damage Assessment | 初期損害評価 |
| IDD | Irrigation & Drainage Division | 灌漑・排水部門 |
| IDM | Introduction of Disaster Management | 災害管理の導入 |
| IEE | Initial Environmental Examination | 初期環境調査 |
| IRC | International Red Cross | 国際赤十字 |
| IT/R | Interim Report | インテリムレポート |
| IWRM | Integrated Water Resource Management | 統合水資源管理 |
| JCC | Joint Coordination Committee | 合同調整委員会 |
| JICA | Japan International Cooperation Agency | 独立行政法人　国際協力機構 |
| KP | Kyoto Protocol | 京都議定書 |
| LRPD | Department of Land Resource Planning & Development | 土地資源計画・開発局 |
| LWRM | Land &Water Resource Management | 土地水資源管理部 |
| MDGs | Millennium Development Goals | ミレニアム開発目標 |
| MFA&IC | Ministry of Foreign Affairs & International Co-operation | 外務・国際協力省 |
| MFSPNDS | Ministry of Finance Strategic Planning, National Development & Statistics | 財務戦略計画・国家開発・統計省 |
| MLGUDHE | Ministry of Local Government, Urban Development, Housing &Environment | 地方行政・都市開発・住宅・環境省 |
| MLMR | Ministry of Lands & Mineral Resources | 土地鉱物資源省 |
| M/M | Minutes of Meeting | 会議議事録 |
| MOA | Ministry of Agriculture | 農業省 |
| MOU | Memorandum Of Understanding | 覚書 |
| M/P | Master Plan | 基本計画 |
| MP Radar | Multi Parameter Radar | マルチパラメータ気象レーダ |
| MRMSNDM | Ministry of Rural & Maritime Safety & National Disaster Management | 地域・海上保安・国家災害管理省 |
| MTCP | Ministry of Town and Country Planning | 都市計画省 |
| MWTPU | Ministry of Works, Transport & Public Utilities | 公共事業・運輸・公益事業省 |
| NBCC | Nadi Basin Catchment Committee | ナンディ流域委員会 |
| NCCP | National Climate Change Policy | 国家気候変動政策 |
| NDMC | National Disaster Management Council | 国家災害管理評議会 |

| | | |
|---|---|---|
| NDMO | National Disaster Management Office | 国家災害管理室 |
| NEOC | National Emergency Operation Centre | 国家緊急オペレーション・センター |
| NIWA | The National Institute of Water and Atmospheric Research | 水・大気研究国立機関 |
| NTC | Nadi Town Council | ナンディ町議会 |
| NZAID | New Zealand Agency for International Development | ニュージーランド国際開発庁 |
| O&M | Operation and Maintenance | 運用維持管理 |
| OCHA | Office for the Coordination of Humanitarian Affairs | 国連人道問題調整事務所 |
| ODA | Official Development Assistance | 政府開発援助 |
| OJT | On the Job Training | 実地訓練 |
| PCIDRR | The Pacific Community-focused Integrated Disaster Risk Reduction | 大洋州コミュニティ統合的災害リスク削減 |
| PDM | Project Design Matrix | プロジェクトデザインマトリックス |
| PDN | Pacific Disaster Net | 大洋州災害ネット |
| PDRMP | Pacific Disaster Risk Management (Training) Programme | 大洋州災害リスク管理(研修)プログラム |
| PDRMPN | Pacific Disaster Risk Management Partnership Network | 大洋州災害リスク管理パートナーシップ・ネットワーク |
| PHT | The Pacific Humanitarian Team | 大洋州人道チーム |
| PIFACC | Pacific Islands Framework for Action on Climate Change | 大洋州気候変動行動枠組み |
| PMO | Prime Minister Office | 首相府 |
| PMU | Project Management Unit | プロジェクト・マネジメント・ユニット |
| P/R | Progress Report | プログレスレポート |
| PRMS | Planning & Resource Management Section | 計画・資源管理部門 |
| PRSP | Poverty Reduction Strategy Paper | 貧困削減戦略文書 |
| PWD | Public Works Division | 公共事業部 |
| RAP | Resettlement Action Plan | 住民移転計画 |
| R/D | Record of Discussion | 討論議事録 |
| RES | River Engineering Section | 河川エンジニアリング部門 |
| SOP | Standard Operation Procedure | 標準作業手順書 |
| SOPAC | South Pacific Applied Geoscience Commission | 太平洋諸島応用科学委員会 |
| SPC | Secretariat for the Pacific Community | 太平洋コミュニティ事務局 |
| SPCZ | South Pacific Convergence Zone | 南太平洋収束帯 |
| SPREP | South Pacific Regional Environment Programme | 大洋州環境プログラム事務局 |
| TC | Tropical Cyclone | 熱帯性サイクロン |
| TLTB | iTauke Land Trust Board | イ・タウケイ土地信託委員会 |
| ToT | Training of Trainers | 指導員研修 |
| UNCCD | United Nations Convention to Combat Desertification | 国連砂漠化防止条約 |
| UNDP | United Nations Development Programme | 国連開発計画 |
| UNESCAP | United Nations Economic & Social Commission for Asia & the Pacific | 国連アジア太平洋経済社会委員会 |
| UNFCCC | United Nations Framework Convention on Climate Change | 国連気候変動枠組条約 |
| UNICEF | United Nations International Children's Emergency Fund | 国連国際児童緊急基金 |
| UNISDR | United Nations International Strategy for Disaster | 国連国際防災戦略 |

| | | |
|---|---|---|
| | Reduction | |
| UNOCHA | United Nations Office for Coordination of Humanitarian Affairs | 国連人道問題支援室 |
| USAID | United State Agency for International Development | 米国国際開発庁 |
| WAF | Water Authority of Fiji | フィジー水公社 |
| WB | World Bank | 世界銀行（世銀） |
| WMO | World Meteorological Organization | 世界気象機関 |
| WMS | Watershed Management Section | 流域管理部門 |

**THE REPUBLIC OF FIJI**
**THE PROJECT FOR THE PLANNING OF**
**THE NADI RIVER FLOOD CONTROL STRUCTURES**

# FINAL REPORT
# VOLUME II MAIN REPORT

## Part I: Master Plan Study

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**（Separate Volume）**

## Part II: Feasibility Study

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# Chapter 1 Introduction

## 1.1 Background and Necessity of the Project

The Republic of Fiji (hereinafter refer to as "Fiji") plays a central role in the development and economy of the Pacific Ocean Island Nations Region, having headquarters of regional international organizations such as Secretariat of PIF (Pacific Ocean Islands Forum). Stabile and sustainable development of Fiji is important for the Pacific Ocean region as a whole.

Nadi Town, which is located in the target river basin (the Nadi River Basin) of the Project, is the third largest city of Fiji. Nadi Town is the commercial and sightseeing center of Fiji, not only because of its traditional sugar industry but also because of its prospering tourist business. About 700 thousand tourists visit Fiji every year through mainly Nadi International Airport, the main gateway to Fiji. On the other hand, the Nadi River Basin is vulnerable to flood disaster. Extensive flood damage has occurred in recent years (January 2009, and March and January 2012). However, systematic and comprehensive flood control planning and/or flood control projects have not been formulated yet, and the Nadi River Basin is facing a natural disaster risk.

Therefore, formulation of flood control master plan for the Nadi River Basin and implementation of flood control project(s) are urgently required, and they are expected to have a very large impact in the near future. Furthermore, the effectiveness of the master plan will contribute to other basin of Fiji and to the development of the Pacific region as a whole.

Considering the above conditions, JICA is dealing with strengthening of disaster prevention of the Pacific region, as disaster prevention program(s) and climate change adaptation program(s), through (1) Capacity Development of Disaster Management of the Government of Fiji (hereinafter referred as "GOF"); (2) Strengthening of Disaster Response Capacity of the Community"; and (3) Strengthening of Capacity of the Climate Observation and Weather Forecasting". JICA implemented the development survey, "The Study on Watershed Management and Flood Control for the Four Major Viti Levu Rivers in the Republic of Fiji Islands" in 1996 to 1998. Nevertheless, no actual measures had been taken. In addition, together with the economic development of the target area, land utilization and asset situation have greatly changed in the last 16 years. The targeted flood and the expected amount of rainfall and its spatial distribution have also changed drastically. Other challenges such as improvement of hydraulic analysis, comprehensive sediment management, impact on coastal environment, capacity development of related organization and so on were also confirmed in the detailed planning survey conducted by JICA in 2014. In this study, considering the background and initiatives conducted by JICA so far, the results of the development survey will be reviewed without prejudice and with the latest technology and knowledge.

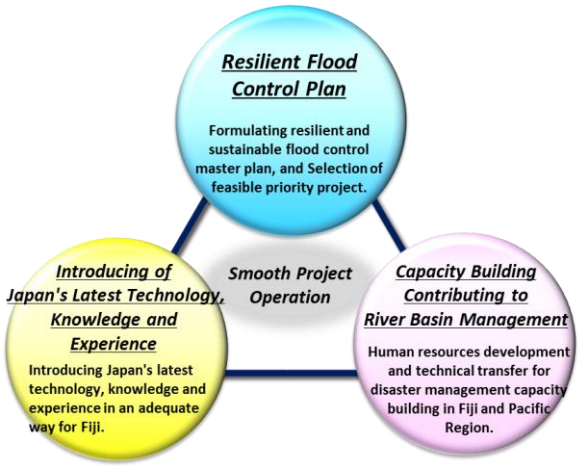



**Figure 1-1 Basic Concepts of the Project**

Considering the issues of Nadi River Basin, the whole perspective of the Project and the contents of technical specifications of the Project, 3 basic concepts of the Project implementation are proposed as follows: ***(1) Formulation of Resilient Flood Control Plan, (2) Capacity Building leading to Improvement of Capability on Disaster Management, and (3) Introducing Japanese Technology, Experiences and Knowledge to Fiji***. Then, by reducing the flood damage of the Nadi River Basin and creating a virtuous cycle of social, environmental and economic condition of Fiji, this project will contribute to the sustainable development of Fiji and the Pacific region.

## 1.2 Framework of the Project

The project is conducted based on Minutes of Meeting (M/M) and Record of Discussion (R/D) which were agreed and signed between MOA and JICA on February 7, 2014 and March 31, 2014 respectively. The outline of these documents is shown below.

### 1.2.1 Objectives of the Project

Goal of the Proposed Plan:

The Master Plan and the results of the Feasibility Study will be approved by GOF

Goal, which will be attained by utilizing the Proposed Plan:

Flood damages in Nadi Town will be mitigated

### 1.2.2 Outputs of the Project

The outputs of the Project are as follows:

1) The Master Plan of the flood management of the Nadi River Basin
2) The Feasibility Study on urgent and/or priority project(s)
3) Technical transfer to C/P through the Project

### 1.2.3 Activities

The activities of the Project during the three (3) stages and entire period of the project are as follows:

Stage-1: Basic Study
Stage-2: Master Plan Study
Stage-3: Feasibility Study
Entire Period: Technical Transfer

### 1.2.4 Target Area of the Project

The Nadi River Basin (approx. 516km$^2$ in catchment area) and its coastal area

### 1.2.5 Implementing Agency

Land and Water Resources Management Division (hereinafter refer to as "LWRM"), Ministry of Agriculture (hereinafter refer to as "MOA")

## 1.3 Outline of the Study

### 1.3.1 Objective of the Study

The objective of the Study is to contribute to the mitigation of the flood damage in the Nadi River Basin with formulating a flood control master plan and implementing a feasibility study.

### 1.3.2 Implementation Schedule

From July 22 2014 to July 29 2016 (about 24 months)

### 1.3.3 Implementation Schedule and Flow

The entire implementation schedule and flow are shown as Figure 1-2 and Figure 1-3 respectively. The entire implementation schedule has been modified form the version on IC/R together with the progress of Stage-1 in March, 2015 and it is shown below.

Work Schedule of the Project for the Planning of Nadi River Flood Control Structures in the Republic of Fiji

| | | Year | 2014 | | | | | | 2015 | | | | | | | | | | | | 2016 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Month | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| Work Stage | Stage1 | Basic Study | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Stage2 | Master Plan Study | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Stage3 | Feasibility Study | | | | | | | | | | | | | | | | | | | | | | | | | |
| Committee | | Committee for the Progress of the Study | IC/R | 1st JCC | | | | | | 1st TWG | | | 2nd JCC | 3rd JCC | | | 2nd TWG | 4th JCC | | | 3rd TWG | | | 5th JCC | 6th JCC | | Semi-nar |
| | | | □ | ▲ | | | | | | ◇ | | | | ▲ ▲ | | | ◇ | ▲ | | | ◇ | | | ▲ | ▲ | | ★ |
| | | Committee for the Disclosure Process | | | | | | | | | | | | | 1st PC,SM | | | | 2nd PC,SM | | | | | 3rd PC,SM | | | |
| | | | | | | | | | | | | | | | ● | | | | ● | | | | | ● | | | |
| Report | | | IC/R | | | | | | | | | | | P/R | | | | | IT/R | | | | | | DF/R | | F/R |
| | | | ◎ | | | | | | | | | | | ◎ | | | | | ◎ | | | | | | ◎ | | ◎ |

(*)This TWG will be held if necessary after discussions about situation and necessity with MOA

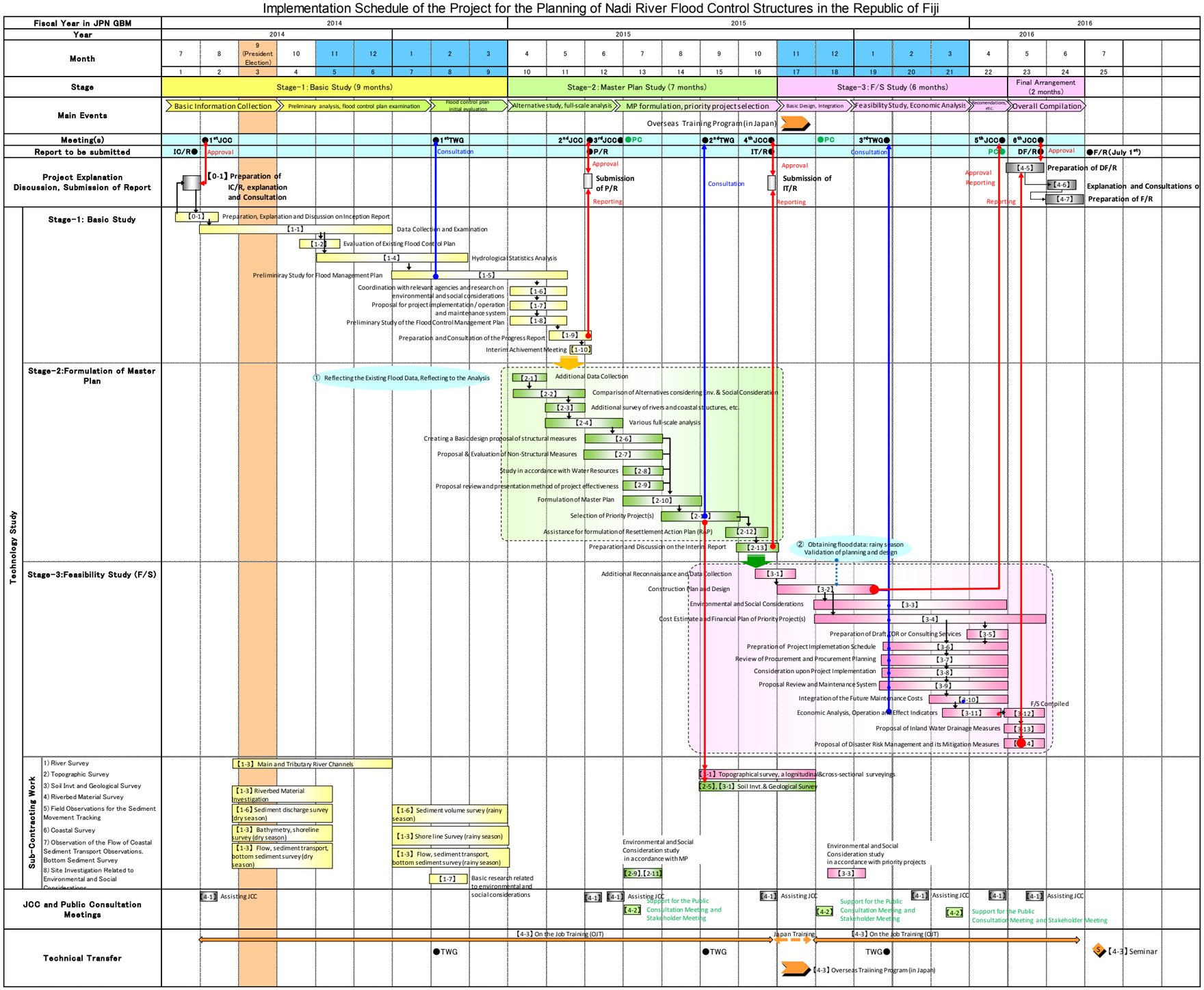
[Meetings]
IC/R : Inception Report Meeting
JCC : Joint Coordination Committee
TWG : Technical Working Group
PC : Public Consultation
SM : Stakeholder Meeting

[Report]
IC/R : Inception Report
P/R : Progress Report
IT/R : Interim Report
DF/R : Draft Final Report
F/R : Final Report

**Figure 1-2 Implementation Schedule**

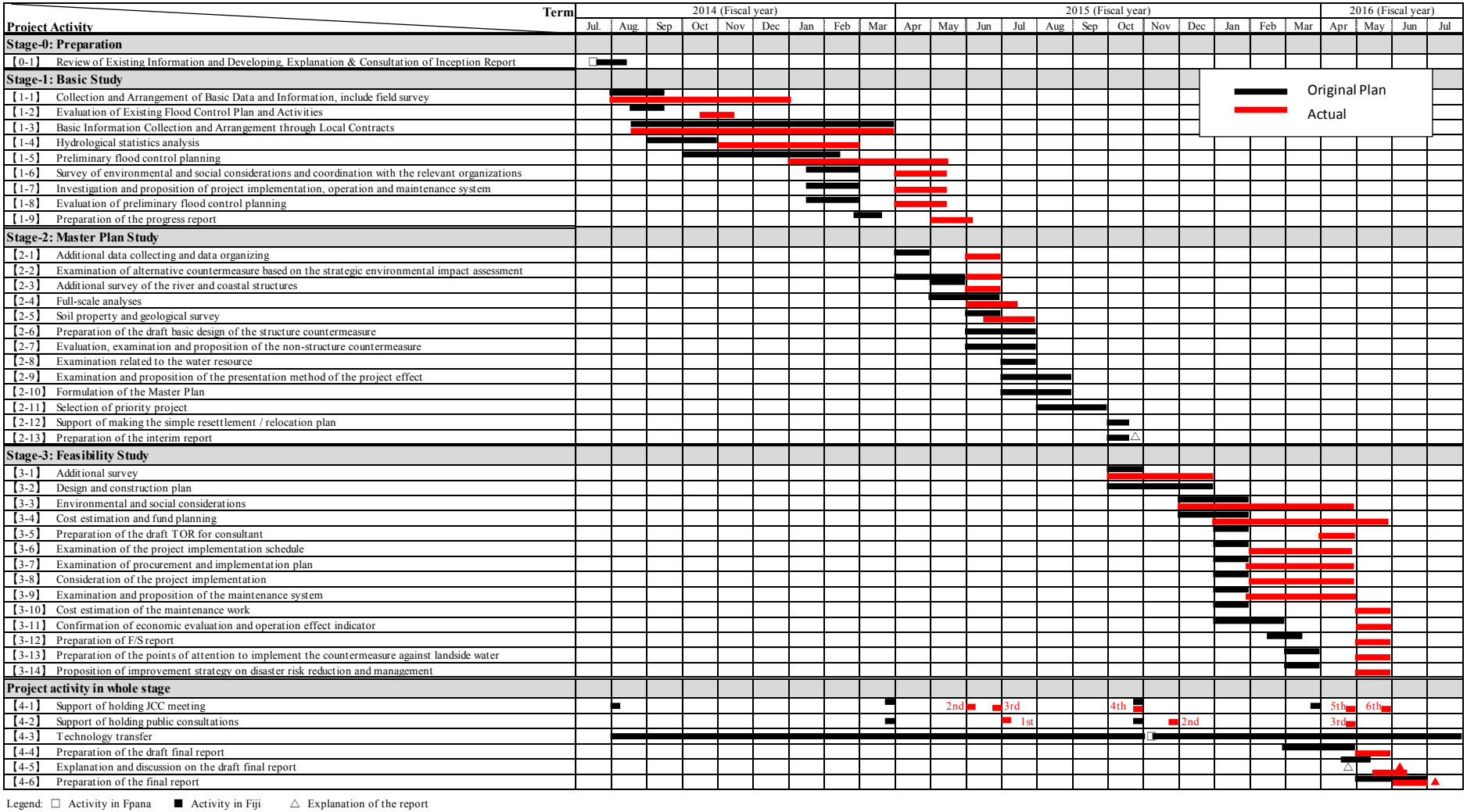
In addition, implementation items and each schedule are shown in Figure 1-4.

Implementation Schedule of the Project for the Planning of Nadi River Flood Control Structures in the Republic of Fiji




Remaks: JCC: Joint Coordination Committee, TWG: Technical Working Group (Technical Work Group), Submission of a Report: IC/R: Inception Report, P/R: Progress Report, IT/R: Interim Report, DF/R: Draft/Final Report, F/R: Final Report

**Figure 1-3 Implementation Flow**




Legend: □ Activity in Fpana ■ Activity in Fiji △ Explanation of the report

**Figure 1-4 Implementation Items**

### 1.3.4 Implementation Structure of the Study

The Implementation Structure of the Study is as shown in Figure 1-5. The Team is organized with core of project management group, and it will conduct the Study mainly based in Nadi and Suva. The Joint Coordination Committee (hereinafter referred to as "JCC") mentioned in R/D has been established in order to facilitate inter-organizational coordination, deliberate and make decisions on the project findings and results.

Technical Working Group (hereinafter referred to as "TWG") have been established in order to discuss the technical contents in detail for understanding of the technical issues.

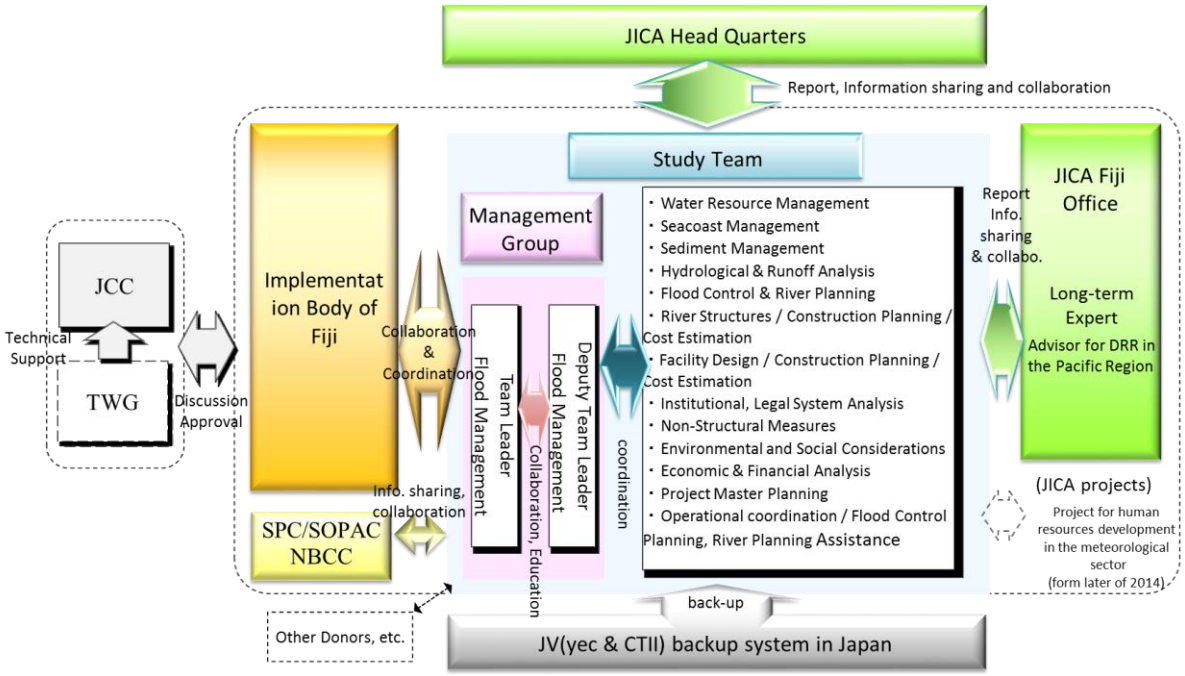



**Figure 1-5 Implementation Structure**

## 1.4 Main Activities of Stage-1

In Stage-1, for 11 months, the Team conducted the collection and analysis of basic information, sight inspection, surveys (through sub-contractors), initial examination of flood control measures, preparation and discussion of progress report, conferences, and technical transfer. The outline of each activity is described below.

### 1.4.1 Collection and Analysis of Basic Information

In Stage-1, the Team collected topography and survey data, hydro-meteorological data, information regarding historical flood damages, information regarding river and marine structures, natural, social and economic condition of the target area, upper level plan and flood control plan, institutional and legal situation and so on for the examinations. It took long time to collect the hydro-meteorological data but most of the data needed are collected. At the occasion of data collection from organizations, the Team held meetings to collect information.

Part of the documents such as past aerial photos, the details of Master Plan for drinking water by Water Authority of Fiji(WAF), design and construction standards, unit prices, construction project implementation and economic analysis, which needed in Stage-3(F/S Stage) are not in the hands of the Team. The Team will continue to collect such documents during Stage-2 (M/S Stage).

The results of collection and analysis of basic information are reported in Chapter 2.

### 1.4.2 Field Investigations

As the site investigation in Stage-1, the Team carried out the investigations of rivers, sediments and coasts.

In the rivers investigations, the Team conducted helicopter survey to see and take pictures of the Nadi River Basin. Also conducted the ground survey to grasp the characteristics of the basin, the Nadi River and its tributaries, inspect the river structures, confirm the hydraulic and run off analysis conditions, asses the possibility of flood control measures (structural measures), figure out the location of flow observation stations, etc.

In the sediments investigations, from the point of integrated sediment management, the Team conducted the ground inspections in rivers and coasts. Furthermore, the Team conducted the field inspection for identifying the locations to be surveyed by sub-contractors (River bed materials, Sediment transport and Discharge).

In the coasts investigation, the Team inspects the coastal areas to grasp the coastal topography, inspect the coastal structures and situation of coastal erosion. Furthermore, the Team conducted the field inspection for the locations for surveys by sub-contractors (Measurement of tidal current and sand drift and Sea bed materials).

The results of Field Investigations are reported in Chapter 3"Field Investigations".

### 1.4.3 Surveys by Sub-Contractors

In Stage-1, the Team conducted the following surveys by sub-contractors.

**(1) River Survey**

**Table 1-1 Quantities of Cross-Sections Survey and Longitudinal Leveling**

| River | Item | Quantities | Quantities in the TOR |
|---|---|---|---|
| Nadi River | Surveying range | 28km | 50km<br>250m and crossing structures |
| | No of cross-sections | more than 102 | |
| | Survey interval | 250m、500m and crossing structures | |
| Namosi River | Surveying range | 5km | |
| | No of cross-sections | more than 17 | |
| | Survey interval | 250m、500m and crossing structures | |
| Nawaka River | Surveying range | 10km | |
| | No of cross-sections | more than 37 | |
| | Survey interval | 250m、500m and crossing structures | |
| Malakua River | Surveying range | 7km | |
| | No of cross-sections | more than 22 | |
| | Survey interval | 250m、500m and crossing structures | |

**(2) River Bed Materials and Sediment Transport**

**Table 1-2 Quantities of River Bed Materials and Sediment Transport**

| Type | Items | Quantities | Quantities in the TOR |
|---|---|---|---|
| River Bed Materials | Particle Size Distribution Analysis | 13 sites | 11sites |
| | Surface gravel size survey | 8 sites | |
| Sediment Transport | Water Sampling | 7 sites | 8sites |
| | Turbidity meter | 2 sites | |
| | Discharge Measurement | 4 sites | |

### (3) Coastal Survey, Measurement of tidal current and sand drift and Sea Bed materials

**Table 1-3 Quantities of Coastal Survey**

| Area | Items | Quantities | Quantities in the TOR |
|---|---|---|---|
| Nadi river mouth coastal area | 1)Bathymetric Survey | | Along the coast 16km<br>Along the coast 500m interval<br>(250m interval for river mouth) |
| | Area of Survey | 9.0km x 1.0km = 9.0km$^2$ | |
| | Number of Sections | 23 sections | |
| | Section interval | 500m (in total 14 sections) | |
| | | 250m (in total 9 sections) | |
| | Length | 1000m (14 sections) | |
| | | 2000m (9 sections) | |
| | 2)Shoreline Survey | | |
| | Area | 9.0km | |
| | South edge of survey | Sonaisali area | |
| | North edge of survey | Denarau island | |
| Nadi Bay | 1)Bathymetric Survey | | |
| | Area of Survey | 7.0km x 1.0km = 7.0km$^2$ | |
| | Number of Sections | 15 liens | |
| | Section interval | 500m interval | |
| | 2)Shoreline Survey | | |
| | Area | 7.0km | |
| | South edge of survey | Denarau marina | |
| | North edge of survey | Sabeto river mouth | |

**Table 1-4 Quantities of Measurement of Tidal Current and Sand Drift and Sea Bed Materials**

| Type | Area | Item | Quantities | Quantities in the TOR |
|---|---|---|---|---|
| Measurement | Nadi river mouth coastal area | 1)Wave | 2 sites | Current and sand drift: 6 sites、<br>Sea bed materials: 54 sites |
| | | 2)Tidal Current | 4 sites | |
| | | 3)Sand Drift | 4 sites | |
| | | 4)Sea Bed Materials | | |
| | | General Sections | Measurement site 15sites<br>Shore line 5 lines<br>Shoreward: 3 sites | |
| | | River Mouth Sections | Measurement site 24sites<br>Shore line 6 lines<br>Shoreward: 3 - 5 sites | |
| | | 5) River Mouth water level measurement | 1 site | |
| | Nadi Bay | 1)Wave | 1 site | |
| | | 2)Tidal Current | 2 sites | |
| | | 3)Sand Drift | 2 sites | |
| | | 4)Sea Bed Materials | Measurement site 15sites<br>Shore line 5 lines<br>Shoreward: 3 sites | |
| 2.Laboratory Tests | | | Sieve Test:8 samples<br>Hydrometer:8 samples<br>Gravity: 8 samples<br>Moisture Content: 8 samples<br>Ignition Loss: 8 samples<br>LL/PL:8 samples | Modified from "Sieve Test 66 samples", which is written on operational plan, to below:<br>Sieve Test:8 samples<br>Hydrometer:8 samples<br>Gravity: 8 samples<br>Moisture Content: 8 samples<br>Ignition Loss: 8 samples<br>LL/PL:8 samples |

### (4) Survey for Environmental and Social Considerations

**Table 1-5 Quantities of Environmental and Social Considerations Survey (Basic Study Stage, IEE level)**

| Survey items | Quantities | Quantities in the TOR |
|---|---|---|
| Legal and Institutional system of EIA | Lamp sum | Conduct if necessary |
| Items for Land Acquisition | Lamp sum | |
| Items for social Environment | Lamp sum | |
| Items for Natural Environment | Lamp sum | |
| Items for Pollutions | Lamp sum | |

### 1.4.4 Preliminary examination of flood control measures

Details of primary examination of flood control measures are described in **Chapter 6** and **Chapter 7**.

### 1.4.5 Preparation and Discussion of Progress Report

The Team prepared the Progress Report with the results of Stage-1; also in response to the comments from JICA and JCC, the Team revised and finalized the Progress Report.

### 1.4.6 Technical Transfer in Stage-1

In the Study, discussions and opinion exchanges between the Team and C/P have been conducted through the daily surveys. At the time of the TWG, the Team and TWG members discussed on the technical issues for hydraulic analysis and examination of flood control measures intended to technical transfer from Japan side to Fiji side.

Furthermore, based on the request form the principal engineer of C/P, the Team performed the training on river discharge measurement for junior engineers of C/P. In addition, the Team and C/P performed joint field measurement.

## 1.5 Main Activities of Stage-2

In Stage-2, for 7 months, the Team conducted development and proposal of the Master plan and study on the contents of the Priority Project based on the basic information and the result of the initial examination of flood control measures, which were obtained from the activities of Stage-1. Moreover, preparation and discussion of the interim report, conferences, and technical transfer were conducted. The outline of each activity is described below.

### 1.5.1 Collection and Analysis of Additional Basic Information

In Stage-2, the Team collected additional information which is required for the study on the Master Plan and the F/S. Information regarding river and river basin condition, which are required for the detailed analysis and the selection of contents of the Master Plan and the Priority Project was collected through the field survey and so on. Moreover, information regarding environmental and social considerations; non-structural measures; design, cost estimation and construction of structural measures was collected. Procedures and issues for project implementation were also collected and examined aiming the implementation of F/S. Discussion with the C/P organizations was conducted along with data collection.

### 1.5.2 Detailed analyses

Run-off and inundation analysis, riverbed fluctuation analysis and analysis on change of the seashore line were implemented later in Stage-1. Therefore, detailed analyses were conducted considering the contents of the Master Plan and the Priority Project in Stage-2. The result of run-off and inundation analysis was utilized for examination of specification / basic design of flood control plan and facilities for the Master Plan and the Priority Project. It is also used for the study on the negative effects of the Priority Project. Effects of the selected Master Plan and Priority Project on geography were analyzed with riverbed fluctuation analysis and analysis on change of the seashore line. River widening was

selected as one of the contents of the Master Plan and the Priority Project instead of diversion channel, and it is found that the effects on configuration of sediment transportation and shoreline change are relatively small from the results of the analyses.

### 1.5.3 Strategic Environmental Assessment and Detailed analyses

Effects of flood control measures on natural environment, such as sea coast, and the effects on society, such as land acquisition and relocation, are examined and evaluated at the early stage of the study as a strategic environmental assessment. Examination and evaluation were conducted considering the "JICA Guidelines for Environmental and Social Considerations" and the procedure of environmental assessment in Fiji and based on the discussion with C/P organizations. Moreover, a monitoring plan was developed for the selected Priority Project.

### 1.5.4 Examination and Proposal of Non-Structural Measures

Current situation and issues related to non-structural measures in the Nadi River basin were clarified and organized based on the interview / discussion with the relevant C/P organizations, and non-structural measures for the Master Plan and the Priority Project were proposed.

Protection of human lives, understanding of disaster risks and evacuation are considered as a top priority, under condition that the progress of structural measures project will be at initial phase.

Therefore, activities accompanied with development and disclosure of hazard maps and development of hydrological devices for awareness of flood risks and so on were proposed as the contents of the non-structural measures for the Priority Project.

### 1.5.5 Determination of the Master Plan and the Priority Project for Flood Control

Contents and its optimized combination of the structural measures for the Master Plan and the Priority Project were examined based on the results of detailed analyses. It was explained and discussed at the JCC meetings, TWG meeting, individual meeting with the relevant C/P organizations and public consultation meeting, and it was determined through the JCC meeting considering the comments of the public and the stakeholder. As a result, river widening of middle-stream of the Nadi River instead of river diversion, which was proposed in the previous development survey in 1998, was adopted as a basic concept of the flood control in the Nadi River basin. Measures, which can preferentially-protect the important protection area / urban area (population / property concentration area) in the Nadi River basin, were selected as a priority project.

### 1.5.6 Development of Draft Basic Design of the Structural Measures

Basic design of the selected structural measures for the Master Plan was conducted. Flood control plan, project contents and its scale were crystallized.

### 1.5.7 Support of Development ofthe Abbreviated Resettlement Action Plan

The Abbreviated Resettlement Action Plan (RAP) for the Priority Project is formulated by the Fiji Government through Feasibility Study stage. In 2nd Study Stage, the outline of the plan, items to be examined, items for filed survey, etc. have been examined by JICA Study Team with relevant organization in Fiji Government. RAP will be finalized in F/S stage.

### 1.5.8 Preparation and Discussion for Interim Report

The team prepared the interim report including the results of the study conducted in Stage-2. The comments from JICA and the JCC were reflected on the report. Since the description of the interim report is based on the study conducted by the end of Stage-2, it will be reviewed and modified based on the additional information and study.

### 1.5.9 Technical Transfer in Stage-2

In the Study, discussions and opinion exchanges between the Team and C/P have been conducted through the daily surveys. At the time of the TWG, the Team and TWG members discussed on procedures, system and issues for implementation of the Priority Project and the Master Plan intended to technical transfer from Japan side to Fiji side.

Furthermore, based on the request form the Project Director of C/P, the Team demonstrated the run-off and inundation analysis and conducted the technical explanation on it.

## 1.6 Main Activities of Stage-3

In Stage-3, the Team implemented Feasibility Study for selected components through Stage-1 and Stage-2 and summarizes Draft Final Report. The outline of each activity is described below.

### 1.6.1 Additional Survey

Following additional surveys were implemented by sub-contract in Stage-3.

#### (1) Topographical Survey

Contents of topographical survey are as shown in Table 1-6.

**Table 1-6 Quantities of Topographical Survey**

| Area | | Item | Quantities | |
|---|---|---|---|---|
| | | | Unit | Quantities |
| River Area | South of Nadi Town | Topographical Survey | km2 | 0.100 |
| | Retarding Basin | Topographical Survey | km2 | 0.200 |
| Bridge Area | Nadi Town Bridge | Topographical Survey | km2 | 0.0175 |
| | | Longitudinal, Cross-sectional Survey | km | 0.40 |
| | | Cross-sectional Survey | Nos | 20 |
| | | Cross-sectional Survey | m | 20 |
| | Old Queens Road | Topographical Survey | km2 | 0.0175 |
| | | Longitudinal, Cross-sectional Survey | km | 0.40 |
| | | Cross-sectional Survey | Nos | 20 |
| | | Cross-sectional Survey | m | 20 |

#### (2) Soil Investigation

Contents of soil investigations are as shown in Table 1-7 and Table 1-8.

**Table 1-7 Quantities of Boring**

| Bor No | Depth | | Site Location | |
|---|---|---|---|---|
| | Unit | Quantities | | |
| No.1 | m | 20 | Nadi River | 1k000, Left Bank Side |
| No.2 | m | 20 | Nadi River | 8k500, Left Bank Side |
| No.3 | m | 20 | Nawaka River | 3k250, Right Bank Side |
| No.4 | m | 30 | Nadi River | 9k750, Right Bank Side |
| No.5 | m | 30 | Nadi River | 9k750, Left Bank Side |
| No.6 | m | 20 | Nadi River | 13k500, Left Bank Side |
| No.7 | m | 30 | Nadi River | 16k750, Right Bank Side |
| No.8 | m | 30 | Nadi River | 16k750, Left Bank Side |
| No.9 | m | 30 | Nadi River | 19k250, Left Bank Side |
| No.10 | m | 30 | Nadi River | 20k500, Left Bank Side |
| No.11 | m | 30 | Nadi River | 20k000, Right Bank Side |
| No.12 | m | 30 | Nadi River | 21k250, Right Bank Side |
| No.13 | m | 30 | Nadi River | 23k000, Right Bank Side |
| No.14 | m | 30 | Nawaka River | 2k500, Right Bank Side |
| No.15 | m | 30 | Nawaka River | 3k200, Right Bank Side |
| No.16 | m | 30 | Nawaka River | 4k750, Right Bank Side |

**Table 1-8 Quantities of Soil Test**

| Bor | Site Tests | Lab Tests Required | | | | | |
|---|---|---|---|---|---|---|---|
| | Permeability | Density | Moisture Content | PSD | Atterberg | UCS | Consolidation |
| No.1 | 1 | 2 | 10 | 6 | 3 | 2 | 2 |
| No.2 | 1 | 3 | 10 | 6 | 3 | 3 | 3 |
| No.3 | 1 | 3 | 10 | 6 | 3 | 3 | 3 |
| No.4 | 1 | 4 | 10 | 6 | 3 | 2 | 1 |
| No.5 | 1 | 2 | 10 | 6 | 3 | 2 | 2 |
| No.6 | 1 | 3 | 10 | 6 | 3 | 3 | 3 |
| No.7 | 1 | 1 | 10 | 6 | 3 | 1 | 1 |
| No.8 | 1 | 1 | 10 | 6 | 2 | 1 | 1 |
| No.9 | 1 | 1 | 10 | 6 | 3 | 1 | 1 |
| No.10 | 1 | 1 | 10 | 6 | 3 | 1 | 1 |
| No.11 | 1 | 2 | 10 | 6 | 3 | 2 | 2 |
| No.12 | 1 | 3 | 10 | 6 | 3 | 0 | 0 |
| No.13 | 1 | 3 | 10 | 6 | 3 | 1 | 1 |
| No.14 | 1 | 3 | 10 | 3 | 3 | 1 | 0 |
| No.15 | 1 | 3 | 10 | 6 | 3 | 3 | 3 |
| No.16 | 1 | 3 | 10 | 6 | 3 | 2 | 3 |

### (3) Environmental and Social Survey

Contents of Environmental and Social Survey are as shown in Table 1-9.

**Table 1-9 Environmental and Social Survey**

| Survey Item | Initial | Additional | Remarks |
|---|---|---|---|
| 1) Water Quality Survey | 5 sites | 7 sites | Parameter:<br>Temperature, pH, Salinity, Dissolved Oxygen, Turbidity, Conductivity, Total Suspended Solids, Total Dissolved Solids, Total Phosphorus, Nitrate, BOD, COD |
| 2) River Bed Soil Survey | 5 sites | 8 sites | Parameter:<br>Organic matter Content, Dry matter content, Ash content, Moisture content, Mn, K, pH, T-N, pH, Heavy metals trace (As, Cd, Cr, Cu, Ni, Pb, Zn, Hg) |
| 3) Biological Survey | | | |
| 3-1) Flora and Fauna | 22 selected environment along the Nadi River | 8 selected environment along theMalakua & Nawaka River, and 1 environment in Moala village | Parameter:<br>Plants, animals, insects, birds |
| 3-1) Water ecology | 7 sites | 9 sites | Parameter:<br>Macro-invertebrates, Fish, Algae & Macrophytes |
| 4) Social Surveys | Randomly selected 122 households in the Project area | | Interview survey |

### 1.6.2 Preliminary Design and Construction Planning

Preliminary Design and Construction Planning for target components of the Feasibility Study were implemented. Target components of the Feasibility Study are as shown in Figure 1-6.

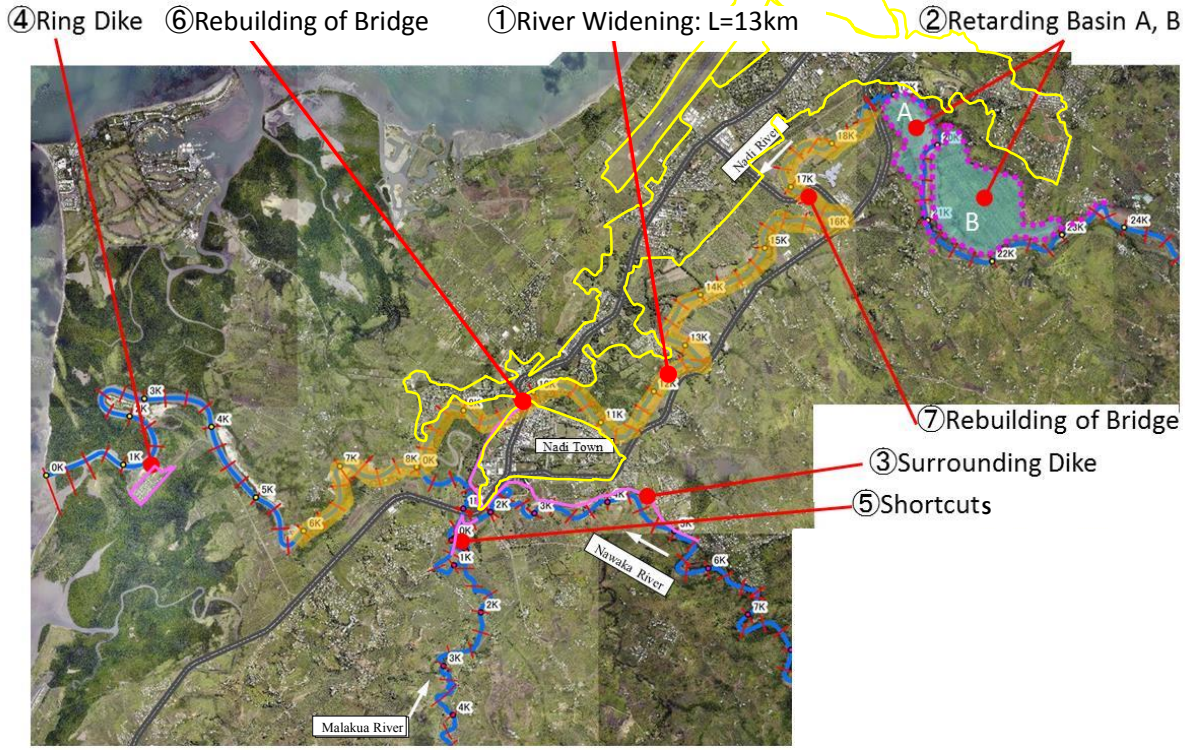



**Figure 1-6 Target components of the Feasibility Study (Structural Measures)**

### 1.6.3 Project Cost Estimation

Project cost for target components was estimated based on preliminary design. Estimated project cost is as shown in Table 1-10. Estimated project cost is 385 million FJD (21 billion JPY).

**Table 1-10 Project Cost**

| Item | | Total | | | |
|---|---|---|---|---|---|
| | | FC | LC | Total | |
| | | million (Yen) | million (F$) | million (Yen) | million (F$) |
| **A. ELIGIBLE PORTION** | | | | | |
| Ⅰ) | Procurement / Construction | 6,778 | 134 | 14,074 | 258 |
| | Package 1 River Widening, Rebuilding of Bridge | 4,213 | 77 | 8,432 | 155 |
| | Package 2 Retarding Basin | 1,281 | 19 | 2,299 | 42 |
| | Package 3 Ring Dike | 40 | 1 | 76 | 1 |
| | Package 4 Surrounding Dike | 392 | 5 | 657 | 12 |
| | Base cost for JICA financing | 5,926 | 102 | 11,464 | 210 |
| | Price escalation | 529 | 26 | 1,940 | 36 |
| | Physical contingency | 323 | 6 | 670 | 12 |
| Ⅱ) | Consulting services | 933 | 18 | 1,893 | 35 |
| | Base cost | 828 | 14 | 1,579 | 29 |
| | Price escalation | 60 | 3 | 223 | 4 |
| | Physical contingency | 44 | 1 | 90 | 2 |
| Total ( Ⅰ + Ⅱ ) | | 7,711 | 151 | 15,967 | 293 |
| **B. NON ELIGIBLE PORTION** | | | | | |
| a | Procurement / Construction | 0 | 0 | 0 | 0 |
| | | | | | |
| | Base cost for JICA financing | 0 | 0 | 0 | 0 |
| | Price escalation | 0 | 0 | 0 | 0 |
| | Physical contingency | 0 | 0 | 0 | 0 |
| b | Land Acquisition | 0 | 38 | 2,093 | 38 |
| | Base cost | 0 | 34 | 1,845 | 34 |
| | Price escalation | 0 | 3 | 148 | 3 |
| | Physical contingency | 0 | 2 | 100 | 2 |
| c | Administration cost | 0 | 17 | 903 | 17 |
| d | VAT | 0 | 30 | 1,625 | 30 |
| e | Import Tax | 0 | 0 | 0 | 0 |
| Total (a+b+c+d+e) | | 0 | 85 | 4,621 | 85 |
| **TOTAL (A+B)** | | 7,711 | 236 | 20,588 | 378 |
| | | | | | 0 |
| **C. Interest during Construction** | | 351 | 0 | 351 | 6 |
| | Interest during Construction(Const.) | 350 | 0 | 350 | 6 |
| | Interest during Construction (Consul.) | 1 | 0 | 1 | 0 |
| **D. Front End Fee** | | 32 | 0 | 32 | 1 |
| **GRAND TOTAL (A+B+C+D)** | | 8,094 | 236 | 20,971 | 385 |
| | | | | | |
| **E. JICA finance portion (A)** | | 7,711 | 151 | 15,967 | 293 |

US$1=2.17 F$, 1F$= JPY 54.5

### 1.6.4 Project Implementation Planning

For project implementation planning, objective, outline, budget planning, implementation Schedule, contents of consulting services, procurement method of consultant and contractor, project implementing structure and so on was studied and proposed.

### 1.6.5 Economic Evaluation

Economic evaluation was implemented with project cost and benefit estimated from flood damage. Economic feasibility of the Priority Project is as shown in Table 1-11.

**Table 1-11 Economic Evaluation of the Priority Project**

| Economic indicator | Result | Evaluation |
|---|---|---|
| Economic internal rate of return (EIRR) | 12.0% | Since EIRR is well over 10% which is applied to the development assistance project in Fiji, the economic effectiveness is high. |
| Benefit-cost (B/C) ratio | 1.20 | Since the B/C ratio is over 1.0, the cost-effectiveness is high. |
| Net present value (NPV) | JPY 1.8 billion (FJD33 million) | Since the value is plus, the cost-effectiveness is high. |

Source: JICA study team

### 1.6.6 Reporting of Feasibility Study

Result of Feasibility Study was summarized in Draft Final Report

### 1.6.7 Draft Final Report

All study results were summarized and compiled in Draft Final Report.

### 1.6.8 Technical Transfer in Stage-3

In the Stage-3, discussions and opinion exchanges between the Team and C/P have been conducted through the daily studies of feasibility studies. At the time of the TWG, the Team and TWG members discussed on technical matters of the Priority Project and at the time of JCC, the Team and JCC members discussed on procedures, system and issues for implementation of the Priority Project intended to technical transfer from Japan side to Fiji side.