### 12.7 Proposed Layout of Facilities

As s result of the examination above, layout of facilities with the diversion channel was determined and is shown in Figure-E12.19.

### 12.8 Short Cut Channel

Short cut channel connecting 7.5 km and 9.0 km points of Nadi river with the total length of approximately 250 m was designed with the following conditions. Results are shown in Figure-E12.20 and Figure-E12.21.

1) Bed width of the short cut channel is 30 m based on the hydraulic examination and slope gradient is 1:2 because all section is cutting but not embankment.
2) Crest width is 4 m and its elevation is EL. 6 m considering 1 m freeboard.
3) Bed elevations of upstream and downstream ends are EL -0.9 m and EL. -1.0 m, respectively, taking same elevation as Nadi river.
4) The present section of Nadi river from the confluence with Nawaka river to around 9.0 km point from river mouth is filled by surplus soil of approximately 13,000 $m^3$ from construction of the short cut channel (refer to Figure-E12.20).
5) Design of the short cut channel does not vary with the scale of floods concerned (1/20, 1/15, 1/10, and 1/5 probability floods).

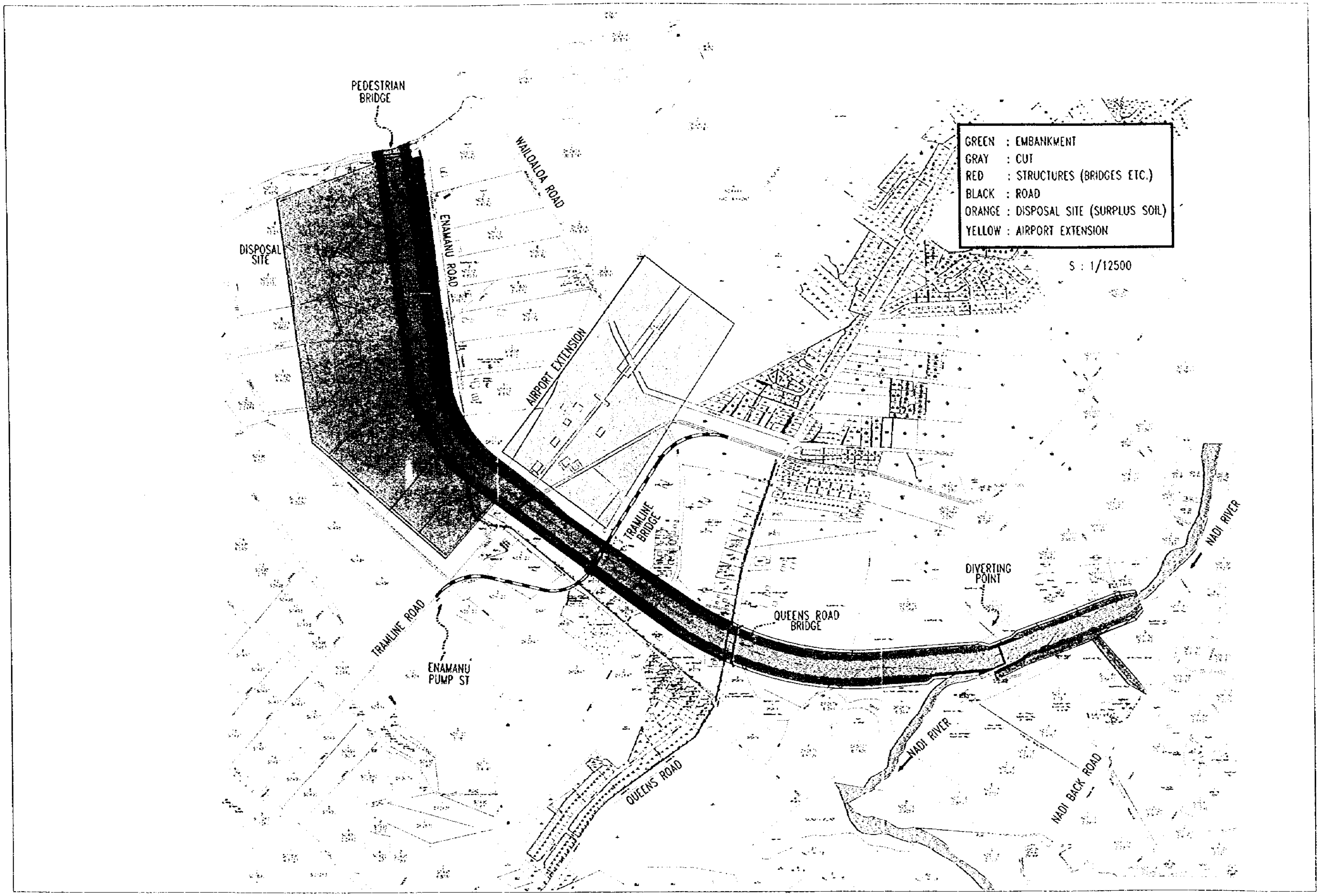



Figure-E12.19 Proposed Layout of Facilities

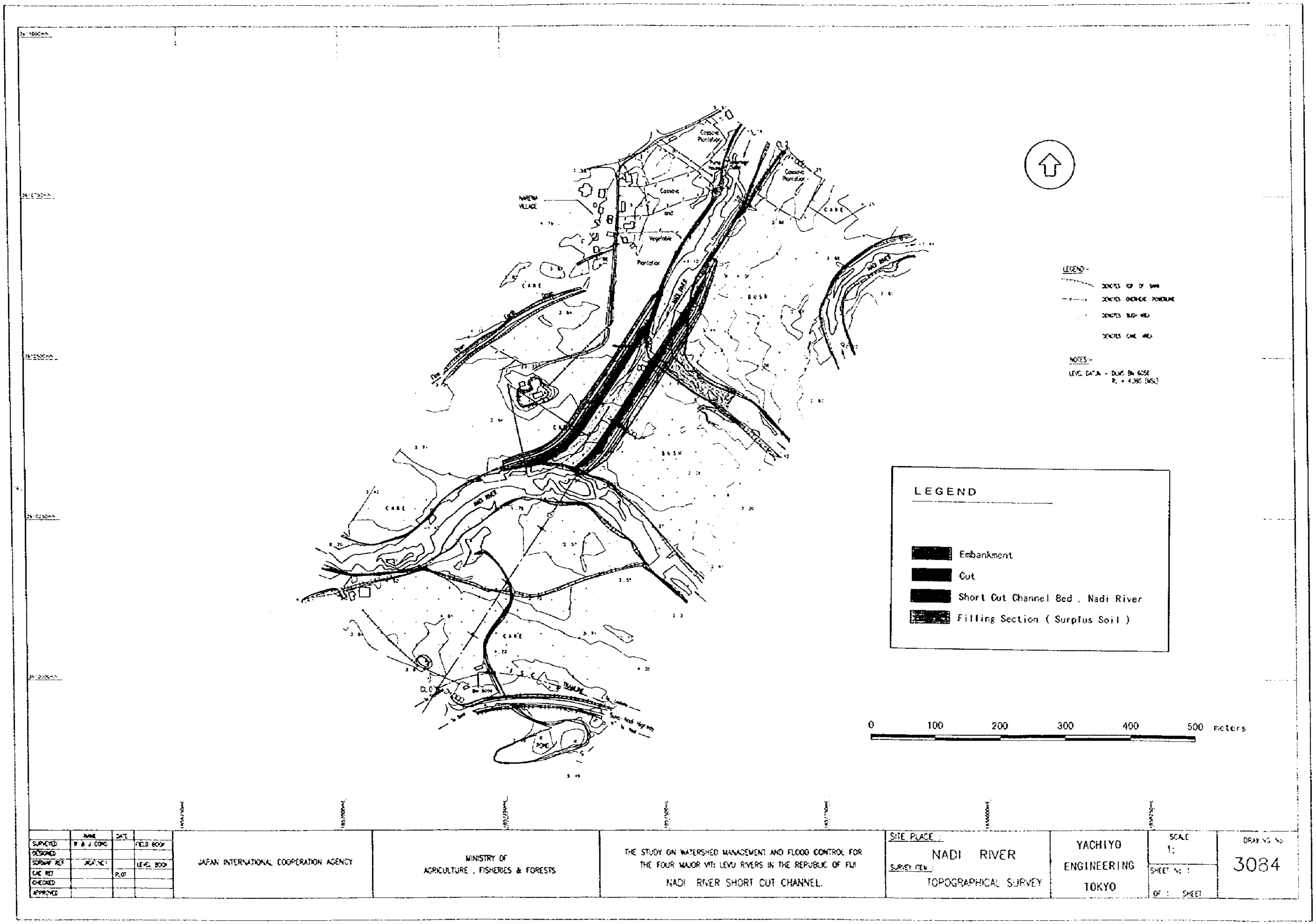
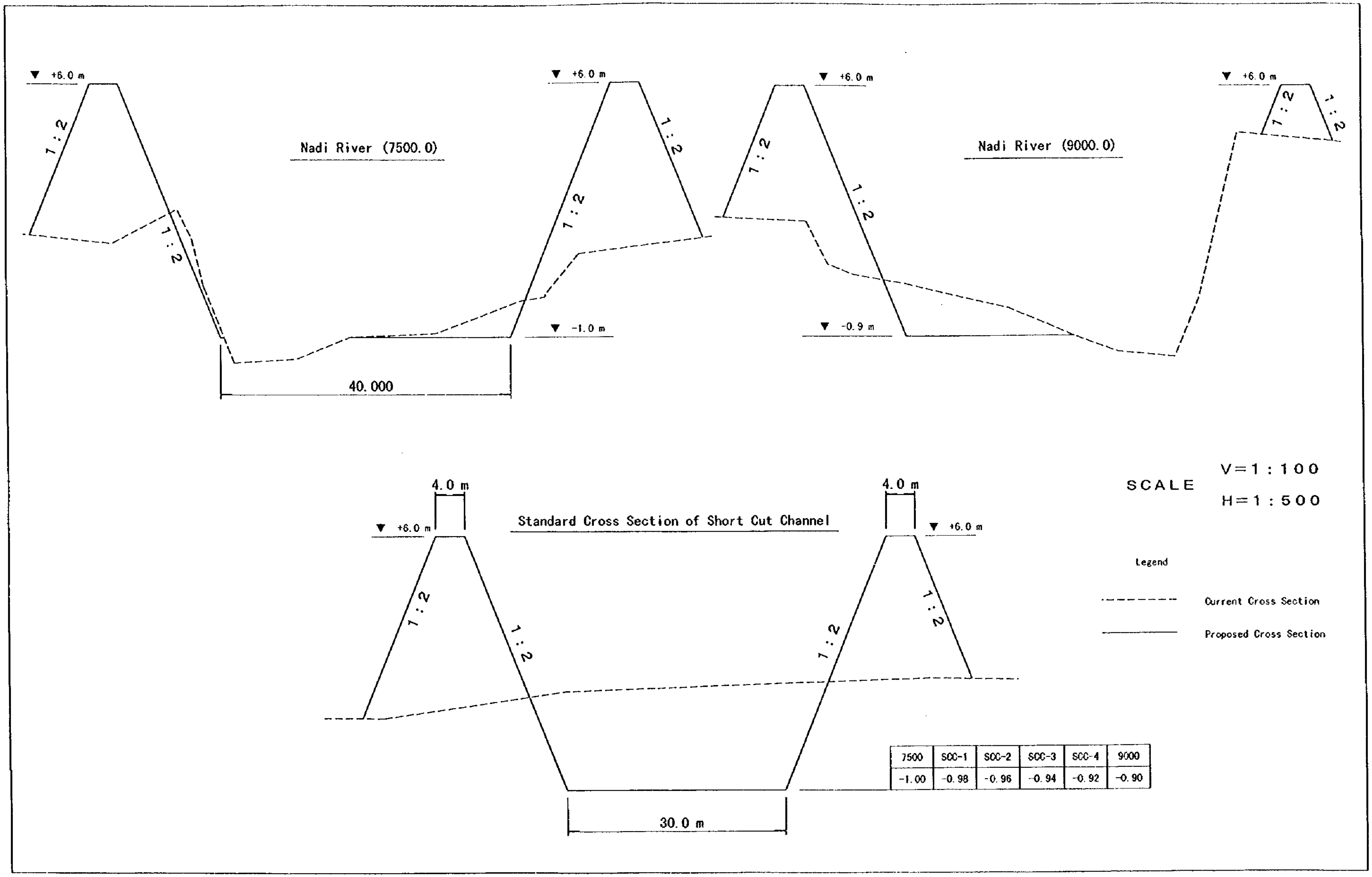



Figure-E12.20 Plan of Short Cut Channel




| 7500 | SCC-1 | SCC-2 | SCC-3 | SCC-4 | 9000 |
|---|---|---|---|---|---|
| -1.00 | -0.98 | -0.96 | -0.94 | -0.92 | -0.90 |

Figure-E12.21 Cross Section of Short Cut Channel

# CHAPTER 13 WORK QUANTITY AND CONSTRUCTION PLAN

## 13.1 Work Quantities

Work quantities of the Nadi diversion channel and short cut channel was estimated varying return period of flood from 1/5 to 1/20. Although the design flood is 1/20, work quantities for smaller floods were estimated considering the stepwise implementation (refer to Chapter 10).

Quantities of earth works were estimated based on the results of cross section survey conducted by the Study Team. In the Master Plan Study, transportation distance of excavated soil was assumed to be 1,500 m; however, in the Feasibility Study, the distance for embankment and that for surplus soil were separated. The former was assumed to be 200 m because excavated soil can be consumed for embankment near the excavation site. The latter was assumed to be 2,000 m because excavated soil needs to be carried to the soil disposal area.

Results of work quantity estimate are shown in Table-E13.1.

Table-E13.1 Work Quantities of Diversion Channel and Short Cut Channel

| Description | | | Unit | Return Period of Flood | | | |
|---|---|---|---|---|---|---|---|
| | | | | 1/20 | 1/15 | 1/10 | 1/5 |
| Main Work | Excavation*1 | Sand and Soil | $m^3$ | 2,290,000 | 2,030,000 | 1,780,000 | 1,470,000 |
| | Loading*1 | | $m^3$ | 2,290,000 | 2,030,000 | 1,780,000 | 1,470,000 |
| | Embankment | Transportation (L=2,000 m) | $m^3$ | 130,000 | 130,000 | 130,000 | 130,000 |
| | | Grading | $m^3$ | 130,000 | 130,000 | 130,000 | 130,000 |
| | | Compaction | $m^3$ | 130,000 | 130,000 | 130,000 | 130,000 |
| | Banking (Surplus Soil) | Transportation (L=200 m) | $m^3$ | 570,000 | 510,000 | 440,000 | 360,000 |
| | | Transportation (L=2,000 m) | $m^3$ | 1,590,000 | 1,390,000 | 1,210,000 | 980,000 |
| | | Grading, Compaction | $m^3$ | 2,160,000 | 1,900,000 | 1,650,000 | 1,340,000 |
| Compensation Work | Queens Road Bridge | | m | 120 | 108 | 96 | 81 |
| | Sugarcane Tramline Bridge | | m | 111 | 99 | 87 | 72 |
| | Pedestrian Bridge | | m | 93 | 81 | 69 | 54 |
| | Road | | m | 4,000 | 4,000 | 4,000 | 4,000 |

*1: including 50,000 $m^3$ for short cut channel and 120,000 $m^3$ for pre-loading

## 13.2 Construction Plan

(1) Basic Idea of Construction

Basic idea of the diversion channel construction is that excavated soil at hilly place (EL. 10 m) in the upper reach of the channel (1,600 ~ 3,300 m from outlet) is used for embankment of the channel in the lower reach where elevation is approximately 2 m. In addition, surplus soil is dumped in the soil disposal area on the left bank side of the channel.

(2) Material Supply

Main construction material, such as cement, gravel, sand, timber, concrete, fuel, steel, asphalt, are obtainable in Fiji. In addition, concrete blocks for bed and bank protection are available in Fiji.

There is no problem in access to carry the material to the site.

(3) Construction Schedule

Construction schedule of the diversion and short cut channels for 20 year return period flood was determined considering the followings and the result is shown in Table-E13.2.

- Construction period is 2 years based on the work quantities.
- Excavation in the cutting section starts prior to pre-loading in the embankment section because excavated soil is used for pre-loading.
- In the embankment section, pre-loading is implemented first to improve the soft and weak layer before actual works start.
- Actual works (excavation and embankment) of the diversion channel in the embankment section starts where consolidation by pre-loading is completed. Required period for consolidation is 3 months.
- Pavement of roads on both banks of the diversion channel is conducted 3 months later after embankment is completed. Period of 3 months was determined considering settlement of banks.
- Excavation of the short cut channel starts regardless of pre-loading.

Table-E13.2 Construction Schedule of Diversion and Short Cut Channels
(20 Year Return Period Flood)

| Description | Unit | Quantity | First Year | | | | | | | | | | | | Second Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| (1) Preparation of Works | | | ■ | ■ | | | | | | | | | | | | | | | | | | | | | | |
| (2) Earth Works | | | | | | | | | | | | | | | | | | | | | | | | | | |
| - Excavation | $m^3$ | 2,290,000 | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| - Embankment | $m^3$ | 139,000 | | | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | |
| - Banking (Surplus Soil) | $m^3$ | 1,900,000 | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| - Pre-loading | $m^3$ | 260,000 | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | | |
| (3) Bridges | | | | | | | | | | | | | | | | | | | | | | | | | | |
| - Queens Road Bridge | m | 120 | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | | | | |
| - Sugarcane Tramline Bridge | m | 111 | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | |
| - Pedestrian Bridge | m | 93 | | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| (4) Shift Works | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| (5) Road (w = 8.00 m) | m | 4,000 | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | |

(4) Plan of Construction Machinery

Based on the construction schedule above, necessary number of construction machinery was estimated and the result is shown in Table-E13.3.

Table-E13.3 Necessary Number of Construction Machinery for Diversion and Short Cut Channels (20 Year Return Period Flood)

| Work | Machinery | Necessary Number |
|---|---|---|
| (1) Earth Works | Bulldozer, 21 t | 16 |
| | Back Hoe, 0.6 $m^3$ | 10 |
| | Dump Truck, 11 t | 30 |
| | Tire Roller 8~20 t (for Dike) | 2 |
| (2) Bridges | Truck Crane, 30 t (for Erection Girders) | 2 |
| | Truck Crane, 10 t | 1 |
| | Concrete Mixer Truck, 4.5 $m^3$ | 3 |
| | Concrete Mixer Truck, 65~85 $m^3$/hr | 1 |
| | Clamshell, 0.4 $m^3$ | 1 |
| (3) Shift Works | Truck Crane, 10 t | 1 |
| | Concrete Mixer Truck, 4.5 $m^3$ | 3 |
| | Concrete Mixer Truck, 65~85 $m^3$/hr | 1 |
| (4) Road (w = 8.00 m) | Motor Grader, 3.1 m | 1 |
| | Road Roller, 10~12 t | 1 |
| | Tire Roller, 8~20 t | 1 |
| | Asphalt Finisher, 2.4 m | 1 |
| | Water Tank Car, 3,800 ltr | 1 |

# CHAPTER 14 COST ESTIMATE

## 14.1 Composition of Project Cost

The composition of project cost is shown below. Ratios of the administration cost, engineering cost and contingency were estimated based on comparison of similar projects in the world.

1) Construction cost
2) Land acquisition
3) Administration: 5 % of 1)
4) Engineering: 15 % of 1)
5) Physical contingency of construction quantities: 5 % of the sum of 1) ~ 4)
6) Price contingency: based on annual inflation rate of 5 % for local cost and 3 % for foreign cost, and construction period of 2 years
7) Taxes and duties: 10 % of the sum of 1) ~ 6)

In the Master Plan Study, physical contingency was assumed to be 10 % of the sum of 1) ~ 4). Since the accuracy of proposed plan has been improved by the geological survey, topographical survey and so on, 5 % is considered appropriate.

## 14.2 Estimate of Construction Cost

1) Condition of Unit Cost

a) In Fiji, the standard price per unit work is not available for the cost estimate. Therefore, the unit price of each work item was estimated based on the costs of previous works similar to the project. The unit price for the earth work in Fiji is approximately 80 % of that in Japan.

b) The unit price of the construction work for the bridges and roads in compensation work was estimated with data collection and interview study to the contractors in Fiji.

2) Estimate of Construction Cost

The construction cost for the 4 floods was estimated as shown in Table-E14.1 to Table-E14.4, based on the above conditions.

Table-E14.1 Construction Cost of Diversion and Short Cut Channels for 1/20 Probability Flood

| Description | | | Unit Price | Quantity | Amount (F$) | Remarks |
|---|---|---|---|---|---|---|
| Main Work | Excavation*1 | Sand and Soil | 2.7 F$/m³ | 2,290,000 m³ | 6,183,000 | Distance to Bulldoze = 60 m |
| | Loading*1 | | 2.1 F$/m³ | 2,290,000 m³ | 4,809,000 | |
| | Embankment | Transportation | 4.0 F$/m³ | 130,000 m³ | 520,000 | Distance = 2,000 m |
| | | Grading | 1.6 F$/m³ | 130,000 m³ | 208,000 | |
| | | Compaction | 0.4 F$/m³ | 130,000 m³ | 52,000 | |
| | Banking (Surplus Soil) | Transportation | 2.7 F$/m³ | 570,000 m³ | 1,539,000 | Distance = 200 m |
| | | Transportation | 4.0 F$/m³ | 1,590,000 m³ | 6,360,000 | Distance = 2,000 m |
| | | Grading & Compaction | 2.1 F$/m³ | 2,160,000 m³ | 4,536,000 | |
| | Bed & Bank Protection | | | Lump Sum | 4,841,400 | Main Work x 20 % |
| | Sub-Total | | | | 29,048,400 | |
| Compensation Work | Bridge (Vehicles) | | 32,500.0 F$/m | 120 m | 3,900,000 | |
| | Bridge (Sugarcane Tramline) | | 12,000.0 F$/m | 111 m | 1,332,000 | |
| | Bridge (Pedestrians) | | 6,500.0 F$/m | 93 m | 604,500 | |
| | Road | | 350.0 F$/m | 4,000 m | 1,400,000 | |
| | Shift Works | | | Lump Sum | 723,650 | Total of Above Compensation Works x 10 % |
| | Sub-Total | | | | 7,960,150 | |
| Construction Cost = Main Work + Compensation Work | | | | | 37,008,550 | |

*1: including 50,000 m³ for short cut channel and 120,000 m³ for pre-loading

Shift Works: pipe lines for water supply, sewage pile line, electric cable, telephone line, cable between transmitter station & airport, sugarcane tramline

Table-E14.2 Construction Cost of Diversion and Short Cut Channels for 1/15 Probability Flood

| Description | | | Unit Price | Quantity | Amount (F$) | Remarks |
|---|---|---|---|---|---|---|
| Main Work | Excavation*1 | Sand and Soil | 2.7 F$/m³ | 2,030,000 m³ | 5,481,000 | Distance to Bulldoze = 60 m |
| | Loading*1 | | 2.1 F$/m³ | 2,030,000 m³ | 4,263,000 | |
| | Embankment | Transportation | 4.0 F$/m³ | 130,000 m³ | 520,000 | Distance = 2,000 m |
| | | Grading | 1.6 F$/m³ | 130,000 m³ | 208,000 | |
| | | Compaction | 0.4 F$/m³ | 130,000 m³ | 52,000 | |
| | Banking (Surplus Soil) | Transportation | 2.7 F$/m³ | 510,000 m³ | 1,377,000 | Distance = 200 m |
| | | Transportation | 4.0 F$/m³ | 1,390,000 m³ | 5,560,000 | Distance = 2,000 m |
| | | Grading & Compaction | 2.1 F$/m³ | 1,900,000 m³ | 3,990,000 | |
| | Bed & Bank Protection | | | Lump Sum | 4,290,200 | Main Work x 20 % |
| | Sub-Total | | | | 25,741,200 | |
| Compensation Work | Bridge (vehicles) | | 32,500.0 F$/m | 108 m | 3,510,000 | |
| | Bridge (Sugarcane Tramline) | | 12,000.0 F$/m | 99 m | 1,188,000 | |
| | Bridge (Pedestrians) | | 6,500.0 F$/m | 81 m | 526,500 | |
| | Road | | 350.0 F$/m | 4,000 m | 1,400,000 | |
| | Shift Works | | | Lump Sum | 662,450 | Total of Above Compensation Works x 10 % |
| | Sub-Total | | | | 7,286,950 | |
| Construction Cost = Main Work + Compensation Work | | | | | 33,028,150 | |

*1: including 50,000 m³ for short cut channel and 120,000 m³ for pre-loading

Shift Works: pipe lines for water supply, sewage pile line, electric cable, telephone line, cable between transmitter station & airport, sugarcane tramline

Table-E14.3 Construction Cost of Diversion and Short Cut Channels for 1/10 Probability Flood

| Description | | | Unit Price | Quantity | Amount (F$) | Remarks |
|---|---|---|---|---|---|---|
| Main Work | Excavation*1 | Sand and Soil | 2.7 F$/m$^3$ | 1,780,000 m$^3$ | 4,806,000 | Distance to Bulldoze = 60 m |
| | Loading*1 | | 2.1 F$/m$^3$ | 1,780,000 m$^3$ | 3,738,000 | |
| | Embankment | Transportation | 4.0 F$/m$^3$ | 130,000 m$^3$ | 520,000 | Distance = 2,000 m |
| | | Grading | 1.6 F$/m$^3$ | 130,000 m$^3$ | 208,000 | |
| | | Compaction | 0.4 F$/m$^3$ | 130,000 m$^3$ | 52,000 | |
| | Banking (Surplus Soil) | Transportation | 2.7 F$/m$^3$ | 440,000 m$^3$ | 1,188,000 | Distance = 200 m |
| | | Transportation | 4.0 F$/m$^3$ | 1,210,000 m$^3$ | 4,840,000 | Distance = 2,000 m |
| | | Grading & Compaction | 2.1 F$/m$^3$ | 1,650,000 m$^3$ | 3,465,000 | |
| | Bed & Bank Protection | | | Lump Sum | 3,763,400 | Main Work x 20 % |
| | Sub-Total | | | | 22,580,400 | |
| Compensation Work | Bridge (Vehicles) | | 32,500.0 F$/m | 96 m | 3,120,000 | |
| | Bridge (Sugarcane Tramline) | | 12,000.0 F$/m | 87 m | 1,044,000 | |
| | Bridge (Pedestrians) | | 6,500.0 F$/m | 69 m | 448,500 | |
| | Road | | 350.0 F$/m | 4,000 m | 1,400,000 | |
| | Shift Works | | | Lump Sum | 601,250 | Total of Above Compensation Works x 10 % |
| | Sub-Total | | | | 6,613,750 | |
| Construction Cost = Main Work + Compensation Work | | | | | 29,194,150 | |

*1: including 50,000 m$^3$ for short cut channel and 120,000 m$^3$ for pre-loading
Shift Works: pipe lines for water supply, sewage pile line, electric cable, telephone line, cable between transmitter station & airport, sugarcane tramline

Table-E14.4 Construction Cost of Diversion and Short Cut Channels for 1/5 Probability Flood

| Description | | | Unit Price | Quantity | Amount (F$) | Remarks |
|---|---|---|---|---|---|---|
| Main Work | Excavation*1 | Sand and Soil | 2.7 F$/m$^3$ | 1,470,000 m$^3$ | 3,969,000 | Distance to Bulldoze = 60 m |
| | Loading*1 | | 2.1 F$/m$^3$ | 1,470,000 m$^3$ | 3,087,000 | |
| | Embankment | Transportation | 4.0 F$/m$^3$ | 130,000 m$^3$ | 520,000 | Distance = 2,000 m |
| | | Grading | 1.6 F$/m$^3$ | 130,000 m$^3$ | 208,000 | |
| | | Compaction | 0.4 F$/m$^3$ | 130,000 m$^3$ | 52,000 | |
| | Banking (Surplus Soil) | Transportation | 2.7 F$/m$^3$ | 360,000 m$^3$ | 972,000 | Distance = 200 m |
| | | Transportation | 4.0 F$/m$^3$ | 980,000 m$^3$ | 3,920,000 | Distance = 2,000 m |
| | | Grading & Compaction | 2.1 F$/m$^3$ | 1,340,000 m$^3$ | 2,814,000 | |
| | Bed & Bank Protection | | | Lump Sum | 3,108,400 | Main Work x 20 % |
| | Sub-Total | | | | 18,650,400 | |
| Compensation Work | Bridge (Vehicles) | | 32,500.0 F$/m | 81 m | 2,632,500 | |
| | Bridge (Sugarcane Tramline) | | 12,000.0 F$/m | 72 m | 864,000 | |
| | Bridge (Pedestrians) | | 6,500.0 F$/m | 54 m | 351,000 | |
| | Road | | 350.0 F$/m | 4,000 m | 1,400,000 | |
| | Shift Works | | | Lump Sum | 524,750 | Total of Above Compensation Works x 10 % |
| | Sub-Total | | | | 5,772,250 | |
| Construction Cost = Main Work + Compensation Work | | | | | 24,422,650 | |

*1: including 50,000 m$^3$ for short cut channel and 120,000 m$^3$ for pre-loading
Shift Works: pipe lines for water supply, sewage pile line, electric cable, telephone line, cable between transmitter station & airport, sugarcane tramline

## 14.3 Estimate of Land Acquisition and Compensation Cost

Estimate of land acquisition and compensation cost is discussed in Supporting Report, Part K. The result is summarized in Table-E14.5.

Table-E14.5 Cost for Land Acquisition and Compensation
(20 Year Return Period Flood)

(Unit: F$ 1,000)

| | Diversion Channel | Short Cut |
|---|---|---|
| (1) Land | 5,468 | 89 |
| (2) Buildings/Investment | 2,896 | --- |
| (3) Crops | 414 | 12 |
| Total | 8,778 | 101 |

The land acquisition and compensation cost for the diversion and channels is more than twice as large as that in the Master Plan Study due to the following reasons.

- Required area in the Master Plan Study is 72.1 ha, while that in the Feasibility Study is 108.8 ha. This discrepancy is due to results of the detailed study, such as topographical survey, geological survey, social environmental survey and so on.
- In the Master Plan Study, all area in the freehold land, except a large commercial lot, was assumed as agricultural land whose unit cost is F$ 13,500/ha; however, in the Feasibility Study, 12 % of that area was classified as residential area (unit cost = F$ 250,000/ha) by Department of Land and Surveys. In addition, Department of Land and Surveys suggested higher unit prices for agricultural land in the freehold and compensation in the state land based on the field reconnaissance.
- Compensation costs for building was also increased almost double based on the field reconnaissance by Department of Land and Surveys, and Housing Authority.

## 14.4 Estimate of Project Cost

The project cost (1996 prices) was estimated based on the conditions below.

- The ratio between local currency portion and foreign currency portion was set as shown in Table-E14.6 based on the construction works in Fiji.
- The price contingency was taken into consideration with annual inflation rate of 5 % for the local currency portion and 3 % for the foreign currency portion.

Table-E14.6 Ratio of Local Currency and Foreign Currency

| Item | Local Currency | Foreign Currency |
|---|---|---|
| 1. Construction Cost | | |
| 1) Material & Equipment | 20 % | 80 % |
| 2) Labor | 80 % | 20 % |
| 2. Land Acquisition | 100 % | 0 % |
| 3. Administration | 100 % | 0 % |
| 4. Engineering | 20 % | 80 % |
| 5. Physical Contingency | 40 % | 60 % |

The result of project cost estimate is shown in Table-E14.7.

Table-E14.7 Project Cost of Diversion and Short Cut Channels

Unit: F$ 1,000

| Flood Scale | Item | Project Cost | Local Currency | Foreign Currency |
|---|---|---|---|---|
| 1/20 | 1. Construction Cost | 37,000 | 14,060 | 22,940 |
| | 1) Material & Equipment | 25,900 | 5,180 | 20,720 |
| | 2) Labor | 11,100 | 8,880 | 2,220 |
| | 2. Land Acquisition | 8,900 | 8,900 | – |
| | 3. Administration | 1,900 | 1,900 | – |
| | 4. Engineering | 5,600 | 1,120 | 4,480 |
| | 5. Physical Contingency | 2,700 | 1,080 | 1,620 |
| | Sub Total | 56,100 | 27,060 | 29,040 |
| | 6. Price Contingency | 1,120 | 680 | 440 |
| | 7. Tax | 5,720 | 5,720 | 0 |
| | Grand Total | 62,940 | 33,460 | 29,480 |
| 1/15 | 1. Construction Cost | 33,000 | 12,540 | 20,460 |
| | 1) Material & Equipment | 23,100 | 4,620 | 18,480 |
| | 2) Labor | 9,900 | 7,920 | 1,980 |
| | 2. Land Acquisition | 8,000 | 8,000 | – |
| | 3. Administration | 1,700 | 1,700 | – |
| | 4. Engineering | 5,000 | 1,000 | 4,000 |
| | 5. Physical Contingency | 2,400 | 960 | 1,440 |
| | Sub Total | 50,100 | 24,200 | 25,900 |
| | 6. Price Contingency | 1,000 | 610 | 390 |
| | 7. Tax | 5,110 | 5,110 | 0 |
| | Grand Total | 56,210 | 29,920 | 26,290 |
| 1/10 | 1. Construction Cost | 29,200 | 11,120 | 18,080 |
| | 1) Material & Equipment | 20,400 | 4,080 | 16,320 |
| | 2) Labor | 8,800 | 7,040 | 1,760 |
| | 2. Land Acquisition | 7,400 | 7,400 | – |
| | 3. Administration | 1,500 | 1,500 | – |
| | 4. Engineering | 4,400 | 880 | 3,520 |
| | 5. Physical Contingency | 2,100 | 840 | 1,260 |
| | Sub Total | 44,600 | 21,740 | 22,860 |
| | 6. Price Contingency | 880 | 540 | 340 |
| | 7. Tax | 4,550 | 4,550 | 0 |
| | Grand Total | 50,030 | 26,830 | 23,200 |
| 1/5 | 1. Construction Cost | 24,400 | 9,260 | 15,140 |
| | 1) Material & Equipment | 17,100 | 3,420 | 13,680 |
| | 2) Labor | 7,300 | 5,840 | 1,460 |
| | 2. Land Acquisition | 6,700 | 6,700 | – |
| | 3. Administration | 1,200 | 1,200 | – |
| | 4. Engineering | 3,700 | 740 | 2,960 |
| | 5. Physical Contingency | 1,800 | 720 | 1,080 |
| | Sub Total | 37,800 | 18,620 | 19,180 |
| | 6. Price Contingency | 760 | 470 | 290 |
| | 7. Tax | 3,860 | 3,860 | 0 |
| | Grand Total | 42,420 | 22,950 | 19,470 |

Note: 1) Tax: Value Added Tax (VAT), 10 %
2) Material & Equipment = Construction Cost x 70 %
3) Labor = Construction Cost x 30 %

# CHAPTER 15 ECONOMIC EVALUATION

## 15.1 General

As discussed in Chapter 10, discharge of the diversion channel is 5 times as much as the current flow capacity of Nadi river for the design flood (20 year return period flood). The design flood may be too large to realize flood control measures for Nadi river. Therefore, the scale of diversion channel with not only the designed flood but also smaller probability floods, 1/15, 1/10 and 1/5, were examined in the previous chapters.

The main objectives of the economic evaluation are 1) to evaluate 4 cases of the flood control measures (Nadi diversion and short cut channels with 4 different floods) from economic point of view, and 2) to conduct sensitivity analysis and examine financial aspect for the most feasible case.

The details of Economic evaluation are discussed in Supporting Report Part A. In this chapter, only summary is discussed.

## 15.2 Annual Average Economic Benefit

The same method (Chapter 3) and same relation between discharge and flood damage (Figure-E3.4 in Chapter 3) was adopted to estimate the annual average flood damage reduction for each case. The results of estimate are shown in Table-E15.1.

Table-E15.1 Annual Average Damage Reduction by Nadi Diversion and Short Cut Channels

| Design Flood | Return Period | | Annual Average Return Periods | Discharge Current | Discharge After Imple-mentation | Discharge Effect | Flood Damage Current | Flood Damage After Imple-mentation | Flood Damage Reduction | Average Flood Damage Reduction | Annual Average Flood Damage Reduction |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ① | ② | ③ | ④=②-③ | ⑤ | ⑥ | ⑦=⑤-⑥ | ⑧=(⑦n+⑦n-1)/2 | ⑨=①x⑧ |
| | | | | m³/sec | m³/sec | m³/sec | 10³F$ | 10³F$ | 10³F$ | 10³F$ | 10³F$ |
| 1/20 Probability Flood | 1/20 | 0.050 | - | 2,100 | 550 | 1,550 | 78,241 | 0 | 78,241 | - | - |
| | 1/10 | 0.100 | 0.050 | 1,400 | 370 | 1,030 | 42,906 | 0 | 42,906 | 60,574 | 3,028 |
| | 1/5 | 0.200 | 0.100 | 960 | 250 | 710 | 20,696 | 0 | 20,696 | 31,801 | 3,180 |
| | 1/2.5 | 0.400 | 0.200 | 550 | 140 | 410 | 0 | 0 | 0 | 10,348 | 2,070 |
| Total | | | | | | | | | | | 8,278 |
| 1/15 Probability Flood | 1/20 | 0.050 | - | 2,100 | 550 | 1,550 | 78,241 | 0 | 78,241 | - | - |
| | 1/15 | 0.067 | - | 1,750 | 460 | 1,290 | 60,574 | 0 | 60,574 | - | - |
| | 1/10 | 0.100 | 0.033 | 1,400 | 370 | 1,030 | 42,906 | 0 | 42,906 | 51,740 | 1,724 |
| | 1/5 | 0.200 | 0.100 | 960 | 250 | 710 | 20,696 | 0 | 20,696 | 31,801 | 3,180 |
| | 1/2.5 | 0.400 | 0.200 | 550 | 140 | 410 | 0 | 0 | 0 | 10,348 | 2,070 |
| Total | | | | | | | | | | | 6,974 |
| 1/10 Probability Flood | 1/20 | 0.050 | - | 2,100 | 550 | 1,550 | 78,241 | 0 | 78,241 | - | - |
| | 1/10 | 0.100 | - | 1,400 | 370 | 1,030 | 42,906 | 0 | 42,906 | - | - |
| | 1/5 | 0.200 | 0.100 | 960 | 250 | 710 | 20,696 | 0 | 20,696 | 31,801 | 3,180 |
| | 1/2.5 | 0.400 | 0.200 | 550 | 140 | 410 | 0 | 0 | 0 | 10,348 | 2,070 |
| Total | | | | | | | | | | | 5,250 |
| 1/5 Probability Flood | 1/20 | 0.050 | - | 2,100 | 550 | 1,550 | 78,241 | 0 | 78,241 | - | - |
| | 1/10 | 0.100 | - | 1,400 | 370 | 1,030 | 42,906 | 0 | 42,906 | - | - |
| | 1/5 | 0.200 | - | 960 | 250 | 710 | 20,696 | 0 | 20,696 | - | - |
| | 1/2.5 | 0.400 | 0.200 | 550 | 140 | 410 | 0 | 0 | 0 | 10,348 | 2,070 |
| Total | | | | | | | | | | | 2,070 |

Annual average damage reduction varies from F$ 2,070,000 to F$ 8,278,000 depending on the scale of the diversion channel. Economic benefit is assumed to be equivalent to annual average damage reduction. Therefore, figures in Table-E15.1 were used as annual average economic benefit. Annual average economic benefit is expected to accrue every year during the project life of 50 years after completion of the construction works.

## 15.3 Economic Cost

Economic cost is converted value from the project cost. Applying the same conditions and assumptions in Chapter 4, economic costs for the 4 cases were estimated based on the project costs (financial costs) in Chapter 14.

Annual OM cost (operation and maintenance), which is required every year during the period of project life (50 years), was assumed to be 0.1 % of the construction cost. Financial OM cost was converted to economic OM cost.

Table-E15.2 Financial and Economic Cost of Projects

| Cost | | Scale of Project (Flood Probability) | | | |
|---|---|---|---|---|---|
| | | 1/20 | 1/15 | 1/10 | 1/5 |
| Financial Cost | Project Cost (F$ 1,000) | 62,940 | 56,210 | 50,030 | 42,420 |
| | Annual OM Cost (F$ 1,000/year) | 37 | 33 | 29 | 24 |
| Economic Cost | Project Cost (F$ 1,000) | 53,139 | 47,449 | 42,203 | 35,724 |
| | Annual OM Cost (F$ 1,000/year) | 36 | 32 | 28 | 24 |

## 15.4 Economic Evaluation

The 4 cases with different return period floods were evaluated from economic point of view, with the following assumptions. The results are shown in Table-E15.3.

1) The project life is 50 years.
2) Construction period is 2 years.
3) Discount rate is 10 % same as the Master Plan Study.

Table-E15.3 Economic Evaluation of Nadi Diversion Channel and Short Cut Channel

| Scale of Project (Flood Probability) | 1/20 | 1/15 | 1/10 | 1/5 |
|---|---|---|---|---|
| Annual Economic Benefit (F$ 1,000/year) | 8,278 | 6,974 | 5,250 | 2,070 |
| Economic Project Cost (F$ 1,000) | 53,139 | 47,449 | 42,203 | 35,724 |
| Economic Annual Maintenance Cost (F$ 1,000/year) | 36 | 32 | 28 | 24 |
| EIRR (%) | 14.45 | 13.67 | 11.65 | 5.13 |
| B/C (Ratio) | 1.46 | 1.38 | 1.17 | 0.54 |
| NPV (F$ 1,000) | 21,423 | 15,708 | 6,167 | -14,235 |

Discount Rate: 10 %

EIRR of the project for 1/20, 1/15, 1/10 and 1/5 probability floods is 14.45 %, 13.67 %, 11.65 % and 5.13 %, respectively. Those figures indicate that the projects are feasible for 1/20, 1/15 and 1/10 probability floods, as long as the opportunity cost of capital is assumed to be 10 %. In addition, respective B/C of 1.46, 1.38 and 1.17 supports the feasibility of these projects. Meanwhile, EIRR of 5.13 % for 1/5 probability flood indicates that the project is not feasible, and B/C of 0.54 implies the difficulty of the project implementation.

The project for 1/20 probability flood is the most feasible because of its highest economic indices, compared to other two feasible projects. In the case that there are some financial constraints, the project at least for 1/10 probability flood should be implemented.

## 15.5 Sensitivity Analysis

Sensitivity analysis was conducted to the most feasible project (1/20 probability flood). Its objective is to assess whether the project can maintain its viability, when placed under unfavorable circumstances during and after implementation of the project.

Conditions of the sensitivity analysis are as follows.

1) Economic cost increase 5 % and 10 % due to unexpected factors.
2) Economic benefit decreases 5 % and 10 % due to unexpected factors.
3) Project life, construction period and discount rate are same as the base case.

The results are shown in Table-E15.4. Sensitivity analysis index is EIRR.

Table-E15.4 Results of Sensitivity Analysis (EIRR)

| | | Increase in Cost | | |
|---|---|---|---|---|
| | | 0 % | 5 % | 10 % |
| Decrease in Benefit | 0 % | 14.45 | 13.79 | 13.19 |
| | -5 % | 13.76 | 13.13 | 12.56 |
| | -10 % | 13.07 | 12.47 | 11.92 |

Note: The project analyzed is for 1/20 probability flood.

EIRR sensitivity analysis for the Operation and Maintenance Cost (OM Cost) was also examined under the conditions of the increase in 0.5 %, 1.0 % and 1.5 % of construction cost. The results are summarized below.

| | | | | |
|---|---|---|---|---|
| OM Cost (%) | 0.1 | 0.5 | 1.0 | 1.5 |
| EIRR (%) | 14.45 | 14.21 | 13.91 | 13.61 |

EIRR of the project (Nadi diversion channel and short cut channel for 1/20 probability flood) varies from 14.45 % (no increase in cost and no decrease in benefit) to 11.92 % (increase in cost = 10 %, decrease in benefit = 10 %). In the most unfavorable case of OM Cost, EIRR is 13.61 %. These figures indicate that the project is feasible even in the most unfavorable case.

## 15.6 Financial Aspect

Financial project cost for 1/20 probability flood is F$ 62.94 million and this cost is scheduled to be disbursed over the construction period of 2 years. Since the project requires such a substantial amount of fund for the short period, the government of Fiji may need a loan from overseas financial agency. Therefore, considering the financial capability of the Fijian government, applicability of loan to the project was examined with the following two scenarios.

Conditions of scenario 1 are as follows.

1) Interest rate of loan is 1.7 % per annum.
2) Term of repayment is 25 years, inclusive of a grace period of 7 years.
3) Only the interest is paid during the grace period, while principal and interest are paid after the grace period.
4) An amount of loan is 85 % of the financial project cost.

Conditions of scenario 2 are as follows.

1) Interest rate of loan is 7.0 % per annum.
2) Term of repayment is 17 years, inclusive of a grace period of 5 years.
3) Only the interest is paid during the grace period, while principal and interest are paid after the grace period.
4) An amount of loan is 85 % of the financial project cost.

In the case of scenario 1, the total repayment with interest amounts to F$ 67.14 million and the maximum annual repayment amounts to F$ 3.83 million at the eighth year from the commencement of the project.

In the case of scenario 2, the total repayment with interest amounts to F$ 90.95 million and the maximum annual repayment amounts to F$ 7.89 million at the sixth year from the commencement of the project.

Table-E15.5 shows the mid-term schedule of government repayment to overseas loan up to the year of 2000. The figures of scenario 1 and 2 were compared to average figures in schedule. As a result, the maximum annual repayment of scenario 1 and 2 is 11.7 % and 24.0 % of the average total repayment by the Government of Fiji, respectively. Scenario 1 increases the average debt coverage ratio from 3.1 % to 3.5 %, while scenario 2 increases that from 3.1 % to 3.9 %. Although scenario 1 is preferable, even scenario 2 is possible to be implemented considering the above ratio to the total repayment projected and small increase in the debt coverage ratio.

In both scenarios, the Government of Fiji has to finance the rest of cost (15 % of the financial project cost). Its total is F$ 9.44 million and annual cost is F$ 4.72 million which is 4.8 % of the average total capital expenditure of the Government (F$ 98.00 million, averaged value for 1991 ~ 1995) and 11.5 % of the average capital expenditure of infrastructural development by the Government (F$ 40.90 million).

Based on the above examination, the flood control project for 1/20 probability flood (Nadi diversion channel and short cut channel) is considered feasible to be implemented in terms of financial aspect.

Table-E15.5 Government Repayment to Overseas Loans

Unit: F$ 1,000

| | | Actual | Estimate | | Projection | | |
|---|---|---|---|---|---|---|---|
| | | 1996 | 1997 | 1998 | 1999 | 2000 | Average (1996/2000) |
| Overseas Loan Interest Payments | | 11,171 | 12,917 | 13,653 | 12,475 | 11,223 | 12,288 |
| Overseas Loan Principal Payments | | 19,670 | 16,954 | 21,241 | 21,868 | 22,924 | 20,531 |
| (1) Total Repayment (without the Project) | | 30,840 | 29,871 | 34,894 | 34,343 | 34,147 | 32,819 |
| (2) Total Expenditure of the Government | | 958,436 | 1,093,237 | 1,101,507 | 1,046,645 | 1,032,356 | 1,046,436 |
| (3) (1) / (2) x 100: (%)* | | 3.22 | 2.73 | 3.17 | 3.28 | 3.31 | 3.14 |
| Comparison of Peak Repayment for the Project with the whole Government Repayment of each year | | | | | | | |
| (4) Peak Repayment (8th year) of Scenario 1 (F$3,831 thousand) | (5) (4) / (1) x 100 (%) | 12.4 | 12.8 | 11.0 | 11.2 | 11.2 | 11.7 |
| | (6) (4) / (2) x 100: (%) | 0.4 | 0.4 | 0.3 | 0.4 | 0.4 | 0.4 |
| | (7) 3) + (6) : (%)* | 3.62 | 3.08 | 3.52 | 3.65 | 3.68 | 3.51 |
| (8) Peak Repayment (6th year) of Scenario 2 (F$7,891 thousand) | (9) (8) / (1) x 100 (%) | 25.6 | 26.4 | 22.6 | 23.0 | 23.1 | 24.0 |
| | (10) (8) / (2) x 100: (%) | 0.8 | 0.7 | 0.7 | 0.8 | 0.8 | 0.8 |
| | (11) (3) + (10) : (%)* | 4.04 | 3.45 | 3.88 | 4.04 | 4.07 | 3.90 |

Source: Fiji Budget Estimate as Presented to Parliament,1998, Ministry of Finance
Note: * Debt Coverage Ratio; the ratio of overseas loan repayment to government expenditure.

# CHAPTER 16 EFFECT OF PROJECT IMPLEMENTATION

## 16.1 Direct Effect

Economic effect of the Nadi diversion channel and short cut channel is discussed in Chapter 15. In this chapter, effect of the above flood control measures on area of inundation, flood level and flood duration was examined in two cases for the design flood (20 year return period flood) and excess flood (50 year return period flood).

(1) Flood Discharge and Flood Duration

Discharges of two floods (1/20 and 1/50 probability) was calculated with and without flood control measures (Nadi diversion channel and short cut channel). The cyclone Kina's hyetograph was enlarged to simulate flood discharges by the storage function model. Results are shown in Table-E16.1 and hydrograph of each case is shown in Figure-E16.1. Discharges in Table and Figure are at river mouth of Nadi river.

The maximum discharge of 20 year return period flood without the flood control measures is approximately 2,050 $m^3$/sec at river mouth, while that with the flood control measures is reduced to about 600 $m^3$/sec. Since flow capacity of Nadi river is 600 $m^3$/sec (converted discharge at river mouth), there is no flood in the area downstream from the diverting point.

Flood duration of 20 year return period flood without the flood control measures is 16 hours as shown in Figure-E16.1. 16 hours means duration which discharge more than flow capacity flows in Nadi river. Actual duration inclusive of time required to drain the flood from inundated areas is estimated roughly to be 44 hours at minimum without the measures and it would be reduced to zero with the measures.

The maximum discharge of 50 year return period flood is reduced from 3,050 $m^3$/sec to 880 $m^3$/sec by implementation of the flood control measures. On the other hand, flood duration is also estimated to be reduced from 62 hours at minimum without the measures 10 hours at minimum with the measures.

(2) Maximum Water Level

The maximum water level of Nadi river at Nadi bridge for 20 year return period flood is reduced from EL. 11.4 m to EL. 5.1 m by implementation of the flood control measures. On the other hand, that for 50 year return period flood is reduced from EL. 14.1 m to EL. 6.3 m. Since elevation of bank crest at Nadi bridge is approximately 5.9 m, the maximum water level for 20 year return period flood is within the river channel and that for 50 year return period flood is slightly higher than the bank crest, causing small inundation.

(3) Inundated Area

Inundated area with and without implementation of the flood control measures are shown in Figure-E16.2 and Figure-E16.3. The flood control measures are effective in the area downstream from the diverting point.

Inundated area without the implementation is 36.2 $km^2$ for 20 year return period flood and it is reduced to 5.2 $km^2$ with the implementation. There is no inundated area in the downstream from the diverting point.

For 50 year return period flood, inundated area is reduced from 45.4 $km^2$ to 16.0 $km^2$ by the implementation of the flood control measures. Inundated area downstream from the diverting point is reduced from 39.0 $km^2$ to 9.6 $km^2$. The area of 9.6 $km^2$ is distributed along Nadi river.

Table-E16.1 (1/2) Flood Discharge with and without Diversion and Short Cut Channels

| Day | Time (hr:min) | 50 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 50 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) |
|---|---|---|---|---|---|
| 1 | 00:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 00:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 01:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 01:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 02:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 02:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 03:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 03:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 04:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 04:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 05:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 05:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 06:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 06:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 07:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 07:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 08:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 08:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 09.00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 09:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 10.00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 10:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 11:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 11:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 12:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 12:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 13:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 13:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 14:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 14:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 15:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 15:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 16:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 16:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 17:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 17:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 18:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 18:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 19.00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 19:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 20:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 20.30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 21:00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 21:30 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 22.00 | 51.7 | 14.9 | 51.7 | 14.9 |
| 1 | 22:30 | 51.8 | 14.9 | 51.7 | 14.9 |
| 1 | 23:00 | 52.0 | 15.0 | 51.9 | 15.0 |
| 1 | 23:30 | 53.4 | 15.4 | 52.6 | 15.2 |

| Day | Time (hr:min) | 50 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 50 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) |
|---|---|---|---|---|---|
| 2 | 00:00 | 57.1 | 16.5 | 54.8 | 15.8 |
| 2 | 00:30 | 69.3 | 20.0 | 61.8 | 17.8 |
| 2 | 01:00 | 94.6 | 27.3 | 76.5 | 22.1 |
| 2 | 01:30 | 116.5 | 33.6 | 89.1 | 25.7 |
| 2 | 02:00 | 146.5 | 42.3 | 106.2 | 30.7 |
| 2 | 02:30 | 191.3 | 55.2 | 132.0 | 38.1 |
| 2 | 03:00 | 254.4 | 73.4 | 169.3 | 48.9 |
| 2 | 03:30 | 329.6 | 95.1 | 216.6 | 62.5 |
| 2 | 04:00 | 393.2 | 113.5 | 261.1 | 75.4 |
| 2 | 04:30 | 453.1 | 130.7 | 305.1 | 88.1 |
| 2 | 05:00 | 537.7 | 155.1 | 365.8 | 105.6 |
| 2 | 05:30 | 634.3 | 183.0 | 438.4 | 126.6 |
| 2 | 06:00 | 720.6 | 207.9 | 509.5 | 147.1 |
| 2 | 06:30 | 778.5 | 224.6 | 563.6 | 162.7 |
| 2 | 07:00 | 805.5 | 232.4 | 595.9 | 172.0 |
| 2 | 07:30 | 819.4 | 236.4 | 616.3 | 177.9 |
| 2 | 08:00 | 830.0 | 239.5 | 632.1 | 182.5 |
| 2 | 08:30 | 841.8 | 242.9 | 647.1 | 186.8 |
| 2 | 09.00 | 855.7 | 246.9 | 661.8 | 191.1 |
| 2 | 09:30 | 880.3 | 254.0 | 682.6 | 197.1 |
| 2 | 10:00 | 919.6 | 265.3 | 713.0 | 205.8 |
| 2 | 10:30 | 990.2 | 285.7 | 765.6 | 221.0 |
| 2 | 11:00 | 1,085.8 | 313.3 | 836.0 | 241.3 |
| 2 | 11:30 | 1,262.1 | 364.2 | 953.3 | 275.2 |
| 2 | 12:00 | 1,612.2 | 465.2 | 1,148.2 | 331.5 |
| 2 | 12:30 | 2,105.0 | 607.4 | 1,371.0 | 395.8 |
| 2 | 13:00 | 2,672.2 | 771.0 | 1,611.1 | 465.1 |
| 2 | 13:30 | 3,003.4 | 866.6 | 1,811.7 | 523.0 |
| 2 | 14:00 | 3,043.0 | 878.0 | 1,948.0 | 562.4 |
| 2 | 14:30 | 2,972.6 | 857.7 | 2,048.7 | 591.5 |
| 2 | 15.00 | 2,727.9 | 787.1 | 2,035.4 | 587.6 |
| 2 | 15:30 | 2,493.1 | 719.3 | 1,945.2 | 561.6 |
| 2 | 16:00 | 2,342.1 | 675.8 | 1,862.2 | 537.6 |
| 2 | 16:30 | 2,231.0 | 643.7 | 1,791.6 | 517.2 |
| 2 | 17:00 | 2,149.9 | 620.3 | 1,736.0 | 501.2 |
| 2 | 17:30 | 2,064.6 | 595.7 | 1,675.4 | 483.7 |
| 2 | 18:00 | 1,966.2 | 567.3 | 1,603.0 | 462.8 |
| 2 | 18:30 | 1,849.4 | 533.6 | 1,515.0 | 437.4 |
| 2 | 19:00 | 1,715.6 | 495.0 | 1,413.0 | 407.9 |
| 2 | 19:30 | 1,577.8 | 455.2 | 1,306.0 | 377.0 |
| 2 | 20:00 | 1,440.3 | 415.6 | 1,197.9 | 345.8 |
| 2 | 20:30 | 1,305.9 | 376.8 | 1,091.4 | 315.1 |
| 2 | 21:00 | 1,177.3 | 339.7 | 988.8 | 285.5 |
| 2 | 21:30 | 1,065.4 | 307.4 | 897.8 | 259.2 |
| 2 | 22:00 | 972.8 | 280.7 | 821.1 | 237.0 |
| 2 | 22:30 | 891.8 | 257.3 | 753.7 | 217.6 |
| 2 | 23:00 | 817.8 | 236.0 | 692.1 | 199.8 |
| 2 | 23:30 | 752.3 | 217.1 | 637.4 | 184.0 |

Structural Measures: Nadi diversion and short cut channels
Q: discharge at river mouth of Nadi river

Table-E16.1 (2/2) Flood Discharge with and without Diversion and Short Cut Channels

| Day | Time (hr:min) | 50 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 50 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q without Structural Measures ($m^3$/sec) | 20 Year Return Period Flood: Q with Structural Measures ($m^3$/sec) |
|---|---|---|---|---|---|
| 3 | 00:00 | 696.1 | 200.8 | 590.3 | 170.4 |
| 3 | 00:30 | 647.3 | 186.8 | 549.4 | 158.6 |
| 3 | 01:00 | 604.6 | 174.4 | 513.4 | 148.2 |
| 3 | 01:30 | 566.2 | 163.4 | 481.0 | 138.9 |
| 3 | 02:00 | 530.6 | 153.1 | 451.2 | 130.3 |
| 3 | 02:30 | 498.2 | 143.7 | 424.0 | 122.4 |
| 3 | 03:00 | 468.7 | 135.2 | 399.4 | 115.3 |
| 3 | 03:30 | 442.0 | 127.5 | 377.1 | 108.9 |
| 3 | 04:00 | 418.0 | 120.6 | 357.0 | 103.1 |
| 3 | 04:30 | 396.2 | 114.3 | 338.9 | 97.8 |
| 3 | 05:00 | 376.6 | 108.7 | 322.4 | 93.1 |
| 3 | 05:30 | 358.9 | 103.6 | 307.6 | 88.8 |
| 3 | 06:00 | 343.0 | 99.0 | 294.2 | 84.9 |
| 3 | 06:30 | 328.5 | 94.8 | 282.0 | 81.4 |
| 3 | 07:00 | 315.3 | 91.0 | 270.8 | 78.2 |
| 3 | 07:30 | 303.1 | 87.5 | 260.5 | 75.2 |
| 3 | 08:00 | 291.9 | 84.2 | 251.1 | 72.5 |
| 3 | 08:30 | 281.9 | 81.3 | 242.5 | 70.0 |
| 3 | 09:00 | 273.1 | 78.8 | 235.1 | 67.9 |
| 3 | 09:30 | 265.3 | 76.5 | 228.4 | 65.9 |
| 3 | 10:00 | 258.2 | 74.5 | 222.3 | 64.2 |
| 3 | 10:30 | 251.4 | 72.5 | 216.5 | 62.5 |
| 3 | 11:00 | 244.8 | 70.6 | 210.9 | 60.9 |
| 3 | 11:30 | 238.4 | 68.8 | 205.5 | 59.3 |
| 3 | 12:00 | 232.2 | 67.0 | 200.2 | 57.8 |
| 3 | 12:30 | 226.2 | 65.3 | 195.3 | 56.4 |
| 3 | 13:00 | 220.7 | 63.7 | 190.6 | 55.0 |
| 3 | 13:30 | 215.4 | 62.1 | 186.3 | 53.8 |
| 3 | 14:00 | 210.6 | 60.8 | 182.2 | 52.6 |
| 3 | 14:30 | 206.0 | 59.4 | 178.3 | 51.5 |
| 3 | 15:00 | 201.4 | 58.1 | 174.6 | 50.4 |
| 3 | 15:30 | 197.0 | 56.8 | 170.9 | 49.3 |
| 3 | 16:00 | 192.8 | 55.6 | 167.4 | 48.3 |
| 3 | 16:30 | 188.7 | 54.4 | 164.0 | 47.3 |
| 3 | 17:00 | 184.7 | 53.3 | 160.7 | 46.4 |
| 3 | 17:30 | 180.8 | 52.2 | 157.5 | 45.5 |
| 3 | 18:00 | 177.2 | 51.1 | 154.4 | 44.6 |
| 3 | 18:30 | 173.6 | 50.1 | 151.5 | 43.7 |
| 3 | 19:00 | 170.2 | 49.1 | 148.7 | 42.9 |
| 3 | 19:30 | 166.9 | 48.2 | 146.0 | 42.1 |
| 3 | 20:00 | 163.8 | 47.3 | 143.4 | 41.4 |
| 3 | 20:30 | 160.8 | 46.4 | 140.9 | 40.7 |
| 3 | 21:00 | 158.0 | 45.6 | 138.5 | 40.0 |
| 3 | 21:30 | 155.2 | 44.8 | 136.2 | 39.3 |
| 3 | 22:00 | 152.5 | 44.0 | 134.0 | 38.7 |
| 3 | 22:30 | 150.0 | 43.3 | 131.9 | 38.1 |
| 3 | 23:00 | 147.5 | 42.6 | 129.9 | 37.5 |
| 3 | 23:30 | 145.2 | 41.9 | 128.0 | 37.0 |
| 4 | 00:00 | 143.0 | 41.3 | 126.1 | 36.4 |

Structural Measures: Nadi diversion and short cut channels

Q: discharge at river mouth of Nadi river

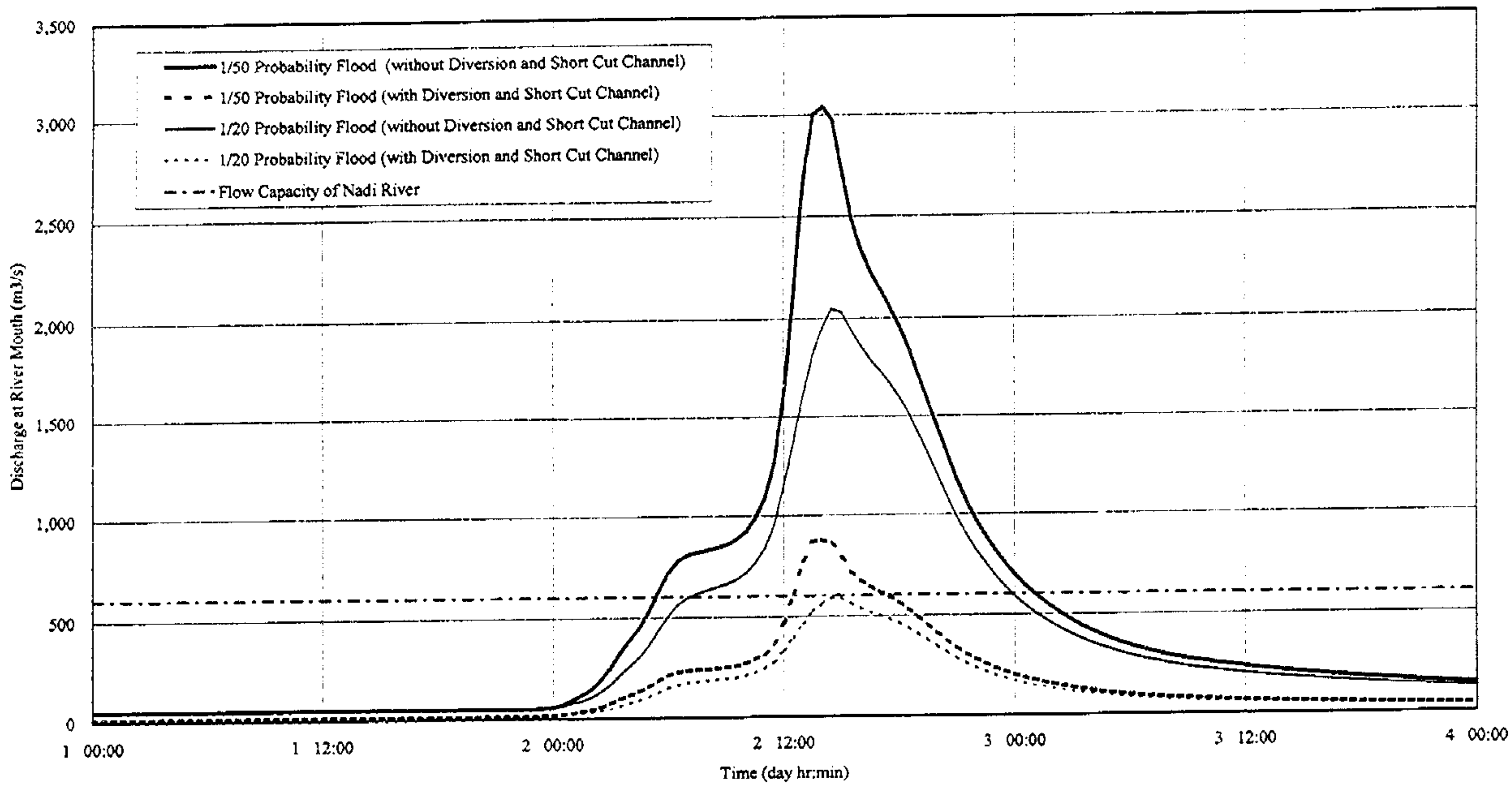



Figure-E16.1 Hydrograph with and without Diversion and Short Cut Channels

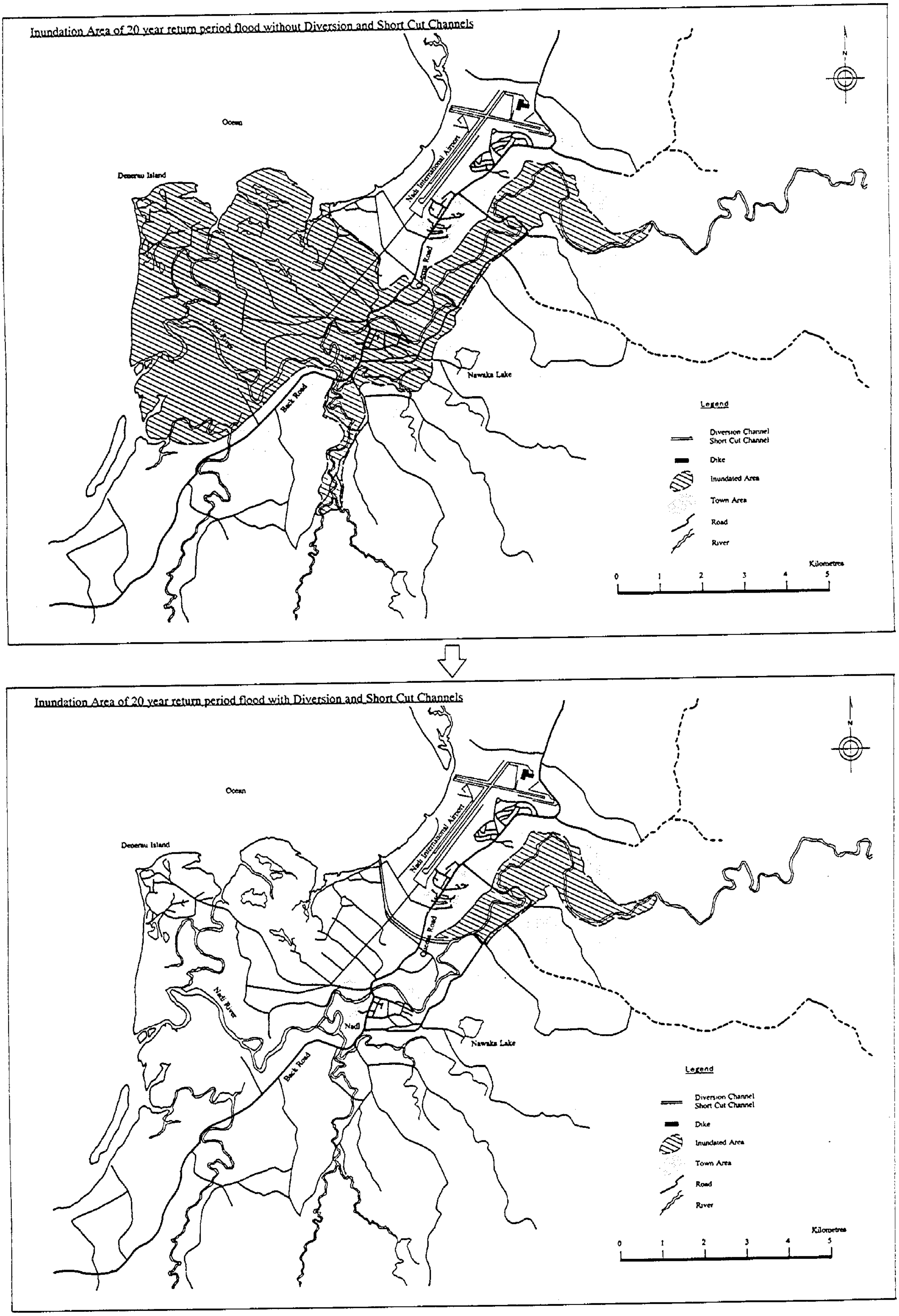



Figure-E16.2 Effect of Project Implementation on Inundated Area of 20 Year Return Period Flood

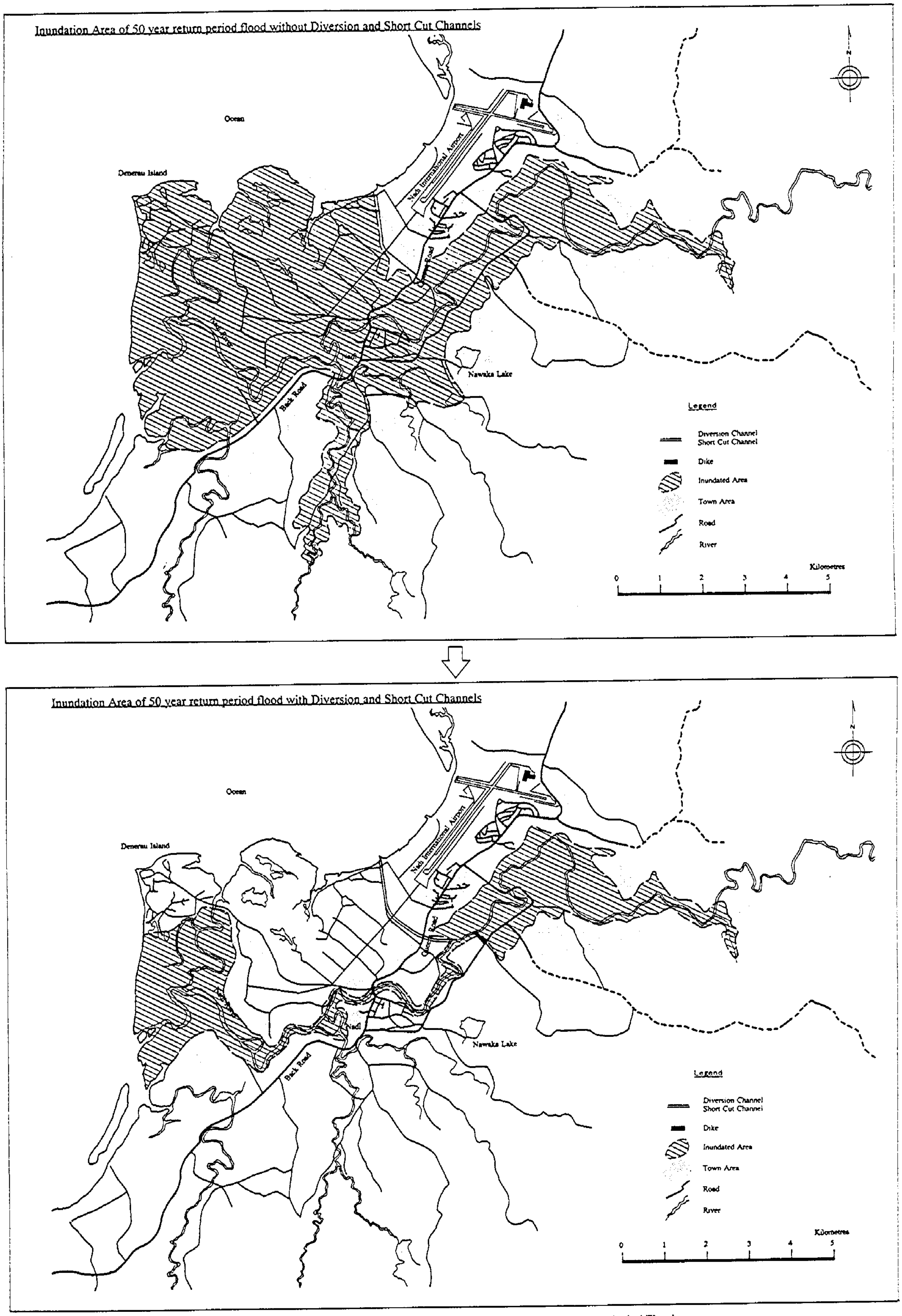



Figure-E16.3 Effect of Project Implementation on Inundated Area of 50 Year Return Period Flood

## 16.2 Indirect and Intangible Effect

Effects of flood control measures consist of direct and indirect ones. The former is examined quantitatively as discussed in the previous section, while the latter is difficult to be examined quantitatively. Therefore, indirect effects are examined qualitatively in the following section.

Indirect effects of flood control measures extend mainly to the following items, contributing to improvement of living conditions.

1) multiplier effects of project cost investment
2) technology transfer
3) land development
4) effective usage of maintenance roads
5) mental damage to suffers
6) distribution and communication system
7) public health
8) tourism
9) landuse

(1) Multiplier Effects of Project Cost Investment

The project cost investment brings the multiplier effects to the project area and its vicinity. The employment opportunity is one aspect. During the construction period of two years, considerable amount of investment is executed in local portion of laborers, engineering and administration which respond to the employment creation. Consequently, the consumption coming out from those wages paid to the people concerned accelerates the commercial and economic activities in the surrounding area of the Nadi project sites. The compensation cost for land acquisition also brings the multiplier effects to the economy in this area.

(2) Technology Transfer

Technology transfer, during the construction, operation and maintenance, may be categorized into the human resources development which is the formation and development of capabilities of personnel through knowledge and skills. The development of people is the most important aspect of social and economic development. On the job training during the two year construction improves the abilities of the engineers and also create the capable technicians. The technology transfer for the operation and maintenance brings not only improvement of engineers' abilities but also creates the men of talent for the administration and management system.

(3) Land Development

The Nadi diversion channel project can develop a 49 ha of land close to the seashore, as a site for the disposal of excavated soil. This size of land is large enough to establish the hotel of totaling 500 guest rooms, which eventually create the new employment opportunity of approximately 700 people. In addition to this, the citizen's green park can be located on this land. Thus, in parallel with the main project of diversion channel, this new reclaimed land brings both economic and social benefits to the inhabitants in the project area and its vicinity.

(4) Effective Usage of Maintenance Roads

The wide enough maintenance roads on both banks along the diversion channel can be the access roads to the potential residential area. Since the location of this area is favorable, close to the Nadi town and Nadi airport, the maintenance roads may stipulate the development of new residential area .

(5) Mental Damage to Suffers

Floods cause not only damage to public infrastructure and properties but also injury and death of people. Once people have flood damage, mental anguish extends to the person himself and his relatives. Even people not suffered from flood have anxiety when water level of river raise due to heavy rain. Those mental damage cannot be compensated by money and has to be removed for the sound society.

The lower reach of Nadi river is susceptible to flood damage because flow capacity of Nadi river is small and Nadi town is located along the river. With implementation of flood control measures, damage to properties and infrastructure in that area would be reduced considerably. As a result, mental damage also would be mitigated.

(6) Distribution and Communication System

Submerged road and power failure by floods suspend distribution and communication system in the inundated area. This damage influence those system in other areas not suffered from floods. Although it is difficult to estimate the damage inclusive of influence to other areas quantitatively, the suspension of distribution and communication system induces stagnation of economic activities in the whole areas.

With implementation of the Nadi diversion channel and short cut channel, stagnation of economic activities would be mitigated.

(7) Public Health

Floods contain many things distributed in inundated areas, such as garbage, sewage, waste water and so on. This contaminated water may induce infectious diseases not only during inundation but also after a flood is drained.

The Nadi diversion channel and short cut channel are effective to mitigate those problems of public health.

(8) Tourism

Major industry in Fiji is tourism and Nadi town is a main gateway to tourist resorts. Problems on the above 5) ~ 7) have negative effects on tourism resulting in decrease of tourists from overseas and depression of tourism business.

Implementation of the Nadi diversion channel and short cut channel mitigates negative effects on tourism and leaves favorable impressions of Fiji on tourists.

(9) Landuse

Frequent floods limit landuse in inundated areas. Potential of landuse in inundated areas increases considerably by implementation of flood control measures because much less frequency of floods secures land from the enormous damage. Therefore, implementation of the Nadi diversion channel and short cut channel contributes to increase in value of currently inundated areas.

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