CHAPTER 6 ENVIRONMENT

The National Environment Management Project (NEMP) with a technical assistance by the Asian Development Bank was commenced in August 1990 and completed in October 1992. The most important output of the NEMP is "The National Environment Strategy, Fiji" (Watling D. & Chape S. 1993) which has set a strategy framework for sustainable development and put forward action plans for environmental legislation, natural and cultural heritage protection and land use. The Department of Environment (DOE) was established in 1993 based on the proposal in the NEMP.

The environmental legislation was drafted at the end of 1996 under the title of "Fiji's Draft Sustainable Development Bill". It will be cited as the "Sustainable Development Act" after the approval by the Parliament. In the draft, EIA (Environmental Impact Assessment) procedures are proposed as follows:

1) Screening by the relevant ministry, department or statutory body to determine whether an EIA may be required or not;
2) Registering the matter and publishing a notice for public awareness;
3) Comprehensive EIA study;
4) Environmental mediation process;
5) Review and approval of the EIA and mediation reports.

(1) EIA Methodologies for This Study

The EIA for this Study basically follows the EIA procedures specified in the Sustainable Development Bill. At the same time, JICA Environmental Guidelines (JICA, 1992) was referred. Environmental assessment for this Study includes an initial environmental examination (IEE) for the Master Plan and an EIA for the priority project. Table-6.1 shows the environmental elements to be considered in the IEE and EIA.

Table-6.1 Environmental Elements to be Examined

(1) Social Environment	(2) Natural Environment	(3) Environmental Pollution
- Resettlement	- Topography & Geography	- Air Pollution
- Economic Activity	- Soil Erosion	- Water Pollution
- Traffic & public Facilities	- Groundwater	- Soil Pollution
- Community Separation	- Lake & Rivers	- Noise & Vibration
- Archaeological & Cultural Properties	- Coastal Area	- Ground Subsidence
	- Flora & Fauna	- Offensive Odor
- Water Right/Right of Common	- Meteorology	- Hazardous Substances*
- Public Health & Sanitation	- Landscape	
- Solid Wastes		
- Risk of Disaster		

Source: JICA (1992) Environmental Guidelines V. for River and Sabo Engineering.

* Item suggested by Department of Environment.

The IEE was conducted in the course of formulation of the Master Plan, using an environmental matrix to examine the possible impacts of each of the project implementation envisaged in the Master Plan for each of the environmental elements to identify items on which adverse impacts would be anticipated. The EIA was conducted for the priority project based on the IEE results. The environmental items identified by the IEE became the objectives of the EIA study. Qualitative and semi-quantitative analysis was applied. The EIA includes recommendation of countermeasures to avoid or mitigate any of the adverse impacts, environment protection and environmental monitoring plan.

(2) IEE

The results of screening through the environmental examination matrix are shown in Table-6.2, significant adverse impact was identified on 5 environmental elements, and possible adverse impact was envisaged on 13 environmental elements from some part of project implementation. The five elements identified at the level of significant adverse impact are as follows.

1) Resettlement

For the construction of diversion channels and dikes, land acquisition is inevitable. Resettlement of people living at the site would be necessary.

2) Traffic and Living Facilities

During project construction, a large number of vehicles will be employed. This may affect the traffic condition. The road traffic where the diversion channels cross may have adverse impacts. Preparation of temporary bypass and traffic regulation may have to be considered.

3) Waste Soil

Construction of diversion channels and dikes, and dredging accompany earth works of large scale. Transportation and disposal of large volume of soil may cause problems of scattered soil or dust.

4) Coastal Areas

Sedimentation and reduction of salinity in mangrove forests caused by inflow of discharge from diversion channels may result in some negative impacts on the growth of mangrove. There may be a possibility contamination of sea water or change on coastal line due to the sediment conveyed through diversion channels.

5) Water Pollution

By construction of diversion channels, water pollution may progress resulted from reduction of discharge in main stream of rivers. Water quality may be deteriorated by stagnant water or intrusion of saline water to the diversion channels.

Table-6.2 Environmental Examination Matrix

Project Activities			Social Environment									Natural Environment								Environmental Pollution						
Project Phase	River Basin	Project Item	Resettlement	Economic Activity	Traffic & Living Facilities	Community Separation	Archaeological & Cultural Properties	Water Right / Right of Common	Public Health & Sanitation	Solid Waste	Risk of Disaster	Topography & Geography	Soil Erosion	Groundwater	Lake and Rivers	Coastal Area	Flora & Fauna	Meteorology	Landscape	Air Pollution	Water Pollution	Soil Pollution	Noise & Vibration	Ground Subsidence	Offensive Odor	Hazardous Substances
Construction Phase	Rewa	Diversion channel	×	△	×			△		×		△				×	△		△		△		△			
		Dike construction	×	△	△					△											△		△			
	Sigatoka	Dredging					△			×											△		△			
	Nadi	Diversion channel	×	△	×			△		×		△				×			△		△		△			
		Short cut channel		△	△					△											△		△			
	Ba	Dike construction	△	△	△					△											△		△			
Operation Phase	Rewa	Diversion channel						△						△		△	△									
		Dike construction																								
	Sigatoka	Dredging																								
	Nadi	Diversion channel						△						△		△					×					
		Short cut channel																								
	Ba	Dike construction																								

×: Significant Adverse Impact △: Possible Adverse Impact Shade: No Adverse Impact

CHAPTER 7 INSTITUTION

(1) Major Issues

Institutional problems/constraints/necessities related to the Study are discussed on the following six points.

1) Hydrological Measurement and Analysis

Current hydrological measurement and analysis which are carried out by the Hydrological Section in Ministry of Public Works, Infrastructure and Transport, are insufficient regarding stable data collection, data storage and analysis. The installation and maintenance of hydrological stations are inadequate allocation and manners, concentrating in the Rewa watershed and being scarce in other watersheds. Lack of data often occurs caused by discontinuous operation, resulting in unreliable analyses. The reasons seem to be insufficient staff with high level of knowledge and skills and financial resources.

2) Flood Control by Structural Measures

Currently major activities in flood control by structural measures by the Land and Water Resources Management Division (LWRMD), in the Ministry of Agriculture Fisheries and Forests are limited to dredging river mouths of large rivers. Since the Master Plan proposed in the Study contains other types of projects, such as construction of a diversion channel, it would be necessary to formulate institutional plan for smooth construction, operation, maintenance and monitoring the performance of the project implementation. Current capacity of the River Engineering Section in the LWRMD is quite limited in data collection, analysis, project planning and project evaluation for effective and efficient watershed management and flood control. The capability of the Division and the Section should be strengthened.

3) Land Use Regulation in Flood Prone Areas

Although the lowest floor levels of habitable rooms are provided in the General Provisions under Town and Country Planning Act (Cap. 139), from 2.5m (relative to the mean sea level) for Sigatoka to 7.6 m for Nausori, adequacy of the levels is unknown. The provision appears to be applied for all of each town area, while flood level may differs by areas. Although the coverage of the provision is limited to habitable rooms, some important facilities or equipment installation may also have to be regulated. Proper provisions can be stipulated after preparation of adequate flood hazard maps and necessary information with close consultations with the Hydrological Section as discussed in above 1).

4) Disaster Management

As emphasized in the National Disaster Management Plan, preparedness and early warning, rather than responding disaster relief after the occurrence, is the key to the effective and efficient disaster management. Enhancing preparedness will be promoted by the provision of flood hazard maps and related information, while early warning will be realized after the establishment and operation of flood forecast system.

Immediate damage evaluation will be the base for proper disaster relief activities, while post damage evaluation will be the start for flood control planning, including that through structural and non-structural measures, as well as for enhancement of the preparedness. The framework of immediate damage evaluation is well covered in the Plan, while no major description for the post damage investigation and information accumulation was given in the Plan. Some post damage evaluation should be carried out.

5) Land Conservation

Current stage of land conservation activities seems to be at the phases of research and development, and pilot farming, besides significant land degradation has progressed. Promotion of the activities identified most effective and efficient by the research and pilot farming should be extended by organizational strengthening and legal arrangements.

6) Forests and Forestry Management

Department of Forests in the Ministry of Agriculture, Fisheries and Forests administers forests and Forestry under Forest Act (Cap. 150). Wide areas of land have been deforested without any contribution to production. Although tree plantation is carried out by the Department of Forests and Fiji Pine limited, there still remain wide areas of waste lands. Exhaustive logging practices allegedly prevail without replanting logged out areas and account large share of deforestation. Wide areas of forests, especially in Western Division, have been observed to be burnt by the extension of fire. Sufficient afforestation, enforcement of sustainable logging practices and control of burning vegetation and accidental fire are necessary.

(2) Recommended Institutional Improvements

To solve the problems and to meet the necessities, following institutional arrangements are recommended.

1) Defining Watershed Management Entities and Administrative Units

i) Organization Set-up by Function

- Deliberative Functions: The Land Conservation Board should take the responsibility.
  Watershed management committees should be established.
- Regulatory Functions: Re-organized Land and Water Resources Management Division and the Sections of Hydrology, River Engineering, and Land Use should take the functions
- Operational Functions: A Project office should be established for a large-scale project.
  Operational parts of Drainage Boards can take a part of functions.
  Regional branches of the Division, Extension Division and the above Sections

ii) Administrative Unit

The two divisions in the Study Area are recommendable similar to the Central and Western Divisions of the general administrative unit, grouping watersheds including small ones in Viti Levu island.

1) Shift of the Hydrological Section and its Strengthening for Expanded Role

- The Hydrological Section in the Water and Sewerage Division would preferably be shifted to the Land and Water Resources Management.
- Training should be carried out to increase the staff with high level of knowledge and skills, to review and manage of hydrological network and to expand the role in flood control.
- Financial arrangement, such as sufficient budget allocation, is necessary.

2) Facilitating Flood Control by Structural Measures

- A project advisory committee as a task force for preparation and supervision of the design and construction of structures for flood control should be recommended.
- The capacity of the River Engineering Section should be strengthened through technical transfers and training.
- Cost recovery programs should be examined.
- Arrangements for smooth land acquisition compensation should be formulated.

3) Enhancing Preparedness in Disaster Management

- Post damage evaluation should be prepared and implemented.
- Preparation of "Disaster Management Plan for Other Agencies" should be promoted.

4) Institutional Strengthening for Extension of Land Conservation Practices

- Standards and guidelines for provisions in the tenant agreement should be prepared and duly executed leases should be promoted.
- Organization for extension of land conservation practices should be strengthened.
- Massive training programs should be implemented.
- Incentives and penalties should be given.

5) Strengthening the Forest and Forestry Management

- Critical areas for afforestation should be identified and afforestation there should be promoted.
- Stricter control of logging practices should be enforced.
- Burning vegetation should be regulated.
- Agro-forestry should be spread.

CHAPTER 8 MASTER PLAN FOR WATERSHED MANAGEMENT AND FLOOD CONTROL

8.1 Outline of Master Plan

(1) Structural Measures

1) Rewa River

The proposed flood control plan in the Rewa river, combination of diversion channel and dike on the left and right banks, is not feasible in economic evaluation for the design flood with 20 years return period. However, as an alternative solution, step wise implementation of the project could be proposed. After a comparative study among possible alternatives of step wise implementation, the dike construction on the left bank of the river were found economically viable as step I of the project. The Master Plan includes the dike construction on the left bank of Rewa river as one of structural measures. The technical and economic outline of the dike construction is shown in Table-8.1.

Table-8.1 Outline of the Dike Construction in Rewa River

Dike Specification		
Design Flood Discharge	5,900	m^3/sec with Return Period of 11 years
Present Capacity	3,800	m^3/sec with Return Period of 7 years
Length of Dike	4.5	km
Height of Dike	3	m
Volume of Dike	200,000	m^3
Project Cost	7,350,000	F$
Economic Evaluation		
Economic Benefit	798,000	F$/year
Economic Cost	6,039,000	F$
Maintenance Cost	2,000	F$/year
EIRR	13.15	%
B/C	1.31	
NPV	1,685,000	F$

Discount Rate: 10 %

2) Sigatoka River

Either dredging or afforestation is not feasible in economic evaluation. Although the economic viability of afforestation would be less than that of dredging, the afforestation in the upstream of the Sigatoka watershed is recommended in the Master Plan. During the economic evaluation, the benefit was counted in terms of flood control only; however, afforestation has various effects, such as prevention of soil erosion, mitigation of sedimentation, conservation of water resources, preservation of water quality, conservation of diversified animals, plants and coral reef, contribution to tourism and so on which are difficult to evaluate the effect quantitatively. If those effects are included in the benefit, the afforestation is expected to be economically feasible.

3) Nadi River

The combination of diversion channel and short cut channel is quite feasible and proposed in the Master Plan.

4) Ba River

The dike construction is feasible and proposed in the Master Plan.

(2) Non-Structural Measures

The following non-structural measures are proposed in the Master Plan for the watershed management and flood control.

1) Improvement of Land Use Regulation
   - Zoning and restriction of residence area in flood prone area
   - Preservation of land for water retention and water retarding such as agricultural lands, bushes, forests, parks, swamp and ponds.
   - Flood proofing such as elevating ground and houses

2) Flood Forecasting, Alarming and Evacuation System

3) Soil Erosion Control
   - Fire prevention in forest, grassland and agricultural land
   - Improvement of commercial cropping area by means of planting vetiver grass, hedgerow planting and installing sedimentation pits or ditches
   - Agroforestry for small farming
   - Forest belts along river for river bank protection

4) Conservation of Forest and Afforestation
   - Preservation of protection forest and newly designated forest
   - Maintenance of sustainable forestry production
   - Afforestation of non-commercial forest, devastated forest, grassland and grazing land

5) Institutional Improvement
   - Defining watershed management entities and functionalizing the Land Conservation Board
   - Defining administrative units and establishment of watershed management committees.
   - Reorganization of the hydrological section and its strengthening
   - Establishment and strengthening organizations for planning and implementing structural flood control measures
   - Enhancement of preparedness in disaster management, including implementation of post damage evaluation
   - Institutional strengthening for extension of land conservation practices
   - Strengthening the forest and forestry management

8.2 Implementation Schedule

The implementation schedule of the Master Plan is shown in Table-8.2. Structural measures with higher of economic viability are planed to be implemented earlier. Flood forecast and alarming system in the area where the structural measure is implemented later is planned to be established earlier to avoid concentration of budget allocation. Priority in afforestation as a flood control measure is place on the Sigatoka watershed. The afforestation in other watersheds have to be implemented after 2015, considering required area to be afforested, capacity of implementation and equitable budget allocation.

Table-8.2 Implementation Schedule of Master Plan

Contents of Master Plan	Cost	Implementation Schedule			
	F$ 1,000	~ 2000	2001 ~ 2005	2006 ~ 2010	2011 ~ 2015
I. Structural Measures					
(1) Rewa River					
Dike (L= 4.5 km), (Step I)	7,350				
(2) Nadi River					
Diversion (L=3.0 km) and Short Cut (L= 0.25 km)	50,950				
(3) Ba River					
Dike (L=13 km)	13,170				
Sub total	71,470				
II. Non-Structural Measures					
(1) Improvement of Land Use Regulation	N.A.				
- Zoning and restriction of residence					
- Preservation of land for water retention and retarding					
- Flood proofing					
(2) Flood Forecasting, Alarming and Evacuation					
- Rewa River	1,800				
- Sigatoka River	800				
- Nadi River	300				
- Ba River	500				
Sub total	3,400				
(3) Soil Erosion Control	N.A.				
- Fire prevention					
- Improvement of commercial crop area					
- Agroforestry for small farming					
- Forest belt along river					
(4) Afforestation					
- Sigatoka River (232 km^2)	21,900				
- Nadi, Ba, Rewa River (611 km^2)*	-	(to be implemented after 2015)			
(5) Institutional Improvement	N.A.				
- Defining watershed management entities					
- Defining administrative units and establishment of water management committees					
- Reorganization/strengthening of the hydrological section					
- Establishment/strengthening organizations for structural flood control measures					
- Enhancement of preparedness in disaster management (facilitating post damage evaluation)					
- Institutional strengthening for extension of land conservation practices					
- Strengthening the forest and forestry management					
Annual Average Cost (per year)	5,690		8,860	2,910	4,050
Total Cost	96,770		62,010 (64 %)	14,530 (15 %)	20,230 (21 %)

* It may be implemented much earlier than 2015 if alternative finance is available.

8.3 Evaluation of Master Plan

(1) Economic Evaluation and Financial Consideration

1) Magnitude of Investment

The average capital expenditure, grant aid and overseas loan of the Central Government are shown in Table-8.3.

Table-8.3 Average Capital Expenditure and Foreign Aid

Unit: F$ 1,000/year

	Average Amount (1991-1995)
Government Total	98,000
Infrastructure	40,900
MAFFA	10,700
Grant Aid	5,900
Overseas Loan	19,400

Note: The above figures exclude VAT.
Infrastructure; Ministry of Infrastructure and Public Works (inclusive Marine Dept. and Road Transport Dept.), Dept. of Civil Aviation, and Dept. of Meteorological Service
MAFFA; Ministry of Agriculture, Fisheries, Forests and ALTA inclusive Dept. of Forests

The total capital cost required for implementation of the Master Plan is estimated F$ 96.9 million with the annual average cost of F$ 5.7 million and the maximum annual average cost of F$ 8.9 million to 2005. The annual average cost over the whole implementation period (F$ 5.7 million) is 6 % of the total capital expenditure of the Government, 14 % of total capital expenditure for infrastructure construction and 29 % of the overseas loan. Even to the maximum average cost, the ratios of these expenditure and loan are 9 %, 22 % and 46 %, respectively. Taking into consideration importance and urgent necessity of the Master Plan (for example the reduced damage by the structural measures would account for nearly 0.5 % of the GDP of Fiji in 1994), such magnitude of budget allocation to the implementation of the Master Plan is quite reasonable and possible.

2) Economic Evaluation

The results of economic evaluation for proposed structural flood control measures are shown in the Table-8.4.

Table-8.4 Economic Evaluation of Flood Control Measure

Watershed		Rewa	Nadi	Ba
Project		Dike (4.5 km) (Step I)	Diversion (3.0 km) & Short Cut (0.25 km)	Dike (13.0 km)
Economic Benefit	(F$ 1,000/year)	884	8,278	1,446
Project Cost	(F$ 1,000)	6,005	43,794	11,358
Maintenance Cost	(F$ 1,000/year)	2	31	8
EIRR	(%)	12.2	15.1	10.7
B/C	(ratio)	1.25	1.61	1.08
NPV	(F$ 1,000)	1,214	21,143	737

Note: EIRR (Economic Internal Rate of Return), B/C (Benefit and Cost Ratio), NPV (Net Present Value)
Discount Rate: 10 %

The opportunity cost of capital (OCC) in Fiji, a criterion with which EIRR can be compared, is 10 %. Therefore, the proposed three projects are economically feasible and recommendable. Among the three, the diversion and short cut channel in the Nadi watershed has the highest economic effect, secondly the dike in the Rewa river (Step-I) and thirdly the dike in the Ba river.

(2) Social and Natural Environment Evaluation

The structural and non-structural measures proposed in the Master Plan have much greater positive impact rather than negative impact on environment. Since this Study is at the master plan level, detailed examination of the negative impacts would be difficult. According to the Initial Environmental Examination (IEE), the following negative issues should be examined in detail in feasibility studies.

1) Significant Impacts

- Lands acquisition, compensation and resettlement
- Effect on traffic and living facilities
- Solid waste during earth work
- Sedimentation and ecology in coastal area
- Water pollution

2) Possible Impacts

- Economic activity
- Water right and right of common
- Topography and geography
- Groundwater
- Landscape
- Noise and vibration during construction stage

8.4 Recommendations

(1) Implementation of the Master Plan

Proposed measures in the Mater Plan for watershed management and flood control, whether structural or non structural, are quite important for socio-economic development of Fiji. Those measures should be implemented by the target year of 2015, following the proposed schedule. Comparing to the scale of the current expenditure by the Government of Fiji, and assuming overseas loans, the project cost could be allocated within the financial capability of the Government. Introduction of a kind of earmarked tax in the beneficial area could also be considered.

(2) Review of the Master Plan

Since the Master Plan is formulated according to the current socio-economic framework of Fiji, the Mater Plan should be reviewed in every five years. For example, the benefit of diversion and dike construction near Nausori in the Rewa watershed currently estimated is not so large to make the measure economically viable. The areas to be protected by the measure are located in the Greater Suva, and have significant importance. Corresponding to the development of the Greater Suva, the area will have, and should have in terms of land use development policy, further importance. The same measure could be feasible, if analyzed in five or ten years later.

(3) Hydro-power Development

At present, 90 % of the electricity in Viti Levu island is generated only at Monasavu Power Plant. The power supply is quite vulnerable to risks, such as disordered facilities. Besides, the demand for electricity in 2015 is estimated to reach twice as much as the present one. To meet the growing demand and to reduce the vulnerability, a hydro-power development project in the upstream or middle stream of Rewa river, where there is abundant hydropower potential, should be started immediately.

(4) Water Quality Management

Although water quality in the four major rivers in Viti Levu island is good, except in the middle reach of the Ba river, strengthened water quality management is necessary to control water pollution and to improve water quality for the promotion of tourism development. Measures, such as designation of water area and water quality criteria, regular water quality monitoring, restriction on industrial wastewater and untreated domestic discharge, sanitary education programs should be implemented immediately.

(5) Enhancement of Hydrological Observation and Analysis

Hydrological data, such as those of rainfall or discharge, are the basis of watershed management and flood control planning. Sufficient human and financial resources should be allocated in order to enhance hydrological networks, regular observation, data collection and storage, and hydrological analysis.

(6) Accumulation of Data on Flood Damages

Data on damages occurred in the past floods, such as levels of flood marks, the amount of damages on human lives, crops, houses and buildings, household effects, commercial goods and activities, public facilities, are inevitable to assess economic effects of a flood control measure. A system to collect, store and evaluate the data on flood damage should be established.

(7) Accumulation of Data for Watershed Management

Formulation of watershed management plan with sufficient preciseness is very difficult because of the limited data on land use, soil erosion and loss, forest and forestry. Collection of these data in Fiji seems to have just started. Much more efforts should be continuously given in collection and accumulation of these data.

(8) Review of Land Tenure

Fiji has a unique land tenure system. The area of 84 % of the total land is Native Land, owned by native communities. Transfer of the Native Land is prohibited by the law, and Indians can use the area only by leaseholding. Although the system has merits, there are demerits as well, such as hindrance to lands acquisition for public interests and ignorance of long-term productivity by land users, resulting in exhaustive use and waste of lands. Some review might be necessary.

CHAPTER 9 SELECTION OF PRIORITY PROJECT

A priority project for the Feasibility Study was selected among the projects which compose the Master Plan. Among the projects proposed, the structural measures in four watershed were adopted for comparison because of their clear and drastic effect on flood damage mitigation compared with other non-structural measures.

(1) Factors to be Considered

The following major factors should be considered for selection of priority project.

1) Present Flow Capacity of River Channel
2) Population in Beneficial Area
3) Total Project Cost
4) Average Annual Damage Reduction
5) Economic Effect
6) Land Acquisition and Compensation
7) Impact on Social and Natural Environment

(2) Significance Criteria

After examination of each factor for a flood control measure, significance of a factor in each flood control measure was evaluated and classified into four classes from A to D: A; high significance, B: medium significance, C; low significance, D; negligible significance. The result of the evaluation is shown in Table-9.1. Based on the integrated assessment of the degree of significance for each factor, the priority for Feasibility Study was given to the flood control measure in the Nadi watershed, namely the combination project of Nadi diversion channel and short cut channel, because the number of A is highest and that of D is lowest among the proposed projects.

Table-9.1 Selection of Priority Project

Watershed		Rewa		Sigatoka	Nadi	Ba
Flood Control Measure		Diversion & Dike	Dike (Step I)	Dredging	Diversion & Short Cut Channel	Dike
Present Capacity of River Channel	Flood Return Period (year)	7	7	16	1	5
	Evaluation	B	B	D	A	B
Population in Beneficial Area	person	10,800	10,800	5,300	9,100	7,700
	Evaluation	A	A	D	B	C
Total Project Cost	F$ 1,000	153,800	7,770	12,340	50,950	13,170
	Evaluation	D	A	B	C	B
Average Annual Damage Reduction	F$ 1,000	1,966	884	381	8,278	1,446
	Evaluation	C	D	D	A	C
Economic Effect	EIRR (%)	Negative	12 2	2 0	15.1	10.7
	Evaluation	D	C	D	A	C
Land Acquisition and Compensation	Cost (F$ 1,000)	5,000	3,500	0	4,000	1,000
	Evaluation	D	C	A	C	A
Impact on Social and Natural Environment	No. of Significant Adverse Impact	5 (16)	1 (5)	1(3)	5 (14)	0 (6)
	Evaluation	C	B	B	C	A
Priority Order					I	

* Number in the parentheses shown number of possible adverse impact from IEE.

PART 2 FEASIBILITY STUDY ON NADI DIVERSION CHANNEL

CHAPTER 10 FIELD INVESTIGATIONS

Construction of a diversion channel with a short cut channel was selected as a priority project for the Feasibility Study. As a start of the Feasibility Study the following field investigations were conducted.

(1) Topographical Survey

Topographical survey in proposed site of the diversion channel and the short cut channel was conducted in order to improve the preciseness of examinations on hydraulic design, alignment and construction plan with the specifications shown in Table-10.1.

Table-10.1 Contents of Topographical Survey

Topographical Survey	Diversion Channel	Area: 2.7 km^2 = 0.6 km x 4.5 km Accuracy: 1/2,500
	Diverting Point	Area: 0.4 km^2 = 0.4 km x 1.0 km Accuracy: 1/500
	Outlet (Echo-sounding)	Area: 1.0 km^2 = 1.0 km x 1.0 km Accuracy: 1/2,500
	Short Cut Channel	Area: 0.5 km^2 = 0.5 km x 1.0 km Accuracy: 1/2,500
Longitudinal Profile and Cross Section Survey	Longitudinal Profile	Diversion Channel: 4.5km Short Cut Channel: 1.0 km
	Cross Section	Diversion Channel: 46 sections with 100 m interval Short Cut Channel: 11 sections with 100 m interval

(2) Geological and Goetechnical Survey

Geological and geotechnical survey was conducted to examine use of surplus soil, slope gradient, necessity of slope protection and so on. Twelve exploratory boreholes with a total depth of 138 m were drilled and samples were taken for laboratory test. Items and quantity of the geological and geotechnical survey are shown in Table-10.2.

Table-10.2 Items and Quantities in Geological and Geotechnical Survey

In-situ/Laboratory	Items to be Tested	Nos. of Sample
In-situ	Standard Penetration	112
	Groundwater Level, Electric Conductivity	12
Laboratory	Particle Size Distribution	127
	Particle Density	127
	Moisture Content	129
	Consistency Limit	100
	Unconfined Compression	18
	Consolidation	18

(3) Tidal Current Survey

For buoys were located in the Nadi bay and their coordinates were measured by GPS (Global Positioning System). Tidal current was observed every one hour for 25 hours when spring tidal range was high. Measurement of the direction and velocity of tidal current were conducted at 104 times (26 times x 4 points).

(4) Social Environmental Survey

Main objectives of the social environmental survey are to obtain data for assessment of the environmental impacts of the Project, land use projection, and estimation of costs for land acquisition and compensation. Social environmental survey consists of interview survey to residents, traffic volume survey, groundwater survey and land use survey in the proposed sites.

1) Interview Survey to the Residents

The interview survey was conducted in the areas of proposed site and adjacent areas for the diversion channel (2.7 km^2) and the short cut channel (0.5 km^2) after confirmation of land owners and distribution of houses with cadastral maps. The questionnaire for the survey included the questions on; composition of households, race, religion, occupation, income, conditions of houses, value of properties, cropping, etc.

2) Traffic Volume Survey

The traffic volume survey was conducted at 3 points on Queens Road and Enamanu Road. Traffic volume was counted by vehicle type during 14 hours from 6:00 a.m. to 8:00 p.m.

3) Groundwater Survey

The groundwater survey covered the area for diversion channel site and its vicinity with a total area of 6 km^2. The coordinates of the existing wells were measured by GPS. The survey included the items of; well structure, groundwater level, purpose and quantity of groundwater use, temperature, electric conductivity, etc.

4) Landuse Survey

The land use survey was conducted in a total area of 6.0 km^2 in and near the proposed sites of the Project. The survey method was field reconnaissance and the current land use were identified and classified into; residential areas, commercial areas, industrial areas, airport, tourist areas, parks, crop lands, mangrove, river and native villages, etc. The distribution of public facilities and their major elements were investigated. The result is plotted on the cadastral maps.

CHAPTER 11 EXAMINATION OF SCALE OF DIVERSION CHANNEL

11.1 Design Flood and Scale of Diversion Channel

In this Study, 20 year return period flood was determined as the designed flood; however, it may be too large to realize flood control measures for Nadi river in terms of finance. Therefore, the stepwise implementation of the Nadi diversion channel was examined. To assess the possibility of stepwise implementation of the diversion channel, the scale of diversion channel with smaller probability floods, 1/15, 1/10 and 1/5, was examined in terms of structural scale, cost and economic effect. The distribution of different flood discharges with implementation of the diversion channel is shown in Figure-11.1 and the standard cross section of diversion channel for each flood probability is shown in Figure-11.2.

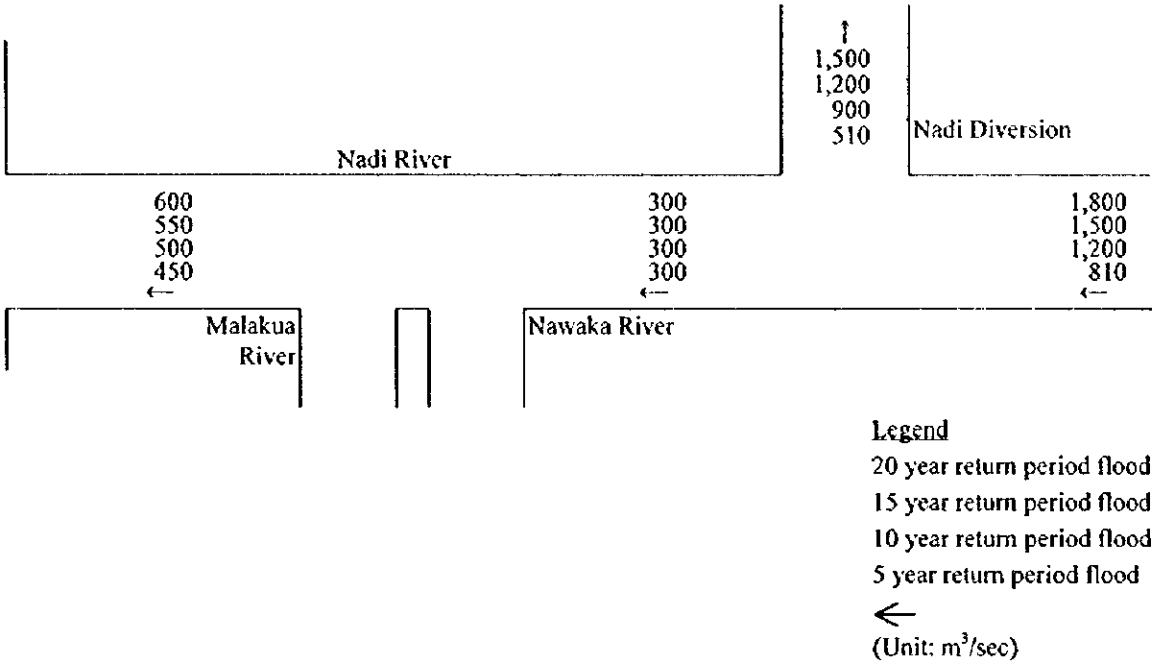


Figure-11.1 Distribution of Different Flood Discharges with Diversion Channel

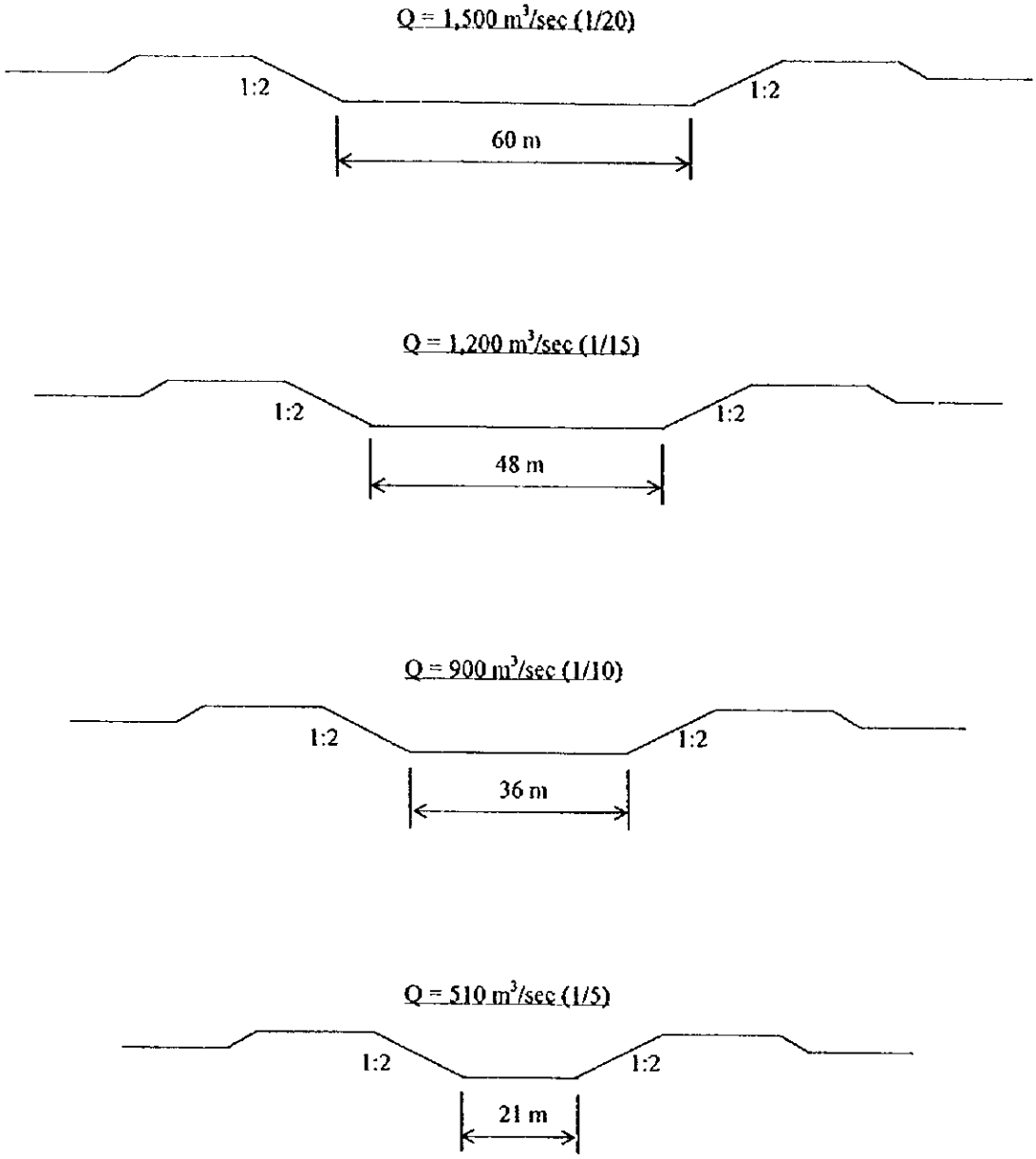


Figure-11.2 Standard Cross Section of Nadi Diversion Channel for Different Flood Probability

11.2 Cost and Economic Evaluation

Cost and result of economic evaluation for each project with different return period are shown in Table-11.1 and Table-11.2. As shown in Table-11.2, the project for 1/20 probability food is the most feasible because of its highest economic indices and the economic indices of project for less than 1/10 probability flood are not satisfactory. Therefore, even if the stepwise implementation is determined, the project at least for 1/10 probability flood should be implemented.

Table-11.1 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

Table-11.2 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 %

CHAPTER 12 PRELIMINARY DESIGN OF PROJECT

12.1 Hydraulic Design

(1) Conditions of Design

Conditions of hydraulic design are as follows.

1) The design discharge of 1,800 m^3/sec (20 year return period flood) at diverting point is drained through the diversion channel (1,500 m^3/sec) and Nadi river (300 m^3/sec). Flow capacity of Nadi river around Nadi town is improved from 250 m^3/sec to 300 m^3/sec by the short cut channel.

2) Bed elevation of the diversion channel is designed 1.0 m higher than that of Nadi river to maintain ordinal flow of the river for prevention of water quality degradation and prevent bed load from flowing into the channel. As a result, the diversion channel starts drainage when discharge of Nadi river is approximately 15 m^3/sec. Since discharges for 75 % of year are less than 15 m^3/sec, Nadi river drains flow for 75 % of year without the diversion channel.

3) Flood is diverted naturally by energy head. Therefore, non-uniform flow is employed to determine hydraulic design which water levels and energy heads of Nadi river and diversion channel are equal to each other at diverting point.

4) Width of the diversion channel is minimized to reduce work quantity and cost, while bed elevation of the channel at outlet is as high as possible to reduce work quantity in the sea resulting cheaper cost.

5) Assuming that flow from the diversion channel spreads with an angle of 5°, a staring point of non-uniform flow computation where velocity of the flow is dissipated is 1.5 km offshore from the downstream end. Since the mean high water is approximately EL. 0.6 m (above mean sea level), EL. 1.0 m is adopted as a boundary condition of non-uniform calculation considering the safety factor.

6) Cross section of the channel, slope gradient and roughness coefficient are assumed to be uninform, 1:2 and 0.03, respectvely.

(2) Results of Hydraulic Design

The hydraulic design of the diversion channel is summarized in Table-12.1 for not only the design flood (1/20 probability flood) but also 1/15, 1/10 and 1/5 probability floods. Water level of Nadi river for 20 year return period flood with implementation the diversion and short cut channels is shown in Figure-12.1 and water level of the diversion channel is shown in Figure-12.2.

Since width of Nadi river is narrowed to 10 m at diverting point, velocity of flow increases resulting in lower water level. However, the flow is stable because it is not supercritical flow. Bed slope of the diversion channel is flat from downstream end to 2,500 m; however, there is no stagnation during drainage even if discharge is small because flow is governed by not bed slope but energy gradient.

Table-12.1 Summary of Hydraulic Design (Diversion Channel and Short Cut Channel)

Item			Probability of Design Flood			
			1/20	1/15	1/10	1/5
Discharge	NR upstream DC		1,800 m^3/sec	1,500 m^3/sec	1,200 m^3/sec	810 m^3/sec
	NR downstream DC		300 m^3/sec	300 m^3/sec	300 m^3/sec	300 m^3/sec
	Diversion		1,500 m^3/sec	1,200 m^3/sec	900 m^3/sec	510 m^3/sec
	Start of diverting		15 m^3/sec	15 m^3/sec	15 m^3/sec	15 m^3/sec
Diverting Point	Location of diverting		Nadi river 14.6 km upstrem from river mouth			
	Bed slope		1/5,000			
	Bed elevation		EL. -1.00 m			
	Width of NR (bed)		10.0 m	10.0 m	10.0 m	10.0 m
	Width of inlet (DC)		60.0 m	48.0 m	36.0 m	21.0 m
	WL at inlet		EL. 5.145 m	EL. 5.019 m	EL. 4.899 m	EL. 4.787 m
	WL at inlet without DC		(EL. 13.041 m)	(EL. 11.971 m)	(EL. 10.799 m)	(EL. 10.313 m)
	Total head		EL. 6.361 m	EL. 6.286 m	EL. 6.219 m	EL. 6.158 m
	Velocity		4.88 m/sec	4.98 m/sec	5.09 m/sec	5.18 m/sec
	Froude number		0.63	0.65	0.67	0.69
Diversion Channel	Total length		approximately 3,300 m			
	Bed slope		downstrem from 2.5 km point : Level			
			upstream from 2.5 km point : 1/320			
	Elevation at downstream end		EL. -2.500 m			
	Elevation of inlet		EL. 0.000 m			
	Bed width		60.0 m	48.0 m	36.0 m	21.0 m
Short Cut Channel	Location		between 7.5 km and 9.0 km of Nadi river from river mouth (length : 250 m)			
	Bed slope		1/2,500			
	Bed elevation	7.5 km	EL. -1.000 m			
		9.0 km	EL. -0.900 m			
	Bed width	7.5 km	40.0 m			
		Short cut	30.0 m			
	WL at 9.0 km point		EL. 4.810 m	EL. 4.607 m	EL. 4.395 m	EL. 4.174 m
	WL at 9.0 km poit with DC without short cut		(EL. 5.147 m)	(EL. 4.957 m)	(EL. 4.764 m)	(EL. 4.547 m)
	Velocity		1.27 m/sec	1.33 m/sec	1.40 m/sec	1.47 m/sec
	Froude number		0.19	0.20	0.22	0.23

NR: Nadi River

DC: Diversion Channel

WL: Water Level

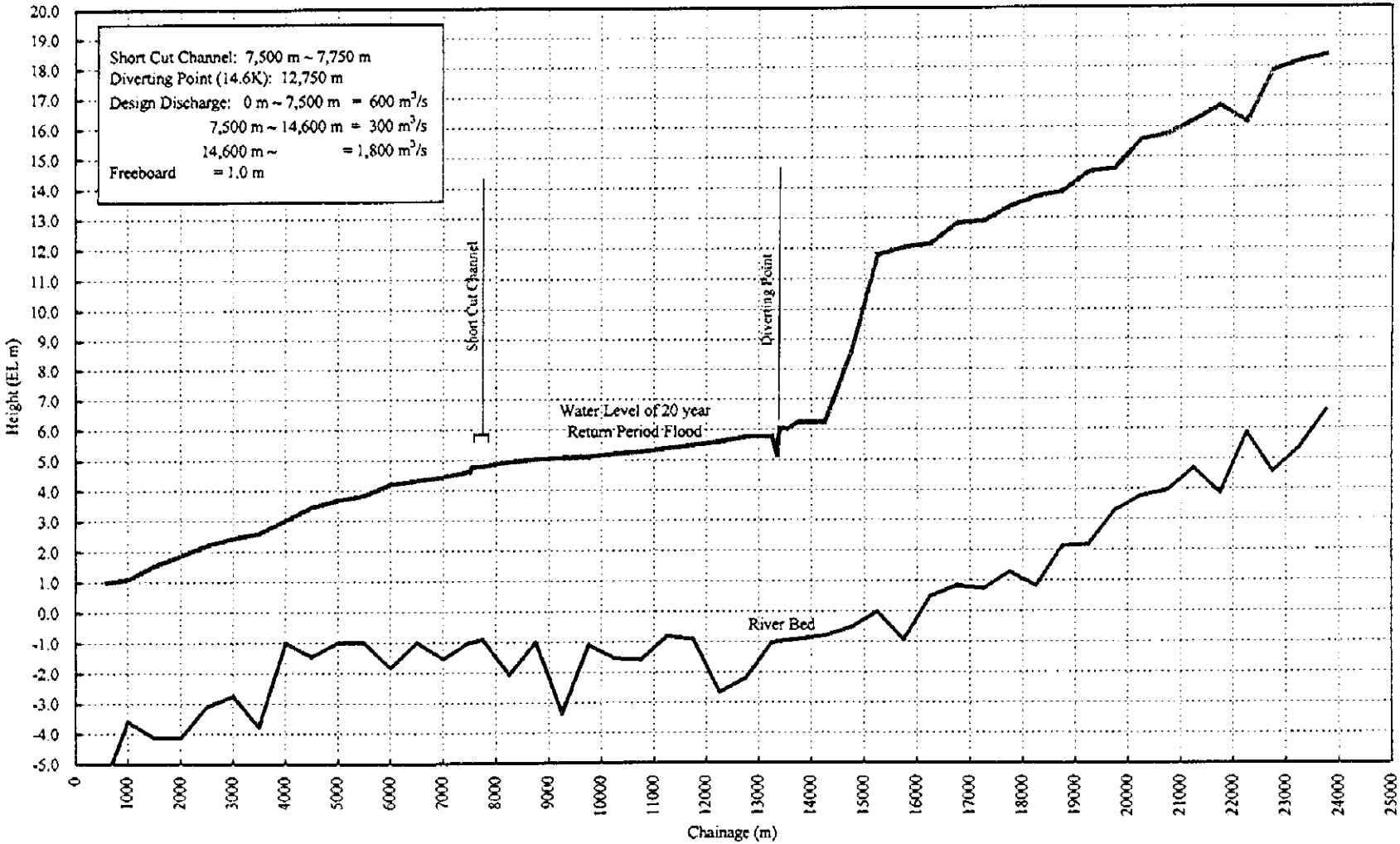


Figure-12.1 Longitudinal Profile of Nadi River with Expected Water Level

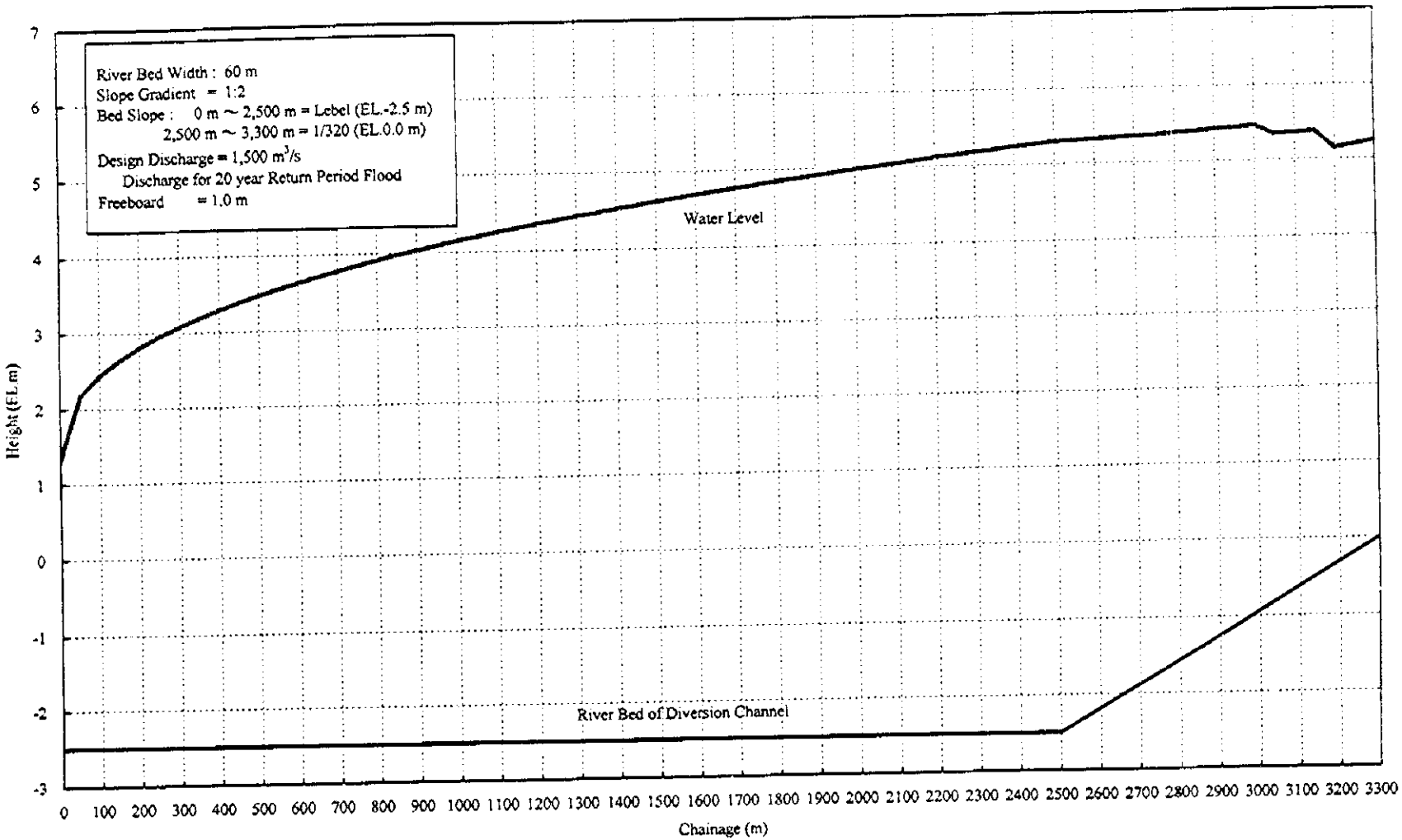


Figure-12.2 Longitudinal Profile of Nadi Diversion Channel with Expected Water Level

The followings are results of the hydraulic examination of the diversion channel.

1) Hydraulic design of the diversion channel and short cut channel in this study was conducted by one dimensional analysis. To understand flow conditions at diverting point and of Nadi river which is a natural channel, hydraulic conditions, such as diverting discharge, sediment transportation and so on, should be examined by hydraulic model experiment.

2) Large scale bank and bed protection works are not necessary based on the hydraulic examination; however, it should be confirmed by the hydraulic model experiment.

3) Assuming that sea level is EL. 3.0 m and discharge of the diversion channel is 1,500 m^3/sec (drainage for 20 year return period flood), water level of the diversion channel was calculated. As a result, the water level when sea level is EL. 3.0 m is within freeboard at any section of the diversion channel. Therefore, even if storm surge was EL. 3.0 m, the diversion channel would drain the deign discharge safely.

4) Seawater intrusion through the diversion channel was roughly examined. As a result, effective length of saltwater wedge is approximately 2,000 m ~ 3,100 m. Since total length of the diversion channel is 3,300 m, seawater intrusion is not expected to reach Nadi river through the channel.

5) Since bed elevation of the diversion channel is 1.0 m higher than that of Nadi river at diverting point, only suspended and wash loads which mostly consists of particles smaller than 0.03 cm flow into the diversion channel. Those particles are easily drained into the sea and diffused by the ordinal tide and high waves. Therefore, serious problems of sedimentation at outlet are not expected to occur.

12.2 Structural Design

(1) Objective Structures for Feasibility Study

Feasibility Study of the Nadi diversion channel and short cut channel includes the following structures.

1) Diversion channel

2) Short cut channel

3) Bridges for vehicles, sugarcane tramline and pedestrians

4) Others (shift works)
sugarcane tramline, water and sewage pipe lines, electric cable and telephone line

(2) Design of Diversion Channel

Based on the alignment No.2 selected in the Master Plan Study, the specific route of the channel was determined considering the following conditions and the result is shown in Figure-12.3.

1) To locate the diversion channel in the airport extension site has been agreed by the Civil Aviation Authority of Fiji, as long as the diversion channel does not cross the area within 300 m from the end of planned runway.

2) A cemetery and transmitter station of the Nadi airport are located along the western side of Enamanu road between Queens road and site for the airport extension. Therefore, those area should be avoided for the diversion channel.

3) Since compensation for McDonald's is expected very high, it should be avoided for the diversion channel.

4) There is a private cemetery in Waqadra garden on the east of Queens road and there is a traditional sacred site in the north of McDonald's and on the west of Queens road. Those areas should be avoided for the diversion channel.

5) Since there are residential and tourism development plans in the area on the north of site for the airport extension and on the east of Enamanu road, this area should be avoided for the diversion channel.

Based on the hydraulic design, bed slope of the diversion channel was determined as flat from outlet to 2,500 m (El. -2.5 m) and 1/320 from 2,500 m to inlet. As shown in Figure-12.4, the longitudinal profile of the diversion channel has two sections, embankment and cutting sections. The former is located from sea to 1,400 m upstream and the latter is located from 1,400 m to inlet.

Slope gradient in the cutting section was determined as 1:2 based on the results of soil test conducted by the Study Team. Since the deepest depth of cutting is 13 m, berm with 3 m width was designed at 5.0 m high from channel bed for maintenance of the channel. Since there are loose and weak sand and clay deposits underlying in the embankment section, slope gradient was determined as 1:3 after applying the pre-loading to improve the strength of loose layers by consolidation.

Soils not suitable for embankment, such as gravelly sand layer with high permeability, and weak silt and clay layers whose strength is not enough, are distributed partially in the geological profile along the diversion channel. Therefore, most of surplus soils (excavated soils) can be used for embankment of the diversion channel. The standard cross section of the diversion channel is shown in Figure-12.5. The cross sections adopted in the structural design are slightly different from that assumed in the hydraulic design. As the area of the former cross section is almost same to or slightly wider than the latter, the difference does not cause any significant change in the hydraulic analysis at the feasibility study level.

Some of surplus soil is used for embankment of the diversion channel, while the rest of soil is dumped in the disposal area located on the left bank side in the lower reach of the channel. The maximum height of the disposal area is 6 m based on the bank stability analysis, and the disposal area is 10 m away from top slope of the diversion channel. Necessary area for the disposal site is 49 ha.

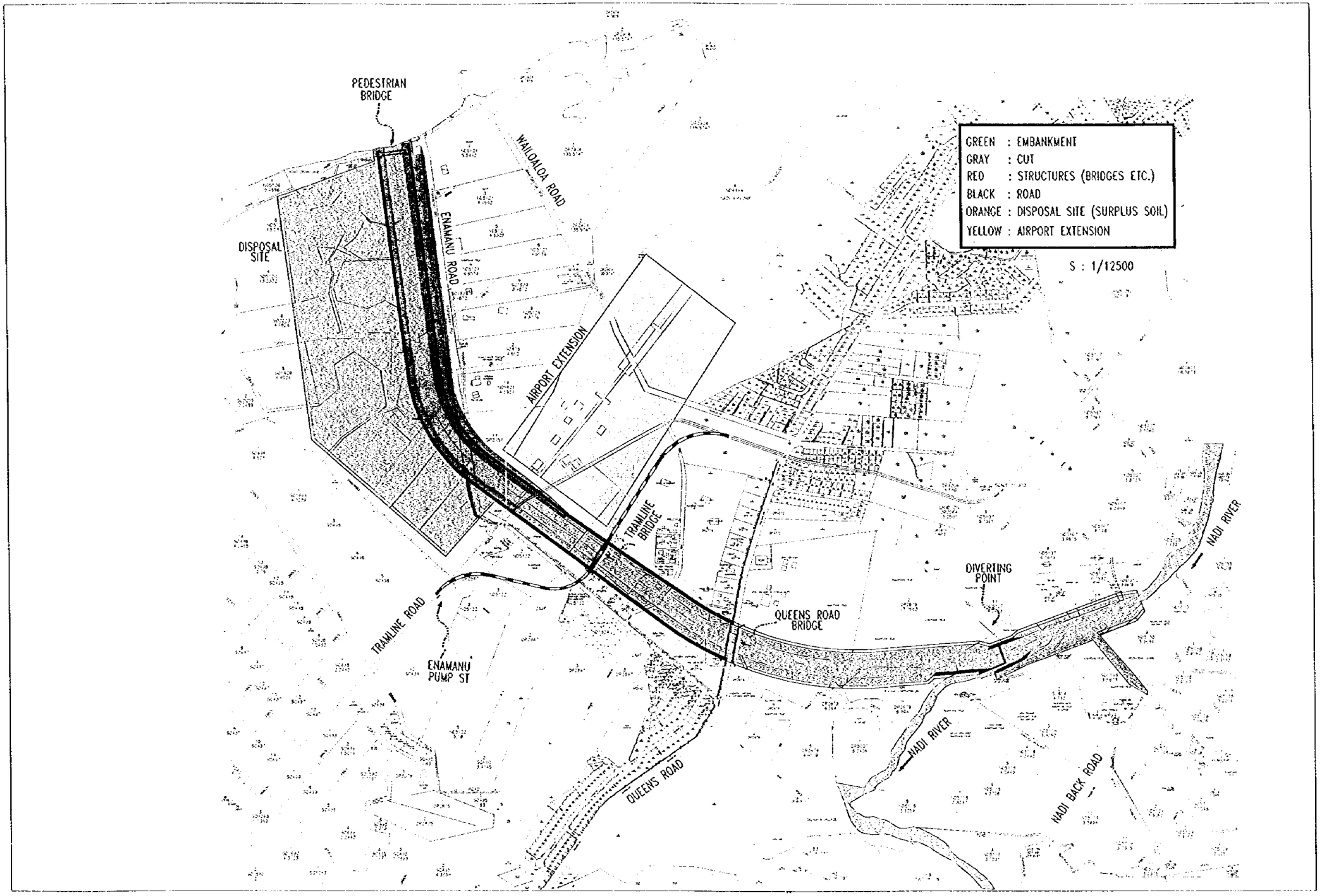


Figure-12.3 Plan of Diversion Channel for 20 Year Return Period Flood

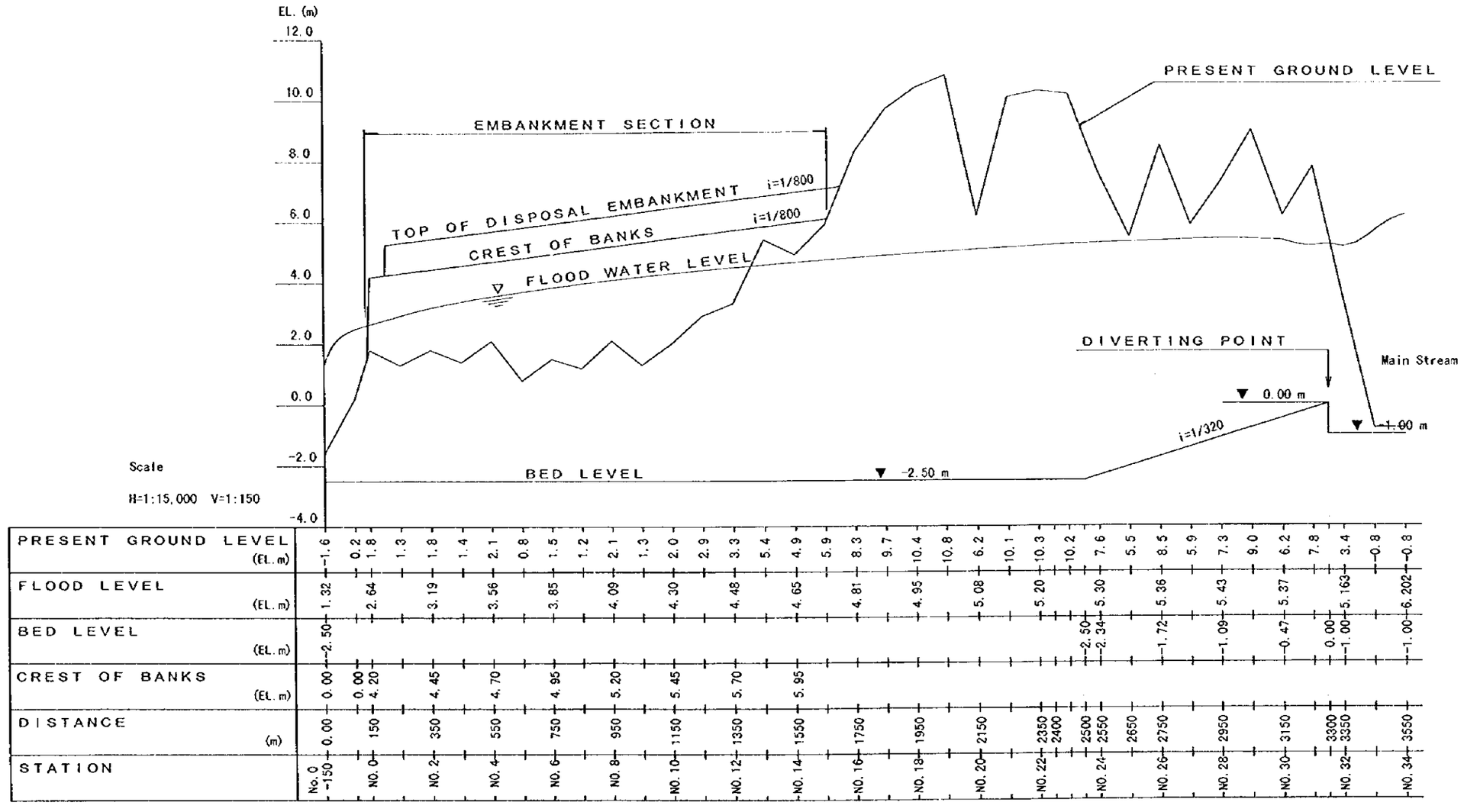
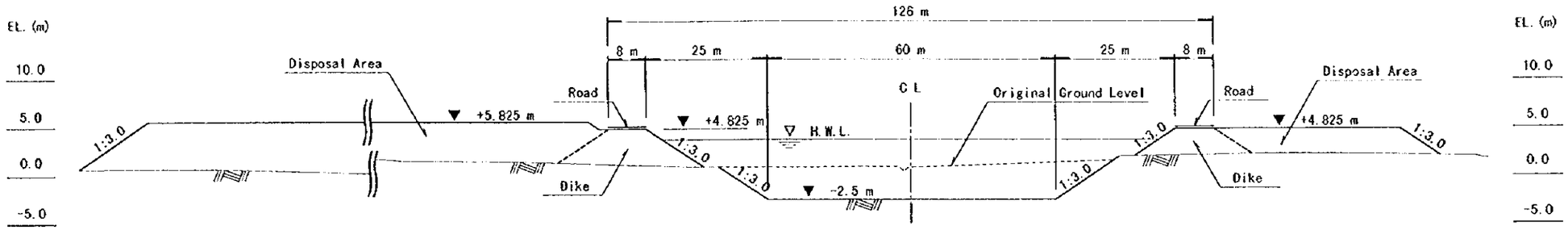


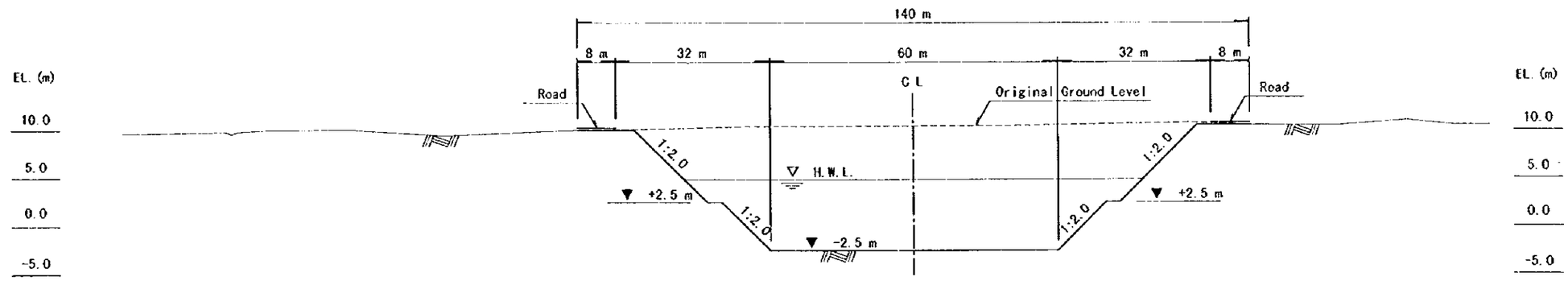
Figure-12.4 Longitudinal Profile of Diversion Channel for 20 Year Return Period Flood

Embankment Section



No. 5

Excavation Section



No. 19

SCALE

Hz scale 1:1000

Vt scale 1:500

Figure-12.5 Cross Section of Diversion Channel for 20 Year Return Period Flood

(3) Short Cut Channel

Short cut channel connects 7.5 km and 9.0 km points of Nadi river with the total length of approximately 250 m. Bed slope is 1/2,500 and bed elevations of upstream and downstream ends are EL -0.9 m (9.0 km point) and EL. -1.0 m (7.5 km point), respectively, taking same elevation as Nadi river. Bed width is 30 m resulting in 60 m width of the channel with 1:2 slope gradient

(4) Design of Bridges

The following three bridges are planned to provide the access crossing the diversion channel.

1) Queens Road Bridge

a bridge in the upper reach of the channel to cross Queens road, roadway consisting of 2 lanes and foot way at both sides, 10.9 m width x 120 m length

2) Sugarcane Tramline Bridge

a bridge in the middle reach of the channel for sugarcane tramline and pedestrians, 4.5 m width x 111 m length

3) Bridge for Pedestrians

a bridge in the lower reach of the channel for pedestrians, 2.8 m width x 93 m length

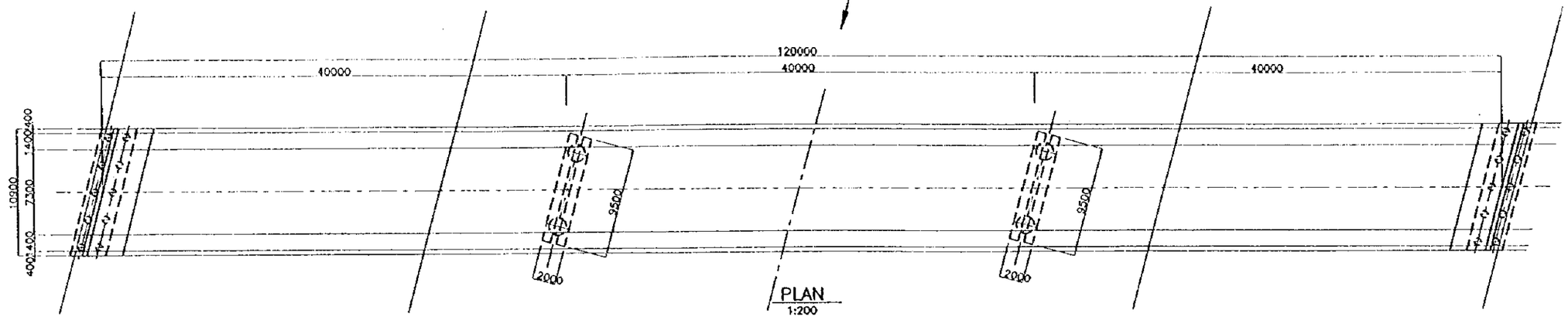
Cross section of the Queens road bridge is shown in Figure-12.6.

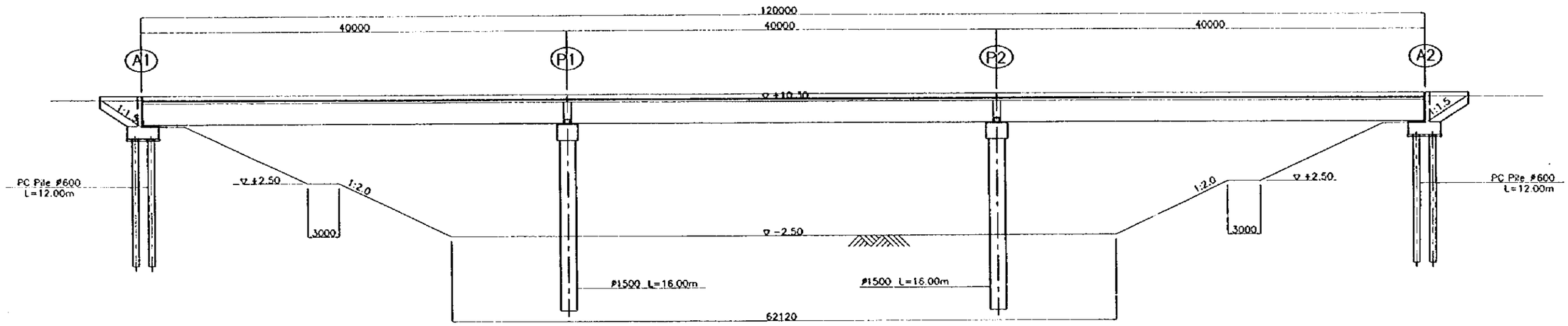
(5) Road

At present, Enamanu road runs along the site of the diversion channel. Therefore, 2 lane road with 8.0 m width is designed on the both side of the channel.

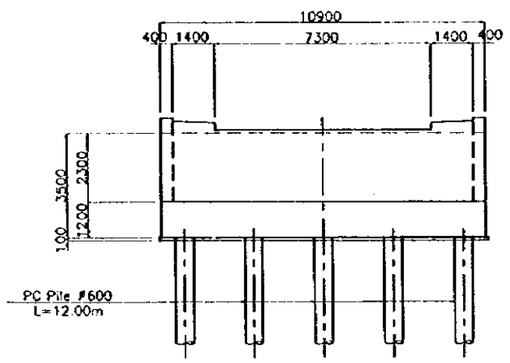
(6) Others

Pipe lines for water supply, sewage pipe line, electric cable and telephone cable which cross the proposed alignment of the diversion channel need to be shifted.

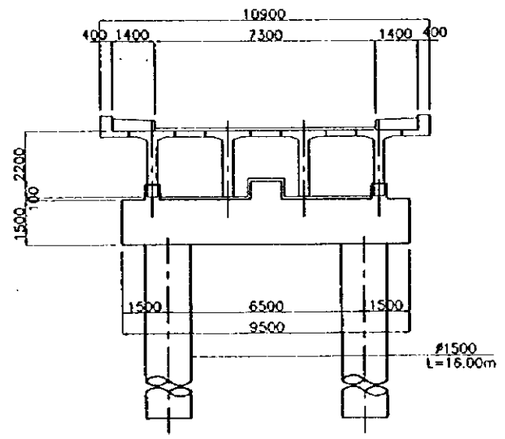




ELEVATION LOOKING SOUTH



TYPICAL CROSS SECTION – ABAT 1 AND 2
1:100



TYPICAL CROSS SECTION – PIERS 1 AND 2
1:100

Figure-12.6 Queens Road Bridge

JAPAN INTERNATIONAL COOPERATION AGENCY	MINISTRY OF AGRICULTURE , FISHERIES & FORESTS	THE STUDY ON WATERSHED MANAGEMENT AND FLOOD CONTROL FOR THE FOUR MAJOR VITI LEVU RIVERS IN THE REPUBLIC OF FIJI QUEENS ROAD BRIDGE	NADI DIVERSION	YACHIYO ENGINEERING TOKYO S-86	SCALE 1:200 SHEET No 1 OF 3 SHEETS

12.3 Work Quantity and Construction Cost

Results of work quantity estimate are shown in Table-12.2 for not only the design flood but also smaller floods, 1/15, 1/10 and 1/5 probability floods.

Table-12.2 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

Earth work is main in the diversion and short cut channels. Basic idea of the diversion channel construction is that excavated soil at hilly place (EL. 10 m) in the upper reach of the channel (1,500 ~ 3,150 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.

Excavation in the cutting section starts prior to pre-loading in the embankment section and actual works of the diversion channel in the embankment section starts where consolidation by pre-loading is completed. During the earth work, compensation works, such as bridges, is conducted. The whole construction is expected to take 2 years.

Table-12.3 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	130,000																								
- 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																								

CHAPTER 13 LAND ACQUISITION AND COMPENSATION

(1) Land Acquisition

Proposed site for the diversion channel is located in State Lands and freehold lands, and used dominantly for sugarcane farming and partly as residential areas. As for the State Lands, land purchasing is not necessary. Compensation for the current use, however, is required. For the freehold lands, they can be acquired after agreement with the landowners and occupiers.

The site for the short cut channel, where currently sugarcane fields and bushes are spread, is situated in the Native Reserve. The Native Reserve was originally designated for the subsistence of native Fijians and used only by native owners or leased only to native Fijians. The site should be de-reserved and some State Lands are required to substitute the Native Reserve to acquire the land for short cut channel construction. Field reconnaissance with the officers of the Department of Lands and Surveys and the Native Land Trust Board revealed the possibility to find candidate State Land for the exchange.

(2) Compensation

Compensation should be made for relocation of houses, buildings and other improvement by occupiers or owners, and of public facilities, such as roads, water pipes, sewers, telephone and electric lines, and tramline, and for standing crops. Although other compensation such as that for fishing rights in Nadi Bay, public nuisance during the construction work, intrusion of saline water to wells, etc, would be necessary, the required compensation for those adverse impacts might be small.

(3) Quantity and Cost

Based on the data on lands and other properties in the sites obtained through the social environmental survey and the cost data given by the Department of Lands and Surveys and the Housing Authority, the costs for the land acquisition and compensation were estimated as shown in Table-13.1.

Table-13.1 Costs for Land Acquisition and Compensation

(Unit: F$ 1,000)

Item	Quantity	Cost
(1) Land	108.8 ha	5,557
(2) Buildings/Investment	6,300 m^2	2,896
(3) Crops	88.4 ha	426
Total	-----	8,879

CHAPTER 14 COST ESTIMATE

(1) Composition of Project Cost

The composition of project cost is shown below.

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, the survey for the estimation of land acquisition and compensation cost, etc., 5 % is considered appropriate.

(2) Estimate of Construction Cost

After investigations on unit prices of existing construction works and inquiries to contractors and related government authorities, unit prices were determined. The construction cost was estimated by different return period of four floods (probability of 1/20, 1/15, 1/10 and 1/5) applying estimates of work quantities and the unit prices. The construction cost for the design flood (1/20 probability) is shown in Table-14.1.

Table-14.1 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

(3) Estimate of Project Cost

The project cost was estimated by return period of the four floods, applying the cost for land acquisition and compensation estimated in Chapter 13. The cost estimates are shown in Table-14.2. The project cost is divided into local currency portion, which can be procured domestically, and foreign currency portion, which should be procured from aboard.

Table-14.2 Project Cost by Return Period of Floods

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 %
4) Cost for land acquisition and compensation is discussed in Chapter 14.

CHAPTER 15 ECONOMIC EVALUATION AND FINANCIAL EXAMINATION

(1) Economic Evaluation

Results of the economic evaluation of the project, namely Nadi diversion channel and shot cut channel, with design flood of 1/20 probability are shown in Table-15.1. EIRR of the project is calculated as 14.5 %, which means that the project is economically feasible, comparing the EIRR with the opportunity cost of capital of 10 %. The B/C of the project is 1.46 and the NPV is F$ 21.4 million.

Table-15.1 Economic Evaluation of Nadi Diversion Channel and Short Cut Channel

Annual Economic Benefit (F$ 1,000/year)	8,278
Economic Project Cost (F$ 1,000)	53,139
Economic Annual Maintenance Cost (F$ 1,000/year)	36
Economic Internal Rate of Return (%)	14.5
Benefit/Cost Ratio	1.46
NPV (Net Present Value, F$ 1,000)	21,423

(Note) 1) Project Life; 50 years
2) Construction Period; 2 years
3) Discount Rate; 10%

(2) Sensitivity Analysis

The EIRRs for cases of decrease in benefits by 5 % and 10 % and increase in cost by 5 % and 10 % were calculated as sensitivity analysis. The results of the analysis are given in Table-15.2.

Table-15.2 Sensitivity Analysis to EIRR

(Unit of EIRR: %)

		Increase in Cost		
		0 %	5 %	10 %
Decrease in Benefit	0 %	14.5	13.8	13.2
	5 %	13.8	13.1	12.6
	10 %	13.1	12.5	11.9

The EIRRs for cases of increase of Operation and Maintenance Cost (OM Cost) by 0.5 %, 1.0 % and 1.5 % of construction cost were also calculated. The results of the analysis are given below.

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

Comparing the EIRRs calculated above with the opportunity cost of capital of 10 %, the project is feasible even in case of 10 % decrease in the economic benefit and 10 % increase in the economic project cost, and in increase of OM Cost in 1.5 %.

(3) Financial Examination

The construction of Nadi diversion channel and short cut channel requires F$ 62.9 million, as the project cots. Most of the cost would be spent in two years. In the financial examination, 85 % of the cost is assumed to be financed with overseas loans. The examination was made with two scenarios. The loan conditions assumed in each scenario and the results of the examination are shown in Table-15.3. The table shows that total repayment and maximum annual repayment will vary widely, corresponding to the difference in loan conditions, such as interests and grace periods.

Table-15.3 Loan Conditions and Repayments

	Scenario 1	Scenario 2
Loan Conditions		
- total debt (F$ million)	53.5	53.5
- interest (%/year)	1.7	7.0
- repayment period (years)	25	17
- grace period (years)	7	5
Repayment		
- total repayment	67.1	90.9
- maximum annual repayment (F$ million)	3.8	7.8
- average annual repayment (F$ million)	2.7	5.3

Note :1) The repayment period includes the grace period.
2) Only interest is repaid during the grace period and principal and interest are repaid afterwards.

The maximum and average annual repayment in Scenario 1 correspond to 12 % and 8 % of the average overseas loan repayment (F$ 32.8 million) in the mid-term projection of the government overseas loan repayments (1996 ~ 2000) by the Ministry of Finance. The average annual repayment in Scenario 1 is only 3 % of the average capital expenditure (1991 ~ 1995) by the whole Government and 7 % of the infrastructure development by the Government (refer to Table-8.3).

In parallel with the repayment of the overseas loan, 15 % of the project cost, F$ 9.4 million, should be allocated with the Government budget. The average cost of F$ 4.7 million over construction period of 2 years accounts for 5 % of the average capital expenditure (1991 ~ 1995) by the whole Government, and 11 % of the average expenditure for infrastructure development by the Government. The allocation of this portion can be considered quite possible.

CHAPTER 16 EFFECT OF PROJECT IMPLEMENTATION

16.1 Direct Effect in Inundated Areas

Economic benefits are described in Chapter 15. In this chapter, physical effects of the project implementation are examined in terms of inundated area, flood level and duration. Although only topographical maps of 1/50,000 scale were available, except areas covered by the survey for the project conducted in this study, and the detail examination was impossible, rough estimation was made with various assumptions.

The results of the examination are shown in Table-16.1. Significant effects can be expected in flood control by the implementation of the project.

Table-16.1 Direct Effect in by Project Implementation

	Flood of 20 year return period		Flood of 50 year return period	
	before implementation	after implementation	before implementation	after implementation
Flood discharge (m^3/sec) *1)	2,050	600	3,050	880
Inundation duration (hrs) *2)	44	0	62	10
Maximum water level (EL. m) *3)	11.4	5.1	14.1	6.3
Whole inundated area (km^2)	36.2	5.2	45.4	16.0
Inundated area in downstream from diverting point (km^2)	31.0	0	39.0	9.6

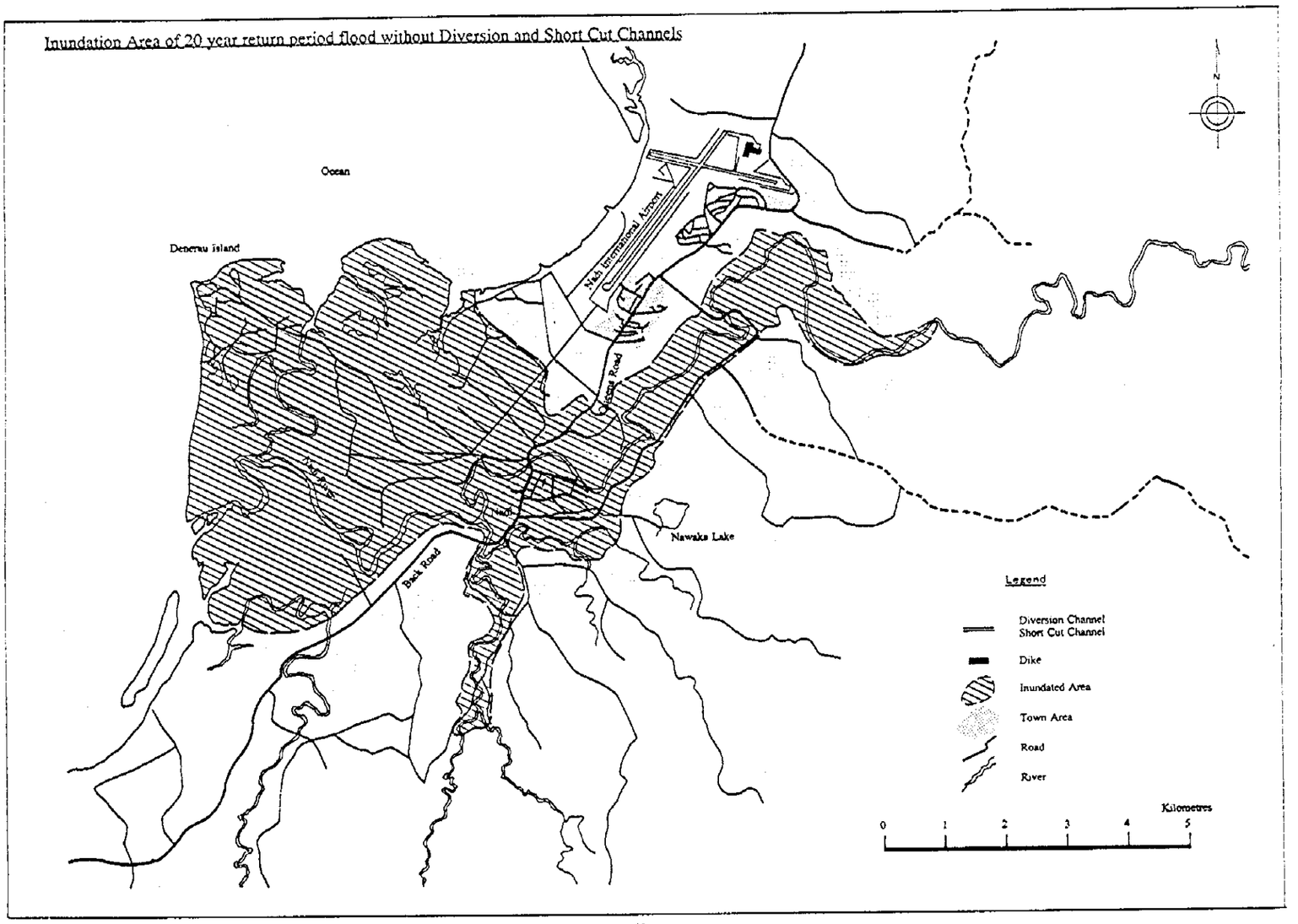
Note: *1) Flood discharge at the river mouth
*2) Minimum estimates to be required to drain flood water from inundated areas.
*3) Maximum water level at Nadi Bridge

Inundated areas in case of floods of 20 year return period and 50 years return period before and after the project implementation were estimated and are compared in Figure-16.1 and Figure-16.2.

16.2 Indirect Effects

By the project implementation, the following indirect effects are expected.

- Multiplier effects to local economy: employment generation and increase in consumption around the sites.
- Technical transfer: transfer of knowledge, techniques, skills and experiences to engineers in Fiji through the detail designing and construction.
- Land development: development of a hotel and high-grade residential lots using disposal site of the excavated soil, and its multiplier effect to local economy
- Utilization of access roads constructed on the banks of the diversion channel for maintenance
- Tourism development: brighter image brought to prospective tourists by reduction of inundation and its damage
- Relief in mentality of residents by reduction of flood damage



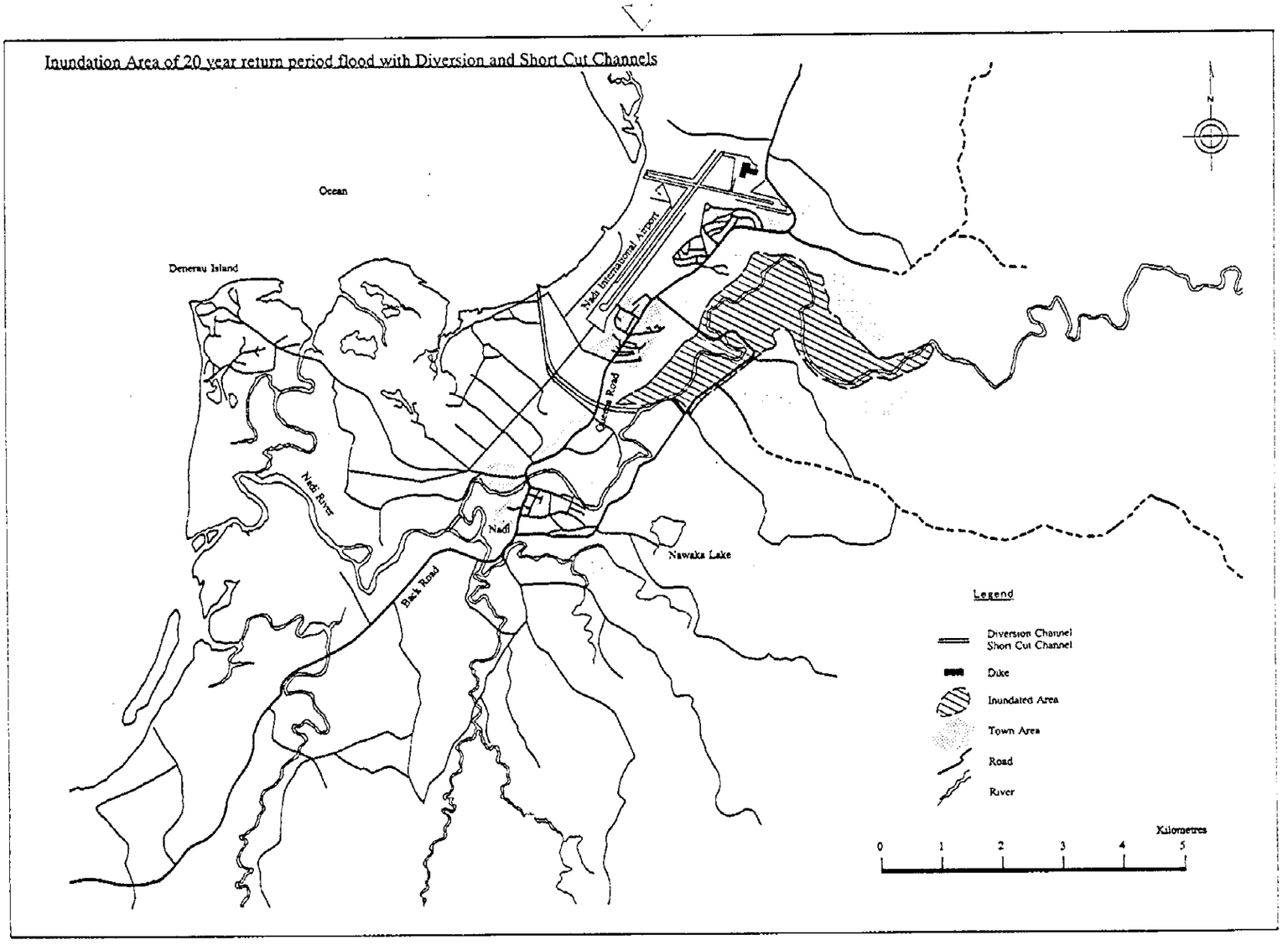
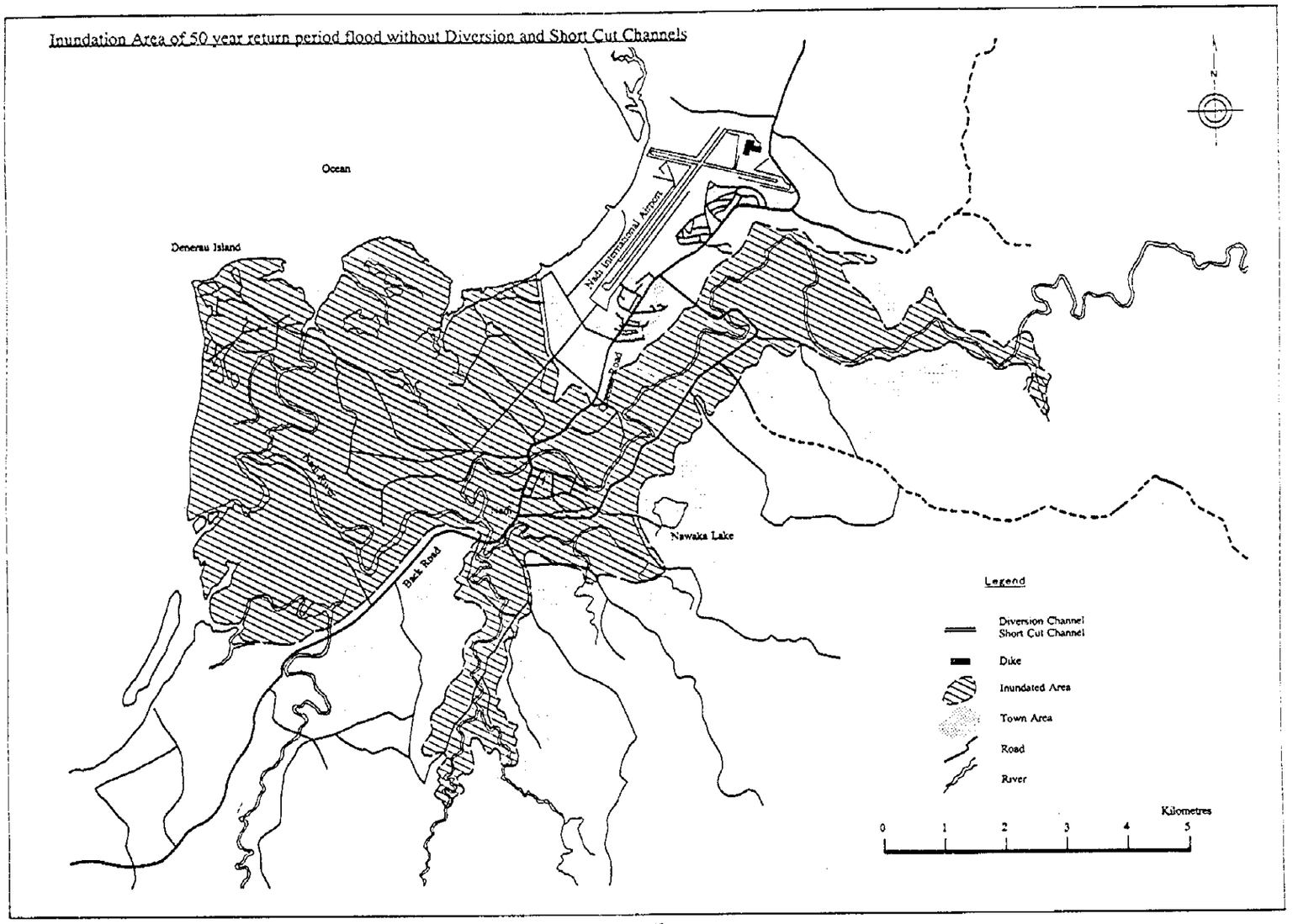


Figure-16.1 Inundated Area by Flood of 20 Year Return Period



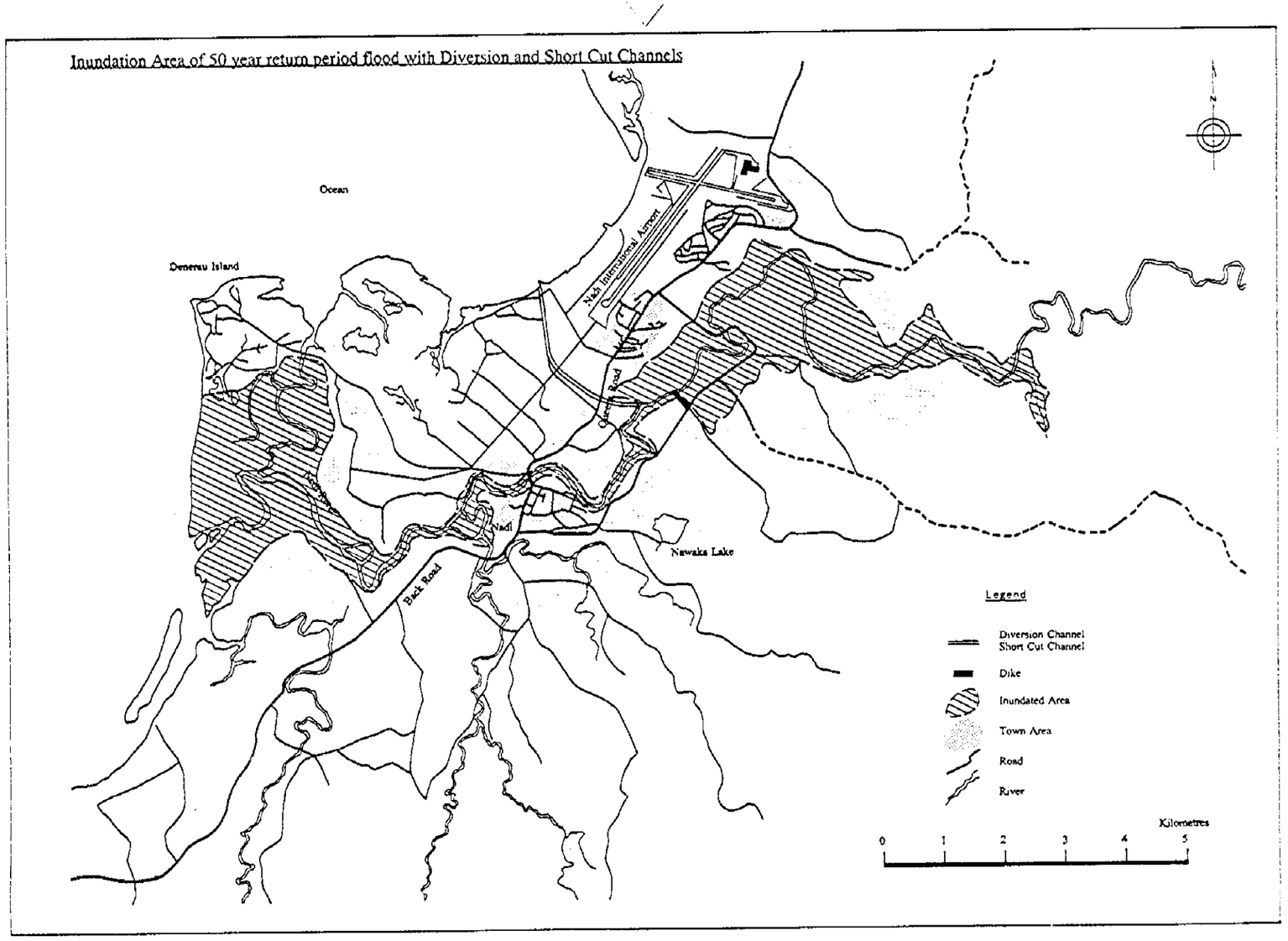


Figure-16.2 Inundated Area by Flood of 50 Year Return Period

- Reliable distribution and communication system: stable economic activities in the location
- Improvements in sanitary conditions and public health

16.3 Effect of Diversion Channel on Coastal Area

(1) Conditions of Coastal Area

1) Wind

Regarding wind in the Nadi bay area, in the dry season (from May to October) the predominant directions are East, Southeast and South (approximately 50 %), and in the rainy season (from November to April), when cyclones occur frequently, the wind of these directions decreases to about 26 %, while the frequency of wind with directions of West, Northwest and North increases to about 27 %. As for wind velocity, it does not exceed 21 knots (10.8 m/sec) in the dry season, and in the rainy season the velocity sometimes exceeds 22 knots (11.4 m/sec).

2) Tide Level

Based on tide data at Vunda Point, the mean high water springs are 1.70 m, the mean high water neaps are 1.50 m, the mean sea level is 0.97 m, the mean low water neaps are 0.40 m, and the mean low water springs are 0.20 m. Chart Datum (Lowest Astronomical Tide, LAT) is -0.97 m from mean sea level at the Standard Port.

3) Wave Heights

Wave heights in ordinary sea conditions were estimated at 40 cm by the SMB (Sverdrup-Munk-Bretschneider) method, with parameters of the wind direction and velocity (wind velocity: 5.9 m/sec, fetch: 17 km).

Wave heights in case of storms by return period of 2 to 20 yeas are estimated at 2.7 m to 7.1 m, and storm surges by the same range of return period at 0.9 m to 3.0 m in a report issued by Civil Aviation Authority of Fiji. However, the duplicated application of return period of central pressure and sustained wind speed may have caused over-estimation of storm surge.

4) Tidal Current

Tidal current was measured in the Study at four points in Nadi bay during 25 hours. Mean and the maximum velocity at the point with the sea depth of 5 m are 0.04 ~ 0.06 m/sec and 0.15 m/sec, respectively. At the points with the sea depth of 10 m, these two figures are 0.11 m/sec and 0.25 m/sec, respectively. The directions of the tidal current were irregular and no tendency was found.

It is reported that the west coast of the Denarau island located in the South of Nadi bay is eroded. According to field reconnaissance, comparison of aerial photos of the mouth of the Nadi river taken in 1967, 1986 and 1994, no change in coast line or the appearance seems to have occurred in the past 30 years. The opinion that the seashore along the west coast is formed by the current from the river mouth along the west cost is not agreeable.

(2) Effect of Sediment Deposit from Diversion Channel

1) Sediment Load Analysis

During floods, most part of the flood discharge is drained into the Nadi bay through the diversion channel. To examine effect of sediment on the Nadi bay, the sediment load analysis was conducted. Although bed elevation of the diversion channel is designed 1 m higher than that of the Nadi river and most of the bed load, which account for a large portion of the sediment load, will be transported through the Nadi river, the effect of the design is conservatively neglected in the sediment load analysis. The preconditions assumed in the analysis are listed below.

- Area of the analysis extends from the diverting point to 2 km offshore from the outlet of the diversion channel.
- Flow from the diversion channel to the sea spreads with an angle of 5°. Based on echo-sounding results, slope of the bay was determined as 1/500.
- Particle size of the sediment was assumed to be equal to the bed material of Nadi river and the results of the bed material analysis in the Study was applied.
- Sediment load was assumed to be supplied without limitation and to be a function of only the hydraulic force at the diverting point.
- Five different floods (1/20, 1/10, 1/5, 1/2 and 1/1.1 probability floods) were applied in the simulation for the analysis.

2) Result of the Sediment Load Analysis

Annual average sediment load into the diversion channel was estimated at around 6,300 m^3/year, at most. Little sedimentation occurs in the diversion channel. Conditions of sedimentation in the sea are summarized in Table-16.2. After a flood of 1/20 probability, sedimentation in the sea would occur within the area of 1.2 km from the outlet of the diversion channel (the sea depth of about 6.0 m) with a width of 270 m and with thickness of 0.4 m. The total volume of sediment is estimated to be 42,000m^3. Particle sized would range from 0.2 to 0.6 mm, but most them would be less than 0.2mm.

Table-16.2 Sedimentation in the Sea after Floods

Item	Scale of Flood				
	1/20 Probability	1/10 Probability	1/5 Probability	1/2 Probability	1/1.1 Probability
Location of Sedimentation	-0.1 ~ -1.2 km	-0.1 ~ -0.9km	-0.1 ~ -0.6 km	-0.1 ~ -0.4 km	-0.1 ~ -0.2 km
Length of Sedimentation	1,100 m	800 m	500 m	300 m	200 m
Width of Sedimentation	270 m	220 m	150 m	130 m	100 m
Maximum Thickness of Sedimentation	0.37 m	030 m	0.23 m	0.12 m	0.07 m
Volume of Sedimentation	41,700 m^3	25,400 m^3	10,700 m^3	3,400 m^3	1,400 m^3
Particle Size	0.02 ~ 0.06 cm	0.02 ~ 0.0425 cm	less than 0.02 cm	less than 0.02 cm	less than 0.02 cm

location for the sea: distance offshore from outlet

3) Sediment Move in the Sea

As described above, the particle size of the sediment in the sea is less than 0.2 mm. According to the tidal current survey, the average velocity of tidal current where the sea depth is 5 m is approximately 200 m/hr (6 cm/sec), causing suspended sediment whose grain size is smaller than 0.06 mm. In this case no sediment transport would occur in the sea. The maximum velocity at the same sea depth, however, is about 540 m/hr (15 cm/sec), causing suspended sediment whose grain size is less than 0.4 mm. Therefore, most or all part of sediment drained through the diversion channel is carried off. Since the seabed shallower than 4 m is disturbed and stirred by high waves due to strong wind, sediment load from the diversion channel is considered to be dispersed and carried off by the high waves. Considering slow tidal current and random directions of tidal current and waves, almost no adverse effects would be caused in terms of sedimentation and erosion by construction of the diversion channel.

CHAPTER 17 ENVIRONMENTAL IMPACT ASSESSMENT

17.1 Current Conditions of the Project Area

Nadi is the gateway to Fiji and renowned for its valuable contribution to the national economy due to foreign currency earning as tourism base. The project area for the diversion channel belongs to the Namaka/Wailoaloa district and that for the short cut channel within the Nadi Town district. In addition to tourism industry, small-scale manufacturing and sugarcane farming are the main economic activities. Major public facilities are represented by Nadi International Airport, Queens Road which connects Nadi to Lautoka, and Enamanu Road, diverting from Queens Road to Wailoaloa beach.

17.2 EIA (Environmental Impact Assessment)

(1) Environmental Elements for EIA

Based on the results of the initial environmental examination (IEE) conducted for the Master Plan, environmental elements, on which some adverse impact would be caused by implementation of the project, were included in the EIA as shown in Table-17.1.

Table-17.1 Environmental Elements for the EIA

Social Environment	Natural Environment	Environmental Hazard
Resettlement	Topography & geology	Water pollution
Community separation	Groundwater	Noise & vibration
Economic activity	Coastal area	Soil pollution
Traffic facilities	Flora & fauna	
Fishing right*	Landscape	
Public health		
Solid waste		

* The term, "Water Right/Right of Common", includes water right and fishing right, but there exists no problem of water right for the diversion channel and shortcut channel.

(2) Impacts on Social Environment

1) Resettlement

The site for the diversion is currently used for agricultural and residential purposes, located in State Lands and freehold lands, and land acquisition might be comparatively easy. The site for the short cut channel comprises of agricultural fields and bushes, situated in a Native Reserve. For the land acquisition for the short cut channel, some land swap would be necessary. Resettlement of 36 households would be necessary for the diversion channel construction. At the site for the short cut channel, no residence were found. As land acquisition and resettlement are sensitive affairs, the Government should find equitable solutions agreeable both for the Government and the residents before the construction.

2) Community Separation

Although the project will not cause community separation, the diversion channel will cross some lands, and may block the passage of the people living near the channel. For some farmers, whose farming land will be separated from their houses, or for some

resettled people, it will take longer time to reach their working place. Most of these inconveniences in passage or traffic could be solved by construction of a bridge at the crossing point with the Queens Road, a tramline bridge in the middle reach and a pedestrian bridge near the outlet, and access roads on the both sides of the banks.

3) Economic Activity

To those people involved in the resettlement program or to the McDonald's shop, some adverse impacts can be anticipated on their business or economic activities. However, to the whole area, positive impacts, caused by generating employment opportunity for the construction, reduced flood damage, land development of soil disposal site for a hotel and high-grade residences, would overwhelm the negative factors.

4) Traffic in the Related Roads

Although some impacts are anticipated during construction caused by the detour or traffic of vehicles for construction, no major adverse impacts would be resulted after the completion because of construction of a bridge at the crossing point with the Queens Road with sufficient capacity and access roads on the left and right banks of the diversion channel.

5) Fishery Rights

Customary fishery rights are situated at the river mouth and the sea near the site. These fishery rights are demarcated into 4 areas. Impacts on the fishery activities would be small because discharge in the diversion channel occurs not frequently, and most of the sediment is deposited from the existing river. Sufficient meetings on compensation should be held with fishermen, however, to obtain equitable agreement with them.

6) Public Health

The diversion channel will work only in case of flood. In normal times, it will have no flow if a flood gate is installed to stop the tides. In the case, some stagnant water may cause mosquito breeding, emitting of unpleasant smell or odor, and unwanted growth of vegetation in the channel, and consequently deteriorate public health. Therefore, no flood gate is planned to keep good water quality, despite possibilities of saline water intrusion.

7) Scattered Soil and Dust

Since the construction of the diversion channel will involve large-scale earth woks and large volume of soil will be transported during construction. Problems of scattered soil or dust would possibly occur in the construction site. No sensible impacts, however, are anticipated outside the site.

(3) Impacts on Natural Environment

1) Topography and Geology

Since the construction of the diversion channel will employ excavation in upper reach and embankment in lower reach and a man-made river with a width of 100 m will appear, substantial changes would occur in topographic and scenic conditions. The adverse effects could be mitigated by developing parks along the channel and by installing green

belts around the soil disposal site. The land development at soil disposal site for a hotel and high-grade residential lots would contribute to mitigation of the adverse effects.

2) Coastal Area

Since the elevation of the bed of the diversion channel at diverting point is designed to be 1 m higher than the bed of the mainstream at the point, sediment load to the diversion channel will be small. No significant effect on sedimentation in Nadi bay or the erosion of the coast would be caused by the project implementation.

There is no coral reef in front of Wailoaloa beach around the outlet, and the nearest coral reef is situated in Malan Cay, about 3.5km far from the outlet. The coral development at Malan Cay is comparatively poor. Sedimentation in Nadi bay after the diversion channel construction would not differ much from that before the construction, since even now most of flood is discharged to Nadi bay, and the sediment analysis in Nadi bay (refer to 16.3) indicate no sedimentation possibility. Mangrove forests at southwest area to the project site would not be negatively affected. On the contrary, construction of the diversion channel might help preservation of the mangrove forests along the mainstream, because a large part of flood will drain through the diversion channel and the reduced flood in mainstream would cause less damage.

3) Groundwater

In the geotechnical survey, 12 boreholes were drilled. Groundwater abstracted from 4 boreholes near the beach had comparatively higher salinity. Salinity from 2 boreholes out of the 4 was extremely high, showing the possibility of seawater infiltration through drainage canal near the 2 boreholes. There are 4 wells in the area from the right bank of the Nadi river to the beach, and 3 wells are dry and the rest 1 well is not used. Therefore, the impacts on groundwater use are not anticipated. However, monitoring of groundwater level and salinity would be recommendable.

4) Flora and Fauna

Mangrove is the most important flora in this area. In the project site, however, almost no mangrove trees were observed. Coconut trees were found in some areas, and those trees would be removed for the construction. Replanting would be necessary. Wading birds utilize the mangrove and intertidal areas for feeding and roosting. Since the route of the diversion channel is not located in their habitat, no impacts are anticipated on these birds.

5) Landscape

As described 1) of the above, the diversion channel would change the landscape substantially. The beach near the outlet is resort area. If it appears as bare earth works or structures, it would obstacle the view of tourists. Land development for parks, a hotel and high-grade residential lots is recommended, employing landscape design.

(4) Hazard Related Issue

1) Water Pollution

During project construction, pollutant load may increase due to employment of machinery, labors and result in water pollution of Nadi River and Nadi Bay. Measures should be

taken in the design and construction to minimize water pollution. Without installing flood gate at the outlet, the water quality in the channel would be maintained by periodical flow of tide. Infiltration of saline water to groundwater or soil would possibly occur. Careful design and construction have to be employed to mitigate the adverse effect. Regular monitoring of ground water quality should be conducted.

2) Noise and Vibration

The machinery employed for the diversion channel construction would cause noise and vibration. There is no regulation in Fiji on construction work regarding noise level yet. Referring to the regulation in Japan, a construction work with a noise level higher than 85 dB is only permitted in day. The impacts of noise and vibration from project construction might not be significant, because surrounding area of the route of the diversion channel is not densely populated. The construction work, however, should be carried out only in day time.

3) Soil Pollution

As has been mentioned in 3) of (2) above for groundwater, seawater intrusion might result in an increase of groundwater salinity. This could also cause a build-up of soil salinity. In the project area, most of the agricultural lands are used for sugarcane farming. Although sugarcane is not a crop sensitive to soil salinity, protection against soil pollution should still be considered. The countermeasures are the same as those proposed for groundwater protection.

17.3 Environmental Management Plan

Environmental management is important before, during and after the construction. The management includes not only the environmental issues related to the project, but also those related to environmental improvement in the whole project area. Recommendations can be given as followings.

(1) Organization for Environmental Management

Officers, at least one, in charge of environmental management should be assigned in the project office. The officers should carry out measures for environmental protection and improvement.

(2) Management of Resettlement and Land Acquisition

Resettlement and land acquisition are sensitive to social impacts and have to be well managed. Totally 36 households would possibly be involved in the resettlement program. Careful investigation is indispensable on their properties, and hearing on their opinions and wishes.

(3) Environmental Surveillance of Construction Work

Construction works should follow environmental regulations. Well organized works and surveillance during the works are necessary. Dispute may arise with local residents on environmental issues, or complaints may be made to the project office or local government. These issues have to be solved according to environmental laws and regulations.

(4) Safety Management of the Diversion Channel

Safety management of the diversion channel includes the safety of structural and people who maintain the channel or live near the channel as well as tourists entering the channel area. The Government should put forward regulations on all issues related to its management and usage. Arbitrary plantation in the channel area or on the banks should be prohibited. Discharge of sewage, wastewater or dumping garbage and refuse into the channel should be forbidden.

(5) River and Coastal Environment Management

As one of the non-structural measures, river environment management proposed in the Master Plan has to be considered after the construction. The measures include restriction of industrial wastewater and reduction of pollutants from domestic discharge. The environmental condition of the Nadi bay is good at present. However, to improve the coastal environment and to create a more beautiful coastal area should always be the objective of the watershed management.

(6) Environmental Education

For an effective environment management, environmental and sanitary education is indispensable for raising public awareness of the importance of environment protection.

17.4 Environmental Monitoring

Before, during and after the construction, the following conditions should be monitored to understand environmental settings and to identify what has to be done.

- Traffic volume; Queens Road, Enamanu Road, etc.
- Noise and vibration; surrounding area of the construction site
- Groundwater monitoring; water level and electric conductivity (salinity)
- Coastal environment; tidal movement, coastal erosion, sedimentation (including detail investigation before the construction)
- Resettlement investigation; living conditions, problems, wishes, etc.

CHAPTER 18 PRESENT LAND USE AND LAND DEVELOPMENT

18.1 Present Land Use

The project area is located in the center of the urban area and between the international airport and Nadi town. The present land use of Nadi town and its vicinity is schematically as shown in Figure-18.1 and characterized as follows:

- Urban development along Queens road with Nadi town in the south
- International airport located in the north - main gateway to Fiji
- Tourism development - concentration of hotels and tourist shops/restaurants
- Sugarcane - historical background and still major industry and landscape
- Fijian native villages distributed adjacent to the urban area
- Urban expansion to the south and to the north-east

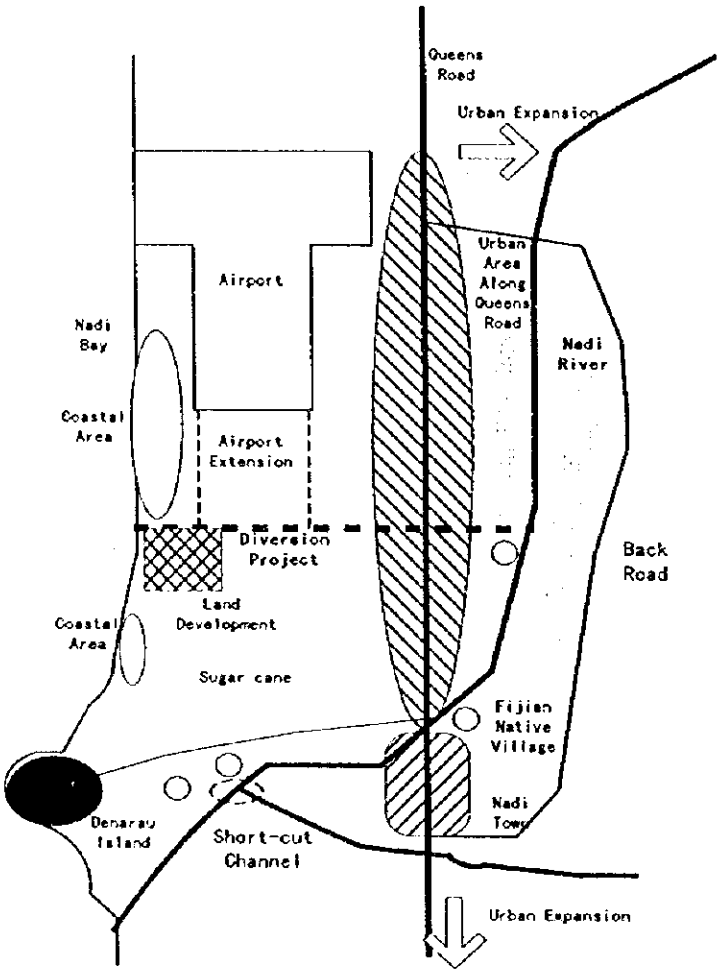
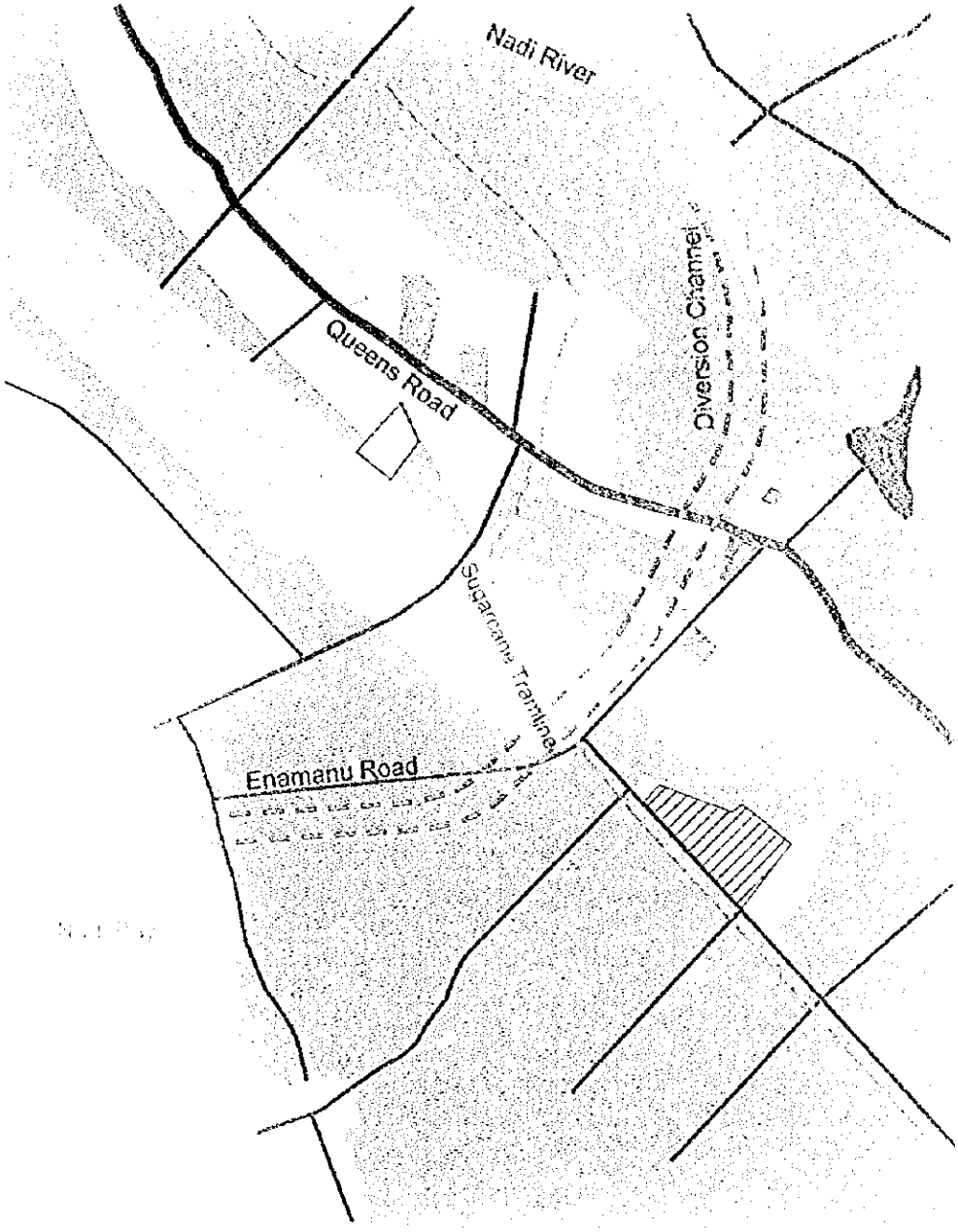


Figure-18.1 Schematic Plan of Nadi Area

The present land use around the project area is shown in Figure-18.2.

Figure-18.2 Present Land Use around Diversion Project Area


Nadi River
Queens Road
Diversion Channel
Sugarcane Tramline
Enamanu Road

18.2 Future Land Use

The future land use in Nadi town and its vicinity shall be lead by Nadi Town Planning Scheme which is prepared by the Department of Town and Country Planning as shown in Figure-18.3. The expected changes are extension of the airport in the east of Enamanu road and tourism development on the coastal area integrated with the Fiji Tourism Development Plan.

The projected future land use around the project area is as shown in Figure-18.4 and the characteristics are as follows:

- Both sides of Nadi river adjacent to the diversion channel site are rural or agricultural areas.
- The area along Queens road is residential. The east side is about 20 m wide and the west side extends to the airport extension area.
- The airport runway will be extended up to Enamanu road and the airport facilities will be constructed on the west of Enamanu road. Accordingly the route of the tramline will be relocated outside the airport extension.
- The west of Enamanu road is rural area except the area along Queens road which is residential.
- The area in the north of the airport extension between Enamanu road and Wailoaloa road will be residential and hotel areas. The hotel area is located seaside and residential area is between the hotel area and the airport extension.
- The beach is public open space for recreation and access to the sea.
- The coastal area along Nadi bay road is designated as residential and hotel areas.

18.3 Proposed Land Development Plan with Diversion Project

(1) Outline of Land Development

The huge volume of excavated soil will be disposed from the construction site of the diversion channel, and the land of about 49 ha will be developed by filling or embankment to a height of about 6m. For the use of the land, hotel, housing, shopping center, park and international conference center etc. are nominated. Considering the fact that there is no appropriate park in Nadi area and that the demand for hotels and housing will increase in future, the land use of the land development is planned as indicated in Table-18.1.

Table-18.1 Land Development Plan

Land Use	Area (ha)
Park	12
Hotel	20
Residential Area	15
Buffer Slope Green Belt	2
Total	49

The image of the land development based on the above land use plan is shown in Figure-18.5.

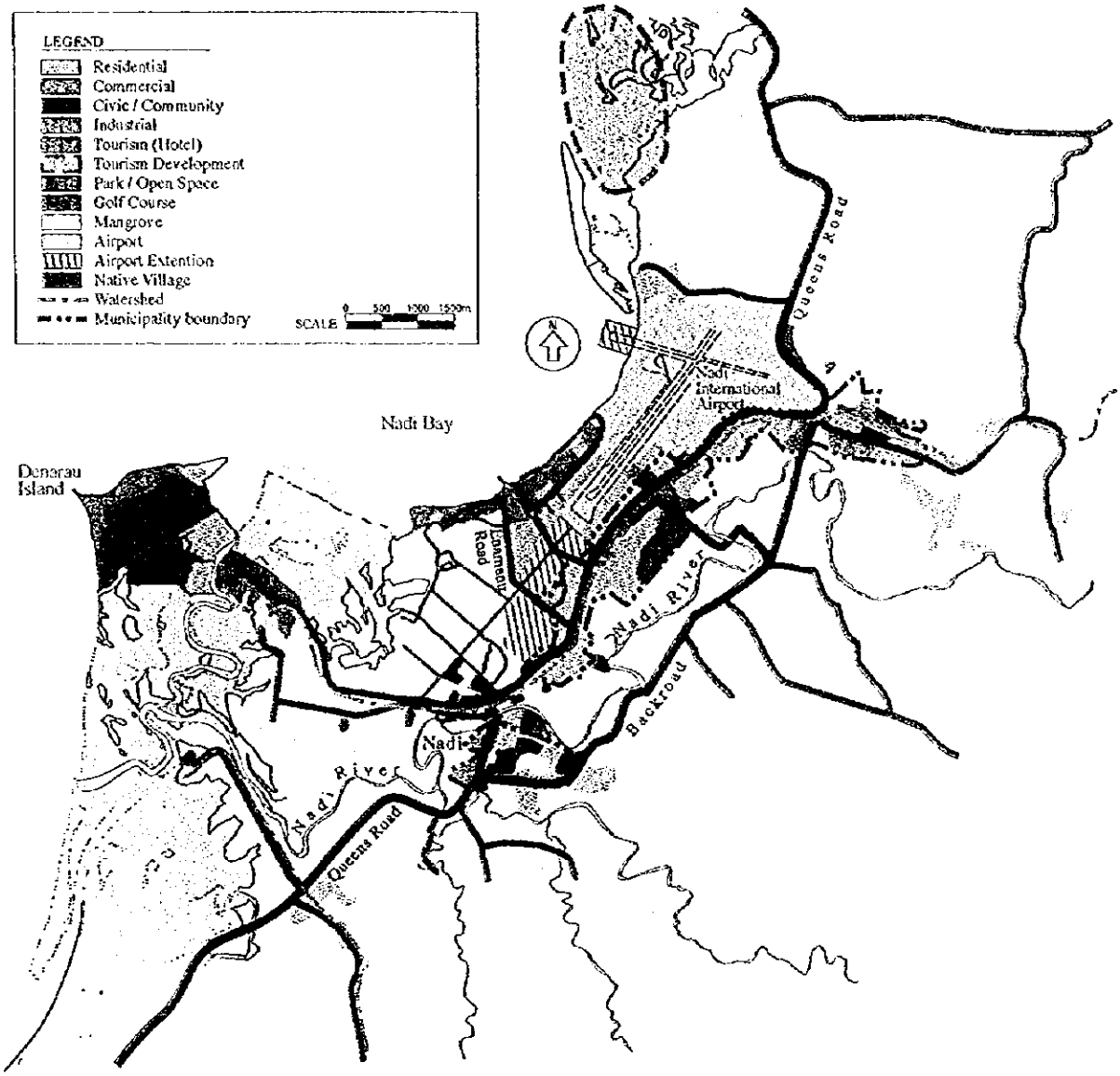


Figure-18.3 Nadi Town Planning Scheme

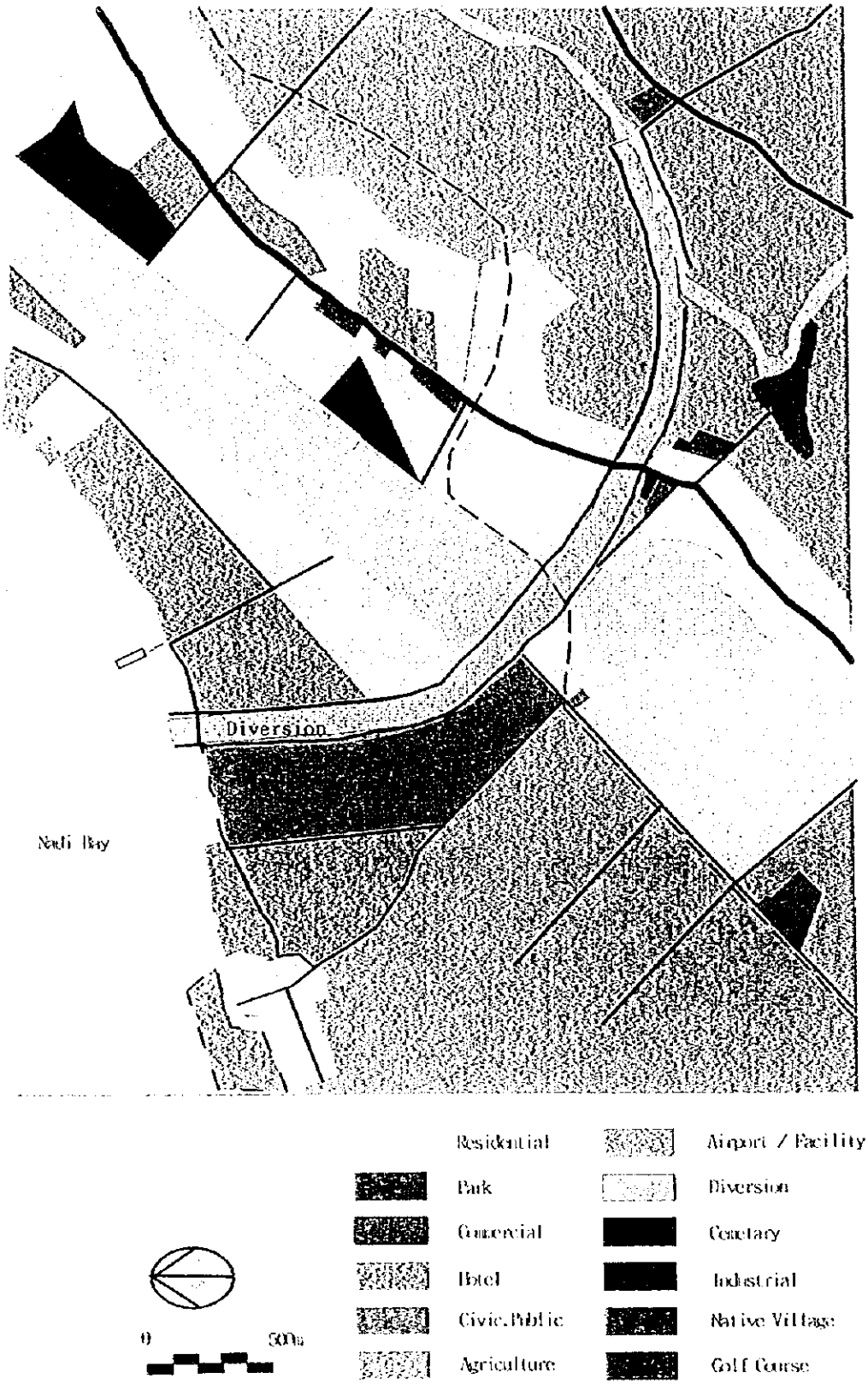


Figure-18.4 Future Land Use around the Project Area

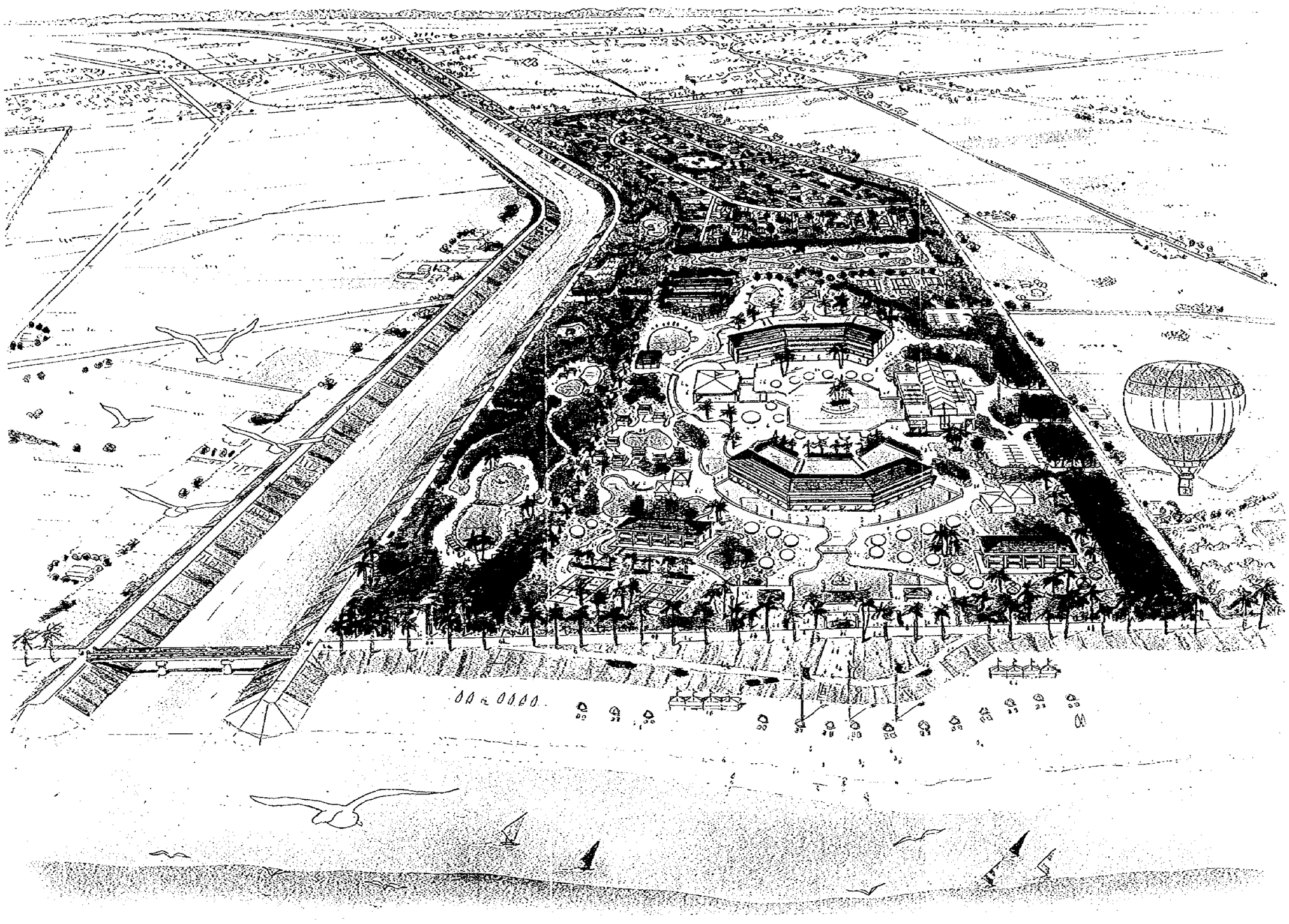


Figure-18.5 Imaginary View of Land Development

(2) Cost Estimate and Economic Evaluation

The cost of land development is mainly preparation of site with the public infrastructures, such as a park, roads, water supply, sewerage, electricity and telephone. The construction cost including facilities in residential lots is estimated at F$ 6.0 million. The project cost would be F$ 8.3 million. The sales of the development are expected to be F$ 22.4 million (F$ 70 x 320,000 m^2).

The results of economic evaluation of the combination project of flood control (Nadi diversion channel and short cut channel) and land development are shown in Table-18.2. The EIRR and B/C of the whole project are 17.2 % and 1.58 respectively, while those for the diversion and short cut channels are 14.5 % and 1.46. Total financial project cost approximately F$ 71.3 million for the combination project could be financed by the sales the developed land and the remaining cost to be financed by the Government would be F$ 48.9 million. The result is favorable to the combined project.

Table-18.2 Economic Analysis for Combination of Flood Control & Land Development

Item of Analysis	Result of Analysis
Annual economic benefit of 3rd year (F$1,000/year)	27,228
Annual economic benefit after 4th year (F$1,000/year)	8,278
Economic project cost (F$1,000)	56,297
Annual economic OM cost (F$1,000/year)	36
EIRR (%)	17.24
B/C (ratio)	1.58
NPV (F$1,000)	30,176

Discount rate: 10 %

CHAPTER 19 INSTITUTION AND TRAINING

(1) Organization for Project Implementation

The Land and Water Resource Management Division (LWRMD) in the Ministry of Agriculture, Fisheries and Forests (MAFF) would be in charge of implementation of the project of construction of Nadi diversion channel and short cut channel. Since the project will be related to many fields of the government administration, some advisory committee should be organized, whose member should represent various departments/divisions of the Government. Because of the large scale and importance of the Project, some project office should be established. Relevant existing organizations and required set-up is shown in Figure-19.1.

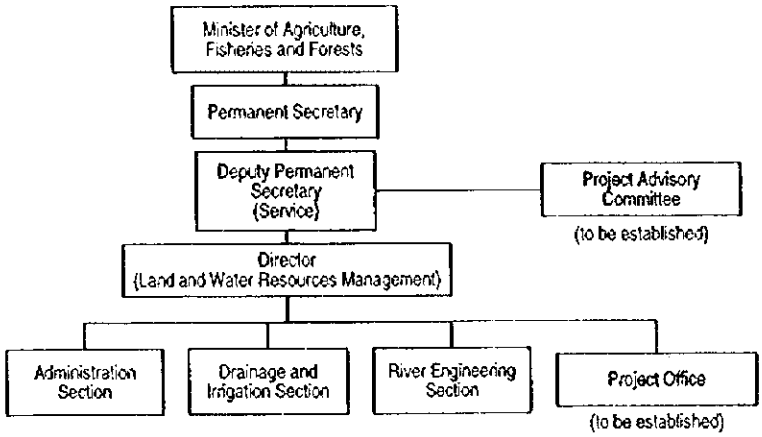


Figure-19.1 Proposed Set-up for Project Implementation

(2) Organization of the Project Office

Project office for the implementation should include administration unit, accounting unit, land acquisition unit, survey unit, design unit, operation unit, and inspection unit corresponding to the development of implementation. Models of organization at detail design stage and construction stage are illustrated in Figure-19.2 and Figure-19.3.

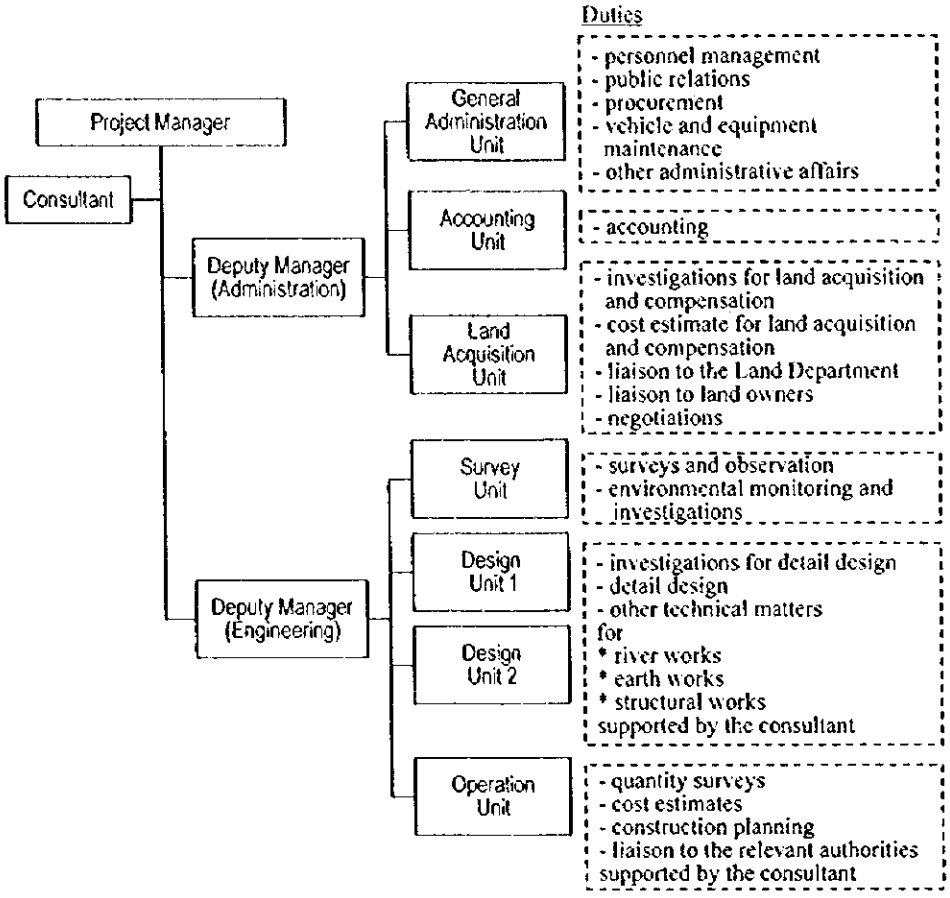


Figure-19.2 Proposed Project Office at Detail Design Stage

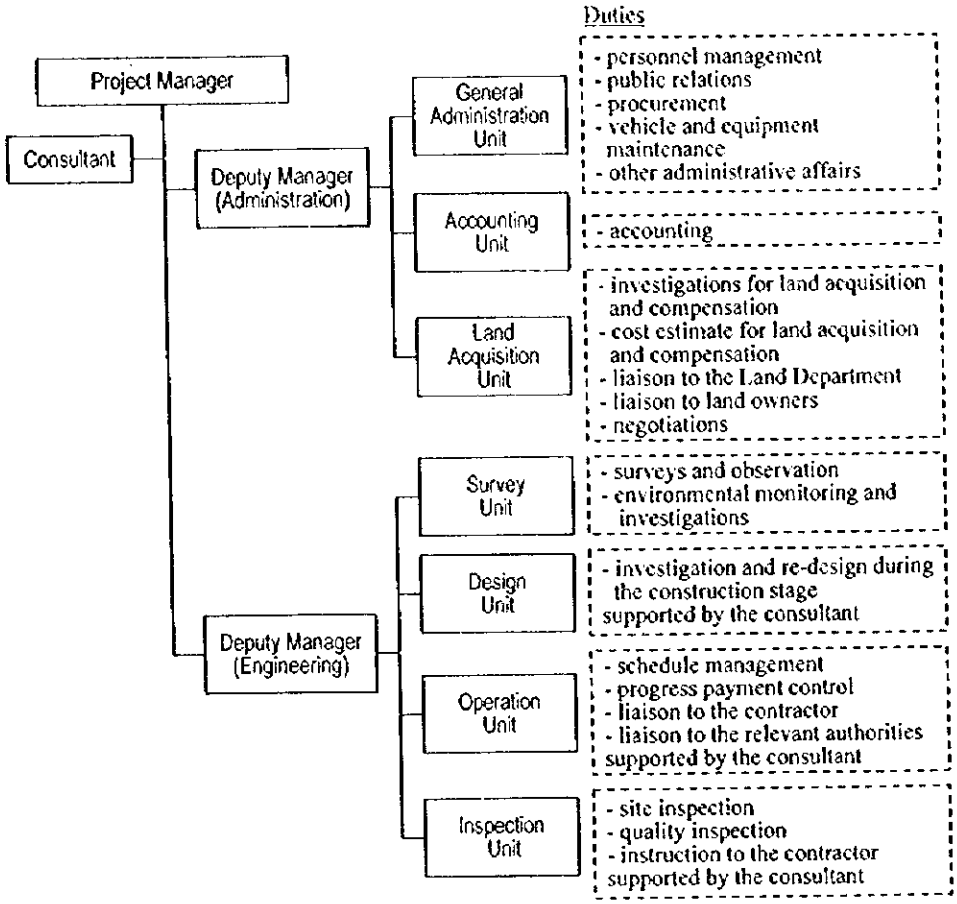


Figure-19.3 Proposed Project Office at Construction Stage

(3) Organization in Charge of Operation and Maintenance

The diversion channel and the shortcut channel can be maintained by the Western Drainage Board. The Board currently maintains drainage schemes with a total length of 271 km with the organization as shown in Figure-19.4. Additional assignment of one of the established staff specialized for the operation/maintenance of the diversion channel and the shortcut channel in the Board could be enough. The cost for the operation/maintenance should be borne by the Government budget unless some rate collection for the cost recovery is approved.

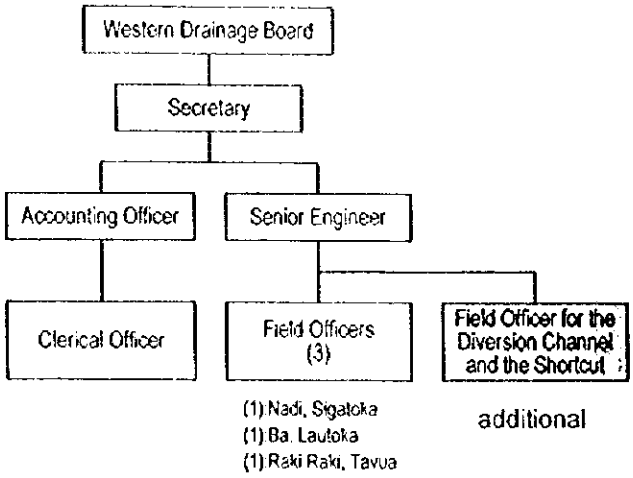


Figure-19.4 Organization of the Western Drainage Board

(4) Required Training for Project Implementation

Since the LWRMD of the MAFF has no experience for construction of diversion channel in the scale of the Project, some training for the implementation of the Project is necessary. Some training to prospective staff of the Project Office at all phases, and the staff of the River Engineering Section and the Drainage and Irrigation Section is required before the implementation of the Project. The training should include site observation of the similar projects, case studies on the model projects. Assistance of foreign experts with experience of similar projects would be quite helpful.

CHAPTER 20 EVALUATION AND RECOMMENDATIONS

20.1 Evaluation of Priority Project

(1) Economic Evaluation

Construction of priority project (Nadi diversion channel and short cut channel) with design flood of 20 year return period would require the project cost of F$ 62.9 million and bear the annual economic benefit of F$ 8.3 million. The economic internal rate of return (EIRR) of the project was estimated at 14.5 %, the benefit-cost ratio (B/C) is 1.46, and the net present value (NPV) is F$ 21.4 million. The economic feasibility is high, comparing with the opportunity cost of capital of 10 % in Fiji. The EIRR would be 11.9 % in an unfavorable condition, 10 % decrease in the economic benefit and 10 % increase in the cost. The economic viability holds even in the condition.

Land development of 49 ha for a hotel and high-grade residential lots reclaimed with surplus soil of the diversion channel construction can be combined, would accrue a total cost of F$ 71.3 million and enable sales of F$ 22.4 million, resulting in reduction of financial requirement to F$ 48.9 million. The EIRR, B/C, and NPV of the combination project was estimated at 17.2 %, 1.58 and F$ 30.2 million, respectively. The combination would enhance the economic viability of the project.

(2) Financial Examination

Because of the large scale of the project cost, a large portion of the costs should be funded with overseas loans. Financial feasibility was examined with two typical scenarios as follows, assuming 85 % of the cost is to be financed by overseas loans.

Scenario 1: 1.7 % of interest rate, 25 years of repayment including 7 years of the grace period

Scenario 2: 7.0 % of interest rate, 17 years of repayment including 5 years of the grace period

In Scenario 1, the total repayment, maximum and average annual repayment would be F$ 67.1 million, F$ 3.8 million and F$ 2.7 million, respectively. These figures in Scenario 2 would be F$ 90.9 million, F$ 7.8 million and F$ 5.3 million, respectively. The maximum annual repayment and average annual repayment in Scenario 1 corresponds to 12 %, and 8 % of the average overseas loan repayment (F$ 32.8 million) in the mid-term projection of the government overseas loan repayments (1996 ~ 2000) by Ministry of Finance.

In parallel with the repayment of the overseas loan, 15 % of the project cost, F$ 9.4 million, should be allocated with the government budget. The average cost of F$ 4.7 million over construction period of 2 years accounts for 5 % of average capital expenditure (1991-1995) by the whole Government (F$ 98.0 million), and 11 % of average expenditure for infrastructure development by the Government (F$ 40.9 million). The allocation of this portion can be considered quite possible. If the land development at soil disposal site is combined, the profit of the land development would be F$ 14.1 million (F$ 22.4 million of sales of developed land minus F$ 8.3 million of cost of the land development). The profits

might be enough to cover the cost of F$ 9.4 million, which would not be financed by overseas loan.

(3) Environmental Impact Assessment

Construction of the diversion channel and the short cut channel will largely reduce areas and duration of inundation caused by floods and mitigate direct and indirect flood damage drastically, contributing to socio-economic development and improvement of social welfare in the area. The positive effects would be huge.

Adverse effects on social and natural environment by the project, coupled with the countermeasures against the effects, are discussed in Chapter 17. Recommended countermeasures would adequately cope with the effects. Among them, significant adverse effects would be as follows.

- Resettlement: Before the construction, 36 household would possibly be involved in resettlement. Sufficient negotiation with residents on conditions for the land acquisition and compensation is necessary.
- Topographical and scenic change: The appearance of the diversion channel with a width of 100 m would cause substantial changes in topographical conditions and the landscape. Land development in the disposal site of excavated soil for parks, a hotel and high-grade residences with sufficient landscape design would better be combined.
- Coastal areas: The results of sediment load analysis in the Study show that no particular impacts would be caused by sedimentation. There are no mangrove forests near the outlet and the nearest coral reef is as far as 3.5 km.
- Deterioration in water quality: Since the diversion channel is designed to let Nadi river drain daily discharge of 75 % of year, no sensible change in water quality would be resulted in the mainstream. No flood gate at the outlet of the diversion channel is planned to avoid stagnant water and to keep the water quality in the channel by periodical flow of tide. Although saltwater wedge cannot reach to the diverting point, infiltration of saline water to groundwater or soil would possibly occur. Careful design and construction have to be employed to mitigate the adverse effect. Regular monitoring of ground water quality should be conducted.

20.2 Recommendations

(1) Implementation of the Priority Project

Proposed project of Nadi diversion channel and short cut channel will bear a great deal of economic benefits and is financially feasible. The implementation would contribute socio-economic development and improvement in the welfare of the residents. The project should be implemented immediately.

(2) Forming Consensus in the Government and with the Residents

Formation of consensus in the Government of Fiji should be encouraged as early as possible through examining the results of the Study and establishing an organization for promotion of

the implementation. In parallel, understanding and agreement of the residents and the nation should be obtained through sufficient explanation.

(3) Application for Overseas Loan

A large portion of the project cost has to be covered by overseas loans. It would take a long time to reach loan agreements. Preparation of application should be started promptly. Budget allocation for the rest of the cost should be prepared immediately.

(4) Starting Negotiation for Land Acquisition and Compensation

Land acquisition and compensation agreement takes a long time generally. Sufficient explanation and meetings would be required for equitable agreement with the residents. Meetings with the residents should be started as soon as possible.

(5) Hydraulic Model Experiment and Environmental Monitoring

Before the construction, hydraulic model experiment would be strongly recommended to reexamine the design of the diversion and short cut channels. Environmental monitoring should be started soon to evaluate impacts of project implementation.

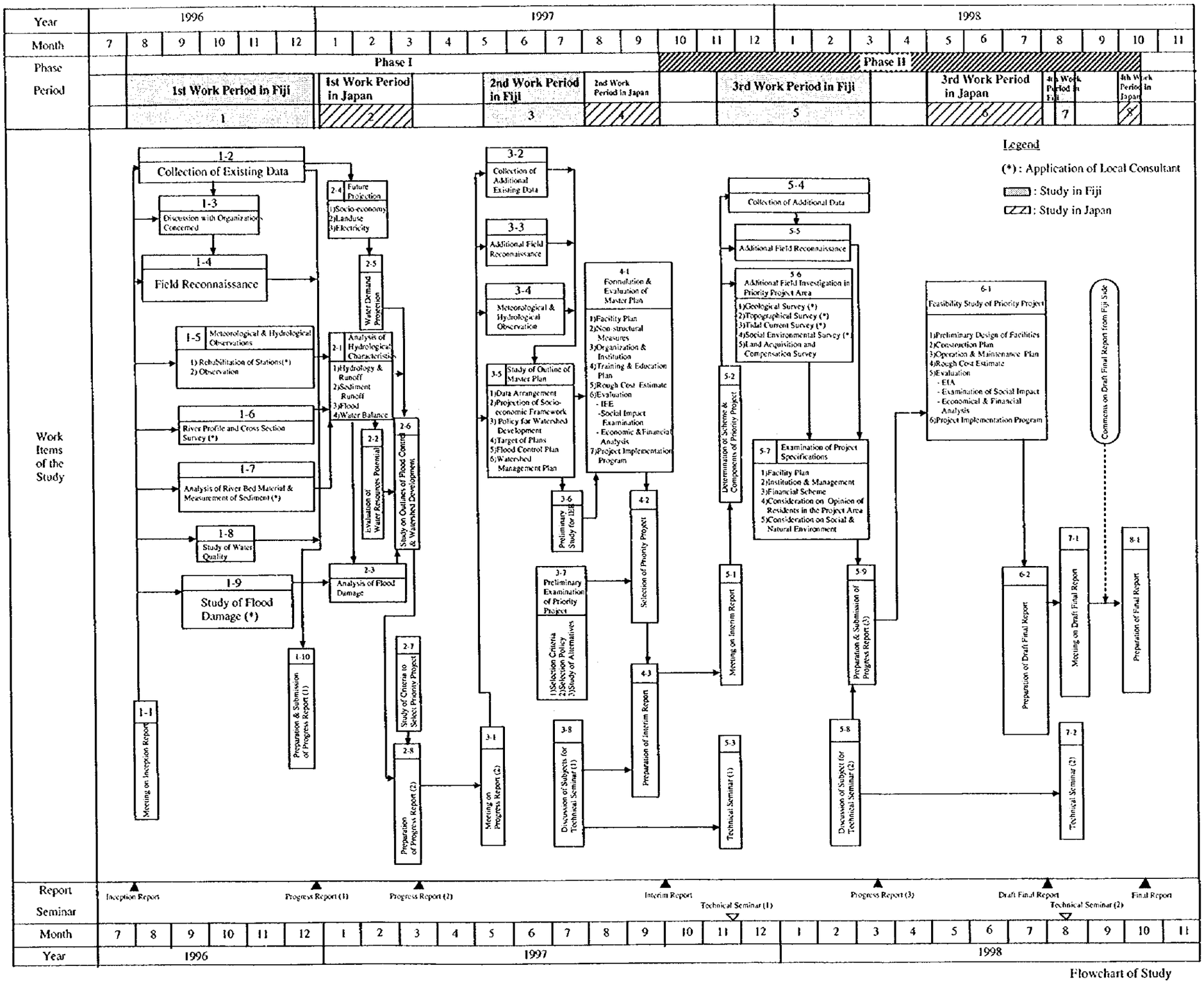
(6) Land Development of Soil Disposal Area

Proposed land development combined with the project would be of significant importance in terms of financing the project cost. Procedures, such as determination of implementing entity, organization set-up, marketing, planning and design, manner of sales or leasing, etc., for the implementation of the land development should be examined and determined early.

APPENDICES

APPENDIX 1

Flowchart of Study



Flowchart of Study

APPENDIX 2

Members and Assignment Schedule of the Study Team

Assignment Schedule

Assignment	Name	1996									1997												1998						
		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	8	9	10
Team Leader /Watershed Management	Yoshio Nakagawa																												
Flood Control	Norio Hanaoka																												
Water Resources Development	Ryuzou Higashijima																												
Meteorology, Hydrology & Flood Analysis	Kazuhiko Otani																												
Topography & Geology	Yosuke Sasaki																												
Forest & Soil	Masaharu Mizoguchi																												
Surveying	Toshiki Kuroiwa																												
Facility Design/ Construction & Cost Estimate	Kazuya Hirano																												
Landuse/ Regional Development	Naoyuki Minami																												
Institution	Naoki Hara																												
Socio-economy	Kiyoshi Tanioka																												
Environment	Wang Xiaochang																												
Coast	Satoru Nishino																												
Coordinator	Taikan Kuwabara/ David Merrett																												
Report			▲IC/R						▲PR(1)	▲PR(2)								▲IT/R				▲PR(3)					▲DF/R		▲F/R

Legend ▬ Work in Fiji

▭ Work in Japan

APPENDIX 3

List of Committee Members

LIST OF JICA ADVISORY COMMITTEE

NAME	POSITION	ASSIGNMENT PERIOD
1. Shin TSUBOKA	Chairman	July 1996 ~ May 1997
2. Toshiyuki AOYAMA	Chairman	May 1997 ~ October 1998
3. Kenzou HIROKI	Member	July 1996 ~ October 1998

LIST OF STEERING COMMITTEE

as of 18 August, 1998

	DESIGNATION	DEPARTMENT	NAME
1.	Deputy Permanent Secretary	MAFF	S. Ulitu
2.	Permanent Secretary	Ministry of Planning	R. Yarrow
3.	Deputy Permanent Secretary	Ministry of Regional Development and Multi-ethnic Affairs	P. Ravea
4.	Director	Department of Energy	D. Kumaran
5.	Director	Land and Water Resource Management Division, MAFFA	S. N. Swami
6.	Acting Director	National Trust of Fiji	E. Erasito
7.	Principal Town Planner	Department of Town and Country Planning	S. Dakaika
8.	Principal Environment Officer	Department of Environment	M. Sovaki
9.	Principal Engineer (RE)	Land and Water Resource Management Division, MAFF	K. Win
10.	Disaster Co-ordinator	Department of Regional Development	A. Tuifagalele
11.	Senior Hydrologist	PWD	R. Raj
12.	Senior Economic Planning Officer	Ministry of Planning	C. Yuen
13.	Disaster Mitigation Advisor	UNDHA	A. Kaloumaria
14.	Engineer (Road Design)	PWD	A. Ketenilagi
15.	Senior Agricultural Officer	MAFF	J. Feresi
16.	Engineer (Admin.)	MAFF	A. Lal

LIST OF TECHNICAL COMMITTEE

DESIGNATION	DEPARTMENT	NAME
1. Director (D&I)	Drainage and Irrigation MAFF & ALTA	Satya N. Swami
2. Director (Extension)	Extension Division MAFF & ALTA	Samisoni Ulitu
3. Director (W&S)	Water and Sewerage Section Public Works Department	Shandil
4. Director (NTF)	National Trust of Fiji	Birandra Singh
5. A/Principal Economic Planning Officer	Central Planning Office	Reena Ram
6. A/Principal Economic Planning Officer	Central Planning Office	Aisake Taito
7. Senior Research Officer	Land Use Section MAFF & ALTA	Inoke Ratukalou
8. Senior Hydrologist	Hydrology Section Public Works Department	Rishi Raj
9. A/Deputy Conservator of Forests	Department of Forestry MAFF & ALTA	Sairusi Bulai
10. Principal Scientific Officer (Applied Geology)	Mineral Resources Department	Prem Kumar
11. Principal Environmental Officer	Department of Environment	Sefanaia Nawadra
12. Disaster Coodinator	Ministry of Regional Development	S. Varea
13. A/Principal Engineer (RE) Administration	Drainage and Irrigation MAFF & ALTA	Anup Lal
14. A/Principal Engineer (RE) Technical	Drainage and Irrigation MAFF & ALTA	Khin Maung Cho
15. Senior Engineer (Design)	Drainage and Irrigation MAFF & ALTA	M. M. Myint
16. Senior Forestry Officer	Department of Forestry MAFF & ALTA	Etuate Basaga
17. Senior Town Planner	Department of Town and Country Planning	Maria Ubitau
18. Senior Technical Officer	Fiji Meteorological Service Suva Office	Marika Rokoduru
19. A/Senior Engineer (RE)	Drainage and Irrigation MAFF & ALTA	Shabnam Yee Yet
20. Dredge Superintendent	Drainage and Irrigation MAFF & ALTA	Colin Simmons