CHAPTER 3 EFFECT OF DIVERSION CHANNEL ON COASTAL AREA

3.1 Sediment Load Analysis

3.1.1 Analysis Method

(1) General

Bed evolution simulation is conducted with the following three formulas solved by the finite difference equation.

Dynamic equation of flow	(I)
Equation of sediment load	(II)
Continuity equation of sediment load	(III)

Formula (I) expresses flow in the river channel. Actual flow in the river channel is unsteady flow; however, it is generally calculated as steady flow in the case that long term phenomena, such as sedimentation at river mouth, dam sedimentation and so on, are analyzed. Non-uniform and uniform flow calculations based on Manning roughness coefficient are applied to estimate water level in the river channel with conditions that discharge and cross sections of river are given.

Formula (II) computes sediment passing at a certain point of river based on average velocity of cross section and tractive force calculated by formula (I).

Formula (III) computes incomings and outgoings of sediment at each point concerned of river by continuity equation. Successively, bed elevation at each point is calculated based on the incomings and outgoings of sediment, and new elevations of river channel are determined.

In formula (II) and (III), sediment load, and incomings and outgoings of sediment are estimated by particle size.

Flow of the simulation is shown in Figure-I3.1 and calculations are repeated for required time span.

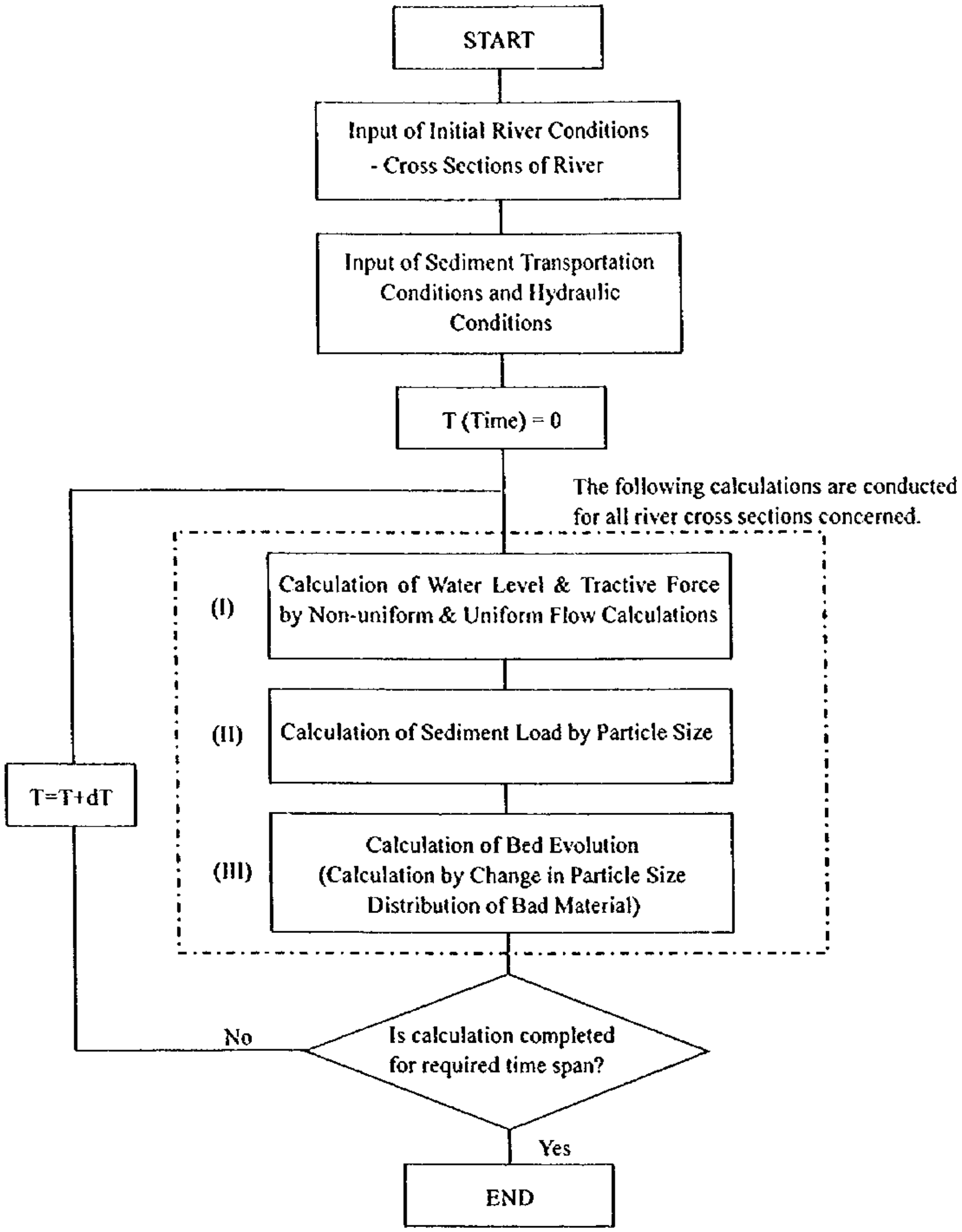

Figure-13.1 Flowchart of Bed Evolution Simulation

(2) Calculation Method of Sediment Load

1) Basic Idea of Sediment Load Calculation

When sedimentation at river mouth is concerned, sediment consists of bed load, suspended load and wash load. Since bed load and suspended load are transported by hydraulic force of flow, sediment of same particle size is transported in either way depending on hydraulic force. Wash load is transported in the form of nearly permanent suspension from the origin. Therefore, analysis concept for bed load and suspended load is different from that for wash load.

There are several formulas proposed to estimate bed load and suspended load. The following two formulas are generally employed because of their wide applications.

Bed Load	Sato, Kitsukawa and Ashida formula (Sato et al., 1958)
Suspended Load	Michiue formula (Ashida and Michiue, 1965)

Wash load (Q_w) is assumed to be transported from the origin by the following relation with discharge (Q) and start sedimentation when slope of water surface is smaller than 1/600 (Ashida et al., 1983)

$$Q_w = a \cdot (Q - c)^b$$

Sediment load inclusive of wash load starts when tractive force exceeds critical tractive force for average particle size of surface bed material. Modified Egiazaroff formula is employed to estimate critical tractive force for each particle size and sediment load per unit width is estimated for each particle size.

Sediment load (Q_T) is calculated by multiplication of unit sediment load (q_T) and width of river (B').

$$Q_T = q_T \times B'$$

B' is defined as regime width estimated by the following formula.

$$B' = 5.0 \cdot Q^{1/2}$$

where, B': regime width (m)

Q: discharge (m^3/sec)

2) Formula for Bed Load

Sato, Kitsukawa and Ashida formula is employed to estimate bed load.

$$\frac{q_{Bi}}{f_0(d_i)} = \frac{u_*^3}{(\sigma/\rho - 1) \cdot g} \cdot \varphi \cdot F(\tau_0/\tau_{ci})$$

where,

q_{Bi}:	sediment load with particle size of d_i per unit width
$f_o(d_i)$:	share of sediment with particle size of d_i in bed material
σ:	density of sediment (=2.65 t/m^3)
ρ:	density of water (=1.0 t/m^3)
g:	acceleration of gravity
u_*:	friction velocity $(= \sqrt{\tau_0/\rho})$

φ:	constant determined by roughness coefficient $n \geq 0.025$: $\varphi = 0.623$ $n < 0.025$: $\varphi = 0.623\,(40\,n)^{-3.5}$
$F(\tau_0/\tau_c)$:	relation between F and τ_0/τ_c (Figure-I3.2)
τ_0:	tractive force
τ_{ci}:	critical tractive force for particle size of d_i

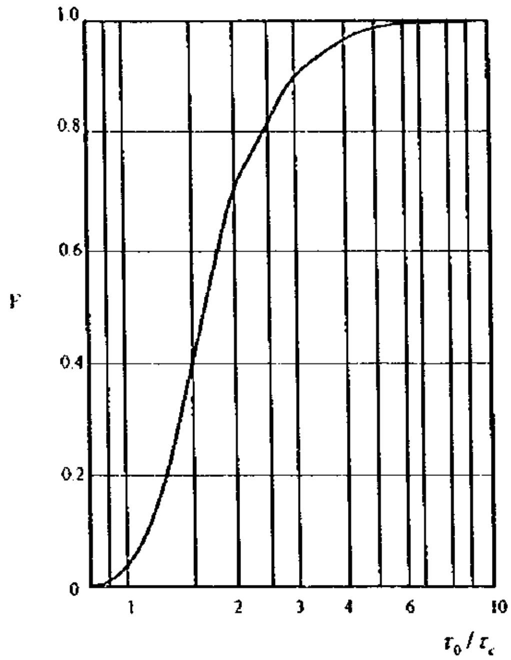

Figure-I3.2 Relation between F and τ_0/τ_c

Critical tractive force for each particle size is estimated by Modified Egiazaroff formula (Ashida et al., 1983)

$$d_i/d_m < 0.4 \quad \frac{\tau_{ci}}{\tau_{cm}} = 0.85$$

$$d_i/d_m \geq 0.4 \quad \frac{\tau_{ci}}{\tau_{cm}} = \frac{(\log 19)^2}{\left\{\log\left(19 \cdot \frac{d_i}{d_m}\right)\right\}^2} \cdot \frac{d_i}{d_m}$$

$$\tau_{cm} / (\sigma - \rho) \cdot g \cdot d_m = 0.05$$

where, d_i: certain particle size

d_m: average particle size

$\tau_{ci} \cdot \tau_{cm}$: critical tractive force for particle size of d_i and d_m, respectively

3) Formula for Suspended Load

Ashida and Dojyo formula for suspended load is as follows.

$$\frac{q_{di}}{q \cdot f_o(d_i)} = C_B \cdot \left[\left(1 + \frac{1}{\kappa} \cdot \frac{n \cdot \sqrt{g}}{h^{1/6}} \right) \cdot A_1 + \frac{1}{\kappa} \cdot \frac{n \cdot \sqrt{g}}{h^{1/6}} \cdot A_2 \right]$$

where, q_{di}: sediment load with particle size of d_i per unit width

q discharge per unit width

$f_o(d_i)$: share of sediment with particle size of d_i in bed material

$C_B = 0.025 \cdot [g(\xi_0)/\xi_0 - G(\xi_0)]$

$\xi_0 = \omega_0 /(0.75 \cdot u_{*e})$

$g(\xi_0) = \frac{1}{\sqrt{2\pi}} \cdot \exp\left(-\frac{1}{2}\xi_0^2 \right)$

$G(\xi_0) = \frac{1}{\sqrt{2\pi}} \cdot \int_{\xi_0}^{\infty} \exp\left(-\frac{1}{2}\xi^2 \right) \cdot d\xi$

ω_0: fall velocity

n: Manning roughness coefficient

h: water depth

κ: Karman's constant

A_1: $A_1 = \left(\frac{a}{h-a} \right) \cdot \int_{a/h}^{1} \left(\frac{1}{\eta} - 1 \right)^Z \cdot d\eta$

A_2: $A_2 = \left(\frac{a}{h-a} \right) \cdot \int_{a/h}^{1} \ln \eta \cdot \left(\frac{1}{\eta} - 1 \right)^Z \cdot d\eta$

Z: $Z = \frac{\omega_0}{1.2 \cdot \kappa \cdot u_x}$

Fall velocity (ω_0) is calculated by Rubey formula (Kawamura, 1976).

$$\omega_0 = \sqrt{(\sigma/\rho - 1) \cdot g \cdot d} \cdot \left[\sqrt{\frac{2}{3} + \frac{36 \cdot \nu^2}{s \cdot g \cdot d_i^3}} - \sqrt{\frac{36 \cdot \nu^2}{s \cdot g \cdot d_i^3}} \right]$$

where, ν: Coefficient of kinematic
(ν=0.01 cm^2/sec when water temperature is 20°)

s: $(\sigma/\rho - 1)$

d_i: representative particle size (cm)

4) Wash Load

For wash load, there is no formula proposed as a function of hydraulic force; however, there is an empirical formula determined by observation of suspended sediment. In general, suspended sediment observed consists mainly of wash load.

$$Q_w = a \times (Q-c)^b$$

where, Q_w: wash load

Q: discharge

a, b, c: constants

According to Japanese experiences, $a = 5 \times 10^{-7}$, b = 2 and c = 0.

(3) Calculation Method of Bed Evolution

Continuity equation for bed evolution is as follows.

$$\frac{\partial Z}{\partial t} + \frac{1}{(1-\lambda)\cdot B} \cdot \frac{\partial Q_v}{\partial x} = 0$$

$$Q_v = (q_B + q_s) \cdot B' + Q_W$$

where, z: elevation of river

t: time

B': regime river width

λ: porosity

Q_v: total sediment load

q_b, q_s: bed load per unit width and suspended load per unit width

Q_w: wash load

The continuity equation is solved by finite difference equation as follows.

$$\frac{A_{Zj}^{\,n+1} - A_{Zj}^{\,n}}{\Delta t} + \frac{1}{(1-\lambda)} \cdot \frac{Q_{vj}^{\,n} - Q_{v(j-k)}^{\,n}}{\Delta x} = 0$$

where, $Az_{(j,k)}$: cross section area of sediment deposit with particle size of k

Δt: time interval

$Q_{v(j,k)}$: sediment load with particle size of k

Δx: distance

n, n+1: subscript to show time
(Δt time passes when time proceeds from n to n+1)

3.1.2 Model for Analysis

A section where the sediment load analysis was applied is from diverting point to 2 km offshore from outlet of the diversion channel. Longitudinal profile and cross sections of the channel for the sediment load analysis is same as the hydraulic design for 20 year return period flood.

Based on echo-sounding results, slope of sea was determined as 1/500 and dispersion of flow in the sea was assumed to be 5°.

3.1.3 Conditions of Sediment Transportation

Sediment load to be transported to diverting point was assumed to be bed material of Nadi river in the upstream from the diverting point, transported by increase in flow velocity due to flood. Sediment load was also assumed to be supplied without limitation and is a function of only the hydraulic force.

Bed material in the upstream was obtained from the result of the bed material analysis conducted by the Study Team (Supporting Report Part H). Therefore, particle size distribution of N-1 point was adopted and is shown in Table-13.1.

Table-13.1 Particle Size Distribution of Nadi River (N-1)

Sieve Size (mm)	Weight of Remained Material (g)	Remained Ratio (%)
75.0		
53.0		
37.5		
26.5	77.0	1.98
19.0	97.3	2.51
13.2	316.9	8.16
9.5	424.7	10.94
6.7	578.5	14.90
4.8	381.9	9.84
2.4	753.1	19.40
1.2	531.0	13.68
0.600	300.2	7.73
0.425	81.0	2.09
0.300	92.3	2.38
0.150	171.5	4.42
0.075	53.8	1.39
less than 0.075	23.0	0.59
Total	3882.2	100.00%

Average Particle Size (D_{50}) = 4.59 mm

Applying the cyclone Kina's hyetograph, 5 different floods (1/20, 1/10, 1/5, 1/2 and 1/1.1 probability floods) were calculated at 30 minute interval by the storage function model. The model is described in Supporting Report Part E. Velocities at the point of sediment load supply were calculated for the discharges at 30 minute interval by non-uniform flow calculation.

Based on the velocities above, sediment load in the upstream from diverting point was estimated by comparing flow velocities and critical tractive force of each particle size.

3.1.4 Sediment Load into Diversion Channel

Sediment load into the diversion channel was estimated by sediment transportation calculation from the upstream of Nadi river to the diverting point. Sediment load into the channel depends on velocities at the diverting point.

3.1.5 Channel Bed Evolution

Applying sediment load into the diversion channel, sediment transportation in the channel was calculated at each cross section with change in a time series. As a result, passed and deposited sediment loads were obtained at each cross section and successively bed evolution of the channel was calculated.

Channel bed evolution is defined as sediment transportation from initial stage of flood to depression stage of flood. Therefore, it expresses conditions of sedimentation when a flood is over.

To examine the channel bed evolution, sediment transportation in 5 cases from small scale to large scale floods were calculate as shown in Table-13.2. Discharges in the channel were determined in accordance with the diverting ratio. Velocities were calculated by non-uniform flow computation based on discharges in Table-13.2. The results are shown in Table-13.3 ~ Table-13.7.

Table-13.2 (1/4) Flood Discharge of Diversion Channel

Day	hr.	min.	Return Period of Flood 1/20 Q (m³/s)	1/10 Q (m³/s)	1/5 Q (m³/s)	1/2 Q (m³/s)	1/1.1 Q (m³/s)
1	0	0	28.1	25.3	23.9	22.5	19.7
1	0	30	28.1	25.3	23.9	22.5	19.7
1	1	0	28.1	25.3	23.9	22.5	19.7
1	1	30	28.1	25.3	23.9	22.5	19.7
1	2	0	28.1	25.3	23.9	22.5	19.7
1	2	30	28.1	25.3	23.9	22.5	19.7
1	3	0	28.1	25.3	23.9	22.5	19.7
1	3	30	28.1	25.3	23.9	22.5	19.7
1	4	0	28.1	25.3	23.9	22.5	19.7
1	4	30	28.1	25.3	23.9	22.5	19.7
1	5	0	28.1	25.3	23.9	22.5	19.7
1	5	30	28.1	25.3	23.9	22.5	19.7
1	6	0	28.1	25.3	23.9	22.5	19.7
1	6	30	28.1	25.3	23.9	22.5	19.7
1	7	0	28.1	25.3	23.9	22.5	19.7
1	7	30	28.1	25.3	23.9	22.5	19.7
1	8	0	28.1	25.3	23.9	22.5	19.7
1	8	30	28.1	25.3	23.9	22.5	19.7
1	9	0	28.1	25.3	23.9	22.5	19.7
1	9	30	28.1	25.3	23.9	22.5	19.7
1	10	0	28.1	25.3	23.9	22.5	19.7
1	10	30	28.1	25.3	23.9	22.5	19.7
1	11	0	28.1	25.3	23.9	22.5	19.7
1	11	30	28.1	25.3	23.9	22.5	19.7
1	12	0	28.1	25.3	23.9	22.5	19.7
1	12	30	28.1	25.3	23.9	22.5	19.7
1	13	0	28.1	25.3	23.9	22.5	19.7
1	13	30	28.1	25.3	23.9	22.5	19.7
1	14	0	28.1	25.3	23.9	22.5	19.7
1	14	30	28.1	25.3	23.9	22.5	19.7
1	15	0	28.1	25.3	23.9	22.5	19.7
1	15	30	28.1	25.3	23.9	22.5	19.7
1	16	0	28.1	25.3	23.9	22.5	19.7
1	16	30	28.1	25.3	23.9	22.5	19.7
1	17	0	28.1	25.3	23.9	22.5	19.7
1	17	30	28.1	25.3	23.9	22.5	19.7
1	18	0	28.1	25.3	23.9	22.5	19.7
1	18	30	28.1	25.3	23.9	22.5	19.7
1	19	0	28.1	25.3	23.9	22.5	19.7
1	19	30	28.1	25.3	23.9	22.5	19.7
1	20	0	28.1	25.3	23.9	22.5	19.7
1	20	30	28.1	25.3	23.9	22.5	19.7
1	21	0	28.1	25.3	23.9	22.5	19.7
1	21	30	28.1	25.3	23.9	22.5	19.7
1	22	0	28.1	25.3	23.9	22.5	19.7
1	22	30	28.1	25.3	23.9	22.5	19.7
1	23	0	28.2	25.4	24.0	22.6	19.7
1	23	30	28.8	25.9	24.5	23.0	20.2
2	0	0	30.5	27.5	25.9	24.4	21.4
2	0	30	35.7	32.1	30.3	28.6	25.0
2	1	0	46.2	41.6	39.3	37.0	32.3
2	1	30	52.5	47.3	44.6	42.0	36.8
2	2	0	63.9	51.0	38.4	30.5	26.7
2	2	30	86.0	64.7	45.1	32.4	28.4
2	3	0	116.1	83.7	54.3	35.0	33.3
2	3	30	152.4	107.4	66.3	38.4	34.5
2	4	0	184.0	129.7	78.3	42.0	35.8
2	4	30	212.2	150.7	90.2	45.6	37.1
2	5	0	256.2	182.7	108.0	51.1	39.1
2	5	30	313.1	225.4	132.6	58.9	41.9
2	6	0	366.4	268.9	159.9	68.3	45.3
2	6	30	402.7	302.9	184.4	77.9	49.0
2	7	0	421.5	325.2	203.9	87.1	52.8

Table-13.2 (2/4) Flood Discharge of Diversion Channel

Day	hr.	min.	Return Period of Flood 1/20 Q (m³/s)	1/10 Q (m³/s)	1/5 Q (m³/s)	1/2 Q (m³/s)	1/1.1 Q (m³/s)
2	7	30	432.1	340.6	219.8	96.1	56.8
2	8	0	438.1	351.4	232.9	104.9	60.9
2	8	30	442.6	360.2	244.3	113.5	65.3
2	9	0	446.1	367.0	253.9	122.0	69.9
2	9	30	453.8	375.8	263.9	130.7	74.9
2	10	0	470.2	390.2	276.3	140.3	80.6
2	10	30	505.6	418.3	296.7	152.9	87.8
2	11	0	548.0	451.8	320.3	166.9	96.0
2	11	30	622.6	507.5	356.4	185.4	106.2
2	12	0	771.6	616.8	424.0	215.7	121.6
2	12	30	953.2	749.6	510.4	255.9	142.3
2	13	0	1,150.6	872.3	597.5	301.3	167.2
2	13	30	1,315.1	945.1	656.3	340.7	192.2
2	14	0	1,423.3	970.7	675.0	365.2	212.7
2	14	30	1,500.0	991.5	672.2	377.3	227.8
2	15	0	1,483.6	1,000.0	655.7	380.0	238.1
2	15	30	1,405.7	988.0	631.5	376.3	244.5
2	16	0	1,338.0	972.4	608.7	369.8	248.5
2	16	30	1,284.2	957.4	586.6	361.0	250.0
2	17	0	1,244.5	949.5	568.4	351.1	249.4
2	17	30	1,201.6	939.0	551.7	339.6	246.5
2	18	0	1,151.2	921.6	537.5	327.3	241.9
2	18	30	1,089.2	891.5	523.1	313.9	235.6
2	19	0	1,014.6	847.4	506.6	299.5	228.1
2	19	30	935.0	794.4	487.3	284.6	219.7
2	20	0	852.6	735.3	464.2	269.4	210.7
2	20	30	770.3	673.0	437.3	253.8	201.1
2	21	0	691.7	611.3	408.3	238.4	191.4
2	21	30	623.2	555.7	380.1	223.8	182.0
2	22	0	565.2	507.5	353.9	210.4	173.1
2	22	30	513.7	464.0	329.2	197.8	164.5
2	23	0	467.3	424.4	306.0	186.0	156.4
2	23	30	426.8	389.3	284.8	175.2	148.7
3	0	0	392.3	359.1	266.0	165.4	141.7
3	0	30	362.7	333.0	249.4	156.4	135.2
3	1	0	336.9	310.0	234.5	148.4	129.3
3	1	30	313.7	289.3	220.9	141.0	123.8
3	2	0	292.4	270.2	208.3	134.2	118.7
3	2	30	272.9	252.8	196.8	127.9	113.9
3	3	0	255.3	237.0	186.1	122.1	109.5
3	3	30	239.5	222.7	176.4	116.8	105.4
3	4	0	225.3	209.9	167.6	111.9	101.6
3	4	30	212.5	198.3	159.5	107.4	98.1
3	5	0	201.0	187.9	152.2	103.3	94.9
3	5	30	190.7	178.5	145.5	99.5	91.9
3	6	0	181.5	170.0	139.3	96.0	89.2
3	6	30	173.2	162.4	133.8	92.8	86.6
3	7	0	165.5	155.3	128.6	89.8	84.2
3	7	30	158.6	148.9	123.9	87.1	82.0
3	8	0	152.2	143.0	119.6	84.6	79.9
3	8	30	146.5	137.8	115.6	82.2	78.1
3	9	0	141.7	133.2	112.1	80.1	76.1
3	9	30	137.4	129.1	109.0	78.1	74.2
3	10	0	133.6	125.4	106.1	76.3	72.5
3	10	30	129.9	121.9	103.4	74.6	70.9
3	11	0	126.3	118.4	100.8	72.9	69.3
3	11	30	122.8	115.1	98.3	71.4	67.8
3	12	0	119.5	112.0	95.9	69.9	66.4
3	12	30	116.3	109.0	93.6	68.5	65.1
3	13	0	113.3	106.2	91.4	67.2	63.8
3	13	30	110.6	103.6	89.4	66.0	62.7
3	14	0	108.0	101.2	87.6	64.8	61.6
3	14	30	105.5	98.9	85.8	63.7	60.5

Table-13.2 (3/4) Flood Discharge of Diversion Channel

Day	hr.	min.	Return Period of Flood 1/20 Q (m³/s)	1/10 Q (m³/s)	1/5 Q (m³/s)	1/2 Q (m³/s)	1/1.1 Q (m³/s)
3	15	0	103.1	96.6	84.1	62.6	59.5
3	15	30	100.8	94.4	82.3	61.6	58.5
3	16	0	98.5	92.3	80.7	60.6	57.6
3	16	30	96.4	90.3	79.1	59.7	56.7
3	17	0	94.2	88.4	77.5	58.8	55.9
3	17	30	92.2	86.5	76.1	57.9	55.0
3	18	0	90.2	84.7	74.7	57.1	54.3
3	18	30	88.3	83.0	73.3	56.3	53.5
3	19	0	86.5	81.3	72.0	55.5	52.7
3	19	30	84.8	79.7	70.7	54.8	52.1
3	20	0	83.1	78.2	69.5	54.0	51.3
3	20	30	81.5	76.8	68.4	53.4	50.7
3	21	0	79.9	75.3	67.2	52.7	50.1
3	21	30	78.4	74.0	66.1	52.1	49.5
3	22	0	77.0	72.7	65.1	51.5	48.9
3	22	30	75.7	71.4	64.1	50.9	48.4
3	23	0	74.4	70.2	63.2	50.4	47.9
3	23	30	73.2	69.1	62.3	49.8	47.3
4	0	0	72.0	68.0	61.4	49.3	46.8
4	0	30	70.8	67.0	60.5	48.8	46.4
4	1	0	69.7	66.0	59.7	48.3	45.9
4	1	30	68.7	65.0	58.9	47.9	45.5
4	2	0	67.7	64.1	58.2	47.4	45.0
4	2	30	66.8	63.2	57.5	46.9	44.6
4	3	0	65.9	62.4	56.8	46.5	44.2
4	3	30	65.0	61.6	56.1	46.1	43.8
4	4	0	64.1	60.8	55.4	45.7	43.4
4	4	30	63.3	60.0	54.8	45.3	43.0
4	5	0	62.5	59.2	54.2	45.0	42.8
4	5	30	61.7	58.5	53.6	44.7	42.5
4	6	0	61.0	57.9	53.1	44.3	42.1
4	6	30	60.3	57.2	52.5	44.0	41.8
4	7	0	59.6	56.6	52.0	43.7	41.5
4	7	30	59.0	56.0	51.5	43.4	41.2
4	8	0	58.4	55.4	51.0	43.1	41.0
4	8	30	57.8	54.9	50.6	42.8	40.7
4	9	0	57.2	54.3	50.1	42.6	40.5
4	9	30	56.6	53.8	49.7	42.3	40.2
4	10	0	56.0	53.3	49.2	42.0	39.9
4	10	30	55.5	52.8	48.8	41.8	39.7
4	11	0	55.0	52.3	48.4	41.5	39.4
4	11	30	54.5	51.9	48.0	41.2	39.1
4	12	0	53.9	51.4	47.6	41.0	39.0
4	12	30	53.5	51.0	47.3	40.7	38.7
4	13	0	53.0	50.6	47.0	40.5	38.5
4	13	30	52.6	50.2	46.6	40.3	38.3
4	14	0	52.2	49.8	46.3	40.1	38.1
4	14	30	51.8	49.4	46.0	39.9	37.9
4	15	0	51.4	49.1	45.7	39.7	37.7
4	15	30	51.0	48.7	45.4	39.5	37.5
4	16	0	50.6	48.4	45.0	39.3	37.3
4	16	30	50.2	48.1	44.8	39.1	37.1
4	17	0	49.9	47.7	44.5	38.9	37.0
4	17	30	49.6	47.4	44.3	38.7	36.8
4	18	0	49.2	47.1	44.0	38.6	36.7
4	18	30	48.9	46.8	43.7	38.4	36.5
4	19	0	48.6	46.5	43.5	38.3	36.4
4	19	30	48.3	46.2	43.2	38.2	36.3
4	20	0	47.9	46.0	43.0	38.0	36.1
4	20	30	47.6	45.7	42.7	37.9	36.0
4	21	0	47.4	45.4	42.5	37.8	35.9
4	21	30	47.1	45.2	42.3	37.6	35.7
4	22	0	46.8	44.9	42.1	37.5	35.6

Table-13.2 (4/4) Flood Discharge of Diversion Channel

Day	hr.	min	Return Period of Flood 1/20 Q (m^3/s)	1/10 Q (m^3/s)	1/5 Q (m^3/s)	1/2 Q (m^3/s)	1/1.1 Q (m^3/s)
4	22	30	46.6	44.6	41.9	37.4	35.5
4	23	0	46.3	44.4	41.7	37.2	35.3
4	23	30	46.1	44.1	41.5	37.1	35.2
5	0	0	45.8	43.9	41.3	37.0	35.2
5	0	30	45.5	43.7	41.1	36.8	35.0
5	1	0	45.3	43.5	40.9	36.7	34.9
5	1	30	45.0	43.3	40.7	36.6	34.8
5	2	0	44.8	43.1	40.5	36.4	34.6
5	2	30	44.5	42.9	40.3	36.3	34.5
5	3	0	44.3	42.7	40.1	36.2	34.4
5	3	30	44.1	42.5	39.9	36.0	34.2
5	4	0	43.9	42.3	39.7	36.0	34.2
5	4	30	43.7	42.1	39.5	35.9	34.1
5	5	0	43.5	41.9	39.4	35.8	34.0
5	5	30	43.3	41.7	39.3	35.7	33.9
5	6	0	43.1	41.5	39.2	35.6	33.8
5	6	30	42.9	41.4	39.0	35.5	33.7
5	7	0	42.7	41.2	38.9	35.5	33.7
5	7	30	42.5	41.0	38.8	35.4	33.6
5	8	0	42.3	40.9	38.6	35.3	33.5
5	8	30	42.1	40.7	38.5	35.2	33.4
5	9	0	42.0	40.6	38.4	35.1	33.3
5	9	30	41.9	40.5	38.2	35.1	33.3
5	10	0	41.7	40.3	38.1	35.0	33.3
5	10	30	41.5	40.2	38.0	34.9	33.2
5	11	0	41.4	40.1	37.9	34.9	33.2
5	11	30	41.3	39.9	37.7	34.7	33.0
5	12	0	41.1	39.8	37.6	34.7	33.0
5	12	30	41.0	39.7	37.5	34.6	32.9
5	13	0	40.9	39.5	37.3	34.5	32.8
5	13	30	40.8	39.4	37.2	34.5	32.8
5	14	0	40.6	39.3	37.1	34.4	32.7
5	14	30	40.5	39.1	37.0	34.3	32.6
5	15	0	40.4	39.0	36.8	34.2	32.5
5	15	30	40.2	38.9	36.8	34.2	32.5
5	16	0	40.1	38.7	36.6	34.1	32.4
5	16	30	40.0	38.6	36.6	34.0	32.3
5	17	0	39.8	38.5	36.5	34.0	32.3
5	17	30	39.7	38.4	36.4	33.9	32.2
5	18	0	39.6	38.3	36.3	33.8	32.1
5	18	30	39.4	38.2	36.2	33.8	32.1
5	19	0	39.3	38.1	36.2	33.7	32.0
5	19	30	39.2	38.0	36.1	33.6	31.9
5	20	0	39.1	38.0	36.0	33.6	31.9
5	20	30	38.9	37.9	35.9	33.5	31.8
5	21	0	38.8	37.8	35.8	33.4	31.7
5	21	30	38.7	37.7	35.8	33.4	31.7
5	22	0	38.6	37.6	35.7	33.3	31.6
5	22	30	38.5	37.6	35.6	33.2	31.5
5	23	0	38.5	37.4	35.5	33.2	31.5
5	23	30	38.4	37.4	35.4	33.1	31.4
6	0	0	38.3	37.3	35.4	33.0	31.4
Q Peak			1,500.0	1,000.0	675.0	380.0	250.0

Q : Flood Discharge

Table-13.3 (1/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/20 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D -1,500	0	1,500	1.000	0.008	1.008	1.13E-05	3,900.000	600.00	6.36	6.50	0.03	1.00	0.38	0.05
Nadi-D -1,000	500	1,500	0.999	0.022	1.020	4.05E-05	2,309.568	420.00	5.36	5.50	0.03	1.00	0.65	0.09
Nadi-D -500	500	1,500	0.994	0.099	1.092	2.47E-04	1,078.455	240.00	4.33	4.49	0.03	1.00	1.39	0.21
Nadi-D -450	50	1,500	0.985	0.121	1.106	3.13E-04	973.499	222.00	4.22	4.39	0.03	1.00	1.54	0.24
Nadi-D -400	50	1,500	0.973	0.151	1.124	4.06E-04	871.729	204.00	4.10	4.27	0.03	1.00	1.72	0.27
Nadi-D -350	50	1,500	0.956	0.192	1.148	5.38E-04	772.960	186.00	3.98	4.16	0.03	1.00	1.94	0.30
Nadi-D -300	50	1,500	0.929	0.251	1.180	7.34E-04	676.883	168.00	3.84	4.03	0.03	1.00	2.22	0.35
Nadi-D -250	50	1,500	0.886	0.338	1.224	1.04E-03	582.934	150.00	3.69	3.89	0.03	1.00	2.57	0.42
Nadi-D -200	50	1,500	0.811	0.478	1.290	1.58E-03	489.890	132.00	3.51	3.71	0.03	1.00	3.06	0.51
Nadi-D -150	50	1,500	0.658	0.739	1.397	2.70E-03	394.176	114.00	3.26	3.46	0.03	1.00	3.81	0.65
Nadi-D -100	50	1,500	0.221	1.460	1.681	6.68E-03	280.377	96.00	2.75	2.92	0.03	1.00	5.35	1.00
Nadi-D -50	50	1,500	0.754	1.677	2.431	6.58E-03	261.628	78.00	3.09	3.35	0.03	1.00	5.73	1.00
Nadi-D 0	50	1,500	1.322	1.717	3.039	6.03E-03	258.560	75.29	3.35	3.43	0.03	1.00	5.80	1.00
Nadi-D 50	50	1,500	2.172	1.093	3.266	3.03E-03	324.023	78.69	4.01	4.12	0.03	1.00	4.63	0.73
Nadi-D 100	50	1,500	2.442	0.962	3.404	2.50E-03	345.358	79.77	4.21	4.33	0.03	1.00	4.34	0.67
Nadi-D 150	50	1,500	2.643	0.879	3.521	2.18E-03	361.459	80.57	4.35	4.49	0.03	1.00	4.15	0.63
Nadi-D 200	50	1,500	2.807	0.817	3.625	1.95E-03	374.769	81.23	4.48	4.61	0.03	1.00	4.00	0.60
Nadi-D 250	50	1,500	2.949	0.769	3.718	1.78E-03	386.328	81.80	4.58	4.72	0.03	1.00	3.88	0.57
Nadi-D 300	50	1,500	3.074	0.730	3.804	1.65E-03	396.602	82.30	4.67	4.82	0.03	1.00	3.78	0.55
Nadi-D 350	50	1,500	3.187	0.697	3.884	1.54E-03	405.891	82.75	4.75	4.91	0.03	1.00	3.70	0.53
Nadi-D 400	50	1,500	3.290	0.668	3.958	1.45E-03	414.462	83.16	4.82	4.98	0.03	1.00	3.62	0.52
Nadi-D 450	50	1,500	3.385	0.643	4.029	1.37E-03	422.375	83.54	4.89	5.06	0.03	1.00	3.55	0.50
Nadi-D 500	50	1,500	3.474	0.621	4.095	1.30E-03	429.811	83.89	4.96	5.12	0.03	1.00	3.49	0.49
Nadi-D 550	50	1,500	3.557	0.602	4.158	1.24E-03	436.785	84.23	5.02	5.19	0.03	1.00	3.43	0.48
Nadi-D 600	50	1,500	3.635	0.584	4.219	1.18E-03	443.386	84.54	5.07	5.24	0.03	1.00	3.38	0.47
Nadi-D 650	50	1,500	3.709	0.568	4.277	1.13E-03	449.671	84.84	5.12	5.30	0.03	1.00	3.34	0.46
Nadi-D 700	50	1,500	3.779	0.553	4.332	1.09E-03	455.640	85.12	5.17	5.35	0.03	1.00	3.29	0.45
Nadi-D 750	50	1,500	3.847	0.539	4.386	1.05E-03	461.373	85.39	5.22	5.40	0.03	1.00	3.25	0.45
Nadi-D 800	50	1,500	3.911	0.527	4.438	1.01E-03	466.873	85.64	5.26	5.45	0.03	1.00	3.21	0.44
Nadi-D 850	50	1,500	3.972	0.515	4.487	9.81E-04	472.144	85.89	5.31	5.50	0.03	1.00	3.18	0.43
Nadi-D 900	50	1,500	4.032	0.504	4.536	9.50E-04	477.239	86.13	5.35	5.54	0.03	1.00	3.14	0.43
Nadi-D 950	50	1,500	4.089	0.494	4.583	9.22E-04	482.169	86.36	5.39	5.58	0.03	1.00	3.11	0.42
Nadi-D 1,000	50	1,500	4.144	0.484	4.628	8.95E-04	486.923	86.58	5.43	5.62	0.03	1.00	3.08	0.41
Nadi-D 1,050	50	1,500	4.197	0.475	4.672	8.71E-04	491.517	86.79	5.46	5.66	0.03	1.00	3.05	0.41
Nadi-D 1,100	50	1,500	4.248	0.467	4.715	8.48E-04	496.008	86.99	5.50	5.70	0.03	1.00	3.02	0.40
Nadi-D 1,150	50	1,500	4.298	0.459	4.757	8.26E-04	500.363	87.19	5.53	5.74	0.03	1.00	3.00	0.40
Nadi-D 1,200	50	1,500	4.347	0.451	4.798	8.06E-04	504.587	87.39	5.57	5.77	0.03	1.00	2.97	0.40
Nadi-D 1,250	50	1,500	4.394	0.444	4.838	7.87E-04	508.691	87.58	5.60	5.81	0.03	1.00	2.95	0.39
Nadi-D 1,300	50	1,500	4.440	0.437	4.876	7.69E-04	512.720	87.76	5.63	5.84	0.03	1.00	2.93	0.39
Nadi-D 1,350	50	1,500	4.484	0.430	4.914	7.52E-04	516.646	87.94	5.66	5.88	0.03	1.00	2.90	0.38
Nadi-D 1,400	50	1,500	4.528	0.424	4.952	7.35E-04	520.473	88.11	5.69	5.91	0.03	1.00	2.88	0.38
Nadi-D 1,450	50	1,500	4.570	0.418	4.988	7.20E-04	524.204	88.28	5.72	5.94	0.03	1.00	2.86	0.38
Nadi-D 1,500	50	1,500	4.612	0.412	5.024	7.06E-04	527.857	88.45	5.75	5.97	0.03	1.00	2.84	0.37
Nadi-D 1,550	50	1,500	4.652	0.406	5.059	6.92E-04	531.452	88.61	5.78	6.00	0.03	1.00	2.82	0.37
Nadi-D 1,600	50	1,500	4.692	0.401	5.093	6.78E-04	534.966	88.77	5.80	6.03	0.03	1.00	2.80	0.36
Nadi-D 1,650	50	1,500	4.730	0.396	5.126	6.66E-04	538.403	88.92	5.83	6.05	0.03	1.00	2.79	0.36
Nadi-D 1,700	50	1,500	4.768	0.391	5.159	6.54E-04	541.766	89.07	5.86	6.08	0.03	1.00	2.77	0.36
Nadi-D 1,750	50	1,500	4.805	0.386	5.192	6.42E-04	545.065	89.22	5.88	6.11	0.03	1.00	2.75	0.36
Nadi-D 1,800	50	1,500	4.842	0.382	5.224	6.31E-04	548.327	89.37	5.91	6.14	0.03	1.00	2.74	0.35
Nadi-D 1,850	50	1,500	4.878	0.377	5.255	6.20E-04	551.525	89.51	5.93	6.16	0.03	1.00	2.72	0.35
Nadi-D 1,900	50	1,500	4.913	0.373	5.286	6.10E-04	554.661	89.65	5.95	6.19	0.03	1.00	2.70	0.35
Nadi-D 1,950	50	1,500	4.947	0.369	5.316	6.00E-04	557.740	89.79	5.98	6.21	0.03	1.00	2.69	0.34
Nadi-D 2,000	50	1,500	4.981	0.365	5.346	5.91E-04	560.762	89.92	6.00	6.24	0.03	1.00	2.67	0.34
Nadi-D 2,050	50	1,500	5.014	0.361	5.375	5.82E-04	563.743	90.05	6.02	6.26	0.03	1.00	2.66	0.34
Nadi-D 2,100	50	1,500	5.046	0.357	5.404	5.73E-04	566.690	90.19	6.04	6.28	0.03	1.00	2.65	0.34
Nadi-D 2,150	50	1,500	5.078	0.354	5.432	5.64E-04	569.587	90.31	6.07	6.31	0.03	1.00	2.63	0.33
Nadi-D 2,200	50	1,500	5.110	0.350	5.460	5.56E-04	572.436	90.44	6.09	6.33	0.03	1.00	2.62	0.33
Nadi-D 2,250	50	1,500	5.141	0.347	5.488	5.48E-04	575.238	90.56	6.11	6.35	0.03	1.00	2.61	0.33
Nadi-D 2,300	50	1,500	5.171	0.344	5.515	5.40E-04	577.997	90.69	6.13	6.37	0.03	1.00	2.60	0.33
Nadi-D 2,350	50	1,500	5.201	0.340	5.542	5.33E-04	580.713	90.81	6.15	6.40	0.03	1.00	2.58	0.33
Nadi-D 2,400	50	1,500	5.231	0.337	5.568	5.26E-04	583.414	90.92	6.17	6.42	0.03	1.00	2.57	0.32
Nadi-D 2,450	50	1,500	5.260	0.334	5.594	5.19E-04	586.074	91.04	6.19	6.44	0.03	1.00	2.56	0.32
Nadi-D 2,500	50	1,500	5.289	0.331	5.620	5.12E-04	588.696	91.16	6.21	6.46	0.03	1.00	2.55	0.32

Table-13.3 (2/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/20 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D 2,550	50	1,500	5.300	0.347	5.647	5.48E-04	575.131	90.56	6.11	6.35	0.03	1.00	2.61	0.33
Nadi-D 2,600	50	1,500	5.313	0.362	5.675	5.85E-04	562.750	90.01	6.02	6.25	0.03	1.00	2.67	0.34
Nadi-D 2,650	50	1,500	5.325	0.380	5.705	6.27E-04	549.528	89.42	5.92	6.15	0.03	1.00	2.73	0.35
Nadi-D 2,700	50	1,500	5.340	0.397	5.738	6.69E-04	537.508	88.88	5.82	6.05	0.03	1.00	2.79	0.36
Nadi-D 2,750	50	1,500	5.355	0.417	5.772	7.18E-04	524.658	88.30	5.72	5.94	0.03	1.00	2.86	0.37
Nadi-D 2,800	50	1,500	5.372	0.438	5.810	7.72E-04	512.015	87.73	5.63	5.84	0.03	1.00	2.93	0.39
Nadi-D 2,850	50	1,500	5.392	0.458	5.850	8.25E-04	500.616	87.21	5.54	5.74	0.03	1.00	3.00	0.40
Nadi-D 2,900	50	1,500	5.411	0.481	5.892	8.87E-04	488.416	86.64	5.44	5.64	0.03	1.00	3.07	0.41
Nadi-D 2,950	50	1,500	5.433	0.506	5.938	9.55E-04	476.472	86.09	5.34	5.53	0.03	1.00	3.15	0.43
Nadi-D 3,000	50	1,500	5.459	0.529	5.988	1.02E-03	465.836	85.60	5.26	5.44	0.03	1.00	3.22	0.44
Nadi-D 3,050	50	1,500	5.336	0.702	6.038	9.88E-04	404.376	72.23	5.07	5.60	0.03	1.00	3.71	0.50
Nadi-D 3,100	50	1,500	5.353	0.737	6.089	1.06E-03	394.760	71.97	4.97	5.49	0.03	1.00	3.80	0.52
Nadi-D 3,150	50	1,500	5.368	0.777	6.145	1.15E-03	384.337	71.68	4.87	5.36	0.03	1.00	3.90	0.54
Nadi-D 3,200	50	1,500	5.144	1.072	6.216	1.71E-03	327.265	60.00	4.62	5.45	0.03	1.00	4.58	0.63
Nadi-D 3,250	50	1,500	5.190	1.114	6.304	1.81E-03	321.027	60.00	4.54	5.35	0.03	1.00	4.67	0.65
Nadi-D 3,300	50	1,500	5.235	1.164	6.398	1.94E-03	314.072	60.00	4.46	5.23	0.03	1.00	4.78	0.67

dx:	distance	Q:	discharge	H:	water Level
V.H:	velocity head	total E:	total energy head	IE:	energy gradient
A:	discharge area	B:	width of water surface	R:	hydraulic radius
A/B:	hydraulic depth	n:	roughness coefficient	alpha:	energy correction coefficient
V:	velocity	Fr:	Frauds number		

Nadi-D-1,500: point which is 1,500 m off shore from outlet of the channel

Nadi-D 0: outlet of the channel

Nadi-D 1,000: point which is 1,000 m upstream form outlet of the channel

Table-13.4 (1/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/10 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D -1,500	0	1,000	1.000	0.003	1.003	5.02E-06	3,900.000	600.00	6.36	6.50	0.03	1.00	0.26	0.03
Nadi-D -1,000	500	1,000	1.000	0.010	1.009	1.80E-05	2,309.809	420.00	5.36	5.50	0.03	1.00	0.43	0.06
Nadi-D -500	500	1,000	0.997	0.044	1.041	1.09E-04	1,079.313	240.00	4.33	4.50	0.03	1.00	0.93	0.14
Nadi-D -450	50	1,000	0.993	0.054	1.047	1.38E-04	975.356	222.00	4.23	4.39	0.03	1.00	1.03	0.16
Nadi-D -400	50	1,000	0.988	0.067	1.055	1.78E-04	874.830	204.00	4.12	4.29	0.03	1.00	1.14	0.18
Nadi-D -350	50	1,000	0.981	0.084	1.065	2.34E-04	777.665	186.00	4.00	4.18	0.03	1.00	1.29	0.20
Nadi-D -300	50	1,000	0.970	0.109	1.079	3.16E-04	683.756	168.00	3.88	4.07	0.03	1.00	1.46	0.23
Nadi-D -250	50	1,000	0.953	0.145	1.098	4.39E-04	592.924	150.00	3.75	3.95	0.03	1.00	1.69	0.27
Nadi-D -200	50	1,000	0.925	0.200	1.125	6.36E-04	504.853	132.00	3.62	3.82	0.03	1.00	1.98	0.32
Nadi-D -150	50	1,000	0.875	0.291	1.165	9.83E-04	418.900	114.00	3.45	3.67	0.03	1.00	2.39	0.40
Nadi-D -100	50	1,000	0.773	0.459	1.232	1.69E-03	333.427	96.00	3.24	3.47	0.03	1.00	3.00	0.51
Nadi-D -50	50	1,000	0.493	0.877	1.369	3.80E-03	241.216	78.00	2.87	3.09	0.03	1.00	4.15	0.75
Nadi-D 0	50	1,000	0.447	1.353	1.800	6.50E-03	194.212	71.79	2.65	2.71	0.03	1.00	5.15	1.00
Nadi-D 50	50	1,000	1.229	0.806	2.035	2.92E-03	251.544	74.92	3.28	3.36	0.03	1.00	3.98	0.69
Nadi-D 100	50	1,000	1.463	0.704	2.167	2.37E-03	269.245	75.85	3.46	3.55	0.03	1.00	3.71	0.63
Nadi-D 150	50	1,000	1.639	0.639	2.278	2.04E-03	282.593	76.55	3.60	3.69	0.03	1.00	3.54	0.59
Nadi-D 200	50	1,000	1.782	0.592	2.374	1.82E-03	293.623	77.13	3.71	3.81	0.03	1.00	3.41	0.56
Nadi-D 250	50	1,000	1.906	0.555	2.461	1.65E-03	303.186	77.62	3.80	3.91	0.03	1.00	3.30	0.53
Nadi-D 300	50	1,000	2.015	0.525	2.540	1.52E-03	311.645	78.06	3.89	3.99	0.03	1.00	3.21	0.51
Nadi-D 350	50	1,000	2.113	0.500	2.613	1.41E-03	319.339	78.45	3.96	4.07	0.03	1.00	3.13	0.50
Nadi-D 400	50	1,000	2.202	0.479	2.681	1.32E-03	326.354	78.81	4.03	4.14	0.03	1.00	3.06	0.48
Nadi-D 450	50	1,000	2.285	0.460	2.745	1.24E-03	332.902	79.14	4.09	4.21	0.03	1.00	3.00	0.47
Nadi-D 500	50	1,000	2.362	0.444	2.806	1.18E-03	338.985	79.45	4.15	4.27	0.03	1.00	2.95	0.46
Nadi-D 550	50	1,000	2.434	0.429	2.863	1.12E-03	344.711	79.73	4.20	4.32	0.03	1.00	2.90	0.45
Nadi-D 600	50	1,000	2.501	0.416	2.918	1.07E-03	350.135	80.01	4.25	4.38	0.03	1.00	2.86	0.44
Nadi-D 650	50	1,000	2.566	0.404	2.970	1.02E-03	355.262	80.26	4.30	4.43	0.03	1.00	2.81	0.43
Nadi-D 700	50	1,000	2.626	0.393	3.020	9.79E-04	360.155	80.51	4.34	4.47	0.03	1.00	2.78	0.42
Nadi-D 750	50	1,000	2.685	0.383	3.068	9.42E-04	364.848	80.74	4.39	4.52	0.03	1.00	2.74	0.41
Nadi-D 800	50	1,000	2.740	0.374	3.114	9.08E-04	369.332	80.96	4.43	4.56	0.03	1.00	2.71	0.40
Nadi-D 850	50	1,000	2.793	0.365	3.159	8.77E-04	373.628	81.17	4.47	4.60	0.03	1.00	2.68	0.40
Nadi-D 900	50	1,000	2.844	0.357	3.202	8.48E-04	377.795	81.38	4.50	4.64	0.03	1.00	2.65	0.39
Nadi-D 950	50	1,000	2.894	0.350	3.244	8.22E-04	381.812	81.57	4.54	4.68	0.03	1.00	2.62	0.39
Nadi-D 1,000	50	1,000	2.941	0.343	3.284	7.97E-04	385.684	81.76	4.57	4.72	0.03	1.00	2.59	0.38
Nadi-D 1,050	50	1,000	2.987	0.336	3.323	7.74E-04	389.425	81.95	4.61	4.75	0.03	1.00	2.57	0.38
Nadi-D 1,100	50	1,000	3.031	0.330	3.361	7.53E-04	393.073	82.12	4.64	4.79	0.03	1.00	2.54	0.37
Nadi-D 1,150	50	1,000	3.074	0.324	3.399	7.33E-04	396.617	82.30	4.67	4.82	0.03	1.00	2.52	0.37
Nadi-D 1,200	50	1,000	3.116	0.319	3.435	7.14E-04	400.056	82.46	4.70	4.85	0.03	1.00	2.50	0.36
Nadi-D 1,250	50	1,000	3.157	0.314	3.470	6.97E-04	403.396	82.63	4.73	4.88	0.03	1.00	2.48	0.36
Nadi-D 1,300	50	1,000	3.196	0.309	3.504	6.80E-04	406.644	82.78	4.76	4.91	0.03	1.00	2.46	0.35
Nadi-D 1,350	50	1,000	3.234	0.304	3.538	6.65E-04	409.836	82.94	4.79	4.94	0.03	1.00	2.44	0.35
Nadi-D 1,400	50	1,000	3.272	0.299	3.571	6.50E-04	412.949	83.09	4.81	4.97	0.03	1.00	2.42	0.35
Nadi-D 1,450	50	1,000	3.308	0.295	3.603	6.36E-04	415.984	83.23	4.84	5.00	0.03	1.00	2.40	0.34
Nadi-D 1,500	50	1,000	3.344	0.291	3.635	6.22E-04	418.946	83.38	4.86	5.02	0.03	1.00	2.39	0.34
Nadi-D 1,550	50	1,000	3.379	0.287	3.665	6.10E-04	421.839	83.51	4.89	5.05	0.03	1.00	2.37	0.34
Nadi-D 1,600	50	1,000	3.413	0.283	3.695	5.98E-04	424.677	83.65	4.91	5.08	0.03	1.00	2.35	0.33
Nadi-D 1,650	50	1,000	3.446	0.279	3.725	5.86E-04	427.472	83.78	4.94	5.10	0.03	1.00	2.34	0.33
Nadi-D 1,700	50	1,000	3.478	0.276	3.754	5.75E-04	430.207	83.91	4.96	5.13	0.03	1.00	2.32	0.33
Nadi-D 1,750	50	1,000	3.510	0.272	3.783	5.64E-04	432.885	84.04	4.98	5.15	0.03	1.00	2.31	0.33
Nadi-D 1,800	50	1,000	3.542	0.269	3.811	5.54E-04	435.509	84.17	5.00	5.17	0.03	1.00	2.30	0.32
Nadi-D 1,850	50	1,000	3.572	0.266	3.838	5.45E-04	438.081	84.29	5.03	5.20	0.03	1.00	2.28	0.32
Nadi-D 1,900	50	1,000	3.602	0.263	3.865	5.35E-04	440.606	84.41	5.05	5.22	0.03	1.00	2.27	0.32
Nadi-D 1,950	50	1,000	3.632	0.260	3.892	5.26E-04	443.108	84.53	5.07	5.24	0.03	1.00	2.26	0.31
Nadi-D 2,000	50	1,000	3.661	0.257	3.918	5.18E-04	445.563	84.64	5.09	5.26	0.03	1.00	2.24	0.31
Nadi-D 2,050	50	1,000	3.689	0.254	3.943	5.10E-04	447.975	84.76	5.11	5.29	0.03	1.00	2.23	0.31
Nadi-D 2,100	50	1,000	3.717	0.252	3.969	5.02E-04	450.345	84.87	5.13	5.31	0.03	1.00	2.22	0.31
Nadi-D 2,150	50	1,000	3.745	0.249	3.993	4.94E-04	452.674	84.98	5.15	5.33	0.03	1.00	2.21	0.31
Nadi-D 2,200	50	1,000	3.772	0.246	4.018	4.87E-04	454.965	85.09	5.17	5.35	0.03	1.00	2.20	0.30
Nadi-D 2,250	50	1,000	3.798	0.244	4.042	4.80E-04	457.219	85.19	5.19	5.37	0.03	1.00	2.19	0.30
Nadi-D 2,300	50	1,000	3.824	0.242	4.066	4.73E-04	459.458	85.30	5.20	5.39	0.03	1.00	2.18	0.30
Nadi-D 2,350	50	1,000	3.850	0.239	4.089	4.66E-04	461.663	85.40	5.22	5.41	0.03	1.00	2.17	0.30
Nadi-D 2,400	50	1,000	3.875	0.237	4.113	4.60E-04	463.835	85.50	5.24	5.42	0.03	1.00	2.16	0.30
Nadi-D 2,450	50	1,000	3.900	0.235	4.135	4.53E-04	465.975	85.60	5.26	5.44	0.03	1.00	2.15	0.29
Nadi-D 2,500	50	1,000	3.925	0.233	4.158	4.47E-04	468.083	85.70	5.27	5.46	0.03	1.00	2.14	0.29

Table-13.4 (2/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/10 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D 2,550	50	1,000	3.935	0.246	4.181	4.86E-04	455.275	85.10	5.17	5.35	0.03	1.00	2.20	0.30
Nadi-D 2,600	50	1,000	3.947	0.259	4.206	5.25E-04	443.576	84.55	5.07	5.25	0.03	1.00	2.25	0.31
Nadi-D 2,650	50	1,000	3.959	0.275	4.234	5.71E-04	431.121	83.96	4.97	5.13	0.03	1.00	2.32	0.33
Nadi-D 2,700	50	1,000	3.974	0.290	4.264	6.19E-04	419.797	83.42	4.87	5.03	0.03	1.00	2.38	0.34
Nadi-D 2,750	50	1,000	3.989	0.307	4.296	6.75E-04	407.735	82.84	4.77	4.92	0.03	1.00	2.45	0.35
Nadi-D 2,800	50	1,000	4.006	0.326	4.331	7.37E-04	395.901	82.26	4.66	4.81	0.03	1.00	2.53	0.37
Nadi-D 2,850	50	1,000	4.026	0.344	4.370	8.00E-04	385.263	81.74	4.57	4.71	0.03	1.00	2.60	0.38
Nadi-D 2,900	50	1,000	4.047	0.365	4.412	8.75E-04	373.919	81.19	4.47	4.61	0.03	1.00	2.67	0.40
Nadi-D 2,950	50	1,000	4.070	0.388	4.457	9.58E-04	362.855	80.64	4.37	4.50	0.03	1.00	2.76	0.42
Nadi-D 3,000	50	1,000	4.098	0.409	4.507	1.04E-03	353.059	80.15	4.28	4.40	0.03	1.00	2.83	0.43
Nadi-D 3,050	50	1,000	4.033	0.524	4.558	9.70E-04	311.970	69.63	4.13	4.48	0.03	1.00	3.21	0.48
Nadi-D 3,100	50	1,000	4.052	0.556	4.608	1.06E-03	302.852	69.36	4.03	4.37	0.03	1.00	3.30	0.50
Nadi-D 3,150	50	1,000	4.070	0.594	4.664	1.18E-03	293.027	69.08	3.92	4.24	0.03	1.00	3.41	0.53
Nadi-D 3,200	50	1,000	3.956	0.779	4.735	1.65E-03	255.970	60.00	3.73	4.27	0.03	1.00	3.91	0.60
Nadi-D 3,250	50	1,000	4.003	0.818	4.820	1.78E-03	249.753	60.00	3.66	4.16	0.03	1.00	4.00	0.63
Nadi-D 3,300	50	1,000	4.049	0.864	4.914	1.94E-03	242.948	60.00	3.57	4.05	0.03	1.00	4.12	0.65

dx: distance; Q: discharge; H: water Level
V.H: velocity head; total E: total energy head; IE: energy gradient
A: discharge area; B: width of water surface; R: hydraulic radius
A/B: hydraulic depth; n: roughness coefficient; alpha: energy correction coefficient
V: velocity; Fr: Frauds number

Nadi-D-1,500: point which is 1,500 m off shore from outlet of the channel

Nadi-D 0: outlet of the channel

Nadi-D 1,000: point which is 1,000 m upstream form outlet of the channel

Table-13.5 (1/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/5 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D -1,500	0	675	1.000	0.002	1.002	2.29E-06	3,900.000	600.00	6.36	6.50	0.03	1.00	0.17	0.02
Nadi-D -1,000	500	675	1.000	0.004	1.004	8.19E-06	2,309.914	420.00	5.36	5.50	0.03	1.00	0.29	0.04
Nadi-D -500	500	675	0.999	0.020	1.019	4.97E-05	1,079.687	240.00	4.34	4.50	0.03	1.00	0.63	0.09
Nadi-D -450	50	675	0.997	0.024	1.021	6.29E-05	976.147	222.00	4.23	4.40	0.03	1.00	0.69	0.11
Nadi-D -400	50	675	0.995	0.030	1.025	8.08E-05	876.132	204.00	4.12	4.29	0.03	1.00	0.77	0.12
Nadi-D -350	50	675	0.991	0.038	1.030	1.06E-04	779.613	186.00	4.01	4.19	0.03	1.00	0.87	0.14
Nadi-D -300	50	675	0.987	0.049	1.036	1.42E-04	686.547	168.00	3.90	4.09	0.03	1.00	0.98	0.16
Nadi-D -250	50	675	0.979	0.065	1.044	1.96E-04	596.864	150.00	3.78	3.98	0.03	1.00	1.13	0.18
Nadi-D -200	50	675	0.967	0.089	1.056	2.80E-04	510.445	132.00	3.65	3.87	0.03	1.00	1.32	0.21
Nadi-D -150	50	675	0.946	0.127	1.074	4.21E-04	427.076	114.00	3.52	3.75	0.03	1.00	1.58	0.26
Nadi-D -100	50	675	0.907	0.194	1.101	6.81E-04	346.314	96.00	3.36	3.61	0.03	1.00	1.95	0.33
Nadi-D -50	50	675	0.823	0.326	1.149	1.25E-03	267.028	78.00	3.15	3.42	0.03	1.00	2.53	0.44
Nadi-D 0	50	675	0.731	0.504	1.235	2.17E-03	214.730	72.92	2.88	2.94	0.03	1.00	3.14	0.59
Nadi-D 50	50	675	0.879	0.457	1.335	1.86E-03	225.563	73.51	3.00	3.07	0.03	1.00	2.99	0.55
Nadi-D 100	50	675	1.001	0.423	1.423	1.65E-03	234.547	74.00	3.10	3.17	0.03	1.00	2.88	0.52
Nadi-D 150	50	675	1.106	0.396	1.502	1.49E-03	242.387	74.42	3.18	3.26	0.03	1.00	2.78	0.49
Nadi-D 200	50	675	1.199	0.374	1.573	1.37E-03	249.313	74.80	3.26	3.33	0.03	1.00	2.71	0.47
Nadi-D 250	50	675	1.283	0.356	1.639	1.27E-03	255.634	75.13	3.32	3.40	0.03	1.00	2.64	0.46
Nadi-D 300	50	675	1.360	0.340	1.700	1.18E-03	261.402	75.44	3.38	3.47	0.03	1.00	2.58	0.44
Nadi-D 350	50	675	1.431	0.327	1.757	1.11E-03	266.751	75.72	3.44	3.52	0.03	1.00	2.53	0.43
Nadi-D 400	50	675	1.497	0.315	1.811	1.05E-03	271.761	75.99	3.49	3.58	0.03	1.00	2.48	0.42
Nadi-D 450	50	675	1.558	0.304	1.862	9.96E-04	276.451	76.23	3.54	3.63	0.03	1.00	2.44	0.41
Nadi-D 500	50	675	1.616	0.295	1.911	9.48E-04	280.881	76.47	3.58	3.67	0.03	1.00	2.40	0.40
Nadi-D 550	50	675	1.671	0.286	1.957	9.06E-04	285.107	76.69	3.62	3.72	0.03	1.00	2.37	0.39
Nadi-D 600	50	675	1.724	0.278	2.002	8.68E-04	289.120	76.89	3.66	3.76	0.03	1.00	2.33	0.38
Nadi-D 650	50	675	1.773	0.271	2.044	8.34E-04	292.942	77.09	3.70	3.80	0.03	1.00	2.30	0.38
Nadi-D 700	50	675	1.821	0.264	2.085	8.03E-04	296.614	77.28	3.74	3.84	0.03	1.00	2.28	0.37
Nadi-D 750	50	675	1.867	0.258	2.125	7.75E-04	300.156	77.47	3.77	3.87	0.03	1.00	2.25	0.36
Nadi-D 800	50	675	1.911	0.252	2.163	7.49E-04	303.557	77.64	3.81	3.91	0.03	1.00	2.22	0.36
Nadi-D 850	50	675	1.953	0.247	2.200	7.25E-04	306.830	77.81	3.84	3.94	0.03	1.00	2.20	0.35
Nadi-D 900	50	675	1.993	0.242	2.235	7.02E-04	309.986	77.97	3.87	3.98	0.03	1.00	2.18	0.35
Nadi-D 950	50	675	2.033	0.237	2.270	6.82E-04	313.064	78.13	3.90	4.01	0.03	1.00	2.16	0.34
Nadi-D 1,000	50	675	2.071	0.233	2.303	6.62E-04	316.048	78.28	3.93	4.04	0.03	1.00	2.14	0.34
Nadi-D 1,050	50	675	2.108	0.229	2.336	6.44E-04	318.938	78.43	3.96	4.07	0.03	1.00	2.12	0.34
Nadi-D 1,100	50	675	2.143	0.225	2.368	6.27E-04	321.741	78.57	3.98	4.09	0.03	1.00	2.10	0.33
Nadi-D 1,150	50	675	2.178	0.221	2.399	6.12E-04	324.463	78.71	4.01	4.12	0.03	1.00	2.08	0.33
Nadi-D 1,200	50	675	2.212	0.217	2.429	5.97E-04	327.121	78.85	4.03	4.15	0.03	1.00	2.06	0.32
Nadi-D 1,250	50	675	2.245	0.214	2.459	5.82E-04	329.725	78.98	4.06	4.17	0.03	1.00	2.05	0.32
Nadi-D 1,300	50	675	2.277	0.211	2.487	5.69E-04	332.263	79.11	4.08	4.20	0.03	1.00	2.03	0.32
Nadi-D 1,350	50	675	2.308	0.207	2.516	5.56E-04	334.737	79.23	4.11	4.22	0.03	1.00	2.02	0.31
Nadi-D 1,400	50	675	2.339	0.205	2.543	5.45E-04	337.151	79.35	4.13	4.25	0.03	1.00	2.00	0.31
Nadi-D 1,450	50	675	2.368	0.202	2.570	5.33E-04	339.509	79.47	4.15	4.27	0.03	1.00	1.99	0.31
Nadi-D 1,500	50	675	2.397	0.199	2.596	5.22E-04	341.813	79.59	4.17	4.29	0.03	1.00	1.97	0.30
Nadi-D 1,550	50	675	2.426	0.196	2.622	5.12E-04	344.090	79.70	4.19	4.32	0.03	1.00	1.96	0.30
Nadi-D 1,600	50	675	2.454	0.194	2.648	5.02E-04	346.319	79.81	4.22	4.34	0.03	1.00	1.95	0.30
Nadi-D 1,650	50	675	2.481	0.191	2.672	4.93E-04	348.501	79.92	4.24	4.36	0.03	1.00	1.94	0.30
Nadi-D 1,700	50	675	2.508	0.189	2.697	4.84E-04	350.640	80.03	4.26	4.38	0.03	1.00	1.93	0.29
Nadi-D 1,750	50	675	2.534	0.187	2.721	4.75E-04	352.736	80.14	4.27	4.40	0.03	1.00	1.91	0.29
Nadi-D 1,800	50	675	2.560	0.185	2.744	4.67E-04	354.791	80.24	4.29	4.42	0.03	1.00	1.90	0.29
Nadi-D 1,850	50	675	2.585	0.183	2.767	4.59E-04	356.809	80.34	4.31	4.44	0.03	1.00	1.89	0.29
Nadi-D 1,900	50	675	2.610	0.181	2.790	4.51E-04	358.798	80.44	4.33	4.46	0.03	1.00	1.88	0.28
Nadi-D 1,950	50	675	2.634	0.179	2.813	4.44E-04	360.764	80.54	4.35	4.48	0.03	1.00	1.87	0.28
Nadi-D 2,000	50	675	2.658	0.177	2.835	4.37E-04	362.696	80.63	4.37	4.50	0.03	1.00	1.86	0.28
Nadi-D 2,050	50	675	2.681	0.175	2.856	4.30E-04	364.595	80.73	4.38	4.52	0.03	1.00	1.85	0.28
Nadi-D 2,100	50	675	2.704	0.173	2.878	4.23E-04	366.462	80.82	4.40	4.53	0.03	1.00	1.84	0.28
Nadi-D 2,150	50	675	2.727	0.171	2.899	4.17E-04	368.299	80.91	4.42	4.55	0.03	1.00	1.83	0.27
Nadi-D 2,200	50	675	2.750	0.170	2.919	4.11E-04	370.107	81.00	4.43	4.57	0.03	1.00	1.82	0.27
Nadi-D 2,250	50	675	2.772	0.168	2.940	4.05E-04	371.886	81.09	4.45	4.59	0.03	1.00	1.82	0.27
Nadi-D 2,300	50	675	2.793	0.167	2.960	3.99E-04	373.638	81.17	4.47	4.60	0.03	1.00	1.81	0.27
Nadi-D 2,350	50	675	2.815	0.165	2.980	3.94E-04	375.377	81.26	4.48	4.62	0.03	1.00	1.80	0.27
Nadi-D 2,400	50	675	2.836	0.163	2.999	3.89E-04	377.096	81.34	4.50	4.64	0.03	1.00	1.79	0.27
Nadi-D 2,450	50	675	2.856	0.162	3.019	3.83E-04	378.789	81.43	4.51	4.65	0.03	1.00	1.78	0.26
Nadi-D 2,500	50	675	2.877	0.161	3.038	3.78E-04	380.459	81.51	4.53	4.67	0.03	1.00	1.77	0.26

Table-13.5 (2/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/5 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D 2,550	50	675	2.886	0.171	3.057	4.17E-04	368.199	80.90	4.42	4.55	0.03	1.00	1.83	0.27
Nadi-D 2,600	50	675	2.897	0.182	3.079	4.58E-04	356.988	80.35	4.31	4.44	0.03	1.00	1.89	0.29
Nadi-D 2,650	50	675	2.908	0.195	3.103	5.08E-04	345.088	79.75	4.20	4.33	0.03	1.00	1.96	0.30
Nadi-D 2,700	50	675	2.922	0.208	3.130	5.59E-04	334.263	79.21	4.10	4.22	0.03	1.00	2.02	0.31
Nadi-D 2,750	50	675	2.936	0.223	3.160	6.21E-04	322.773	78.63	3.99	4.11	0.03	1.00	2.09	0.33
Nadi-D 2,800	50	675	2.953	0.240	3.192	6.92E-04	311.522	78.05	3.88	3.99	0.03	1.00	2.17	0.35
Nadi-D 2,850	50	675	2.973	0.256	3.229	7.65E-04	301.410	77.53	3.79	3.89	0.03	1.00	2.24	0.36
Nadi-D 2,900	50	675	2.994	0.275	3.269	8.54E-04	290.683	76.98	3.68	3.78	0.03	1.00	2.32	0.38
Nadi-D 2,950	50	675	3.019	0.296	3.315	9.54E-04	280.288	76.43	3.58	3.67	0.03	1.00	2.41	0.40
Nadi-D 3,000	50	675	3.049	0.316	3.365	1.06E-03	271.152	75.95	3.48	3.57	0.03	1.00	2.49	0.42
Nadi-D 3,050	50	675	3.020	0.396	3.415	9.65E-04	242.433	67.60	3.35	3.59	0.03	1.00	2.78	0.47
Nadi-D 3,100	50	675	3.041	0.425	3.467	1.08E-03	233.749	67.34	3.25	3.47	0.03	1.00	2.89	0.50
Nadi-D 3,150	50	675	3.063	0.461	3.524	1.23E-03	224.465	67.07	3.14	3.35	0.03	1.00	3.01	0.53
Nadi-D 3,200	50	675	3.011	0.585	3.597	1.66E-03	199.272	60.00	2.99	3.32	0.03	1.00	3.39	0.59
Nadi-D 3,250	50	675	3.062	0.622	3.684	1.83E-03	193.327	60.00	2.91	3.22	0.03	1.00	3.49	0.62
Nadi-D 3,300	50	675	3.116	0.665	3.781	2.04E-03	186.955	60.00	2.82	3.12	0.03	1.00	3.61	0.65

dx: distance
Q: discharge
H: water Level
V.H: velocity head
total E: total energy head
IE: energy gradient
A: discharge area
B: width of water surface
R: hydraulic radius
A/B: hydraulic depth
n: roughness coefficient
alpha: energy correction coefficient
V: velocity
Fr: Frauds number

Nadi-D-1,500: point which is 1,500 m off shore from outlet of the channel
Nadi-D 0: outlet of the channel
Nadi-D 1,000: point which is 1,000 m upstream form outlet of the channel

Table-13.6 (1/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/2 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D -1,500	0	380	1.000	0.000	1.000	7.25E-07	3,900.000	600.00	6.36	6.50	0.03	1.00	0.10	0.01
Nadi-D -1,000	500	380	1.000	0.001	1.001	2.60E-06	2,309.972	420.00	5.36	5.50	0.03	1.00	0.16	0.02
Nadi-D -500	500	380	1.000	0.006	1.006	1.58E-05	1,079.901	240.00	4.34	4.50	0.03	1.00	0.35	0.05
Nadi-D -450	50	380	0.999	0.008	1.007	1.99E-05	976.594	222.00	4.23	4.40	0.03	1.00	0.39	0.06
Nadi-D -400	50	380	0.998	0.010	1.008	2.56E-05	876.862	204.00	4.12	4.30	0.03	1.00	0.43	0.07
Nadi-D -350	50	380	0.997	0.012	1.009	3.34E-05	780.700	186.00	4.02	4.20	0.03	1.00	0.49	0.08
Nadi-D -300	50	380	0.996	0.016	1.011	4.46E-05	688.093	168.00	3.91	4.10	0.03	1.00	0.55	0.09
Nadi-D -250	50	380	0.993	0.021	1.014	6.13E-05	599.020	150.00	3.79	3.99	0.03	1.00	0.63	0.10
Nadi-D -200	50	380	0.990	0.028	1.018	8.70E-05	513.448	132.00	3.67	3.89	0.03	1.00	0.74	0.12
Nadi-D -150	50	380	0.984	0.040	1.023	1.29E-04	431.319	114.00	3.55	3.78	0.03	1.00	0.88	0.14
Nadi-D -100	50	380	0.972	0.059	1.031	2.04E-04	352.525	96.00	3.41	3.67	0.03	1.00	1.08	0.18
Nadi-D -50	50	380	0.949	0.096	1.045	3.52E-04	276.835	78.00	3.25	3.55	0.03	1.00	1.37	0.23
Nadi-D 0	50	380	0.928	0.140	1.068	5.61E-04	229.192	73.71	3.04	3.11	0.03	1.00	1.66	0.30
Nadi-D 50	50	380	0.958	0.138	1.096	5.45E-04	231.425	73.83	3.07	3.13	0.03	1.00	1.64	0.30
Nadi-D 100	50	380	0.988	0.135	1.123	5.29E-04	233.588	73.95	3.09	3.16	0.03	1.00	1.63	0.29
Nadi-D 150	50	380	1.016	0.133	1.149	5.15E-04	235.698	74.06	3.11	3.18	0.03	1.00	1.61	0.29
Nadi-D 200	50	380	1.044	0.130	1.174	5.01E-04	237.758	74.18	3.13	3.21	0.03	1.00	1.60	0.29
Nadi-D 250	50	380	1.071	0.128	1.199	4.88E-04	239.760	74.28	3.16	3.23	0.03	1.00	1.58	0.28
Nadi-D 300	50	380	1.097	0.126	1.223	4.76E-04	241.707	74.39	3.18	3.25	0.03	1.00	1.57	0.28
Nadi-D 350	50	380	1.122	0.124	1.247	4.65E-04	243.604	74.49	3.20	3.27	0.03	1.00	1.56	0.28
Nadi-D 400	50	380	1.147	0.122	1.269	4.54E-04	245.453	74.59	3.22	3.29	0.03	1.00	1.55	0.27
Nadi-D 450	50	380	1.171	0.121	1.292	4.44E-04	247.256	74.69	3.24	3.31	0.03	1.00	1.54	0.27
Nadi-D 500	50	380	1.195	0.119	1.314	4.35E-04	249.017	74.78	3.25	3.33	0.03	1.00	1.53	0.27
Nadi-D 550	50	380	1.218	0.117	1.335	4.25E-04	250.753	74.87	3.27	3.35	0.03	1.00	1.52	0.26
Nadi-D 600	50	380	1.241	0.116	1.356	4.17E-04	252.454	74.96	3.29	3.37	0.03	1.00	1.51	0.26
Nadi-D 650	50	380	1.263	0.114	1.377	4.08E-04	254.119	75.05	3.31	3.39	0.03	1.00	1.50	0.26
Nadi-D 700	50	380	1.285	0.113	1.397	4.01E-04	255.748	75.14	3.32	3.40	0.03	1.00	1.49	0.26
Nadi-D 750	50	380	1.306	0.111	1.417	3.93E-04	257.344	75.22	3.34	3.42	0.03	1.00	1.48	0.26
Nadi-D 800	50	380	1.327	0.110	1.437	3.86E-04	258.908	75.31	3.36	3.44	0.03	1.00	1.47	0.25
Nadi-D 850	50	380	1.347	0.109	1.456	3.79E-04	260.441	75.39	3.37	3.45	0.03	1.00	1.46	0.25
Nadi-D 900	50	380	1.367	0.107	1.474	3.72E-04	261.946	75.47	3.39	3.47	0.03	1.00	1.45	0.25
Nadi-D 950	50	380	1.387	0.106	1.493	3.66E-04	263.423	75.55	3.40	3.49	0.03	1.00	1.44	0.25
Nadi-D 1,000	50	380	1.406	0.105	1.511	3.60E-04	264.879	75.62	3.42	3.50	0.03	1.00	1.43	0.24
Nadi-D 1,050	50	380	1.425	0.104	1.529	3.54E-04	266.320	75.70	3.43	3.52	0.03	1.00	1.43	0.24
Nadi-D 1,100	50	380	1.444	0.103	1.546	3.48E-04	267.736	75.77	3.45	3.53	0.03	1.00	1.42	0.24
Nadi-D 1,150	50	380	1.462	0.102	1.564	3.43E-04	269.128	75.85	3.46	3.55	0.03	1.00	1.41	0.24
Nadi-D 1,200	50	380	1.480	0.101	1.581	3.37E-04	270.497	75.92	3.48	3.56	0.03	1.00	1.40	0.24
Nadi-D 1,250	50	380	1.498	0.100	1.597	3.32E-04	271.845	75.99	3.49	3.58	0.03	1.00	1.40	0.24
Nadi-D 1,300	50	380	1.515	0.099	1.614	3.27E-04	273.171	76.06	3.50	3.59	0.03	1.00	1.39	0.23
Nadi-D 1,350	50	380	1.532	0.098	1.630	3.23E-04	274.477	76.13	3.52	3.61	0.03	1.00	1.38	0.23
Nadi-D 1,400	50	380	1.549	0.097	1.646	3.18E-04	275.762	76.20	3.53	3.62	0.03	1.00	1.38	0.23
Nadi-D 1,450	50	380	1.566	0.096	1.662	3.14E-04	277.029	76.26	3.54	3.63	0.03	1.00	1.37	0.23
Nadi-D 1,500	50	380	1.582	0.095	1.677	3.09E-04	278.278	76.33	3.56	3.65	0.03	1.00	1.37	0.23
Nadi-D 1,550	50	380	1.599	0.094	1.693	3.05E-04	279.508	76.39	3.57	3.66	0.03	1.00	1.36	0.23
Nadi-D 1,600	50	380	1.615	0.093	1.708	3.01E-04	280.734	76.46	3.58	3.67	0.03	1.00	1.35	0.23
Nadi-D 1,650	50	380	1.630	0.093	1.723	2.97E-04	281.944	76.52	3.59	3.68	0.03	1.00	1.35	0.22
Nadi-D 1,700	50	380	1.646	0.092	1.738	2.93E-04	283.137	76.58	3.60	3.70	0.03	1.00	1.34	0.22
Nadi-D 1,750	50	380	1.661	0.091	1.752	2.90E-04	284.315	76.64	3.62	3.71	0.03	1.00	1.34	0.22
Nadi-D 1,800	50	380	1.676	0.090	1.767	2.86E-04	285.477	76.71	3.63	3.72	0.03	1.00	1.33	0.22
Nadi-D 1,850	50	380	1.691	0.090	1.781	2.83E-04	286.624	76.76	3.64	3.73	0.03	1.00	1.33	0.22
Nadi-D 1,900	50	380	1.706	0.089	1.795	2.79E-04	287.757	76.82	3.65	3.75	0.03	1.00	1.32	0.22
Nadi-D 1,950	50	380	1.721	0.088	1.809	2.76E-04	288.875	76.88	3.66	3.76	0.03	1.00	1.32	0.22
Nadi-D 2,000	50	380	1.735	0.088	1.823	2.73E-04	289.980	76.94	3.67	3.77	0.03	1.00	1.31	0.22
Nadi-D 2,050	50	380	1.749	0.087	1.836	2.70E-04	291.071	77.00	3.68	3.78	0.03	1.00	1.31	0.21
Nadi-D 2,100	50	380	1.763	0.086	1.849	2.67E-04	292.150	77.05	3.69	3.79	0.03	1.00	1.30	0.21
Nadi-D 2,150	50	380	1.777	0.086	1.863	2.64E-04	293.216	77.11	3.71	3.80	0.03	1.00	1.30	0.21
Nadi-D 2,200	50	380	1.791	0.085	1.876	2.61E-04	294.269	77.16	3.72	3.81	0.03	1.00	1.29	0.21
Nadi-D 2,250	50	380	1.804	0.084	1.889	2.58E-04	295.315	77.22	3.73	3.82	0.03	1.00	1.29	0.21
Nadi-D 2,300	50	380	1.818	0.084	1.902	2.55E-04	296.356	77.27	3.74	3.84	0.03	1.00	1.28	0.21
Nadi-D 2,350	50	380	1.831	0.083	1.914	2.53E-04	297.386	77.32	3.75	3.85	0.03	1.00	1.28	0.21
Nadi-D 2,400	50	380	1.844	0.083	1.927	2.50E-04	298.404	77.38	3.76	3.86	0.03	1.00	1.27	0.21
Nadi-D 2,450	50	380	1.857	0.082	1.939	2.47E-04	299.412	77.43	3.77	3.87	0.03	1.00	1.27	0.21
Nadi-D 2,500	50	380	1.870	0.082	1.952	2.45E-04	300.409	77.48	3.78	3.88	0.03	1.00	1.26	0.21

Table-13.6 (2/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/2 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D 2,550	50	380	1.876	0.088	1.965	2.77E-04	288.540	76.86	3.66	3.75	0.03	1.00	1.32	0.22
Nadi-D 2,600	50	380	1.884	0.096	1.979	3.11E-04	277.637	76.30	3.55	3.64	0.03	1.00	1.37	0.23
Nadi-D 2,650	50	380	1.892	0.104	1.996	3.55E-04	266.100	75.69	3.43	3.52	0.03	1.00	1.43	0.24
Nadi-D 2,700	50	380	1.902	0.113	2.015	4.01E-04	255.553	75.13	3.32	3.40	0.03	1.00	1.49	0.26
Nadi-D 2,750	50	380	1.913	0.123	2.036	4.60E-04	244.404	74.53	3.20	3.28	0.03	1.00	1.55	0.27
Nadi-D 2,800	50	380	1.926	0.135	2.061	5.30E-04	233.487	73.94	3.09	3.16	0.03	1.00	1.63	0.29
Nadi-D 2,850	50	380	1.942	0.147	2.090	6.06E-04	223.628	73.41	2.98	3.05	0.03	1.00	1.70	0.31
Nadi-D 2,900	50	380	1.960	0.162	2.122	7.02E-04	213.238	72.84	2.87	2.93	0.03	1.00	1.78	0.33
Nadi-D 2,950	50	380	1.982	0.178	2.160	8.15E-04	203.180	72.29	2.76	2.81	0.03	1.00	1.87	0.36
Nadi-D 3,000	50	380	2.009	0.195	2.204	9.36E-04	194.326	71.80	2.66	2.71	0.03	1.00	1.96	0.38
Nadi-D 3,050	50	380	2.008	0.240	2.249	8.51E-04	175.072	65.58	2.54	2.67	0.03	1.00	2.17	0.42
Nadi-D 3,100	50	380	2.030	0.265	2.295	9.95E-04	166.649	65.32	2.43	2.55	0.03	1.00	2.28	0.46
Nadi-D 3,150	50	380	2.053	0.296	2.349	1.18E-03	157.774	65.05	2.31	2.43	0.03	1.00	2.41	0.49
Nadi-D 3,200	50	380	2.051	0.367	2.418	1.58E-03	141.687	60.00	2.19	2.36	0.03	1.00	2.68	0.56
Nadi-D 3,250	50	380	2.104	0.399	2.503	1.81E-03	135.844	60.00	2.10	2.26	0.03	1.00	2.80	0.59
Nadi-D 3,300	50	380	2.164	0.437	2.601	2.10E-03	129.848	60.00	2.02	2.16	0.03	1.00	2.93	0.64

dx: distance
Q: discharge
H: water Level
V.H: velocity head
total E: total energy head
IE: energy gradient
A: discharge area
B: width of water surface
R: hydraulic radius
A/B: hydraulic depth
n: roughness coefficient
alpha: energy correction coefficient
V: velocity
Fr: Frauds number

Nadi-D-1,500: point which is 1,500 m off shore from outlet of the channel
Nadi-D 0: outlet of the channel
Nadi-D 1,000: point which is 1,000 m upstream form outlet of the channel

Table-13.7 (1/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/1.1 Probability Flood)

Name	dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D -1,500	0	250	1.000	0.000	1.000	3.14E-07	3,900.000	600.00	6.36	6.50	0.03	1.00	0.06	0.01
Nadi-D -1,000	500	250	1.000	0.001	1.001	1.12E-06	2,309.988	420.00	5.36	5.50	0.03	1.00	0.11	0.01
Nadi-D -500	500	250	1.000	0.003	1.003	6.82E-06	1,079.959	240.00	4.34	4.50	0.03	1.00	0.23	0.03
Nadi-D -450	50	250	1.000	0.003	1.003	8.61E-06	976.713	222.00	4.23	4.40	0.03	1.00	0.26	0.04
Nadi-D -400	50	250	0.999	0.004	1.003	1.11E-05	877.056	204.00	4.13	4.30	0.03	1.00	0.29	0.04
Nadi-D -350	50	250	0.999	0.005	1.004	1.44E-05	780.984	186.00	4.02	4.20	0.03	1.00	0.32	0.05
Nadi-D -300	50	250	0.998	0.007	1.005	1.93E-05	688.495	168.00	3.91	4.10	0.03	1.00	0.36	0.06
Nadi-D -250	50	250	0.997	0.009	1.006	2.64E-05	599.578	150.00	3.79	4.00	0.03	1.00	0.42	0.07
Nadi-D -200	50	250	0.996	0.012	1.008	3.75E-05	514.218	132.00	3.68	3.90	0.03	1.00	0.49	0.08
Nadi-D -150	50	250	0.993	0.017	1.010	5.54E-05	432.393	114.00	3.56	3.79	0.03	1.00	0.58	0.09
Nadi-D -100	50	250	0.988	0.025	1.014	8.69E-05	354.057	96.00	3.42	3.69	0.03	1.00	0.71	0.12
Nadi-D -50	50	250	0.978	0.041	1.019	1.48E-04	279.122	78.00	3.28	3.58	0.03	1.00	0.90	0.15
Nadi-D 0	50	250	0.970	0.059	1.029	2.33E-04	232.280	73.88	3.08	3.14	0.03	1.00	1.08	0.19
Nadi-D 50	50	250	0.982	0.059	1.041	2.30E-04	233.166	73.93	3.09	3.15	0.03	1.00	1.07	0.19
Nadi-D 100	50	250	0.994	0.058	1.052	2.28E-04	234.041	73.98	3.09	3.16	0.03	1.00	1.07	0.19
Nadi-D 150	50	250	1.006	0.058	1.063	2.25E-04	234.910	74.02	3.10	3.17	0.03	1.00	1.06	0.19
Nadi-D 200	50	250	1.017	0.057	1.074	2.23E-04	235.774	74.07	3.11	3.18	0.03	1.00	1.06	0.19
Nadi-D 250	50	250	1.029	0.057	1.086	2.20E-04	236.628	74.11	3.12	3.19	0.03	1.00	1.06	0.19
Nadi-D 300	50	250	1.040	0.057	1.096	2.18E-04	237.472	74.16	3.13	3.20	0.03	1.00	1.05	0.19
Nadi-D 350	50	250	1.051	0.056	1.107	2.15E-04	238.307	74.20	3.14	3.21	0.03	1.00	1.05	0.19
Nadi-D 400	50	250	1.062	0.056	1.118	2.13E-04	239.133	74.25	3.15	3.22	0.03	1.00	1.05	0.19
Nadi-D 450	50	250	1.073	0.055	1.129	2.11E-04	239.950	74.29	3.16	3.23	0.03	1.00	1.04	0.19
Nadi-D 500	50	250	1.084	0.055	1.139	2.09E-04	240.758	74.34	3.17	3.24	0.03	1.00	1.04	0.18
Nadi-D 550	50	250	1.095	0.055	1.150	2.07E-04	241.557	74.38	3.17	3.25	0.03	1.00	1.03	0.18
Nadi-D 600	50	250	1.105	0.054	1.160	2.05E-04	242.348	74.42	3.18	3.26	0.03	1.00	1.03	0.18
Nadi-D 650	50	250	1.116	0.054	1.170	2.03E-04	243.131	74.46	3.19	3.27	0.03	1.00	1.03	0.18
Nadi-D 700	50	250	1.126	0.054	1.180	2.01E-04	243.906	74.51	3.20	3.27	0.03	1.00	1.02	0.18
Nadi-D 750	50	250	1.137	0.053	1.190	1.99E-04	244.673	74.55	3.21	3.28	0.03	1.00	1.02	0.18
Nadi-D 800	50	250	1.147	0.053	1.200	1.97E-04	245.433	74.59	3.22	3.29	0.03	1.00	1.02	0.18
Nadi-D 850	50	250	1.157	0.053	1.210	1.95E-04	246.186	74.63	3.22	3.30	0.03	1.00	1.02	0.18
Nadi-D 900	50	250	1.167	0.052	1.219	1.93E-04	246.931	74.67	3.23	3.31	0.03	1.00	1.01	0.18
Nadi-D 950	50	250	1.177	0.052	1.229	1.91E-04	247.669	74.71	3.24	3.32	0.03	1.00	1.01	0.18
Nadi-D 1,000	50	250	1.187	0.052	1.239	1.90E-04	248.400	74.75	3.25	3.32	0.03	1.00	1.01	0.18
Nadi-D 1,050	50	250	1.197	0.051	1.248	1.88E-04	249.124	74.79	3.26	3.33	0.03	1.00	1.00	0.18
Nadi-D 1,100	50	250	1.206	0.051	1.257	1.86E-04	249.847	74.82	3.26	3.34	0.03	1.00	1.00	0.17
Nadi-D 1,150	50	250	1.216	0.051	1.267	1.85E-04	250.566	74.86	3.27	3.35	0.03	1.00	1.00	0.17
Nadi-D 1,200	50	250	1.225	0.051	1.276	1.83E-04	251.279	74.90	3.28	3.35	0.03	1.00	0.99	0.17
Nadi-D 1,250	50	250	1.235	0.050	1.285	1.81E-04	251.985	74.94	3.28	3.36	0.03	1.00	0.99	0.17
Nadi-D 1,300	50	250	1.244	0.050	1.294	1.80E-04	252.685	74.98	3.29	3.37	0.03	1.00	0.99	0.17
Nadi-D 1,350	50	250	1.253	0.050	1.303	1.78E-04	253.379	75.01	3.30	3.38	0.03	1.00	0.99	0.17
Nadi-D 1,400	50	250	1.262	0.049	1.312	1.77E-04	254.067	75.05	3.31	3.39	0.03	1.00	0.98	0.17
Nadi-D 1,450	50	250	1.271	0.049	1.321	1.75E-04	254.749	75.09	3.31	3.39	0.03	1.00	0.98	0.17
Nadi-D 1,500	50	250	1.280	0.049	1.329	1.74E-04	255.426	75.12	3.32	3.40	0.03	1.00	0.98	0.17
Nadi-D 1,550	50	250	1.289	0.049	1.338	1.73E-04	256.097	75.16	3.33	3.41	0.03	1.00	0.98	0.17
Nadi-D 1,600	50	250	1.298	0.048	1.347	1.71E-04	256.762	75.19	3.33	3.41	0.03	1.00	0.97	0.17
Nadi-D 1,650	50	250	1.307	0.048	1.355	1.70E-04	257.422	75.23	3.34	3.42	0.03	1.00	0.97	0.17
Nadi-D 1,700	50	250	1.316	0.048	1.364	1.69E-04	258.077	75.26	3.35	3.43	0.03	1.00	0.97	0.17
Nadi-D 1,750	50	250	1.324	0.048	1.372	1.67E-04	258.726	75.30	3.36	3.44	0.03	1.00	0.97	0.17
Nadi-D 1,800	50	250	1.333	0.047	1.380	1.66E-04	259.371	75.33	3.36	3.44	0.03	1.00	0.96	0.17
Nadi-D 1,850	50	250	1.341	0.047	1.389	1.65E-04	260.010	75.37	3.37	3.45	0.03	1.00	0.96	0.17
Nadi-D 1,900	50	250	1.350	0.047	1.397	1.64E-04	260.645	75.40	3.38	3.46	0.03	1.00	0.96	0.16
Nadi-D 1,950	50	250	1.358	0.047	1.405	1.62E-04	261.274	75.43	3.38	3.46	0.03	1.00	0.96	0.16
Nadi-D 2,000	50	250	1.366	0.046	1.413	1.61E-04	261.899	75.47	3.39	3.47	0.03	1.00	0.95	0.16
Nadi-D 2,050	50	250	1.375	0.046	1.421	1.60E-04	262.519	75.50	3.39	3.48	0.03	1.00	0.95	0.16
Nadi-D 2,100	50	250	1.383	0.046	1.429	1.59E-04	263.135	75.53	3.40	3.48	0.03	1.00	0.95	0.16
Nadi-D 2,150	50	250	1.391	0.046	1.437	1.58E-04	263.746	75.56	3.41	3.49	0.03	1.00	0.95	0.16
Nadi-D 2,200	50	250	1.399	0.046	1.445	1.57E-04	264.352	75.60	3.41	3.50	0.03	1.00	0.95	0.16
Nadi-D 2,250	50	250	1.407	0.045	1.453	1.56E-04	264.961	75.63	3.42	3.50	0.03	1.00	0.94	0.16
Nadi-D 2,300	50	250	1.415	0.045	1.460	1.54E-04	265.565	75.66	3.43	3.51	0.03	1.00	0.94	0.16
Nadi-D 2,350	50	250	1.423	0.045	1.468	1.53E-04	266.165	75.69	3.43	3.52	0.03	1.00	0.94	0.16
Nadi-D 2,400	50	250	1.431	0.045	1.476	1.52E-04	266.761	75.72	3.44	3.52	0.03	1.00	0.94	0.16
Nadi-D 2,450	50	250	1.439	0.045	1.483	1.51E-04	267.353	75.75	3.44	3.53	0.03	1.00	0.94	0.16
Nadi-D 2,500	50	250	1.446	0.044	1.491	1.50E-04	267.941	75.79	3.45	3.54	0.03	1.00	0.93	0.16

Table-13.7 (2/2) Non-Uniform Flow Calculation of Nadi Diversion Channel (1/1.1 Probability Flood)

Name		dX (m)	Q (m^3/s)	H (m)	V.H (m)	total E (m)	IE	A (m^2)	B (m)	R (m)	A/B (m)	n	alpha	V (m/s)	Fr
Nadi-D	2,550	50	250	1.450	0.049	1.499	1.72E-04	256.159	75.16	3.33	3.41	0.03	1.00	0.98	0.17
Nadi-D	2,600	50	250	1.455	0.053	1.508	1.97E-04	245.292	74.58	3.21	3.29	0.03	1.00	1.02	0.18
Nadi-D	2,650	50	250	1.460	0.058	1.519	2.28E-04	233.803	73.96	3.09	3.16	0.03	1.00	1.07	0.19
Nadi-D	2,700	50	250	1.467	0.064	1.531	2.64E-04	223.242	73.39	2.98	3.04	0.03	1.00	1.12	0.21
Nadi-D	2,750	50	250	1.474	0.071	1.545	3.09E-04	212.091	72.78	2.85	2.91	0.03	1.00	1.18	0.22
Nadi-D	2,800	50	250	1.483	0.079	1.562	3.64E-04	201.140	72.17	2.73	2.79	0.03	1.00	1.24	0.24
Nadi-D	2,850	50	250	1.495	0.087	1.582	4.26E-04	191.169	71.62	2.62	2.67	0.03	1.00	1.31	0.26
Nadi-D	2,900	50	250	1.508	0.098	1.605	5.09E-04	180.681	71.03	2.50	2.54	0.03	1.00	1.38	0.28
Nadi-D	2,950	50	250	1.523	0.110	1.633	6.10E-04	170.488	70.45	2.38	2.42	0.03	1.00	1.47	0.30
Nadi-D	3,000	50	250	1.544	0.122	1.667	7.24E-04	161.406	69.94	2.27	2.31	0.03	1.00	1.55	0.33
Nadi-D	3,050	50	250	1.550	0.151	1.701	6.67E-04	145.247	64.66	2.15	2.25	0.03	1.00	1.72	0.37
Nadi-D	3,100	50	250	1.568	0.171	1.738	8.10E-04	136.689	64.40	2.04	2.12	0.03	1.00	1.83	0.40
Nadi-D	3,150	50	250	1.588	0.195	1.784	1.01E-03	127.729	64.12	1.92	1.99	0.03	1.00	1.96	0.44
Nadi-D	3,200	50	250	1.600	0.243	1.843	1.36E-03	114.604	60.00	1.80	1.91	0.03	1.00	2.18	0.50
Nadi-D	3,250	50	250	1.646	0.271	1.918	1.63E-03	108.378	60.00	1.70	1.81	0.03	1.00	2.31	0.55
Nadi-D	3,300	50	250	1.703	0.306	2.008	1.98E-03	102.159	60.00	1.61	1.70	0.03	1.00	2.45	0.60

dx: distance — Q: discharge — H: water Level

V.H: velocity head — total E: total energy head — IE: energy gradient

A: discharge area — B: width of water surface — R: hydraulic radius

A/B: hydraulic depth — n: roughness coefficient — alpha: energy correction coefficient

V: velocity — Fr: Frauds number

Nadi-D-1,500: point which is 1,500 m off shore from outlet of the channel

Nadi-D 0: outlet of the channel

Nadi-D 1,000: point which is 1,000 m upstream form outlet of the channel

3.1.6 Results

Sediment loads into the diversion channel are summarized by particle size in Table-13.8. Volume of suspended load inclusive of wash load is shown in Table-13.9.

Table-13.8 Sediment Loads into Diversion Channel

Particle Size (cm)	Sediment Load into Diversion Channel by Scale of Flood				
	20 year return period (10^3m^3)	10 year return period (10^3m^3)	5 year return period (10^3m^3)	2 year return period (10^3m^3)	1.1 year return period (10^3m^3)
Less than 0.02	40.0	24.6	10.7	3.4	1.5
0.03	1.1	0.6	0.2	0.1	0
0.0425	0.3	0.2	0	0	0
0.06	0.4	0.1	0	0	0
0.12	0.1	0.1	0	0	0
0.24	0.1	0.1	0	0	0
0.48	0	0	0	0	0
0.67	0.1	0	0	0	0
Total	42.1	25.7	10.9	3.5	1.5

Table-13.9 Sediment and Suspended Loads into Diversion Channel

	Particle size (cm)	Sediment Load ($10^3 m^3$)	Suspended Load ($10^3 m^3$)
20 year return period flood	less than 0.02	40.0	39.9
	0.03	1.1	1.1
	0.0425	0.3	0.3
	0.06	0.4	0.3
	0.12	0.1	0.0
	0.24	0.1	0.0
	0.48	0.0	0.0
	0.67	0.1	0.0
	0.95	0.0	0.0
	1.32	0.0	0.0
	1.9	0.0	0.0
	2.65	0.0	0.0
	Total	42.1	41.6
	Mean Particle Size	0.0206	0.0160
10 year return period flood	less than 0.02	24.6	24.6
	0.03	0.6	0.6
	0.0425	0.2	0.2
	0.06	0.1	0.1
	0.12	0.1	0.0
	0.24	0.1	0.0
	0.48	0.0	0.0
	0.67	0.0	0.0
	0.95	0.0	0.0
	1.32	0.0	0.0
	1.9	0.0	0.0
	2.65	0.0	0.0
	Total	25.7	25.5
	Mean Particle Size	0.0212	0.0157
5 year return period flood	less than 0.02	10.7	10.7
	0.03	0.2	0.2
	0.0425	0.0	0.0
	0.06	0.0	0.0
	0.12	0.0	0.0
	0.24	0.0	0.0
	0.48	0.0	0.0
	0.67	0.0	0.0
	0.95	0.0	0.0
	1.32	0.0	0.0
	1.9	0.0	0.0
	2.65	0.0	0.0
	Total	10.9	10.9
	Mean Particle Size	0.0218	0.0155
2 year return period flood	less than 0.02	3.4	3.3
	0.03	0.1	0.1
	0.0425	0.0	0.0
	0.06	0.0	0.0
	0.12	0.0	0.0
	0.24	0.0	0.0
	0.48	0.0	0.0
	0.67	0.0	0.0
	0.95	0.0	0.0
	1.32	0.0	0.0
	1.9	0.0	0.0
	2.65	0.0	0.0
	Total	3.5	3.4
	Mean Particle Size	0.0214	0.0153
1.1 year return period flood	less than 0.02	1.5	1.5
	0.03	0.0	0.0
	0.0425	0.0	0.0
	0.06	0.0	0.0
	0.12	0.0	0.0
	0.24	0.0	0.0
	0.48	0.0	0.0
	0.67	0.0	0.0
	0.95	0.0	0.0
	1.32	0.0	0.0
	1.9	0.0	0.0
	2.65	0.0	0.0
	Total	1.5	1.5
	Mean Particle Size	0.0203	0.0152

Note: Suspended Load includes wash load.

Annual average sediment load into the diversion channel was roughly estimated. As shown in Table-13.10, it is approximately 6,300 m^3/year.

Table-13.10 Annual Average Sediment Load into Diversion Channel

Turn Period	(a) Number of Occurrence in 20 years	(b) Sediment Load per Flood (10^3 m^3)	(a)×(b) (10^3 m^3)
20 years	1	42.1	42.1
10 years	1	25.7	25.7
5 years	2	10.9	21.8
2 years	6	3.5	21.0
1.1 years	10	1.5	15.0
Total	20	—	125.6*
Annual Average	—	—	6.3

* : total volume in 20 years

Occurrence of 10 year return period flood means occurrence of discharges exceeding 10 year return period flood . Therefore, the occurrence is 20 years is twice; however, since discharge more than 20 year return period flood is already counted, it is one in the table.

Result of channel bed evolution simulation is shown in Table-13.11 ~ Table-13.15 for each flood and the result is also plotted longitudinally in Figure-13.3 ~ 13.7.

Table-13.11 Sedimentation in and out of Diversion Channel due to 20 Year Return Period Flood

-- name --	bed-el (m)	dlz (m)	qsb-t ($1000m^3$)	l-dm (cm)	dep (m)	qb-t ($1000m^3$)	b-dm (cm)	qs-t ($1000m^3$)	s-dm (cm)	c(%) ----
Nadi-D 3K300	0.00	0.00	42.1	0.00	0.00	0.2	0.74	41.9	0.02	0.04
Nadi-D 3K200	-0.31	0.00	42.1	0.00	0.00	0.3	0.73	41.9	0.02	0.04
Nadi-D 3K100	-0.63	-0.01	42.1	0.00	0.00	0.3	0.71	41.9	0.02	0.04
Nadi-D 3K000	-0.94	-0.01	42.2	0.00	0.00	0.3	0.70	41.9	0.02	0.04
Nadi-D 2K900	-1.25	0.00	42.2	0.00	0.00	0.3	0.69	41.9	0.02	0.04
Nadi-D 2K800	-1.56	0.00	42.2	0.66	0.00	0.3	0.67	41.9	0.02	0.04
Nadi-D 2K700	-1.86	0.01	42.1	0.72	0.02	0.3	0.61	41.8	0.02	0.04
Nadi-D 2K600	-2.17	0.01	42.1	0.66	0.02	0.2	0.56	41.8	0.02	0.04
Nadi-D 2K500	-2.48	0.02	41.9	0.46	0.02	0.2	0.44	41.8	0.02	0.04
Nadi-D 2K400	-2.49	0.01	41.9	0.44	0.01	0.1	0.38	41.7	0.02	0.04
Nadi-D 2K300	-2.49	0.01	41.8	0.41	0.01	0.1	0.33	41.7	0.02	0.04
Nadi-D 2K200	-2.50	0.00	41.8	0.38	0.00	0.1	0.29	41.7	0.02	0.04
Nadi-D 2K100	-2.50	0.00	41.8	0.36	0.00	0.1	0.26	41.7	0.02	0.04
Nadi-D 2K000	-2.50	0.00	41.8	0.32	0.00	0.1	0.23	41.7	0.02	0.04
Nadi-D 1K900	-2.50	0.00	41.8	0.30	0.00	0.1	0.22	41.7	0.02	0.04
Nadi-D 1K800	-2.50	0.00	41.8	0.27	0.00	0.1	0.20	41.7	0.02	0.04
Nadi-D 1K700	-2.50	0.00	41.8	0.21	0.00	0.1	0.20	41.7	0.02	0.04
Nadi-D 1K600	-2.50	0.00	41.7	0.20	0.00	0.1	0.19	41.7	0.02	0.04
Nadi-D 1K500	-2.50	0.00	41.7	0.19	0.00	0.0	0.18	41.7	0.02	0.04
Nadi-D 1K400	-2.50	0.00	41.7	0.19	0.00	0.0	0.18	41.7	0.02	0.04
Nadi-D 1K300	-2.50	0.00	41.7	0.19	0.00	0.0	0.17	41.7	0.02	0.04
Nadi-D 1K200	-2.50	0.00	41.7	0.19	0.00	0.0	0.17	41.7	0.02	0.04
Nadi-D 1K100	-2.50	0.00	41.7	0.19	0.00	0.0	0.17	41.7	0.02	0.04
Nadi-D 1K000	-2.50	0.00	41.7	0.19	0.00	0.0	0.16	41.7	0.02	0.04
Nadi-D 0K900	-2.50	0.00	41.7	0.18	0.00	0.0	0.16	41.7	0.02	0.04
Nadi-D 0K800	-2.50	0.00	41.7	0.19	0.00	0.0	0.16	41.7	0.02	0.04
Nadi-D 0K700	-2.50	0.00	41.7	0.19	0.00	0.0	0.16	41.7	0.02	0.04
Nadi-D 0K600	-2.50	0.00	41.7	0.19	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K500	-2.50	0.00	41.7	0.19	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K400	-2.50	0.00	41.7	0.18	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K300	-2.50	0.00	41.7	0.18	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K200	-2.50	0.00	41.7	0.18	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K100	-2.50	0.00	41.7	0.18	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D 0K000	-2.50	0.00	41.7	0.18	0.00	0.0	0.15	41.7	0.02	0.04
Nadi-D-0K100	-2.64	0.06	41.1	0.02	0.06	0.1	0.03	41.0	0.02	0.04
Nadi-D-0K200	-2.83	0.07	40.0	0.02	0.07	0.1	0.04	39.9	0.02	0.04
Nadi-D-0K300	-3.01	0.09	38.4	0.02	0.09	0.1	0.03	38.3	0.02	0.04
Nadi-D-0K400	-3.21	0.09	36.4	0.02	0.09	0.1	0.02	36.3	0.02	0.03
Nadi-D-0K500	-3.41	0.09	34.0	0.02	0.09	0.1	0.02	33.9	0.02	0.03
Nadi-D-0K600	-3.48	0.22	27.2	0.02	0.22	0.2	0.02	27.1	0.02	0.03
Nadi-D-0K700	-3.53	0.37	14.7	0.02	0.37	0.1	0.02	14.6	0.02	0.01
Nadi-D-0K800	-3.89	0.21	6.8	0.02	0.21	0.1	0.02	6.7	0.02	0.01
Nadi-D-0K900	-4.21	0.09	2.9	0.02	0.09	0.1	0.02	2.8	0.02	0.00
Nadi-D-1K000	-4.46	0.04	1.1	0.02	0.04	0.0	0.02	1.1	0.02	0.00
Nadi-D-1K100	-4.69	0.01	0.4	0.02	0.01	0.0	0.02	0.3	0.02	0.00
Nadi-D-1K200	-4.89	0.01	0.1	0.02	0.01	0.0	0.02	0.1	0.02	0.00
Nadi-D-1K300	-5.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.02	0.00
Nadi-D-1K400	-5.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K500	-5.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K600	-5.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K700	-5.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K800	-6.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K900	-6.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-2K000	-6.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00

-- name --: name of cross section
bed-el: bed elevation after evolution
dlz: difference between original bed elevation and elevation after evolution
qsb-t: accumulated volume of sediment load passed at each cross section
l-dm: average particle size of surface bed material
dep: depth of sedimentation on original bed
qb-t: accumulated volume of bed load passed at each cross section
b-dm: average particle size of bed load
qs-t: accumulated volume of suspended load passed at each cross section
s-dm: average particle size of suspended load
c: contents of sediment load
Nadi-D 3K300: point which is 3 km + 300 m upstream from outlet
Nadi-D-2K000: point in the sea which is 2 km offshore from outlet

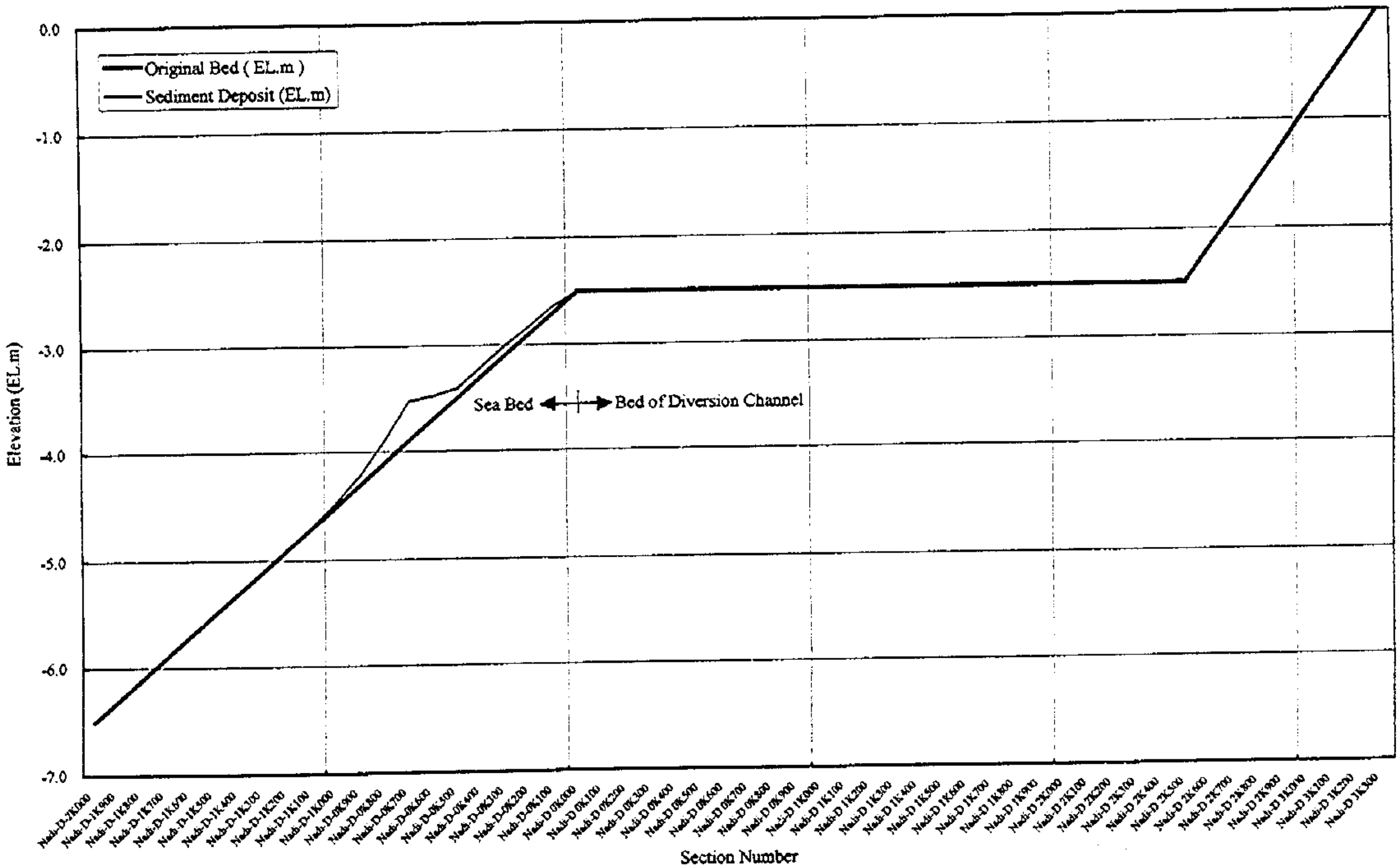

Figure-I3.3 Bed Evolution of Nadi Diversion Channel (20 Year Return Period Flood)

Table-13.12 Sedimentation in and out of Diversion Channel due to 10 Year Return Period Flood

-- name --	bed-el (m)	dlz (m)	qsb-t (1000m³)	l-dm (cm)	dep (m)	qb-t (1000m³)	b-dm (cm)	qs-t (1000m³)	s-dm (cm)	c(%) ----
Nadi-D 3K300	0.00	0.00	25.8	0.00	0.00	0.2	0.69	25.6	0.02	0.03
Nadi-D 3K200	-0.31	0.00	25.8	0.00	0.00	0.2	0.68	25.6	0.02	0.03
Nadi-D 3K100	-0.63	-0.01	25.9	0.00	0.00	0.2	0.67	25.6	0.02	0.03
Nadi-D 3K000	-0.94	-0.01	25.9	0.00	0.00	0.3	0.65	25.6	0.02	0.03
Nadi-D 2K900	-1.25	0.00	25.9	0.00	0.00	0.3	0.64	25.6	0.02	0.03
Nadi-D 2K800	-1.56	0.00	25.9	0.48	0.00	0.3	0.62	25.6	0.02	0.03
Nadi-D 2K700	-1.86	0.01	25.9	0.65	0.01	0.3	0.59	25.6	0.02	0.03
Nadi-D 2K600	-2.18	0.00	25.9	0.64	0.01	0.2	0.58	25.6	0.02	0.03
Nadi-D 2K500	-2.48	0.02	25.8	0.49	0.02	0.2	0.50	25.6	0.02	0.03
Nadi-D 2K400	-2.49	0.01	25.7	0.50	0.01	0.2	0.47	25.6	0.02	0.03
Nadi-D 2K300	-2.49	0.01	25.7	0.48	0.01	0.1	0.44	25.6	0.02	0.03
Nadi-D 2K200	-2.50	0.00	25.7	0.47	0.00	0.1	0.41	25.5	0.02	0.03
Nadi-D 2K100	-2.50	0.00	25.7	0.45	0.00	0.1	0.40	25.5	0.02	0.03
Nadi-D 2K000	-2.50	0.00	25.6	0.44	0.00	0.1	0.38	25.5	0.02	0.03
Nadi-D 1K900	-2.50	0.00	25.6	0.43	0.00	0.1	0.38	25.5	0.02	0.03
Nadi-D 1K800	-2.50	0.00	25.6	0.41	0.00	0.1	0.37	25.5	0.02	0.03
Nadi-D 1K700	-2.50	0.00	25.6	0.40	0.00	0.1	0.37	25.5	0.02	0.03
Nadi-D 1K600	-2.50	0.00	25.6	0.39	0.00	0.1	0.37	25.5	0.02	0.03
Nadi-D 1K500	-2.50	0.00	25.6	0.39	0.00	0.1	0.36	25.5	0.02	0.03
Nadi-D 1K400	-2.50	0.00	25.6	0.39	0.00	0.1	0.36	25.5	0.02	0.03
Nadi-D 1K300	-2.50	0.00	25.6	0.39	0.00	0.1	0.36	25.5	0.02	0.03
Nadi-D 1K200	-2.50	0.00	25.6	0.39	0.00	0.1	0.36	25.5	0.02	0.03
Nadi-D 1K100	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 1K000	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 0K900	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 0K800	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 0K700	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 0K600	-2.50	0.00	25.6	0.39	0.00	0.1	0.35	25.5	0.02	0.03
Nadi-D 0K500	-2.50	0.00	25.6	0.39	0.00	0.1	0.34	25.5	0.02	0.03
Nadi-D 0K400	-2.50	0.00	25.6	0.39	0.00	0.1	0.34	25.5	0.02	0.03
Nadi-D 0K300	-2.50	0.00	25.6	0.41	0.00	0.1	0.34	25.5	0.02	0.03
Nadi-D 0K200	-2.50	0.00	25.6	0.42	0.00	0.0	0.34	25.5	0.02	0.03
Nadi-D 0K100	-2.50	0.00	25.6	0.43	0.00	0.0	0.33	25.5	0.02	0.03
Nadi-D 0K000	-2.50	0.00	25.6	0.43	0.00	0.0	0.33	25.5	0.02	0.03
Nadi-D-0K100	-2.64	0.06	25.0	0.04	0.06	0.1	0.06	24.9	0.02	0.03
Nadi-D-0K200	-2.82	0.08	23.9	0.02	0.08	0.1	0.04	23.8	0.02	0.03
Nadi-D-0K300	-3.02	0.08	22.4	0.02	0.08	0.1	0.02	22.4	0.02	0.03
Nadi-D-0K400	-3.23	0.07	20.9	0.02	0.07	0.1	0.02	20.8	0.02	0.03
Nadi-D-0K500	-3.20	0.30	13.1	0.02	0.30	0.1	0.02	13.0	0.02	0.02
Nadi-D-0K600	-3.44	0.26	5.3	0.02	0.26	0.1	0.02	5.2	0.02	0.01
Nadi-D-0K700	-3.79	0.11	1.6	0.02	0.11	0.0	0.02	1.6	0.02	0.00
Nadi-D-0K800	-4.07	0.03	0.4	0.02	0.03	0.0	0.02	0.4	0.02	0.00
Nadi-D-0K900	-4.29	0.01	0.1	0.02	0.01	0.0	0.02	0.1	0.02	0.00
Nadi-D-1K000	-4.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K100	-4.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K200	-4.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K300	-5.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K400	-5.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K500	-5.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K600	-5.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K700	-5.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K800	-6.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K900	-6.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-2K000	-6.50	0.00	0.0	0.02	0.00	0.0	0.00	0.0	0.00	0.00

-- name --: name of cross section
bed-el: bed elevation after evolution
dlz: difference between original bed elevation and elevation after evolution
qsb-t: accumulated volume of sediment load passed at each cross section
l-dm: average particle size of surface bed material
dep: depth of sedimentation on original bed
qb-t: accumulated volume of bed load passed at each cross section
b-dm: average particle size of bed load
qs-t: accumulated volume of suspended load passed at each cross section
s-dm: average particle size of suspended load
c: contents of sediment load
Nadi-D 3K300: point which is 3 km + 300 m upstream from outlet
Nadi-D-2K000: point in the sea which is 2 km offshore from outlet

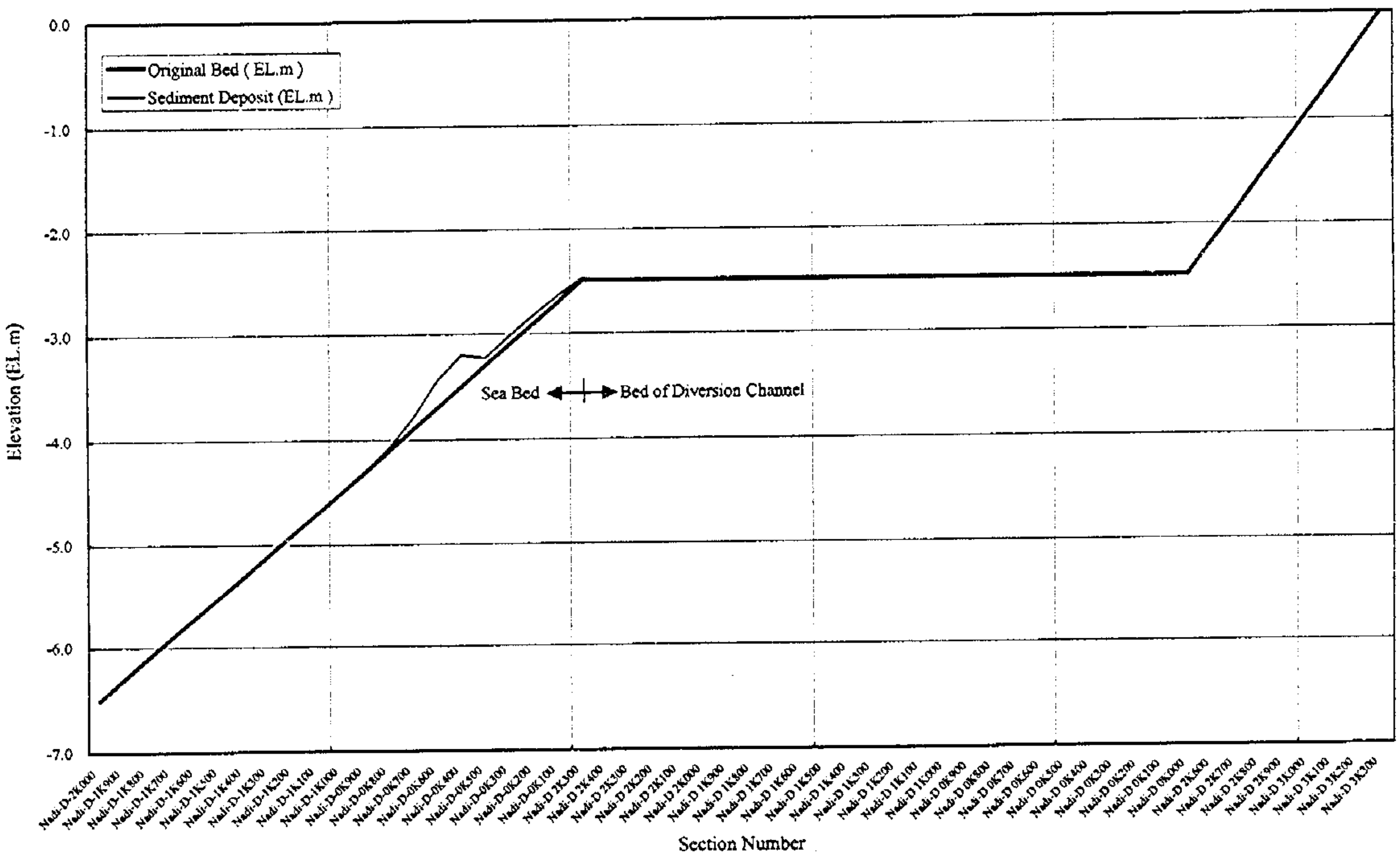

Figure-I3.4 Bed Evolution of Nadi Diversion Channel (10 Year Return Period Flood)

Table-13.13 Sedimentation in and out of Diversion Channel due to 5 Year Return Period Flood

-- name --	bed-el (m)	dlz (m)	qsb-t (1000m³)	l-dm (cm)	dep (m)	qb-t (1000m³)	b-dm (cm)	qs-t (1000m³)	s-dm (cm)	c(%) ----
Nadi-D 3K300	0.00	0.00	11.2	0.00	0.00	0.1	0.60	11.1	0.02	0.02
Nadi-D 3K200	-0.31	0.00	11.2	0.00	0.00	0.1	0.59	11.1	0.02	0.02
Nadi-D 3K100	-0.63	-0.01	11.2	0.00	0.00	0.2	0.59	11.1	0.02	0.02
Nadi-D 3K000	-0.94	-0.01	11.3	0.00	0.00	0.2	0.59	11.1	0.02	0.02
Nadi-D 2K900	-1.25	0.00	11.3	0.00	0.00	0.2	0.57	11.1	0.02	0.02
Nadi-D 2K800	-1.56	0.00	11.3	0.50	0.00	0.2	0.56	11.1	0.02	0.02
Nadi-D 2K700	-1.87	0.00	11.3	0.42	0.00	0.2	0.58	11.1	0.02	0.02
Nadi-D 2K600	-2.17	0.01	11.3	0.56	0.01	0.2	0.57	11.1	0.02	0.02
Nadi-D 2K500	-2.48	0.02	11.2	0.53	0.02	0.1	0.46	11.0	0.02	0.02
Nadi-D 2K400	-2.49	0.01	11.1	0.51	0.01	0.1	0.39	11.0	0.02	0.02
Nadi-D 2K300	-2.50	0.00	11.1	0.48	0.00	0.1	0.35	11.0	0.02	0.02
Nadi-D 2K200	-2.50	0.00	11.1	0.47	0.00	0.1	0.33	11.0	0.02	0.02
Nadi-D 2K100	-2.50	0.00	11.1	0.47	0.00	0.1	0.31	11.0	0.02	0.02
Nadi-D 2K000	-2.50	0.00	11.1	0.45	0.00	0.1	0.30	11.0	0.02	0.02
Nadi-D 1K900	-2.50	0.00	11.1	0.42	0.00	0.1	0.29	11.0	0.02	0.02
Nadi-D 1K800	-2.50	0.00	11.1	0.40	0.00	0.1	0.28	11.0	0.02	0.02
Nadi-D 1K700	-2.50	0.00	11.1	0.38	0.00	0.1	0.27	11.0	0.02	0.02
Nadi-D 1K600	-2.50	0.00	11.1	0.38	0.00	0.1	0.27	11.0	0.02	0.02
Nadi-D 1K500	-2.50	0.00	11.1	0.38	0.00	0.0	0.26	11.0	0.02	0.02
Nadi-D 1K400	-2.50	0.00	11.1	0.37	0.00	0.0	0.25	11.0	0.02	0.02
Nadi-D 1K300	-2.50	0.00	11.1	0.35	0.00	0.0	0.25	11.0	0.02	0.02
Nadi-D 1K200	-2.50	0.00	11.1	0.34	0.00	0.0	0.24	11.0	0.02	0.02
Nadi-D 1K100	-2.50	0.00	11.1	0.33	0.00	0.0	0.24	11.0	0.02	0.02
Nadi-D 1K000	-2.50	0.00	11.1	0.32	0.00	0.0	0.24	11.0	0.02	0.02
Nadi-D 0K900	-2.50	0.00	11.1	0.32	0.00	0.0	0.23	11.0	0.02	0.02
Nadi-D 0K800	-2.50	0.00	11.1	0.32	0.00	0.0	0.23	11.0	0.02	0.02
Nadi-D 0K700	-2.50	0.00	11.1	0.32	0.00	0.0	0.22	11.0	0.02	0.02
Nadi-D 0K600	-2.50	0.00	11.1	0.32	0.00	0.0	0.22	11.0	0.02	0.02
Nadi-D 0K500	-2.50	0.00	11.1	0.32	0.00	0.0	0.22	11.0	0.02	0.02
Nadi-D 0K400	-2.50	0.00	11.1	0.32	0.00	0.0	0.21	11.0	0.02	0.02
Nadi-D 0K300	-2.50	0.00	11.1	0.32	0.00	0.0	0.21	11.0	0.02	0.02
Nadi-D 0K200	-2.50	0.00	11.1	0.30	0.00	0.0	0.20	11.0	0.02	0.02
Nadi-D 0K100	-2.50	0.00	11.1	0.29	0.00	0.0	0.20	11.0	0.02	0.02
Nadi-D 0K000	-2.50	0.00	11.0	0.29	0.00	0.0	0.20	11.0	0.02	0.02
Nadi-D-0K100	-2.64	0.06	10.4	0.03	0.06	0.1	0.03	10.3	0.02	0.02
Nadi-D-0K200	-2.83	0.07	9.5	0.02	0.07	0.0	0.02	9.5	0.02	0.02
Nadi-D-0K300	-3.01	0.09	7.8	0.02	0.09	0.1	0.02	7.7	0.02	0.01
Nadi-D-0K400	-3.07	0.23	2.7	0.02	0.23	0.0	0.02	2.6	0.02	0.01
Nadi-D-0K500	-3.42	0.08	0.6	0.02	0.08	0.0	0.02	0.5	0.02	0.00
Nadi-D-0K600	-3.68	0.02	0.1	0.02	0.02	0.0	0.02	0.1	0.02	0.00
Nadi-D-0K700	-3.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K800	-4.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K900	-4.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K000	-4.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K100	-4.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K200	-4.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K300	-5.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K400	-5.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K500	-5.50	0.00	0.0	0.02	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K600	-5.70	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K700	-5.90	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K800	-6.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K900	-6.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-2K000	-6.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00

-- name --: name of cross section
bed-el: bed elevation after evolution
dlz: difference between original bed elevation and elevation after evolution
qsb-t: accumulated volume of sediment load passed at each cross section
l-dm: average particle size of surface bed material
dep: depth of sedimentation on original bed
qb-t: accumulated volume of bed load passed at each cross section
b-dm: average particle size of bed load
qs-t: accumulated volume of suspended load passed at each cross section
s-dm: average particle size of suspended load
c: contents of sediment load
Nadi-D 3K300: point which is 3 km + 300 m upstream from outlet
Nadi-D-2K000: point in the sea which is 2 km offshore from outlet

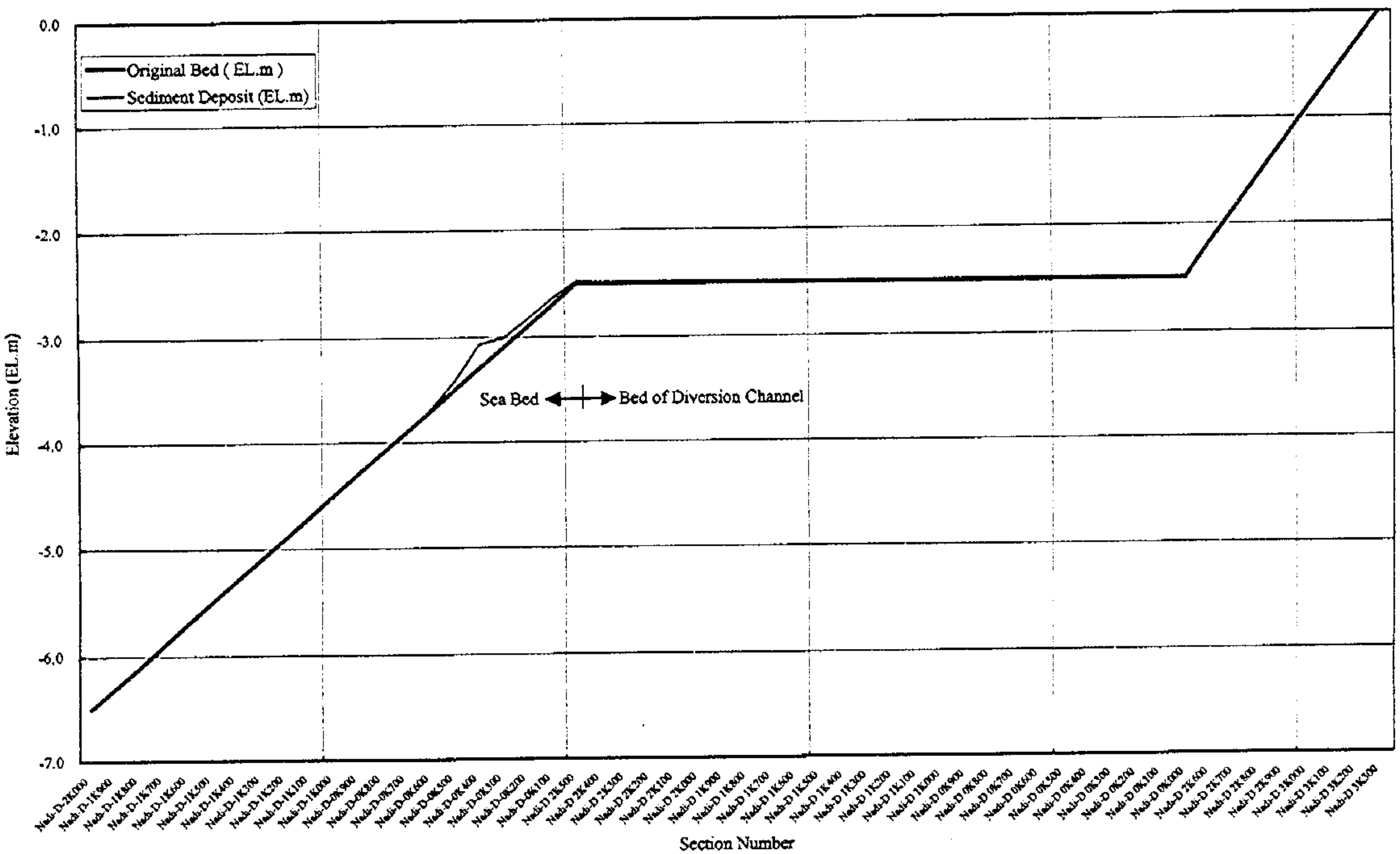

Figure-13.5 Bed Evolution of Nadi Diversion Channel (5 Year Return Period Flood)

Table-13.14 Sedimentation in and out of Diversion Channel due to 2 Year Return Period Flood

-- name --	bed-el (m)	dlz (m)	qsb-t (1000m³)	l-dm (cm)	dep (m)	qb-t (1000m³)	b-dm (cm)	qs-t (1000m³)	s-dm (cm)	c(%) ----
Nadi-D 3K300	0.00	0.00	3.5	0.00	0.00	0.0	0.47	3.4	0.02	0.01
Nadi-D 3K200	-0.31	0.00	3.5	0.00	0.00	0.1	0.49	3.4	0.02	0.01
Nadi-D 3K100	-0.63	-0.01	3.5	0.00	0.00	0.1	0.52	3.4	0.02	0.01
Nadi-D 3K000	-0.94	-0.01	3.6	0.00	0.00	0.1	0.54	3.4	0.02	0.01
Nadi-D 2K900	-1.25	0.00	3.6	0.67	0.00	0.1	0.53	3.4	0.02	0.01
Nadi-D 2K800	-1.56	0.00	3.6	0.42	0.00	0.1	0.53	3.4	0.02	0.01
Nadi-D 2K700	-1.87	0.00	3.6	0.27	0.00	0.2	0.54	3.4	0.02	0.01
Nadi-D 2K600	-2.19	-0.01	3.6	0.42	0.00	0.2	0.55	3.4	0.02	0.01
Nadi-D 2K500	-2.48	0.02	3.5	0.48	0.02	0.1	0.48	3.4	0.02	0.01
Nadi-D 2K400	-2.50	0.00	3.5	0.55	0.00	0.1	0.47	3.4	0.02	0.01
Nadi-D 2K300	-2.50	0.00	3.5	0.57	0.00	0.1	0.46	3.4	0.02	0.01
Nadi-D 2K200	-2.50	0.00	3.5	0.57	0.00	0.1	0.45	3.4	0.02	0.01
Nadi-D 2K100	-2.50	0.00	3.5	0.56	0.00	0.1	0.44	3.4	0.02	0.01
Nadi-D 2K000	-2.50	0.00	3.5	0.55	0.00	0.1	0.43	3.4	0.02	0.01
Nadi-D 1K900	-2.50	0.00	3.5	0.54	0.00	0.1	0.43	3.4	0.02	0.01
Nadi-D 1K800	-2.50	0.00	3.5	0.54	0.00	0.1	0.42	3.4	0.02	0.01
Nadi-D 1K700	-2.50	0.00	3.5	0.53	0.00	0.1	0.42	3.4	0.02	0.01
Nadi-D 1K600	-2.50	0.00	3.5	0.53	0.00	0.1	0.41	3.4	0.02	0.01
Nadi-D 1K500	-2.50	0.00	3.5	0.52	0.00	0.1	0.41	3.4	0.02	0.01
Nadi-D 1K400	-2.50	0.00	3.5	0.52	0.00	0.1	0.40	3.4	0.02	0.01
Nadi-D 1K300	-2.50	0.00	3.5	0.52	0.00	0.1	0.40	3.4	0.02	0.01
Nadi-D 1K200	-2.50	0.00	3.5	0.51	0.00	0.1	0.39	3.4	0.02	0.01
Nadi-D 1K100	-2.50	0.00	3.5	0.51	0.00	0.1	0.39	3.4	0.02	0.01
Nadi-D 1K000	-2.50	0.00	3.5	0.51	0.00	0.1	0.38	3.4	0.02	0.01
Nadi-D 0K900	-2.50	0.00	3.5	0.50	0.00	0.1	0.38	3.4	0.02	0.01
Nadi-D 0K800	-2.50	0.00	3.5	0.50	0.00	0.1	0.37	3.4	0.02	0.01
Nadi-D 0K700	-2.50	0.00	3.5	0.50	0.00	0.1	0.36	3.4	0.02	0.01
Nadi-D 0K600	-2.50	0.00	3.5	0.49	0.00	0.1	0.36	3.4	0.02	0.01
Nadi-D 0K500	-2.50	0.00	3.5	0.49	0.00	0.1	0.35	3.4	0.02	0.01
Nadi-D 0K400	-2.50	0.00	3.5	0.48	0.00	0.1	0.35	3.4	0.02	0.01
Nadi-D 0K300	-2.50	0.00	3.5	0.48	0.00	0.1	0.34	3.4	0.02	0.01
Nadi-D 0K200	-2.50	0.00	3.5	0.48	0.00	0.0	0.34	3.4	0.02	0.01
Nadi-D 0K100	-2.50	0.00	3.5	0.48	0.00	0.0	0.33	3.4	0.02	0.01
Nadi-D 0K000	-2.50	0.00	3.5	0.48	0.00	0.0	0.33	3.4	0.02	0.01
Nadi-D-0K100	-2.65	0.05	3.0	0.04	0.05	0.1	0.05	2.9	0.02	0.01
Nadi-D-0K200	-2.78	0.12	1.4	0.02	0.12	0.0	0.02	1.3	0.02	0.00
Nadi-D-0K300	-3.03	0.07	0.1	0.02	0.07	0.0	0.02	0.1	0.02	0.00
Nadi-D-0K400	-3.29	0.01	0.0	0.02	0.01	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K500	-3.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K600	-3.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K700	-3.90	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K800	-4.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K900	-4.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-1K000	-4.50	0.00	0.0	0.02	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K100	-4.70	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K200	-4.90	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K300	-5.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K400	-5.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K500	-5.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K600	-5.70	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K700	-5.90	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K800	-6.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K900	-6.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-2K000	-6.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00

-- name --: name of cross section
bed-el: bed elevation after evolution
dlz: difference between original bed elevation and elevation after evolution
qsb-t: accumulated volume of sediment load passed at each cross section
l-dm: average particle size of surface bed material
dep: depth of sedimentation on original bed
qb-t: accumulated volume of bed load passed at each cross section
b-dm: average particle size of bed load
qs-t: accumulated volume of suspended load passed at each cross section
s-dm: average particle size of suspended load
c: contents of sediment load
Nadi-D 3K300: point which is 3 km + 300 m upstream from outlet
Nadi-D-2K000: point in the sea which is 2 km offshore from outlet

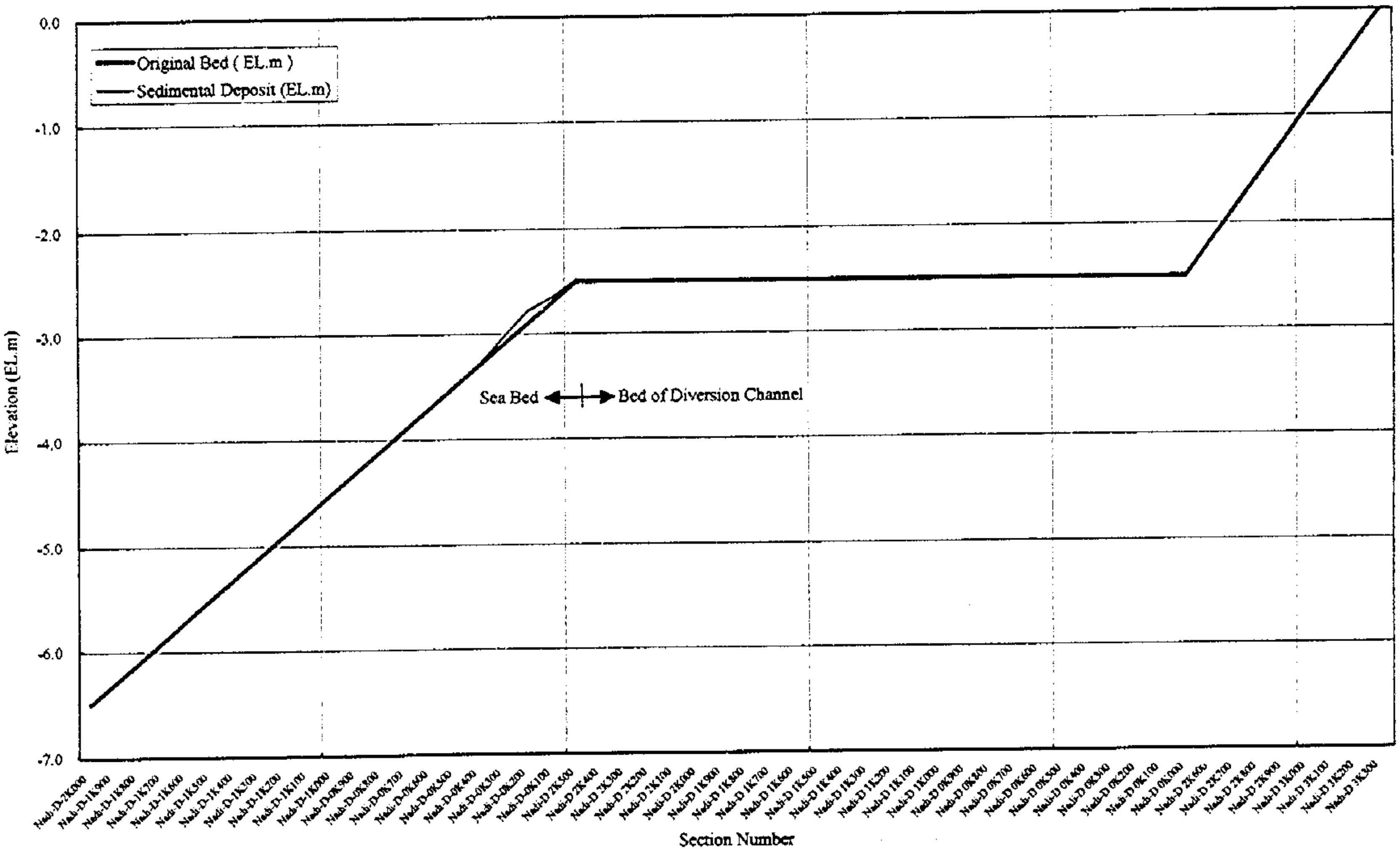

Figure-I3.6 Bed Evolution of Nadi Diversion Channel (2 Year Return Period Flood)

Table-13.15 Sedimentation in and out of Diversion Channel due to 1.1 Year Return Period Flood

-- name --	bed-el (m)	dlz (m)	qsb-t (1000m³)	l-dm (cm)	dep (m)	qb-t (1000m³)	b-dm (cm)	qs-t (1000m³)	s-dm (cm)	c(%) ----
Nadi-D 3K300	0.00	0.00	1.5	0.00	0.00	0.0	0.38	1.5	0.02	0.01
Nadi-D 3K200	-0.31	0.00	1.5	0.00	0.00	0.0	0.46	1.5	0.02	0.01
Nadi-D 3K100	-0.63	-0.01	1.6	0.00	0.00	0.1	0.51	1.5	0.02	0.01
Nadi-D 3K000	-0.94	-0.01	1.6	0.00	0.00	0.1	0.54	1.5	0.02	0.01
Nadi-D 2K900	-1.25	0.00	1.6	0.67	0.00	0.1	0.53	1.5	0.02	0.01
Nadi-D 2K800	-1.56	0.00	1.6	0.47	0.00	0.1	0.53	1.5	0.02	0.01
Nadi-D 2K700	-1.86	0.01	1.6	0.60	0.01	0.1	0.42	1.5	0.02	0.01
Nadi-D 2K600	-2.17	0.01	1.5	0.49	0.01	0.0	0.33	1.5	0.02	0.01
Nadi-D 2K500	-2.50	0.00	1.5	0.23	0.00	0.0	0.25	1.5	0.02	0.01
Nadi-D 2K400	-2.50	0.00	1.5	0.35	0.00	0.0	0.24	1.5	0.02	0.01
Nadi-D 2K300	-2.50	0.00	1.5	0.37	0.00	0.0	0.22	1.5	0.02	0.01
Nadi-D 2K200	-2.50	0.00	1.5	0.35	0.00	0.0	0.21	1.5	0.02	0.01
Nadi-D 2K100	-2.50	0.00	1.5	0.30	0.00	0.0	0.20	1.5	0.02	0.01
Nadi-D 2K000	-2.50	0.00	1.5	0.30	0.00	0.0	0.20	1.5	0.02	0.01
Nadi-D 1K900	-2.50	0.00	1.5	0.30	0.00	0.0	0.19	1.5	0.02	0.01
Nadi-D 1K800	-2.50	0.00	1.5	0.26	0.00	0.0	0.18	1.5	0.02	0.01
Nadi-D 1K700	-2.50	0.00	1.5	0.25	0.00	0.0	0.18	1.5	0.02	0.01
Nadi-D 1K600	-2.50	0.00	1.5	0.25	0.00	0.0	0.17	1.5	0.02	0.01
Nadi-D 1K500	-2.50	0.00	1.5	0.25	0.00	0.0	0.16	1.5	0.02	0.01
Nadi-D 1K400	-2.50	0.00	1.5	0.25	0.00	0.0	0.16	1.5	0.02	0.01
Nadi-D 1K300	-2.50	0.00	1.5	0.23	0.00	0.0	0.15	1.5	0.02	0.01
Nadi-D 1K200	-2.50	0.00	1.5	0.22	0.00	0.0	0.15	1.5	0.02	0.01
Nadi-D 1K100	-2.50	0.00	1.5	0.22	0.00	0.0	0.14	1.5	0.02	0.01
Nadi-D 1K000	-2.50	0.00	1.5	0.21	0.00	0.0	0.14	1.5	0.02	0.01
Nadi-D 0K900	-2.50	0.00	1.5	0.19	0.00	0.0	0.14	1.5	0.02	0.01
Nadi-D 0K800	-2.50	0.00	1.5	0.20	0.00	0.0	0.13	1.5	0.02	0.01
Nadi-D 0K700	-2.50	0.00	1.5	0.21	0.00	0.0	0.13	1.5	0.02	0.01
Nadi-D 0K600	-2.50	0.00	1.5	0.21	0.00	0.0	0.13	1.5	0.02	0.01
Nadi-D 0K500	-2.50	0.00	1.5	0.20	0.00	0.0	0.12	1.5	0.02	0.01
Nadi-D 0K400	-2.50	0.00	1.5	0.19	0.00	0.0	0.12	1.5	0.02	0.01
Nadi-D 0K300	-2.50	0.00	1.5	0.19	0.00	0.0	0.11	1.5	0.02	0.01
Nadi-D 0K200	-2.50	0.00	1.5	0.19	0.00	0.0	0.11	1.5	0.02	0.01
Nadi-D 0K100	-2.50	0.00	1.5	0.18	0.00	0.0	0.11	1.5	0.02	0.01
Nadi-D 0K000	-2.50	0.00	1.5	0.18	0.00	0.0	0.10	1.5	0.02	0.01
Nadi-D-0K100	-2.63	0.07	0.8	0.02	0.07	0.0	0.02	0.8	0.02	0.00
Nadi-D-0K200	-2.84	0.06	0.0	0.02	0.06	0.0	0.02	0.0	0.02	0.00
Nadi-D-0K300	-3.10	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K400	-3.30	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K500	-3.50	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K600	-3.70	0.00	0.0	0.02	0.00	0.0	0.02	0.0	0.00	0.00
Nadi-D-0K700	-3.90	0.00	0.0	0.02	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-0K800	-4.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-0K900	-4.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K000	-4.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K100	-4.70	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K200	-4.90	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K300	-5.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K400	-5.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K500	-5.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K600	-5.70	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K700	-5.90	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K800	-6.10	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-1K900	-6.30	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00
Nadi-D-2K000	-6.50	0.00	0.0	0.53	0.00	0.0	0.00	0.0	0.00	0.00

-- name --: name of cross section
bed-el: bed elevation after evolution
dlz: difference between original bed elevation and elevation after evolution
qsb-t: accumulated volume of sediment load passed at each cross section
l-dm: average particle size of surface bed material
dep: depth of sedimentation on original bed
qb-t: accumulated volume of bed load passed at each cross section
b-dm: average particle size of bed load
qs-t: accumulated volume of suspended load passed at each cross section
s-dm: average particle size of suspended load
c: contents of sediment load
Nadi-D 3K300: point which is 3 km + 300 m upstream from outlet
Nadi-D-2K000: point in the sea which is 2 km offshore from outlet

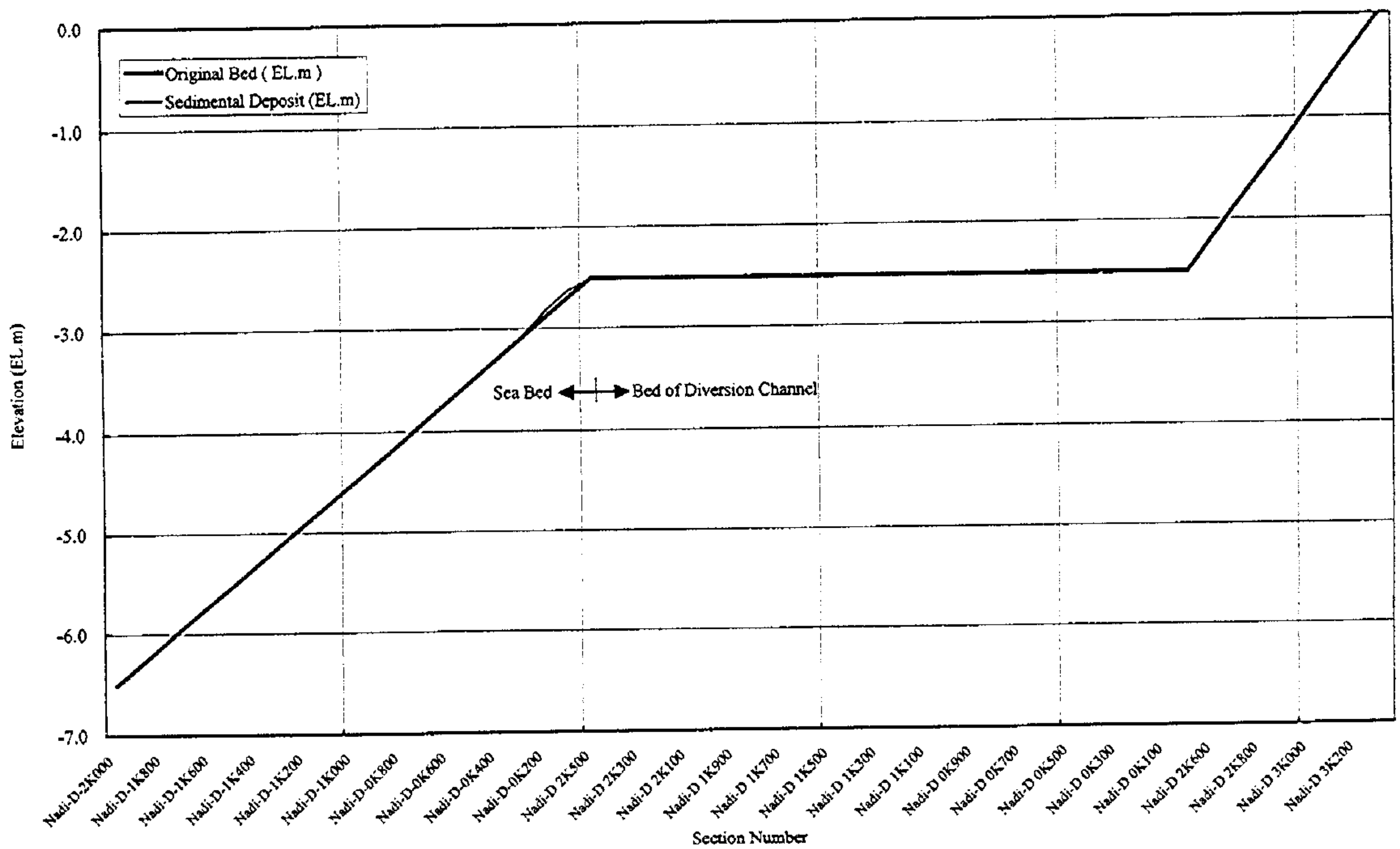

Figure-I3.7 Bed Evolution of Nadi Diversion Channel (1.1 Year Return Period Flood)

Condition of sedimentation in the diversion channel and the sea are summarized in Table-13.16.

Table-13.16 Conditions of Sedimentation after Floods

Place of Sedimentation	Item	Scale of Flood				
		1/20 Probability	1/10 Probability	1/5 Probability	1/2 Probability	1/1.1 Probability
In Diversion Channel	Location of Sedimentation	2.7 ~ 2.3 km	2.7 ~ 2.3 km	2.6 ~ 2.4 km	2.6 ~ 2.5 km	2.7 ~ 2.6 km
	Length of Sedimentation	400 m	400 m	200 m	100 m	100 m
	Width of Sedimentation	60 m	60 m	60 m	60 m	60 m
	Maximum Thickness of Sedimentation	0.02 m	0.02 m	0.02 m	0.02 m	0.01 m
	Volume of Sedimentation	400 m^3	300 m^3	200 m^3	100 m^3	100 m^3
	Particle Size	0.06 ~ 0.67 cm	0.06 ~ 0.24 cm	0.03 cm	0.03 cm	less than 0.02 cm
In the Sea	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	0.30 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 channel: distance in the upstream from outlet
location for the sea: distance offshore from outlet

Sedimentation in the diversion channel occurs between 2.7 km and 2.3 km (upstream from outlet) where bed slope is bent, after 20 year return period flood. Particle sizes of sedimentation are quite large at range between 0.06 cm and 0.67 cm and the maximum depth is about 2 cm. Sedimentation in the diversion channel is less than 1 % of the total sediment load into the channel. Therefore, it is considerably small amount.

Place of sedimentation in the channel does not vary with scale of floods and it is around 2.5 km point from outlet. However, as smaller a flood is, particle size is finer and volume of sedimentation is smaller.

Sedimentation in the channel is flushed by the next flood and successively another sedimentation occurs after the flood. However, sedimentation is not accumulated by floods.

Sedimentation into the channel is mostly drained to the sea, about 99 %. In the case of 20 year return period flood, sedimentation in the sea occurs between outlet and 1.2 km offshore. The maximum depth is expected at 0.7 km offshore and it is approximately 37 cm. 99 % of sedimentation in the sea consists of particles less than 0.03 cm which is almost equivalent to particle size of sea bed material.

3.2 Examination of Effect

As a result of sediment load analysis, most of sediment load in the diversion channel is drained into the sea and deposited on the sea bed where the sea depth is approximately 4 m or shallower, regardless of discharge. Sediment deposited mostly consists of particles smaller than 0.2 mm. It is noted that sea depth datum is Lowest Astronomical Tide, while elevation datum is Mean Sea Level at standard port (Suva harbour).

Relation between velocity which induces suspended sediment, and its particle size is shown in Table-13.17 and Figure-13.7. According to the tidal current survey, the average velocity of tidal current where the sea depth is 5 m is approximately 200 m/hr, causing suspended sediment whose grain size is smaller than 0.06 mm. On the other hand, the maximum velocity at the same sea depth is about 540 m/hr, causing suspended sediment whose grain size is less than 0.4 mm. Therefore, most of sediment drained through the diversion channel is carried off by the maximum velocity but not by the average velocity.

Since the sea bed shallower than 4 m is disturbed and stirred by high waves due to strong wind, such as cyclones, sediment load from the diversion channel is considered to be dispersed and carried off by the high waves. Therefore, even if there were sediment deposits, the sea bed would recover to the original after certain period.

Considering the small velocity and random directions of tidal current, and high waves, neither considerable erosion nor sedimentation is expected in the Nadi bay due to the diversion channel. However, it is recommendable to conduct the further study on sedimentation in the Nadi bay by the hydraulic model experiment at the detail design stage if the proposed project is realized.

Table-13.17 Relation between Velocity and Grain Size of Suspended Sediment

Grain Size (mm)	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.4
Current Velocity (m/hr)	110	270	370	460	550	600	650	700	770	800	850	1,000

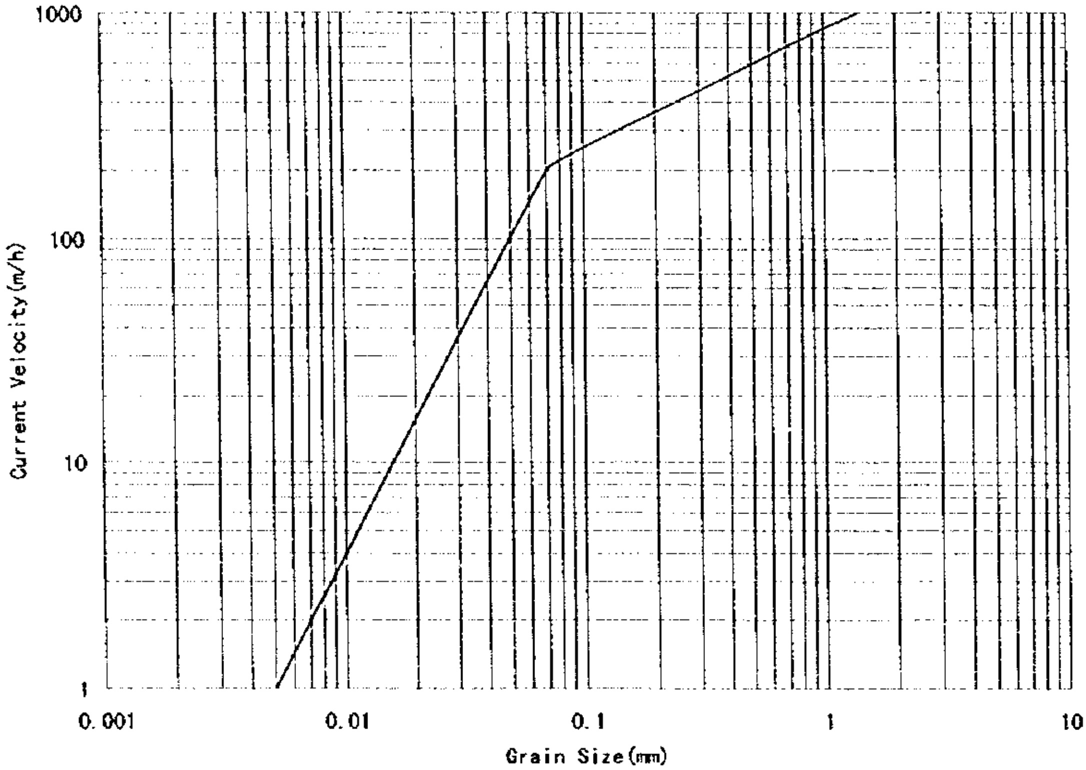

Figure-13.8 Velocity and Grain Size of Suspended Sediment

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SUPPORTING REPORT

PART J

ENVIRONMENT

THE STUDY ON WATERSHED MANAGEMENT AND FLOOD CONTROL FOR THE FOUR MAJOR VITI LEVU RIVERS IN THE REPUBLIC OF FIJI ISLANDS

SUPPORTING REPORT
PART J, ENVIRONMENT

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LIST OF ABBREVIATION

B/C	: Benefit Cost Ratio
BOD	: Biological Oxygen Demand
COD	: Chemical Oxygen Demand
D&I	: Drainage and Irrigation Division, MAFF
DO	: Dissolved Oxygen
DOE	: Department of Environment, MUDHE
DOF	: Department of Forest, MAFF
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
FAO	: Food and Agriculture Organization of the United Nations
FEA	: Fiji Electricity Authority
FMS	: Fiji Meteorological Service, MTCA
FSC	: Fiji Sugar Corporation
GDP	: Gross Domestic Product
GIS	: Geographical Information System
IEE	: Initial Environmental Examination
INR	: Institute of Natural Resources
JICA	: Japan International Cooperation Agency
MAFFA	: Ministry of Agriculture, Fisheries, Forests and ALTA
MAFF	: Ministry of Agriculture, Fisheries, and Forests
MPWIT	: Ministry of Public Works, Infrastructure and Transport
MRD	: Mineral Resources Department
MTCA	: Ministry of Tourism and Civil Aviation
MUDHE	: Ministry of Urban Development, Housing and Environment
NLTB	: Native Land Trust Board
NPV	: Net Present Value
PWD	: Public Works Department, MPWIT
SOPAC	: South Pacific Applied Geoscience Commission
SPC	: South Pacific Commission
SS	: Suspended Solids
TH	: Total Hardness
TN	: Total Nitrogen
TOR	: Terms of Reference
TP	: Total Phosphorus
UNDP	: United Nation Development Programme
USP	: University of the South Pacific
WHO	: World Health Organization

CHAPTER 1 PRESENT SITUATION OF ENVIRONMENT IN FIJI

1.1 Environmental Management in Fiji

1.1.1 Environmental Legislation

Since 1971, Fiji has presented some environmental policies and objectives, but there have been no national environmental policies which have formed the basis of practical application. In 1990, the Asian Development Bank provided a technical assistance grant for the National Environment Management Project (NEMP) which 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. Projects have also been proposed for implementing the National Environment Strategy (NES). Table-J1.1 shows the progress state of the major projects proposed in the NES.

Table-J1.1 Progress State of the Major Projects Proposed in the NES

Project Name	Planned Duration and Target	State of Progress
Institutional Strengthening of the Department of Environment	5 years from the end of 1993	1 Director, 1 Principal Officer, 1 Senior Officer, 2 Environment Officers, 1 Technical Officers, 1 Secretary, 1 Clerical Officer
National Waste Management - Pollution Control Strategy	Completion by the end of 1993	Workshop held in 1994. Following up waste feasibility study of Suva landfill
Environmental Impact Assessment Legislation	EIA Legislation to be drafted by the end of 1993 and enacted by mid 1994	Draft legislation by Dec. 1, 1996
National Land Use Plan	3 years from mid 1994 (TOR by mid 1993)	Working with MAFFA, Land Use Section and D&I to carry this out. Project proposal to be submitted to the European Union.
Introduction of Soil Conservation Practices	8 years minimum from early 1994	as above
Examination of the Feasibility of a Comprehensive Resource Management Act for Fiji	6 months from early 1994	to be included in the environmental legislation drafted by Dec. 1, 1996

Source: JICA Study Team based on information provided by Nawadra S., DOE
Reference: DOE 1996.12; MAFFA, DOE & NLTB 1996.7; Nawadra S. 1994

The Department of Environment (DOE) was established in 1993 for environmental management at the national level. With a staff as shown in Table-J1.1, DOE is engaged in environment awareness, legislation and database. These include: a directed public awareness campaign, upgrading environmental education, environmental impact assessment legislation, examination of the feasibility of a comprehensive resource management act, and development of a national environment database.

In addition, DOE is also engaged in meeting the obligations ratified in treaties and conventions signed by the government. In view of that, DOE looks after the following projects: ozone depleting substance, bio-diversity and Pacific Island Climate Change Assistance Program (PICCAP). DOE works in partnership with WWF on conservation and development. DOE is also involved with SPREP (South Pacific Regional

Environmental Program) initiated projects such as Capacity Building in Environmental Management Project (CBEMP), Persistent Organic Pollutants (POP) and international waters project. DOE is also engaged in promoting waste minimization activities through its Pollution and Waste Minimization Unit.

The environmental legislation was drafted at the end of 1996 under the title of "Fiji's Draft Sustainable Development Bill" (Ministry of Urban Development, Housing and Environment 1996. 11) , which included 19 parts covering all fields of the environment. It will be cited as the "Sustainable Development Act" after approval by the Parliament.

1.1.2 Environmental Impact Assessment (EIA)

In the draft environmental legislation mentioned above, EIA procedures were proposed for all developments in Fiji (see 1.2.5 for details). An Environmental Assessment Unit shall be established within DOE for environmental assessment administration.

For river improvement projects, the Food & Agriculture Organization (FAO) of the United Nations proposed the "Environmental Guidelines for Dredging and River Improvement in Fiji" (Tortell P. et al, 1992) which explained the environmental policy, basic environment items and fundamental methods of assessment such as checklists and matrices.

The Drainage and Irrigation Division (D & I) conducted EIA for a dredging project for Ba River (D & I, 1995a, 1995b, 1996) basically following the FAO environmental guidelines. For other river improvement project, such as the Rewa River dredging project (Hine P. et al, 1992), environmental study was conducted to certain extent on some individual items but not a complete EIA.

An environmental study was conducted by CEE Pty Ltd for Kinoya Treatment Plant and Lauthala Bay (Wallis I et al, 1995) regarding effluent discharge from the sewage treatment plant to Lauthala Bay adjacent to Suva City. Some physical and biological characteristics of Lauthala Bay were studied and a water quality monitoring program was proposed.

Few EIA reports for projects of other fields were collected during this study period. It is expected that EIA will be integrated into the planning process of all the envisaged projects after the enactment of the EIA legislation.

1.2 Environmental Settings

1.2.1 Environmental Sanitation

To understand the present situation of environmental sanitation in the Study Area, the Study Team collected information on water supply, sewage treatment and solid waste management and visited water treatment plants, sewage treatment plants in Suva, Lautoka and Nadi. The general condition is summarized in Table-J1.2 based on the data of 1994 (PWD 1994, Nawadra S. 1994). Master Plans have been prepared for water supply and sewerage for the large cities and towns in the Study Area such as Suva, Nausori, Ba, Nadi and Sigatoka.

For drinking water supply, WHO Guidelines for Drinking-water Quality (WHO 1993) are applied. For domestic and industrial effluent discharge, there have been no regulations. But it is reported that effluent from all the public sewerage systems achieves a BOD below 30 ppm and SS below 20 - 40 ppm (PWD 1994). However, Water Quality Management

Criteria and Guidelines have been proposed in the newly drafted environmental legislation which classify waters in accordance with their uses and set water quality objectives (DOE 1996. 5).

Table-J1.2 Water Supply, Sewerage and Solid Waste Dumps in Viti Levu

(1) Water Supply

Center	Consumers	Capacity (m^3/day)	Population Served
Suva (Tamavua)	Urban/Rural	45,454	271,495
Suva (Waila)	Urban/Rural	45,454	(Suva total)
Korovou	Urban/Rural	340	2,010
R.K.S.	School	650	980
Q.V.S	School	550	520
Colo I Suva	Rural/Forestry	75	730
Naboro	Rural/Prison	1,636	735
Deuba	Rural/Tourism	2,7.17	14,406
Navua	Urban/Rural	909	1,050
Lautoka	Urban	13,090	121,810
Nadi	Urban/Rural	43,000	78,380
Sigatoka	Urban/Rural	5,160	22,890
Ba (including Varavu, Navoli, Koronubu and Veisaru)	Urban/Rural	11,210	42,755
Tavua/Vatukoula	Urban/Rural	5,500	15,825
Rakiraki	Urban/Rural	1,090	8,650
Korotogo	Urban/Tourism	454	(Linked to Sigatoka)
Keiyasi	Rural/Government	440	155

(2) Sewerage Systems

Center	Consumers	Capacity (Equiv. No. of Persons)	Quality of Effluent			No. of Connections	Population Served
			BOD (ppm)	SS (ppm)	F. Coli (No./100ml)		
Kinoya	Urban	80,000	30	20	$3x10^4$	11,000	60,000
Raiwaqa	Urban	15,000	30	20	$3x10^4$	2,136	15,000
Nadi	Urban	10,000	30	20	$3x10^2$	1,800	10,000
Lautoka	Urban	25,000	30	40	$2x10^2$	4,300	29,500
Sigatoka	Urban	4,000	30	40	$2x10^2$	100	700
Nausori	Urban	6,000	30	40	$4x10^2$	160	1,000
Ba	Urban	6,500	30	40	$2x10^2$	(Under Construction)	
Pacific Harbour	Urban	10,000	30	20	$3x10^2$	334	2,000

(3) Solid Waste Dumps in Operation

Dump	Served Population	Dumping Area	Surface Area (ha)	
			Total	In Use
Lami (Suva)	145,000	Mangrove	5	5
Navua	25,000	Mangrove	1	0.2
Sigatoka	2,700	Sand Dunes	1	0.2
Lautoka (Lautoka/Nadi)	106,000	Mangrove	15	3
Ba	8,000	Forest	5	1
Tavua	33,000	Near Hill	2	1
Vaileka	5,000	Mangrove	2	0.2
Korovou	321	Forest		
Nausori	5,000	River Bank	1	1

Source: PWD 1994 Annual Report
Nawadra S. (DOE) Proposed Waste Minimization and Management Strategy for the Republic of Fiji (1994)

1.2.2 Sites of Historical and National Significance

The Study Team visited Fiji Museum and government agencies concerned and collected information on the sites of historical and national significance in the Study Area.

(1) Historical and Archaeological Sites

In Fiji Museum, archaeologists including some international cooperation volunteers from Japan, Australia, etc. are engaged in sorting data and information on historical and archaeological sites and building a computer data base. However, due to lack of systematic investigation in the past and short of financial and manpower source, their work has not yet been at a stage to provide information on the distribution of these sites in the Study Area except some data for Rewa Delta and Sigatoka Valley area where certain archaeological sites have been identified by air-photo interpretation (Parry J. T. 1977 & 1987). Ring-ditch fortifications of various settlement sizes dating back to the 16th century are found to be distributed in the Rewa Delta area. Similar ring-ditch and also hill & ridge fortifications are discovered along two sides of the downstream of Sigatoka River.

One of the most important archaeological sites in the Pacific is located in Sigatoka Sand Dune where a burial ground of more than 100 people dating back nearly 2000 years has been found (Chape S. and Watling D. 1992). Many pottery vessels and discs have been excavated there (Birks L. 1973).

(2) Sites of National Significance

Registration of sites of national significance is one of the projects proposed in the NES (Watling D. and Chape S. 1993). It is in progress under the participation of the Native Land Trust Board (NLTB), Department of Forestry (DOF), DOE and Fiji Museum. A preliminary register of these sites has been compiled in the NES with a list of 140 sites selected on the basis of their biological, ecological, geological, geomorphological, landscape or other natural values, of which 47 are located in Viti Levu including Sigatoka Sand Dunes, Fiji's first National Park.

1.2.3 Natural Environment

(1) Flora and Fauna

Regarding flora and fauna, the present condition is well described in the "Country Report for UNCED - Fiji" (Chape S. and Watling D. 1992) and "Environment: Fiji - the National State of the Environment Report" (Watling D. and Chape S. 1992). 476 indigenous Fijian plants genera have been identified, of which 10 % are endemic. A book published by DOF has illustrated major species of indigenous Fijian trees as a result of the Fiji German Forestry Project (GTZ) (DOF 1996). As for wildlife, there exist several species of bat, birds, reptile etc.

Vuleito palm and barred-wing rail are reported to be endangered plant and wildlife, respectively, in Fiji.

(2) Mangroves

The Study Team visited DOF, Lands Department, South Pacific Commission (SPC), University of the South Pacific (USP) and Fisheries Department and collected information about mangroves in the Study Area.

In Viti Levu, the largest mangrove forests are found in deltaic formations at the mouths of Ba, Rewa and Nadi Rivers. A "Mangrove Management Plan for Fiji" (Watling D. 1987, 1988) estimated the area of mangrove resource in the 3 Deltas to be 3714, 5130 and 3614 ha, respectively. Mangrove forests are very important ecosystem which supply valuable sources of wood, yield large amount of finfish and shellfish, stabilize coastline and act as filter for sediments and nutrients. There are also studies on using mangrove swamps for the removal of nutrients from sewage treatment plant effluent (Banner S. E. T. et al 1996).

(3) Coral Reefs

There are few data available on coral reefs in the marine area related to this Study except certain studies done by USP, South Pacific Applied Geoscience Commission (SOPAC) and some local consultants dealing with coral reefs in other areas.

Generally speaking, coral reefs are only formed in warm salt water where the light can penetrate sufficiently (Knox M. 1990, Squires D. F. 1962). Therefore, estuaries of large rivers are not suitable for coral reefs to grow because of the inflow of less saline river water with possible runoff of sediment resulting in reduction of light penetration. In the Study Area, existing coral reef systems which may be affected by river flow are thought to be Yarawa and Cakau na Sasi Reefs outside Ba River and Ucuisila and Wainita Reefs outside Rewa River. A study on coral reef ecosystem of Yarawa and Cakau na Sasi was conducted by the Fisheries Department for the Ba River Dredging Project (D & I 1996).

The "International Coral Reef Initiative (ICRI) Pacific Region Strategy" stresses the effects of freshwater runoff on coral reefs and calls for actions to develop and implement appropriate watershed management and drainage plans (South Pacific Regional Environment Programme 1996).

1.2.4 Environment Hazards

There are few data available to show the present condition of environmental pollution related to air, soil, noise and vibration. Regarding water quality, data were collected from the National Water Quality Laboratory PWD (Deb S. C. 1995), USP (Anderson E. P. et al 1995, Sulu R. J. 1994, Reddy V. et al 1995) on drinking water, sewage, river water in Ba and Rewa.

The existing data have shown that water pollution is not severe for these rivers except that a low value of dissolved oxygen (DO) has been detected at a section of Ba River where industrial pollution is suspicious.

The Study Team also conducted water quality survey during this Study for the four major Viti Levu Rivers. The results are described in Supporting Report Part F (Surface Water Quality).

1.2.5 Consideration on Environmental Impact Assessment

(1) Procedures of Environmental Impact Assessment in Fiji

In November 1996, "Fiji's Draft Sustainable Development Bill" (hereafter referred to as the Bill) was published by the Ministry of Urban Development, Housing and Environment. After public review, this document will be finally enacted by the Parliament and cited as the "Sustainable Development Act, 1997". The Bill has established the basic governmental policy on environmental management, especially on administration, environmental impact assessment (EIA), waste management and pollution control, resource management and conservation. It is specified that all proposed developments which are likely to have significant environmental, human health or social impacts, or which have caused, or are likely to cause public concern, shall be subject to the EIA process. The EIA procedure proposed in the Bill can be described schematically in Figure-J1.1. This includes mainly the following processes:

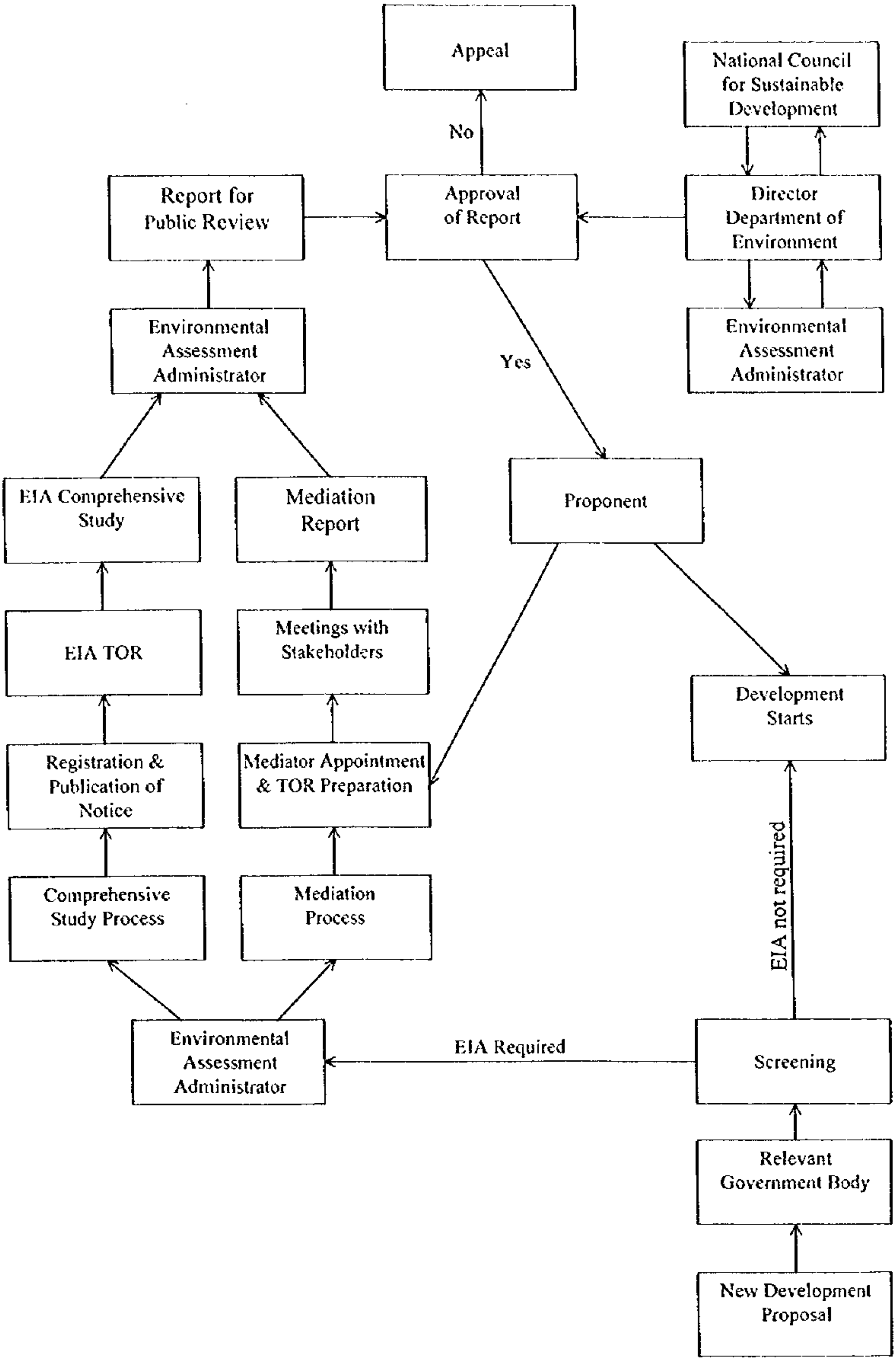
- Screening by the relevant ministry, department or statutory body to determine whether an EIA may be required;
- Registering the matter and publishing a notice for public awareness;
- Comprehensive EIA study;
- Environmental mediation process;
- Review and approval of the EIA and mediation reports.

Table-J1.3 shows the required items as the contents of the comprehensive EIA report. The environmental mediation is a process for mediating among affected parties regarding the environmental impacts caused by the development. A mediator shall be appointed by the Environmental Assessment Administrator in consultation with the proponent for undertaking duties and responsibilities for the mediation process. The mediation report shall also be submitted for review and approval.

Table-J1.3 Contents of the Comprehensive EIA Report

1	Introduction of the proposal
2	Description of the purpose and scope of the proposed activity or undertaking
3	Description of the proposed action and any alternatives
4	Description of the environmental setting
5	Description of the social and environmental impacts
6	Description of adverse environmental and social impacts that cannot be avoided
7	Environment management plan
8	Environment monitoring and surveillance program
9	List of individuals and organizations consulted
10	Recommendations on the selected project alternative, mitigation measures etc.
11	Other matters specified by Regulation

Source: Fiji's Draft Sustainable Development Bill, 1996. 11.



(Source: Department of Environment)

Figure-J1.1 Schematic Representation of Proposed EIA Procedure

(2) EIA Methodologies for This Study

The EIA for this Study shall basically follow the EIA procedures specified in the Bill. At the same time, JICA Environmental Guidelines (JICA, 1992) and other international organizations' environmental guidelines such as that of FAO for dredging and river improvement in Fiji (Tortell, 1992) will be referred.

Environmental assessment for this Study includes an initial environmental examination (IEE) for the Master Plan and an EIA for the priority project. Table-J1.4 shows the environmental elements to be considered in the IEE and EIA.

Table-J1.4 Environmental Elements to be Examined

(1) Social Environment	(2) Natural Environment	(3) Environment Hazards
- 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
- Water Right / Right of Common	- Flora & Fauna	- Offensive Odor
- Public Health & Sanitation	- Meteorology	- Hazardous Substances*
- Solid Wastes	- Landscape	
- Risk of Disaster		

Source: JICA (1992) Environmental Guidelines V. for River and Sabo Engineering.
* Item suggested by Department of Environment.

The IEE to be conducted in Phase I of the Study for the Master Plan shall use an environmental matrix to examine the possible impacts of each of the project activities envisaged in the Master Plan on each of the environmental elements. Items on which adverse impacts are anticipated will be identified, and the Master Plan will be examined from an environmental viewpoint.

The EIA to be conducted in Phase II of the Study for the priority project shall be conducted on the basis of the IEE results. The environmental items identified by the IEE shall become the objectives of the EIA study. Qualitative and semi-quantitative analysis methods such as hazard identification, vulnerability analysis, risk analysis and benefit analysis will be applied. The EIA will also include recommendation of countermeasures to erase or relieve any of the adverse impacts and environment protection and environmental monitoring plan as has been required in the Bill.

The Study Team have discussed with the Department of Environment and reached consensus that at the feasibility study stage, the EIA process shall mainly follow JICA's environmental guidelines with considerations of the procedures shown in Figure-J1.1. The EIA results shall be compiled into the Final Report of this Study and referred in the future when the proposed project is to be implemented.

CHAPTER 2 INITIAL ENVIRONMENTAL EXAMINATION

2.1 Objectives

The objectives of Initial Environmental Examination (IEE) are to examine the possible impacts of each of the project activities proposed in the Flood Control Master Plan on the environment, to identify the environmental items on which significant adverse impacts are anticipated and to evaluate the Master Plan from an environmental viewpoint.

The IEE results shall also provide basis for the Environmental Impact Assessment (EIA) to be conducted in the next phase of this study for the priority project.

2.2 Guidelines and Methodologies

For the IEE, the following environmental guidelines were applied and/or referred:

1) Fiji's Sustainable Development Bill, Part III-Environmental Impact Assessment (Ministry of Urban Development, Housing and Environment, 1996);
2) Environmental Guidelines V. for River and Sabo Engineering (JICA, 1992);
3) Environmental Guidelines for Dredging and River Improvement in Fiji (FAO, 1992).

The first document will become the Sustainable Development Act - the first legislation of this kind in Fiji after Parliament approval, and the principles given in this document shall govern all the activities or undertakings that are subject to environmental examination. The second document establishes the basic policy of environmental consideration for JICA technical cooperation projects and specifies the environmental elements on which impacts may be caused by the projects. The third document is currently applied in Fiji for carrying out environmental impact assessment for dredging and river improvement projects, and some of the methods proposed were referred in this study.

The IEE was conducted mainly by using an environmental examination matrix which enables a screening of all the impacts on each of the environmental items from each of the project activities proposed in the Master Plan, for an identification of the significant environmental impacts. As shown in Table-J2.1, the environmental examination matrix has vertical axis consisting of rows for project activities, and horizontal axis consisting of columns of environmental elements grouped in 3 categories: social environment, natural environment and environment pollution. The project activities include all those proposed in the Master Plan for Rewa, Sigatoka, Nadi and Ba Rivers. For each of the project activities, both the construction phase and operation phase are considered. The environmental elements include 23 items specified in the JICA Environmental Guidelines and 1 additional item - Hazardous Substances suggested by the Dept. of Environment. Three kinds of symbols are used to identify the extent of the impact according to an examination of the environmental condition at the proposed project sites and a prediction of the environmental quality in the future. Since environmental impacts identification is the main objective of the IEE, qualitative and semi-quantitative examination by analogical method and professional judgment are the main methodologies used at this stage.

Table-J2.1 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

2.3 Impacts Examination

As a result of screening through the environmental examination matrix shown in Table-J2.1, significant adverse impact was identified on 4 environmental elements, and possible adverse impact was envisaged on 13 environmental elements from some project activities. The following paragraphs give the rationale.

2.3.1 Social Environment

(1) Resettlement, Economic Activities and Traffic & Living Facilities

Table-J2.2 summarizes the general condition at the project sites related to resettlement and land acquisition, economic activity, traffic & living facilities. For the diversion channels, with their broad width, e.g. 368 m for the Rewa and 352 m for the Nadi, acquisition of larger areas of land will be required, and within these areas certain number of residential houses will be involved in a resettlement program although the routes have been carefully chosen in order to reduce the resettlement scale as far as possible. For the dike construction in Rewa river, land acquisition area will be much smaller but since the left bank of the river near Nausori Town is densely populated, the number of houses for resettlement will be larger. As for public facilities, 1 elementary school at Vunimono will be affected by the dike construction for Rewa river, and 1 nursery at Saunaka will have to be relocated for the Nadi diversion channel. Land acquisition and resettlement often cause significant social impacts and therefore have to be carefully coped with.

Table-J2.2 Condition Related to Resettlement etc. at Project Sites

Project Sites	Land Acquisition Area (ha)			Number of Houses	Public Facility	Traffic Facility
	Free hold	Native	State			
(1) Rewa River						
Diversion channel	0	179.6	101.7	40	None	Cross Kings Road, Vuci Road, Vusuya Road and Mara Road
Dike construction	0	7.5	6.1	53	1 elementary school	May affect Kings Road and Wainibokasi Road
(4) Sigatoka River						
Dredging	None			None	None	None
(3) Nadi River						
Diversion channel	29.3	0	42.8	35	1 nursery	Cross Queens Road, Wailoaloa Road and a tram line
Short cut channel	0	3.3	0	None	None	Cross a small access road
(4) Ba River						
Dike construction	12.6	12	0	4	None	May affect some small access road

Possible impacts on economic activity are envisaged, since farmers with their land lost may have to seek other ways of production and villagers separated apart from their farms or workplaces by the project construction may have to take longer time for commuting. The commercial activities of shops and restaurants near the project sites may also be affected during the construction. Therefore, countermeasures have to be taken regarding such kind of impacts.

During project construction, a large number of vehicles will be employed. This may affect the traffic condition of all the roads in and leading to the project area in addition to the direct hindrance of traffic from the project at several locations such as the places where the diversion channels cross Kings Road at Nausori and Queens Road at Nadi. Preparation of temporary bypass roads and traffic regulation may have to be considered.

(2) Archaeological & Cultural Properties

Talbe-J2.3 shows the sites of archaeological and cultural properties, national reserves and protected areas in the project area. Their approximate locations are shown in Figure-J2.1. These sites have been cited in the National Environment Strategy (Watling D. and Chape S. 1993) as preliminary register of sites of national significance. Although all the proposed project locations are not in the vicinities of these sites, it is still recommendable that consideration should be given on their protection during project implementation, especially in the Rewa and Sigatoka river basins where numbers of unidentified ruins of ancient fortifications are said to be scattered along the valleys.

Table-J2.3 Sites of Archaeology, Culture and National Significance in the Project Area

Site Number	Site Name	Significance
Rewa River		
1	Wailotua Limestone	Limestone ecosystem and cave
2	Waidawara	Geological site-river process
3	Wabu Creek	Intact Fiji dakua montane rainforest
4	Wainsabulevu Falls	Water fall
5	Monasabu	Dam, hydro catchment protection, rainforest
6	Monasabu Swamp	Rare montane swamp community
7	Wainibudi R.	Geological site-rock type
8	Naqali	*Neovetchia storckii* palm habitat
9	Sovi Basin	Rainforest, wilderness area, high scenic value
10	Sovi Gorge	River gorge of high scenic value
11	Korobasabasaga Range	High scenic value
Sigatoka River		
12	Sautabu Cave	Limestone cave
13	Naqalimare Limestone	Limestone ecosystem
14	Tatuba Cave	Limestone cave system
15	Rairaimatuku Plateau	Mountain rainforest
16	Korokune	*Veitchia johannis* palm forest
17	Yadua Quarry	Geological site-rock type
18	Makasiko	Geological site-rock type
Nadi River		
19	Nausori Highlands	Dry zone mountain rainforest
20	Vaturu Dam Catchment	Catchment protection; dry zone rainforest
Ba River		
21	Nadarivatu Nat. Res	Dakua dominated rainforest

Source: Watling D. and Chape S. (1993). "The national environment strategy: Fiji". Government of Fiji and IUCN - The World Conservation Union

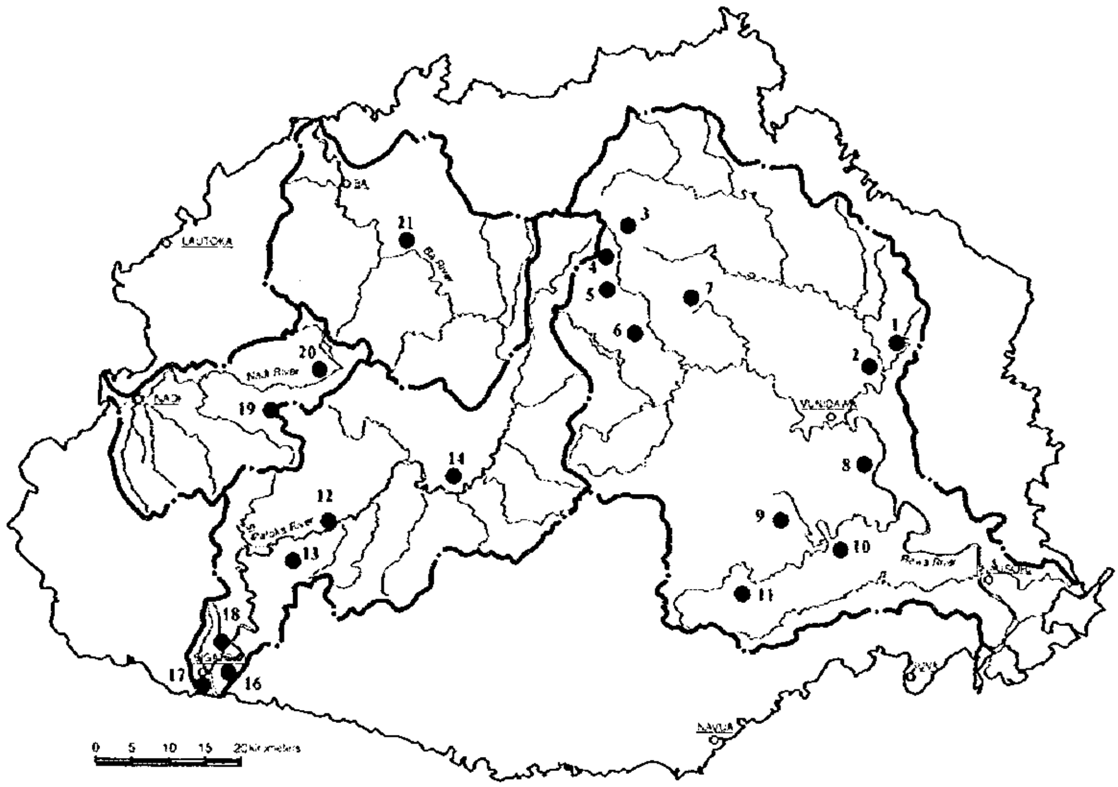


Figure-J2.1 Sites of Archaeology, Culture and National Significance in the Project Area

(3) Water Right / Right of Common

The implementation of the flood control projects may not involve the problem of water right. However, since rivers are very important for fishery in Fiji and many residents live on fishing from the river or mangrove forest in the estuary area, the impact on the Customary Fishing Rights should be taken into consideration.

The diversion channel planned for Rewa river will finally go through the mangrove forest area toward the sea. In this case, certain area of the mangroves may have to be cleared for the construction, and diverged flood flow may result in a change of the biological condition in the mangrove forests (refer to 2.3.2 under natural environment). This will more or less affect fishing in the related area.

There have been cases of compensation for Customary Fishing Rights loss related to developments in mangrove area in Viti Levu.

(4) Solid Waste

The construction of the diversion channels and work for river dredging will need a large scale excavation and result in generating large quantity of earth and river sediments. Although most of the earth and sediments will be used at the site for dike construction, transport and disposal of certain amount of construction wastes will still be required.

Therefore, solid waste disposal has to be well planned. Similar problem may also be encountered during the construction of other facilities.

2.3.2 Natural Environment

(1) Topography/Geography and Soil Erosion

Among the proposed flood control projects, the constructions of the diversion channels are of great scale and may more or less cause a change in the topography at the project sites. Consideration should be given on this impact.

As described in Supporting Report Part H (Forest and Soil Erosion), soil erosion is a serious problem in the four river basins and a total soil loss of about 30 million ton per year has been estimated. During project construction, prevention of soil erosion should be stressed.

(2) Groundwater

Regarding groundwater, possible impacts may be caused by the diversion channels in the operation phase.

Since the diversion channels head to the sea, backward tidal flow through the channels will be unavoidable. For example, Nadi river often experiences a tidal flow backward up to the bridge in Nadi Town. In such a case, sea water may probably intrude into the diversion channel up to more than half of its length. If the bottom of the channel is not well sheeted, sea water may infiltrate into groundwater aquifer and result in groundwater pollution.

The extent of the above mentioned impacts depends on the condition of groundwater utilization in the related area. Further identification of the impacts is necessary at the feasibility study stage.

(3) Coastal Area

For the diversion channel in the Rewa, its outlet will be in the mangrove forest area. Clearance of some mangrove trees for channel construction is one reason for the impacts and intrusion of the diverged flood water into the mangrove forest is another. Figure-J2.2 shows the mangrove communities at the Rewa diversion channel site where there are mainly the Dogo Forest Alliance (dominant species: Dogo) and Mixed Alliance (dominant species: Dogo and Selala). According to the Mangrove Management Plan for Fiji (Watling, 1987; 1988), the mangroves at the Rewa have been designated as the Traditional Use Zone - mangrove areas which are subject to continual use and are required for the sustainable subsistence needs of rural communities. The traditional use zone is thought to be of secondary importance in mangrove management and conservation in comparison with the Resource Reserve Zone which is the mangrove area identified as being of primary importance specifically in the sustenance of the capture fisheries.

When the diversion channel introduces flood water into the mangrove area, possible impacts may mainly caused by two factors: 1) accumulation of sediments and 2) reduction of salinity. The former may alter the structure of the substrate where mangroves lay their roots in, and the later may affect the nutrient balance necessary for mangroves to grow.

However, environment studies have pointed out the problem of drought (lack of fresh water) which makes mangroves stunted in some mangrove forests in Fiji (Raj, U and Seeto, J, 1986). Such a condition is observed in the Rewa Delta area. From this viewpoint, positive impacts are envisaged when the diversion channel brings more fresh water to the mangrove forest, but possible adverse impacts may be caused by sediments accumulation.

For the Rewa diversion channel, because Bau Island lies at the offshore not far from the Namata river mouth and several coral communities are scattered around the island, sediments carried to this area may increase sea water turbidity and affect its scenery. Further study on this impact shall be required before project implementation.

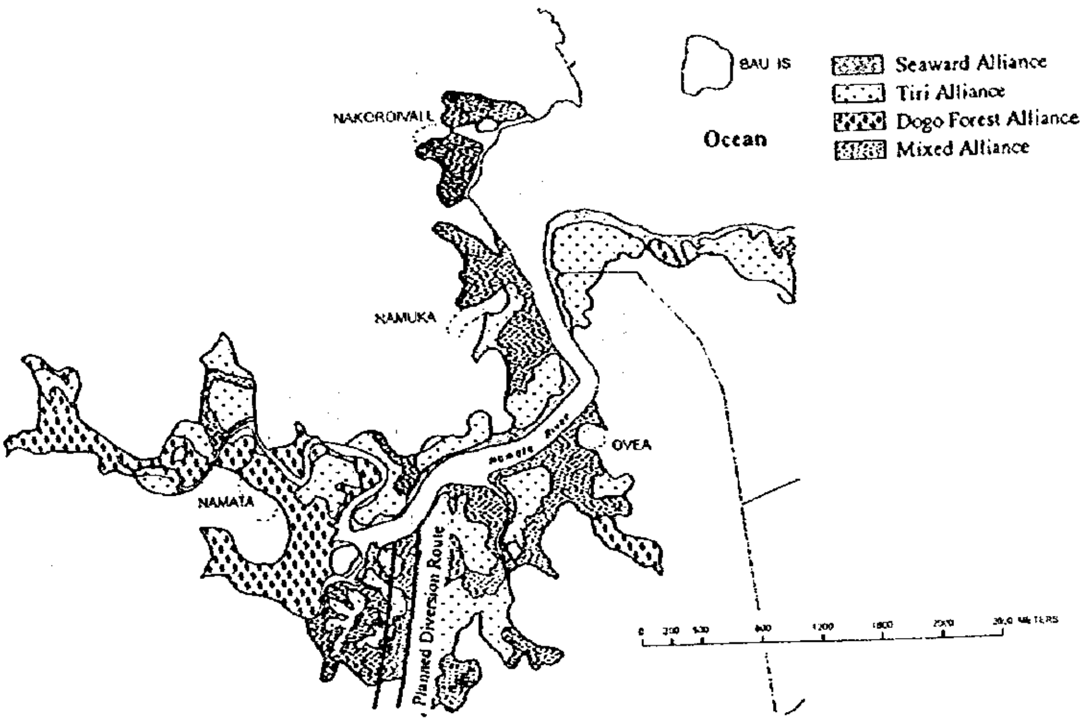


Figure-J2.2 Mangrove Communities at the Site of Diversion Channel for Rewa River

As for the Nadi diversion channel, the impacts anticipated are coastal erosion and sediment accumulation since the channel's outlet will be at the sand beach area with shallow water depth and naturally shaped coastal line. This problem shall be investigated at the feasibility study stage. There exist no coral reefs in the vicinity area.

(4) Flora & Fauna

Generally speaking, all the proposed projects will not pose impacts on flora and fauna except the Rewa diversion channel with its outlet at the mangrove area. The impacts on the mangroves have already been discussed above.

(5) Landscape

The proposed projects at the downstream areas of Rewa and Nadi Rivers may change the landscape, because the diversion channels are large river engineering constructions.

However, the impacts may become positive if aesthetic factors are taken into consideration in the engineering design.

2.3.3 Environmental Hazards

(1) Water Pollution

For the Nadi diversion channel, water quality in the main river course downstream of the diversion point has to be well considered regarding the distribution of flow to the river course and channel course during the non-flooding period. Although the total population of Nadi Town is not big, most of the residents and commercial activities are concentrated in the town area which lies in between the diversion point and the confluence of the Nawaka creek to the Nadi river. With a comparatively high pollutant load (including that from a sewage treatment plant outlet and many septic tanks and sewers) discharged into this section of stream but no additional flow from any tributary to contribute to pollutant dilution, river water pollution progresses up to the confluence point where the Nawaka creek carries an amount of flow from a large catchment area into the Nadi river. Based on the results of water quality survey conducted by the Study Team (JICA, 1997. 3), COD is estimated to have increased for about 20 % as river flows through this section. The National Water Quality Laboratory, PWD has even noticed nuisance condition in Nadi River at extremely dry period (no recorded data).

If part of the flow is diverged through the diversion channel, water quality in the main river will be more or less deteriorated. Table-J2.4 is a rough estimate of the change in river water quality corresponding to flow distribution ratio.

Table-J2.4 Estimate of Change in River Water Quality [a]

Case	Flow Distribution Ratio River : Channel	COD Increase [b]
1	2 : 1	about 9.5 %
2	1 : 1	about 19 %
3	1 : 2	about 38 %

Note : (a) Estimate based on water quality survey results;
(b) Results can only be given as percent because of lack of flow rate data.

From a viewpoint of river water quality conservation, it is recommendable that for Nadi river, diversion channel construction should not worsen the sanitary condition of the main stream, and diversion of a large amount of flow during the non-flooding period should be avoided.

For the Rewa diversion channel, because the flow in the main stream is much larger and river water quality is better at present, the above mentioned problem is less serious. However, during project construction, deterioration of river water may also happen, such as an increase in suspended solids from the work site. This is a common problem for all the proposed projects. Therefore, suitable countermeasures have to be taken.

(2) Noise & Vibration

Noise and vibration from construction machinery and vehicles may more or less affect the life of residents near a work site and/or transportation road for the project constructions in the populated area. Restriction and regulation of working hour etc. should be considered for mitigating the possible impacts.

2.3.4 Other Environmental Items

Regarding the other environmental elements, no adverse impacts are anticipated from any of the project activities for the following reasons:

- Community Separation: The implementation of any of the proposed projects may not result in this problem.
- Public Health & Sanitation: All the projects may not cause any adverse impact on this item. On the contrary, flood damage mitigation can improve the residents' living condition and benefit public health.
- Risk of Disaster: Flooding is the most serious natural disaster in Fiji, and all the flood control projects can mitigate the risk.
- Lake and Rivers: Impact is positive since the projects are for river improvement.
- Meteorology: The projects are not liable to cause any change in the weather.
- Air Pollution: There may not be any source to cause air pollution from the projects.
- Soil Pollution: No pollution source is anticipated.
- Ground Subsidence: Impossible to be induced by the projects.
- Offensive Odor: No source to emit offensive odor.
- Hazardous Substances: Although hazardous substances management is important from a view point of water resource conservation, the implementation of the projects may not impose adverse impact on this item.

2.3.5 Environmental Impact Assessment for the Priority Project

The IEE is a preliminary examination of all the environmental elements related to the projects proposed in the Flood Control Master Plan. Its output shall provide 1) the basis for the environmental impact assessment (EIA) to be conducted in the next phase of the study for the priority project, and 2) a reference for the EIA for the other projects when they are implemented in the future as is suggested in the Master Plan.

For the priority project, the environmental elements on which significant or possible adverse impacts have been identified by the IEE shall be further studied in accordance with the detailed plan of the project at that stage. The EIA study shall mainly include 1) description of the environmental setting, 2) assessment of environmental impacts, 3) recommendation of mitigation measures, 4) environmental management and monitoring plan and 5) consideration on environmental mediation.

CHAPTER 3 SITE SURVEY FOR SOCIAL AND NATURAL ENVIRONMENT

3.1 Introduction

In order to understand the present condition of social and natural environment at the sites for the priority project, i.e. the Nadi diversion channel and shortcut channel, the Study Team conducted site investigations through the subcontract with a local consultant. The investigations related to the EIA study include interview survey, traffic survey and groundwater survey.

3.2 Interview Survey for Social Environment

3.2.1 Survey Area

The survey area covers the area where land acquisition and resettlement may probably happen with project implementation. It includes the planned sites for the Nadi diversion channel and shortcut channel (Figure-J3.1).

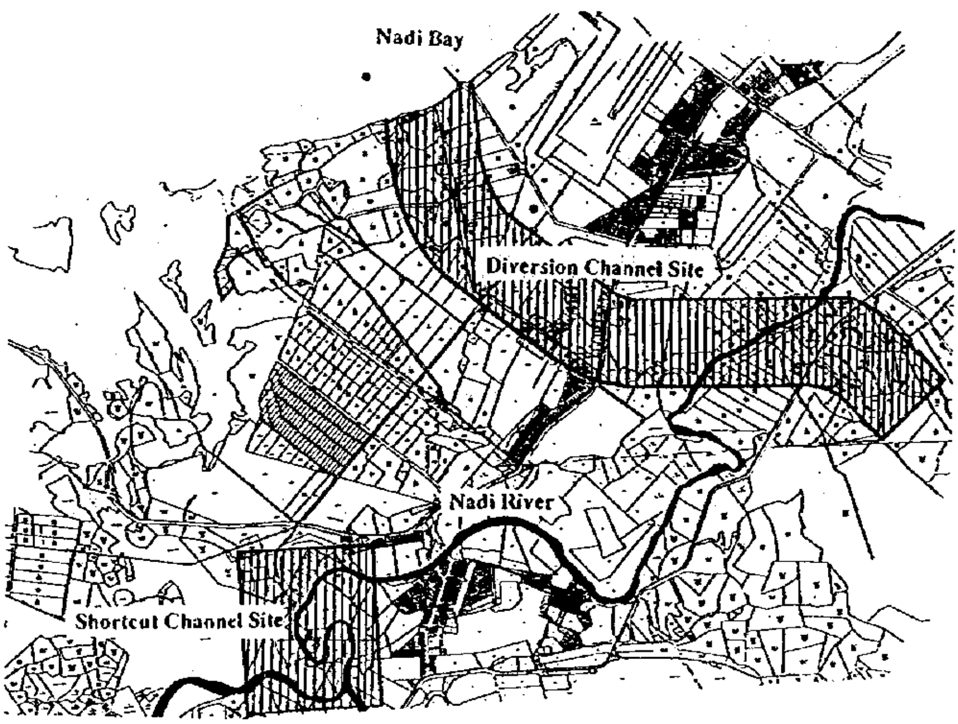


Figure-J3.1 Interview Survey Area

3.2.2 Interview Items

The interview survey was conducted by visiting the households living in the survey area by a subcontractor. The interview items are as below:

- Composition of the household (name, age, sex, education, etc.)
- Living in the present house since (when) and came from (where)
- Reasons for choosing the location for the present house
- Race and religion
- Occupation and work place location
- School learning and its location
- Location of medical care
- Monthly or annual income of the household
- Area and condition (building, garden, parking etc.) of land
- House condition (building area, floor area, structure, quality, year built, maintenance condition)
- Land ownership and status
- Size of farmland owned/occupied, land status, average income of farming
- Values of house, land and property owned/occupied
- Effect of resettlement
- Utilities (road, water supply, sewerage, electricity, telephone, etc.)
- Other social aspects

Public and private facilities other than residential houses were also visited regarding the above items.

134 households were visited during the interview survey from Dec. 1997 to Feb. 1998. The results were inputted into a data base in Microsoft Access format.

3.3 Survey on Traffic Volume at Queens Road

3.3.1 Survey Location and Method

Figure-J3.2 shows the location of the traffic survey points. Three representative sections were selected at the crossing of Queens Road and Enamanu Road near McDonald's -- two at Queens Road (upper and down the crossing) and one at Enamanu Road. The survey points are at the two sides of each section for counting the traffic volume of each lane. The survey was conducted on a weekday (Jan. 28, 1998) from 6:00 a.m. to 8:00 p.m. by the subcontractor. Vehicle number was counted by vehicle type as heavy truck, small truck, large bus, microbus/minivan, passenger car passing the survey point. Numbers were noted at 30-minute interval.

3.3.2 Survey Results

The survey results were inputted into a data base in Microsoft Excel format. Detailed analysis was explained in Chapter 4 below.

3.4 Survey on Groundwater Utilization

3.4.1 Survey Area

The survey area covers the diversion channel site and its vicinity with a total area of 6 km^2 (Figure-J3.3).

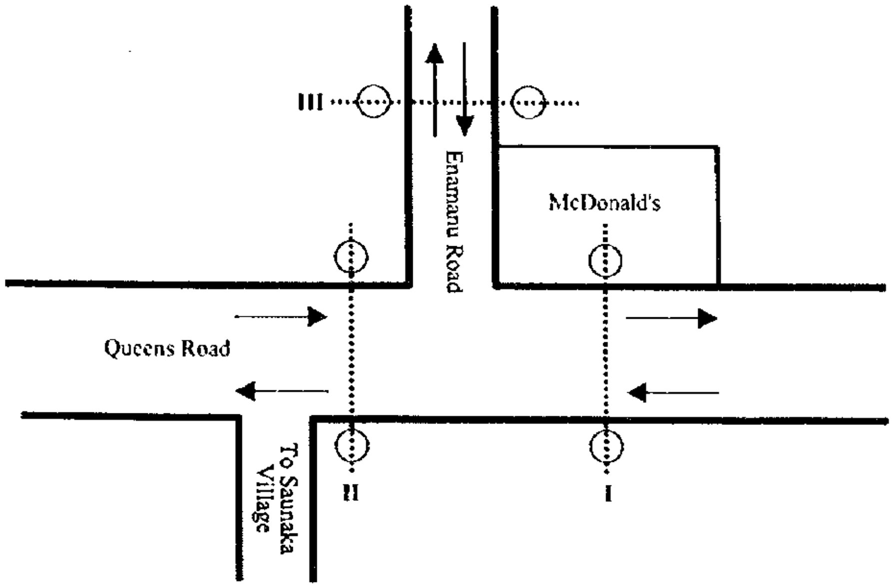


Figure-J3.2 Location of Traffic Survey Points

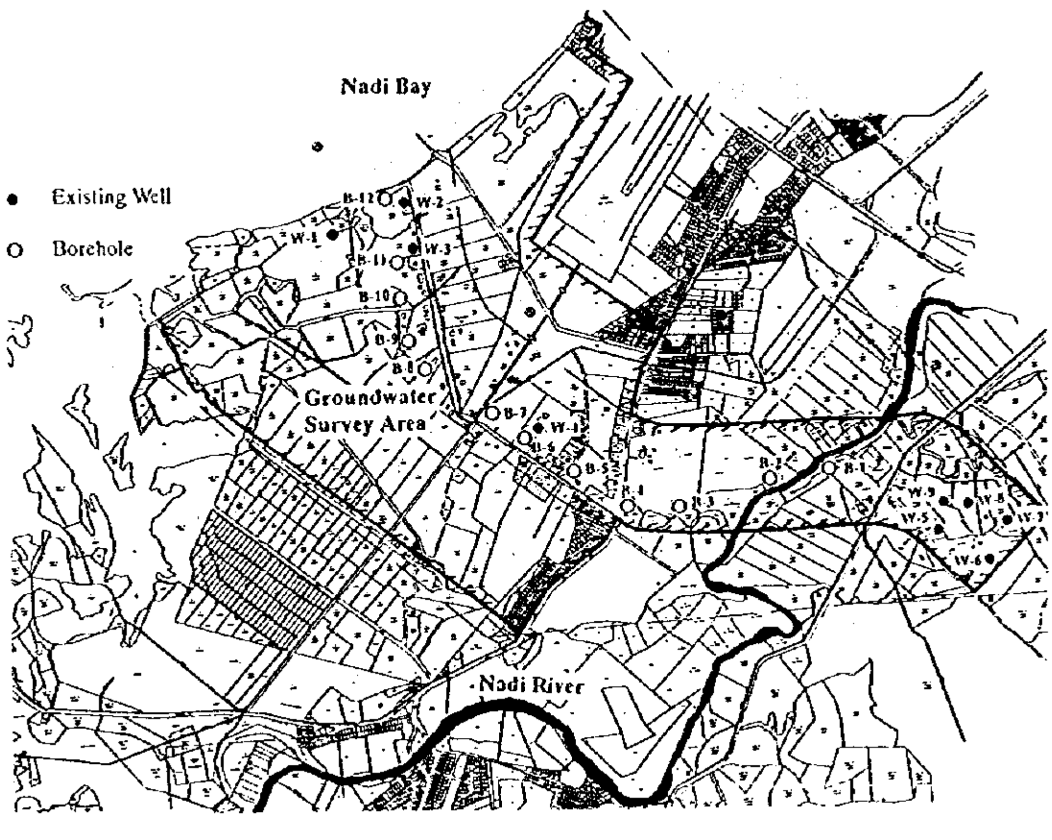


Figure-J3.3 Location of Existing Wells and Boreholes Drilled During This Study

3.4.2 Survey Results

In the whole survey area, 9 existing wells were identified (refer to Figure-J3.3 for well locations) – 4 at the right bank (coastal side) and 5 at the left bank (inland side) of Nadi River. Table-J3.1 shows the depth, electric conductivity (EC) and utilization condition of these wells. The EC measurement was carried out by using a potable EC meter.

For better understanding of groundwater quality in the project area, EC measurement was also conducted for the 12 boreholes drilled during the geological survey for this study. Their locations are also shown in Figure-J3.3 and measurement results in Table-J3.2.

Table-J3.1 Existing Wells in the Project Area

Well No.	Depth (m)	EC (μS/cm)	Description
W-1	-	-	Dry well, no longer using.
W-2	-	-	Dry well, no longer using.
W-3	15	251	Drinking in emergency, but not often. Even waste gasoline was dumped to the well.
W-4	-	-	Dry well, no longer use.
W-5	6	460	Washing, emergency drinking.
W-6	5	610	Washing, emergency drinking.
W-7	5	368	Washing, emergency drinking.
W-8	6	171	Washing, emergency drinking.
W-9	7	311	Washing, emergency drinking.

Table-J3.2 EC-Measurement of Borehole Water

Borehole No	Depth (m)	EC (μS/cm)	Description
B-1	5.0	1080	Nadi River side
B-2	6.0	411	-
B-3	7.0	115	-
B-4	4.5	120	-
B-5	5.0	161	-
B-6	5.0	205	-
B-7	3.0	580	-
B-8	2.0	1000	-
B-9	1.5	2700	-
B-10	1.5	5600	Near a drainage channel
B-11	2.0	10000	Near a drainage channel
B-12	1.0	4000	Sea side

3.5 Survey on Coastal Environment

Regarding the present condition of coastal environment, tidal current survey was conducted by a subcontractor during third work period in Fiji, November '97 ~ March '97 (refer to Supporting Report Part I). In addition, the Study Team and MAFF counterparts carried out site investigation of the coastal area, and the condition of several drainage channels and flood gates near the project area (Wailoaloa and Nasoso). This includes EC measurement of water along the channels and observation of biological conditions. The results shall be used for the analysis of environmental impacts.