Appendix 12.4.2 Sewage Treatment Plant - Capacity Calculation

CAPACITY CALCULATION OF FACILITIES
Alternative 2 - Nuwara Eliya (Aerated Lagoon)

1 BASIC CONDITIONS

1-1 BASIC ITEMS

(1) Name : Nuwara Eliya Sewage Treatment Plant

(2) Land Area : Approximately 2.00 ha

(3) Elevation : 1855.000 m

(4) Inlet Pipe Level : 1854.850 m

(5) Pipe Diameter : 400 m

(6) Land Use : Tea Plantation

(7) Collection System : Seperate Type

(8) Treatment Method : Sewage Treatment : Aerated Lagoon Method
Sludge Treatment : Pond Accumulation

(9) Effluent Point : Nanu Oya

(10) Effluent Point Water Level : 1852.000 m

(11) Target Year : Year 2000 (Phase 1)

(12) Lowest Monthly Average Temperature 15 °C (January)

1-2 Design Population

Design Population : 1,830 Persons (Total)

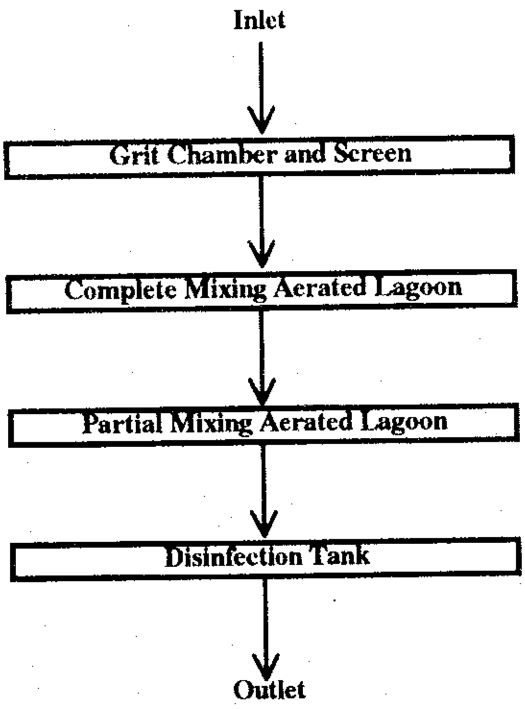
1-3 Design Sewage Flow

ITEM	m3/day	m3/hr	m3/min	m3/sec
Daily Average	1,200	50.0	0.83	0.014
Daily Maximum	1,250	52.1	0.87	0.014
Hourly Maximum	2,400	100.0	1.67	0.028

1-4 Design Sewage Quality

ITEM	INFLUENT (mg/L)	EFFLUENT (mg/L)	REMOVAL RATIO (%)	REMARKS
BOD	240	30	88	
SS	250	50	80	

1-5 Flow Chart (Dual Power Aerated Lagoon)



1-6 Design Criteria for Dual Power Aerated Lagoon

ITEMS	UNIT	Formula or Value	Application
1-6-1 Grit Chamber			
(1) Water Surface Load	m3/m2/day	> 1800	1,800
(2) Average Velocity	m/sec	> 0.3	0.3
1-6-2 Complete Mixing Aerated Lagoon			
(1) Retention Time	day	1.5 - 2.5	1.50
(2) Water Depth	m	3.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 6.0	6.0
1-6-3 Partial Mixing Aerated Lagoon			
(1) Retention Time	day	2.0	2.0
(2) Water Depth	m	2.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 1.0	1.0
(4) Number of Cell	Cell/Basin	1 - 3	3
1-6-4 Storm Water Settling Tank			
(1) Water Depth	m	1.5 - 3.0	1.5
(2) Retention Time (Hourly Max. - Rain)	hour	> 0.5	0.5
(3) Water Surface Load (Hourly Max. - Rain)	m3/m2/day	75 - 150	150.0
1-6-5 Disinfection Tank			
(1) Retention Time	min.	> 15	15.0
(2) Dosage	mg/l	2.0 - 4.0	3.0

2 CAPACITY CALCULATION

2-1 Grit Chamber and Screen (Hourly Maximum)

ITEM		SIGN	UNIT	CALCULATION	RESULT
Type		-	-	Parallel Flow Type	
Design Flow		Q1	m3/day	-	2,400
		Q2	m3/sec	-	0.028
Water Surface Load		WSL	m3/m2/day	-	1,800
Required Surface Area		RSA	m2	Q1/WSL	1.333
Basin Number (Total)		BN	basin	-	3
Basin Number (Stand-By)		BNS	basin	-	1
Average Velocity		V	m/sec	-	0.30
Depth		H	m	-	0.30
Width		W1	m	Q2/(V*H)	0.309
	Therefore	W2	m	-	0.50
Length		L1	m	RSA/W2/(BN-BNS)	1.333
	Therefore	L2	m	-	1.40
Dimension	(W)	W	m	W2	0.50
	(L)	L	m	L2	1.40
	(Basin)	-	basin	BN	2
	(Stand-By)	-	stand-by	BNS	1
Screen Type		-	-	Fine Bar Screen	
Screen Set Number		SSN	set	BN	3
Check			UNIT	APPLICATION	RESULT
Water Surface Load			m3/m2/day	> 1800	1,714
Average Velocity			m/sec	> 0.3	0.09

2-2 Complete Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	1,250
	Q2	m3/hr	-	52.08
Retention Time	T1	day	-	1.50
Inlet BOD Quality	So	mg/L	-	240
Required Volume	V1	m3/basin	Q1*T	1,875
Basin Number	BN	basin	-	4
Required Volume per Basin	VBN	m3/basin	Q1*T/BN	469
Water Depth	H	m	-	3.00
Required Surface Area	A	m2	V/H	156
Width	W	m	-	14.00
Length	L1	m	A/W	11.161
Therefore	L2	m	-	12.00
Oxygen Demand Rate	PR1	kg/h	(4.16*10^-5)*r*Q1*So	19
-max. oxygen uptake	r	W/m3	-	1.5
Aeration Unit Power Rate	PRO	kg/h	1000*PR1/(N*Q1*T1)	5.25
Therefore	PRO	W/m3	-	5.3
-aeration performance	N	W/m3	-	1.9
Power Requirement	P1	kW	-	12.0
1) Oxygen Requirement	P1O	kW	PR1/N	9.9
2) Mixing Power	P1M	kW	V1*P0*10^-3	11.3
Dimension (Width)	W	m	W	14.00
(Length)	L	m	L2	12.00
(Depth)	H	m	H	3.00
(Basin)	-	basin	BN	4
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Retention Time		day	1.5 - 2.5	1.61

2-3 Partial Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	1,250
	Q2	m3/hr	-	52.08
Retention Time	T2	day	-	2.00
Required Volume	V2	m3/basin	Q2*T	2,500
Basin Number	BN	basin	-	4
Cells Number	CN	cell/basin	-	3
Stand-by Cell Number	CNS	basin	-	1
Sludge Accumulation	SA	m3/year	365*Q1*Xi/(x*10^6)	627
-inert solid concentration	Xi	mg/l	-	55
-weight fracrion of solids	x	-	-	0.04
No. of Cells Cleaned per Year	CNC	basin	-	2
Total Sludge Accumulation	TSA	m3	-	941
Required Volume	V	m3/cell	(Q1*T+TSA)/(BN*CN-CNS)	313
Water Depth	D	m	-	4.00
Required Surface Area	A	m2/cell	V/H	78
Width	W	m	-	12.00
Length	L1	m	A/W	6.517
Therefore	L1	m	-	15.00
Power Requirement	P2	kW	-	3.0
1) Mixing Power	P2M	kW	Q1*T2*CN*10^-3	2.5
Dimension (Width)	W	m	W	12.00
(Length)	L	m	L1	15.00
(Depth)	H	m	H	4.00
(Basin)	-	basin	BN	4
(Cell)	-	cell/basin	CN	3
(Stand-by Cell)	-	cell	-	1
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Surface Area		m2	-	2,160
Retention Time		day	2.0	5.58

2-4 Disinfection Tank (Daily Maximum)

ITEM		SIGN	UNIT	CALCULATION	RESULT
Chemical Type		-	-	Chlorination Type	
Design Flow		Q1	m3/day	-	1,250
		Q2	m3/min	-	0.87
Retention Time		T	min.	-	15.0
Basin Number		BN	basin	-	1
Required Volume		V	m3	Q2*T	13
Width		W	m	-	1.00
Water Depth		H	m	-	1.00
Length		L1	m	V/(W*H)	13.021
	therefore	L2	m	-	13.00
Dosage		D	mg/L	-	3.0
Required Chemical		RC1	kg/day	Q1*D*10^-3/C	3.75
	Therefore	RC2	kg/hr	RC1/24	0.16
Dimension	(Width)	W	m	W	1.00
	(Length)	L	m	L2	13.00
	(Depth)	H	m	H	1.00
	(Depth)	BN	basin	-	1
Chlorine Feeder		-	unit	including 1 for stand-by	2
Check			UNIT	APPLICATION	RESULT
Retention Time			min.	> 15	15.0

Appendix 12.4.3 Sewage Treatment Plant - Capacity Calculation

CAPACITY CALCULATION OF FACILITIES

Alternative 2 - Hospital/Brewery (Aerated Lagoon)

1 BASIC CONDITIONS

1-1 BASIC ITEMS

(1) Name : Nuwara Eliya Sewage Treatment Plant

(2) Land Area : Approximately - ha

(3) Elevation : 1861.730 m

(4) Inlet Pipe Level : 1858.882 m

(5) Pipe Diameter : 225 m

(6) Land Use : -

(7) Collection System : Seperate Type

(8) Treatment Method : Sewage Treatment : Aerated Lagoon Method
Sludge Treatment : Pond Accumulation

(9) Effluent Point : Stream to Barrack Plain

(10) Effluent Point Water Level : 1860.000 m

(11) Target Year : Year 2015 (Phase 2)

(12) Lowest Monthly Average Temperature 15 °C (January)

1-2 Design Population

Design Population : 8,631 Persons (Total)

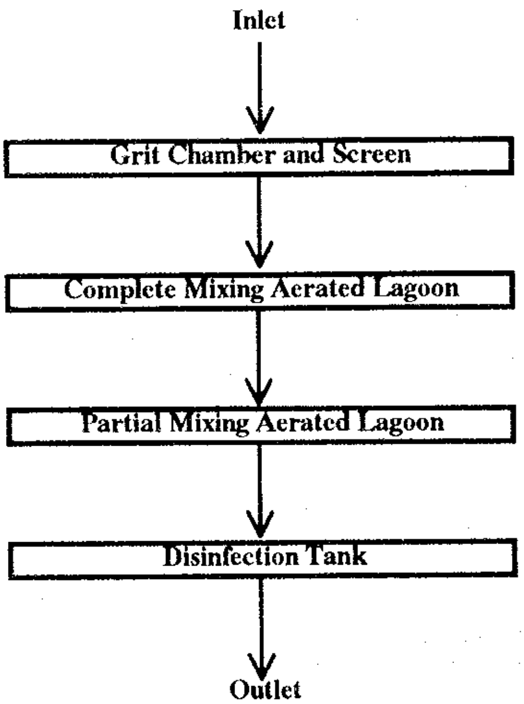
1-3 Design Sewage Flow

ITEM	m3/day	m3/hr	m3/min	m3/sec
Daily Average	170	7.1	0.12	0.002
Daily Maximum	200	8.3	0.14	0.002
Hourly Maximum	330	13.8	0.23	0.004

1-4 Design Sewage Quality

ITEM	INFLUENT (mg/L)	EFFLUENT (mg/L)	REMOVAL RATIO (%)	REMARKS
BOD	240	30	88	
SS	250	50	80	

1-5 Flow Chart (Dual Power Aerated Lagoon)



1-6 Design Criteria for Dual Power Aerated Lagoon

ITEMS	UNIT	Formula or Value	Application
1-6-1 Grit Chamber			
(1) Water Surface Load	m3/m2/day	> 1800	1,800
(2) Average Velocity	m/sec	> 0.3	0.3
1-6-2 Complete Mixing Aerated Lagoon			
(1) Retention Time	day	1.5 - 2.5	1.50
(2) Water Depth	m	3.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 6.0	6.0
1-6-3 Partial Mixing Aerated Lagoon			
(1) Retention Time	day	2.0	2.0
(2) Water Depth	m	2.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 1.0	1.0
(4) Number of Cell	Cell/Basin	1 - 3	3
1-6-4 Storm Water Settling Tank			
(1) Water Depth	m	1.5 - 3.0	1.5
(2) Retention Time (Hourly Max. - Rain)	hour	> 0.5	0.5
(3) Water Surface Load (Hourly Max. - Rain)	m3/m2/day	75 - 150	150.0
1-6-5 Disinfection Tank			
(1) Retention Time	min.	> 15	15.0
(2) Dosage	mg/l	2.0 - 4.0	3.0

2 CAPACITY CALCULATION

2-1 Grit Chamber and Screen (Hourly Maximum)

ITEM		SIGN	UNIT	CALCULATION	RESULT
Type		-	-	Parallel Flow Type	
Design Flow		Q1	m3/day	-	330
		Q2	m3/sec	-	0.004
Water Surface Load		WSL	m3/m2/day	-	1,800
Required Surface Area		RSA	m2	Q1/WSL	0.183
Basin Number (Total)		BN	basin	-	2
Basin Number (Stand-By)		BNS	basin	-	1
Average Velocity		V	m/sec	-	0.30
Depth		H	m	-	0.10
Width		W1	m	Q2/(V*H)	0.127
	Therefore	W2	m	-	0.30
Length		L1	m	RSA/W2/(BN-BNS)	0.611
	Therefore	L2	m	-	2.20
Dimension	(W)	W	m	W2	0.30
	(L)	L	m	L2	2.20
	(Basin)	-	basin	BN	1
	(Stand-By)	-	stand-by	BNS	1
Screen Type		-	-	Fine Bar Screen	
Screen Set Number		SSN	set	BN	2
Check			UNIT	APPLICATION	RESULT
Water Surface Load			m3/m2/day	> 1800	500
Average Velocity			m/sec	> 0.3	0.13

2-2 Complete Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	200
	Q2	m3/hr	-	8.33
Retention Time	T1	day	-	1.50
Inlet BOD Quality	So	mg/L	-	240
Required Volume	V1	m3/basin	Q1*T	300
Basin Number	BN	basin	-	1
Required Volume per Basin	VBN	m3/basin	Q1*T/BN	300
Water Depth	H	m	-	3.00
Required Surface Area	A	m2	V/H	100
Width	W	m	-	10.00
Length	L1	m	A/W	10.000
Therefore	L2	m	-	10.00
Oxygen Demand Rate	PR1	kg/h	(4.16*10^-5)*r*Q1*So	3
-max. oxygen uptake	r	W/m3	-	1.5
Aeration Unit Power Rate	PRO	kg/h	1000*PR1/(N*Q1*T1)	5.25
Therefore	PRO	W/m3	-	5.3
-aeration performance	N	W/m3	-	1.9
Power Requirement	P1	kW	-	2.0
1) Oxygen Requirement	P1O	kW	PR1/N	1.6
2) Mixing Power	P1M	kW	V1*P0*10^-3	1.8
Dimension (Width)	W	m	W	10.00
(Length)	L	m	L2	10.00
(Depth)	H	m	H	3.00
(Basin)	-	basin	BN	1
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Retention Time		day	1.5 - 2.5	1.50

2-3 Partial Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	200
	Q2	m3/hr	-	8.33
Retention Time	T2	day	-	2.00
Required Volume	V2	m3/basin	Q2*T	400
Basin Number	BN	basin	-	1
Cells Number	CN	cell/basin	-	3
Stand-by Cell Number	CNS	basin	-	1
Sludge Accumulation	SA	m3/year	365*Q1*Xi/(x*10^6)	100
-inert solid concentration	Xi	mg/l	-	55
-weight fracrion of solids	x	-	-	0.04
No. of Cells Cleaned per Year	CNC	basin	-	3
Total Sludge Accumulation	TSA	m3	-	151
Required Volume	V	m3/cell	(Q1*T+TSA)/(BN*CN-CNS)	275
Water Depth	D	m	-	4.00
Required Surface Area	A	m2/cell	V/H	69
Width	W	m	-	10.00
Length	L1	m	A/W	6.882
Therefore	L1	m	-	7.00
Power Requirement	P2	kW	-	1.5
1) Mixing Power	P2M	kW	Q1*T2*CN*10^-3	0.4
Dimension (Width)	W	m	W	10.00
(Length)	L	m	L1	7.00
(Depth)	H	m	H	4.00
(Basin)	-	basin	BN	1
(Cell)	-	cell/basin	CN	3
(Stand-by Cell)	-	cell	-	1
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Surface Area		m2	-	210
Retention Time		day	2.0	2.05

2-6 Disinfection Tank (Daily Maximum)

ITEM		SIGN	UNIT	CALCULATION	RESULT
Chemical Type		-	-	Chlorination Type	
Design Flow		Q1	m3/day	-	200
		Q2	m3/min	-	0.14
Retention Time		T	min.	-	15.0
Basin Number		BN	basin	-	1
Required Volume		V	m3	Q2*T	2
Width		W	m	-	0.50
Water Depth		H	m	-	0.50
Length		L1	m	V/(W*H)	8.333
	therefore	L2	m	-	9.00
Dosage		D	mg/L	-	3.0
Required Chemical		RC1	kg/day	Q1*D*10^-3/C	0.60
	Therefore	RC2	kg/hr	RC1/24	0.03
Dimension	(Width)	W	m	W	0.50
	(Length)	L	m	L2	9.00
	(Depth)	H	m	H	0.50
	(Depth)	BN	basin	-	1
Chlorine Feeder		-	unit	including 1 for stand-by	3

Check		UNIT	APPLICATION	RESULT
Retention Time		min.	> 15	16.2

Appendix 12.5 Summary of Construction Cost

Nuwara Eliya Exchange Rate = 1.8 Yen/Rs

Construction Cost - Master Plan : Alternatives

Facilities	Alternative 1				Alternative 2			
	Specifications	Civil	M & E	Total	Specifications	Civil	M & E	Total
1. Sewer								
Sub-Total		236,022		236,022		225,720		225,720
2. Pumping Station								
P/S 1	0.89*39*2	828	3,553		0.89*10*2	828	3,266	
P/S 2	2.82*24*2	1,634	4,602		1.93*24*2	1,442	4,294	
Sub-Total		2,462	8,155	10,617		2,270	7,561	9,831
2. Sewage Treatment Plant								
Nuwara Eliya	2,700m3/day	73,321	78,957		2,500m3/day	72,228	74,477	
Hospital/Brewery					200m3/day	11,652	22,664	
Sub-Total		73,321	78,957	152,278		83,880	97,141	181,021
Total		311,805	87,112	398,917		311,870	104,702	416,572

Construction Cost - Feasibility Study

Facilities	M/P (Alternative 1)				F/S (Phase 1)				Phase 2			
	Specifications	Civil	M & E	Total	Specifications	Civil	M & E	Total	Specifications	Civil	M & E	Total
1. Sewer												
Sub-Total		236,022		236,022		145,085		145,085		90,937		90,937
2. Pumping Station												
P/S 1	0.87*35*2	828	3,553		0.87*35*2	828	3,553			0	0	
P/S 2	2.89*24*2	1,634	4,602		2.89*24*2	1,634	4,602			0	0	
Sub-Total		2,462	8,155	10,617		2,462	8,155	10,617		0	0	0
2. Sewage Treatment Plant												
Nuwara Eliya	2,700m3/day	73,321	78,957		1,400m3/day	41,910	40,116		1,400m3/day	31,411	38,841	
Hospital/Brewery												
Sub-Total		73,321	78,957	152,278		41,910	40,116	82,026		31,411	38,841	70,252
Total		311,805	87,112	398,917		189,457	48,271	237,728		122,348	38,841	161,189

Appendix 12.6 Cost of Sewer

Alternative 1 (Applied) (Unit : Rs)

ITEM	DESCRIPTION	Depth	UNIT	RATE	Master Plan QUANTITY	Master Plan COST	Feasibility Study QUANTITY	Feasibility Study COST
Clay Pipe Laying	150 mm (Lateral)	1.5	m	5,498	5,200	28,589,600	4,000	21,992,000
	150 mm	1.5	m	5,498	7,139	39,250,222	3,769	20,721,962
	225 mm	1.5	m	7,142	2,245	16,033,790	2,245	16,033,790
	225 mm	2.5	m	9,603	310	2,976,930	310	2,976,930
	300 mm	1.5	m	10,593	270	2,860,110	270	2,860,110
	300 mm	2.5	m	13,173	470	6,191,310	470	6,191,310
	300 mm	3.5	m	16,147	350	5,651,450	350	5,651,450
	400 mm	1.5	m	15,652	730	11,425,960	730	11,425,960
	400 mm	3.5	m	21,489	50	1,074,450	50	1,074,450
DI Pipe Laying	150 mm	1.5	m	7,358	1,400	10,301,200	1,400	10,301,200
	200 mm	1.5	m	8,514	620	5,278,680	620	5,278,680
Manhole	Type 1		Nr	67,379	335	22,571,965	244	16,440,476
	Type 2		Nr	79,205	—	—	—	—
	Type 3		Nr	91,957	—	—	—	—
Connection Pipe	100mmPVC ,L=4m		Nr	25,712	2,691	69,190,992	754	19,386,848
Inspection Pit	RC,300×300		Nr	5,098	2,691	13,718,718	754	3,843,892
Siphon		3.5	Nr	480,671	1	480,671	1	480,671
Siphon Pipe	150mm×2	3.5	m	10,641	40	425,640	40	425,640
TOTAL	Sewer Main + Lateral				18,784	236,021,688	14,214	145,085,369
	Sewer Main				13,584		10,214	

Alternative 2 (Unit : Rs)

ITEM	DESCRIPTION	Depth	UNIT	RATE	Master Plan QUANTITY	Master Plan COST	Feasibility Study QUANTITY	Feasibility Study COST
Clay Pipe Laying	150 mm (Lateral)	1.5	m	5,498	5,200	28,589,600		
	150 mm	1.5	m	5,498	7,139	39,250,222		
	225 mm	1.5	m	7,142	2,245	16,033,790		
	225 mm	2.5	m	9,603	310	2,976,930		
	300 mm	1.5	m	10,593	270	2,860,110		
	300 mm	2.5	m	13,173	470	6,191,310		
	300 mm	3.5	m	16,147	350	5,651,450		
	400 mm	1.5	m	15,652	730	11,425,960		
	400 mm	3.5	m	21,489	50	1,074,450		
DI Pipe Laying	150 mm	1.5	m	7,358	—	—		
	200 mm	1.5	m	8,514	620	5,278,680		
Manhole	Type 1		Nr	67,379	335	22,571,965		
	Type 2		Nr	79,205	—	—		
	Type 3		Nr	91,957	—	—		
Connection Pipe	100mmPVC ,L=4m		Nr	25,712	2,691	69,190,992		
Inspection Pit	RC,300×300		Nr	5,098	2,691	13,718,718		
Siphon		3.5	Nr	480,671	1	480,671		
Siphon Pipe	150mm×2	3.5	m	10,641	40	425,640		
TOTAL	Sewer Main + Lateral				17,384	225,720,488		
	Sewer Main				12,184			

Manhole Span	50 m	
Manhole Type	φ 150～600	Type 1
	φ 700～900	Type 2
	φ 900～1200	Type 3

Numbers of Service Connections

	Nuwara Eliya	Reference
Size of Family (people/house)	4.84	
M/P Population (2015)	8,681	
Domestic (No. of Houses)	1,794	
Total (No. of houses)	2,691	Domestic × 1.5
F/S Population (2005)	1,827	
Domestic (No. of Houses)	377	
Total (No. of Connections)	754	Domestic × 2

Appendix 12.7 Unit Cost

Appendix 12.7.1 Unit Cost of Civil Works

[ ] are used for cost estimate.

Item	Unit	NWSDB Rate 97		Towns South - Ground Reservoir			Towns South - Pumping Station			Applied	Adjusted
			Overhead 20%	Local (Rs)	Forign(Yen)	Total (Rs)	Local (Rs)	Forign(Yen)	Total (Rs)		
1. Excavation											
Bulldozer (incl. Backfilling)		(Basement)	(Basement)								490.00
Backfoe (incl. Backfilling)		(Pit/Trench)	(Pit/Trench)	(150 mm)			(225 mm)				790.00
Rock excavation	m^3	1,469.00	1,763.00	69.00	544.38	371.43	1,716.00	195.27	1,824.48	1,808.99	1,990.00
2. Earth Filling											430.00
earth available at site	m^3	141.00	169.00							169.00	190.00
earth to be borrowed	m^2	324.00	389.00							389.00	430.00
3. Soil Disposal											310.00
On site	m^3	68.00	82.00							68.00	80.00
Off site	m^3	232.00	278.00							278.00	310.00
4. Piling											
On site 600 mm dia.	m			1,824.81	14,399.00	9,824.25				9,824.25	10,810.00
5. Concrete Work											
Grade 10											7,840.00
Foundations	m^3	3,743.00	4,492.00	76.07	600.18	409.50	514.80	58.58	547.34	7,123.19	
Grade 20/30		(Grade 20)		(Grade 30)			(Grade 30)			8,658.97	9,530.00
Columns	m^3	4,868.00	5,842.00	1,820.50	14,362.89	9,799.88	6,864.00	781.07	7,297.93	8,659.97	9,530.00
6. Form Work										960.43	1,060.00
7. Reinforcement										66,328.41	72,970.00
Tor steel		50,220.00	60,264.00	13,510.53	106,591.98	72,728.30	62,920.00	7,159.76	66,897.64	66,329.41	72,970.00
Mild steel	ton	46,920.00	56,304.00	11,312.83	89,253.07	60,897.87	62,920.00	7,159.76	66,897.64	66,329.41	72,970.00
8. Building											
Offices 2F, 126 m^2	m^2	9,600.00	11,520.00	13,494.97	1,535.61	14,348.09				14,226.22	15,700.00
Operating houses	m^2	8,600.00	10,320.00								20,000.00
Pumping Station BF, 181m^2							31,855.72	3,624.91	33,869.56	33,581.87	37,000.00
Chlorine House 1F, 24m^2	m^2			17,014.23	1,973.50	18,110.62				17,953.99	19,800.00
Store houses 1F, 24m^2	m^2	8,200.00	9,840.00	18,950.98	2,156.46	20,149.01				19,977.86	22,000.00
Quarters 1F, 100m^2	m^2			17,496.47	1,971.32	18,591.64				18,435.19	20,300.00
9. Pavement											
Reinstatement	m^2	-	-	206.58	1,629.82	1,112.04	(Actual payment to RDA Rs. 2000.00)			2,000.00	2,000.00
10. Miscellaneous											
Miscellaneous	%	-	-								5 to 20 %

Appendix 12.7.2 Unit Cost of Piping Materials

[ ] are used for cost estimate.

Diameter (mm)		NWSDB Rate 97		Beire Lake	Manufacturer	Towns South				Applied	Adjusted
		Rs/m	Overhead 20%	Rs/m	Rs/m	Local (Rs)	Forign(Yen)	C. D. (Rs)	Total (Rs)		
1. Water Supply											
DIP		(CIF+C.D.)									
200	mm	2,647.48	3,177.00								3,500.00
250	mm	2,981.44	3,578.00			65.58	6,467.59	661.72	3,807.10	3,807.10	4,190.00
300	mm	3,794.56	4,553.00			82.79	8,165.06	835.39	4,806.30	4,806.30	5,290.00
350	mm	4,537.50	5,445.00			103.27	10,234.03	1,041.95	6,018.57	6,018.57	6,630.00
400	mm	5,324.00	6,389.00			137.05	13,515.35	1,382.79	7,955.72	7,955.72	8,760.00
450	mm	6,352.50	7,623.00			144.09	14,210.53	1,453.92	8,364.93	8,364.93	9,210.00
500	mm	7,292.67	8,751.00			193.08	19,041.13	1,948.15	11,208.43	11,208.43	12,330.00
600	mm	9,075.00	10,890.00			223.43	22,034.08	2,254.36	12,970.21	12,970.21	14,270.00
700	mm	11,918.50	14,302.00								20,000.00
800	mm	14,762.00	17,714.00			462.19	45,580.63	4,663.47	26,830.72	26,830.72	29,520.00
900	mm	15,851.00	19,021.00								35,000.00
PVC (type 600)											(type 600)
63	mm	50.00	60.00			55.95	55.18		82.23	82.23	100.00
75	mm	78.00	94.00							114.78	130.00
90	mm	118.00	142.00			109.75	108.23		161.29	161.29	180.00
110	mm	173.00	208.00			161.15	158.93		236.83	236.83	270.00
160	mm	340.00	408.00			340.35	335.65		500.18	500.18	560.00
225	mm	655.00	786.00			667.15	657.94		980.45	980.45	1,080.00
2. Sewerage											
PVC (type 600)					(type 400)	(type 600)					(type 600)
110	mm	173.00	208.00			161.15	158.93		236.83	236.83	270.00
160	mm	340.00	408.00		786.95	340.35	335.65		500.18	500.18	510.00
225	mm	655.00	786.00		1,496.80	667.15	657.94		980.45	980.45	990.00
280	mm	1,013.00	1,216.00		2,294.65					2,294.65	2,300.00
315	mm				2,888.02					2,888.02	2,890.00
Hume Pipe											
150	mm	352.00	422.00		198.39						
225	mm	497.00	596.00		273.13						
250	mm										
300	mm	660.00	792.00		355.25					792.00	800.00
375	mm	900.00	1,080.00		516.73					1,080.00	1,080.00
400	mm										
450	mm	995.00	1,194.00		611.31	2,577.99	1,307.04		3,200.39	1,194.00	1,200.00
500	mm										
544	mm					4,124.78	2,091.26		5,120.62	(with inner lining)	
600	mm	1,386.00	1,663.00		847.07					1,663.00	1,670.00
675	mm			5,960.00						5,960.00	5,960.00
750	mm	1,868.00	2,242.00	6,790.00	1,092.52					6,790.00	6,790.00
825	mm			7,630.00	1,093.52					7,630.00	7,630.00
900	mm	2,542.00	3,050.00		1,495.76					3,660.00	3,660.00
1050	mm	3,300.00	3,960.00		3,820.13					4,752.00	4,760.00
Clay Pipe											
150	mm	410.00	492.00	730.88						730.88	740.00
225	mm	648.00	778.00	1,789.84						1,789.84	1,790.00
250	mm										
300	mm	1,235.00	1,482.00	4,464.66						4,464.66	4,470.00
400	mm			8,578.39						8,578.39	8,580.00
450	mm			9,959.28						9,959.28	9,960.00
500	mm			12,457.10						12,457.10	12,460.00
600	mm			24,476.30						24,476.30	24,480.00

Note : 1. For transmission mains of water supply, 20 % of the cost of pipes shall be add to compensate the cost of specials,valves etc.

2. For diatribution mains of water supply, 35 % of the cost of pipes shall be add to compensate the cost of specials,valves etc.

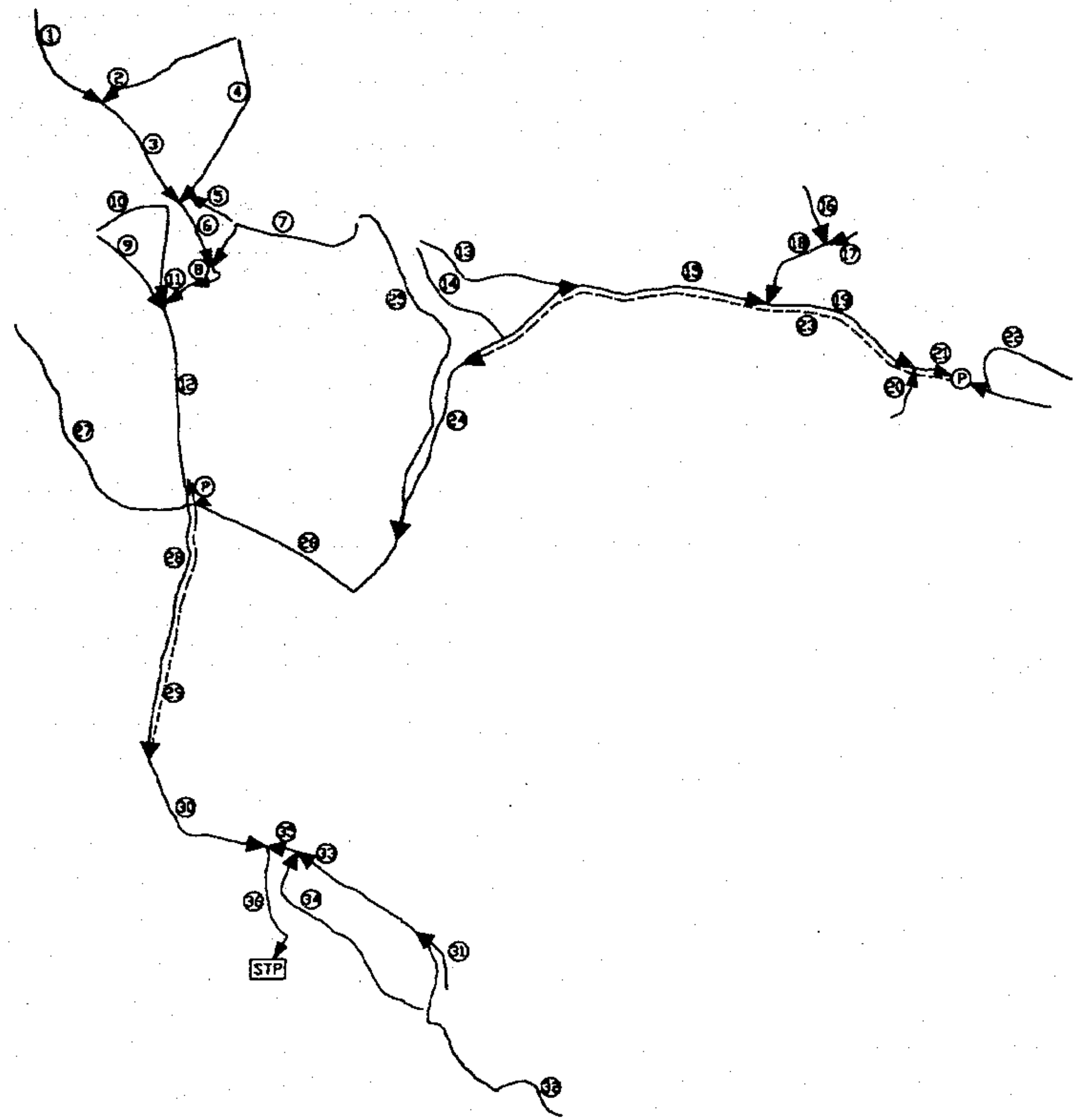
Appendix 12.7.3 Unit Cost of Pipe Laying

[ ] are used for cost estimate.

Item	Diameter (mm)		NWSDB Rate 97 Rs/m	NWSDB Rate 97 Overhead 20%	Towns South Local (Rs)	Towns South Forign(Yen)	Towns South Total (Rs)	Japan Man-Day	Sri Lanka Rs/m	Applied	Adjusted (only Pipe Laying)
1. Laying											
DIP			(with 1 to 2m excavation, backfilling etc.)								
	200	mm	559.00	671.00				0.18	124.60	124.60	125.00
	250	mm	580.00	696.00	100.06	789.40	475.96	0.22	154.00	154.00	154.00
	300	mm	698.00	838.00	105.58	832.96	502.23	0.26	182.70	182.70	183.00
	350	mm	740.00	888.00	123.73	976.16	588.57	0.32	222.60	222.60	223.00
	400	mm	795.00	954.00	129.25	1,019.72	614.83	0.38	269.03	269.03	270.00
	450	mm	852.00	1,022.00	149.53	1,180.10	711.48	0.45	316.87	316.87	317.00
	500	mm	942.00	1,130.00	258.50	2,039.45	1,229.67	0.52	365.40	365.40	366.00
	600	mm	1,077.00	1,292.00				0.66	463.87	463.87	464.00
	700	mm	1,234.00	1,481.00				0.80	562.33	562.33	563.00
	800	mm	1,395.00	1,674.00	385.00	3,037.48	1,831.42	0.96	672.00	672.00	672.00
	900	mm	1,578.00	1,894.00				1.09	765.10	765.10	766.00
PVC			(only Pipe Laying)		(with 1 to 2m excavation, backfilling etc.)						
	63	mm	11.76	14.00	29.04	229.11	138.14	0.04	30.10	30.10	31.00
	75	mm	11.76	14.00	29.04	229.11	138.14	0.04	30.10	30.10	31.00
	90	mm	13.94	17.00	29.04	229.11	138.14	0.06	39.90	39.90	40.00
	110	mm	15.00	18.00	34.98	275.98	166.40	0.06	39.90	39.90	40.00
	160	mm	15.00	18.00	38.94	307.22	185.24	0.07	51.80	51.80	52.00
	225	mm	18.15	22.00	40.04	315.90	190.47	0.10	72.80	72.80	73.00
	280	mm	18.74	22.00				0.14	98.00	98.00	98.00
	315	mm						0.17	119.00	119.00	119.00
Hume Pipe/Clay Pipe			(with excavation, backfilling)		(depth is unknown)						
	150	mm	134.00	161.00				0.32	224.00	112.00	112.00
	225	mm	164.00	197.00				0.40	277.20	138.60	139.00
	250	mm						0.46	319.20	159.60	160.00
	300	mm	227.00	272.00				0.53	369.60	184.80	185.00
	375	mm	270.00	324.00				0.60	420.00	210.00	210.00
	400	mm						0.61	428.40	214.20	215.00
	450	mm	330.00	396.00	2,033.77	2,883.18	3,406.71	0.84	588.00	294.00	294.00
	500	mm						0.86	604.80	302.40	303.00
	544	mm			2,033.77	2,883.18	3,406.71	0.96	672.00	336.00	336.00
	600	mm	410.00	492.00				1.06	744.80	372.40	373.00
	675	mm						1.12	784.00	392.00	392.00
	750	mm	500.00	600.00				1.15	803.60	401.80	402.00
	825	mm						1.20	840.00	420.00	420.00
	900	mm	650.00	780.00				1.23	862.40	431.20	432.00
	1050	mm	680.00	816.00				1.34	940.80	470.40	471.00
2. Excavation											
Backfoe (incl. Backfilling)											790.00
3. Soil Disposal											
Off site		m^3									310.00
4. Backfilling with sand											
with sand supply		m^3									1,000.00
5. Pavement											
Reinstatement		m^2									2,000.00

Chapter 13

Appendix 13.1 Sewer Network Hydraulic Analysis (Feasibility Study)



Pipe List

Pipe No.	Diameter (mm)	Length (m)	Slope (‰)	Pipe No.	Diameter (mm)	Length (m)	Slope (‰)
1	225CP	340	4.10	21	225CP	120	5.00
2	150CP	360	52.10	22	150CP	350	40.80
3	225CP	300	5.00	23	150CP	1400	0.01
4	150CP	400	20.40	24	225CP	400	5.00
5	150CP	150	2.00	25	150CP	750	2.00
6	225CP	150	5.00	26	300CP	620	3.50
7	150CP	479	55.60	27	225CP	650	5.00
8	225CP	70	5.00	28	150CP	620	2.00
9	150CP	230	2.00	29	200CP	620	0.01
10	150CP	440	2.00	30	400CP	380	2.40
11	150CP	50	20.10	31	150CP	120	2.00
12	300CP	470	3.50	32	150CP	650	13.20
13	150CP	400	40.50	33	150CP	210	2.00
14	150CP	500	40.30	34	150CP	450	2.00
15	150CP	500	2.00	35	150CP	90	4.60
16	150CP	90	20.60	36	400CP	400	2.40
17	150CP	150	65.00				
18	225CP	150	5.00				
19	225CP	375	5.00				
20	150CP	150	8.40				

Note : 13,14,15,25,31,32,34 Excluded from F/S Area.

Sewage Flow Calculation Table (Nuwara Eliya)

※Unit Sewage Flow : 0.187m3/capita·day

Pipe No.	Down stream	Service Area Sec.	Service Area Accum.	Length Sec.	Length Accum.	T	Storm Run-off Rainfall per ha	Storm Run-off C	Storm Run-off Service Area Sec.	Storm Run-off Service Area Accum.	Storm Run-off R.O.	Sewage Flow Pop/D	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow	Other Flow Sec.	Other Flow Accum.	Accum.	Design Sewer Dia.	Design Sewer Slope	Design Sewer V	Design Sewer Flow	Design Sewer G.L.	Design Sewer Level	Design Sewer D	Remarks
		ha	ha	m	m	min	m3/s·ha		ha	ha	m3/s	P/ha	P	P	m3/s	m3/s	m3/s	m3/s	mm	‰	m/s	m3/s	M	M	m	
1	3	120	120	340	340											000588	000588	00059	φ 225	410	0723	00288	188579 188438	1884538 1881132	100 300	0.00334+0.00254
2		87	87	360	360											000184	000184	00018	φ 150	5210	1967	00348	190316 188438	1901983 1883209	101 100	
3	6	31	238	300	660											000400	001172	00117	φ 225	500	0799	00318	188438 188071	1881132 1879462	300 100	0.00334+0.00066
4	6	68	68	400	400											000144	000144	00014	φ 150	2040	1231	00218	190316 188071	1901979 1879539	101 100	
5		09	09	150	150											000011	000011	00001	φ 150	200	0385	00068	188100 188071	1879329 1879529	100 101	
6	8	07	322	150	810											000015	001342	00134	φ 225	500	0799	00318	188071 187916	1879454 1877912	101 100	
7		109	109	479	479								148	148	00003	000150	000150	00018	φ 150	5560	2032	00359	190581 187916	1904635 1877989	100 100	
8		05	436	20	830									148	00003	000011	001503	00153	φ 225	500	0799	00318	187916 187905	1877902 1877802	101 100	
8-1			436	20	850									148	00003		001503	00153	φ 150	800	0771	00136	187905 187893	1875899 1875739	298 302	
8-2	12		436	30	880									148	00003		001503	00153	φ 225	500	0799	00318	187893 187876	1877802 1877602	088 091	
9	11	39	39	230	230											000083	000083	00008	φ 150	200	0385	00068	188203 187993	1880859 1878759	100 100	

Sewage Flow Calculation Table (Nuwara Eliya)

※Unit Sewage Flow : 0.187m3/capita·day

Pipe No.	Down stream	Service Area Sec.	Service Area Accum.	Length Sec.	Length Accum.	T	Storm Run-off Rainfall per ha	Storm Run-off C	Storm Run-off Service Area Sec.	Storm Run-off Service Area Accum.	Storm Run-off R.O.	Sewage Flow Pop/D	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow	Other Flow Sec.	Other Flow Accum.	Accum.	Design Sewer Dia.	Design Sewer Slope	Design Sewer V	Design Sewer Flow	Design Sewer G.L.	Design Sewer Level	Design Sewer D	Remarks
		ha	ha	m	m	min	m3/s·ha		ha	ha	m3/s	P/ha	P	P	m3/s	m3/s	m3/s	m3/s	mm	‰	m/s	m3/s	M	M	m	
10		35	35	440	440											000074	000074	00007	φ 150	200	0385	00068	188170 187993	1880249 1878595	128 116	
11		03	77	50	490											000006	000163	00016	φ 150	2010	1222	00216	187993 187876	1878594 1877689	117 100	
12	29		513	470	1350									148	00003		001666	00170	φ 300	350	0809	00572	187876 187787	1877429 1875784	100 175	
13	15	67	67	400	400								261	261	00006			00006	φ 150	4050	1734	00306	190255 187405	1899264 1872379	312 100	
14		111	111	500	500								433	433	00009			00009	φ 150	4030	1730	00306	190255 187405	1901374 1872879	101 100	
15	19	143	321	500	1000								558	1252	00027			00027	φ 150	200	0385	00068	187405 186575	1872869 1863379	101 220	
16	18	84	84	90	90								328	328	00007	000093	000093	00016	φ 150	2060	1237	00219	186900 186714	1867823 1865969	101 100	
17		72	72	150	150								258	258	00006	000533	000533	00059	φ 150	6500	2197	00388	187723 186714	1876054 1865039	101 193	
18		25	181	150	300								98	684	00015		000626	00078	φ 225	500	0799	00318	186714 186575	1864964 1864214	193 129	
19	21	110	612	375	1375								400	2336	00051	000133	000759	00127	φ 225	500	0799	00318	186575 186173	1863304 1860482	220 100	

Sewage Flow Calculation Table (Nuwara Eliya)

※Unit Sewage Flow : 0.187m3/capita·day

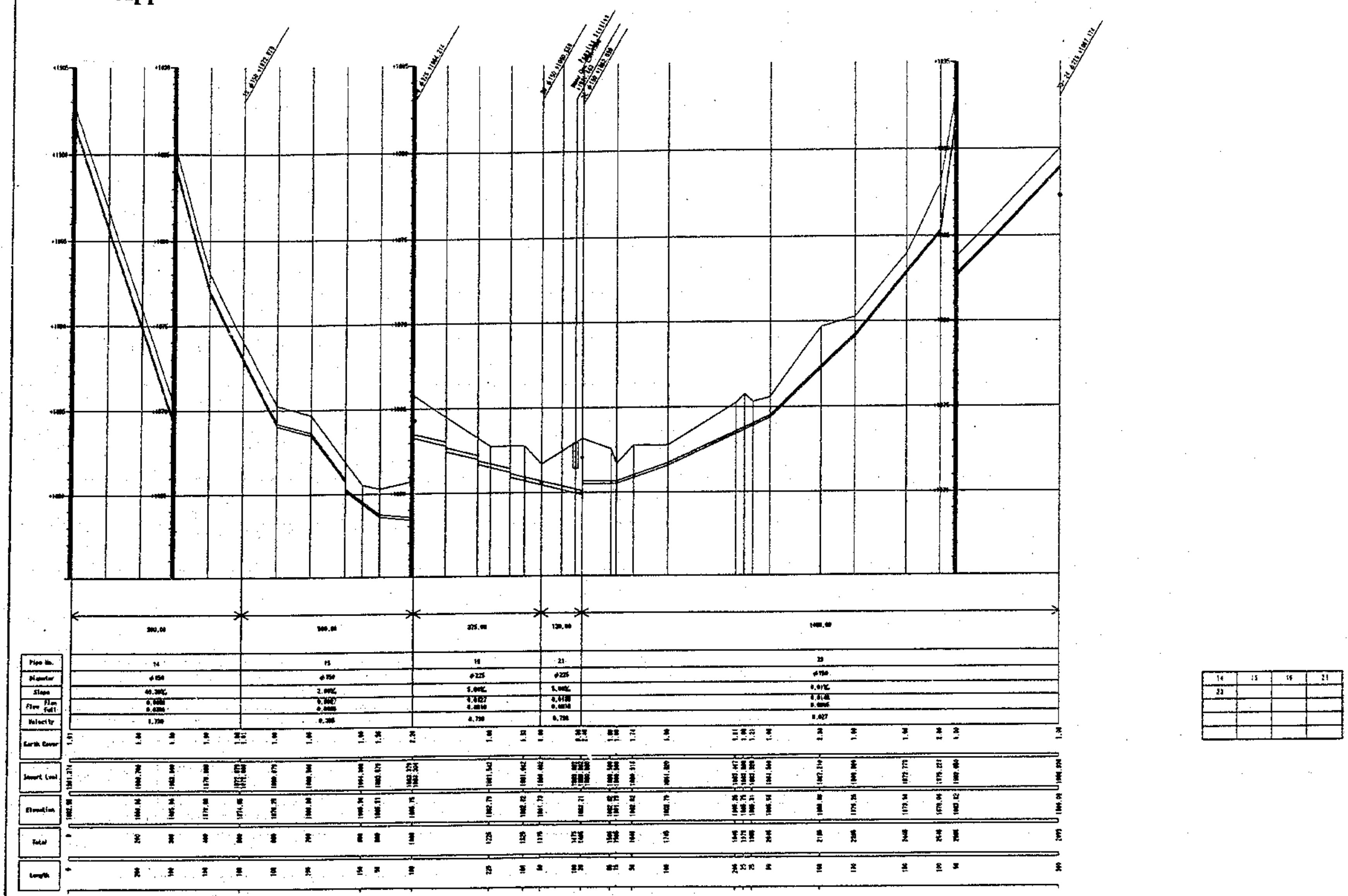
Pipe No.	Down stream	Service Area Sec.	Service Area Accum.	Length Sec.	Length Accum.	T	Storm Run-off Rainfall per ha	Storm Run-off C	Storm Run-off Service Area Sec.	Storm Run-off Service Area Accum.	Storm Run-off R.O.	Sewage Flow Pop/D	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow	Other Flow Sec.	Other Flow Accum.	Accum.	Design Sewer Dia.	Design Sewer Slope	Design Sewer V	Design Sewer Flow	Design Sewer G.L.	Design Sewer Level	Design Sewer D	Remarks
		ha	ha	m	m	min	m3/s·ha		ha	ha	m3/s	P/ha	P	P	m3/s	m3/s	m3/s	m3/s	mm	‰	m/s	m3/s	M	M	m	
20		186	186	150	150								205	205	00004			00004	φ 150	840	0790	00140	186300 / 186173	1861824 / 1860559	101 / 100	
21	23	120	918	120	1495								321	2862	00062		000759	00138	φ 225	500	0799	00318	186173 / 186321	1860482 / 1859882	100 / 308	
22		181	181	350	350								476	476	00010			00010	φ 150	4080	1741	00308	187751 / 186321	1876334 / 1862039	101 / 100	
23			1099	1400	2895									3338	00072		000759	00148	φ 150	001	0027	00005	186321 / 189000	1860560 / 1888830	248 / 100	Pumping Station
24	26	87	1186	400	3295								272	3610	00078		000759	00154	φ 225	500	0799	00318	189000 / 188229	1887174 / 1881014	258 / 103	
25		92	92	750	750								289	289	00006	000038	000038	00010	φ 150	200	0385	00068	190571 / 188229	1904539 / 1881119	100 / 100	
26	29	184	1462	620	3915								340	4239	00092		000797	00172	φ 300	350	0809	00572	188229 / 187787	1877447 / 1873538	451 / 400	
27	29	256	256	650	650								666	666	00014	001002	001002	00114	φ 225	500	0799	00318	189042 / 187787	1889172 / 1876202	100 / 142	
28		239	239	620	620								621	621	00013			00013	φ 150	200	0385	00068	188771 / 187787	1886538 / 1875528	100 / 217	
29			2470	620	4535									5674	00123		003465	00470	φ 200	001	0033	00010	187787 / 188771	1876100 / 1886490	156 / 101	Pumping Station
30	36	207	2677	380	4915								538	6212	00134		003465	00481	φ 400	240	0812	01020	188771 / 188170	1885075 / 1880055	219 / 120	

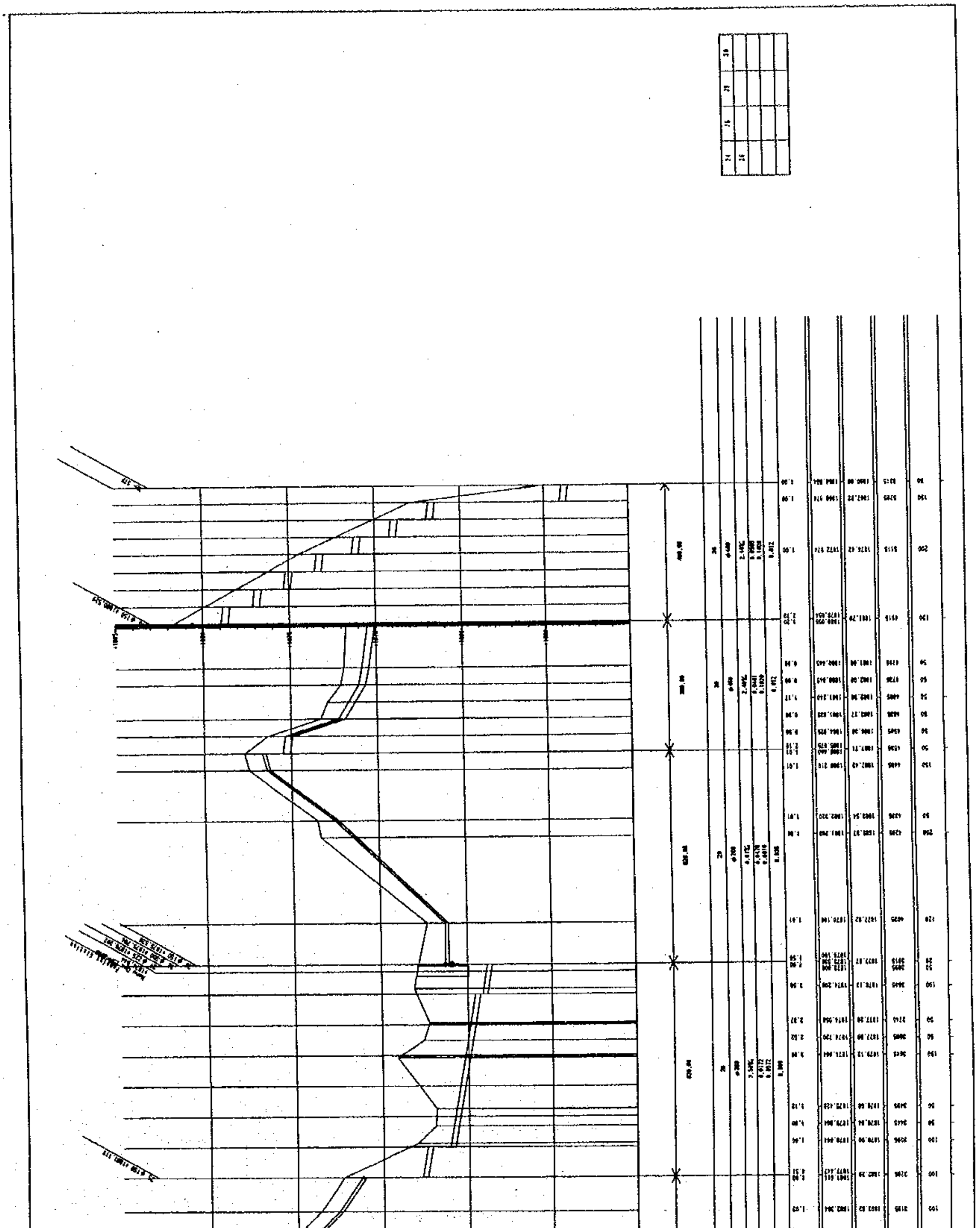
Sewage Flow Calculation Table (Nuwara Eliya)

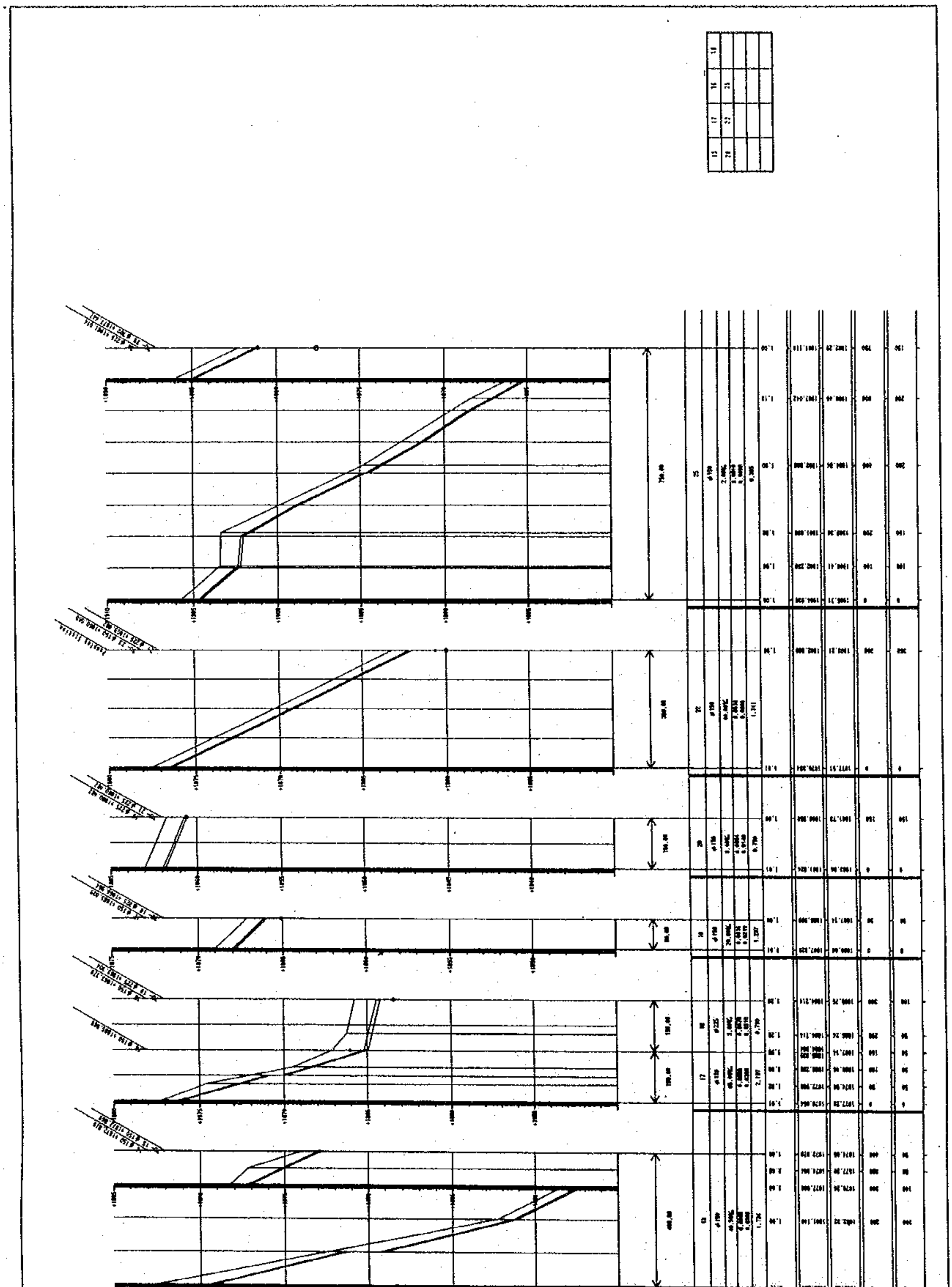
※Unit Sewage Flow : 0.187m3/capita·day

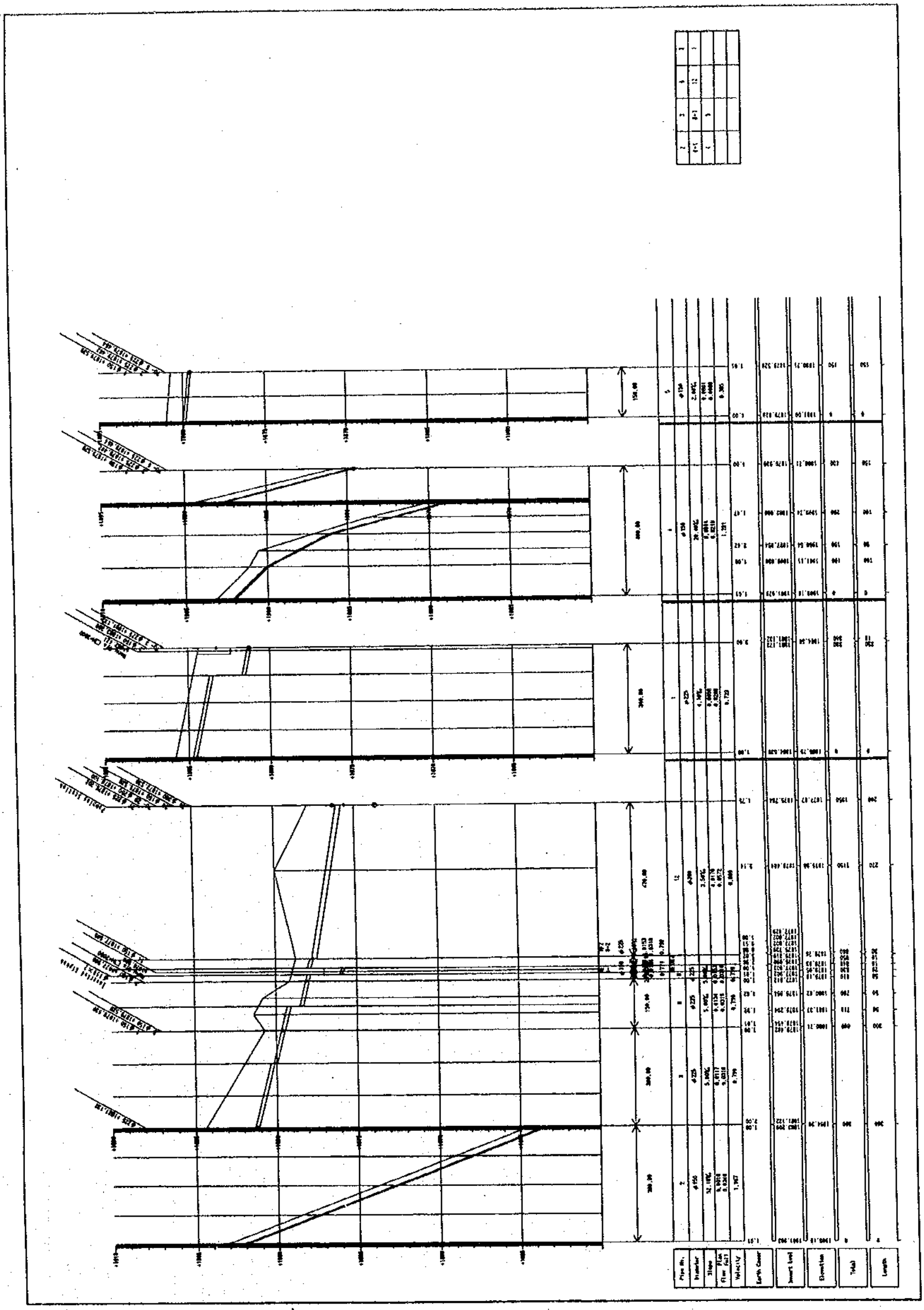
Pipe No.	Down stream	Service Area		Length		T	Storm Run-off					Sewage Flow				Other Flow		Accum.	Design Sewer							Remarks
		Sec.	Accum.	Sec.	Accum.		Rainfall per ha	C	Service Area Sec.	Service Area Accum.	R.O.	Pop/D	Population Sec.	Population Accum.	Flow	Sec.	Accum.		Dia.	Slope	V	Flow	G.L.	Level	D	
		ha	ha	m	m	min	m3/s·ha		ha	ha	m3/s	P/ha	P	P	m3/s	m3/s	m3/s	m3/s	mm	‰	m/s	m3/s	M	M	m	
31	33	124	124	120	120								285	285	00006			00006	φ 150	200	0385	00068	188292 188298	1881719 1881371	103 144	
32		119	119	650	650								274	274	00006			00006	φ 150	1320	0990	00175	189901 188298	1897330 1881809	101 100	
33	35	25	288	210	860								58	617	00013			00013	φ 150	200	0385	00068	188298 188249	1881371 1880951	144 137	
34		153	153	450	450								352	352	00008			00008	φ 150	200	0385	00068	190108 188249	1899909 1881319	100 100	
35		03	424	90	950								7	976	00021			00021	φ 150	460	0585	00103	188249 188170	1880943 1880529	138 100	
36		44	3145	400	5315								103	7291	00158		003465	00505	φ 400	240	0812	01020	188170 186000	1878554 1858554	270 100	TO Nuwara STP

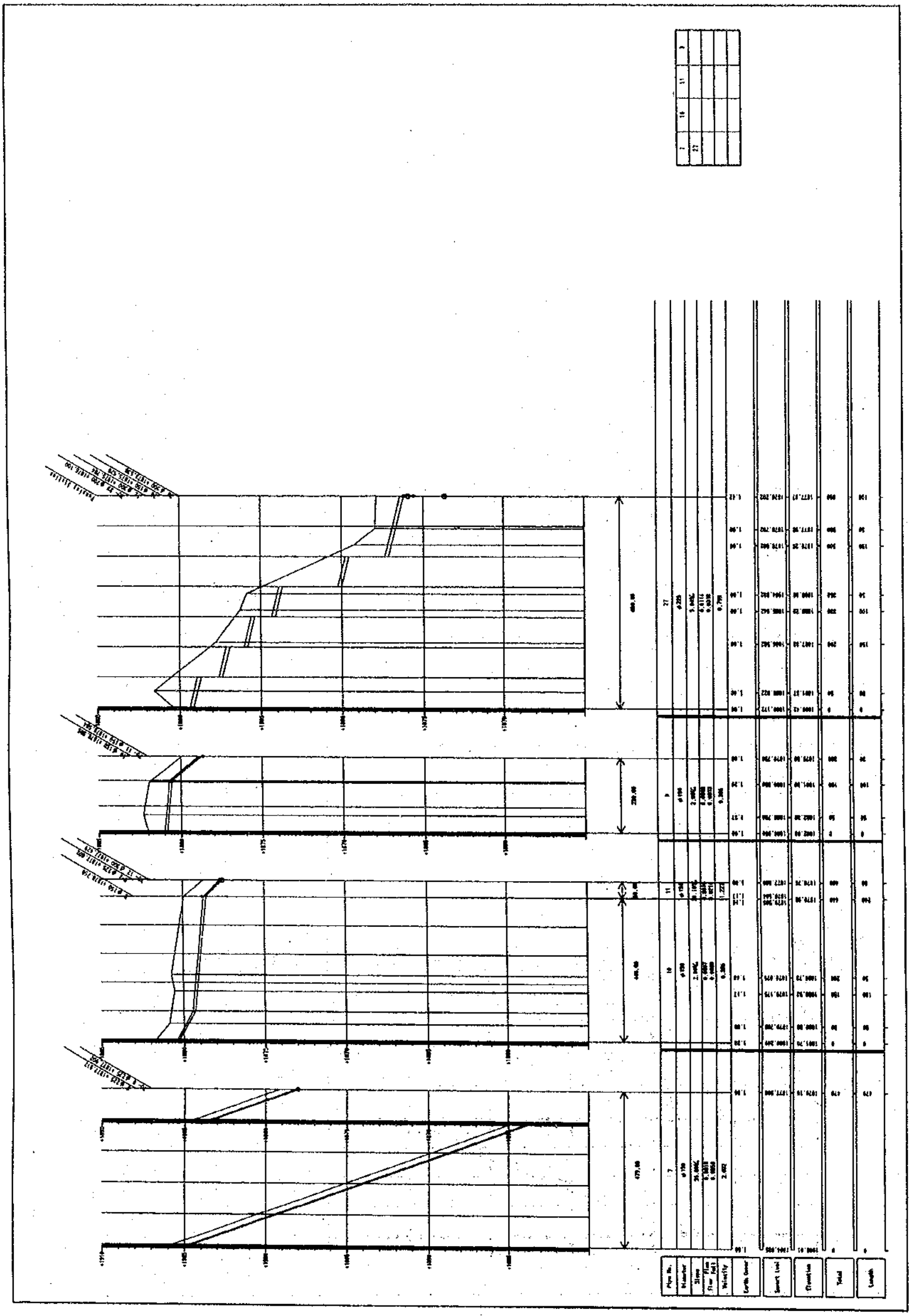
Appendix 13.2 Trunk Sewer Profile

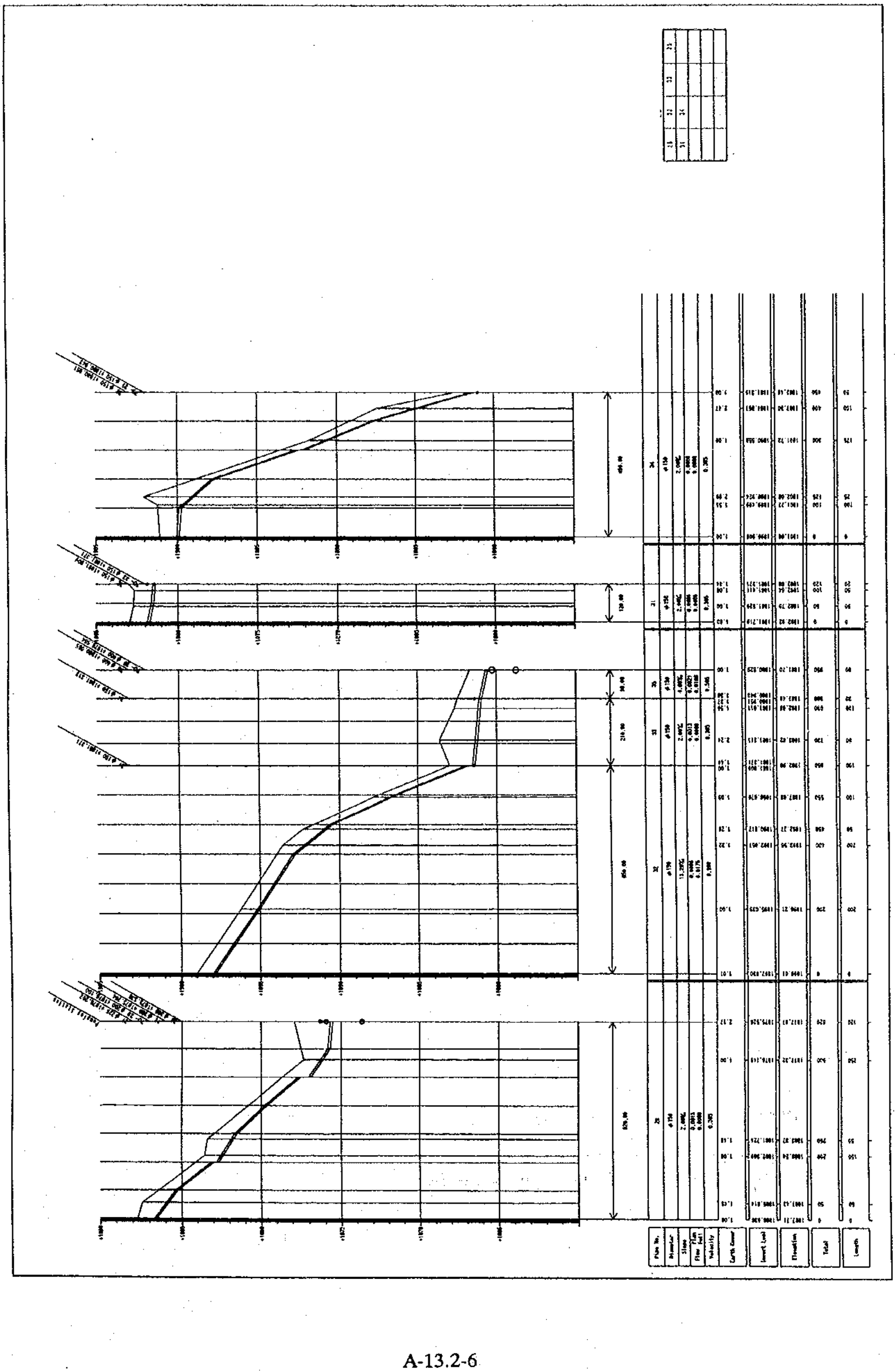












Appendix 13.3 Pumping Equipment-Capacity Caluculation
Nuiwara Eliya

1. Pumping Station No.1 (Hospital)

Total Capacity 1,279 m3/day= 0.89 m3/min
Quantity of pump 1 sets + 1 set for stand-by
Pump Capacity 1,279 m3/day
Q = 0.888 m3/min
q = 0.0148 m3/sec

Diameter
Diameter = 146*(Q/v)^(1/2)
= 112 mm to 79 mm
= 100 mm
where,v= 1.50 to 3.00

Total Head
Total Head H=h1+h2+h3= 38.3 m
= 39.0 m
actual head h1 = hd - hs = 29.42 m
suction level hs= 1,859.41 m
delivery level hd= 1,888.83 m
friction loss (Hazen Williams) :straight pipe
h2 = 10.666*c^-1.85*D^-4.87*q^1.85*L
= 7.78 m
where, c= 130
D = 150 mm dia /1000
L = 1,400 m
(v= 0.838 m/sec)
friction loss : fittings
h3 = f * (v ^ 2 / 2 * g)
= 1.07 m
where, v = 1.88 m/sec

where,	Q'ty	f/pc	f
check valve	1	1.50	1.50
sluice valve	2	0.10	0.20
increase	0	0.15	0.00
90deg	5	0.18	0.90
tee	2	1.15	2.30
outlet	1	1.00	1.00
		total	5.90

Motor Output
Motor Output = (0.163*r*Q*H/e)*(1+a)
= 10.8 kW
= 11.0 kW
where,r= 1.00
e= 0.60
a= 0.15

Specification
Type Submersible Sewage Pump
Diameter 100 mm
Capacity 0.89 m3/min
Head 39.0 m
Motor Output 11 kW
Quantity 1 sets + 1 set for standby

2. Pumping Station No.2 (Victoria Park)

Total Capacity		4,061 m3/day=	2.82	m3/min
Quantity of pump		1 sets + 1 set for stand-by		
Pump Capacity		4,061 m3/day		
	Q =	2.820 m3/min		
	q =	0.0470 m3/sec		

Diameter

Diameter = 146*(Q/v)^(1/2)
= 200 mm to 142 mm
= 150 mm
where,v= 1.50 to 3.00

Total Head

Total Head H=h1+h2+h3= 22.8 m
= 24.0 m
actual head h1 = hd - hs = 13.44 m
suction level hs= 1,873.05 m
delivery level hd= 1,886.49 m
friction loss (Hazen Williams) :straight pipe
h2 = 10.666*c^-1.85*D^-4.87*q^1.85*L
= 7.19 m
where, c= 130
D = 200 mm dia /1000
L = 620 m
(v= 1.496 m/sec)
friction loss : fittings
h3 = f * (v ^ 2 / 2 * g)
= 2.13 m
where, v = 2.66 m/sec

where,	Q'ty	f/pc	f
check valve	1	1.50	1.50
sluice valve	2	0.10	0.20
increase	0	0.15	0.00
90deg	5	0.18	0.90
tee	2	1.15	2.30
outlet	1	1.00	1.00
		total	5.90

Motor Output

Motor Output = (0.163*r*Q*H/e)*(1+a)
= 21.1 kW
= 22.0 kW
where,r= 1.00
e= 0.60
a= 0.15

Specification

Type	Submersible Sewage Pump
Diameter	150 mm
Capacity	2.82 m3/min
Head	24.0 m
Motor Output	22 kW
Quantity	1 sets + 1 set for standby

Appendix 13.4 Sewage Treatment Plant - Capacity Calculation

CAPACITY CALCULATION OF FACILITIES
(Dual Power Aerated Lagoon)

1 BASIC CONDITIONS

1-1 BASIC ITEMS

(1) Name : Nuwara Eliya Sewage Treatment Plant

(2) Land Area : Approximately 2.3 ha

(3) Elevation : 1855.000 m

(4) Inlet Pipe Level : 1854.850 m

(5) Pipe Diameter : 400 m

(6) Land Use : Tea Plantation

(7) Collection System : Seperate Type

(8) Treatment Method : Sewage Treatment : Aerated Lagoon Method
Sludge Treatment : Pond Accumulation

(9) Effluent Point : Nanu Oya

(10) Effluent Point Water Level : 1852.000 m

(11) Target Year : Year 2000 (Phase 1)

(12) Lowest Monthly Average Temperature 15 °C (January)

1-2 Design Population

Design Population : 1,830 Persons (Total)

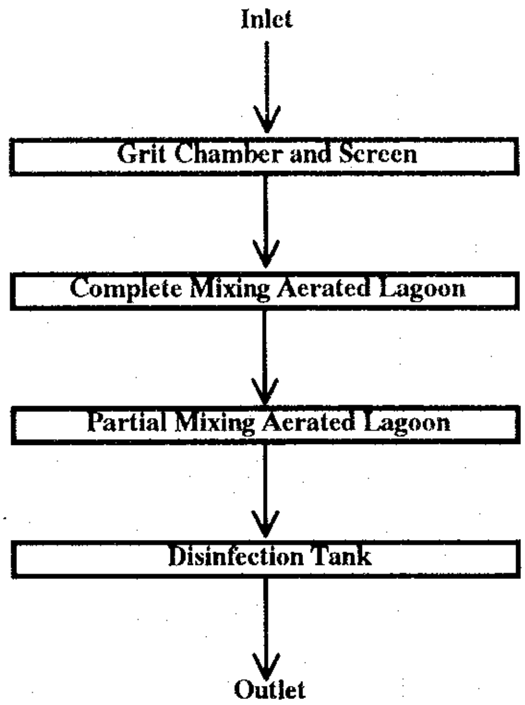
1-3 Design Sewage Flow

ITEM	m3/day	m3/hr	m3/min	m3/sec
Daily Average	1,200	50.0	0.83	0.014
Daily Maximum	1,400	58.3	0.97	0.016
Hourly Maximum	2,400	100.0	1.67	0.028

1-4 Design Sewage Quality

ITEM	INFLUENT (mg/L)	EFFLUENT (mg/L)	REMOVAL RATIO (%)	REMARKS
BOD	240	30	88	
SS	250	50	80	

1-5 Flow Chart (Dual Power Aerated Lagoon)



1-6 Design Criteria for Dual Power Aerated Lagoon

ITEMS	UNIT	Formula or Value	Application
1-6-1 Grit Chamber			
(1) Water Surface Load	m3/m2/day	> 1800	1,800
(2) Average Velocity	m/sec	> 0.3	0.3
1-6-2 Complete Mixing Aerated Lagoon			
(1) Retention Time	day	1.5 - 2.5	1.50
(2) Water Depth	m	3.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 6.0	6.0
1-6-3 Partial Mixing Aerated Lagoon			
(1) Retention Time	day	2.0	2.0
(2) Water Depth	m	2.0 - 4.0	3.0
(3) Power Requirement for Mixing	W/m3	> 1.0	1.0
(4) Number of Cell	Cell/Basin	1 - 3	3
1-6-4 Storm Water Settling Tank			
(1) Water Depth	m	1.5 - 3.0	1.5
(2) Retention Time (Hourly Max. - Rain)	hour	> 0.5	0.5
(3) Water Surface Load (Hourly Max. - Rain)	m3/m2/day	75 - 150	150.0
1-6-5 Disinfection Tank			
(1) Retention Time	min.	> 15	15.0
(2) Dosage	mg/l	2.0 - 4.0	3.0

2 CAPACITY CALCULATION

2-1 Grit Chamber and Screen (Hourly Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Parallel Flow Type	
Design Flow	Q1	m3/day	-	2,400
	Q2	m3/sec	-	0.028
Water Surface Load	WSL	m3/m2/day	-	1,800
Required Surface Area	RSA	m2	Q1/WSL	1.333
Basin Number (Total)	BN	basin	-	2
Basin Number (Stand-By)	BNS	basin	-	1
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.30
Width	W1	m	Q2/(V*H)	0.309
Therefore	W2	m	-	0.50
Length	L1	m	RSA/W2/(BN-BNS)	2.667
Therefore	L2	m	-	2.70
Dimension (W)	W	m	W2	0.50
(L)	L	m	L2	2.70
(Basin)	-	basin	BN	1
(Stand-By)	-	stand-by	BNS	1
Screen Type	-	-	Fine Bar Screen	
Screen Set Number	SSN	set	BN	2
Check		UNIT	APPLICATION	RESULT
Water Surface Load		m3/m2/day	> 1800	1,778
Average Velocity		m/sec	> 0.3	0.19

2-2 Complete Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	1,400
	Q2	m3/hr	-	58.33
Retention Time	T1	day	-	1.50
Inlet BOD Quality	So	mg/L	-	240
Required Volume	V1	m3/basin	Q1*T	2,100
Basin Number	BN	basin	-	2
Required Volume per Basin	VBN	m3/basin	Q1*T/BN	1,050
Water Depth	H	m	-	3.00
Required Surface Area	A	m2	V/H	350
Width	W	m	-	14.00
Length	L1	m	A/W	25.000
Therefore	L2	m	-	25.00
Oxygen Demand Rate	PR1	kg/h	(4.16*10^-5)*r*Q1*So	21
-max. oxygen uptake	r	W/m3	-	1.5
Aeration Unit Power Rate	PRO	kg/h	1000*PR1/(N*Q1*T1)	5.25
Therefore	PRO	W/m3	-	5.3
-aeration performance	N	W/m3	-	1.9
Power Requirement	P1	kW	-	13.0
1) Oxygen Requirement	P1O	kW	PR1/N	11.0
2) Mixing Power	P1M	kW	V1*P0*10^-3	12.6
Dimension (Width)	W	m	W	14.00
(Length)	L	m	L2	25.00
(Depth)	H	m	H	3.00
(Basin)	-	basin	BN	2
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Retention Time		day	1.5 - 2.5	1.50

2-3 Partial Mixing Aerated Lagoon (Daily Maximum)

ITEM	SIGN	UNIT	CALCULATION	RESULT
Type	-	-	Rectangular Type	
Design Flow	Q1	m3/day	-	1,400
	Q2	m3/hr	-	58.33
Retention Time	T2	day	-	2.00
Required Volume	V2	m3/basin	Q2*T	2,800
Basin Number	BN	basin	-	2
Cells Number	CN	cell/basin	-	3
Stand-by Cell Number	CNS	basin	-	1
Sludge Accumulation	SA	m3/year	365*Q1*Xi/(x*10^6)	703
-inert solid concentration	Xi	mg/l	-	55
-weight fracrion of solids	x	-	-	0.04
No. of Cells Cleaned per Year	CNC	basin	-	2
Total Sludge Accumulation	TSA	m3	-	1,054
Required Volume	V	m3/cell	(Q1*T+TSA)/(BN*CN-CNS)	771
Water Depth	D	m	-	4.00
Required Surface Area	A	m2/cell	V/H	193
Width	W	m	-	12.00
Length	L1	m	A/W	16.058
Therefore	L1	m	-	16.00
Power Requirement	P2	kW	-	3.0
1) Mixing Power	P2M	kW	Q1*T2*CN*10^-3	2.8
Dimension (Width)	W	m	W	12.00
(Length)	L	m	L1	16.00
(Depth)	H	m	H	4.00
(Basin)	-	basin	BN	2
(Cell)	-	cell/basin	CN	3
(Stand-by Cell)	-	cell	-	1
Aerator Type	-	-	Slanting Shaft Screw Aerator	
Check		UNIT	APPLICATION	RESULT
Surface Area		m2	-	1,152
Retention Time		day	2.0	1.99

2-6 Disinfection Tank (Daily Maximum)

ITEM		SIGN	UNIT	CALCULATION	RESULT
Chemical Type		-	-	Chlorination Type	
Design Flow		Q1	m3/day	-	1,400
		Q2	m3/min	-	0.97
Retention Time		T	min.	-	15.0
Basin Number		BN	basin	-	1
Required Volume		V	m3	Q2*T	15
Width		W	m	-	1.00
Water Depth		H	m	-	1.00
Length		L1	m	V/(W*H)	14.583
	therefore	L2	m	-	15.00
Dosage		D	mg/L	-	3.0
Required Chemical		RC1	kg/day	Q1*D*10^-3/C	4.20
	Therefore	RC2	kg/hr	RC1/24	0.18
Dimension	(Width)	W	m	W	1.00
	(Length)	L	m	L2	15.00
	(Depth)	H	m	H	1.00
	(Depth)	BN	basin	-	1
Chlorine Feeder		-	unit	including 1 for stand-by	2
Check			UNIT	APPLICATION	RESULT
Retention Time			min.	> 15	15.4

Appendix 13.5 Hydraulic Calculation

1. Design Condition

1.1 Design Wastewater Quantity

Flow		m^3/day	m^3/hour	m^3/min	m^3/sec
Daily Average	Qd-ave	1,200	50.0	0.833	0.014
Daily Maxmum	Qd-max	1,400	58.3	0.972	0.016
Hourly Maximum	Qh-max	2,400	100.0	1.667	0.028

1.2 Unit and Capacity of Treatment Facilities

Facilities	Total	Duty	Stand-by	Capacity
Grit Chamber/Screen	2	1	1	Qh-max
Complete Mix Lagoon	1	1	0	Qd-max
Partial Mix Lagoon	3	3	0	Qd-max
Disinfection Tank	1	1	0	Qd-max

1.3 Discharge

Discharge Point Nanu Oya

HWL 1852.00 m

1.4 Formula for Hydraulic Calculation

a. Friction loss for streight pipe

Darcy-Weisbach

Head Loss $h = f * V ^ 2 / (2 * g)$

where, $f1 = (0.02 + 1 / (2000 * D)) * (L / D)$

b. Friction loss for fittings

Head Loss $h = f * V ^ 2 / (2 * g)$

where, $f2 =$ 1.00 (Inlet)

$f3 =$ 0.50 (Outet)

2. Hydraulic Calculation

2.1 Water Level of Disinfection Tank Effluent Chamber (WL1)

		Qd-ave	Qd-max	Qh-max	(Unit)
Design Flow	Q	1,200	1,400	2,400	m^3/day
	q	0.014	0.016	0.028	m^3/sec

Pipe Diameter 150 mm
Pipe Length 50.0 m
No. of Pipe 1 set

Velocity	V =	0.79	0.92	1.57	m/sec

Hydraulic Loss h =

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)
= 7.78E-06 (Straight Pipe)
f2 = 1.00 (Inlet)
f3 = 0.50 (Outet)

Hydraulic Loss	h1 =	0.047	0.064	0.189	m

WL1 = 1852.00 + h1 = 1852.064 1852.189 m
say, **1852.07** 1852.19 m
(Qd-max) (Qh-max)

2.2 Water Level of Disinfection Tank (WL2)

Weir Width W = 1.0 m
No. of Weir 1 set
Weir level hw = 1852.95 m
Overflow height h = (Q / (1.84 * W))^(2/3)

	h2 =	0.038	0.043	0.061	m

WL2 = hw + h2 = 1852.993 1853.011 m
say, **1853.00** 1853.02 m
(Qd-max) (Qh-max)

2.3 Water Level of Partial Mixing No.3 Effluent Chamber (WL3)

Pipe Diameter 150 mm
Pipe Length 50.0 m
No. of Pipe 1 sets

Velocity	V =	0.79	0.92	1.57	m/sec

Hydraulic Loss h = f * V ^ 2 / (2 * g)

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)
= 7.78E-06 (Straight Pipe)
f2 = 1.00 (Inlet)
f3 = 0.50 (Outet)

Hydraulic Loss	h3 =	0.047	0.064	0.189	m

WL3 = WL2 + h3 = 1853.064 1853.209 m
say, **1853.07** 1853.21 m
(Qd-max) (Qh-max)

2.4 Water Level of Partial Mixing Lagoon No.3 (WL4)

Weir Width W = 1.0 m
No. of Weir 2 set
Weir level hw = 1853.37 m
Overflow height h = (Q / (1.84 * W))^(2/3)

	h4=	0.024	0.027	0.038	m

WL4 = hw + h4 = 1853.397 1853.408 m
say, **1853.40** 1853.41 m
(Qd-max) (Qh-max)

2.5 Water Level of Partial Mixing Lagoon No.1-2 (WL5,6)

(2 sets of Connection Pipes)

Pipe Diameter 150 mm

Pipe Length 20.0 m

No. of Pipe 2 sets

Velocity	V =	0.39	0.46	0.79	m/sec

Hydraulic Loss h = f * V ^ 2 / (2 * g)

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)

= 3.11E-06 (Straight Pipe)

f2 = 1.00 (Inlet)

f3 = 0.50 (Outet)

Hydraulic Loss	h =	0.012	0.016	0.047	m

say,

Partial Mixing Lagoon No.2 (WL5) 1853.416 **1853.45** m (Qd-max)

1853.457 m (Qh-max)

Partial Mixing Lagoon No.1 (WL6) 1853.466 **1853.50** m (Qd-max)

1853.505 m (Qh-max)

2.6 Water Level of Complete Mixing Effluent Chamber (WL7)

Pipe Diameter 150 mm

Pipe Length 50.0 m

No. of Pipe 2 sets

Velocity	V =	0.39	0.46	0.79	m/sec

Hydraulic Loss h = f * V ^ 2 / (2 * g)

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)

= 7.78E-06 (Straight Pipe)

f2 = 1.00 (Inlet)

f3 = 0.50 (Outet)

Hydraulic Loss	h7 =	0.012	0.016	0.047	m

WL7 = WL6 + h7 = 1853.516 1853.552 m

say, **1853.52** 1853.56 m

(Qd-max) (Qh-max)

2.7 Water Level of Complete Mixing Lagoon (WL8)

Weir Width W = 1.0 m

No. of Weir 2 set

Weir level hw = 1853.97 m

Overflow height h = (Q / (1.84 * W))^(2/3)

	h8=	0.024	0.027	0.038	m

WL8 = hw + h8 = 1853.997 1854.008 m

say, **1854.00** 1854.01 m

(Qd-max) (Qh-max)

2.8 Water Level of Distribution Chamber Effluent Chamber (WL9)

Pipe Diameter 100 mm

Pipe Length 50.0 m

No. of Pipe 2 sets

Velocity	V =	0.88	1.03	1.77	m/sec

Hydraulic Loss h = f * V ^ 2 / (2 * g)

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)

= 1.25E-05 (Straight Pipe)

f2 = 1.00 (Inlet)
f3 = 0.50 (Outet)

Hydraulic Loss	h9 =	0.060	0.082	0.240	m

WL9 = WL8 + h9 = 1854.082 1854.250 m

say, **1854.10** 1854.25 m

(Qd-max) (Qh-max)

2.9 Water Level of Distribution Chamber (WL10)

Weir Width W = 0.5 m

No. of Weir 2 set

Weir level hw = 1854.30 m

Overflow height h = (Q / (1.84 * W))^(2/3)

	h10 =	0.038	0.043	0.061	m

WL10 = hw + h10 = 1854.343 1854.361 m

say, **1854.35** 1854.37 m

(Qd-max) (Qh-max)

2.10 Water Level of Parshall Flum Effluent Chamber (WL11)

Pipe Diameter 150 mm

Pipe Length 50.0 m

No. of Pipe 1 sets

Velocity	V =	0.79	0.92	1.57	m/sec

Hydraulic Loss h = f * V ^ 2 / (2 * g)

where, f1 = (0.02 + 1 / (2000 * D)) * (L / D)

= 7.78E-06 (Straight Pipe)

f2 = 1.00 (Inlet)

f3 = 0.50 (Outet)

Hydraulic Loss	h11 =	0.047	0.064	0.189	m

WL11 = WL10 + h11 = 1854.414 1854.559 m

say, **1854.45** 1854.56 m

(Qd-max) (Qh-max)

2.11 Water Level of Parshall Flum Influent Chamber (WL12)

No. of PF 1 set

Head loss h12 = 0.30 m

WL12 = WL11 + h12 = 1854.75 1854.86 m

say, **1854.75** 1854.86 m

(Qd-max) (Qh-max)

2.12 Water Level of Grit Chamber Influent Chamber (WL13)

No. of Screens 8 sets including 2 stes

Head loss h13 = 0.20 m

WL13 = WL12 + h13 = 1854.950 1855.060 m

say, **1854.95** 1855.06 m

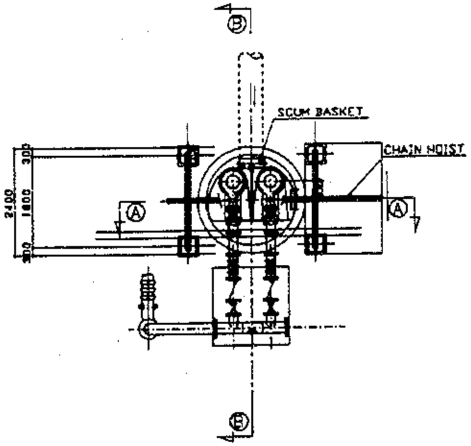
(Qd-max) (Qh-max)

Appendix 13.6 DRAWING

DRAWING LIST

No.	DRAWING NAME
S.1-1	PUMP STATION (HOSPITAL)
S.1-2	PUMP STATION (VICTORIA PARK)
S.2-1	LAYOUT PLAN
S.2-2	HYDRAULIC PROFILE
S.2-3	FLOW DIAGRAM
S.2-4	GRID CHAMBER
S.2-5	COMPLETE MIXING AERATED LAGOON
S.2-6	PARTIAL MIXING AERATED LAGOON
S.2-7	CHLORINATION TANK
S.2-8	ADMINISTRATION BUILDING

PLAN S=1/100



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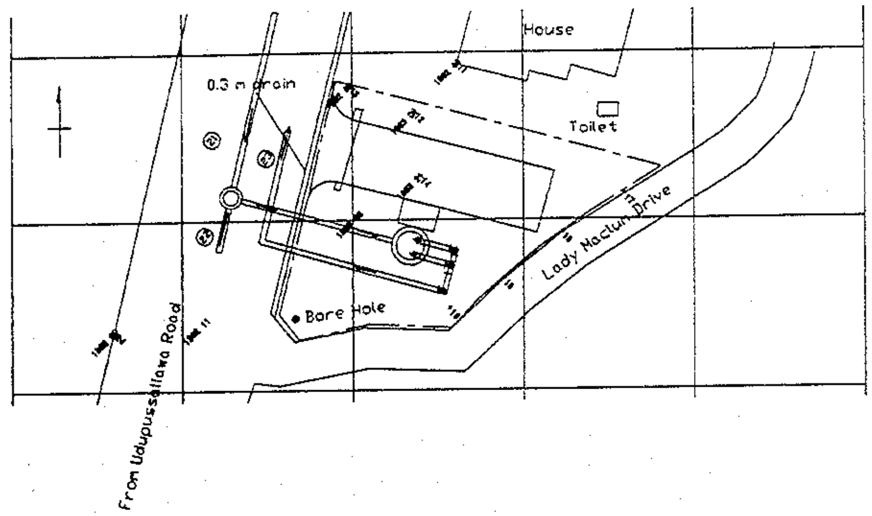

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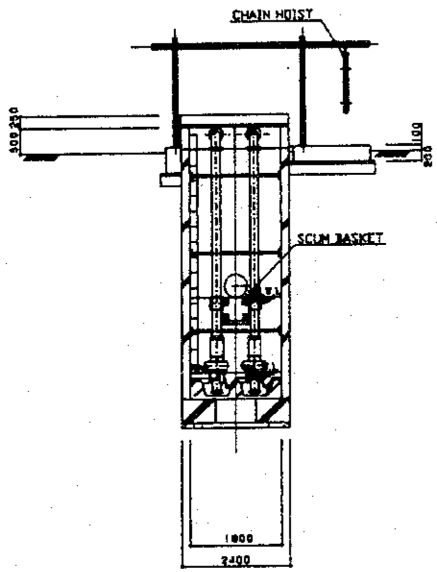
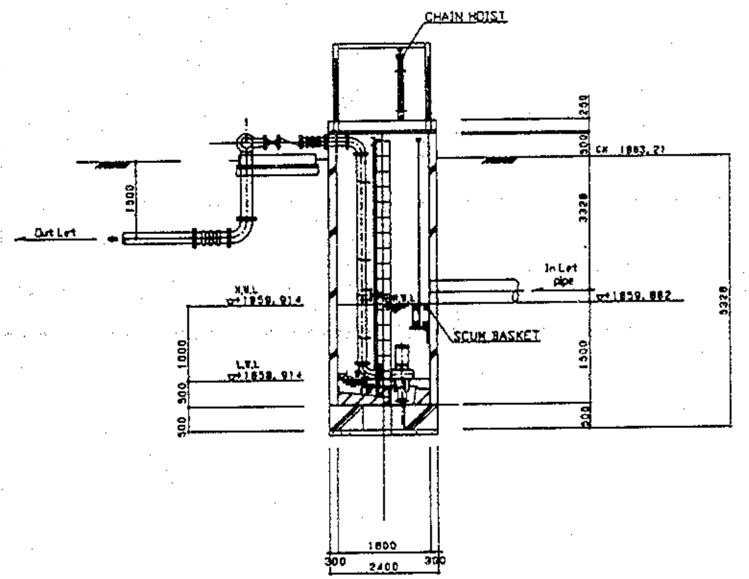
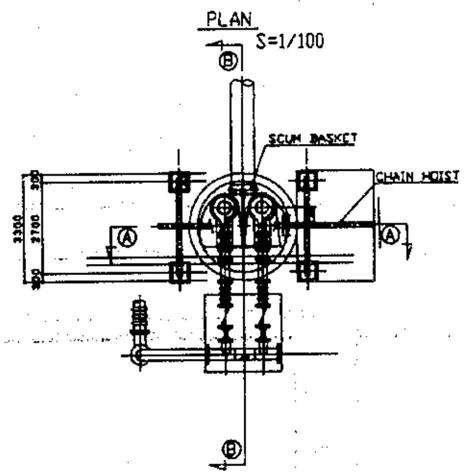
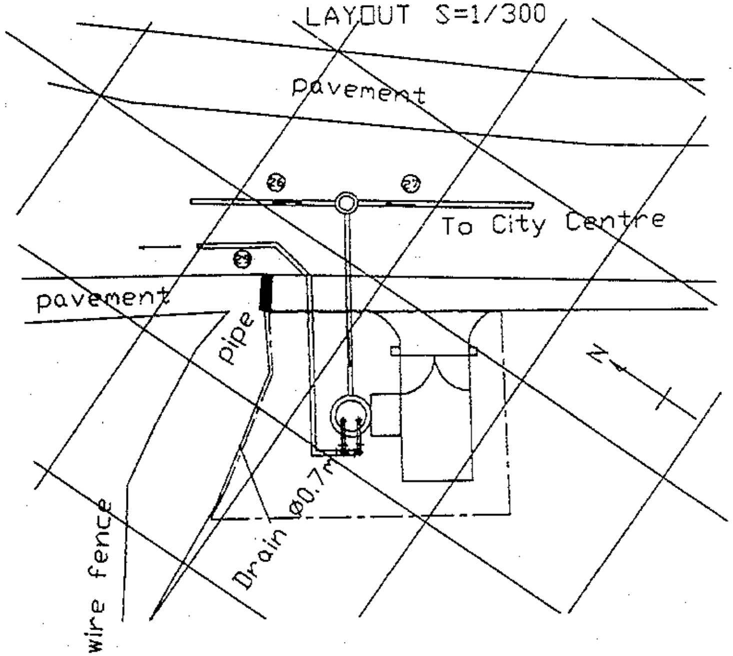


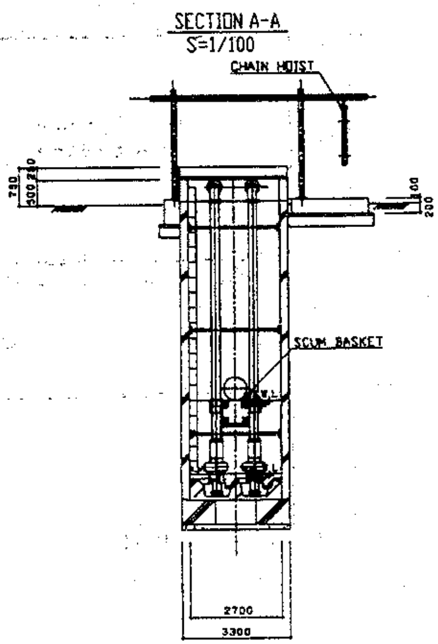
SECTION B-B S=1/100

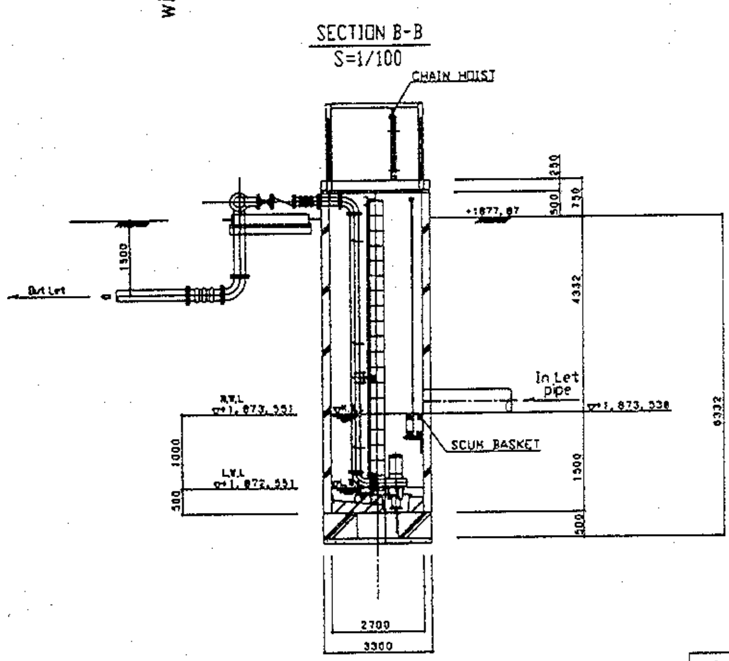


S.1-1
PUNPING STATION
(Hosipital)

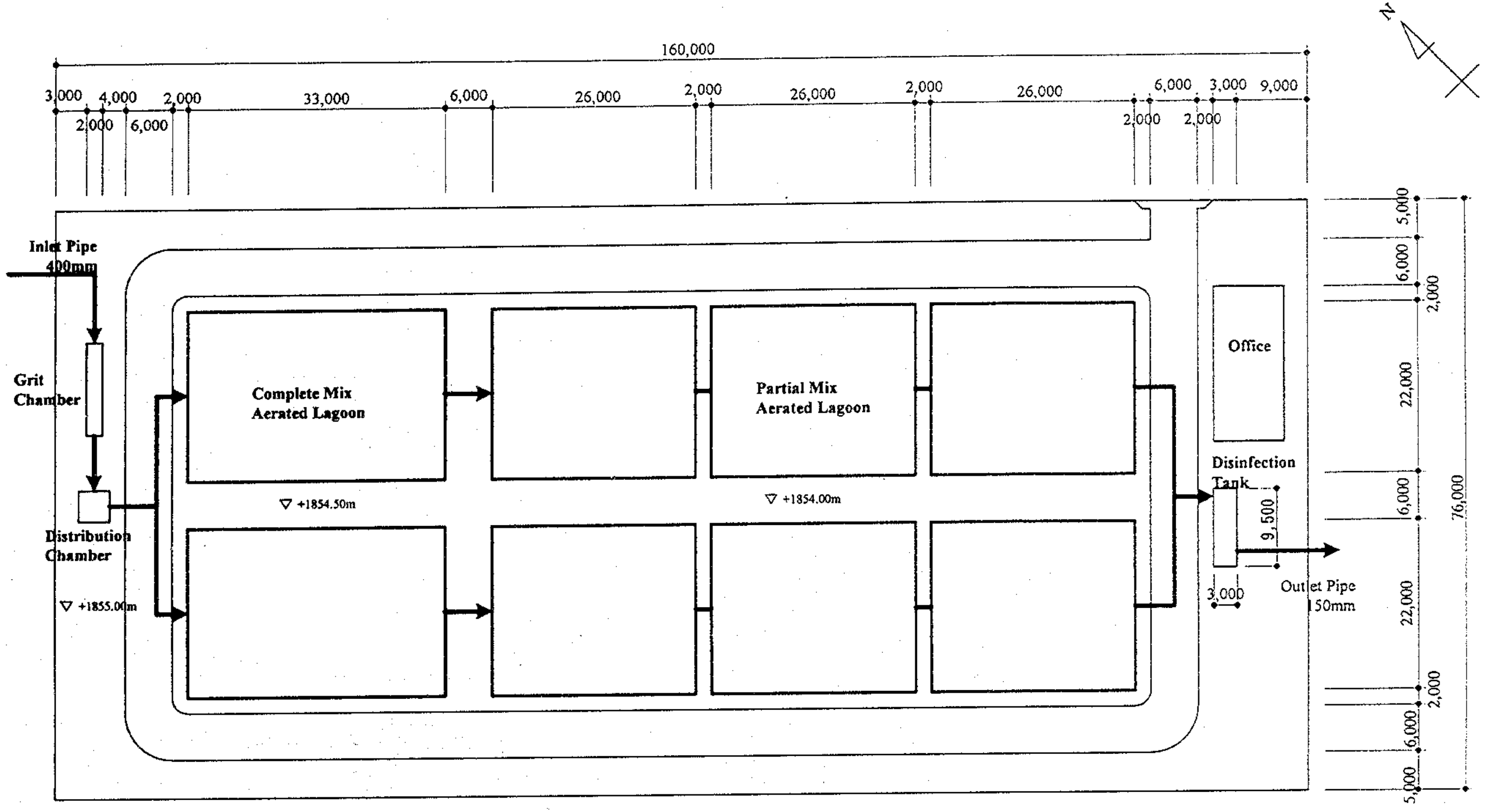






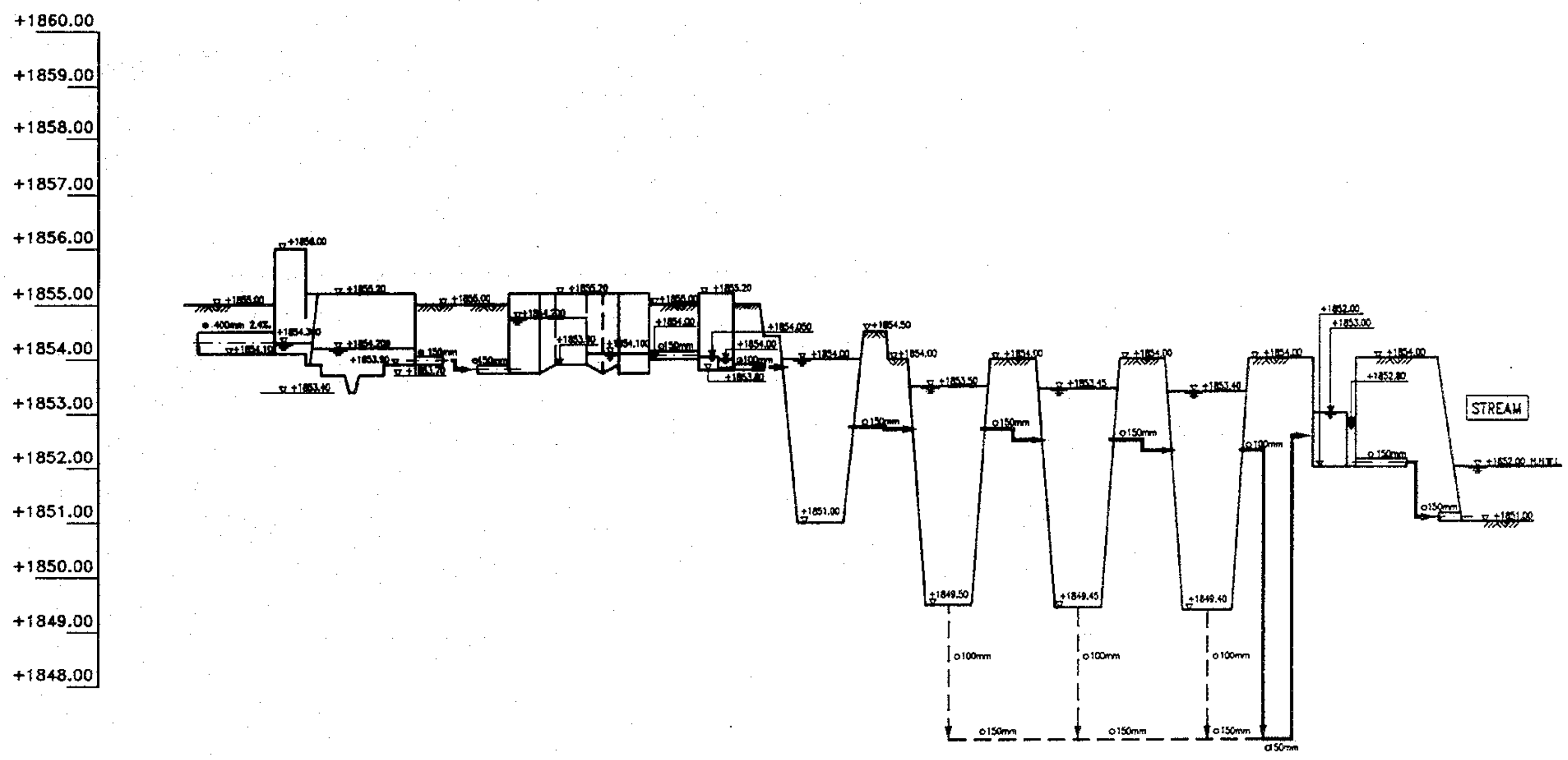


S.1-2
PUNPING STATION
(Victoria park)



Layout Plan S=1/500

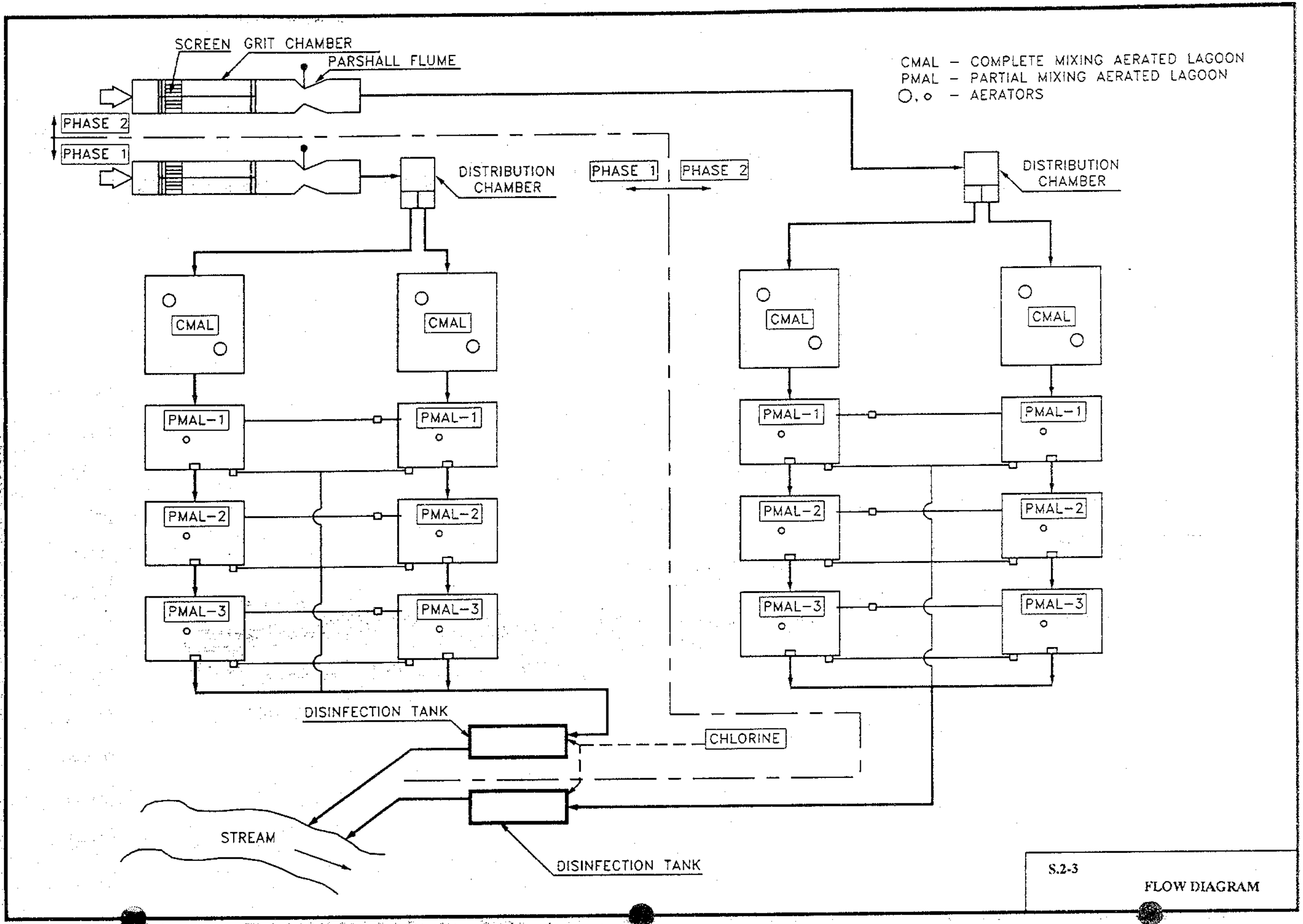
S.2-1 Layout Plan



	INLET PIPE	GRIT CHAMBER	PARSHALL FLUM	DISTRIBUTION CHAMBER	COMPLETE MIXING AERATED LAGOON	PARTIAL MIXING AERATED LAGOON	DISINFECTION TANK	OUTLET PIPE
PHASE 1	1	2	1	1	1	2 x 3 CELLS	1	1
PHASE 2	1	2	1	1	1	2 x 3 CELLS	1	1
TOTAL	2	4	2	2	2	4 x 3 CELLS	2	2

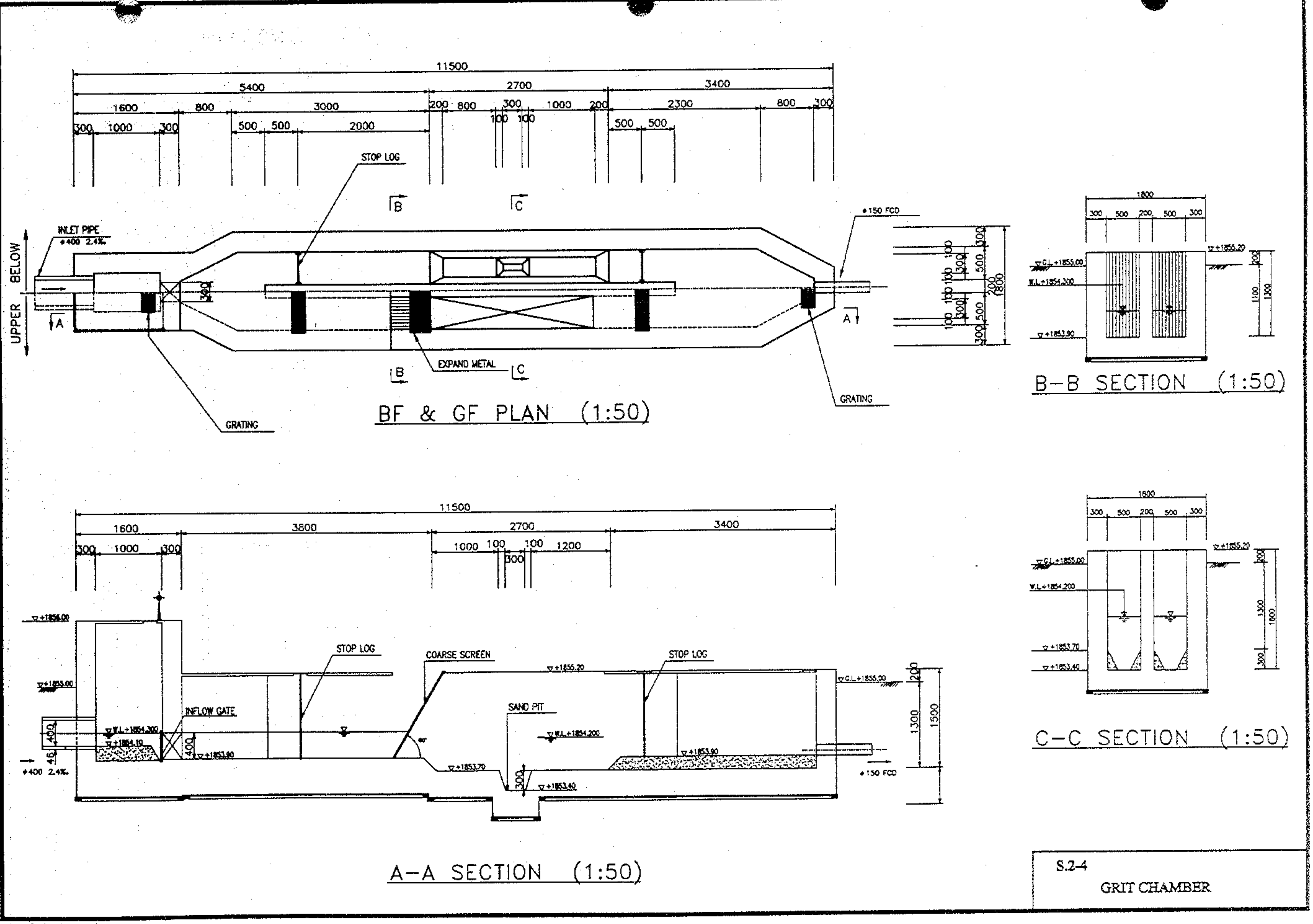
S.2-2

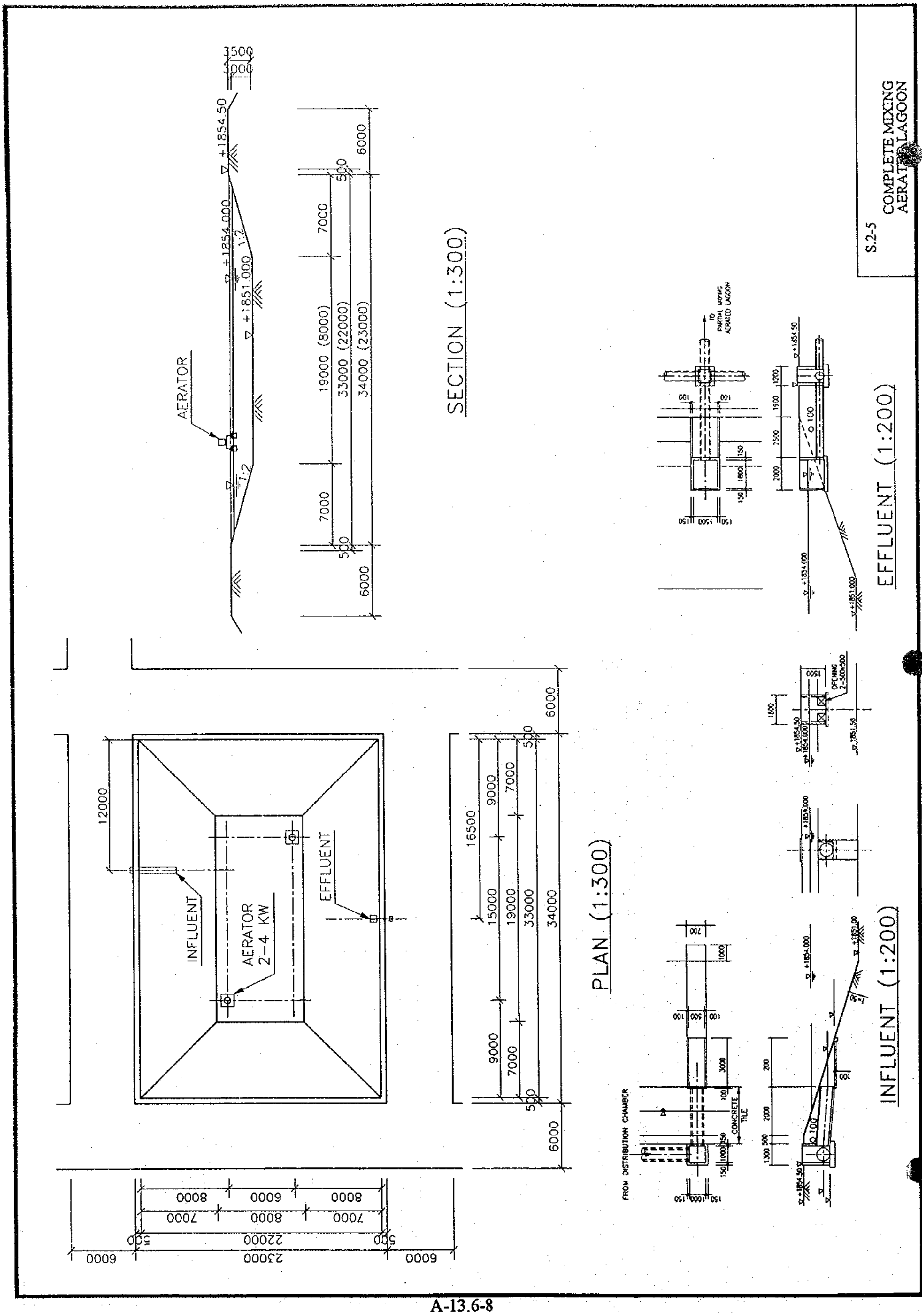
HYDRAULIC PROFILE

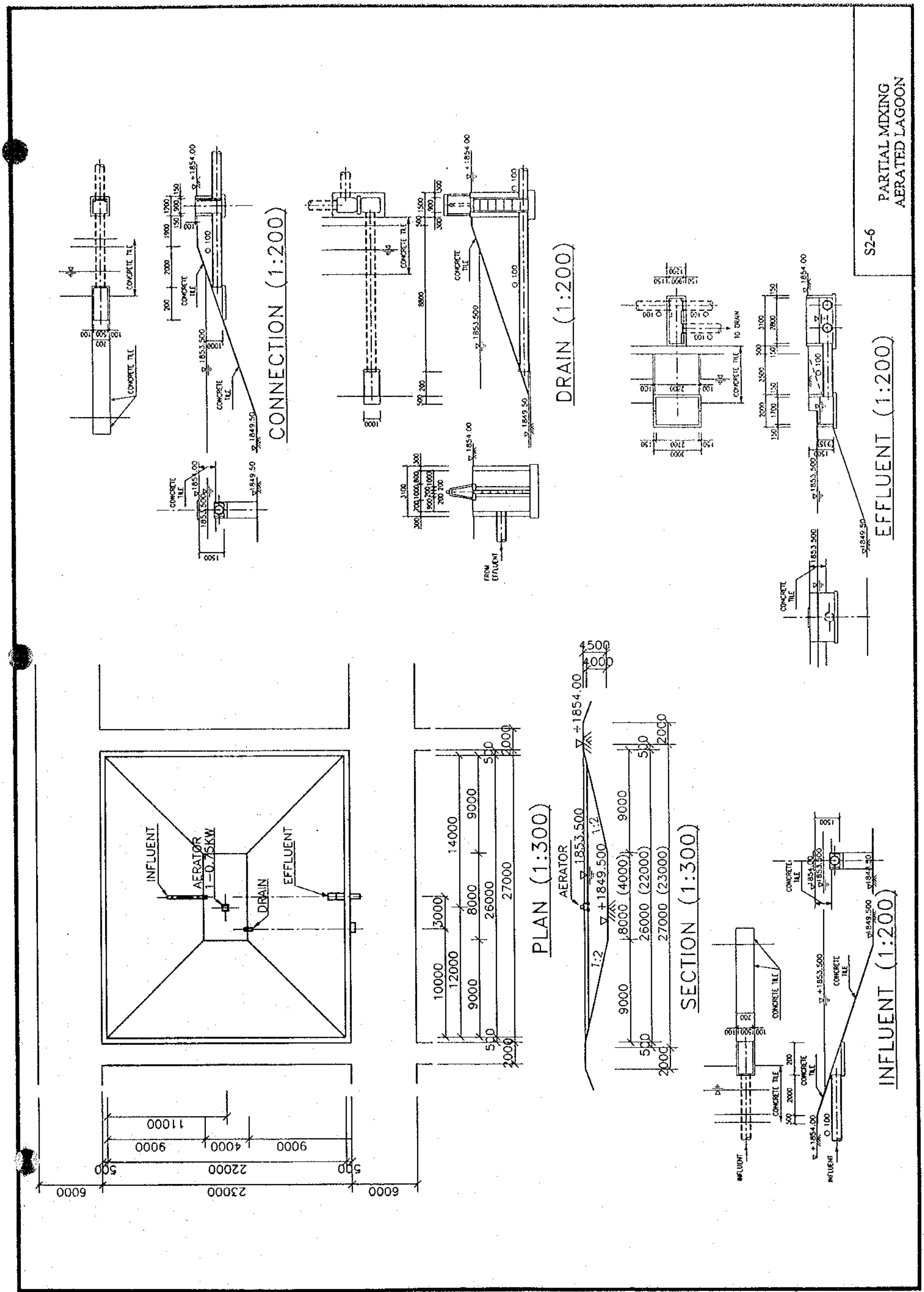


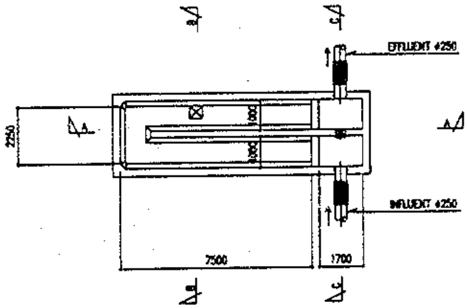
S.2-3

FLOW DIAGRAM

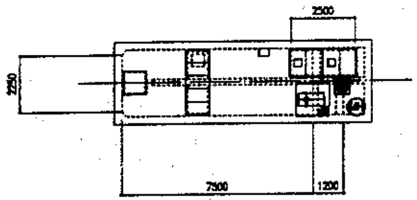

BF & GF PLAN (1:50)
B-B SECTION (1:50)
C-C SECTION (1:50)
A-A SECTION (1:50)
INLET PIPE
STOP LOG
EXPAND METAL
GRATING
COARSE SCREEN
SAND PIT
INFLOW GATE
UPPER
BELOW
S.2-4
GRIT CHAMBER


S.2-5
COMPLETE MIXING AERATED LAGOON
SECTION (1:300)
AERATOR
+1854.50
+1854.000
+1851.000
1:2
19000 (8000)
33000 (22000)
34000 (23000)
PLAN (1:300)
INFLUENT
EFFLUENT
AERATOR 2-4 KW
EFFLUENT (1:200)
TO PARTIAL MIXING AERATED LAGOON
OPENING 2-500x500
INFLUENT (1:200)
FROM DISTRIBUTION CHAMBER
CONCRETE TILE

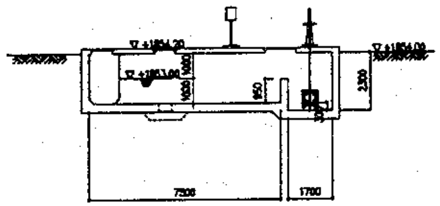

S2-6
PARTIAL MIXING
AERATED LAGOON
CONNECTION (1:200)
DRAIN (1:200)
EFFLUENT (1:200)
PLAN (1:300)
SECTION (1:300)
INFLUENT (1:200)
INFLUENT
AERATOR
1-0.75KW
DRAIN
EFFLUENT
CONCRETE TILE
TO DRAIN
FROM EFFLUENT
+1854.00
1853.500
+1849.500
1849.50
1:2
26000 (22000)
27000 (23000)
8000 (4000)



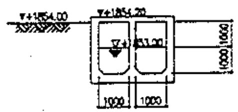
PLOT PLAN BASEMENT (1/200)



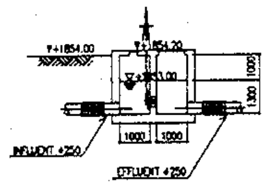
PLOT PLAN GROUND LEVEL (1/200)



SECTION A-A (1/200)



SECTION B-B (1/200)

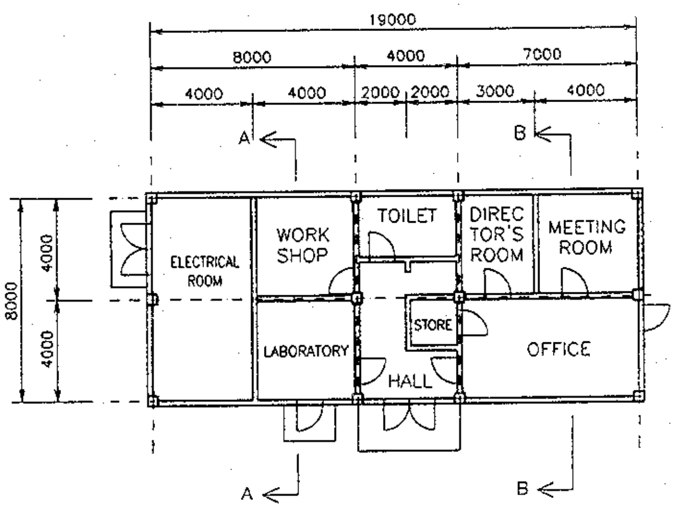


SECTION C-C (1/200)

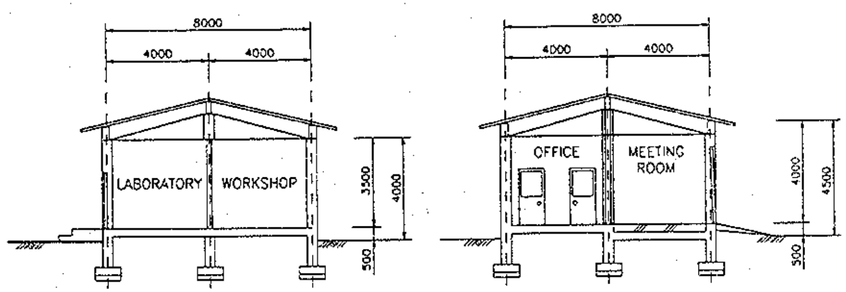
S.2-7

CHLORINATION TANK

ADMINISTRATION BUILDING



PLAN (1:20)



A–A SECTION (1:20) B–B SECTION (1:20)

S.2-8
ADMINISTRATION BUILDING

Appendix 13.7 Storage Capacity of Sewer (Nuwara Eliya)

Phase 1 (2005)

1. Hospital Pumping Station

(1) Sewage Flow

Q_{HM} = 0.89 m3/min = 53.4 m3/hour (Hourly Maximum Sewage Flow to Ps)

(2) Sewer to be used for Sewage

Since the lowest elevation near the pumping Station is +1,861.73m, sewers with invert level of +1,861.5m is considered to use for sewer storage. Length and Pipe Nos. of these sewers are as follows;

No. 19	ϕ225	L = 150 m (Allowance 100%)
No. 21	ϕ225	L = 120 m (Allowance 100%)

(3) Manhole

Nos. of Manhole $\frac{150+120}{50} \fallingdotseq 6$ (50m pitch)

Manhole Depth 1861.93 − 1860.482 = 1.25 m (No. 21)

(4) Calculation of Storage Capacity

a) Sewer

$$\frac{0.225^2 \times 3.14}{4} \times (150+120) \times (1-\frac{1}{2.0}) = 5.4\ m^3$$

b) Manhole

$$\frac{0.9^2 \times 3.14}{4} \times (1.25-0.225) \times 6 = 3.9\ m^3$$

Total 9.3 m^3

(5) Storage Time

$$\frac{9.3\ m^3}{53.4\ m^3/day}$$ = **0.17 hour = 10.4min**

2. Victoria Park Pumping Station

(1) Sewage Flow

Q_{HM} = 2.82 m^3/min = 169.2 m^3/hour (Hourly Maximum Sewage Flow to PS)

(2) Sewer to be used for Sewage

Since the lowest elevation near the pumping Station is +1,877m, sewers with invert level of +1,876.5m is considered to use for sewer storage. Length and Pipe Nos. of these sewers are as follows;

No.27	ϕ225	L = 150 m	(Allowance 100%)
No.26	ϕ300	L = 520 m	(〃)
No.12	ϕ300	L = 200 m	(〃)
No.28	ϕ150	L = 200 m	(〃)

(3) Manhole

Nos. Manhole $\frac{150+520+200+200}{50} \fallingdotseq 22$ (50m pitch)

Manhole Depth 1877.26 − 1874.556 = 2.70 m
(No.26)

(4) Calculation of Storage Capacity

a) Sewre

$$\left\{ \frac{0.225^2 \times 3.14}{4} \times 150 + \frac{0.300^2 \times 3.14}{4} \times (520+200) + \frac{0.1502 \times 3.14}{4} \times 200 \right\}$$

$$\times (1 - \frac{1}{2.0}) = 30.2\ m^3$$

b) Manhole

$$\frac{0.9^2 \times 3.14}{4} \times (2.7 - 0.30) \times 22 = 33.6\ m^3$$

Total 63.8 m^3

(5) Pipe Storage Time

$$\frac{63.8\ m^3}{169.2\ m^3/hour} = \mathbf{0.38\ hour} = \mathbf{\underline{22.6\ min}}$$

Chapter 14

Appendix 14.1 Annual Operation and Maintenance Cost

Appendix 14.1 Annual Operation and Maintenance Cost

Nuwara Eliya

Master Plan Alternative 1 (Applied) -Operation Starting 2014

Item	Electricity						Man-Power			Spare Parts	
	m3/day	m3/hr	hrs	kW	kWh	Rs/month	No.	Rs/month	Rs/month	Cost	Rs/month
1. Sewer							3	6,000	18,000		
2. Pumping Station											
Nuwara Eliya											
P/S 1	985	53	18.4	11	203	34,599	0	6,000	0	3,553	2,961
P/S 2	2,506	169	14.8	22	326	51,559	0	6,000	0	4,602	3,835
3. Sewage Treatment Plant											
Nuwara Eliya	2,700m3/day		24	35	840	122,520	5	6,000	30,000	78,957	65,798
Hospital/Brewery											
4. Chlorine	2,338	2 mg/l				4,286					
5. Maintenance							2	10,000	20,000		
6. Manager/Engineer							2	15,000	30,000		
Sub-Total						212,964	12		98,000	87,112	72,593

Total	
month	383,557
year	4,602,683

Chlorine	Electricity
51,427	2,504,137

Man-Power
1,176,000

Spare Parts
871,120

Master Plan Alternative 2 (Not Applied)

Item	Electricity						Man-Power			Spare Parts	
	m3/day	m3/hr	hrs	kW	kWh	Rs/month	No.	Rs/month	Rs/month	Cost	Rs/month
1. Sewer							3	6,000	18,000		
2. Lift Station											
Nuwara Eliya											
L/S 1	747	53	14.0	3.7	52	13,746	1	6,000	6,000	3,266	2,722
L/S 2	1,745	116	15.1	15	226	37,798	0	6,000	0	4,294	3,578
3. Sewage Treatment Plant											
Nuwara Eliya	2,500m3/day		24	35	840	122,520	5	6,000	30,000	74,477	62,064
Hospital/Brewery	200m3/day		24	10	240	39,720	2		0	22,664	18,887
4. Chlorine	2,338	2 mg/l				4,286					
5. Maintenance							2	10,000	20,000		
6. Manager/Engineer							2	15,000	30,000		
Sub-Total						218,070	15		104,000	104,701	87,251

Total	
month	409,321
year	4,911,846

Chlorine	Electricity
51,427	2,565,409

Man-Power
1,248,000

Spare Parts
1,047,010

Feasibility Study -Operation Starting 2004

Item	Electricity						Man-Power			Spare Parts	
	m3/day	m3/hr	hrs	kW	kWh	Rs/month	No.	Rs/month	Rs/month	Cost	Rs/month
1. Sewer							2	6,000	12,000		
2. Pumping Station											
Nuwara Eliya											
P/S 1	985	53	18.4	11	203	34,599	0	6,000	0	3,553	2,961
P/S 2	2,506	169	14.8	22	326	51,559	0	6,000	0	4,602	3,835
3. Sewage Treatment Plant											
Nuwara Eliya	1,400m3/day		24	21	504	76,152	3	6,000	18,000	40,116	33,430
Hospital/Brewery											
4. Chlorine	1,220	2 mg/l				2,236					
5. Maintenance							1	10,000	10,000		
6. Manager/Engineer							2	15,000	30,000		
Sub-Total						164,546	8		70,000	48,271	40,226

Total	
month	274,772
year	3,297,266

Chlorine	Electricity
26,835	1,947,721

Man-Power
840,000

Spare Parts
482,710

Chapter 15

Appendix 15.1	Initial Environmental Examination Findings and Conclusions
Appendix 15.2	Water Quality Survey (Wet Season)
Appendix 15.3	Water Quality Survey (Dry Season)
Appendix 15.4	Land Acquisition Procedures
Appendix 15.5	Wastewater Treatment Plants Monitoring and Reporting Program

Appendix 15.1

INITIAL ENVIRONMENTAL EXAMINATION

FINDINGS AND CONCLUSIONS

(EXECUTIVE SUMMARY)

1. *Purpose of the Initial Environmental examination*

The Initial Environmental Examination (IEE) is conducted as an integral part of the Water Supply and Environmental Improvement Master Plan for the Greater Kandy and Nuwara Eliya areas.

The IEE has the following specific objects:

1) to achieve a sound knowledge of the actual condition of the environment within the project impact areas;

based on this, to preliminarily assess the possible and/or potential environmental impacts which may be realized through the implementation of the proposed Water Supply (WS) and Waste Water (WW) projects, and

2) to assess the need of implementing a full Environmental Impact Assessment (EIA), which, if necessary, will be conducted as an integral part of the Feasibility Studies which will follow the Master Plan.

2. *Served population and water demand*

2.1 Kandy Municipal

1) Served population in 1998 is 554,310 persons;
2) Served population in 2015 will be 694,160 persons;
3) Present water demand is 117,200 m3/day (211 L/persons*day)
4) Water demand in 2015 will be 195,900 m3/day (282 L/persons*day)

2.2 Nuwara Eliya

1) Served population in 1998 is 25,500 persons;

2) Served population in 2015 will be 51,400 persons;
3) Present water demand is 6,161 m3/day (241.6 L/person*day)
4) Water demand in 2015 will be 16,320 m3/day (317.5 L/person*day)

3. Project description

3.1 Water supply

3.1.1 Kandy Municipal

1) Extraction of additional 42,500 m3/day at existing Kandy Municipal Plant (actual capacity 33,400 m^3/day);
2) Up to 118,000 m^3/day new treatment plant at Polgolla (actual capacity: 1440 m3/day)
3) Construction of 254 Km of transmission mains, ranging from 110 mm to 900 mm in diameter;
4) 61 reservoirs with a total storage capacity of 32,925 m^3;
5) 45 pump stations, most of which will be located adjacent to reservoirs or treatment facilities.

3.1.2 Nuwara Eliya

1) Expansion of groundwater water sources;
2) Expansion of existing stream supply at Bambarakele by construction of a new dam;
3) Expansion of existing Lovers Leap stream supply with construction of two new dams;
4) New supply from a stream near Jayalauka with a new dam and 10-12 Km transmission main.

Existing transmission and distribution system will require upgrade to handle additional supply.

3.2 Wastewater treatment

3.2.1 Greater Kandy

Three separate sub-areas are considered for priority interventions in the Greater Kandy Area: 1) Kandy Municipal, 2) Katugastota and 3) Akurana.

1) Kandy Municipal

1) New Treatment Plant, aerated lagoons, to be located in Getambe, with capacity of 90 L/s (about 8,000 m3/day). Required area is 2.7 ha.
2) Collection mains with diameter varying from 200 to 100m mm, for a total length of 20.13 km.
3) Two pump stations, with capacity of 8 L/sec and 100 L/sec, located at Lake side and Railroad.

2) Katugastota

1) New treatment plant, aerated lagoons, with capacity of 6.5 L/s. (561 m3/day). Total area required 0.5 ha.
2) 6.5 Km of collection mains, with diameter varying from 200 mm to 300 mm;
3) Two pump stations with capacity 3 L/s and 9 L/s, located at the bridge and at treatment plant site.

3) Akurana

1) New treatment plant, aerated lagoons, with capacity of 6.0 L/s. (518 m3/day). Total area required: 0.5 ha.
2) 1.9 Km of collection mains, with diameter varying from 200 mm to 300 mm.

3.2.2 Newara Eliya

The following WW treatment facilities are planned in Nuwara Eliya (**FIG 2.2**):

1) New treatment plant, aerated lagoons, with capacity of 20 L/sec (1728 m3/day), located in an area south of the Recreational Ground. Total required land is 0.5 ha;
2) 12.4 Km of collection mains, with diameter varying from 200 mm to 300 mm;
3) Two pump stations with capacity 9 L/s and 20 L/s, located at the brewery and at racetrack.

4. Summary review of beneficial/adverse impacts

1) The purpose of the present project is to prevent or alleviate the effect on the environment produced by the discharge of untreated or inadequately treated wastewater, and to improve the quality of life of resident people by increasing the amount of safe drinkable water supplied. When properly planned, designed, constructed and managed, the project will therefore have an overall beneficial impact on the environment.
2) The most important beneficial impacts will be:
- Reduction of public nuisance, because of increased safe water sources and reduction of open air sewers in urban areas;
- Improvement of public health, because of reduction of water vector diseases;
- Improvement of surface and underground water quality, because of reduction of untreated wastewater discharge.
3) The major permanent negative effect will be dislocation or resettlement of a few families actually living in the area selected for the new Polgolla water treatment plant. Resettlement, even if concerning a limited number of families, should be done in compliance with Sri Lankan Laws and regulations (see Par. 4.4). Compensation should be adequate in order to guarantee that dislocated/resettled families after the project will be "equal or better" than before.
4) Land acquisition for plant siting may also represent a problem, because almost all lands are private and chances of finding public lands where treatment plants or pumping stations may be sited are minimal.
5) Water quality in receiving surface and underground water bodies is likely to improve, because many raw sewage discharges will be replaced by a single treated waste water discharge, with strong reduction in the contaminants' content.
6) Major negative impact during construction will be on traffic and transportation, especially in densely populated urban areas, because of construction of mains. Kandy Municipal, Nuwara Eliya Municipal, and some of the minors town in Kandy District (Katugastota and Arakuna) will be affected.

7) A preliminary survey on traffic intensity in critical points of Kandy District has been carried out during the present study. Applicable mitigation measures (such as traffic diversion) will be studied in the EIA, but disturbances to population cannot be completely offset. A sound and thorough information campaign will also be helpful to mitigate the effects of public nuisance.
8) Noise and vibrations during construction are a routinely concern of EIA for projects which include deep trench excavation in urban areas, and may represent a critical issue in specific areas (high level residential areas, schools, hospitals). Mitigation measures will be provided in the EIA, but it is evident that negative impact cannot be completely offset. Again, an information campaign may help to overcame residents' complaints. Fortunately, this will be a temporary impact.
9) Offensive odors can be controlled at WS treatment plants, but are present at WW treatment plants, as a consequence of anaerobic decomposition. Impacts may be offset using adequate odor control techniques and with proper plant siting.
10) An important issue will be safety of workers and general public during construction, considering that all works will be conducted in densely populated areas. Suggestions on how to mitigate these effects will be given in the EIA. A specific Control and Monitoring Plan will be needed, establishing responsibilities as well as routinely and emergency procedures to be followed.
11) To make sure that the project will benefit the environment as expected, all domestic, public and commercial uses within the service areas should be required to connect to the system on a mandatory basis. The NWSDB, CEA and the Municipalities of Kandy and Nuwara Eliya, should be responsible for the enforcement of this measure.

5. *Intensity of Impacts*

Intensity of impacts is evaluated according to criteria established by CEA and reported at Para. 2.3, page 9 of "Guidance for Implementing the Environmental Impact Assessment (EIA) Process. Intensity is referred to permanent impacts only. An overall evaluation will be given for each criteria, turning for details to the previous Environmental Impact Matrix and/or to the specific chapters.

Intensity of impacts

Criteria for impacts' intensity evaluation	Degree of intensity
Degree to which the proposed action will affect public health or safety	Highly positive
Degree to which the proposed action will affect unique characteristics of a geographical area.	None
Degree to which the impacts on the environment and related social conditions are likely to be highly controversial:	Minor controversies may arise related to resettlement of families in Kandy and land acquisition procedures;
Degree to which the possible effects on environment are highly uncertain on involve unique or unknown risks	None
Anticipated cumulative significant impacts which cannot be avoided / offset or mitigated:	None
Degree to which the proposed action may affect the right of future generation to benefit from environmental and cultural resources:	None

6 *Conclusions about EIA requirement*

6.1 General

According to present Sri Lankan regulations, the water extraction, WS treatment plants, WW treatment plants and appurtenant works which are part of the present project, are subject to the EIA process only as plant siting is concerned.

The laying of pipeline in Kandy, Nuwara Eliya and minor town of Kandy District is not a prescribed project and therefore is not required to follow the EIA process. However, because of the potential social and environmental impacts arising out of this activity, it is recommended to formulate a sound management plan for this activity which will minimize the adverse impacts on the society and the natural environment.

EIA requirement for the different project components are summarized in Table 6.2.

6.2 Recommendations of Central Environmental Authority

The following procedure is recommended by the Central Environmental Authority

1. NWSDB will officially submit the IEE to CEA;
2. CEA will examine the report, and will assess if an EIA is needed or not, and to which extent. This step is necessary because the regulations expressed in Gazette 722/22 are to be considered as a general reference, and are subject to interpretation of the CEA;
3. CEA, on the base of IEE findings, will officially communicate to the NWSDB, within a two weeks period, if an EIA is definitely required or not.
4. If an EIA is required, the PP will also officially apply to the CEA, to know which will be the PAA entitled for revision and approval of the EIA;
5. The CEA will name a PAA and will officially communicate the name of the Agency to the PP.

6.3 Consultant's recommendations and justification for an EIA

Considering the preliminary evaluation of anticipated environmental effects presented in Chapter 5, and the recommendations received by the CEA in Colombo, it's the Consultant's opinion that an EIA is fully justified and will be needed.

The EIA must comply with both JICA and Sri Lankan CEA regulations.

Terms of Reference are given in Chapter 7.

POSTGRADUATE INSTITUTE OF SCIENCE

UNIVERSITY OF PERADENIYA
PERADENIYA
SRI LANKA

Report on

WATER QUALITY EXAMINATION

In the Kandy and Nuwara-Eliya Districts

Second phase - Rainy Season

Submitted to

JICA study Team, NWSDB,Kandy

By

Prof. O.A.Ileperuma (Project co-ordinator)
Department of Chemistry
University of Peradeniya
Peradeniya, Sri Lanka

September 8,98

INTRODUCTION

An agreement was signed between the JICA study team and the Postgraduate Institute of Science, University of Peradeniya in March 1998 for the chemical and biological analysis of water quality of springs, streams, ground water sources, raw sewage, water bodies (rivers and lakes) and sludge. This study was to take in two phases namely, the dry season and the rainy season . The report for the phase 1 of this project (dry season) has already been submitted and the present report is on the study carried out during the rainy season. This reason season from July to September was quite normal with intermittent dry days. The dry season in contrast was quite unusual in that it was an exceptionally warm dry season in the hill country. The study area covered the greater Kandy area and the Nuwara Eliya basin. The corresponding collection points are depicted in the attached maps.

Experimental

Samples were collected in cleaned acid washed bottles and sampling was carried out according to accepted methods. Sample preservation depending on the parameter to be analysed was carried out in situ. The general procedures employed for all analytical determinations are those given in " Standard Methods for the Examination of Water and Wastewater" 19^{th} edition (1995) published by the American Public Health Association, Washington, D.C. The following table gives the analytical procedures followed.

Parameter	Method
BOD,COD	Standard titrimetric procedure
Chloride, Fluoride	Ion-selective electrodes
Total nitrogen	Kjeldhal method
Total phosphorus	Spectrophotometry (Vanadomolybdate method)
Sulphate	Turbidimetry
Nitrate, nitrite	Spectrophotometry (Azo dye method with cadmium reduction)
Cd,Fe,Pb,Mn,Co,Zn Cu	Atomic absorption spectrophotometry
As,Hg	Atomic absorption with hydride reduction
SS,TDS	Gravimetry

Microbiological examinations for *E.Coli* and coliforms were estimated according to the ISO 4831:1990 International standards using the most probable number counts. These gave far more accurate readings for sewege samples compared with the data reported in the first report.

Results and Discussion

(I) Raw water quality survey

Results of the raw water quality survey are given in tables 1-3 and the results of the pesticide analysis and their detection limits are given separately in annexure 1. There was total absence of any of the pesticides generally used in Sri Lanka in any of the water quality samples which were investigated (Annexure 1). In general these samples show increased turbidity and increased suspended solids compared to the values obtained during the dry season. The phosphate concentration also showed a significant increase in concentration during the rainy season specially in the Nuwara Eliya district. This is perhaps due to the washing of phosphate fertilisers which remain close to the ground during the dry season and gets leached into the streams and underground water resources during the rainy season. The total hardness of the water during the rainy season is about 50% of its values during the dry season.

The conductivity of ground water sources was high compared to those collected from springs from Nuwara-Eliya.This is probably due to high calcium and magnesium salts as indicated by total alkalinity and hardness. The sulphate contents of these samples were also high. Out of the bore hole wells, those at the Race course, Galway forest lodge, Interfashion, Hill club and Palladium had relatively high mineralisation as seen in higher conductivities. The nitrate and free ammonia contents of the Palladium bore hole was very high most probably due to faecal contamination. There was an unusual situation with respect of the analytical results of WQ/N/15.1 compared to analyses obtained later from the same bore hole. This is because this is a shallow bore hole and WQ/N/15.1 was collected when the weather was dry and samples WQ/N/15.2 and WQ/N/15.3 during very high rain. As a result its iron content was very high, turbidity was also high and Cl^- was also high. In particular, this particular bore hole has high iron content also for the same reason. The water from this bore hole appeared brownish and this explains its high TDS values. There was no significant variation of the water composition for samples collected from springs over a 24 h period indicating little human activity. There is also no evidence of pesticide contamination for any of these samples (both spring water & bore holes at Nuwara Eliya). It is also clear that the sample at Lovers leap and Pedro intake had relatively high contamination by coliforms indicating human faecal contamination. The residual coliform counts from bore hole water samples probably arises due to contamination of the rubber hoses used to collect the sample and attached to the bore hole well.

It is also clear that the Palladium bore hole water is also highly contaminated as seen in its high bacterial contamination, high iron content, high chloride etc. This is a shallow bore hole present in a highly contaminated area and it is not surprising that its water is highly polluted. The high iron content may arise due to corroding metallic pipes since this bore hole is situated in the heart of the city. Also because of close proximity to septic tanks it exhibits a high level of ammonia. The Brewery bore hole was not in

general use at the time samples were collected and the levels of heavy metals may be high for this reason.
The race course bore hole shows increased mineralisation (high conductivity) with higher concentrations of phosphate compared to other bore holes. This is due to it being close to an area which is intensively fertilised. Such fertiliser run-offs could explain its high phosphate level.

Samples from new bore holes WQ/N/18 and WQ/N/19 showed that the one near the golf course (WQ/N/19) has relatively high hardness and conductivity while that dug near Galway forest showed quite normal results.

Additional raw water quality samples were collected near the Gohagoda site where sample WQ/K/3 is the sample collected about 100 metres upstream of the sewage effluent flow. This sample clearly showed increased nitrate contamination but no big differences from other water quality samples.

Survey points and the keys to samples

Raw water quality

KANDY

WQ/K/1	Intake point of Kandy water treatment plant.
WQ/K/2	Polgolla dam intake

Additional sample for raw water quality was selected near the proposed intake at Gohagoda (near Katugastota) just up river from the sewage dumping site.

WQ/K/3 Gohagoda -proposed intake point before sewage flow

NUWARA ELIYA

Surface intakes

WQ/N/ 1	Bambarakele
WQ/N/2	Shanthipura
WQ/N/3	Pedro intake
WQ/N/4	Water field (new)
WQ/N/5	Water field(old)
WQ/N/6	Piyatissapura
WQ/N/7	Brewery falls
WQ/N/8	Gemunupura
WQ/N/9	Lovers leap

Ground water resources

WQ/N/10	Hill club bore hole
WQ/N/11	Race course bore hole

Table 1. Raw water quality data (Kandy district)
Units employed: Tempertaure ^{0}C,COD,BOD,SS,TDS,Cl^-,SO_4^{2-},As,Cd,Zn,Co ppm, Conductivity $uscm^{-1}$, Coliform total at 35 C/100ml, *E.Coli.* At 44 C/100ml

Sample	T air	T water	Turbidity	pH	onductivity	TDS	Cl^-	Total alkalinity	Free NH_3	NO_3^-	NO_2^-	F^-	PO_4^{3-}	Total hardness
WQ/K/1.1	24.8	22.9	14.9	5.5	57.1	28.5	4.2	7.8	ND	1.89	0.05	0.02	0.62	6.7
WQ/K/1.2	27.0	24.7	22.3	5.9	43.6	22.4	2.5	16.9	0.09	4.19	0.10	0.02	2.04	4.8
WQ/K/1.3	22.9	23.3	47.1	6.8	46.4	23.1	3.1	16.3	0.10	1.33	0.18	0.04	3.01	15.2
WQ/K/1.4	23.5	23.1	14.7	6.7	44.2	22.1	3.1	20.5	0.13	1.98	0.08	0.03	3.14	15.2
WQ/K/1.5	27.0	24.0	25.1	7.2	43.3	21.7	2.1	16.9	0.05	3.22	0.27	0.03	3.01	17.0
WQ/K/1.6	27.5	24.2	11.5	6.4	49.8	24.5	2.5	18.7	1.00	1.70	0.10	0.02	4.04	17.0
WQ/K/1.7	28.0	23.6	26.1	6.5	49.7	24.8	3.6	21.7	0.08	2.06	0.08	0.06	0.91	18.9
WQ/K/1.8	24.0	22.2	25.1	6.4	51.1	25.5	3.6	22.3	0.22	2.41	0.10	0.10	1.88	18.9
WQ/K/2.1	24.9	24.3	54.3	5.2	54.9	27.5	3.8	16.9	0.06	2.53	0.10	0.02	2.04	17.1
WQ/K/2.2	25.5	24.5	23.3	6.8	51.7	25.9	2.7	16.9	0.08	2.08	0.09	0.02	1.81	4.8
WQ/K/2.3	23.8	23.4	19.9	7.1	51.4	27.7	4.1	19.9	0.12	1.76	0.07	0.05	1.71	21.0
WQ/K/2.4	24.7	24.2	16.4	6.5	59.2	29.7	5.0	19.9	0.10	1.91	0.13	0.06	6.85	21.0
WQ/K/2.5	27.0	24.3	28.2	7.2	50.7	25.3	4.3	18.7	0.13	1.32	0.08	0.03	3.85	17.0
WQ/K/2.6	27.0	24.6	11.7	6.4	56.0	28.0	3.3	21.7	0.13	1.63	0.07	0.33	1.58	17.0
WQ/K/2.7	27.4	24.3	12.8	6.9	52.9	26.4	3.9	23.6	0.10	1.40	0.08	0.07	3.58	20.8
WQ/K/2.8	22.2	23.4	27.5	6.8	55.8	58.0	4.1	35.6	0.29	1.57	0.08	0.09	1.97	28.3
WQ/K/3.1	27.8	23.0	15.0	6.9	63.5	31.2	2.5	20.5	0.46	4.78	0.19	0.15	2.15	37.8
WQ/K/3.2	26.5	23.3	10.0	6.8	52.1	26.0	1.99	21.1	ND	3.52	0.13	0.16	1.51	39.6

Table 1. Raw water quality data (Kandy district)continued

Sample	SO_4^{2-}	CN^-	Total coliform	*E. coli*	Cu	Cd	Cr	Mn	Hg	As	Pb	Total iron
WQ/K/1.1	1.8	$<10^{-4}$	1800	1100	ND	ND	ND	ND	ND	ND	ND	ND
WQ/K/1.2	1.4	$<10^{-4}$	100	20	ND	ND	ND	ND	ND	ND	ND	ND
WQ/K/1.3	2.1	$<10^{-4}$	1100	260	ND	ND	ND	ND	ND	ND	ND	1.05
WQ/K/1.4	1.8	$<10^{-4}$	900	100	ND	ND	ND	ND	ND	ND	ND	0.35
WQ/K/1.5	2.2	$<10^{-4}$	3400	1600	ND	ND	ND	ND	ND	ND	ND	3.42
WQ/K/1.6	2.4	$<10^{-4}$	2200	190	ND	ND	ND	ND	ND	ND	ND	0.96
WQ/K/1.7	1.3	$<10^{-4}$	640	60	ND	ND	ND	ND	ND	ND	ND	1.38
WQ/K/1.8	1.9	$<10^{-4}$	800	80	ND	ND	ND	ND	ND	ND	ND	0.29
WQ/K/2.1	3.3	$<10^{-4}$	300	80	ND	ND	ND	ND	ND	ND	ND	0.23
WQ/K/2.2	1.4	$<10^{-4}$	200	70	ND	ND	ND	ND	ND	ND	ND	0.18
WQ/K/2.3	1.7	$<10^{-4}$	3600	480	ND	ND	ND	ND	ND	ND	ND	0.54
WQ/K/2.4	5.8	$<10^{-4}$	210	30	ND	ND	ND	ND	ND	ND	ND	0.35
WQ/K/2.5	2.6	$<10^{-4}$	2080	200	ND	ND	ND	ND	ND	ND	ND	0.54
WQ/K/2.6	0.7	$<10^{-4}$	2600	240	ND	ND	ND	ND	ND	ND	ND	0.29
WQ/K/2.7	1.3	$<10^{-4}$	800	250	ND	ND	ND	ND	ND	ND	ND	1.94
WQ/K/2.8	0.7	$<10^{-4}$	600	60	ND	ND	ND	ND	ND	ND	ND	0.6
WQ/K/3.1	0.7	$<10^{-4}$	100	30	ND	ND	ND	ND	ND	ND	ND	ND
WQ/K/3.2	0.7	$<10^{-4}$	1100	260	ND	ND	ND	ND	ND	ND	ND	ND

Table 2. Raw water quality data - Nuwara-Eliya district (Surface intakes)

Sample	T air	T water	Turbidity	pH	onductivity	TDS	Cl^-	Total alkalinity	Free NH_3	NO_3^-	NO_2^-	F^-	PO_4^{3-}	Total hardness
WQ/N/1.1	23.0	15.5	0.89	7.4	10.5	5.2	1.10	6.0	0.05	1.18	0.04	0.04	2.72	3.8
WQ/N/1.2	15.0	14.0	1.35	6.4	11.4	5.6	0.90	8.4	0.14	1.06	0.75	0.02	2.12	4.8
WQ/N/2.1	20.3	15.9	0.79	7.0	15.3	7.2	1.10	5.4	0.02	0.41	0.45	0.20	1.79	5.7
WQ/N/2.2	15.0	14.7	0.70	6.2	15.4	7.0	0.90	6.0	0.13	4.47	0.62	0.02	0.81	8.6
WQ/N/3.1	23.1	16.2	1.20	8.2	11.4	5.8	1.00	7.2	ND	0.20	0.30	0.02	1.96	7.6
WQ/N/3.2	17.0	15.2	1.35	6.2	11.0	5.4	0.85	9.1	0.01	1.94	0.56	0.02	1.82	4.8
WQ/N/4.1	20.3	15.9	1.85	6.2	11.3	5.6	1.10	6.6	0.01	1.26	0.42	0.03	2.64	5.7
WQ/N/4.2	15.0	14.6	1.15	6.8	10.6	5.3	1.00	7.2	0.27	0.93	0.75	0.02	3.21	4.8
WQ/N/5.1	18.8	15.6	0.78	7.1	12.7	6.3	1.10	9.2	0.02	0.27	0.17	0.01	1.20	7.6
WQ/N/5.2	15.4	14.7	1.25	6.2	11.2	5.6	1.00	8.4	0.27	0.84	0.95	0.02	1.25	5.7
WQ/N/6.1	23.4	15.8	0.85	6.7	12.1	6.0	1.07	7.8	ND	0.80	0.27	0.02	3.35	6.7
WQ/N/6.2	16.0	15.0	0.75	6.2	11.4	5.6	1.00	7.2	ND	1.37	0.11	0.02	3.16	4.8
WQ/N/7.1	16.2	15.2	1.00	8.2	13.1	6.5	1.00	8.4	0.02	0.87	0.18	0.02	2.80	4.8
WQ/N/7.2	16.1	14.8	1.40	6.7	11.8	5.9	0.90	9.1	0.19	0.52	0.88	0.02	1.69	4.8
WQ/N/8.1	21.0	15.7	0.95	7.2	12.8	6.3	1.20	8.4	0.02	0.96	0.27	0.05	2.30	8.6
WQ/N/8.2	17.3	14.2	0.82	6.8	11.2	5.5	0.90	7.8	0.23	0.60	0.69	0.03	2.73	7.6
WQ/N/9.1	20.9	15.1	1.84	6.5	11.1	5.5	1.10	8.5	0.02	0.20	0.24	0.05	2.82	5.7
WQ/N/9.2	18.4	14.8	1.20	6.0	10.8	5.0	1.00	7.2	0.38	2.02	0.62	0.02	0.30	4.8

Table 2. Raw water quality data - Nuwara-Eliya district (Surface intakes) continued

Sample	SO_4^{2-}	CN^-	Total coliform	*E. coli*	Cu	Cd	Cr	Mn	Hg	As	Pb	Total iron
WQ/N/1.1	1.30	$<10^{-4}$	36	12	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/1.2	1.10	$<10^{-4}$	200	50	ND	ND	ND	ND	ND	ND	ND	0.35
WQ/N/2.1	1.70	$<10^{-4}$	140	50	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/2.2	1.20	$<10^{-4}$	160	60	0.2	ND	ND	ND	ND	ND	ND	0.35
WQ/N/3.1	1.30	$<10^{-4}$	2400	1000	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/3.2	1.20	$<10^{-4}$	210	120	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/4.1	1.60	$<10^{-4}$	50	16	ND	ND	ND	ND	ND	ND	ND	0.11
WQ/N/4.2	1.40	$<10^{-4}$	40	20	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/5.1	1.70	$<10^{-4}$	36	10	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/5.2	1.50	$<10^{-4}$	20	4	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/6.1	1.20	$<10^{-4}$	110	40	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/6.2	1.40	$<10^{-4}$	240	100	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/7.1	1.40	$<10^{-4}$	40	Nil	ND	ND	ND	ND	ND	ND	ND	0.23
WQ/N/7.2	1.20	$<10^{-4}$	40	10	ND	ND	ND	ND	ND	ND	ND	0.2
WQ/N/8.1	1.30	$<10^{-4}$	72	32	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/8.2	0.90	$<10^{-4}$	170	50	ND	ND	ND	ND	ND	ND	ND	0.18
WQ/N/9.1	1.50	$<10^{-4}$	2100	1000	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/9.2	1.50	$<10^{-4}$	140	80	ND	ND	ND	ND	ND	ND	ND	0.35

Table 3. Raw water quality data - Nuwara-Eliya district (Ground water sources)

Sample	T air	T water	Turbidity	pH	conductivity	TDS	Cl^-	Total alkalinity	Free NH_3	NO_3^-	NO_2^-	F^-	PO_4^{3-}	Total hardness
WQ/N/10.1	19.0	18.0	61.1	6.8	177.0	88.0	2.19	106.0	0.24	1.78	0.08	0.04	4.93	40.0
WQ/N/10.2	20.0	18.8	36.5	7.2	186.0	93.0	1.62	109.0	0.09	2.47	0.12	0.04	9.02	81.0
WQ/N/10.3	19.8	18.2	43.3	7.4	220.0	110.0	1.58	142.0	0.19	2.54	0.09	0.05	3.11	106.0
WQ/N/11.1	20.0	19.8	7.20	6.8	250.0	130.0	1.29	168.0	0.08	1.74	0.09	0.04	2.50	128.0
WQ/N/11.2	16.0	18.5	22.40	7.1	250.0	125.0	1.62	165.0	0.04	1.48	0.08	0.02	9.45	123.0
WQ/N/11.3	23.0	19.4	1.33	6.8	260.0	130.0	1.25	170.0	0.11	4.26	0.09	0.04	3.77	128.0
WQ/N/12.1	22.0	16.0	1.45	6.8	103.0	52.0	1.62	81.0	ND	2.72	0.18	0.03	2.73	55.0
WQ/N/12.2	16.5	16.7	1.28	6.9	99.0	49.0	1.81	54.0	0.07	4.26	0.09	0.02	6.21	43.0
WQ/N/12.3	24.0	16.5	0.96	6.0	99.0	49.0	1.58	57.0	0.10	3.06	0.12	0.07	2.08	40.0
WQ/N/13.1	19.0	17.0	2.18	5.8	176.0	89.0	15.49	11.0	0.13	9.00	0.12	0.06	3.47	60.0
WQ/N/13.2	17.5	17.1	1.15	5.5	176.0	89.0	26.91	12.0	0.07	7.41	0.10	0.04	5.77	53.0
WQ/N/13.3	21.0	17.4	0.54	4.9	180.0	90.0	25.11	12.0	0.16	8.74	0.11	0.05	1.94	54.0
WQ/N/14.1	20.0	19.0	2.34	7.8	260.0	130.0	2.04	171.0	0.07	2.78	0.09	0.04	1.44	128.0
WQ/N/14.2	19.0	24.0	6.90	7.5	260.0	130.0	1.81	169.0	0.01	3.59	0.57	0.04	8.20	128.0
WQ/N/14.3	22.0	20.2	1.57	7.0	250.0	125.0	1.54	166.0	0.21	3.30	0.54	0.05	2.91	124.0
WQ/N/15.1	19.0	17.9	775.0	5.2	1000.0	500.0	1.58	373.0	2.75	97.12	14.2	0.04	4.40	275.0
WQ/N/15.2	19.5	18.5	120.0	7.0	1020.0	490.0	124.00	391.0	0.16	32.17	2.06	0.02	3.45	294.0
WQ/N/15.3	19.0	18.9	800.0	6.3	1000.0	500.0	109.00	301.0	4.45	42.13	2.26	0.02	2.66	184.0
WQ/N/16.1	19.0	18.0	11.5	5.0	37.0	19.0	2.24	7.9	0.19	2.44	0.09	0.02	4.63	9.4
WQ/N/16.2	17.0	18.5	22.5	5.8	29.0	15.0	1.54	9.7	0.27	3.88	0.09	0.02	5.11	4.7
WQ/N/16.3	17.5	18.2	4.8	5.7	42.0	21.0	2.57	14.5	0.62	3.83	0.09	0.03	2.96	5.7
WQ/N/17.1	19.0	17.0	29.00	7.4	198.0	99.0	3.16	115.0	0.20	4.68	0.16	0.04	4.32	87.0
WQ/N/17.2	16.0	17.0	9.30	7.0	200.0	100.0	3.16	110.0	0.06	6.48	0.09	0.04	5.69	91.0
WQ/N/17.3	22.0	17.0	7.10	6.3	220.0	100.0	2.57	122.0	0.16	5.44	0.1	0.03	3.11	92.0
WQ/N/18	17.5	17.0	0.2	6.2	49.8	24.9	2.63	27.3	0.04	4.28	0.09	0.17	0.32	20.8
WQ/N/19	16.0	17.3	5.0	9.4	230.000	115.2	2.19	150.7	0.05	2.38	0.09	0.18	0.68	115.1

Table 3. Raw water quality data - Nuwara-Eliya district (Ground water sources)continued

Sample	SO_4^{2-}	CN^-	Total coliform	*E. coli*	Cu	Cd	Cr	Mn	Hg	As	Pb	Total iron
WQ/N/10.1	2.11	$<10^{-4}$	140	10	ND	ND	ND	0.40	ND	ND	ND	5.19
WQ/N/10.2	2.62	$<10^{-4}$	140	32	ND	ND	ND	0.33	ND	ND	ND	5.14
WQ/N/10.3	2.12	$<10^{-4}$	72	50	ND	ND	ND	0.07	ND	ND	ND	1.27
WQ/N/11.1	1.85	$<10^{-4}$	40	Nil	ND	ND	ND	ND	ND	ND	ND	0.35
WQ/N/11.2	1.65	$<10^{-4}$	50	nd	ND	ND	ND	ND	ND	ND	ND	0.72
WQ/N/11.3	3.78	$<10^{-4}$	40	10	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/12.1	1.45	$<10^{-4}$	90	10	ND	ND	ND	0.47	ND	ND	ND	ND
WQ/N/12.2	3.29	$<10^{-4}$	72	40	ND	ND	ND	ND	ND	ND	ND	1.05
WQ/N/12.3	5.28	$<10^{-4}$	50	20	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/13.1	7.04	$<10^{-4}$	Nil	Nil	ND	ND	ND	ND	ND	ND	ND	1.65
WQ/N/13.2	3.04	$<10^{-4}$	nil	nil	ND	ND	ND	ND	ND	ND	ND	0.50
WQ/N/13.3	8.83	$<10^{-4}$	nil	nil	ND	ND	ND	0.15	ND	ND	ND	0.24
WQ/N/14.1	2.45	$<10^{-4}$	110	30	ND	ND	ND	ND	ND	ND	ND	0.29
WQ/N/14.2	3.37	$<10^{-4}$	140	60	ND	ND	ND	ND	ND	ND	ND	0.44
WQ/N/14.3	2.95	$<10^{-4}$	90	20	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/15.1	2.75	$<10^{-4}$	100	40	ND	ND	ND	1.62	ND	ND	ND	10.20
WQ/N/15.2	3.58	$<10^{-4}$	72	20	0.54	ND	1.34	9.33	ND	ND	ND	418.50
WQ/N/15.3	1.75	$<10^{-4}$	60	30	0.45	ND	0.94	7.93	ND	ND	ND	342.00
WQ/N/16.1	1.61	$<10^{-4}$	20	Nil	ND	0.03	ND	0.07	ND	ND	ND	1.98
WQ/N/16.2	2.37	$<10^{-4}$	50	nd	0.08	ND	ND	0.13	ND	ND	ND	0.90
WQ/N/16.3	2.65	$<10^{-4}$	40	10	ND	ND	ND	0.07	ND	ND	ND	2.72
WQ/N/17.1	1.78	$<10^{-4}$	60	Nil	ND	ND	ND	ND	ND	ND	ND	0.56
WQ/N/17.2	1.12	$<10^{-4}$	110	60	ND	ND	ND	ND	ND	ND	ND	0.57
WQ/N/17.3	3.02	$<10^{-4}$	72	40	ND	ND	ND	0.05	ND	ND	ND	0.20
WQ/N/18	2.18	$<10^{-4}$	20	Nil	ND	ND	ND	ND	ND	ND	ND	ND
WQ/N/19	1.97	$<10^{-4}$	20	Nil	ND	ND	ND	ND	ND	ND	ND	ND

Raw water qualitysurvey

Sample points :

Kandy

1. Gatambe
2. Polgolla
3. Mahaweli river at Gohagoda

Nuwara - Eliya

Surface intakes

1. Bambarakelle
2. Shanthipura
3. Pedro intake
4. Water field - New
5. Water field - Old
6. Piyatissapura
7. Brewery intake
8. Gemunu Mawatha
9. Lovers slip

Ground water sources

10. Hill Club
11. Race Course bore hole
12. Upper Lake Road B.H.
13. Galway Forest Lodge
14. Interfashion
15. Palledium Hotel
16. Golf Club
17. Celon Brewery
18. Galway new bore hole
19. New bore hole near golf ground

WQ/N/12 Upper lake road bore hole
WQ/N/13 Galway forest bore hole
WQ/N/14 Interfashion bore hole
WQ/N/15 Palladium bore hole
WQ/N/16 Golf club bore hole
WQ/N/17 Brewery bore hole
WQ/N/18 Galway new bore hole
WQ/N/19 New bore hole near golf ground

The last two bore holes WQ/N/18 and WQ/N/19 are the newly dug wells and samples were collected once at the time they were dug and these data are also provided in the table for water quality (Nuwara-Eliya district)

2. Sewage quality survey

The location of sample collection and the key to sample numbers are given below:

Kandy K/1. High income house – Domestic sewage
K/2 Middle income house - Domestic sewage
K/3. Low income house - Domestic sewage
K/4. Hantana scheme - Before treatment
K/5. Office sewage - Education office, Kandy
K/6. High Income house- effluent from septic tank
K/7. Middle income house - Effluent from septic tank
K/8. Low income house – Effluent from septic tank
K/9 University office - Effluent from septic tank
K/10. Hantana scheme - After treatment
K/11. Hotel with treatment facility - Swiss Hotel Influent
K/12. Hotel with treatment facility - Swiss Hotel Effluent
K/13. Hotel (without treatment facility) Riverdale grey water
K/14. Industrial waste water - Chocolate company(before treatment
K/15. Industrial waste water - Chocolate company(after treatment)
K/16. Industrial waste water - Sun match company*
K/17. Hospital sewage - Peradeniya teaching hospital - Before treatment
K/18. Hospital sewage - Peradeniya teaching hospital - After treatment
K/19. Sewage effluent from the Gohagoda garbage at the dumping site
K/20. Sewage effluent from Gohagoda at the stream which flows into river just before entry into river

*Only one sample was collected from point 16 (Sun match company) since the effluent is discharged only at 3.00 p.m. from the factory.

Nuwara-Eliya N/1. Domestic sewage (middle income)
N/2. Domestic sewage (low income)
N/3 Domestic sewage (Ceybank hotel)
N/4. Municipality – Nuwara Eliya (office sewage)
N/5. Local eating house (domestic sewage)
N/6 Domestic sewage- hotel without treatment- Windsor hotel
N/7 Effluent from septic tank (middle income house)
N/8. Effluent from septic tank (Cey Bank Rest)
N/9 Effluent from septic tank (slum house)
N/10. Effluent from septic tank (municipality)
N/11.Hotel (with treatment facility) - before treatment (Grand Hotel)
N/12. Hotel (with treatment facility) - after treatment (Grand Hotel)
N/13. Industrial wastewater - drain (Ceylon Brewery)
N/14. Industrial wastewater - effluent after treatment (Ceylon Brewery)
N/15. Hospital sewage
N/16. Tea factory effluent

The analytical results are given in tables 4 & 5. The pH of the sewage samples were generally higher than 7.0 and hence within tolerance limits for disposal. Several had high sulphate contents (K/3,K/11,K/12 ,K/7,K/16). Contamination from chloride is very high in Suisse hotel influent (K/11), and those from K/16,K/19 and K/20 . Phosphates may be high in sewege samples due to increased use of detergents for washing dishes etc. while the treatment appears to reduce this concentration. Among heavy metals, only zinc appears in almost all samples while cadmium is present in the sample K/11 (Riverdale grey water) and K/13 (Sun match company). Zinc probably originates in the galvanised tubing used in most sewage disposal systems.

The sewage effluent from the Gohagoda dumping site is quite dark in colour with a lot of dissolved solids (K/19 & K/20) and also had high Zinc. It also high chloride content. Sample SQ/N/8 (effluent from septic tank at Ceybank Rest) showed very high chloride & phosphate values while industrial waste water from the drain (Brewery) showed high sulphate content perhaps coming from the alum used for the treatment process.

The sample SQ/K/3.1 showing very high values for COD,SS and TDS and total nitrogen is owing to the fact that this particular sample when collected had a lot of suspended solids (taken early morning from the slums area housing scheme). This is the time that the cattle-sheds are washed and the water is highly turbid and contaminated with the excreta and cow-dung. The other two samples had less of all these parameters since only routine washing of dishes was involved at other times when the samples were collected.

3. River water quality

The locations of sample collection and the keys to sample numbers is given below.

Table 4. Sewege Quality Survey (Kandy district)

Sample	T air	Tsewage	pH	BOD	COD	SS	TDS	Cl^-	SO_4^{2-}	T-N	T-P	Total coliform	E. coli	As	Cd	Zn	Co
SQ/K/1.1	27.5	27.8	7.0	210	860	1200	420	35.2	8.2	213.0	1.78	17×10^5	<10	ND	ND	0.08	ND
SQ/K/1.2	27.8	28.2	7.1	220	720	1150	440	25.8	7.6	186.0	1.36	18×10^5	<10	ND	ND	0.12	ND
SQ/K/1.3	27.2	27.8	7.0	236	740	852	380	38.0	8.6	222.0	2.20	17×10^5	<10	ND	ND	0.1	ND
SQ/K/2.1	27.2	27.1	6.8	240	626	260	386	42.0	10.2	230.0	0.80	24×10^5	<10	ND	ND	0.22	ND
SQ/K/2.2	27.4	26.9	6.9	210	548	180	410	36.0	11.2	270.0	1.40	20×10^5	<10	ND	ND	0.24	ND
SQ/K/2.3	26.8	26.4	6.8	180	602	222	360	40.4	8.6	330.0	1.60	18×10^5	<10	ND	ND	0.16	ND
SQ/K/3.1	25.0	24.5	8.8	203	49	940	2680	269.0	43.8	105.2	42.90	68×10^5	18×10^5	ND	ND	0.64	ND
SQ/K/3.2	27.5	26.0	8.1	92.7	380	100	490	50.1	22.5	7.7	27.90	32×10^5	10×10^5	ND	ND	0.22	ND
SQ/K/3.3	27.0	25.0	6.9	123	49	270	650	7.9	7.5	34.5	8.34	28×10^5	8×10^5	ND	ND	0.13	ND
SQ/K/4.1	27.5	25.0	7.4	70	57	140	260	20.0	6.3	77.0	6.39	35×10^4	18×10^4	ND	ND	0.05	ND
SQ/K/4.2	28.0	25.0	7.2	90	300	250	190	25.1	10.8	15.4	10.65	38×10^4	16×10^4	ND	ND	0.05	ND
SQ/K/4.3	27.0	25.0	6.4	135	231	250	362	37.2	12.0	29.0	13.74	26×10^4	14×10^4	ND	ND	0.07	ND
SQ/K/4.4	27.0	25.1	8.2	120	180	160	212	25.2	8.2	54.5	10.10	22×10^4	12×10^4	ND	ND	0.04	ND
SQ/K/4.5	27.0	25.0	7.6	118	210	230	260	20.8	8.6	50.5	10.40	26×10^4	12×10^4	ND	ND	0.06	ND
SQ/K/4.6	26.8	24.9	7.2	90	226	240	320	26.2	8.8	48.6	11.20	20×10^4	10×10^4	ND	ND	0.05	ND
SQ/K/4.7	26.4	25.0	7.4	108	208	250	280	25.8	10.2	60.8	9.80	22×10^4	10×10^4	ND	ND	0.04	ND
SQ/K/4.8	26.4	24.9	6.8	132	280	230	276	25.8	8.8	54.6	12.80	18×10^4	4×10^4	ND	ND	0.12	ND
SQ/K/4.9	26.3	24.9	6.6	140	216	276	312	28.6	12.0	60.6	11.20	24×10^4	5×10^4	ND	ND	0.08	ND
SQ/K/4.10	26.1	24.6	7.2	128	202	190	210	30.2	11.2	58.2	10.50	20×10^4	6×10^4	ND	ND	0.04	ND
SQ/K/4.11	26.0	26.2	7.2	124	200	140	180.0	20.2	7.6	54.60	8.60	22×10^4	6×10^4	ND	ND	0.04	ND
SQ/K/4.12	25.8	26.0	7.1	130	210	150	200.0	22.4	8.8	60.80	9.20	16×10^4	4×10^4	ND	ND	0.04	ND
SQ/K/5.1	26.0	24.0	6.2	238	413	310	200	28.2	16.8	26.2	9.46	13×10^4	<10	ND	ND	0.02	ND
SQ/K/5.2	28.0	24.5	6.7	98	202	250	250	23.4	16.2	15.4	7.80	10×10^4	<10	ND	ND	0.03	ND
SQ/K/5.3	27.0	25.0	6.8	80	575	230	150	63.1	20.4	17.9	7.92	12×10^4	<10	ND	ND	0.02	ND
SQ/K/6.1	28.5	25.0	6.4	110	2866	2361	273	63.1	12.1	92.6	7.36	4×10^5	4×10^5	ND	ND	1.22	ND
SQ/K/6.2	28.8	25.6	6.5	120	2100	2020	320	50.5	10.9	86.4	6.46	4×10^5	4×10^5	ND	ND	0.8	ND
SQ/K/6.3	28.4	25.2	6.4	142	2200	2040	310	62.6	11.8	106.1	6.80	2×10^5	2×10^5	ND	ND	1.06	ND
SQ/K/7.1	27.0	25.0	6.9	15	613	353	220	794.3	33.2	53.3	22.87	33×10^5	33×10^5	ND	ND	0.49	ND
SQ/K/7.2	27.3	26.8	6.9	80	524	240	210	524.0	28.8	63.8	18.90	30×10^5	30×10^5	ND	ND	0.42	ND

Table 4. Sewage Quality Survey (Kandy district) contd..

Sample	T air	Tsewage	pH	BOD	COD	SS	TDS	Cl^-	SO_4^{2-}	T-N	T-P	Total coliform	E. coli	As	Cd	Zn	Co
SQ/K/7.3	26.8	26.3	6.8	86	580	280	220	610.0	30.2	60.8	20.50	$28x10^5$	$28x10^5$	ND	ND	0.46	ND
SQ/K/8.1	28.5	24.5	6.2	20	1716	25931	330	199.5	6.1	85.5	7.08	$16x10^3$	$16x10^3$	ND	ND	1.20	ND
SQ/K/9.1	28.0	26.0	6.6	43	8	289	260	3.8	10.2	16.9	2.28	110	78	ND	ND	0.17	ND
SQ/K/10.1	27.5	26.0	7.5	41	65	190	240	22.4	1.8	31.0	11.89	$30x10^4$	$20x10^4$	ND	ND	0.03	ND
SQ/K/10.2	28.0	27.7	7.6	53	57	250	290	21.4	2.9	26.8	8.31	$28x10^4$	$18x10^4$	ND	ND	0.02	ND
SQ/K/10.3	27.0	25.5	7.5	8	8	280	267	22.4	2.4	24.0	12.20	$24x10^4$	$16x10^4$	ND	ND	0.02	ND
SQ/K/11.1	27.5	26.0	6.7	215	462	130	200	214.0	46.2	30.1	19.05	$76x10^2$	$42x10^2$	ND	ND	ND	ND
SQ/K/11.2	28.0	26.5	6.4	98	227	110	190	135.0	31.2	13.9	10.58	$60x10^2$	$32x10^2$	ND	ND	0.1	ND
SQ/K/11.3	27.0	26.5	6.2	143	121	200	270	126.0	49.8	36.6	15.34	$62x10^2$	$30x10^2$	ND	ND	0.09	ND
SQ/K/12.1	27.5	27.0	6.6	33	97	150	370	20.4	99.0	30.0	10.35	$30x10^2$	$10x10^2$	ND	ND	ND	ND
SQ/K/12.2	28.0	27.0	6.3	81	32	100	560	38.9	87.3	20.6	25.89	$32x10^2$	$12x10^2$	ND	ND	0.07	ND
SQ/K/12.3	27.0	27.5	6.3	30	777	200	323	29.5	69.9	37.1	18.75	$34x10^2$	$8x10^2$	ND	ND	0.17	ND
SQ/K/13.1	25.0	25.5	6.8	12.7	57	100	140	14.1	6.6	61.0	14.32	$30x10^3$	$22x10^2$	ND	ND	0.03	ND
SQ/K/13.2	27.5	25.5	6.6	107	33	90	180	13.5	4.8	20.7	11.44	$28x10^3$	$20x10^2$	ND	ND	0.07	ND
SQ/K/13.3	27.0	25.0	6.6	203	97	100	160	14.4	4.7	33.0	11.44	$32x10^3$	$18x10^2$	ND	ND	0.07	ND
SQ/K/14	30.0	29.5	6.2	340	976	201	296	17.4	3.6	63.2	17.70	$18x10^3$	<10	ND	ND	0.54	ND
SQ/K/15	31.0	29.5	5.2	345	219	681	270	26.9	1.3	31.1	5.40	$12x10^3$	<10	ND	ND	0.07	ND
SQ/K/16	29.5	27.2	6.2	290	202	175	198	380.0	74.5	63.4	13.00	130	<10	0.902	ND	0.13	ND
SQ/K/17.1	26.0	24.0	6.4	10.2	113	270	270	15.5	10.9	39.4	11.17	$48x10^6$	$3x10^6$	ND	ND	0.17	ND
SQ/K/17.2	28.0	26.0	7.2	150	251	450	240	30.9	12.9	44.3	6.13	$40x10^6$	$3x10^6$	ND	ND	0.14	ND
SQ/K/17.3	27.0	25.0	6.8	52.7	48	650	191	17.0	10.8	15.4	8.66	$42x10^6$	$4x10^6$	ND	ND	0.1	ND
SQ/K/18.1	26.0	24.0	10.8	20.2	57	560	260	93.3	21.3	23.1	7.67	$18x10^6$	$2x10^5$	ND	ND	0.06	ND
SQ/K/18.2	28.0	25.0	6.8	100	73	180	260	17.0	13.4	19.5	4.74	$16x10^6$	$3x10^5$	ND	ND	0.1	ND
SQ/K/18.3	27.0	25.0	5.9	75.2	130	160	361	17.0	5.4	19.0	15.52	$14x10^6$	$2x10^5$	ND	ND	0.37	ND
SQ/K/19	33.0	35.5	6.9	3.2	1246	273	5280	794.3	7.8	223.1	8.15	$45x10^4$	2x105	ND	ND	0.30	ND
SQ/K/20	33.0	28.8	7.9	31	1343	201	3100	676.1	17.7	174.2	8.00	4500	1200	ND	ND	0.57	ND
SQ/K/21.1	25.0	25.5	7.5	12.8	24	70	270	25.7	10.9	29.9	7.46	3000	140	ND	ND	0.03	ND
SQ/K/21.2	28.0	25.0	7.5	7.7	24	660	250	74.1	14.4	10.3	7.46	2500	100	ND	ND	0.05	ND
SQ/K/21.3	27.0	25.0	7.0	220	97	110	270	31.6	6.0	43.1	5.75	2500	100	ND	ND	0.06	ND

Sampling points

1. High Income house - domestic sewege
2.Middle income house- domestic sewege
3. Low income house - domestic sewege
4. Hantana scheme- beforte treatment
5.Education office
6. High Income house- effluent from septic tank
7. Middle income house -effluent fromseptic tank
8. Low income house- effluent from septic tank
9. University office -effluent from septic tank
10.Hantana scheme- after treatment
11.Hotel with treatment facility -Suisse hotel influent
12. Hotel with treatment plant Suisse hotel -effluent
13. Hotel without treatment facility - Riverdale grey water
14. Industrial waste water-Chocolate company before treatment
15. Industrial waste water- Chocolate factory after treatment
16.Industrial waste water -Sun match company
17. Hospital sewege- Peradeniya hospital- before treatment
18.Hospital sewege- Peradeniya hospital - after treatment
19. Sewage effluent from Gohagoda at the dumping site
20. Sewage effluent from Gohagoda at the stream which flows into river just before entry into river
21. NWSDB

Table 5. Sewage Quality survey(Nuwara-Eliya district)

Sample	T air	Tsewage	pH	BOD	COD	SS	TDS	Cl^-	SO_4^{2-}	T-N	T-P	Total coliform	E. coli	As	Cd	Zn	Co
SQ/N/1.1	19.5	19.0	7.0	90.2	510.1	220	250	30.2	ND	31.6	7.47	$23x10^6$	<10	ND	ND	0.12	ND
SQ/N/1.2	17.0	18.5	6.8	275.2	866.3	210	270	239.0	13.6	50.8	13.01	$23x10^6$	<10	ND	ND	0.14	ND
SQ/N/1.3	16.5	17.5	5.8	315	591	170	410	193.0	6.9	38.2	18.66	$18x10^6$	<10	ND	ND	0.02	ND
SQ/N/2.1	19.0	17.0	10.4	143	251	82	240	7.9	52.8	78.5	5.58	$11x10^3$	$2x10^3$	ND	ND	0.09	ND
SQ/N/2.2	18.5	16.5	10.2	50	194	67	250	33.9	53.8	23.0	10.33	$9x10^3$	$2x10^3$	ND	ND	0.06	ND
SQ/N/2.3	16.5	17.0	10.4	188	81	50	350	37.2	55.3	44.7	7.49	$11x10^3$	$2x10^3$	ND	ND	0.08	ND
SQ/N/3.1	20.0	21.5	6.2	150	146	150	253	7.1	1.2	52.2	7.97	$130x10^3$	<10	ND	ND	0.08	ND
SQ/N/3.2	23.5	21.0	6.4	120	40	70	225	7.9	1.3	25.1	7.92	$90x10^3$	<10	ND	ND	0.06	ND
SQ/N/3.3	17.0	21.0	6.2	38	81	30	190	6.8	1.9	62.4	10.31	$100x10^3$	<10	ND	ND	0.06	ND
SQ/N/4.1	19.5	17.5	6.6	115	16	80	160	50.1	2.8	15.3	5.80	$300x10^2$	$200x10^2$	ND	ND	0.05	ND
SQ/N/4.2	21.0	18.0	6.9	90	437	70	180	10.9	4.6	72.4	10.98	$250x10^2$	$180x10^2$	ND	ND	0.04	ND
SQ/N/4.3	16.5	17.0	8.0	5	65	60	240	53.7	10.6	28.6	12.50	$320x10^2$	$200x10^2$	ND	ND	0.44	ND
SQ/N/5	19.5	20.5	6.4	325.2	1846	336	350	166.0	17.5	74.5	7.54	$13x10^6$	$49x10^5$	ND	ND	0.28	ND
SQ/N/6	19.9	18.7	7.0	75.2	145.7	148	93	14.4	9.9	21.7	7.84	$33x10^5$	$26x10^3$	ND	ND	ND	ND
SQ/N/7.1	19.8	18.8	6.8	120	540	210	420	156.0	24.2	54.2	11.80	$5x10^6$	$5x10^5$	ND	ND	0.22	ND
SQ/N/7.2	20.2	19.0	6.8	140	526	180	430	128.0	20.2	50.8	10.20	$5x10^5$	$5x10^5$	ND	ND	0.18	ND
SQ/N/7.3	19.7	18.6	6.8	136	488	200	520	148.2	23.8	62.0	12.80	$4x10^5$	$4x10^5$	ND	ND	0.16	ND
SQ/N/8.1	20.0	20.0	6.9	180	809	350	510	299.0	21.8	69.9	21.54	$11x10^6$	$11x10^6$	ND	ND	0.22	ND
SQ/N/8.2	23.5	17.5	6.9	153	518	350	470	162.0	30.6	44.2	20.05	$10x10^6$	$10x10^6$	ND	ND	0.14	ND
SQ/N/8.3	17.0	19.5	6.9	73	243	320	430	229.0	30.9	33.1	21.39	$8x10^6$	$8x10^6$	ND	ND	0.07	ND
SQ/N/9.1	19.5	19.1	6.7	132	320	220	310	120.0	16.2	61.8	18.60	$14x10^3$	$14x10^3$	ND	ND	0.12	ND
SQ/N/9.2	20.1	19.2	6.5	110	276	178	382	110.6	20.4	58.6	17.40	$12x10^3$	$12x10^3$	ND	ND	0.14	ND
SQ/N/9.3	18.8	18.1	6.6	148	318	148	412	100.8	18.6	65.6	18.20	$16x10^3$	$16x10^3$	ND	ND	0.12	ND
SQ/N/10.1	19.0	18.2	6.8	230	710	82	190	100.6	10.2	80.4	6.80	$17x10^6$	$11x10^6$	ND	ND	0.22	ND
SQ/N/10.2	19.5	18.5	6.8	216	652	104	160	120.4	11.5	86.8	7.20	$13x10^6$	$10x10^6$	ND	ND	0.2	ND
SQ/N/10.3	18.5	18.1	6.8	208	720	120	182	110.5	10.8	75.8	5.80	$18x10^6$	$10x10^6$	ND	ND	0.14	ND
SQ/N/11.1	19.5	21.5	6.8	118	178	10	197	79.4	6.2	83.5	14.29	$94x10^2$	$94x10^2$	ND	ND	0.07	ND
SQ/N/11.2	17.0	21.5	6.9	75	219	10	230	44.7	4.2	31.1	12.43	$82x10^2$	$80x10^2$	ND	ND	0.08	ND
SQ/N/11.3	17.0	20.5	7.1	153	146	50	220	33.9	10.5	83.5	16.11	$86x10^2$	$86x10^2$	ND	ND	0.07	ND

Table 5. Sewege Quality survey (Nuwara-Eliya district) contd..

Sample	T air	Tsewage	pH	BOD	COD	SS	TDS	Cl^-	SO_4^{2-}	T-N	T-P	Total coliform	E. coli	As	Cd	Zn	Co
SQ/N/12.1	19.5	21.0	6.8	125	57	20	80	25.1	15.3	36.6	13.80	$6.8x10^2$	<10	ND	ND	0.04	ND
SQ/N/12.2	17.0	21.5	6.8	65	49	30	180	32.4	14.4	22.0	12.10	$6.4x10^2$	<10	ND	ND	0.04	ND
SQ/N/12.3	17.0	20.5	6.8	25	97	10	60	15.8	15.6	27.1	8.82	$5.2x10^2$	<10	ND	ND	0.06	ND
SQ/N/13.1	22.5	21.5	2.9	63	980.7	3300	1090	6.3	97.7	29.6	6.05	$23x10^2$	<10	ND	ND	0.51	ND
SQ/N/13.2	17.0	18.0	3.7	13	1174	370	160	3.1	89.4	32.1	9.74	$18x10^2$	<10	ND	ND	0.27	ND
SQ/N/13.3	17.0	20.0	6.2	80	57	196	120	5.0	8.1	42.7	9.33	$26x10^2$	<10	ND	ND	0.34	ND
SQ/N/14.1	22.5	25.0	6.5	298	820.1	2556	1322	16.2	29.4	31.1	22.51	$17x10^3$	<10	ND	ND	0.09	ND
SQ/N/14.2	17.0	25.0	6.9	190	712	1186	896	16.2	28.8	28.0	13.30	$12x10^3$	<10	ND	ND	0.19	ND
SQ/N/14.3	17.0	24.0	6.9	288	777	2545	1332	7.4	7.8	69.9	15.26	$18x10^3$	<10	ND	ND	0.19	ND
SQ/N/15.1	20.0	17.0	6.2	37	49	90	180	14.1	1.6	44.2	6.82	$79x10^6$	$2x10^6$	ND	ND	0.05	ND
SQ/N/15.2	19.0	17.5	7.4	5	49	110	240	53.7	1.6	31.1	16.98	$82x10^6$	$2x10^6$	ND	ND	0.06	ND
SQ/N/15.3	17.0	17.5	6.6	3	24	180	340	4.4	1.7	44.1	10.17	$86x10^6$	$2x10^6$	ND	ND	0.09	ND
SQ/N/16	24.5	21.5	7.0	60.2	372.4	37	79	5.0	0.3	29.1	4.67	<10	<10	ND	ND	0.82	ND
SQ/N/17	21.0	23.2	7.3	100.2	170	427	346	19.9	0.5	31.3	4.77	$35x10^4$	$18x10^2$	ND	ND	0.19	ND

Sample points

Nuwara - Eliya
1. Domestic sewage (Middle income)
2. Domestic sewage (Low income)
3. Domestic sewage (ceybank hotel)
4.Office sewege-Municipality
5. Local eating house
6. Domestic sewage - hotel without treatment facility- Windsor hotel
7. Effluent from septic tank (Middle income house)
8. Effluent from septic tank (Ceybank rest)
9. Effluent from septic tank (slum house)
10. Effluent from septic tank (municipality)
11. Hotel with treatment facility - Grand Hotel Before treatment
11. Hotel with treatment facility - Grand Hotel After treatment
13. Industrial waste water- drain (Ceylon Brewery)
14. Industrial waste water- effluent after treatment (Ceylon Brewery)
15. Hospital sewage
16. Tea Factory effluent
17.Factory effluent -Interfashion

Kandy:	RWQ/K/1	Gangawata Korale- near University Gymnasium
	RWQ/K/2	Intake point of Kandy water treatment plant
	RWQ/K/3	Katugastota district (Pinga oya near meda-ela bridge)
	RWQ/K/4	Polgolla dam site intake
	RWQ/K/5	Stream near Polgolla University
	RWQ/K/6	Kundasale intake
	RWQ/K/7	Meda Ela
	RWQ/K/8	Down stream of the Gohagoda dumping site
Nuwara-Eliya		
	RWQ/N/1	Upstream of city's borders
	RWQ/N/2	Victoria park
	RWQ/N/3	Influent point to Gregory lake
	RWQ/N/4	Upstream of Hospital and Brewery
	RWQ/N/5	Influent point to Barrack's plain reservoir

The analytical data for samples are given in tables 6 & 7. The samples were most of the times brownish and muddy showing an increase in suspended solids and sometimes even high total dissolved solids during this season compared to the previous dry season data.The samples taken from Meda Ela which is a highly polluted canal show increased nitrate, sulphate, coliforms, suspended solids, etc. Dissolved oxygen was also very low for these samples.

Those samples collected from Nuwara Eliya were highly contaminated compared to Kandy samples. In particular, those samples collected at the influx point to Barracks Plain reservoir had very little dissolved oxygen with relatively high pH values. Also RWQ/N/4 and RWQ/N/5 showed high suspended and dissolved solids, high total nitrogen and high BOD values. These samples also had high COD values indicating increased contamination from organic wastes. This can be easily explained since sewage from the hospital, factories and even households are directly added to the stream feeding the Barracks Plain reservoir. There is also intensive agricultural activities and a lot of houses dumping septic tank wastes direct into this stream which explains the abnormal values for COD,SS, TDS and chloride for sample N/4.1. However apart from zinc which probably originate from rusting galvanized iron, heavy metal contamination is virtually non-existent.

It is also clear that the sample RWQ/N/3at the Victoria Park is highly contaminated due to coliforms and *E. coli* compared to RWQ/N/1 and RWQ/N/2. This is due to increased faecal contamination from human activity in the city.

Out of the Kandy samples RWQ/K/3 and RWQ/K/7 are those collected from Pinga-Oya and Meda-Ela and these are highly polluted streams which feed the Mahaweli river and this is the cause of their high level of contamination. The sample collected

Table 6.River Water Quality Survey (Kandy district)

Sample	T air	T water	pH	COD	SS	TDS	SO_4^{2-}	T-N	T-P	Total	E. coli	Cl^-	Cd	As	Zn	Co	Condu	BOD	DO
RWQ/K/1.1	23.1	23.6	5.4	8.1	60	34.3	1.2	9.9	0.62	2200	600	4.3	ND	ND	0.02	ND	67.8	3.7	7.5
RWQ/K/1.2	24.6	23.7	5.4	8.1	10	24.6	1.6	3.6	0.23	1700	1000	3.2	ND	ND	ND	ND	49.2	4.2	7.4
RWQ/K/1.3	23.9	24.3	5.7	8.1	30	25.5	2.1	8.2	0.67	2400	1200	3.6	ND	ND	0.05	ND	51.0	3.2	7.3
RWQ/K/2.1	24.8	22.9	5.5	8.1	10	28.5	1.8	11.0	0.62	1800	1100	4.2	ND	ND	0.02	ND	57.1	1.7	7.2
RWQ/K/2.2	26.4	23.7	5.4	16.2	80	25.5	1.6	6.2	0.64	2200	800	3.5	ND	ND	ND	ND	50.9	1.2	7.4
RWQ/K/2.3	23.7	23.9	5.0	32.4	110	26.7	1.6	5.1	0.86	1300	800	4.0	ND	ND	ND	ND	53.3	1.7	7.9
RWQ/K/3.1	25.5	25.4	6.2	32.4	70	63.3	2.3	2.6	0.85	700	90	6.9	ND	ND	0.02	ND	126.0	4.7	4.8
RWQ/K/3.2	27.3	27.3	5.2	24.3	70	72.2	1.3	6.2	0.79	1300	400	7.1	ND	ND	ND	ND	145.0	4.7	3.4
RWQ/K/3.3	24.9	26.2	5.2	4.0	70	58.0	1.5	9.2	0.50	1450	1200	6.3	ND	ND	ND	ND	116.0	4.2	3.8
RWQ/K/4.1	27.4	25.0	5.1	8.1	20	29.1	4.0	11.3	0.85	2000	800	3.8	ND	ND	0.14	ND	58.4	4.7	6.4
RWQ/K/4.2	24.9	24.1	5.2	8.1	20	28.9	1.9	1.5	0.65	1300	200	13.5	ND	ND	ND	ND	58.0	3.2	7.0
RWQ/K/4.3	24.8	23.6	5.0	16.2	20	29.3	5.5	16.4	0.80	1600	1100	3.2	ND	ND	ND	ND	58.4	4.2	6.4
RWQ/K/5.1	26.4	26.3	5.4	8.1	20	130.0	1.4	12.3	1.07	1900	1200	17.9	ND	ND	ND	ND	260.0	6.4	4.5
RWQ/K/5.2	27.0	26.5	5.4	16.2	20	130.0	1.6	11.3	0.78	2200	1000	7.1	ND	ND	0.01	ND	260.0	4.2	3.4
RWQ/K/5.3	26.0	26.1	5.6	32.4	30	129.0	1.7	2.5	0.70	1750	1000	7.9	ND	ND	0.02	ND	260.0	3.2	3.8
RWQ/K/6.1	26.4	26.6	5.0	8.1	150	26.8	2.4	12.7	0.81	1300	1050	2.8	ND	ND	0.13	ND	53.7	4.2	7.6
RWQ/K/6.2	27.1	26.0	5.0	8.1	120	28.2	6.2	7.1	0.93	1900	1350	3.1	ND	ND	ND	ND	56.2	3.7	7.3
RWQ/K/6.3	23.4	24.0	5.0	8.1	130	27.3	4.1	12.8	1.61	800	100	2.8	ND	ND	ND	ND	54.7	3.2	7.3
RWQ/K/7.1	25.0	25.1	6.4	48.6	20	200.0	6.6	12.0	0.92	3000	1200	17.8	ND	ND	ND	ND	400.0	7.7	3.6
RWQ/K/7.2	26.0	26.1	5.6	32.4	30	270.0	13.0	10.7	0.41	1750	1100	44.7	ND	ND	0.21	ND	540.0	7.8	8.0
RWQ/K/7.3	24.5	25.2	5.6	24.3	30	220.0	6.4	5.6	0.95	1400	1000	33.1	ND	ND	0.21	ND	450.0	8.2	0.3
RWQ/K/8.1	33.0	24.2	7.4	16.8	113	143.0	1.5	6.27	1.19	2600	1200	6.9	ND	ND	ND	ND	110.8	1.2	7.6

River water quality
Sample points

Kandy

1. Gymnasium
2. Gatambe intake
3. Pinga-Oya
4. Doragamuwa junction
5. Open University - Polgolla
6. Kundasale
7. Meda ela
8. After Gohagoda intake

Table 7. River Water Quality (Nuwara-Eliya district)

Sample	T air	T water	pH	COD	SS	TDS	SO_4^{2-}	T-N	T-P	tal colifor	E. coli	Cl^-	Cd	As	Zn	Co	Conductivity	BOD	DO
RWQ/N/1.1	20.0	14.0	6.6	48.6	40	14	0.95	1.27	3.91	70	Nil	6.8	ND	ND	0.19	ND	15.3	0.6	7.9
RWQ/N/1.2	18.0	14.2	6.6	218.6	50	28	1.60	5.30	4.73	100	20	5.1	ND	ND	0.21	ND	12.3	0.5	8.4
RWQ/N/1.3	16.0	18.0	6.8	12.1	33	44	1.10	13.36	7.16	120	40	5.9	ND	ND	0.03	ND	12.7	0.5	7.7
RWQ/N/2.1	20.0	17.0	6.4	36.4	200	53	1.13	13.36	6.98	150	60	15.8	ND	ND	0.05	ND	53.0	6.8	5.5
RWQ/N/2.2	16.5	16.0	5.8	16.2	180	7	1.18	3.30	2.73	20	20	10.9	ND	ND	0.07	ND	62.0	3.7	5.1
RWQ/N/2.3	16.0	17.0	6.6	291.4	62	63	1.12	8.66	10.56	400	30	17.8	ND	ND	0.39	ND	76.0	25.7	3.5
RWQ/N/3.1	16.0	15.6	6.3	8.1	30	13	4.75	0.59	3.40	2400	600	11.2	ND	ND	0.06	ND	66.0	0.7	5.1
RWQ/N/3.2	17.0	16.2	6.5	40.5	120	83	4.00	1.30	6.26	3000	1180	12.3	ND	ND	0.02	ND	70.0	3.2	5.1
RWQ/N/3.3	16.5	16.5	6.8	680.0	30	69	6.10	20.08	10.86	2000	760	15.8	ND	ND	0.43	ND	84.0	21.7	4.8
RWQ/N/4.1	17.6	17.5	6.6	81.0	46	21	3.60	5.97	8.61	340	70	26.9	ND	ND	0.21	ND	126.0	25.2	5.4
RWQ/N/4.2	19.5	18.2	6.8	307.6	380	121	5.15	3.60	6.46	210	30	26.9	ND	ND	0.10	ND	144.6	18.7	5.3
RWQ/N/4.3	16.8	17.0	6.8	202.4	620	133	6.00	2.61	7.03	110	10	20	ND	ND	0.69	ND	116.0	25.2	3.7
RWQ/N/5.1	18.0	19.2	6.6	60.7	220	290	8.13	20.08	7.41	120	10	22.9	ND	ND	0.25	ND	58.4	28.2	2.2
RWQ/N/5.2	20.0	19.7	6.5	153.8	300	141	8.25	1.90	6.46	4500	1000	46.8	ND	ND	0.15	ND	58.0	28.5	1.9
RWQ/N/5.3	16.0	18.0	7.3	121.4	591	310	16.30	1.94	4.60	1000	650	20.9	ND	ND	0.23	ND	58.4	21.7	4.7

Nuwara - Eliya
1. Top Pass
2. Victoria Park
3. Gregory Lake
4. Hawa Eliya
5. Vajira Mawatha

from a stream near Polgolla (RWQ/K/5) was also polluted which is reflected in the analytical data with high total nitrogen, chloride and BOD.

4. **Lake water quality**

The location from where samples were collected and the key to samples is given below.

Kandy: LWQ/K/1, LWQ/K/2, LWQ/K/3, LWQ/K/4 Kandy Lake water samples along the length of the Lake on the Temple of the Tooth side (locations shown in the attached map)
LWQ/K/5, LWQ/K/6, LWQ/K/7, LWQ/K/8 Kandy lake samples along the length of the Lake opposite the Temple of the Tooth side

LWQ/N/1	Gregory lake (near playground)
LWQ/N/2	Gregory lake (middle of the lake –southern end)
LWQ/N/3	Barrack Plains Reservoir (at the beginning)
LWQ/N/4	Barrack Plains Reservoir (end)
LWQ/N/5	Barrack Plains Reservoir (middle)
LWQ/N/6	Barracks Plains Reservoir (middle)
LWQ/N/7	Gregory lake(middle)
LWQ/N/8	Gregory lake(middle)

Note : More samples were collected from the lakes this season compared to the last season since it was felt that two samples collected in the first phase may not be enough to give a representative picture of the entire lake.

The analytical data are given in table 8 & 9.
The Kandy lake is relatively unpolluted compared to Nuwara Eliya lake system as seen in its higher DO values and lower COD values.
However, the total dissolved solids of the Kandy lake samples was relatively high due to more electrolytes dissolved in it and clearer water (less suspended solids). The barracks Plains reservoir which was virtually dry during the first phase was quite full of water at this time of collection.
Nuwara- Eliya lakes in general had high phosphate, high total nitrogen and high sulphate compared to Kandy lake. This is due to leaching of fertilizer residues sprayed on to vegetable plots during the dry season and which gets washed into lakes during the rainy season. The bacteria counts also show significant enhancement in spite of the dilution effects due to rain. This is because a lot of sewege and human waste get washed down with the rain and increase both coliform and E.Coli counts in the reservoirs.

Table 8. Lake Water Quality survey- Kandy district

SAMPLE	Tair	Twater	pH	DO	COD	BOD	SS	TDS	SO_4^{2-}	T-N	T-P	Total coliform	E.Coli	As	Total Iron	Cd	Zn	Co	Elec Con	Cl^-
LWQ/K/1.1	27.5	28.0	8.2	10.2	32.4	3.2	9	63.0	6.2	9.46	1.83	4500	4500	Nil	0.06	Nil	Nil	Nil	260.0	14.8
LWQ/K/1.2	28.5	29.0	8.6	9.8	36.2	3.6	12	60.0	5.8	8.68	1.76	4500	2000	Nil	0.1	Nil	Nil	Nil	250.0	12.8
LWQ/K/1.3	28.0	28.7	8.0	10.4	34.8	2.8	10	58.0	6.6	8.9	1.68	4500	3000	Nil	0.08	Nil	Nil	Nil	248.0	13.6
LWQ/K/2.1	27.5	27.8	8.2	9.8	32.8	1.9	10	56.0	13.9	16.38	1.23	3000	1000	Nil	0.23	Nil	Nil	Nil	260.0	14.5
LWQ/K/2.2	28.5	29.0	8.4	8.6	34.8	2.8	16	60.2	10.8	12.68	1.26	4500	2200	Nil	0.2	Nil	Nil	Nil	230.0	11.5
LWQ/K/2.3	28.0	28.2	8.2	9.6	30.4	2.2	12	50.2	11.2	15.6	1.42	3600	2000	Nil	0.26	Nil	Nil	Nil	250.0	10.8
LWQ/K/3.1	27.5	28.2	8.4	11.1	40.5	0.2	31	52.0	10.8	14.86	1.36	7600	1200	Nil	0.64	Nil	Nil	Nil	250.0	12.8
LWQ/K/3.2	28.5	29.0	8.2	10.2	46.5	0.2	46	48.0	12.2	12.84	1.32	6800	1400	Nil	0.52	Nil	Nil	Nil	276.0	11.6
LWQ/K/3.3	28.0	29.0	8.4	10.6	38.6	0.2	34	54.0	9.6	11.86	1.23	7600	1200	Nil	0.68	Nil	Nil	Nil	240.0	11.8
LWQ/K/4.1	27.5	28.4	8.4	11.2	42.8	0.5	32	52.0	12.8	14.8	1.2	3000	800	Nil	0.32	Nil	Nil	Nil	240.0	13.5
LWQ/K/4.2	28.5	29.2	7.8	10.8	40.6	0.8	38	48.2	10.8	15.6	1.3	3200	1200	Nil	0.36	Nil	Nil	Nil	244.0	12.5
LWQ/K/4.3	28.0	29.2	8.4	11.0	48.2	0.5	30	50.0	11.2	12.6	1.24	3600	1000	Nil	0.3	Nil	Nil	Nil	238.0	12.8
LWQ/K/5.1	27.5	28.0	8.6	8.4	62.8	3.2	48	73.0	2.8	10.00	1.44	9200	1700	Nil	0.25	Nil	0.96	Nil	260.0	13.2
LWQ/K/5.2	28.5	29.0	8.3	6.3	68.4	2.8	60	80.0	2.2	9.80	1.56	7600	1200	Nil	0.26	Nil	0.78	Nil	250.0	13.0
LWQ/K/5.3	28.0	28.0	8.6	8.4	54.8	3.4	40	66.2	2.4	10.00	1.36	6800	1100	Nil	0.3	Nil	0.88	Nil	244.0	10.2
LWQ/K/6.1	27.5	28.0	8.4	9.4	63.8	4.2	46	78.0	3.2	11.80	1.86	9000	1700	Nil	1.25	Nil	1.96	Nil	261.0	14.2
LWQ/K/6.2	28.5	29.0	8.6	7.8	66.4	4.8	49	74.0	3.8	11.00	2.44	9200	1700	Nil	1.25	Nil	1.96	Nil	250.0	12.8
LWQ/K/6.3	28.0	28.5	8.6	7.9	72.8	3	59	85.0	3.6	9.86	1.48	3000	1700	Nil	1.28	Nil	1.86	Nil	256.0	12.6
LWQ/K/7.1	27.5	28.2	8.0	11.7	34.3	6	63	68.0	4.2	12.46	1.56	30000	14000	Nil	1.2	Nil	Nil	Nil	266.0	11.5
LWQ/K/7.2	28.5	29.0	8.1	12.8	36.4	6.2	78	66.0	3.2	11.8	1.42	35000	14000	Nil	1.2	Nil	Nil	Nil	276.0	11.5
LWQ/K/7.3	28.0	28.2	8.4	12.2	34.2	6.8	56	60.0	3.8	10.46	1.28	28000	14000	Nil	1.2	Nil	Nil	Nil	276.0	11.5
LWQ/K/8.1	27.5	27.8	7.8	8.3	68.2	1.2	59.6	64.2	4.7	12.66	2.49	20000	12000	NIL	2.38	Nil	Nil	Nil	260	12.5
LWQ/K/8.2	28.5	29.2	8.2	8.6	68.3	2.4	48.8	56.8	4.2	13.4	2.56	24000	12000	NIL	1.78	Nil	Nil	Nil	270	14.6
LWQ/K/8.3	28.0	28.6	8	8.3	76.2	1.8	46.8	60.8	3.8	12.8	2.38	26000	10000	NIL	1.68	Nil	Nil	Nil	256	14.5

Sample points: Kandy : 8 points to cover the full area of lake points shown in the attached map

Table 9. Lake Water Quality (Nuwara-Eliya district)

SAMPLE	Tair	Twater	pH	DO	COD	BOD	SS	TDS	SO_4^{2-}	T-N	T-P	Total coliform	E.Coli	As	Total Iron	Cd	Zn	Co	Elec Con	Cl^-
LWQ/N/1.1	16.0	17.0	6.1	7.0	8.1	2.7	17	48.6	8.4	11.06	3.32	280	160	Nil	0.62	Nil	Nil	Nil	87.5	3.6
LWQ/N/1.2	20.0	17.5	6.7	6.8	48.6	1.2	27	48.5	8.4	11.59	3.54	860	100	Nil	0.25	Nil	Nil	Nil	96.7	4.2
LWQ/N/1.3	15.5	17.5	6.4	6.7	32.4	0.7	23	48.3	8.4	2.02	4.32	670	100	Nil	Nil	Nil	Nil	Nil	96.5	4.0
LWQ/N/2.1	16.0	16.5	6.2	5.8	24.1	1.2	29	65.5	11.7	6.28	1.53	320	180	Nil	0.53	Nil	0.24	Nil	130.9	5.8
LWQ/N/2.2	16.5	17.5	6.4	6.2	8.1	0.7	93	58.9	11.7	13.19	1.15	1100	160	Nil	0.39	Nil	Nil	Nil	117.7	5.5
LWQ/N/2.3	16.0	17.5	6.7	6.0	40.5	0.7	51	50.8	11.7	11.25	0.83	1600	400	Nil	0.62	Nil	Nil	Nil	101.6	4.7
LWQ/N/3.1	19.0	17.5	6.4	0.7	32.4	7.2	250	69.6	13.5	7.87	3.12	1960	960	Nil	1.15	Nil	Nil	Nil	138.0	6.8
LWQ/N/3.2	20.0	17.5	6.3	1.3	8.1	8.0	176	68.1	13.5	0.42	4.02	2200	560	Nil	3.11	Nil	Nil	Nil	136.1	6.3
LWQ/N/3.3	20.0	18.5	6.5	0.5	80.9	5.7	166	67.8	13.8	2.02	3.65	1850	720	Nil	1.43	Nil	0.09	Nil	135.6	6.8
LWQ/N/4.1	20.5	17.0	6.4	1.7	32.4	6.7	237	66.8	13.3	0.95	1.09	2400	600	Nil	0.87	Nil	Nil	Nil	133.4	6.0
LWQ/N/4.2	21.0	16.0	6.4	1.5	8.1	5.8	163	66.9	13.6	7.87	2.32	1700	280	Nil	1.21	Nil	Nil	Nil	133.5	6.0
LWQ/N/4.3	20.5	16.5	6.7	Nil	16.2	1.7	147	68.1	13.6	5.74	2.73	2400	700	Nil	2.05	Nil	Nil	Nil	135.8	8.3
LWQ/N/5.1	19.0	22.5	6.4	1.2	97.2	0.2	89	70.1	9.7	0.42	3.84	$35x10^3$	2300	Nil	1.91	Nil	Nil	Nil	139.8	8.1
LWQ/N/5.2	19.5	20.8	6.4	1.0	90.8	0.3	78	76	8.4	0.8	3.7	$30x10^3$	2300	Nil	1.67	Nil	Nil	Nil	147.1	7.8
LWQ/N/5.3	19.3	20.5	6.6	1.6	68.6	0.7	58	58.5	7.8	0.65	3.64	$32x10^3$	2000	Nil	1.78	Nil	Nil	Nil	138.7	6.8
LWQ/N/6.1	18.5	21.0	6.8	1.0	251.0	35.2	103	89.5	10.8	15.85	2.59	$13x10^5$	$1.4x10^5$	Nil	2.1	Nil	Nil	Nil	179.0	19.9
LWQ/N/6.2	19.2	20.6	6.7	1.2	230.2	36.7	87	82.5	9.8	14.7	2.7	$10x10^5$	$1.2x10^5$	Nil	1.8	Nil	Nil	Nil	186.0	17.6
LWQ/N/6.3	18.5	19.8	6.9	1.4	210.6	38.5	82	80.8	9.2	13.8	2.67	$9x10^5$	$1.0x10^5$	Nil	1.7	Nil	Nil	Nil	167.8	16.8
LWQ/N/7.1	16.5	19.0	7.8	10.0	113.3	0.7	68	35.3	5.1	5.74	3.81	580	<100	Nil	0.73	Nil	Nil	Nil	70.9	4.6
LWQ/N/7.2	17.6	19.5	7.6	9.2	98.6	1.0	78	35.6	5.2	5.68	3.56	780	<100	Nil	0.67	Nil	Nil	Nil	67.8	3.8
LWQ/N/7.3	16.3	18.2	7.6	9.8	110.6	0.9	63	34.5	5.6	5.8	3.24	480	<100	Nil	0.65	Nil	Nil	Nil	70.9	4.6
LWQ/N/8.1	16.5	18.5	8.4	10.5	24.3	2.2	107	36.4	6.6	13.19	1.88	130	<100	Nil	0.65	Nil	Nil	Nil	72.3	4.6
LWQ/N/8.2	16.8	18.9	8.2	7.8	20.6	2.4	110	37.8	6.5	12.83	1.9	300	<100	Nil	0.65	Nil	Nil	Nil	72.3	4.6
LWQ/N/8.3	16.0	17.8	8.2	8.7	22.4	2.0	98	36.8	6.8	13.56	1.94	230	<100	Nil	0.65	Nil	Nil	Nil	72.3	4.6

Samples: Nuwara - Eliya

1. Gregory Lake
2. Gregory Lake - near the bridge
3. Barrack plains - middle
4. Barrack plains
5. Barrack plains
6. Barrack plains
7. Gregory Lake- middle
8. Gregory lake -middle

There was no significant variation in the Kandy lake samples collected at different locations except for bacterial counts and this is perhaps due to the close proximity to hotels which discharge raw effluent into this waterbody without any treatment.

5. Sludge quality survey

Samples were collected from both Kandy and Nuwara-Eliya. However there were problems collecting samples during the first survey for this analysis as planned in the schedule of work since septic pits are either permanently sealed or the sludge form septic tanks is regularly cleaned by the municipalities. We were however able to complete the leftover sludge samples from the first survey during this period.

The samples points and the key to samples is given below:

Kandy	SQ/K/1	Septic tank sludge-office complex (University)
	SQ/K/2	Hospital sludge
	SQ/K/3	Sludge from septic tank- middle income house
Nuwara Eliya	SQ/N/1	Sludge from septic tank- middle income house
	SQ/N/2	Public toilet

The analytical results are given in table 10. One notable feature is the presence of Zn as a heavy metal in all these samples. Perhaps this originates from the galvanised piping used in plumbing etc. The high phosphate content in domestic sewege may be a reflection of the increased use of phosphate based detergents.

Table 10.Sludge Quality survey (Kandy and Nuwara-Eliya districts)

SAMPLE	Tair	Tsludge	Water content mg/g	VSSmg/kg	SS mg/g	T-N g/kg	T-P mg/kg	As	Cd	Co	Zn mg/kg
SQ/K/1	28.7	28.3	462.1	20.2	369.2	8.3	6.00	Nil	Nil	Nil	0.19
SQ/K/2	28.6	28.2	172.2	30.7	385.1	5.38	13.00	Nil	Nil	Nil	0.67
SQ/K/3	29.1	28.3	517.3	8.6	174.3	5.95	2.35	Nil	Nil	Nil	0.01
SQ/N/1	21	20.3	547.7	10.5	320.2	8.7	7.5	Nil	Nil	Nil	0.22
SQ/N/2	20.8	20	476.2	14.5	410.4	8.1	8.5	Nil	Nil	Nil	0.12

Sludge quality survey

Sample points:

Kandy
1. Senate
2. Hospital
3. Meewatura

Nuwara Eliya
1. Sludge from septic tank- middle income house
2. Public toilet

Annexure 1- Pesticide analysis on water samples

Parameter	SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7	SP 8	SP 9	SP 10	SP 11	SP 12	SP 13	SP 14	SP 15	SP 16	SP 17	SP 18	SP 19	SP 20	SP 21
α - HCH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
β - HCH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
γ - HCH(Lindane)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
δ - HCH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Heptachlorepoxide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Endosulfan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p'p, DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o'p, DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p'p, DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
o'p, DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
p'p, DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorpyrifos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dimethoate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fenthion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fenitrothion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Monocrotophos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Methamidaphos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parathion Methyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Pirimiphos Methyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Profenofos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Quinalphos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Carbofuran	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorothalonil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Captan	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Metalaxyl	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Alachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Propanil	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Atrazine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Permethrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Parameter	Limit of Determination µg/l
α - HCH	0.2
β - HCH	0.4
γ - HCH(Lindane)	0.2
δ - HCH	0.2
Aldrin	0.5
Dieldrin	0.5
Heptachlorepoxide	0.5
Endosulfan	0.5
p'p, DDE	0.5
o'p, DDT	0.5
p'p, DDT	0.5
o'p, DDD	0.5
p'p, DDD	0.5
Chlorpyrifos	1
Dimethoate	5
Diazinon	2
Fenthion	2
Fenitrothion	2
Malathion	2
Monocrotophos	5
Methamidaphos	5
Parathion	2
Parathion Methyl	2
Pirimiphos Methyl	2
Profenofos	2
Quinalphos	2
Carbofuran	5
Chlorothalonil	5
Captan	1
Metalaxyl	5
Alachlor	2
Propanil	2
Atrazine	5
Permethrin	10

SP1	WQ/K/1.1
SP2	WQ/K/2.1
SP3	WQ/N/1.1
SP4	WQ/N/2.1
SP5	WQ/N/3.1
SP6	WQ/N/4.1
SP7	WQ/N/5.1
SP8	WQ/N/6.1
SP9	WQ/N/7.1
SP10	WQ/N/8.1
SP11	WQ/N/9.1
SP12	WQ/N/12
SP13	WQ/N/13
SP14	WQ/N/14
SP15	WQ/N/11.2
SP16	WQ/N/10.2
SP17	WQ/N/15.2
SP18	WQ/N/17.2
SP19	WQ/N/16.2
SP20	Golf ground - New
SP21	galway - New