LIST OF REFERENCES

1. TRANSBASIN DIVERSION STUDY, FINAL REPORT, ELECTROWATT, 1987

TABLES

Table H.2.1 EVALUATION IN THE TRANSBASIN DIVERSION STUDY (TDS)

		Total Net Benefits (10^6 Rs.)	Capital Cost* (10^6 Rs.)	Energy Lost or Consumed (GWh/year)
1.	SEDZ alone (40,000 ha)	+ 121	3,727	-
2.	NWDZ alone (32,200 ha)	- 225	1,260	72
3.	NCRB, System M only, UNDP/FAO solution (54,200 ha)	- 489	6,430	17
4.	NCRB, Systems I1 & M JVMTDS solution (62,500 ha)	- 604	6,411	126
5.	NCRB, Systems I, M & L1, JVMTDS solution (112,800 ha)	- 941	9,250	440
6.	Full NCRB area, NEDECO solution (195,800 ha)	- 1,585	18,244	1,395

Remarks: * Capital costs for conveyance systems only.

Source: Ref. 27, Table 6.1, Main Report.

Table H.2.2 GENERAL FEATURES OF CANDIDATE RESERVOIR AND TANK

Name of Reservoir	Catchment	Dimension of Dam: Crest E.L.	Crest Width	Crest Height	Crest Length	F.S.L.	L.W.L.	Spillway Type	Spillway Q(m^3/s)	Gate Nos.xBxH	Spill Crest Level	Spill Crest Length
	(km)	(m)	(m)	(m)	(m)	(m)	(m)					
- Hydropower and Multipurpose dam on Mahaweli River Basin												
Caledonia	235	1065	10	70	270	1360	1341	G	2470	-	1360	-
Talawakele	363	1203	10	20	102	1200	1193	G	3500	3x 8x12	-	-
Kotmale Extension	562	735	10	95	945	731.5	665	G	5560	3x14x15	-	-
Watawala	69	1034	10	60	200	1032	1010	G	800	2x 8x 7	-	-
Ulapane	782	603	10	70	500	600	590	G	6500	3x18x15	-	-
Sudu Ganga	305	329	10	55	400	325	300	G	2000	3x8.5x12	-	-
Uma Scheme-1000	168	974	10	90	565	970	910	G	1700	3x 7x 10	-	-
Uma Scheme-500	622	503	10	25	150	500	498	G	3700	3x10x 12	-	-
Wewatenna	267	234	10	80	500	230	200	G	1500	3x8.5x12	-	-
- Irrigation Tank												
Kalu Ganga	204	175.0	10	50	3,060	170.0	148.0	G/C	2000	3x 10x7	170	300
Horowupotana	950	69.5	8	24	3,100	65.5	58.0	G	5600	6x 15x10	65.5	-
Yan oya	1320	45.0	7	16	4,420	41.0	30.0	G	7300	8x15x9.5	41.0	-
Kitulgala	104	89.0	7	18	3,100	85.0	73.0	C	1100	-	85.0	300
Mukunuwewa	142	95.0	8	32	1,250	91.0	73.0	C	1200	-	91.0	340
Galgamuwa	11	104.0	7	10	760	100.0	90.0	C	200	-	100.0	60
Tammannewa	64	117.5	8	19	5,600	113.5	104.0	C	700	-	113.5	200
Malwatu	2113	60.0	7	12	1,720	56.0	49.5	G	8400	9x 15x8	56.0	-
Parangi Aru	427	60.0	8	19	5,600	56.0	47.0	C	2300		56.0	600
Pali Aru	91	79.0	8	19	6,300	75.0	64.0	C	750	-	75.0	230
Kanagarayan	85	83.0	7	17	3,700	79.0	68.5	C	740	-	79.0	210
Gallodai Aru	95	89.5	8	24	2,000	85.5	63.0	C	1000	-	85.5	170
Maha Oya	230	84.0	8	31	2,850	80.0	62.0	C	2000		80.0	520
Ranbukan Aru	140	84.0	8	31	2,600	80.0	60.0	C	950	-	80.0	260
Magalawatawan	115	77.0	8	43	1,900	73.0	50.0	C	1100	-	73.0	310

Remarks: Type of spillway
* C: Overflow type
* G: Radial gate type

Table H.3.1 SUMMARY OF WATER BALANCE SIMULATION FOR SCREENING OF TRANSBASIN CONVEYANCE SYSTEM (Polgolla Diversion: 875 MCM)

Alternative Case		Alternative Case			
Alternative Case		A	B	C	D
Run Case	Unit	A145	B151	C145	D109
1. Irrigation System					
		AMDP	AMDP	AMDP	AMDP
		NCRB	NCRB	NCRB	-
		NWDZ	NWDZ	NWDZ	-
2. Irrigation Area					
- Under AMDP	ha	200,300	200,300	200,300	200,300
- New Irrigation Area	ha	103,450	103,450	103,450	-
- Existing	ha	15,250	15,250	15,250	-
- New Dev. Area	ha	88,200	88,200	88,200	-
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	
- Total	ha	323,750	323,750	323,750	200,300
3. Spillout at					
- Angamedilla	MCM	380	399	377	718
- Minipe	MCM	154	146	185	1,435
- Kandakadu	MCM	2,538	2,541	2,594	4,290
4. Pump-up Volume	MCM	761	1,515	896	-
5. Irr. Demand-Deficit Ratio					
- Sub-system-1	%	9(10)	9(13)	10(13)	7(9)
- Sub-system-2	%	8(9)	7(6)	9(12)	-(-)
- Sub-system-3	%	10(10)	9(11)	9(12)	7(9)
- Sub-system-4	%	1(0)	1(0)	1(0)	0(0)
- Sub-system-5	%	2(2)	2(3)	2(3)	1(2)
- Sub-system-6	%	7(9)	8(12)	8(10)	4(5)
- Sub-system-7	%	2(3)	4(5)	3(5)	0(1)
- Sub-system-8	%	5(7)	4(7)	4(7)	-(-)
- Average	%	7(-)	7(-)	8(-)	5(-)
6. Energy Output					
- Existing Plant	GWh	2,138	2,020	2,017	2,264
- Proposed Hydropower	GWh	1,808	1,824	1,824	-
- Total	GWh	3,946	3,844	3,841	2,264

Remarks: AMDP Area : Existing and comitted irrigation area under the AMDP
Potential Irrigation Area : NWDZ + NCRB
Case A : New alternative (Minipe-Minneriya-Pump St.-NCP)
Case B : TDS's solution (Minipe-Hettipola-Pump St.-Elahera-NCP)
Case C : UNDP/FAO as revised by NEDECO (Minipe-Existing Minipe LBC-Anganedilla-Pump St.-NCP)
Case D : Present case including committed irrgation area
( ) : Number of years exceeding irrigation deficit-demand ratio of more than 10%.

Table H.3.2 SUMMARY OF WATER BALANCE SIMULATION FOR SCREENING OF DEVELOPMENT PLAN (Polgolla Diversion, 875 MCM and 1,280 MCM)

Run Case	Unit	Polgolla Diversion			
		875 MCM		1,280 MCM	
		A118	A145	A209	A242
1. Irrigation System		AMDP NCRB -	AMDP NCRB NWDZ	AMDP NCRB -	AMDP NCRB NWDZ
2. Irrigation Area					
- Under AMDP	ha	200,300	200,300	200,300	200,300
- New Irrigation System	ha	90,200	103,450	90,200	103,450
- Existing	ha	12,700	15,250	12,700	15,250
- New Irrigation Area	ha	77,500	88,200	77,500	88,200
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	20,000
- Total	ha	310,500	323,750	310,500	323,750
3. Spillout at					
- Angamedilla	MCM	421	380	363	392
- Minipe	MCM	197	154	177	151
- Kandakadu	MCM	2,626	2,538	2,577	2,561
4. Pump-up Volume	MCM	653	761	360	435
5. Irr. Demand-Deficit Ratio					
- Sub-system-1	%	9(9)	9(10)	8(11)	6(9)
- Sub-system-2	%	7(7)	8(9)	9(9)	9(11)
- Sub-system-3	%	7(7)	10(10)	10(10)	10(11)
- Sub-system-4	%	1(0)	1(0)	1(0)	1(0)
- Sub-system-5	%	2(2)	2(2)	2(4)	3(4)
- Sub-system-6	%	6(8)	7(9)	9(12)	10(13)
- Sub-system-7	%	2(3)	2(3)	3(4)	3(4)
- Sub-system-8	%	5(7)	5(7)	5(7)	5(7)
- Average	%	6(-)	7(-)	7(-)	7(-)
6. Energy Output					
- Existing Plant	GWh	2,221	2,138	1,967	1,998
- Proposed Hydropower	GWh	1,818	1,808	1,866	1,868
- Total	GWh	4,039	3,946	3,833	3,866

Remarks: AMDP Area : Existing and comitted irrigation area under the AMDP
Potential Irrigation Area : NWDZ + NCRB
Case A : New alternative (Minipe-Minneriya-Pump St.-NCP)
( ) : Number of years exceeding 10% of irrigation deficit-demand ratio

Table H.3.3 GENERAL FEATURES OF CONVEYANCE SYSTEM OF ALTERNATIVE PLAN

Major System	Feature of Conveyance System																	
	Case-A145						Case-B151						Case-C145					
	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)
1. NCP Canal																		
- Elahera Head Works																		
- Canal	55	11	3.8	-	10000	2.7	90	14	4.5	-	10000	2.7	45	12	4.3	-	10000	2.7
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Elahera - Kiri Oya																		
- Canal	55	11	3.8	-	10000	38	90	14	4.5	-	10000	38	45	12	4.3	-	10000	21
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	90	14	4.5	-	10000	17
- Tunnel	55	-	3.3	x1	3000	4	90	-	3.9	x1	3000	4	90	-	3.9	x1	3000	4
- Kiri Oya-Hurulu wewa																		
- Canal	90	14	4.5	-	10000	15.3	90	14	4.5	-	10000	15.3	90	14	4.5	-	10000	15
- Tunnel	90	-	3.9	x1	3000	3.2	90	-	3.9	x1	3000	3.2	90	-	3.9	x1	3000	3.2
- Hurulu-Tammannewa																		
- Canal	60	12	4.0	-	10000	38.6	60	12	4.0	-	10000	38.6	60	12	4.0	-	10000	39
- Tunnel	60	-	3.4	x1	3000	0.4	60	-	3.4	x1	3000	0.4	60	-	3.4	x1	3000	0.4
- Mahakandarama-Tammannewa																		
- Canal	40	8	3.7	-	10000	38.6	40	8	3.7	-	10000	38.6	40	8	3.7	-	10000	39
- Tunnel	40	-	2.8	x1	3000	0.4	40	-	2.8	x1	3000	0.4	40	-	2.8	x1	3000	0.4
- Kalu Ganga-Elahera																		
- Canal	15	3	2.3	-	6000	16.2	80	12	4.5	-	10000	16.2	15	3	2.3	-	10000	16
- Tunnel	15	-	1.9	x1	2500	0.7	80	-	3.8	x1	3000	0.7	15	-	1.9	x1	3000	0.7
2. Minipe-LB																		
- Minipe-Angamedilla																		
- Canal	65	12	4	-	10000	94.3	65	12	4.0	-	10000	74	65	12	4.0	-	10000	74
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Tunnel	65	-	3.5	x1	3000	0.7	65	-	3.5	x1	3000	0.7	65	-	3.5	x1	3000	0.7
- Angamedilla-Minneriya/wewala																		
- Canal	65	12	4	-	10000	16.7	-	-	-	-	-	-	45	9	3.7	-	1000	4.1
- Tunnel	65	-	3.5	x1	3000	1.3	-	-	-	-	-	-	45	-	3.3	x1	3000	5.2
- Angamedilla-Kaudula																		
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	20	6	3.3	-	8000	3.2
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-
- Kaudula-Kantalai																		
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	10	4	2.5	-	5000	2.9
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Pump Station																		
- Minneriya	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Hettipolla	-	-	-	-	-	-	65	-	-	-	-	-	45	-	-	-	-	-
- Wewala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. NWDZ																		
- Bowatenna																		
- Canal	28	-	-	-	-	-	28	-	-	-	-	-	28	-	-	-	-	-
- Tunnel	28	-	2.5	x1	2500	6.9	28	-	2.5	x1	2500	6.9	28	-	2.5	x1	2500	6.9
- Transbasin Canal																		
- Canal	25	4	2.8	-	8000	29.4	25	4	2.8	-	8000	29.4	25	4	2.8	-	8000	29
- Tunnel	25	-	2.3	x1	2000	-	25	-	2.3	x1	2000	-	25	-	2.3	x1	2000	-

Remarks: Q : Discharge
B : Canal Bed Width
H : Canal Height
R : Radius of Tunnel
N : Number of row
L : Length
i : Hydraulic Gradient

* : Refer to ANNEX-I.

Table H.3.4 GENERAL FEATURES OF CONVEYANCE SYSTEM OF DEVELOPMENT PLAN

Major System	Feature of Conveyance System																							
	Present Policy 875 MCM												Alternative Policy 1280 MCM											
	A118						A145						A209						A242					
	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)	Q* (m3/s)	B (m)	HorR (m)	N -	i -	L (km)
1. NCP Canal																								
- Elahera Head Works																								
- Canal	60	12	4.0	-	10000	2.7	55	11	3.8	-	10000	2.7	75	12	4.4	-	10000	2.7	70	12	4.2	-	10000	2.7
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Elahera - Kiri Oya																								
- Canal	60	12	4.0	-	10000	38	55	11	3.8	-	10000	38	75	12	4.4	-	10000	21	70	12	4.2	-	10000	21
- Tunnel	60	-	3.4	x1	3000	4	55	-	3.3	x1	3000	4	75	-	3.7	x1	3000	4	70	-	3.6	x1	3000	4
- Kiri Oya-Hurulu wewa																								
- Canal	90	14	4.5	-	10000	15.3	90	14	4.5	-	10000	15.3	90	14	4.8	-	10000	15.3	90	14	4.5	-	10000	15.3
- Tunnel	90	-	3.9	x1	3000	3.2	90	-	3.9	x1	3000	3.2	90	-	3.4	x1	3000	3.2	90	-	3.9	x1	3000	3.2
- Hurulu-Tammannewa																								
- Canal	60	12	4.0	-	10000	38.6	60	12	4.0	-	10000	38.6	60	12	3.8	-	10000	38.6	60	12	4.0	-	10000	38.6
- Tunnel	60	-	3.4	x1	3000	0.4	60	-	3.4	x1	3000	0.4	60	-	3.2	x1	3000	0.4	60	-	3.4	x1	3000	0.4
- Mahakandarama-Tammannewa																								
- Canal	40	8	3.7	-	10000	38.6	40	8	3.7	-	10000	38.6	40	8	3.7	-	10000	38.6	40	8	3.7	-	10000	38.6
- Tunnel	40	-	2.8	x1	3000	0.4	40	-	2.8	x1	3000	0.4	40	-	2.8	x1	3000	0.4	40	-	2.8	x1	3000	0.4
- Kalu Ganga-Elahera																								
- Canal	15	3	2.3	-	6000	16.2	15	3	2.3	-	6000	16.2	15	3	2.3	-	6000	16.2	15	3	2.3	-	6000	16.2
- Tunnel	15	-	1.9	x1	2500	0.7	15	-	1.9	x1	2500	0.7	15	-	1.9	x1	2500	0.7	15	-	1.9	x1	2500	0.7
2. Minipe-LB																								
- Minipe-Angamedilla																								
- Canal	60	12	4.0	-	10000	94.3	65	12	4.0	-	10000	94.3	55	11	3.8	-	10000	94.3	55	11	3.8	-	10000	94.3
- Tunnel	60	-	3.4	x1	3000	0.7	65	-	3.5	x1	3000	0.7	55	-	3.3	-	3000	0.7	55	-	3.3	-	3000	0.7
- Angamedilla-Minneriya/wewala																								
- Canal	60	12	4.0	-	10000	16.7	65	12	4.0	-	10000	16.7	45	9	3.7	-	10000	4.1	45	9	3.7	-	10000	4.1
- Tunnel	60	-	3.4	x1	3000	1.3	65	-	3.5	x1	3000	1.3	45	-	3.3	x1	3000	5.2	45	-	3.3	x1	3000	5.2
- Angamedilla-Kaudula																								
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Kaudula-Kantalai																								
- Canal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Tunnel	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Pump Station																								
- Minneriya	30	-	-	-	-	-	35	-	-	-	-	-	15	-	-	-	-	-	20	-	-	-	-	-
- Hettipolla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Wewala	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4. NWDZ																								
- Bowatenna																								
- Canal	28	-	-	-	-	-	28	-	-	-	-	-	28	-	-	-	-	-	28	-	-	-	-	-
- Tunnel	28	-	2.5	x1	2500	6.9	28	-	2.5	x1	2500	6.9	28	-	2.5	x1	2500	6.9	28	-	2.5	x1	2500	6.9
- Transbasin Canal																								
- Canal	-	-	-	-	-	-	25	4	2.8	-	8000	29.4	-	-	-	-	-	-	25	4	2.8	-	8000	29.4
- Tunnel	-	-	-	-	-	-	25	-	2.3	x1	2000	-	-	-	-	-	-	-	25	-	2.3	x1	2000	-

Remarks: Q : Discharge
B : Canal Bed Width
H : Canal Height
R : Radius of Tunnel
N : Number of row
L : Length
i : Hydraulic Gradient

* : Refer to ANNEX-I.

Table H.3.5 GENERAL FEATURES OF PLANNED PUMP STATION

Case	Unit	Polgolla Diversion Policy					
		Present Policy 875 MCM				Alternative Policy 1280 MCM	
		A118	A145	B151	C145	A209	A242
Name of Station		Minneriya	Minneriya	Hettipola	Wewala	Minneriya	Minneriya
Annual Discharge	MCM	653	761	1515	896	360	435
Discharge	m^3/sec	30	35	65	45	15	20
High Water Level	m	135	135	162	135	135	135
Low Water Level	m	88	88	82	75	88	88
Net Head	m	47	47	80	60	47	47
Gross Head	m	52	52	88	66	52	52
Required Power	MW	23	27	84	44	12	15
Energy Consumption	GWh	125	146	498	219	70	84
Energy Cost	$10^6	6.1	7.1	24.2	10.6	3.4	4.1
Construction Cost							
- Equipment	$10^6	46	54	169	88	23	31
- Pump House	$10^6	21	24	76	39	10	14
Energy Output in Mahaweli							
- Present output	2264 GWh						
- Existing Plant	GWh	2,221	2,138	2,020	2,017	1,967	1,998
- Loss of Energy	$10^6	2.1	6.1	11.9	12.0	14.4	12.9
Description							
-Approach Channel	km	2.0	2.0	0.5	0.5	2.0	2.0
-Tunnel work R=	m	-	-	2.6	2.2	-	-
-Tunnel work Length	km	-	-	2.0	5.2	-	-
-Pipe Line diameter	mxNo	2.4 x 2	2.4 x 2	3.0 x 3	3.0 x 2	2.4 x 2	2.4 x 2
-Pipe Line Length	m	600	600	500	100	600	600
- Outlet		Kiri Oya	Kiri Oya	Kalu Ganga	NCPSt21 Km	Kiri Oya	Kiri Oya

Table H.3.6 SUMMARY OF CONSTRUCRION COST (CASE-A118)

Item No.	Work Items		Const. Cost Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	60	11.1	10.6	0.9		79	2,185	0.9
3.	NCP Elahera-Kirioya	60	78.5	75.2	6.1		564	247	6.7
4.	NCP Kiri oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0-62Km	60	54.2	51.1	4.2		383	485	4.6
7.	Minipe LB 62Km-113 Km	60	93.5	89.2	7.3		669	247	8.0
C	Pump station	m^3/sec							
1.	Minneriya 23 MW	30	143.0	140.4	11.5	6.1	3,511	58,169	21.1
D	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,352.0	1,283.3	104.8	6.1	11,181	116,682	122.1
II.	NWDZ								
1.	Galgamuwa		0.0	0.0	0.0		0	0	0.0
2.	Additional Bowatenna Tunnel	24 m3/sec	0.0	0.0	0.0		0	0	0.0
3.	NWDZ Transbasin Canal	25 m3/sec	0.0	0.0	0.0		0	0	0.0
4.	System-NWDZ	0	0.0	0.0	0.0		0	0	0.0
	NWDZ TOTAL	0	0.0	0.0	0.0		0	0	0.0
Grand Total		161,600	1,352.0	1,283.3	104.8	6.1	11,181	116,682	122.1
Power+Irrigation		161,600	2,682.6	2,569.2	-	6.1	22,507	327,107	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Table H.3.7 SUMMARY OF CONSTRUCRION COST (CASE-A145)

Item No.	Work Items		Const. Cost Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB									
A	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	55	10.9	10.4	0.8		78	2,185	0.9
3.	NCP Elahera-Kirioya	55	75.2	72.0	5.9		540	247	6.4
4.	NCP Kiri oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe LB 0-62Km	65	56.5	53.2	4.3		399	485	4.7
7.	Minipe LB 62Km-113 Km	65	97.0	92.5	7.6		694	247	8.3
C	Pump station	m^3/sec							
1.	Minneriya 23 MW	35	163.4	160.5	13.1	7.1	4,013	58,169	24.2
D	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,374.7	1,305.5	106.7	7.1	11,700	116,682	125.5
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin Canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,495.2	1,419.5	116.0	7.1	12,517	119,798	135.6
Power+Irrigation		174,850	2,825.8	2,705.4	-	7.1	23,843	330,223	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Table H.3.8 SUMMARY OF CONSTRUCTION COST (CASE-B151)

Item No.	Work Items		Const. Cost Eq. Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Total Annual Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	HYDROPOWER SCHEME		1,330.5	1,285.9	-		11,326	210,425	-
Direct cost									
I.	NCRB								
A.	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera Regulating Tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Level Crossing		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B.	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	80	42.6	40.9	3.3		307	409	3.6
2.	Elahera Head Works	90	13.4	12.7	1.0		96	2,185	1.1
3.	NCP Elahera-Kiri oya	90	101.7	97.5	8.0		731	247	8.7
4.	NCP Kiri oya-Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa-Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe 0-74 km	65	38.8	36.3	3.0		273	485	3.2
7.	Minipe 74-113 km	65	0.0	0.0	0.0		0	0	0.0
C.	Pump station	m^3/sec							
1.	Hettipola 78 MW	65	434.5	427.8	34.9	24.2	10,694	58,169	69.8
D.	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCP TOTAL	161,600	1,587.0	1,517.0	124.0	24.2	17,963	116,435	166.1
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	Sub total	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,707.6	1,631.0	133.3	24.2	18,781	119,551	176.2
Power+Irrigation		174,850	3,038.1	2,916.9	-	24.2	30,107	329,976	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Table H.3.9 SUMMARY OF CONSTRUCTION COST (CASE-C145)

Item No.	Work Items		Const. Cost Eq. Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Economic Cost US$ (10^6)
Water Resources Development									
1.	Watawala		44.2	42.8	-		450	10,450	-
2.	Ulapane		117.0	112.0	-		1,008	20,995	-
3.	Caledonia		156.4	149.3	-		1,194	14,535	-
4.	Talawakele		215.7	207.7	-		2,077	43,605	-
5.	Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.	Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.	Scheme-500		228.5	220.5	-		1,764	45,980	-
8.	Sudu Ganga		83.1	80.8	-		1,050	25,650	-
	POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
I.	NCRB								
A.	Regulating Tank								
1.	Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.	Elahera Regulating Tank		4.8	4.4	0.4		22	171	0.4
3.	Kiri oya Level Crossing		13.5	12.6	1.0		63	466	1.1
4.	Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.	Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.	Tammannewa		47.0	43.2	3.5		216	105	3.7
7.	Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B.	Transbasin canal	m^3/sec							
1.	Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.	Elahera Head Works	45	10.4	9.9	0.8		74	2,185	0.9
3.	NCP Elahera-Kirioya	45/90	94.3	90.5	7.4		679	247	8.1
4.	NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.	NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.	Minipe 0-74 km existing	65	38.8	36.3	3.0		273	485	3.2
7.	Minipe 74 km - Angamedilla	65	72.7	68.2	5.6		511	247	6.1
8.	Angamedilla-Wewala	45	48.1	46.2	3.8		346	247	4.1
9.	Angamedilla-Kaudula	20	23.8	22.4	1.8		168	247	2.0
10.	Kaudula-Kantalai	10	20.8	19.6	1.6		147	247	1.8
C.	Pump station	m^3/sec							
	Wewala 40 MW	45	221.6	218.2	17.8	10.6	5,456	58,169	33.9
D.	Downstream development	ha							
1.	System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.	System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.	System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.	System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.	System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.	System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
	NCRB TOTAL	161,600	1,502.4	1,428.2	116.7	10.6	13,628	117,423	140.8
II.	NWDZ								
1.	Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.	Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.	NWDZ Transbasin canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.	System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
	NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total		174,850	1,622.9	1,542.3	126.0	10.6	14,448	120,539	151.1
Power+Irrigation		174,850	2,953.4	2,828.2	-	10.6	25,774	330,964	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Table H.3.10 SUMMARY OF CONSTRUCTION COST (CASE-A209)

Item No. Work Items		Const. Cost Eq. Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development								
1. Watawala		44.2	42.8	-		450	10,450	-
2. Ulapane		117.0	112.0	-		1,008	20,995	-
3. Caledonia		156.4	149.3	-		1,194	14,535	-
4. Talawakele		215.7	207.7	-		2,077	43,605	-
5. Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6. Scheme-1000		249.1	240.0	-		1,920	43,320	-
7. Scheme-500		228.5	220.5	-		1,764	45,980	-
8. Sudu Ganga		83.1	80.8	-		1,050	25,650	-
POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB								
A Regulating Tank								
1. Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2. Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3. Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4. Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5. Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6. Tammannewa		47.0	43.2	3.5		216	105	3.7
7. Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B Transbasin canal	m^3/sec							
1. Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2. Elahera Head Works	75	11.3	10.7	0.9		81	2,185	1.0
3. NCP Elahera-Kirioya	75	93.0	89.2	7.3		669	247	8.0
4. NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5. NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6. Minipe LB 0-62Km	55	52.0	48.9	4.0		367	485	4.4
7. Minipe LB 62Km-113 Km	55	90.1	85.9	7.0		645	247	7.7
C Pump station	m^3/sec							
1. Minneriya 23 MW	15	77.3	75.9	6.2	3.4	1,897	58,169	11.5
D Downstream development	ha							
1. System-F	1,900	7.7	7.2	0.6		54	285	0.6
2. System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3. System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4. System-H	42,400	11.7	11.2	0.9		84	463	1.0
5. System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6. System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
NCRB TOTAL	161,600	1,295.3	1,227.4	100.3	3.4	9,633	116,682	113.3
II. NWDZ								
1. Galgamuwa		0.0	0.0	0.0		0	0	0.0
2. Additional Bowatenna Tunnel	24 m3/sec	0.0	0.0	0.0		0	0	0.0
3. NWDZ Transbasin Canal	25 m3/sec	0.0	0.0	0.0		0	0	0.0
4. System-NWDZ	0	0.0	0.0	0.0		0	0	0.0
NWDZ TOTAL	0	0.0	0.0	0.0		0	0	0.0
Grand Total	161,600	1,295.3	1,227.4	100.3	3.4	9,633	116,682	113.3
Power+Irrigation	161,600	2,625.9	2,513.3	-	3.4	20,959	327,107	-

Remarks: * Discount rate = 8%
US$ 1.00 = Rs.32.50 = Y140

Table H.3.11 SUMMARY OF OCNSTRUCTION COST (CASE-A242)

Item No. Work Items		Const. Cost Eq. Total US$ (10^6)	Economic Cost Eq. Total US$ (10^6)	Economic Cost Annual* US$ (10^6)	Pump Running Cost US$ (10^6)	O&M Cost US$ (10^3)	Replace Cost US$ (10^3)	Annual Cost US$ (10^6)
Water Resources Development								
1.Watawala		44.2	42.8	-		450	10,450	-
2.Ulapane		117.0	112.0	-		1,008	20,995	-
3.Caledonia		156.4	149.3	-		1,194	14,535	-
4.Talawakele		215.7	207.7	-		2,077	43,605	-
5.Kotmale Extension		236.6	232.7	-		1,862	5,890	-
6.Scheme-1000		249.1	240.0	-		1,920	43,320	-
7.Scheme-500		228.5	220.5	-		1,764	45,980	-
8.Sudu Ganga		83.1	80.8	-		1,050	25,650	-
POWER SCHEME TOTAL		1,330.5	1,285.9	-		11,326	210,425	-
NCRB								
A Regulating Tank								
1.Kalu Ganga		142.4	133.5	10.9		667	2,375	11.6
2.Elahera regulation tank		4.8	4.4	0.4		22	171	0.4
3.Kiri oya Regulating Tank		13.5	12.6	1.0		63	466	1.1
4.Horowupotana		67.1	62.8	5.1		314	8,835	5.4
5.Yan Oya		72.5	68.0	5.6		340	11,400	5.9
6.Tammannewa		47.0	43.2	3.5		216	105	3.7
7.Malwatu Oya		37.7	35.9	2.9		179	12,806	3.1
B Transbasin canal	m^3/sec							
1.Kalu Ganga-Elahera	15	15.8	15.0	1.2		113	409	1.3
2.Elahera Head Works	70	11.1	10.6	0.9		79	2,185	0.9
3.NCP Elahera-Kirioya	70	89.8	86.1	7.0		646	247	7.7
4.NCP Kiri oya- Hurulu wewa	90	73.4	70.4	5.8		528	646	6.3
5.NCP Hurulu wewa- Tammannewa	60/40	47.6	45.1	3.7		338	466	4.0
6.Minipe LB 0-62Km	55	52.0	48.9	4.0		367	485	4.4
7.Minipe LB 62Km-113 Km	55	90.1	85.9	7.0		645	247	7.7
C. Pump station	m^3/sec							
1.Minneriya 19 MW	20	100.2	98.4	8.0	4.1	2,460	58,169	14.6
D Downstream development	ha							
1.System-F	1,900	7.7	7.2	0.6		54	285	0.6
2.System-M	25,000	123.3	116.7	9.5		875	4,845	10.4
3.System-MH	26,300	66.6	63.0	5.1		472	2,616	5.6
4.System-H	42,400	11.7	11.2	0.9		84	463	1.0
5.System-IH	4,700	1.3	1.3	0.1		9	52	0.1
6.System-I	61,300	239.5	226.6	18.5		1,700	9,412	20.2
NCRB TOTAL	161,600	1,314.9	1,246.7	101.9	4.1	10,172	116,682	116.1
II. NWDZ								
1.Galgamuwa		16.1	14.9	1.2		75	342	1.3
2.Additional Bowatenna Tunnel	24 m3/sec	15.7	15.2	1.2		114	200	1.4
3.NWDZ Transbasin Canal	25 m3/sec	21.0	19.8	1.6		148	485	1.8
4.System-NWDZ	13,250	67.7	64.0	5.2		480	2,090	5.7
NWDZ TOTAL	13,250	120.6	114.0	9.3		818	3,116	10.1
Grand Total	174,850	1,435.5	1,360.7	111.2	4.1	10,989	119,798	126.3
Power+Irrigation	174,850	2,766.0	2,646.6	-	4.1	22,315	330,223	-

Remarks: *Discount rate = 8%
US$ 1.00 = Rs.32.50 = ¥140

Table H.3.12 COMPARISON OF TRANSBASIN CONVEYANCE SYSTEMS

	Unit	Alternative Plan A145	Alternative Plan B151	Alternative Plan C145	Present Condition D109
A. Principal Features					
1. Combination of Irrigation Area		AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP - -
2. Irrigation Area					
- AMDP Area	ha	200,300	200,300	200,300	200,300
- New Irrigation Area	ha	103,450	103,450	103,450	-
- Cashew Area (Non-irigated)	ha	20,000	20,000	20,000	-
Total	ha	323,750	323,750	323,750	200,300
3. Pump Station					
- Pumping Volume	MCM	761	1,515	896	-
- Energy Consumption	GWh	146	498	219	-
4. Average Water Deficit	%	6	7	6	4
5. Energy Output					
- Existing Power Station	GWh	2,138	2,020	2,017	2,264
- Proposed Power Station	GWh	1,808	1,824	1,824	-
- Total	GWh	3,946	3,844	3,841	2,264
B. Economic Comparison					
1. Total Irrigation Area	ha	323,750	323,750	323,750	200,300
2. Annual Benefits					
- Agricultural Benefit	$US\$10^6$	161.7	161.7	161.7	-
- Loss of Energy Output	$US\$10^6$	-6.1	-11.9	-12.0	-
Total	$US\$10^6$	155.6	149.8	149.7	-
3. Annual Costs					
- Annual Equivalent Cost*	$US\$10^6$	116.0	133.3	126.0	-
- O&M Costs	$US\$10^6$	12.5	18.8	14.4	-
- Energy Costs for Pump	$US\$10^6$	7.1	24.2	10.6	-
Total	$US\$10^6$	135.6	176.2	151.1	-
4. Economic Comparison					
- B/C		1.15	0.85	0.99	-
- B-C	$US\$10^6$	20.0	-26.4	-1.4	-

Remarks: * A discount rate of 8% was applied.
No consideration was given to the implementation schedule and the built-up period of the scheme.

Table H.3.13 SCREENING OF AGRICULTURAL DEVELOPMENT PLAN

Item	Unit	Present Policy 875 MCM		Alternative Policy 1,280 MCM	
		A118	A145	A209	A242
A. Principal Features					
1. Combination of Irrigation Area		AMDP NCRB -	AMDP NCRB NWDZ	AMDP NCRB -	AMDP NCRB NWDZ
2. Irrigation Area					
- AMDP area	ha	200,300	200,300	200,300	200,300
- New Irrigation area	ha	90,200	103,450	90,200	103,450
- Cashew Area (Non-irrigated)	ha	20,000	20,000	20,000	20,000
Total	ha	310,500	323,750	310,500	323,750
3. Pump Station					
- Pumping volume	MCM	560	761	249	262
- Energy consumption	GWh	108	146	67	64
4. Average Water Deficit	%	6	7	7	7
5. Energy Output					
- Existing hydropower	GWh	2,221	2,138	1,967	1,998
- Proposed hydropower	GWh	1,818	1,808	1,886	1,868
Total	GWh	4,039	3,946	3,833	3,866
B. Economic Comparison					
1. Total Irrigation Area	ha	310,500	323,750	310,500	323,750
2. Annual Benefit					
- Agricultural benefit	$US\$10^6$	149.6	161.7	149.6	161.7
- Loss due to water deficit	$US\$10^6$	-	-0.9	-1.5	-1.4
- Loss of energy	$US\$10^6$	-2.1	-6.1	-14.4	-12.9
Total	$US\$10^6$	147.5	154.7	133.7	147.4
3. Annual Costs					
- Annual equivalent cost*	$US\$10^6$	104.8	116.0	100.3	111.2
- Energy cost for pump	$US\$10^6$	6.1	7.1	3.4	4.1
- O&M costs	$US\$10^6$	11.2	12.5	9.6	11.0
Total	$US\$10^6$	122.1	135.6	113.3	126.3
4. Economic Comparison					
- B/C		1.21	1.14	1.18	1.17
- B-C	$US\$10^6$	25.4	19.1	20.4	21.1

Remarks: * A discount rate of 8% was adopted.
No consideration was given to the implementation schedule and the built-up period of the schemes.

FIGURES

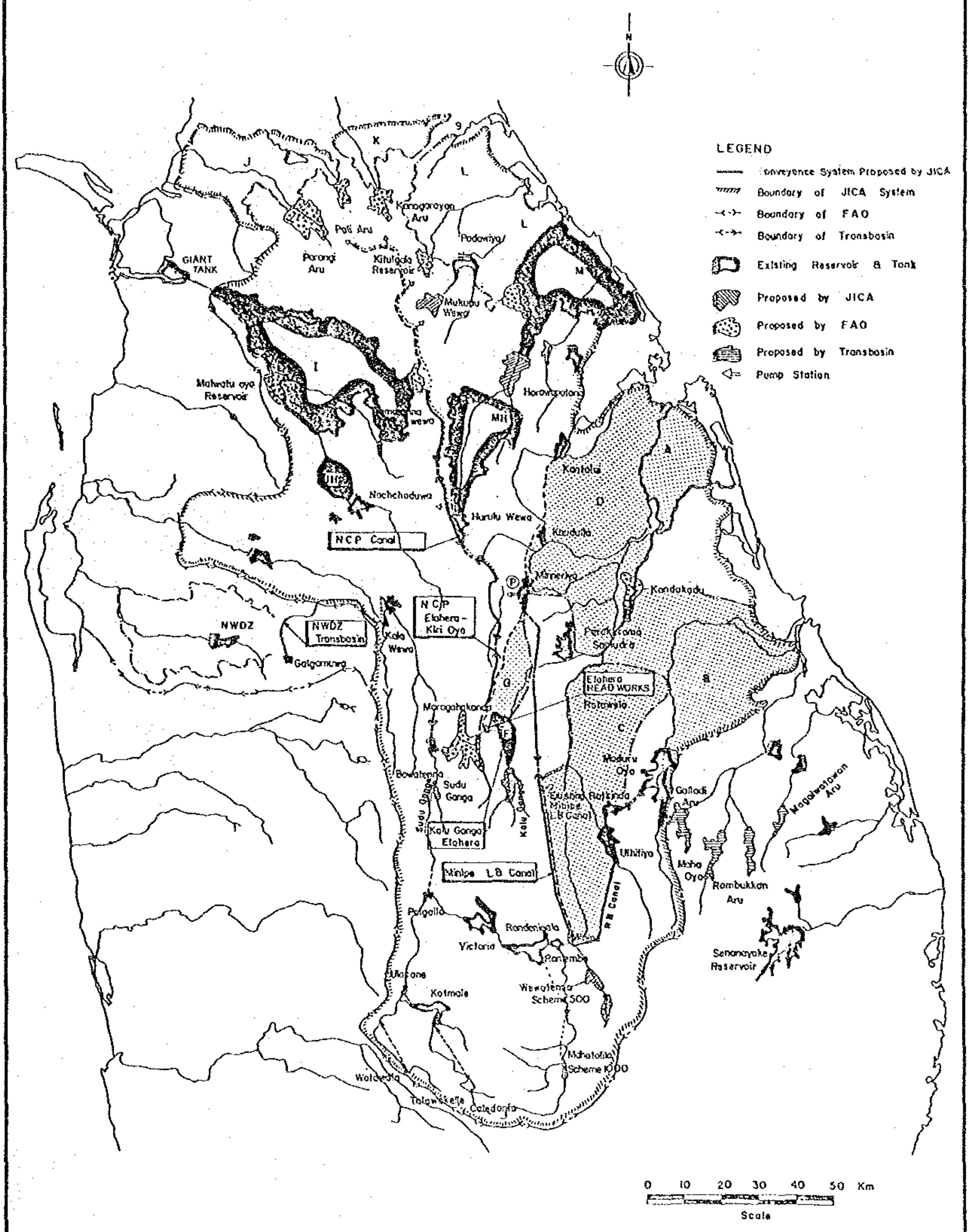

Fig. H.2-1(1/2) General Features of Transbasin System (Case-A)

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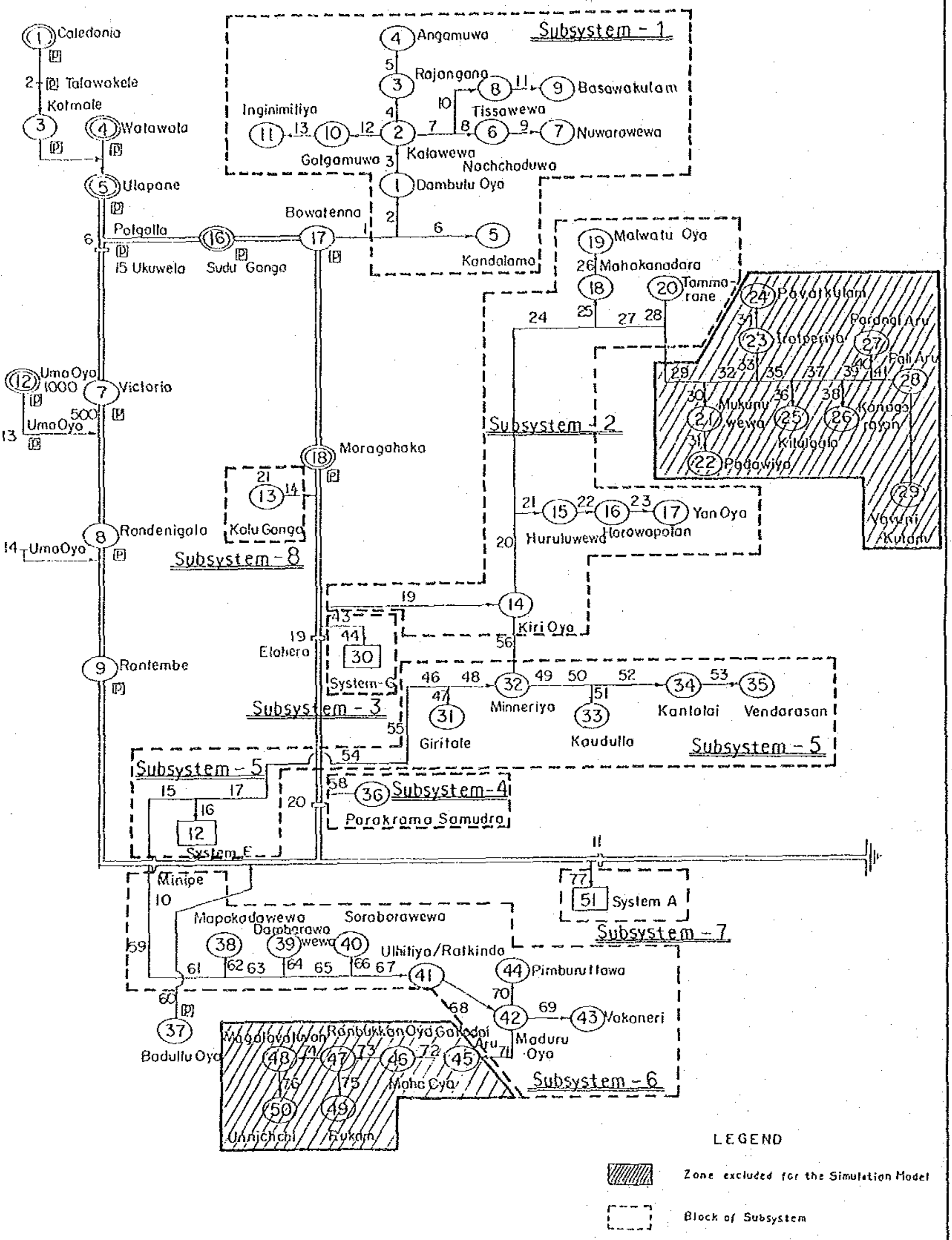

Fig. H.2-1(2/2) Schematic Flow Diagram: Case-A

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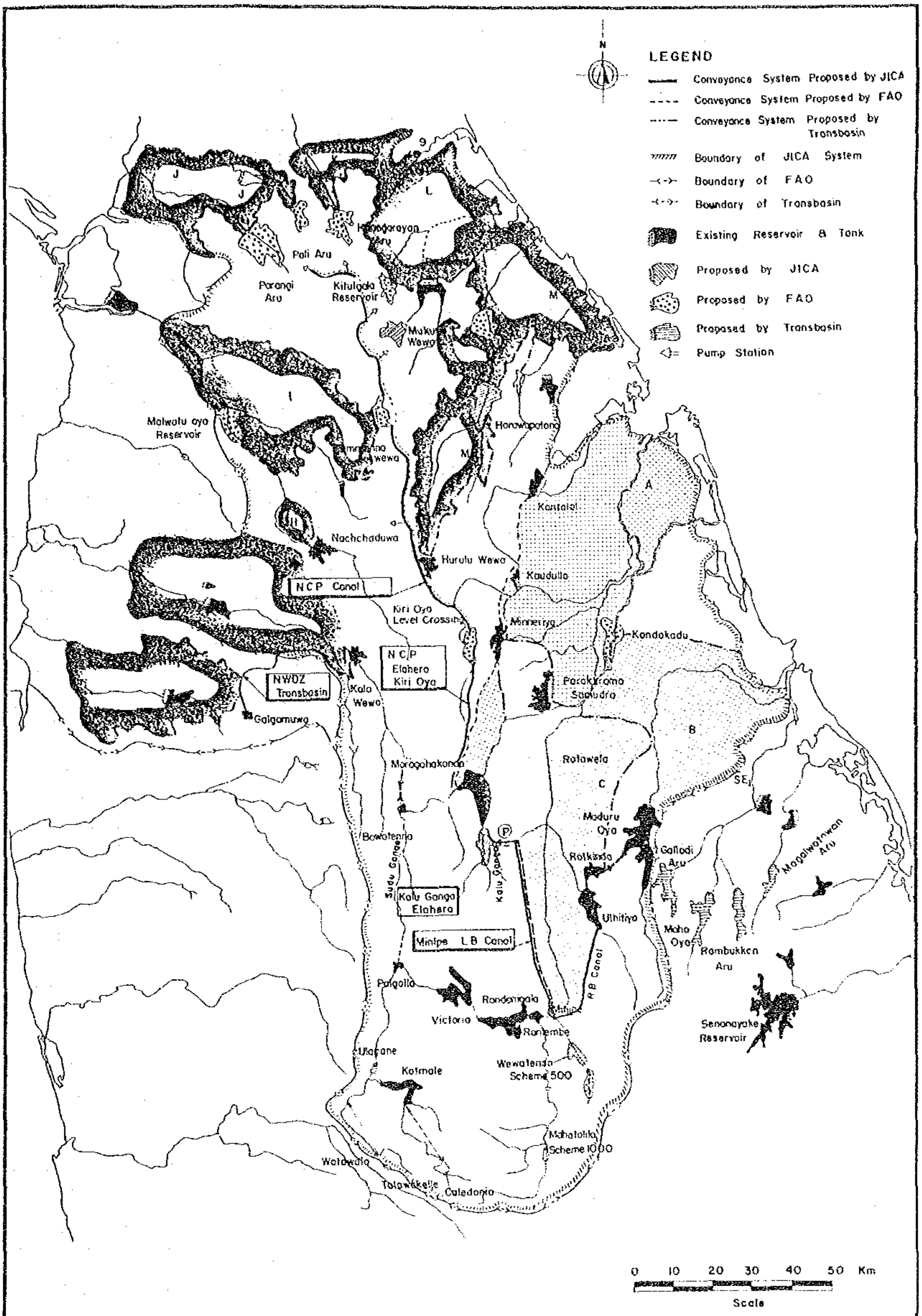

Fig. H.2-2(1/2) General Features of Transbasin System (Case-B)

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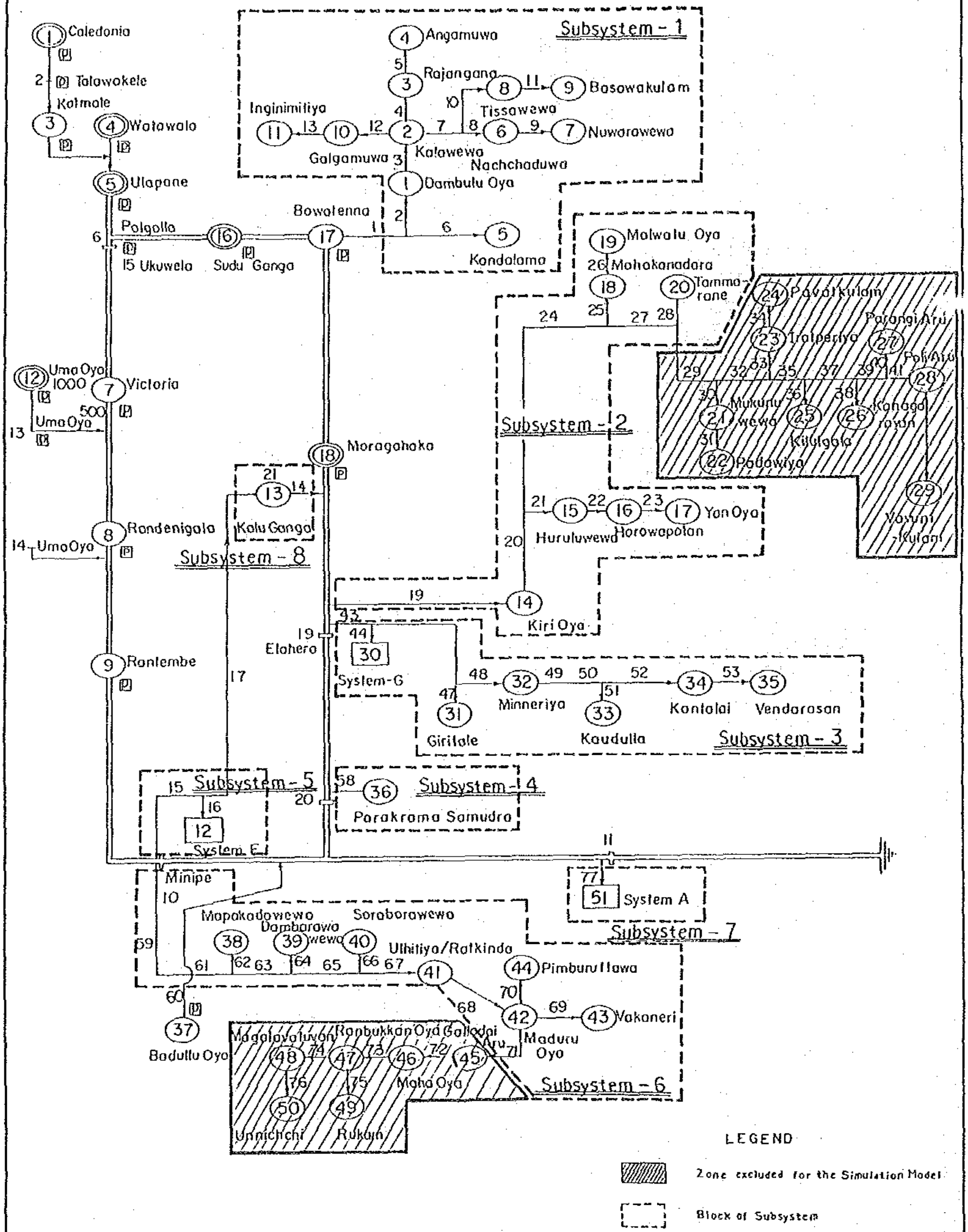

Fig. H.2-2(2/2) Schematic Flow Diagram: Case-B

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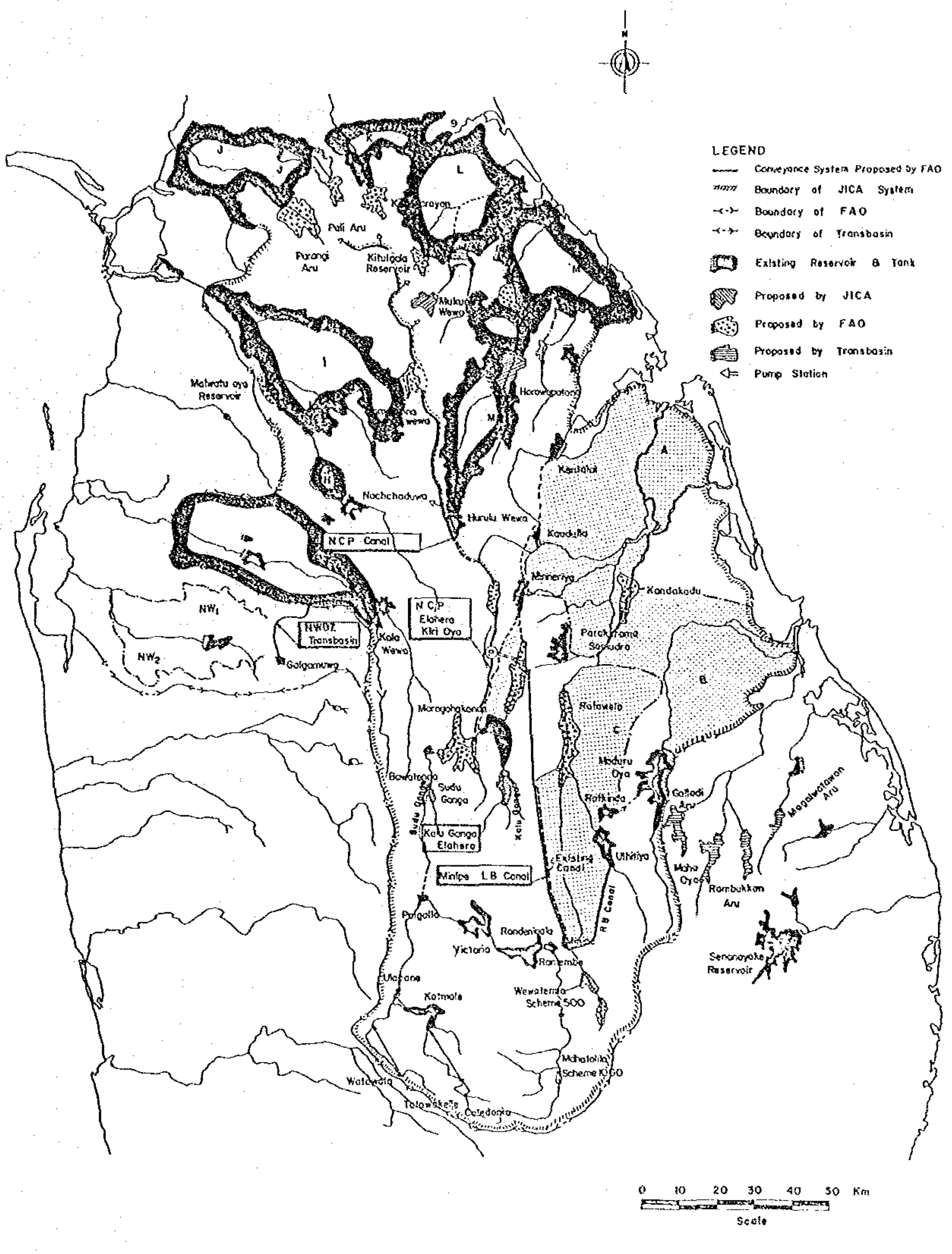

Fig. H.2-3(1/2) General Features of Transbasin System (Case-C)

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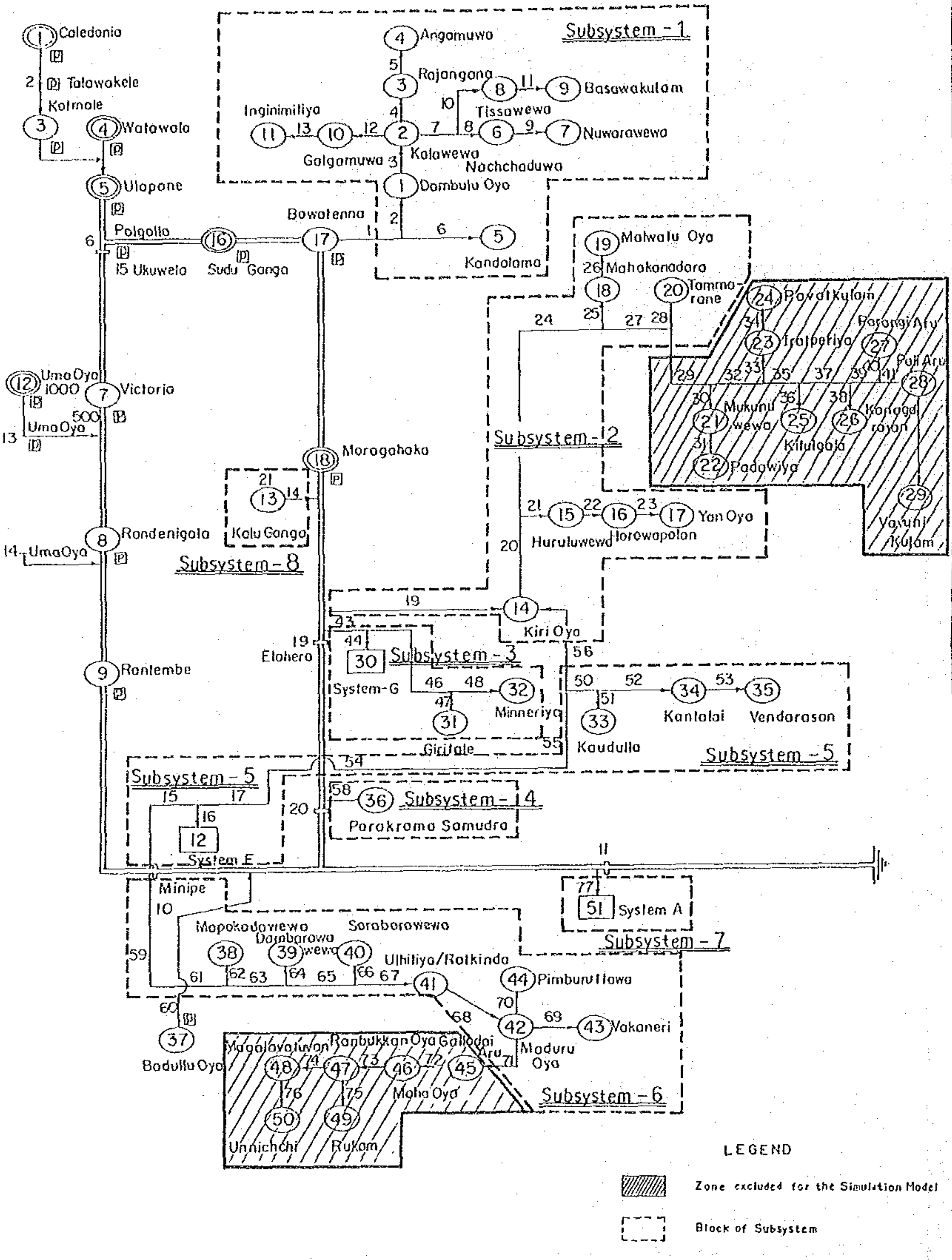

Fig. H.2-3(2/2) Schematic Flow Diagram: Case-C

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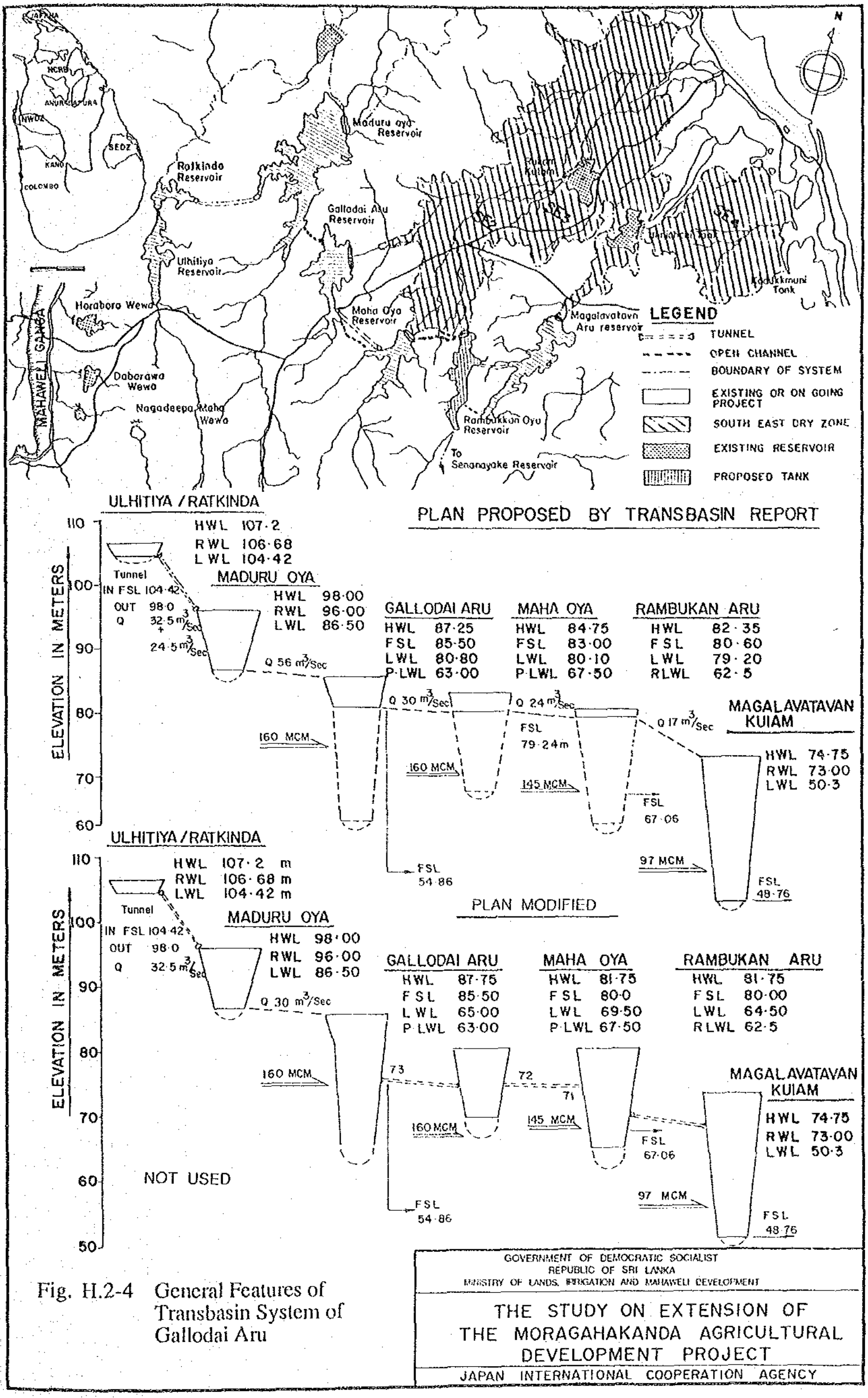

Fig. H.2-4 General Features of Transbasin System of Gallodai Aru

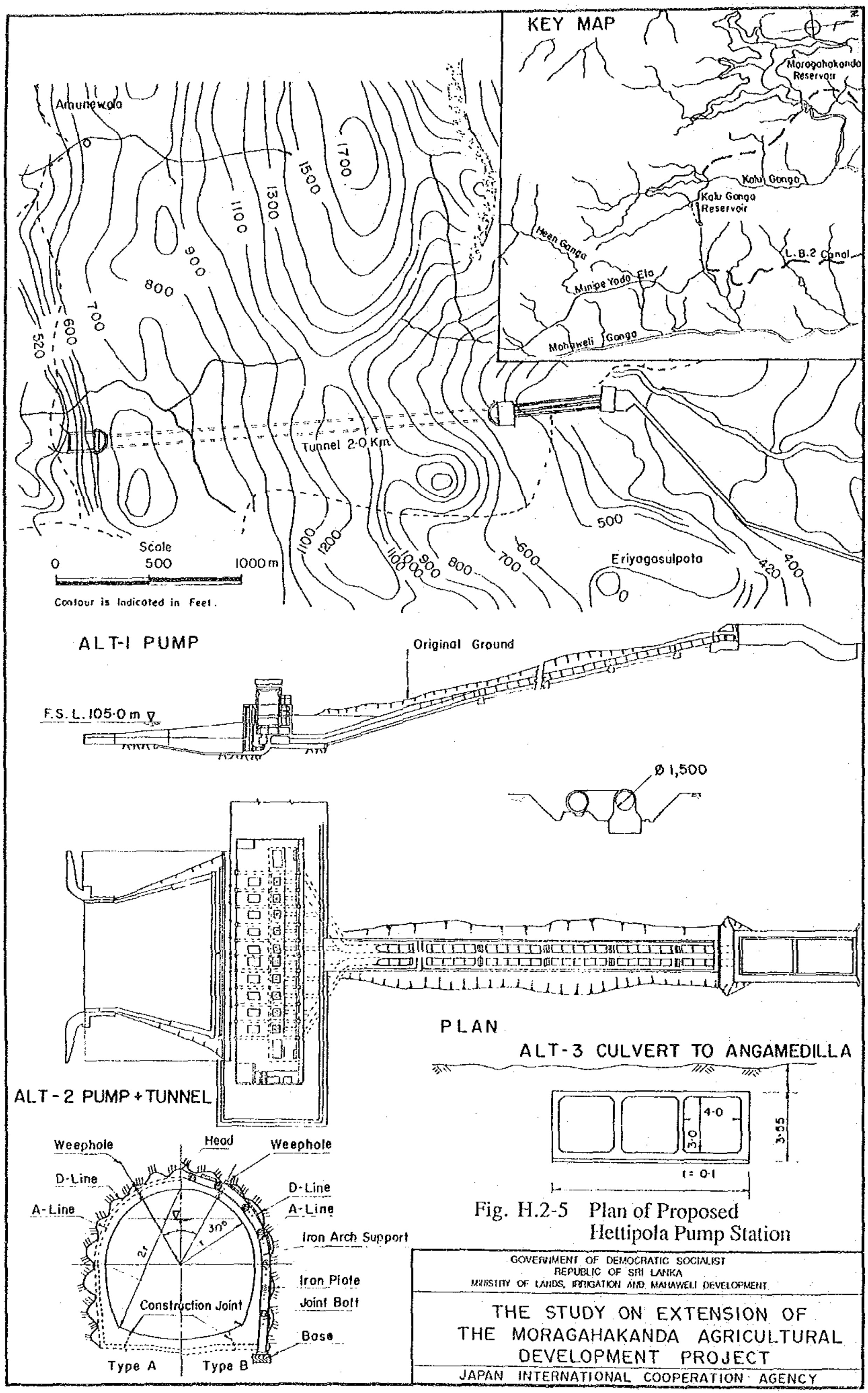

Fig. H.2-5 Plan of Proposed Hettipola Pump Station

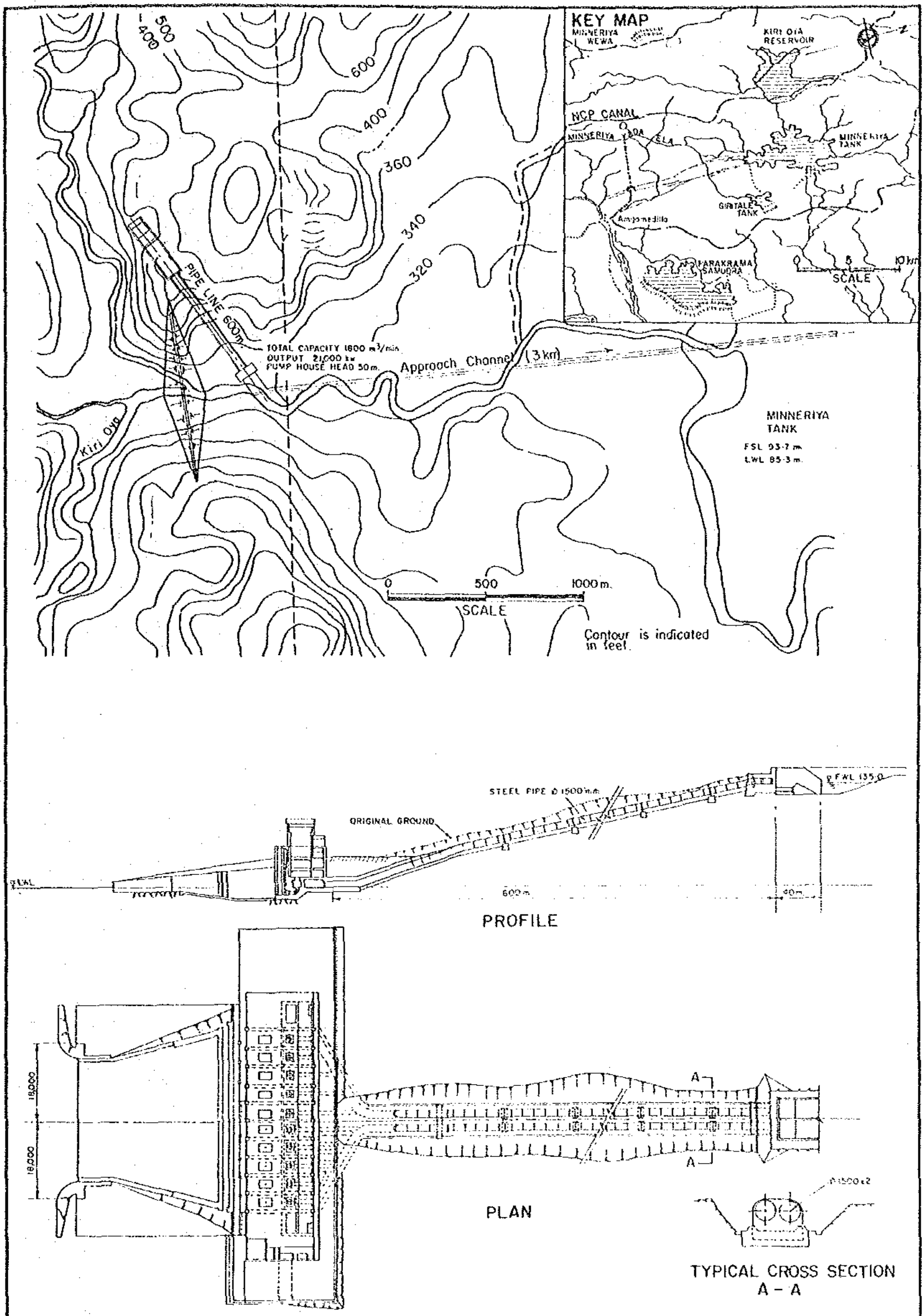

Fig. H.2-6 Plan of Proposed Minneriya Pump Station

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ANNEX–I

WATER BALANCE

ANNEX - I

WATER BALANCE

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ANNEX-I WATER BALANCE

I.1 INTRODUCTION

This ANNEX presents the results of the water balance study, which was made based on the results of hydrological study in ANNEX-B, and study on irrigation water demand in ANNEX-F and on hydropower in ANNEX-G, to formulate an overall agricultural development plan in the NWDZ and NCRB areas.

The aims of the water balance study are to determine irrigation areas, required capacities of conveyance system and reservoirs within an allowable water deficit. As studied in ANNEX-H, there are several alternative plans for transbasin conveyance system from the Mahaweli Ganga to the NCRB area, including possibility to increase the diversion water at Polgolla to the Sudu Ganga. All these alternative plans were simulated by using the water balance simulation model, and all the results were incorporated into formulation of an overall development plan in the study area.

I.2 CONDITION OF WATER BALANCE

I.2.1 Division of Basins

The Mahaweli river basin and other river basins in the study area were divided into 72 sub-basins, considering the existing and potential dams and intake sites, as well as existing and potential irrigation areas. The basin model for the water balance is schematically presented on Figs. I.2-4 to I.2-7 depending on the conveyance system to be selected. Though there are numerous tanks in the study area, only major existing tanks with an active capacity of more than 5 MCM and the proposed tanks are considered in this division of basins.

Catchment area and average monthly runoffs of the respective sub-basins are presented in Tables I.2.1 and I.2.2. The details are discussed in ANNEX-B.

I.2.2 Transbasin Conveyance Systems

There are several transbasin diversion plans from the Mahaweli Ganga to the NWDZ and NCRB areas studied by UNDP/FAO, subsequently in the ISS and in the TDS. The details are discussed in ANNEX-H.

The following these alternatives to convey irrigation water to the NCRB area were selected:

Case A : New Alternative Plan (See Fig. I.2-1)
Minipe - New LB canal - Minneriya tank
(Pumping station) - NCP canal

Case B : Elecrowatt (TDS) Solution Modified (See Fig. I.2-2)
Minipe - Hettipola Oya (Pumping Station) - Kalu Ganga dam - Elahera
- NCP canal (NEDECO route)

Case C : UNDP/FAO (ISS) Solution revised by NEDECO (See Fig. I.2-3)
Minipe LB canal - Angamedilla (Pumping Station) - NCP canal

The schematic system diagrams mentioned above are shown on Figs. I.2-4 to I.2-6.

As discussed in ANNEX-H, Bowatenna - Kalawewa - Mahakatunoruwa - Galgamuwa tanks route was adopted as the NWDZ conveyance system. The schematic flow diagram is shown on Fig. I.2-7.

I.2.3 Natural River Flow

The most important factor for the water balance study is to correct the reliable flow data, which will affect the quality of the study. Flow data for the Mahaweli Ganga and Amban Ganga were scrutinized in the HCP and prepared the data-base system on the weekly basis at each of the major structures and ganging stations.

In the MWRMP, the weekly flow data were recompiled into monthly basis for 31 years (1949-81), considering the existence of series of large storage reservoirs. The monthly natural river flow data complied in the MWRMP for the period of 1949-81 were adopted in the present study. Moreover, additional flow data for the period of 1981-86 could be utilized for the study. However, series of multipurpose dams on the Mahaweli Ganga and Amban Ganga, as well as the irrigation development projects have been performed since the late 1970s. In order to keep the continuity of the data base, all the measured river flows were converted to the natural river flow for the local catchment area.

As discussed in ANNEX-B, local inflows to the respective irrigation tanks were calculated by using available measured flows, or in case of missing data, by sorting rainfall-runoff correlation method to estimate the runoff coefficient in the catchment area.

The average natural river flow (1949-86) at the major control points such as reservoirs, tanks and diversion point are summarized in Tables I.2.1 and I.2.2. The monthly inflow data at the existing and proposed dam sites and major structures are given in ANNEX-B.

I.2.4 Irrigation Water Demand

The irrigation water demand for respective existing, on-going and committed projects under the AMDP as well as potential irrigable areas was calculated on monthly basis for 37 years from October 1949 to September 1986, using Penman formula. The present overall irrigation efficiency was evaluated to be 50% for Systems E and C, and 56% for other systems. The irrigation demand at the matured stage in the year 2020 was calculated by adopting an improved overall irrigation efficiency of 60%, since the GOSL puts enforce the rehabilitation of existing projects to improve farming practices and to save water through proper water management.

The average monthly irrigation demand for respective projects and schemes is presented in Tables I.2.3 and I.2.4, and the details are described in ANNEX-F.

I.2.5 Return Flow

Return flow from irrigation schemes located in the upper stream is considered as usable water resources for the downstream areas. Ratio of return flow to diversion irrigation water is generally considered in a rage of 0.20-0.30. In this study, there is no actual measurement and assessment of the return flow, it is assumed to be 0.25 of the diversion water requirement. Reusable return flows are schematically shown on Fig. I.2-8.

I.2.6 River Maintenance Flow

As discussed in ANNEX-B, the river maintenance flow is the indicator of the allowable limit of water withdrawal from the river, to be considered in allocating and developing water resources. Increased water withdrawal should not be allowed, if it is expected to impair the river maintenance flow frequently.

As seen in Table I.2.5, the minimum river flow at Manampitiya has been substantially decreased with the progress of land and water resources development since 1976. The requirement for the river maintenance flow should be determined for each river, based on the conditions particular to the river. The river maintenance flow at Manampitiya was decreased for last 12 years, however it seems that there was no serious problem. The results of the flow duration analysis show that the average river flows during the low flow period (flow kept more than 275 days of the year) and the extremely low flow period (355 days) were estimated at 31 m^3/sec and 14 m3/sec for the period of 1976-87, respectively.

Usually the river maintenance flow ranges between the above two figures. Therefore, since there is no such available data and studies, the maintenance flow at the estuary was preliminarily assumed to be 15 m^3/sec for the water balance study, referring to the results of the flow duration analysis at Manampitiya, and irrigation demand for the existing Allai scheme of 7,000 ha of which the intake is located at Manampitiya downstream.

I.2.7 Reservoir and Tank Parameters

In the Mahaweli river basin, there are six (6) existing multipurpose dams, i.e. Kotmale, Polgolla, Victoria, Randenigalla, Bowatenna, Maduru Oya. The Rantembe dam is under construction and will be completed in 1990. Moreover, the GOSL has decided to implement the Moragahakanda dam. These eight multipurpose dams are considered as the existing dams in this master plan.

There are nine (9) candidate dam and hydropower schemes and 15 candidate irrigation tanks. Tables I.2.6 to I.2.8 present the principal features of existing and candidate dams and tanks. Tables I.2.9 and I.2.10 show parameters adopted in the water balance simulation.

I.3 SIMULATION MODEL

I.3.1 Simulation Model

A simulation model was developed to represent a water resource system by adopting modes, with or without storage, which are connected by channels having flow limits, based on the schematic flow diagramme shown on Figs. I.2-4 to I.2-7.

Since there are numerous irrigation tanks in the existing and potential irrigation areas, in the model a certain simplification for irrigation system was introduced in representing irrigation systems. Reservoirs or tanks with an active storage of more than 5 MCM were basically incorporated into the model.

In representation of the reservoir system, active reservoir storage was divided into 9 zones for the reservoir operation as illustrated on Fig. I.3-1. Each storage zone has a purpose in storing and releasing water according to system water demand such as flood control, flow conservation and augmentation, etc. Each zone has a upper and lower boundary, and is specified within a space between the high water level (HWL) and the low water level (LWL) of a reservoir.

The upper zone (zone-1) is used for the flood surcharge storage space, the lowest zone (zone-8) for dead water storage, and the zone-7 only for a firm energy generation. The upper and lower rule curves were fixed on the basis of a try and error method, referring to the study results of the MWRMP for the existing dams, to maximize power generation as well as to minimize water deficit in irrigation areas and spillout from respective reservoirs and tanks.

With regard to multipurpose dams, the following operation rule is given:

- In case that reservoir water level at a certain time is higher than the lower rule curve (above the 6th zone), water is released to meet downstream irrigation water demand or to maintain a firm power generation, which is greater.

- In case that reservoir water level is lower than the lowest rule curve (within the 7th zone), water is released to maintain only a firm power generation.

- As a first trial, water balance from the upper to lower reservoirs is carried out to maintain a firm generation at each hydropower station. In case of irrigation water demand being higher than demand for a firm generation, water release is first made from a reservoir or tank with the highest zone among all multipurpose dams and irrigation tanks, and if not to meet the irrigation demand, a downstream reservoir with the 2nd highest zone releases water to meet irrigation demand.

Conceptional flow chart of the simulation model are illustrated on Fig. I.3-2.

I.3.2 Reservoir and Tank Operation

(1) Operation Rule for Main System Reservoirs

For the water balance study, the operation methods of the existing and proposed dams were set at the variable draft operation considering the characteristics of the multipurpose dams, except the proposed Talawakele, Watawela, Uma Oya Scheme-500 hydropower stations which are the river run-off type. Even though existing dam series in the Mahaweli river basin including several steps of transbasin diversion are so complicatedly connected, all the multipurpose reservoirs were set at the variable draft operation to release water to downstream, according to the downstream water demand keeping the present water rights for water users.

The Polgolla diversion policy is the most important key factor for the formulation of a future development policy and plan. Comprehensive economic and social benefit as a whole should be taken in consideration. At Polgolla, water demand for the Amban Ganga will be released through the power channel with maximum discharge of 148 MCM per month.

The principal concept of the rule curve for the main system reservoirs would be to maximize the overall hydroelectric energy, keeping the firm hydroelectric energy production for each system and/or as a whole system, and irrigation demand for the downstream areas.

Simulation was made in order to evaluate the rule curve for each reservoir, referring to the results of the MWRMP for the present condition. For the future development cases, simulation runs were carried out to maximize the overall hydroelectric energy generation, at the same time to meet the irrigation water demand within an allowable deficit by adopting a try and error method. The rule curves for the major reservoirs are illustrated on Fig. I.3-3.

(2) Operation Rule for Irrigation Tanks

The simulation runs were performed to evaluate the rule curve to minimize diversion demands from the main system reservoirs and to make maximum use of local inflows, i.e. to minimize spillout from respective tanks, while at the same time, maintaining allowable irrigation reliability.

Every irrigation tanks have respective characteristics such as commanding area, its own catchment area, storage capacity, etc. As seen in Tables I.2.6 and I.2.8, almost all of the tanks have very limited tank capacity to irrigate its commanding area for about one-two months. High irrigation demand will be usually occur in May to August and November to February. Therefore, reservoir water level at end April and end October be kept at a certain level for the next irrigation water issues. Considering these fact and referring to the results of the MWRMP (Ref. 18), simulation runs were performed to fix the rule curve so as to minimize spillouts at respective tanks. The rule curves for major tanks are presented on Fig. I.3-3.

(3) Diversion Rule at Key Points

- Polgolla : The first priority is to release the river flow for firm energy demand for Ukuwela Power Plant and the second priority is given to the supply of additional released flows for downstream hydropower energy demands of the Mahaweli Ganga and downstream irrigation demands of each system.

- Minipe : Priority is given to the supply of diversion requirements for each system.

- Kandukadu : The first priority is given to the supply of diversion requirements for System A and the second priority is to maintain the downstream river flow.

- Elahera : Priority is given to the supply of diversion requirements for each system.

I.4 WATER BALANCE STUDY

I.4.1 General

Assessment of available water resources under the present condition is essential for a future development plan. Moreover, the Polgolla diversion policy is of paramount importance and a key factor for the future development plan. As discussed in Section I.2.2 and ANNEX-H, there are three alternative transbasin conveyance systems, and two potential irrigation areas (NCRB and NWDZ). Taking into account these possible alternatives and future development plan, the water balance simulations were performed for the following cases:

	Polgolla Diversion						
	875 MCM				1,280 MCM		
Conveyance System	A	B	C	D	A	A	A
Simulation Run case	A145	B151	C145	D109	A118	A209	A242
Irrigation Area	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP NCRB NWDZ	AMDP - -	AMDP NCRB -	AMDP NCRB -	AMDP NCRB NWDZ

The maximum possible irrigable areas were delineated by using the water balance simulation model and allowable deficit criteria for irrigation project, i.e. 80% probability in occurrence and 90% probability in quantity as adopted by the ID. The results are summarized in Tables I.4.1 and I.4.2, and illustrated on Figs. I.4-1 to I.4-8. The results of simulations are briefly described in succeeding Sections.

I.4.2 Procedure of Water Balance Simulation

Water balance simulation was carried out in the following procedures in order to provide the basic information for the alternative transbasin conveyance system study for the NCRB and NWDZ areas.

(1) Case D (Present case including the existing irrigation areas)

In order to grasp the availability of water resources for a future plan and the present reliability of irrigation water supply demands, the study was made on the present condition including the existing, under-construction and committed irrigation areas under the AMDP.

(2) Cases A, B and C with the combination of NWDZ+ NCRB for the screening of a transbasin conveyance system

In order to select a transbasin conveyance system for the NCRB area, the study for potential irrigation areas with the combination of NWDZ + NCRB was made by taking into due consideration the economic comparison study. The comprehensive economic comparison study is described in detail in ANNEX-H.

(3) Based on the transbasin conveyance system selected in the above process (2) for NCRB area, the study was undertaken to select an appropriate combined case through the screening of development plans.

I.4.3 Water Balance Simulation under the Present Condition

Water balance simulation under the present condition including the existing, the under-construction and committed irrigation areas under the AMDP was carried out to grasp the availability of water resources for a future plan and the present reliability of irrigation water supply. The results of the simulation are summarized in Table I.4.1 and system flow diagrams for the present case are illustrated in Fig. I.4-4. As seen in the results, about 1,440 MCM at Minipe and about 4,850 MCM at the proposed Kandakadu intake site on the main stream of the Mahaweli Ganga, and about 720 MCM at Angamedilla on the Amban Ganga are wasted to the downstream or sea.

Keeping the river maintenance flow at the estuary, such surplus water will be utilized for the irrigation purposes. This surplus water is wasted mainly during the Maha season, because hydropower stations are generating electricity throughout the year by discharging water for a firm energy generation even in the Maha season. However, the irrigation demand in the Maha season is less; especially in March and April. It is possible to utilize this surplus water for irrigation purpose by providing regulating dams and tanks, and modifying the rule curve of a certain multipurpose dam.

In order to utilize the surplus water in the Maha season, there is a possibility to release water according to the irrigation demand, i.e. to relax the reservoir operation policy of the Randenigala power station to some extent.

Under the fixed Polgolla diversion policy, i.e. long term average of 875 MCM fixed by NEDECO, almost all of diverted water should be released to Systems H, IH and MH areas through the existing Bowatenna irrigation tunnel. Unless modification of the diversion policy at Polgolla and option to reduce a firm generation were permitted, there is no possibility to increase diversion water to Systems H and the NWDZ.

I.4.4 Water Balance Simulation for Future Case

(1) Water Balance Study for Future Case (Polgolla Diversion: 875 MCM)

Water balance simulations for a future case were performed to select an appropriate transbasin conveyance system among Case A, Case B and Case C. The results of the simulation are summarized in Tables I.4.1, and I.4.2 and illustrated on Figs. I.4-1 to I.4-8. The results of each case are summarized hereunder:

Case - A (New Alternative Plan):

Under a certain limitation of the Polgolla diversion to the Amban Ganga, a new conveyance canal parallel to the existing Minipe LB canal was planned to divert water from the existing the Minipe anicut (crest El. 114) to the Minneriya tank (FSWL: 93.7 m) crossing the Wasgamuwa National Park with minimum disturbance to the park. This diverted water to the Minneriya tank will be utilized for the existing System D1 and its expansion areas of the on-going Moragahakanda Project (about 740 MCM per annum) which would be originally irrigated by using water supplied from the Moragahakanda reservoir. About 760 MCM per annum at the Minneriya tank depending on the conveyance system selected will be pumped up to the NCP canal with a static head of 45-53 m.

The results of the simulation show that about 760 MCM out of about 1,480 MCM to be diverted to the Minneriya tank will be boosted up to the NCRB areas, and about 730 MCM of irrigation water originally supplied to System D1 from the on-going Moragahakanda dam and about 250 MCM from the proposed Kalu Ganga dam will be supplied through a new NCP canal to the NCRB area.

The results indicate that increased diversion water to the NWDZ under the present Polgolla diversion policy (875 MCM) will be so difficult to keep the firm generation at the Bowatenna hydropower station (2 hrs peak operation) and the on-going Moragahakanda multipurpose project.

According to results of water balance study, possible diversion water through the Minipe RB canal was estimated at about 1,420 MCM per annum on an average (1949-1986). There is a certain possibility to divert about 240 MCM from the Maduru Oya reservoir to the Gallodai Aru basin, by using the existing Minipe RB canal and providing additional irrigation tunnel between Ulhitiya and Maduru Oya reservoirs. This diversion is subject to the future study.

Case - B (TDB Solution):

As discussed in Case A, about 1,510 MCM of surplus water at Minipe will be diverted to the NCRB areas. Possible irrigation area in the NCRB is the same as Case A. However since the Kalu Ganga dam is proposed and pumped water should be regulated. In this case, all diversion water should be pumped and static pumping head is about 85 m, and annual O&M costs for the pump station will be very high compared with Cases A and C.

As far as the water balance concerned, possible irrigable area in the study area will be similar to Case A with acceptable reliability of irrigation water supply.

Case - C (UNDP/FAO Solution):

Diversion water at Minipe will be led to Angamedilla then to the Kaudulla tank by gravity through the enlarged and extended existing Minipe LB canal. The results of simulation show that about 900 MCM out of 1,430 MCM diverted at Minipe will be boosted up to the NCP canal, and about 530 MCM of irrigation water originally supplied to a part of System D1 from the on-going Moragahakanda dam and about 250 MCM from the proposed Kalu Ganga dam will be supplied to the NCRB area through the NCP canal within the allowable deficit.

(2) Water Balance Study for Future Case (II) (Polgolla Diversion: 1,280 MCM)

Based on the economic comparison, Case-A was selected for the further detailed study to formulate an overall development plan stated in ANNEX-H. There is a certain possibility to irrigate the NWDZ and NCRB areas, by increasing the Polgolla diversion to the Amban Ganga, the NWDZ and NCRB, and by decreasing pumping water from the pump stations proposed in the respective alternative cases. Water balance simulation runs for the selected conveyance system of Case A under increased Polgolla diversion of 1,280 MCM per annum are carried out by the simulation model. The results of the study are summarized in Table I.4.2 and the schematic flow diagramme are presented on Figs. I.4-6 and I.4-8.

As seen in Table I.4.2, increase of diversion water at Polgolla results in decrease of an average annual energy output especially on the existing hydropower stations on the Mahaweli main stream. Moreover, the irrigation deficit ratio is a little higher than that of the allowable deficit criteria.