Table E.4.9 Financial Cash Flow

(1000 Kshs.)

Year	Cost					Revenue	Balance	
	1) Capital	2) O & M	3) Replacement	4) 2) + 3)	5) Total	6)	7) 6) - 4)	8) 6) - 5)
1991	27161	0	0	0	27161	0	0	-27161
1992	59499	0	0	0	59499	0	0	-59499
1993	29963	0	0	0	29963	0	0	-29963
1994	691951	0	0	0	691951	0	0	-691951
1995	1102234	0	0	0	1102234	0	0	-1102234
1996	1141771	0	0	0	1141771	0	0	-1141771
1997	84632	20396	0	20396	105028	41926	21530	-63102
1998	0	23448	0	23448	23448	49401	25953	25953
1999	19138	26903	0	26903	46041	58065	31162	12024
2000	39760	30761	0	30761	70521	67913	37152	-2608
2001	21053	35458	0	35458	56510	78821	43363	22311
2002	199430	40767	0	40767	240197	91355	50588	-148842
2003	676738	46698	0	46698	723436	105750	59052	-617686
2004	900649	57735	0	57735	958384	122272	64537	-836112
2005	0	65543	0	65543	65543	141207	75664	75664
2006	5350	74498	0	74498	79848	163038	88540	83190
2007	10959	84465	0	84465	95424	188071	103606	92647
2008	5796	96357	0	96357	102053	216763	120406	114710
2009	113289	108632	0	108632	221921	249635	141003	27714
2010	210082	124018	0	124018	334100	287041	163023	-47059
2011	151895	134054	0	134054	285949	310004	175950	24055
2012	0	144778	0	144778	144778	334804	190026	190026
2013	0	156360	0	156360	156360	361589	205229	205229
2014	0	168869	0	168869	168869	390516	221647	221647
2015	0	182379	0	182379	182379	421757	239378	239378
2016	0	196969	0	196969	196969	455498	258529	258529
2017	0	212726	136892	349618	349619	491938	142320	142319
2018	0	229745	0	229745	229745	531293	301548	301548
2019	0	248124	0	248124	248124	573796	325672	325672
2020	0	267974	0	267974	267974	619700	351726	351726
2021	0	289412	0	289412	289412	669276	379864	379864
2022	0	312565	0	312565	312565	722818	410253	410253
2023	0	337570	0	337570	337570	780643	443073	443073
2024	0	364576	68106	432682	432682	843095	410413	410413
2025	0	393742	0	393742	393742	910542	516800	516800
2026	0	425241	0	425241	425241	983386	558145	558145
2027	0	459260	0	459260	459260	1062056	602796	602796
2028	0	496001	0	496001	496001	1147021	651020	651020
2029	0	535681	0	535681	535681	1238783	703102	703102
2030	0	578536	0	578536	578536	1337885	759349	759349
2031	0	624819	3421	628240	628240	1444916	816676	816676

FIRR(%)=
2.60

Table E.4.10 Loan Repayment Schedule (Current Price)

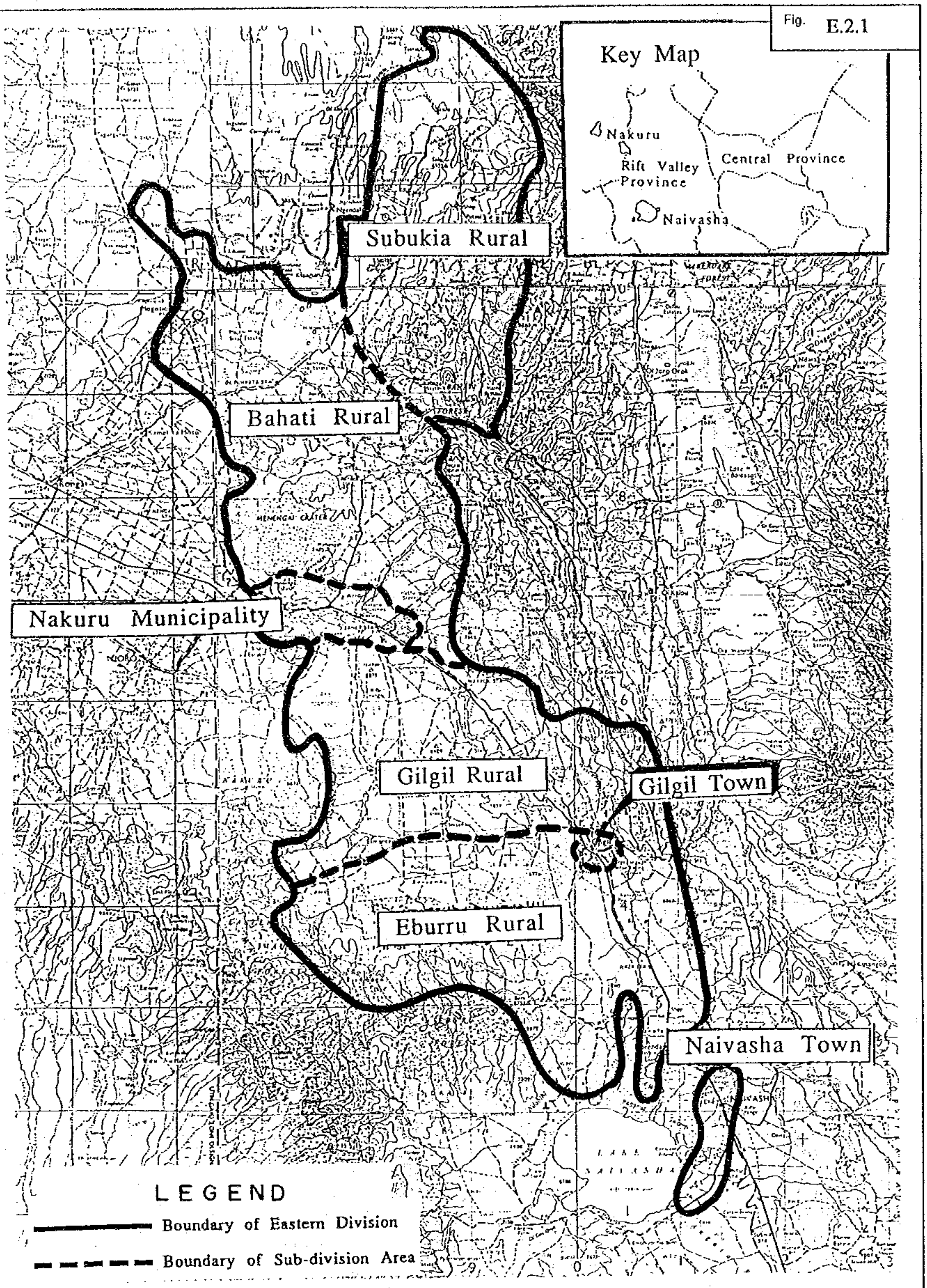
(Unit: 1000Kshs.)

		Dam & Water Facilities(Stage 2-1)						Water Facilities (Stage 2-2)						Water Facilities (Stage 2-3)											
		Loan Disbursement		Accumlated	Repayment			Loan Disbursement		Accumlated	Repayment			Loan Disbursement		Accumlated	Repayment			Capital funded	OMR**	Annual	Annual	Balance	Accumlated
		Capital	IDC*	Loan	Interest	Principal	Total	Capital	IDC*	Loan	Interest	Principal	Total	Capital	IDC*	Loan	Interest	Principal	Total	by Gov.of Kenya		Expenditure	Revenue		Balance
0	1990																								
1	1991	21358	539	21897	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5803	0	5803	0	-5803	-5803
2	1992	47487	1751	71135	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12012	0	12012	0	-12012	-17815
3	1993	23195	1828	96158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6768	0	6768	0	-6768	-24583
4	1994	587937	15427	699522	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104014	0	104014	0	-104014	-128597
5	1995	952853	39142	1691517	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	149381	0	149381	0	-149381	-277978
6	1996	979041	49567	2720125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	162730	0	162730	0	-162730	-440708
7	1997	67063	27560	2814748	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17569	20396	37965	41926	3961	-436747
8	1998	0	0	2722716	70369	92032	162401	0	0	0	0	0	0	0	0	0	0	0	0	0	23448	185849	49401	-136448	-573195
9	1999	0	0	2628383	68068	94333	162401	13929	353	14282	0	0	0	0	0	0	0	0	0	5209	26903	194513	58065	-136448	-709643
10	2000	0	0	2531692	65710	96691	162401	29715	1114	45111	0	0	0	0	0	0	0	0	0	10045	30761	203207	67913	-135294	-844937
11	2001	0	0	2432583	63292	99109	162401	15051	1162	61324	0	0	0	0	0	0	0	0	0	6002	35458	203861	78821	-125040	-969977
12	2002	0	0	2330997	60815	101586	162401	161689	4489	227502	0	0	0	0	0	0	0	0	0	37741	40767	240909	91355	-149554	-1119531
13	2003	0	0	2226871	58275	104126	162401	570293	18547	816342	0	0	0	0	0	0	0	0	0	106445	46698	315544	105750	-209794	-1329325
14	2004	0	0	2120142	55672	106729	162401	766333	34105	1616780	0	0	0	0	0	0	0	0	0	134316	57735	354452	122272	-232180	-1561505
15	2005	0	0	2010745	53004	109397	162401	0	0	1566801	40420	49979	90399	0	0	0	0	0	0	0	65543	318343	141207	-177136	-1738641
16	2006	0	0	1898613	50269	112132	162401	0	0	1515572	39170	51229	90399	3644	93	3737	0	0	0	1706	74498	329004	163038	-165966	-1904607
17	2007	0	0	1783677	47465	114936	162401	0	0	1463062	37889	52510	90399	7639	289	11665	0	0	0	3320	84465	340585	188071	-152514	-2057121
18	2008	0	0	1665868	44592	117809	162401	0	0	1409240	36577	53822	90399	3882	300	15847	0	0	0	1914	96257	350971	216763	-134208	-2191329
19	2009	0	0	1545114	41647	120754	162401	0	0	1354072	35231	55168	90399	88062	2332	106241	0	0	0	25227	108632	386659	249635	-137024	-2328353
20	2010	0	0	1421341	38628	123773	162401	0	0	1297525	33852	56547	90399	164249	6433	276923	0	0	0	45833	124018	422651	287041	-135610	-2463963
21	2011	0	0	1294474	35534	126867	162401	0	0	1239564	32438	57961	90399	118942	7314	403179	0	0	0	32953	134054	419807	310004	-109803	-2573766
22	2012	0	0	1164435	32362	130039	162401	0	0	1180154	30989	59410	90399	0	0	390715	10079	12464	22543	0	144778	420121	334804	-85317	-2659083
23	2013	0	0	1031145	29111	133290	162401	0	0	1119259	29504	60895	90399	0	0	377940	9768	12775	22543	0	156360	431703	361589	-70114	-2729197
24	2014	0	0	894523	25779	136622	162401	0	0	1056841	27981	62418	90399	0	0	364846	9449	13094	22543	0	168869	444212	390516	-53696	-2782893
25	2015	0	0	754485	22363	140038	162401	0	0	992863	26421	63978	90399	0	0	351424	9121	13422	22543	0	182379	457722	421757	-35965	-2818858
26	2016	0	0	610946	18862	143539	162401	0	0	927286	24822	65577	90399	0	0	337667	8786	13757	22543	0	196969	472312	455498	-16814	-2835672
27	2017	0	0	463819	15274	147127	162401	0	0	860069	23182	67217	90399	0	0	323566	8442	14101	22543	0	349618	624961	491938	-133023	-2968695
28	2018	0	0	313013	11595	150806	162401	0	0	791172	21502	68897	90399	0	0	309112	8089	14454	22543	0	229745	505088	531293	26205	-2942490
29	2019	0	0	158437	7825	154576	162401	0	0	720552	19779	70620	90399	0	0	294297	7728	14815	22543	0	248124	523467	573796	50329	-2892161
30	2020	0	0	0	3961	158437	162398	0	0	648167	18014	72385	90399	0	0	279111	7357	15186	22543	0	267974	543314	619700	76386	-2815775
31	2021	0	0	0	0	0	0	0	0	573972	16204	74195	90399	0	0	263546	6978	15565	22543	0	289412	402354	669276	266922	-2548853
32	2022	0	0	0	0	0	0	0	0	497922	14349	76050	90399	0	0	247592	6589	15954	22543	0	312565	425507	722818	297311	-2251542
33	2023	0	0	0	0	0	0	0	0	419971	12448	77951	90399	0	0	231239	6190	16353	22543	0	337570	450512	780643	330131	-1921411
34	2024	0	0	0	0	0	0	0	0	340071	10499	79900	90399	0	0	214477	5781	16762	22543	0	432682	545624	843095	297471	-1623940
35	2025	0	0	0	0	0	0	0	0	258174	8502	81897	90399	0	0	197296	5362	17181	22543	0	393742	506684	910542	403858	-1220082
36	2026	0	0	0	0	0	0	0	0	174229	6454	83945	90399	0	0	179685	4932	17611	22543	0	425241	538183	983386	445203	-774879
37	2027	0	0	0	0	0	0	0	0	88186	4356	86043	90399	0	0	161634	4492	18051	22543	0	459260	572202	1062056	489854	-285025
38	2028	0	0	0	0	0	0	0	0	0	2205	88186	90391	0	0	143132	4041	18502	22543	0	496001	608935	1147021	538086	253061
39	2029	0	0	0	0	0	0	0	0	0	0	0	0	0	0	124167	3578	18965	22543	0	535681	558224	1238783	680559	933620
40	2030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	104728	3104	19439	22543	0	578536	601079	1337885	736806	1670426
41	2031	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84803	2618	19925	22543	0	628240	650783	1444916	794133	2464559
42	2032	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64380	2120	20423	22543	0	0	22543	0	-22543	2442016
43	2033	0	0	0	0	0	0	0	0	0	0	0	0	0	0	43447	1610	20933	22543	0	0	22543	0	-22543	2419473
44	2034	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21990	1086	21457	22543	0	0	22543	0	-22543	2396930
45	2035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	550	21990	22540	0	0	22540	0	-22540	2374390
Total		2678934	135814		920472	2814748	3735220	1557010	59770		552788	1616780	2169568	386418	16761		137850	403179	541029	868988	7803379	15118184	17492574	2374390	

* Interest during construction

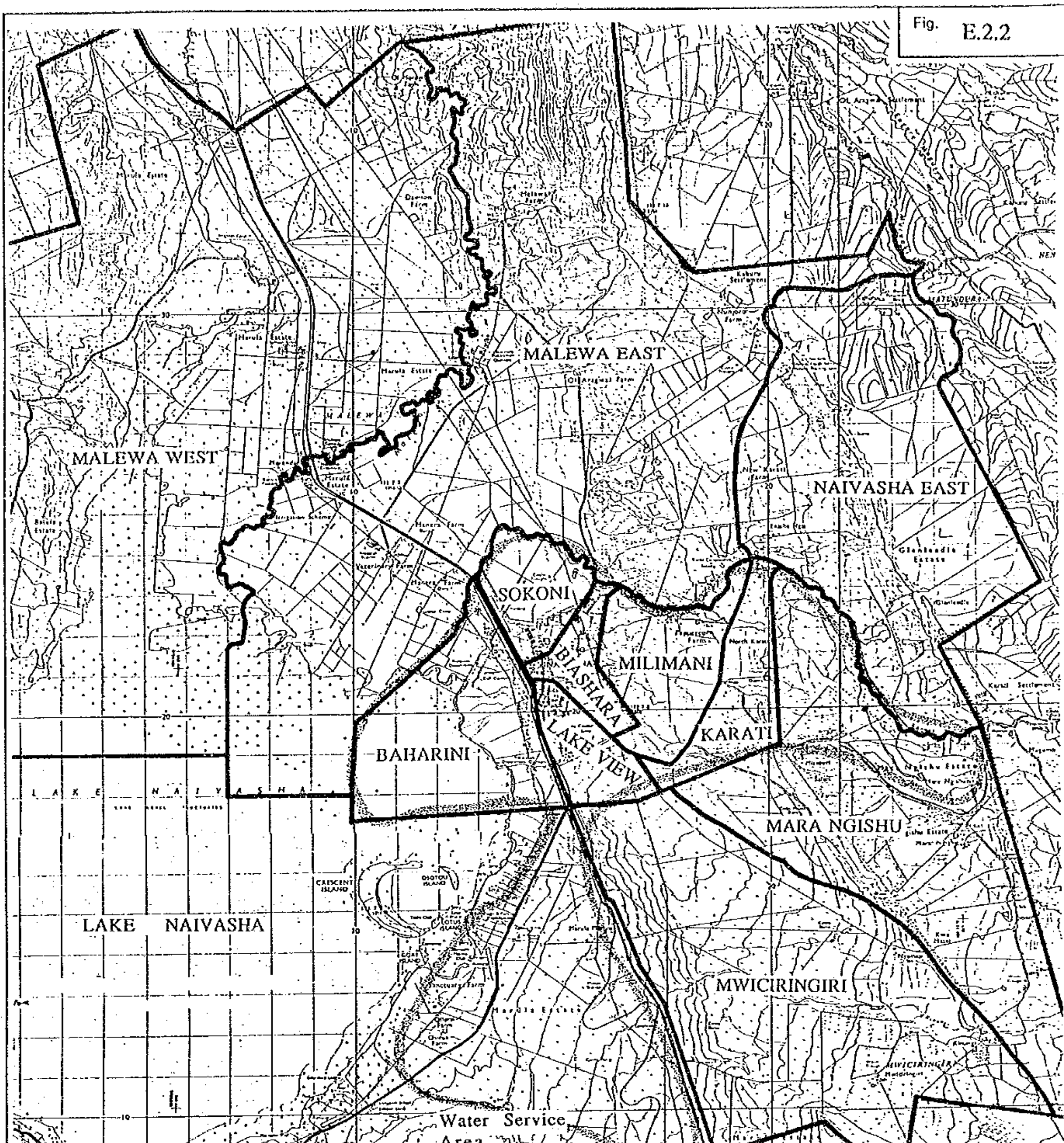
** O&M and Replacement costs

FIGURES

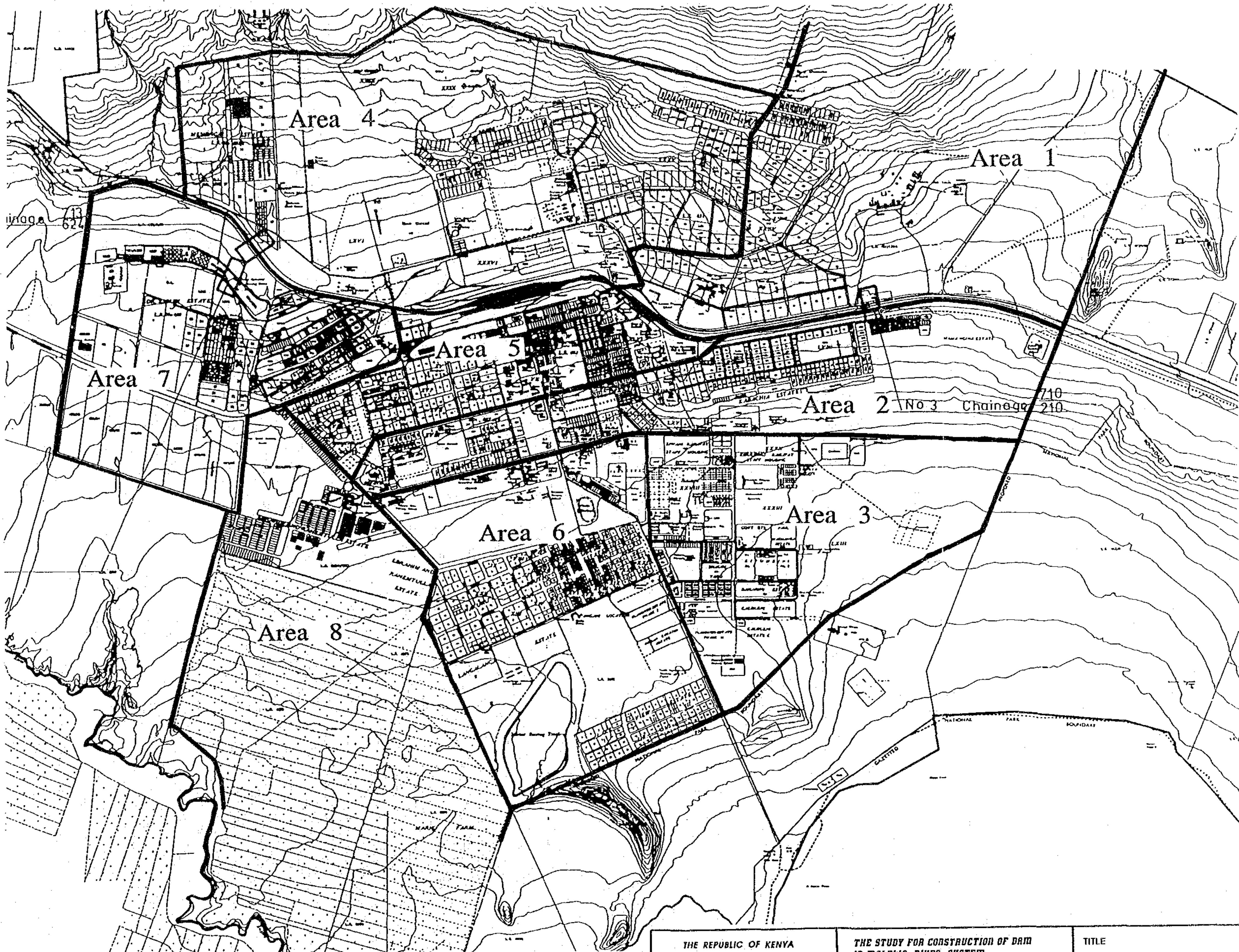


THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Location Map of Proposed Water Service Area

Fig. E.2.2

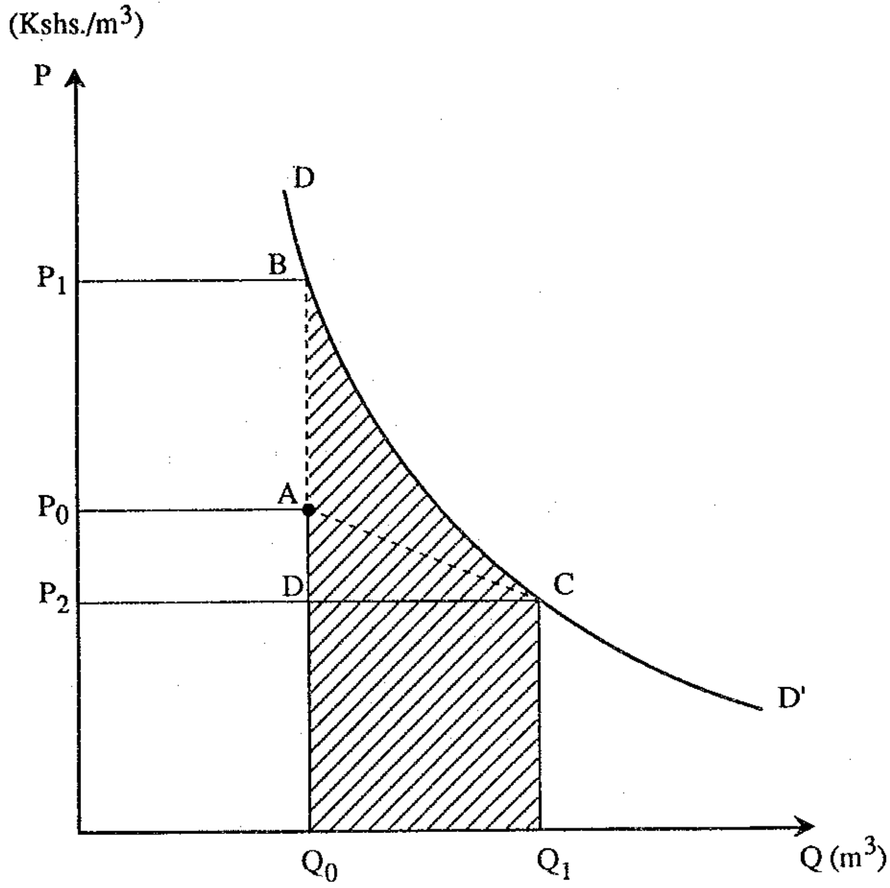


THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Water Service Area in Gilgil Town



THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Sub-areas for Questionnaire Survey

Fig. E4.2



P_0	:	Actual expenditure per cubic meter per household
Q_0	:	Actual consumption per household
P_1	:	Willingness-to-pay per cubic meter at volume Q0
Q_1	:	Volume of water needed per household
P_2	:	Willingness-to-pay per cubic meter at volume Q1

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Conceptual Model for Estimation of Economic Benefit

ANNEX F

WATER RESOURCES DEVELOPMENT PLANNING

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Abbreviation and Local Terms

1. Abbreviation of Measures

1.1 Length

mm	=	millimeter
cm	=	centimeter
m	=	meter
km	=	kilometer

1.2 Area

m^2, sq.m	=	square meter
ha	=	hectare
km^2, sq.km	=	square kilometer

1.3 Volume

lit, l	=	liter
lcd	=	liter per capita per day
cu.m, m^3	=	cubic meter
cu.m/day, m^3/day	=	cubic meter per day
MCM	=	million cubic meter

1.4 Weight

mg	=	milligram
mg/l	=	milligram per liter
g	=	gramme
kg	=	kilogram
t	=	ton

1.5 Time

s, sec	=	second
min	=	minute
h, hr	=	hour
d	=	day
yr	=	year

1.6 Money

Kshs.	=	Kenya Shilling(unit of Kenya currency, US$1.00 = Ksh 23.0 = ¥ 150)
US$, $	=	US dollar
¥	=	Japanese Yen

1.7 Electric Measures

kV	=	kilovolt
kW	=	kilowatt
MW	=	megawatt
kWh	=	kilowatt hour
kVA	=	kilovolt ampere

1.8 Other Measures

mmho	=	micromho = conductance
ppm	=	parts per million
ppb	=	parts per billion
MPN	=	most probable number
‰	=	mill
%	=	per cent
PS	=	0.736 kW
°	=	degree
'	=	minute
"	=	second
℃	=	degree centigrade
n.a.	=	not available
COD	=	Chemical Oxygen Demand
T-N	=	Total Nitrogen
I -	=	Inorganic -
O -	=	Organic -
T-P	=	Total - Phosphorus
DO	=	Dissolved Oxygen
pH	=	Exponent of hydrogen ion concentration

1.9 Derived Measures Based on the Same Symbols

cu.m/sec, m^3/s	=	cubic meter per second
cu.m/day, m^3/day	=	cubic meter per day
t/ha	=	ton per hectare
lpcd	=	liter per capita per day

2. Other Abbreviations

BS	=	British Standards
JIS	=	Japanese Industrial Standards
ASTM	=	American Society for Testing and Material
GNP	=	gross national products

GDP	=	gross domestic product
GRDP	=	gross regional domestic product
El.	=	elevation
FWL	=	flood water level
FSL	=	full supply level
MSL	=	minimum supply level
HWL	=	normal operation level
LWL	=	minimum operation level
f.o.b	=	free on board
c.i.f.	=	cost, insurance and freight
ICB	=	international competitive bid
LCB	=	local competitive bid

3. Abbreviation of Organizations

MOA	=	Ministry of Agriculture
MENR	=	Ministry of Environment & Natural Resources
MOF	=	Ministry of Finance
MOLD	=	Ministry of Livestock Development
MOLG	=	Ministry of Local Government
MOTW	=	Ministry of Tourism & Wildlife
MOTC	=	Ministry of Transport & Communication
MORD	=	Ministry of Regional Development
MOWD	=	Ministry of Water Development
NES	=	National Environmental Secretariat
NWCPC	=	National Water Conservation & Pipeline Corporation
SOK	=	Survey of Kenya
KWS	=	Kenya Wildlife Service
NMC	=	Nakuru Municipal Council
NTC	=	Naivasha Town Council

ASTU	=	Anti-Stock Theft Unit
KYSTC	=	National Youth Service Training Center
GMB	=	Gilgil Military Barracks
KMB	=	Kenyatta Military Barracks
WWF	=	World Wide Fund for Nature
JICA	=	Japan International Cooperation Agency
OECF	=	Overseas Economic Cooperation Fund, Japan

I. INTRODUCTION

This annex presents a plan formulation study with respect to the water resources development scheme. The study was actually carried out in two steps.

The first step was initially to identify the possible dam sites in the Malewa river basin and finally to select the most processing scheme among the alternatives. The procedures and result of this step was actually compiled in an Interim Report, which was submitted to the MOWD/NWCPC in October, 1989.

The second step was commenced subsequent to concurrence of the MOWD/NWCPC on the proposed Malewa Dam Scheme, recommended by the Interim Report, and was aimed at identifying the optimum development scale of the Malewa Dam. Also the process and result of the second step were summarized in a Progress Report No. 2, which was submitted to the MOWD/NWCPC February, 1990.

For carrying out the Study, various advices and assistances were given by the officials of the MOWD/NWCPC. The Study Team would like to state their appreciation particularly for the following officials.

Mr. H. K. Rotich	:	Managing Director, NWCPC
Mr. M. M. Mahamud	:	Chief Corporative Service, NWCPC
Mr. A. M. Makokha	:	Chief Operation Service, NWCPC
Mr. M. Trajanow	:	Chief Dam Construction Unit, NWCPC
Mr. E. M. Mwai	:	Chief Geologist, NWCPC

II. SITE CONDITIONS

2.1 General Description

2.1.1 Identification of Alternative Dam Schemes

Through the topographic map study and field reconnaissance, two damsites particularly favored by topography, hydrology and geology have been identified in the Malewa river basin. One is located in the Malewa river (the Malewa dam scheme) and the other in the Turasha river (the Turasha dam scheme). Both damsites are located at about 8 km upstream from the confluence of the Malewa and Turasha rivers as shown in Fig. F.2.1.

In addition a trans-basin diversion tunnel has been planned between the both rivers in order to efficiently and rationally use the water resources and existing source facilities.

2.1.2 Field Survey and Investigation

In order to verify technical feasibility and economic soundness of the alternative development schemes, various field survey and investigation have been programmed as follows.

(1)	Topographic survey	: - Aerial photography - Photogrametric mapping - River cross section survey
(2)	Hydrological investigation	: - Stream flow gauging - Suspended loads measurement
(3)	Geological investigation	: - Geological mapping over reservoir areas and damsites - Test drilling, standard penetration test and permeability test at damsites

(4) Construction material survey : - Identification of quarry sites and borrow areas survey
- Preparation of topographic map
- Test pitings in borrow area
- Laboratory tests of rock and soil samples

(5) Preliminary environmental study : - Data collection on water quality analysis
- Water balance study
- Forecast of effects of the Project
- Preparation of topographic map of Lake Nakuru

Details of the above survey and investigation are reported in the specific annex : the Topographic Survey in Annex A, the Geological Investigation in Annex B, the Construction Material Survey in Annex C, the Hydrological Investigation in Annex D, and the Preliminary Environmental Study in Annex G.

2.2 Topographic and Geological Conditions of Malewa Dam Scheme

2.2.1 Topographic Condition

The damsite is located almost in the middle of Malewa Gorge and is at immediately downstream of the confluence of a small stream joining the Malewa river at the left bank. The catchment area of the Malewa river is 635 sq.km at the proposed damsite.

The reservoir area is located in a flat hill zone with slopes of low angles, composed of sub-horizontally bedded and pyroclastic flows interbeded with the lake sediments. The gently undulating terrain is dissected by the Malewa river to the depth of 50 m to 50 m from the ground surface of the flat hills, forming a meandering gorge.

The Malewa river bed is at El. 2,082 m at the damsite and the width of the valley there is 190 m at the top of the gorge at El. 2,145 m. Stratigraphic sequences of gently dipping pyroclastic beds and lake sediments are well exposed on the steep slopes of the valley sides, with well cemented welded tuffs forming small cliffs and soft lakes sediment forming flatter parts of the slopes.

Area-storage curve of the reservoir has been constructed as shown in Fig. F.2.2 based on the topographic maps in a scale of 1 to 5,000 with contour intervals of 5 m. The reservoir surface area and storage capacity are 2.98 sq.km and 59.8 million cu.m respectively at El. 2,145 m.

2.2.2 Geological Condition of Reservoir Area

The terrain of the reservoir area and surrounding area is composed of a series of pyroclastic rocks which are stratigraphically classified as a Pliocene Kinangop Tuffs, comprising welded tuffs and massive tuffs interbedded with the lake sediments, being covered with colluvial deposits, the Quaternary overburden on the flat slopes. Geological maps of the proposed scheme area and details of the geological condition are discussed in Annex B.

The welded tuff is wide-spread over the reservoir area and can be distinguished into several different flow beds. All the flow beds are almost commonly dark grey colored and include scoria fragments of pebble to cobble size. The welded tuff is the hardest rock in the reservoir area.

Massive tuffs and lake sediments are also widely developed in the reservoir area. The massive tuffs seem to have had originally similar lithological components to the welded tuff but are less cemented than the welded tuff. The lake sediments consist of alternative layers, tuffaceous sandstone, conglomerate and minor quantity of diatomite which are poorly consolidated and vulnerable to weathering.

Colluvial deposit of silt, sand, pebbles, cobbles and boulders of the welded tuff, covers the gentle slopes in the reservoir area, with the maximum thickness of several meters.

The Pliocene series of the pyroclastic rocks with the lake sediments generally show sub-horizontal bedding with the west-northwest dips of less than 10 degrees, which , however, locally varies because of the undulation. All faults identified in the reservoir area are minor and have no foundation engineering significance.

No sign of significant land sliding, existing or potential, has been found in the reservoir area. The slopes are, however, subject to considerable erosion, particularly below cultivated lands and barren lands. Any potential passage for substantial water leakage from the reservoir has not been found.

2.2.3 Geological Condition at Damsite

The bedrock of the damsite is quite similar to the geology of the reservoir area . The geological profile along the dam axis is shown in Fig. F.2.3.

The welded tuffs have been identified at three different horizons, while the lake sediment layers have been identified at five different horizons. The welded tuff is associated by non-welded layers both in the upper and lower parts. The sediments of all the layers show similar lithological features of those in the reservoir area. Each of these layers is not thicker than one meter and their boundaries are often gradational. Four different horizons of massive tuffs have also identified in the damsite at four different layers. The massive tuffs of different horizons show nearly the same lithologic features , which are not much different from the welded tuff except for the features of welding.

As the reservoir geology the Pliocene beds in the damsite are also sub-horizontally stratified with the dip of less than 10 degrees to the west-northwest. Minor faults of no practical significance have been found at the damsite. The bedrock is moderately to slightly weathered to considerable depths in the both abutment, while weathering is hardly observed in the rocks under the river bed. The weathering is, however, not intensive in general.

Of all the young volcanic and pyroclastic bedrocks, the Pliocene lake sediments are the weakest but are deemed still stable enough for foundation of fill-type dams of some 60 m in height if it is not weathered to more than moderate grade. The overburden and the highly weathered rock zone are thin, except at the foots of both banks. Competent bedrock for the dam foundation can be reached at the depth of several meters from the present ground surface, while about eight meters deep excavation will be required for foundation of impervious earth core in the river bed. For dam shell zone necessary excavation would be 5 m in in the river bed and 2 m in the abutments.

The permeability in fresh rocks and slightly to moderately weathered rocks is usually 5 Lugeon or less, with a few exceptions. Ordinary treatment with curtain grouting will be sufficient for underseepage cut-off. However it is recommended to extend the curtain grouting deep into both abutments with rim grouting for account of the unusually low ground water table on the both banks.

2.3. Topographic and Geological Conditions of Turasha Dam Scheme

2.3.1 Topographic Condition

The Turasha damsite is sited at approximately 150 m upstream from the entrance to the Turasha Gorge. The catchment area of the Turasha river is 711 sq.km at the proposed damsite.

The damsite is situated in a zone of the similar topographic characteristics to the Malewa scheme. At the proposed damsite the river bed at El. 2,096 m is approximately 30 m in width and the Turasha valley has a width of 380 m at El. 2,160 m or at the level 64 m higher than the river bed. There are several portion of low angled inclination, covered with colluvial deposits on the slopes on both sides of the river valley, reflecting existence of the soft lake sediment layers.

Area-storage curve of the reservoir area is presented in Fig. F.2.4. The reservoir storage capacity is 49.2 million cu.m at El. 2,165 m, about one million cu.m lesser than that of the Malewa scheme.

2.3.2 Geological Condition of Reservoir Area

Stratigraphy of the reservoir area and damsite and geological maps of the scheme's area are mentioned in detail in Annex B.

The reservoir area is composed of thick lake sediment and a series of Upper Tertiary volcanic and pyroclatic rocks comprising trachytes, welded tuffs and massive tuffs, covered with Quaternary colluvial deposits in parts of flat topography and gentle slopes.

Trachytes develops only in the proposed damsite and downstream, forming gorge and cliffs. Both normal and auto-brecciated lava features are seen in a condition of of complicated intermixture. The trachyte bed can probably divided into several sub units, each unit seems to have its own joint system.

The welded tuffs, massive tuffs, lake sediments and colluvium are similar in characteristics to those in the Malewa scheme.

The geological structure is also similar to the Malewa scheme. Two major faults have been found and one has been in ferred to pass through the damsite, though it could not be confirmed for the lack of outcrops. All the faults show a trend of north-northwest to south-southeast corresponding to the regional geomorphological trend of the Great Rift Valley.

No evidence of potential landsliding in a substantial scale has been observed in the reservoir area, though possibility of minor, rather harmless slidings remain as in case of the Malewa scheme.

2.3.3 Geological Condition at Damsite

The proposed damsite is situated in the same geological setting with the sub-horizontally bedding volcanic and pyroclastic bedrocks of the Upper Tertiary North Kinangop Trachytes and Kinangop Tuffs. The geological maps around and geological profile along the proposed dam axis are discussed in detail in Annex B. The geological profile along the dam axis is presented in Fig. F.2.5.

The trachyte is situated at the lower horizon of the stratigraphy and encountered only in the vicinity of the damsite and downstream. Occurrence of the massive tuffs, intercalated in the trachyte lavas is rather limited. The rock is generally porous and friable. The lake sediments have been identified in one layer on the left bank and two layers on the right bank. The lake sediment layers seem to be not continuous, intercepted by a fault passing near the river bed. The welded tuffs have also identified at three layers on the left bank and two horizons on the right bank, also intercepted by the said fault.

Bedding of the bedrocks is sub-horizontal with west-northwesterly dip of very low angle, dipping from the left bank to the right bank downward at the damsite. Two major faults have been found and one inferred in the vicinity of the damsite.

- Fault I : This exists on the right bank downstream and trends north-northwest to south-southeast. The sheared zone has a width of 2 m.
- Fault II : This runs from a saddle on the left bank to the right bank, having the same tendency as the Fault I.
- Fault III : This is inferred from geological conditions in the boreholes TB-1 and TB-2 and deemed to run parallel with Fault II

The left bank is moderately to slightly weathered to a depth of 30 m from the ground surface, while weathering on the right bank is deeper and more intensive. Highly previous condition with deep penetration of weathering on the right bank probably prevails in the crackly trachyte downstream of the damsite. The trachyte is bounded by Faults II and III and a considerable descent of river bed amounting about 40 m in height is formed across this trachyte belt, unfavourably for the water tightness.

The highly weathered zone of the bedrock is 8 m thick on the right bank but thin on the river bed and the left bank. The bed rock competent enough for 60 m high fill-type dam will be reached at the depth of nearly 10 m from the ground surface in the abutments, while the depth of the dam core foundation will be around 6 m under the river bed. The excavation depth of the shell zone will be 6 - 7 m in the left bank and 1 - 2 m on the river bed and the right bank. Permeability of the bed rock, in particular in the crackly trachyte cut by the faults, is extraordinary high. Special seepage cut-off structures as a subsurface wall may be necessitated, other than intensive grouting for curtain and rim.

2.4 Availability of Construction Materials

2.4.1 Earthfill Materials

Through intensive field reconnaissance over a wide area around the proposed damsites, three prospective borrow areas, Gilgil, East Road and Mahindu have preliminarily been identified. Test pittings have been executed at the respective area and the representative soil samples have been tested for their physical and mechanical characteristics to facilitate the selection of the most suitable area among the three by the local laboratory. The general features of the three borrow areas are as presented hereunder and details of the preliminary investigation are reported in Annex C.

Description	Gilgil	East Road	Mahindu
Hauling distance to damsite	19 km to Malewa, 18 km to Turasha	17 km to Malewa, 16 km to Turasha	11 km to malewa 8 km to Turasha
Soil classification	Residual soil partial upper	Residual soil &lateritic (SM) -(S-M)	Lateritic soil (MH) soil(CH) - (SM) part(SM)
Quality	Good	Good	Good
Geological condition	Soil is thin partially	Depth to bedrock is two meters.	Soil is very thin generally
Other particulars	Close to residences and railway station	Grass land	Cultivated land

The results of the physical and mechanical tests are mentioned in detail in Annex C.

In due consideration of the results of the physical and mechanical tests, quantity available, surrounding conditions and hauling distance, the East Road borrow area has finally been selected as the proposed borrow area. Its location is shown in Fig. F.2.6.

2.4.2 Fine Concrete Aggregate

There is no suitable sand and gravel deposits within a reasonable distance from the proposed damsites. The existing quarry site for concrete aggregates is in Nakuru, approximately 60 km away from the Malewa damsite, and only fine aggregate is being exploited there by the local miners. According to the results of the laboratory tests, the quality of the sand is classified as a sub-standard. It has, therefore, recommended to produce fine concrete aggregate by means of crushing the quarried rock together with the coarse aggregate. The results of the laboratory tests are presented in Annex C.

2.4.3 Rockfill Material and Concrete Aggregates

Two prospective quarry sites have been identified through the surface geological reconnaissance in and around the proposed damsites. One is "South Gilgil" quarry and the other is "Kipipiri Road" quarry. As the same as the earthfill materials, the representative rock fragments were sampled at the respective quarry site and they were tested in the laboratory to reveal their characteristics. The general features of the two areas are as summarized below.

Description	South Gilgil	Kipipiri Road
Hauling distance	23 km to Malewa, 20 km to Turasha	5 km to Malewa, 10 to damsite km to Turasha
Rock faces	Trachyte	High degree welded tuff
Quality	Moderate	Moderate
Geological condition	Weathered zone is 5 m in a depth or more	Weathered zone is thin. Upper part of 5 m is welded tuff. The bed is 5 m thick.
Other particular suitable f	Presently rock quarrying is. operated	Welded tuff of upper part is for rockfill material.

The results of the laboratory tests are presented in Annex C. The locations of the quarry sites are shown in Fig. F.2.6.

2.5 Hydrology in Malewa River Basin

2.5.1 Stream Gauging

In the Malewa river basin, there are three key stream gauge stations, which have been operated and maintained by the MOWD for more than three decades. Their catchment areas and recording periods are as summarized below :

Stream Gauge Station	River	Catchment Area	Recording Period
2GB1	Malewa	1,551	1931-1985
2GB5	Malewa	776	1959-1987
2GC4	Turasha	724	1951-1988

2GC4 is located close to the Turasha damsite, only 2 km downstream from the proposed Turasha damsite, while 2GB1 is situated at about 7 km downstream from the confluence of the Malewa and Turasha rivers. 2GB5 is located at about 0.5 km upstream from the confluence of the Malewa and Turasha rivers. The location map of these stream gauges is given in Fig. F.2.7.

2.5.2 Runoffs at the Proposed Damsites

The water balance calculation, which is essential to ascertain the magnitude of the water resources development, has been pre-determined to be worked out at the intervals of 5 days. Accordingly the daily runoffs have been converted into the 5-day as runoffs as shown in Tables F.2.1 and F.2.2. The average annual runoffs at the Malewa and Turasha damsites are calculated at 3.19 cu.m/sec and 3.57 cu.m/sec respectively during the period from 1952 to 1985.

2.5.3 Floods at the Proposed Damsites

It is worth to note that the floods events of the Turasha river have been recorded by the automatic water level recorded for a 37-year period from 1954 to 1983. The probable floods necessary for design of the spillway and diversion works during dam construction have accordingly been estimated by means of statistical treatment of the recorded floods at 2GC4.

The Pearson III distribution fits well to the recorded floods. The estimated probable floods at 2GC4 are as summarized below :

Return Period(years	Instantaneous Peak Discharge(cu.m/sec)
5	120
20	270
100	520
200	666
1,000	1,100

The design floods for the river diversion works and spillway have been estimated for both Malewa and Turasha damsites as tabulated below. The same floods as 2GC4 have actually been adopted for the Turasha damsite because of no substantial difference in catchment areas between the both, while the those at the Malewa damsite have been extrapolated in due consideration of difference in the catchment areas.

Design Flood	Return Period	Malewa Damsite	Turasha Damsite
River diversion works	20 years	240 cu.m/sec	270 cu.m/sec
Spillway	1,000 years	960 cu.m/sec	1,100 cu.m/sec

2.6 Sediment Deposit in Reservoir

2.6.1 Suspended Loads Transport by Malewa River

The average annual suspended loads transport by the Malewa river has been assessed with the aids of the envelope curve and flow duration curve at 2GB1. It amounts to 123,000 cu.m/year, corresponding to suspended loads yield of 0.08 mm/sq.km/year, assuming bulk density of the suspended loads at 1.5 ton/cu.m.

2.6.2 Sediment Deposit in Reservoir

The slopes in the proposed reservoir area are highly vulnerable to considerable erosion, particularly below cultivated lands and barren lands. It is foreseenable that rapid population increase in the region would inevitably enhance such human activities as deforestration, intensive land uses for agriculture and livestock grazing, land development for housings etc., resulting in accelerating erosion a rate of erosion. In due consideration of of these facts, the MOWD and the Study Team have mutually accepted to apply the following design criteria for design of the reservoir.

- Sediment yield from the catchment area : 0.5 mm/sq.km/year
- Duration of sediment deposit : 50 years
- Deposit form in the reservoir : Horizontal

According to the MOWD, the above sediment yield is widely adopted to the catchment areas similar to the Malewa river basin in Kenya.

The quantity of the sediment deposit is accordingly calculated at 15.9 million cu.m for the Malewa reservoir and 18.0 million cu.m for the Turasha reservoir.

2.7 Water Right

Any new water resources development project should be planned so as not come into conflict with the existing water uses on riparian lands in particular in the downstream reach of the planned intake. In Kenya use of the stream flow is strictly under the control of the Water Apportionment Board.

In principle water right is distinguished by season, i.e., low flow season and flood flow season. The low flow season covers a 6-month period, January through March, June, July, and December, and the flood flow season the rest of the period of the year. The existing water rights in the Malewa river basin in the downstream from the proposed damsites are as summarized below and their locations are shown in Fig. F.2.8.

Water Use Category	Malewa River(cu.m/sec)		Turasha River(cu.m/sec)	
	Low Flow Season	Flood Flow Season	Low Flow Season	Flood Flow Season
Domestic	0.013	0	0	0
Public	0.028	0	0.008	0
Minor irrigation	0	0.001	0	
Industrial	0	0.033	0	0
Power	0	0.011	0	0.026
General irrigation	0	0.543	0	0.02
Others	0	0.007	0	0
Total	0.041	0.595	0.008	0.046

In addition to the above existing water rights, adequate provision should be made for the stream flow abstraction in the upstream reach from the proposed damsites. So far as information is available, the following three water supply projects have been planned in the upstream of the proposed Malewa and Turasha dam schemes.

Projects	Water Sources	Planned Intake Rate(cu.m/sec)	Year
Kipipiri	Malewa river	0.07	1992
Ol Kalau	Malewa river	0.187	1992
Stage 1 Project	Turasha river	0.22	1991

III. SELECTION OF THE PROPOSED DAMSITE

3.1 Methodology

The proposed water resources development plan should be planned in harmony with the existing water uses and environmentals, and should evidently be satisfied of the following conditions.

- To completely meet the whole water demand at the ultimate target year 2015 for 24 out of 25 years;
- To ensure all the existing water right;
- To maintain throughout the year adequate amount of flow to the downstream reach from the proposed damsite for preservation of fauna-flora, amenity of people, riparian lands, river course, etc.;
- To allow the future stream flow abstraction in the upstream reach.

The selection of the damsite has been elaborated through the procedures depicted in Fig. F.3.1. The major elements are as follows:

- Identification of the alternative development plans;
- Estimate of rate of conservation flow for the respective river reach downstream from damsite;
- Water balance calculation to define the magnitude of the water resources development to meet the water demand at the ultimate target year;
- Layout design and cost estimate of dam;
- Technical and economical comparative study among the alternative damsites.

The details of the respective elements are described in the succeeding sections.

3.2 Alternative Development Plans

The proposed water service area has been forecasted to face acute water shortage, amounting to 158,250 cu.m/day (2.04 cu.m/sec) at the ultimate target year. This water deficit should be borne by means of development of the surface water resources of the Malewa river basin. There would be three different approaches for the water resources development as described below.

(1) Case 1 Single dam construction

This measure contemplates to create a large reservoir in the Malewa river or the Turasha river by means of construction of a dam. The reservoir capacity should be sufficient enough to meet the anticipated water demand.

(2) Case 2 Double dams construction

This measure envisages to construct two dams ; one on the Malewa river and the other on the Turasha river. The reservoir to be created on the respective river is naturally smaller than the case of the single dam construction. Comparative advantage of this plan is that the initial investment could be reduced to some extent, since the dams could be implemented one after another in line with the growth of the water demand. This plan however involves plural number of raw water main and implicates a complicated management of the water source and supply facilities. The total investment cost and annual operation and maintenance cost are foreseenable to be larger than that of the Cases 1 and 3.

(3) Case 3 Single dam with trans-basin diversion tunnel

This measure involves the construction of dam on the Malewa or the Turasha rivers and an trans-basin diversion tunnel between the two rivers. The trans-basin diversion tunnel is to lead water from the reservoir on the one river into another river, when the natural runoff of the other river is short of water demand. The required reservoir capacity would be far lesser than the case of the single dam construction and the trans-basin diversion is technically possible since there is not much difference in river bed elevations between the two rivers(El. 2,082 m at the Malewa damsite and El. 2,096 m at the Turasha damsite).

In case of the single dam construction on the Malewa river for instance, the required dam height is as high as 80 m. Both the Malewa and Turasha damsites are not necessarily favoured with topographic and geological conditions suitable for construction of such high dam. The Case 2 development plan is not attractive in view of cost and management as above noted. From the technical and economical view point, the Case 3 development plan is judged to be most sound and promising.

Even in the Case 3, two alternatives could be conceived : one is to locate a dam on the Malewa river and the other on the Turasha river. Their schematic models are shown in

Figs.F.3.2 and F.3.3. The most sound plan is to be chosen among the two based on the technical and economical assessment.

3.3 Water Balance Study

3.3.1 Process of Water Balance

The objective of the water balance is primarily to indicate a conjunctive use of the runoffs of the Malewa and Turasha rivers and finally to quantitively define the active storage capacity requirement in the reservoir to be created on the Malewa or Turasha rivers. Major components of the study are :

- Setting up of control point,
- Estimate of rate of conservation flow,
- Water balance calculation, and
- Determination of the active storage capacity in the reservoir.

The water balance calculation has been simulated at intervals of 5-day for the period from 1952 to 1987. In order to formulate the water resources development plan as precise as possible, three control points have been set up taking into account the current water uses on the riparian lands and availability of the stream gauging records. The first control point is sited at the Malewa damsite, the second at the Turasha damsite and the third at the Stream Gauge 2GB1 on the main stream of the Malewa river.

The overall process of the water balance calculation is cited in F.3.4 for the Malewa dam scheme and is briefly summarized below.

Step 1 : Forecast of water deficit in the proposed water service area

Step 2 : Setting up the control points

Step 3 : Estimate of 5-day runoffs at each control point

Step 4 : Estimate of a rate of conservation flow for the downstream reach from each control point

Step 5 : Calculation of water shortage at the Control Point 3

If the natural runoffs(from the catchment area from the downstream of the Malewa and Turasha damsites) deducted by the conservation flow is negative, the corresponding amount shall be released from the upstream reach.

Step 6 : Calculation of quantity of water to be diverted from the Malewa river

Raw water for the water supply will be drawn off at an intake at the Control Point 2. If the natural runoff at the Control Point detected by the sum of raw water demand and release to the downstream is negative, the corresponding amount shall inevitably be diverted from the Malewa river.

Step 7 : Calculation of storage requirement in the Malewa reservoir

If the natural runoff of the Malewa river at Control Point 3 deducted by the water diversion to the Turasha river is negative, the corresponding amount indicates the storage requirement in the Malewa reservoir. If the resultant is positive there no needs to create reservoir.

Step 8 : Determination of the active storage capacity in the Malewa reservoir sufficient for 24 out of 25 years.

For the Turasha dam scheme quite the same process as above has been adapted.

3.3.2 Estimate of Conservation Flow

In this report the term "conservation flow" expresses the aggregate of the existing water rights and adequate quantity of flow necessary for preservation of environments. The conservation flow should strictly be maintained throughout the year and is an important factor for the formulation of the water resources development. The MOWD and the Study Team have mutually agreed each other to adopt a larger value among the following two as the conservation flow.

Case A : One third of the runoff corresponding to 95 % of the time in a year plus all the existing water rights

Case B : Probable daily drought runoff with a return period once in 25 years

The above values have been derived from the flow duration curve and by means of statistical calculation of the annual minimum daily runoffs at 2GB1 and 2GC4 as presented hereunder. The annual daily minimum runoffs and statistical distribution are presented in Table F.3.1 and Fig. F.3.5 respectively.

Description		Control Point(cu.m/sec)		
		No.1	No.2	No.3
(1)	Case A			
	Low flow season	0.16	0.15	0.28
	Flood flow season	0.14	0.15	0.83
(2)	Case B	0.22	0.24	0.35

According to the criteria, values of the Case B have been determined to be adopted for all the Control Points and throughout the low and flood flow seasons except for Control Point 3 in flood flow season.

3.3.3 Water Balance Calculation

The water balance has been simulated for both the Malewa and Turasha dam schemes at intervals of 5 days for a period of 36 years from 1952 to 1987. Figs. F.3.6 and F.3.7 show the shortage of the natural runoffs at the Malewa and Turasha damsites respectively. The shortage should eventually be relieved by regulating the natural runoffs at the damsite by means of creating the reservoir, and accordingly it practically corresponds to the storage requirement. Table F.3.2 presents the annual storage requirements during the simulation period for the Malewa and Turasha reservoirs respectively.

It is clear from Figs. F.3.6 and F.3.7 that the hydrological year 1953/54 was an extra-ordinary drought year during a 36-year period studied. The storage requirement in 1953/54 amounted to as large as 62.7 million cu.m in case of the Malewa dam scheme and 62.1 million cu.m in case of the Turasha dam scheme. Such drought year has merely occurs : once more than 200 years according to the statistical assessment.

3.3.4 Required Reservoir Storage Capacity

The reservoir storage capacity has been assessed based on the storage requirements resilted from the water balance calculations. An exponential distribution function method is adopted to derive the storage requirement sufficient for 24 out of 25 years, as it well fits the data series as shown Figs. F.3.8 and F.3.9. The required storages of the Malewa and Turasha reservoirs have been assessed at 51.5 million cu.m and 50.0 million cu.m respectively.

The reservoir shall be designed with provision to the sediment deposit and evaporation from the reservoir surface. The quantity of evaporation has been estimated at 4.32 cu.m million cu.m/year in the Malewa reservoir and 2.55 million cu.m/year in the Turasha reservoir, based on the reservoir surface area and pan evaporation records. The corresponding volume is treated as a part of the active storage capacity. The sediment deposits have been estimated as explained in Section 2.6 of this report. The Malewa and Turasha reservoirs will accordingly have the following features.

Description	Unit	Malewa Reservoir	Turasha Reservoir
Gross storage capacity	million cu.m	71.70	70.51
Active storage capacity	million cu.m	55.82	52.55
Dead storage capacity	million cu.m	15.88	17.96
Full supply level	El. m	2,149.0	2,175.0
Minimum supply level	El. m	2,123.5	2,144.0

3.4 Layout Design and Rough Cost Estimate

3.4.1 Preliminary Design Conditions

In order to determine the proposed development scheme, the following two alternatives are studied from the technical and economical viewpoints :

(i) Malewa dam scheme
(ii) Turasha dam scheme

For both schemes a trans-basin tunnel is planed to be constructed between the Turasha river and the Malewa river to lead the water to another river. Rough construction cost for the respective alternative was estimated based on the layout design. There would practically be not much difference in the construction cost of the trans-basin diversion tunnel between the two alternatives. Rockfill dam has been proposed in both schemes in consideration of geological condition and availability of dam construction materials. The layout design of the dam has been achieved based on the following design conditions :

(1) Design flood for river diversion works : 20-year probable flood
- Malewa damsite : 240 cu.m/sec
- Turasha damsite : 270 cu.m/sec

(2) Design flood for spillway : 1,000-year probable flood
- Malewa damsite : 960 cu.m/sec
- Turasha damsite : 1,100 cu.m/sec

(3) Freeboard : Based on ICOLD's equation
- Malewa damsite : 5 m, tentative
- Turasha damsite : 5 m, tentative

(4) Earthquake coefficient : 0.10 for horizontal

(5) Design values of embankment materials

The following design values are tentatively adopted for the preliminary layout design :

Items	Unit	Rock	Filter	Core	Riverbed
Unit weight, dry	ton/cu.m	1.85	1.85	1.60	1.85
Unit weight, saturated	ton/cu.m	2.10	2.10	1.80	2.10
Internal friction angle	degree	40.00	35.00	30.00	35.00
Cohesion	kg/sq.cm	0.00	0.00	1.00	0.00

The Study Team has used a Computer Aided Design System(the CAD) to the extent as possible to effectively and rationally perform the layout deign for all alternatives.

3.4.2 Layout Designs

(1) Malewa dam

A general layout of the Malewa dam plan is shown in Fig. F.3.10.

Dam crest is set at El. 2,154.00 m, adding 5.0 m freeboard above the full supply level at El.2,149.00 m. Dam is designed with a center core. The upstream and downstream slopes are tentatively 1 : 2.50 and 1: 2.00 respectively. A typical cross section is as shown in Fig. F.3.11.

A slope stability analysis was roughly made with the abovementioned design values for the following three cases.

Case	Water Level	Seismic Coefficient
(1) Full supply level	El. 2,149.00 m	0.10
(2) Flood water level	El. 2,152,50 m	0.00
(3) Reservoir empty	-	0.05

The safety factors have been calculated as summarized below.

Cases	Static Condition		Seismic Condition	
	Upstream slope	Downstream slope	Upstream slope	Downstream slope
(1)	2.184	1.731	1.896	1.531
(2)	2.175	1.635	-	-
(3)	2.132	1.684	1.346	1.280

Since the safety factors are larger than 1.20 in all cases and conditions, the dam is concluded to be safe against the slope stability.

A spillway has been arranged on the left bank taking topographic advantage. Side-spillway with a crest length of 80 m has been tentatively designed so that the design flood with a peak discharge of 960 cu.m/sec could be safely discharged with a overflow depth of 3.5 m. Open chuteway type has been selected and has sloped in 1 to 6.0 in the upper part and 1 to 2.0 in the lower part in order to save excavation volume as much as possible. Stilling basin type has been selected as an energy dissipator from the view point of reliable description of effect. The length of the stilling basin is 80 m.

(2) Turasha dam

A general layout of the Turasha dam plan is shown in Fig. F.3.12.

The crest of the dam has been set at El. 2,180.00 m with a freeboard of 5 m. As the same as the Malewa dam the Turasha dam has also been designed in rockfill type with a center core. The upstream and downstream slopes of the dam are 1 to 2.50 and 2.00 respectively. A typical cross section is as shown in Fig. F.3.13.

The slope stability has been verified for the same cases as the Malewa dam scheme. The resultant safety factors are as summarized below.

Cases	Static Condition		Seismic Condition	
	Upstream slope	Downstream slope	Upstream slope	Downstream slope
(1)	2.164	1.736	1.880	1.535
(2)	2.165	1.655	-	-
(3)	2.144	1.343	1.343	1.290

The dam has been judged to be safe against slope stability.

Foundation condition of the Turasha damsite is inferior to that of the Malewa damsite and special foundation treatment has been suggested to cut off seepage through bed rock. Tentatively curtain grouting more intensive than proposed for the Malewa dam has been considered for the Turasha damsite. It has been designed in 4 rows with a space of 2 m.

A spillway has been arranged on the right bank for account of the topographic condition. The side spillway with a crest length of 90 m has been tentatively designed to evacuate the design flood with a peak discharge of 1,100 cu.m/sec. The overflow depth at the spillway crest is 3.5 m. Open chuteway has also been selected and has a slope of 1 to 4.0. As energy dissipator, stilling basin has been tantatively designed and has a length of 80 m.

(3) Trans-basin diversion tunnel

The trans-basin tunnel will consist of an intake in the reservoir, tunnel and an outlet in the other river, where the the water released from the reservoir is to be discharged. Here the waterway of the Malewa Dam Scheme is briefly desribed and its preliminary design has been tentatively prepared as presented in Fig. F.3.14 for the purpose of the rough cost estimate of the Project. The waterway has the discharge capacity of 2.30 cu.m/sec, which is the maximum rate of flow to be diverted into the Turasha river according to the result of the water balance calculation.

The intake will be located on the left bank and will comprise an inlet, a vertical shaft and a valve chamber. In order to regulate the diversion flow, a flow regulating device like hollow jet valve will be installed at immediately downstream from the inlet. The inlet will be of shaft type.

The trans-basin tunnel will be driven through the mountain range forming the water divide between the Malewa river and the Turasha river and will have a total length of approximately 2,400 m. Its diameter would be 2.50 m, minimum diameter in view of tunnel construction works. The minimum operation level in the Malewa reservoir is El. 2,123.50 m, while the normal water level in the Turasha intake is El. 2,103.20 m. The water released from the reservoir will be diverted into the Turasha river by harnessing a hydraulic head of 20.30 m between the reservoir and the Turasha intake. Slope of the tunnel would be 1 to 1,000.

At the end of the tunnel an energy dissipator will be constructed to smoothly evacuate the flow into the Turasha river and to protect the slope of the river bank.

The waterway of the Turasha dam scheme will be quite the similar to the Malewa dam scheme.

(4) Raw water transmission system

According to the on-going long term water supply plan set forth in the 1988 Preliminary Design Report, the raw water pipeline will be expanded in two stages, namley, Stage 2-1 and Stage 2-2. The maximum daily water deficit has been forecasted at 195,300 cu.m/day for the ultimate target year 2015. The transmission capacity of the raw water pipeline will be therefore 102,500 cu.m/day, which corresponds to the half of the 2015 water deficit multiplied by a daily peak factor.

In case of the Malewa dam scheme an intake structure will be constructed adjacent to the intake of the Stage 1 Project and the raw water pipeline will be laid down along the raw water main of the Stage 1 Project between the Turasha intake and the receiving well in the treatment works. The intake water level is El. 2,103.20 m and the arrival water level in the receiving well is El. 2,076.00 m. Total length of the pipeline is 9,500 m, indicating hydraulic gradient of 0.00286 and diameter is 950 mm, calculated based on the Colebrook-White formula.

On the other hand, in case of the Turasha dam scheme an intake structure should be newly constructed in the Malewa river and the raw water pipeline would be aligned along the raw water pipeline of the Gilgil Nakuru treatment works. For the purpose of the rough construction cost estimate it is assumed that the same intake structure as the Stage 1 Project would be constructed in the Malewa river and the hydraulic properties of the pipeline would also be same as those of the Malewa dam scheme. The length of the pipeline is 10,200 m.

3.4.3 Rough Cost Estimate

Based on the layout design, quantities of the major work items have been calculated for the respective dam scheme. Table F.3.3 presents the construction cost estimate of the Malewa and Turasha dam schemes. The total construction costs of the Malewa and Turasha dam schemes are Kshs.1,578 million and 3,064 million respectively.

Finally it is concluded that the Malewa dam scheme is suitable from the technical and economical viewpoints.

3.4.4 Selection of Damsite

It can be concluded that the Malewa dam scheme is technically and economically superior to the Turasha dam scheme as summarized. Comparative advantages of the Malewa dam scheme can be summarized as follows.

(1) The geological condition of the Malewa dam site is so far indicating no constraint for the construction of rockfill dam with a height of about 60 m. The geological condition at the Turasha dam site is complicated and the bed rock is highly permeable, inducing a special seepage cut-off measure.

(2) With a conjunctive use of the Malewa and Turasha rivers the scale of the reservoir can be minimized to a great extent, only 55.8 million cu.m in terms of the active storage capacity. In case of a single river use the required capacity increases as large as 90 million cu.m.

(3) With the construction of the Malewa dam, raw water for the potable water supply is to be drawn off from the Turasha river, where the intake dam has been programmed to be constructed under the Stage 1 Project. Only minor intake needs to be constructed adjacent to that of the Stage 1 Project and raw water main can be aligned along the raw water main to be installed under the Stage 1 Project. This would largely result in simplifying the water management procedures and reducing the annual operation and maintenance cost to great extent.

(4) The construction cost of the Malewa Dam Scheme is far lesser than that of the Turasha Dam Scheme.

IV. OPTIMUM DEVELOPMENT SCALE OF MALEWA DAM

4.1 Alternatives Examined

An economic comparative study was deployed to ascertain an optimum development scale for the above selected Malewa dam scheme. The study comprised a storage-draft analysis, preliminary designs for various alternative development scales, preliminary cost estimate for the respective alternative, and economic comparison. The following 6 alternatives are studied for the optimization of development scales :

Description	Alternatives					
	1	2	3	4	5	6
Dam Crest Elevation (El.m)	2,135.0	2,139.0	2,144.0	2,150.0	2,154.0	2,160.0
Dam Height (m)	50.0	54.0	59.0	65.0	69.0	75.0

4.2 Storage-Draft Analysis

The water supply capability (draft) of reservoir varies proportionally with the active storage capacity. In order to reveal quantitatively a relationship between the water supply capability and the active storage capacity, a storage - draft analysis was elaborated for the abovementioned 6 alternatives, based on the 5 - day runoffs during a 36 - year period from 1952 to 1987. The results are illustrated in Fig. F.4.1.

As a result, reservoir storage capacity, reservoir water levels and water supply capacity for the alternatives are summarized below.

Description	Alternatives 1	2	3	4	5	6
Dam Crest Elevation (El.m)	2,135.0	2,139.0	2,144.0	2,150.0	2,154.0	2,160.0
Dam Height (m)	50.0	54.0	59.0	65.0	69.0	75.0
Reservoir Storage (10^6 m^3)						
Active	9.16	16.32	26.62	43.88	55.92	78.52
Dead	15.88	15.88	15.88	15.88	15.88	15.88
Gross	25.04	32.20	42.50	59.76	71.80	94.40
Reservoir Water Level (El.m)						
MSL(El. m)	2,123.5	2,123.5	2,123.5	2,123.5	2,123.5	2,123.5
FSL(El. m)	2,130.0	2,134.0	2,139.0	2,145.0	2,149.0	2,155.5
Water Supply (cu.m/day)	71,000	103,500	131,000	160,500	176,300	200,000

4.3 Preliminary Design

in order to determine the optimum development scale, preliminary designs have been made for the alternatives. General layout designs for the alternatives 1,3 and 6 are presented in Figs. F.4.2, F.4.3 and F.4.4, respectively. The general layout for the alternative 5 is shown in Fig. F.3.10. The river diversion tunnels and spillway were laid out under design discharges of 240 cu.m/sec (20-year probable flood) and 960 cu.m/sec (1,000-year probable flood) respectively for all the alternatives. The dam excavation and embankment volumes as well as spillway excavation volume vary largely with the height of the main dam as shown in Fig. F.4.5.

4.4 Preliminary Cost Estimate

The total construction cost was estimated for each alternative as summarized in Table F.4.1. Further construction costs per active storage capacity and per raw water supply were calculated as summarized below.

Description	Alternatives 1	2	3	4	5	6
Dam						
Crest elevation (El.m)	2,135.0	2,139.0	2,144.0	2,150.0	2,154.0	2,160.0
Embankment (10^3 m^3)	455.9	528.4	637.7	831.6	988.2	1,151.9
Reservoir						
Active storage (10^6 m^3)	9.16	16.32	26.62	43.88	55.92	78.52
Water Supply (10^3 m^3/day)	71.0	103.5	131.0	160.5	176.3	200.0
Construction Cost						
Total (10^6 KShs)	1,129	1,121	1,117	1,146	1,180	1,402
Per active storage (KShs/m^3)	123.3	68.7	42.0	26.1	21.1	17.9
Per water supply (KShs/m^3/day)	15,901	10,831	8,527	7,140	6,693	7,010

Relationships between the crest elevation of the dam and the construction costs per unit active storage/water supply are constructed as given in Fig.F.4.6. Furthermore, relationship between the crest elevation and total construction cost is prepared as shown in Fig. F.4.7.

4.5 Determination of Optimum Development Scale

It is concluded that Malewa dam with crest elevation El.2,154.0 m would be technically and economically the optimum development scale under the following consideration.

(i) The construction cost per unit water supply is the lowest among the above 6 alternatives, as is clear from Fig. F.4.7.

(ii) Reservoir is capable of meeting completely the raw water deficit at ultimate target year of water supply 2015 for 24 out of 25 years, if the environmental aspects could be ruled out.

(iii) In view of topographic and geological conditions and dam construction, it is the most technically sound plan.

TABLES

Table F.2.1 5-Day Runoffs at Malewa Damsite (1/4)

Unit : m3/s

Month	Date	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
JAN	1-5	0.40	0.56	0.38	0.53	5.45	0.79	0.66	1.69	0.53	0.50
JAN	6-10	0.54	0.54	0.36	0.49	5.08	0.79	0.63	1.23	0.43	0.49
JAN	11-15	1.00	0.45	0.34	0.45	2.13	0.63	0.58	1.05	0.45	0.42
JAN	16-20	0.82	0.39	0.41	0.46	2.41	0.55	0.52	0.89	0.39	0.40
JAN	21-25	1.07	0.37	0.39	0.45	6.06	0.62	0.65	0.74	0.41	0.39
JAN	26-31	1.74	0.37	1.03	0.42	12.59	0.77	0.81	0.96	0.54	0.39
FEB	1-5	1.51	0.36	0.28	0.67	3.28	1.33	0.51	0.65	0.53	0.42
FEB	6-10	0.68	1.08	0.26	0.92	1.88	1.18	0.83	0.57	0.36	0.52
FEB	11-15	0.55	1.07	0.24	0.48	1.23	0.80	3.15	0.59	0.33	0.41
FEB	16-20	0.50	1.07	0.14	0.39	4.08	0.59	5.41	0.55	0.40	0.35
FEB	21-25	0.69	0.38	0.25	0.56	7.70	0.55	1.82	0.51	0.32	0.38
FEB	26-28	0.59	0.38	0.29	0.90	1.54	0.60	0.85	0.61	0.49	0.38
MAR	6-10	0.83	0.38	0.30	0.95	0.82	0.81	0.70	0.70	0.44	0.41
MAR	5-10	0.62	0.37	0.28	0.57	0.87	0.72	0.58	0.59	0.44	0.37
MAR	11-15	0.91	0.39	0.32	0.44	0.69	1.01	0.60	0.50	0.35	0.36
MAR	16-20	1.02	0.33	0.23	0.37	0.68	0.62	9.29	0.41	0.81	0.38
MAR	21-25	0.62	0.35	0.23	0.50	0.71	0.60	7.15	0.63	0.80	0.39
MAR	26-31	4.35	0.32	0.24	0.66	1.00	0.59	1.52	0.80	1.02	0.42
APR	1-5	7.08	1.10	0.49	0.54	1.73	0.65	1.02	0.64	1.16	0.43
APR	6-10	13.38	0.47	1.13	0.42	0.86	0.62	1.17	0.57	1.33	0.78
APR	11-15	5.16	0.80	1.86	1.63	1.46	1.27	0.87	0.82	1.09	1.08
APR	16-20	1.54	0.56	2.19	1.02	1.29	1.58	1.06	1.41	1.07	0.87
APR	21-25	15.18	0.59	0.93	0.89	1.70	3.44	1.12	1.15	1.01	0.76
APR	26-30	7.50	0.91	2.95	1.68	1.70	3.61	2.18	0.80	1.20	0.57
MAY	6-10	6.22	3.98	3.92	1.00	7.33	2.99	12.52	0.99	2.13	1.74
MAY	5-10	6.92	0.91	2.34	1.13	15.72	13.24	16.07	0.96	1.14	2.45
MAY	11-15	8.32	2.13	8.89	2.14	4.94	6.13	33.85	1.03	0.70	1.38
MAY	16-20	4.86	1.54	18.02	1.36	6.25	4.33	10.31	1.77	0.56	1.44
MAY	21-25	3.77	1.59	15.37	1.00	4.68	5.99	5.95	4.72	0.78	0.87
MAY	26-31	6.34	0.53	8.91	0.75	4.42	15.15	4.44	6.44	1.36	1.13
JUN	1-5	8.23	0.59	12.18	0.69	2.66	12.51	2.60	5.46	1.22	1.75
JUN	6-10	4.52	0.86	13.19	0.70	2.24	6.74	2.91	1.96	0.84	1.12
JUN	11-15	2.48	1.14	22.23	0.51	1.72	3.91	2.51	1.16	0.72	1.18
JUN	16-20	4.28	1.15	11.01	0.55	1.40	3.38	2.25	1.06	0.62	0.78
JUN	21-25	5.55	1.19	4.52	0.53	1.63	4.38	6.12	1.06	0.49	0.66
JUN	26-30	2.74	0.86	3.17	0.67	5.85	6.88	6.71	2.41	0.93	0.69
JUL	1-5	8.05	0.79	5.75	0.87	3.12	4.45	4.85	1.31	0.81	0.67
JUL	6-10	8.04	0.59	3.19	0.93	2.17	3.15	4.77	1.07	0.92	0.54
JUL	11-15	3.16	0.58	2.39	0.70	1.70	4.24	6.22	0.86	0.71	0.52
JUL	16-20	2.37	0.47	1.92	0.95	2.53	2.31	22.19	0.77	0.71	0.47
JUL	21-25	1.49	0.40	2.06	1.27	3.73	1.95	9.11	1.31	0.78	0.45
JUL	26-31	1.16	0.42	10.27	1.37	5.09	4.34	8.14	1.54	0.63	0.54
AUG	1-5	1.17	0.48	5.92	1.31	4.40	4.37	4.56	2.01	0.61	0.54
AUG	6-10	1.19	0.58	2.58	1.85	2.61	3.62	3.57	2.65	0.88	1.54
AUG	11-15	2.04	0.75	2.55	2.61	3.34	2.56	2.16	1.62	0.67	3.38
AUG	16-20	2.63	0.90	2.61	3.31	5.51	2.19	4.47	1.92	0.91	3.13
AUG	21-25	4.29	0.71	6.96	6.13	4.92	1.86	2.83	1.50	0.91	2.31
AUG	26-31	5.08	0.55	4.39	6.12	5.46	5.40	3.68	2.28	1.52	1.66
SEP	1-5	2.33	0.53	4.71	15.88	9.76	4.15	2.95	2.73	1.82	3.38
SEP	6-10	2.97	0.46	9.32	3.22	33.26	2.56	2.64	1.95	3.97	2.18
SEP	11-15	6.31	0.55	5.39	2.75	7.09	2.95	1.74	1.60	3.80	2.21
SEP	16-20	4.54	0.64	2.69	1.80	4.43	3.14	2.08	1.39	2.24	2.05
SEP	21-25	5.88	0.55	2.28	3.19	3.55	2.02	1.94	1.14	1.89	3.23
SEP	26-30	5.11	0.41	2.84	6.07	2.35	1.61	1.47	1.27	2.22	2.41
OCT	1-5	3.84	0.43	4.01	15.71	6.61	1.75	1.91	2.40	4.50	1.44
OCT	6-10	3.17	0.39	2.04	9.90	10.76	3.18	5.23	2.56	2.29	2.86
OCT	11-15	7.61	1.26	1.41	6.62	7.66	1.39	10.10	1.97	1.78	4.19
OCT	16-20	6.27	1.32	1.30	4.83	4.03	1.41	3.56	1.26	1.39	6.91
OCT	21-25	2.95	1.25	1.61	3.64	4.31	0.93	3.49	1.09	1.05	5.94
OCT	26-31	2.42	1.33	2.82	2.90	6.92	1.71	2.18	0.98	1.59	6.43
NOV	1-5	1.46	1.35	2.42	2.53	3.65	1.32	1.48	1.44	3.38	7.89
NOV	6-10	2.21	0.87	1.49	3.56	7.96	1.28	1.75	1.81	3.56	10.80
NOV	11-15	1.31	0.86	1.15	4.77	3.57	1.52	1.36	1.09	3.11	34.13
NOV	16-20	1.51	0.99	0.99	3.09	2.41	1.61	1.58	0.97	2.14	51.34
NOV	21-25	1.41	0.79	0.89	2.52	2.47	1.17	1.51	0.83	2.11	30.67
NOV	26-30	1.61	1.29	0.89	1.67	1.56	1.14	1.52	1.30	1.46	43.64
DEC	1-5	1.11	0.75	1.51	1.54	1.39	1.59	1.04	1.15	1.11	16.10
DEC	6-10	0.88	0.63	1.38	1.17	1.75	1.20	0.95	0.67	0.92	13.27
DEC	11-15	0.78	0.63	0.92	1.03	1.37	1.08	1.14	0.56	0.75	28.46
DEC	16-20	0.75	0.54	0.86	3.30	1.14	0.81	4.35	0.94	0.71	10.58
DEC	21-25	0.65	0.65	0.74	7.27	2.10	0.79	11.71	0.75	0.94	10.77
DEC	26-31	0.61	0.53	0.60	5.01	0.79	0.81	3.49	0.66	0.62	29.78
Mean		3.35	0.78	3.39	2.34	4.18	2.67	4.13	1.38	1.21	5.19

Table F.2.1 5-Day Runoffs at Malewa Damsite (2/4)

Unit : m3/s

Month	Date	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
JAN	1-5	19.69	2.61	1.36	1.46	0.64	0.64	0.74	0.49	0.40	0.70
JAN	6-10	20.42	2.26	2.14	2.24	0.57	0.52	0.69	0.42	0.54	0.53
JAN	11-15	7.87	2.23	1.44	1.15	0.58	0.47	0.59	0.37	1.00	0.49
JAN	16-20	5.51	5.29	1.12	0.84	0.52	0.47	0.53	0.35	0.82	0.81
JAN	21-25	3.38	2.57	1.05	0.77	0.66	0.46	0.54	0.49	1.07	0.58
JAN	26-31	2.53	1.95	0.84	0.84	0.70	0.42	0.51	0.98	1.74	0.52
FEB	1-5	1.70	1.27	0.66	0.66	0.57	0.38	0.49	2.32	1.51	0.51
FEB	6-10	1.27	1.29	0.68	0.72	0.50	0.42	0.55	1.45	0.68	0.46
FEB	11-15	0.91	1.65	0.73	0.60	0.71	0.44	0.58	1.41	0.55	0.40
FEB	16-20	0.79	1.36	0.59	0.51	0.71	0.36	0.73	1.14	0.50	0.38
FEB	21-25	0.71	0.90	0.62	0.49	0.55	0.31	1.28	0.93	0.69	0.36
FEB	26-28	0.68	1.05	0.65	0.47	0.61	0.29	1.56	1.15	0.59	0.32
MAR	6-10	0.81	1.06	1.53	0.49	0.59	0.44	6.84	1.18	0.83	0.32
MAR	5-10	0.71	0.98	2.10	0.57	0.62	0.46	7.59	0.98	0.62	0.30
MAR	11-15	0.68	0.82	0.88	0.48	0.53	0.38	3.23	0.86	0.91	0.34
MAR	16-20	1.26	2.16	0.87	0.50	0.73	0.53	1.87	0.65	1.02	0.36
MAR	21-25	1.21	1.18	1.53	0.53	0.98	0.43	6.26	0.71	0.62	0.36
MAR	26-31	0.88	1.17	2.15	0.83	0.85	0.35	4.69	0.90	4.35	0.38
APR	1-5	1.02	1.13	12.66	0.62	0.94	0.50	14.22	0.72	7.08	0.42
APR	6-10	1.40	0.74	1.46	0.84	1.39	0.72	6.19	0.61	13.38	0.46
APR	11-15	2.51	0.93	4.42	1.35	1.98	1.32	1.65	0.74	5.16	0.55
APR	16-20	1.64	3.23	4.36	1.27	3.41	1.32	1.86	0.83	1.54	1.28
APR	21-25	2.47	10.08	27.30	1.69	7.25	0.70	49.15	0.64	15.18	1.09
APR	26-30	3.78	38.78	17.54	2.68	8.67	1.04	92.55	0.53	7.50	1.92
MAY	6-10	10.45	21.18	8.63	3.92	12.03	1.29	16.82	2.12	6.22	3.89
MAY	5-10	35.08	15.00	9.59	6.21	5.65	9.37	7.04	3.02	6.92	3.73
MAY	11-15	21.81	21.23	15.15	4.39	1.74	30.00	4.04	6.96	8.32	4.02
MAY	16-20	10.31	21.56	11.81	4.27	1.21	4.21	1.84	6.05	4.86	8.70
MAY	21-25	4.20	17.36	6.12	8.08	1.31	6.90	1.38	1.60	3.77	3.45
MAY	26-31	5.21	37.21	2.71	2.42	1.39	5.93	1.61	1.25	6.34	6.06
JUN	1-5	3.27	22.25	2.83	1.32	1.01	6.14	1.96	0.79	8.23	9.00
JUN	6-10	3.01	25.85	3.35	1.08	0.90	3.41	1.28	0.74	4.52	10.87
JUN	11-15	3.94	8.55	2.71	0.86	1.72	5.75	1.42	0.74	2.48	3.44
JUN	16-20	6.81	3.74	5.18	0.72	1.88	4.41	3.59	0.73	4.28	1.82
JUN	21-25	7.60	2.19	1.60	1.06	1.22	4.10	2.70	0.64	5.55	1.32
JUN	26-30	7.66	1.89	1.87	1.79	0.95	3.05	1.61	0.57	2.74	1.48
JUL	1-5	4.71	1.97	2.78	1.46	0.78	2.59	1.05	0.58	8.05	2.81
JUL	6-10	4.24	1.84	2.31	2.24	0.82	2.83	1.10	0.73	8.04	2.82
JUL	11-15	2.84	1.44	1.83	1.15	0.93	3.35	0.99	0.80	3.16	4.10
JUL	16-20	2.77	1.13	1.91	0.84	0.93	5.53	0.80	0.67	2.37	6.05
JUL	21-25	2.68	0.99	1.78	0.77	0.94	9.32	0.73	0.65	1.49	3.38
JUL	26-31	2.15	1.06	4.66	0.84	1.79	3.50	1.04	0.64	1.16	2.33
AUG	1-5	1.87	1.08	4.83	0.66	1.33	2.18	0.96	0.68	1.17	3.00
AUG	6-10	2.18	1.19	10.46	0.72	1.21	2.61	1.01	0.57	1.19	4.07
AUG	11-15	2.22	1.29	5.10	0.60	1.21	2.27	1.03	0.57	2.04	5.94
AUG	16-20	2.26	2.40	3.07	0.51	1.22	1.98	1.98	0.75	2.63	7.22
AUG	21-25	1.78	2.30	2.59	0.49	1.13	3.23	1.88	0.73	4.29	10.07
AUG	26-31	2.47	2.96	2.81	0.47	3.24	1.95	1.51	0.63	5.08	15.88
SEP	1-5	2.33	2.32	3.23	0.49	9.09	1.52	0.97	1.15	2.33	8.71
SEP	6-10	4.74	1.74	2.30	0.57	5.98	1.39	0.76	1.19	2.97	4.50
SEP	11-15	10.89	1.23	2.09	0.48	5.94	1.14	0.66	2.13	6.31	3.62
SEP	16-20	11.93	1.04	3.28	0.50	1.99	1.24	0.73	2.69	4.54	2.46
SEP	21-25	10.59	1.02	4.71	0.53	1.41	1.26	0.61	1.87	5.88	2.45
SEP	26-30	13.00	0.93	3.69	0.83	2.30	1.86	0.57	1.20	5.11	2.62
OCT	1-5	5.22	1.01	5.36	0.62	1.90	1.39	0.55	0.91	3.84	3.35
OCT	6-10	3.67	0.97	6.72	0.84	2.86	1.12	0.58	0.76	3.17	2.47
OCT	11-15	3.92	1.44	7.98	1.35	3.66	1.12	0.56	1.06	7.61	1.79
OCT	16-20	11.51	1.30	6.80	1.27	1.58	2.81	0.55	3.56	6.27	1.54
OCT	21-25	16.62	0.71	3.47	1.69	1.50	4.79	0.48	0.81	2.95	1.34
OCT	26-31	14.58	0.61	2.76	2.68	1.42	4.24	1.32	0.60	2.42	2.15
NOV	1-5	5.76	0.90	1.99	3.92	5.29	1.94	1.36	0.75	1.46	2.21
NOV	6-10	4.60	0.84	1.80	6.21	9.41	1.52	1.71	0.59	2.21	1.49
NOV	11-15	2.58	0.63	2.16	4.39	5.69	1.19	1.05	0.64	1.31	1.46
NOV	16-20	1.98	0.83	2.67	4.27	2.98	2.29	0.96	0.71	1.51	1.05
NOV	21-25	1.90	1.62	1.65	8.08	4.53	2.91	2.48	1.12	1.41	0.95
NOV	26-30	3.80	1.71	1.79	2.42	3.41	3.89	2.19	0.87	1.61	1.11
DEC	1-5	4.82	3.39	1.19	1.32	1.62	5.59	3.11	0.77	1.11	1.05
DEC	6-10	2.39	22.91	1.44	1.08	1.26	2.68	1.81	0.57	0.88	0.79
DEC	11-15	1.74	20.66	1.15	0.86	1.03	1.33	1.03	0.55	0.78	0.68
DEC	16-20	1.47	4.23	1.10	0.72	0.96	1.05	0.77	0.46	0.75	0.89
DEC	21-25	1.16	2.59	1.14	1.06	0.77	0.90	1.12	0.43	0.65	1.50
DEC	26-31	3.70	16.06	1.13	1.79	0.62	0.91	0.54	0.40	0.61	1.63
Mean		5.28	5.49	3.83	1.63	2.21	2.63	4.04	1.11	3.35	2.65

Table F.2.1 5-Day Runoffs at Malewa Damsite (3/4)

Unit : m3/s

Month	Date	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
JAN	1-5	1.05	0.77	0.45	0.64	0.59	1.27	7.34	1.37	0.62	0.56
JAN	6-10	0.89	0.90	0.46	0.52	0.58	0.94	1.59	1.04	0.56	0.49
JAN	11-15	0.86	0.85	0.45	0.50	0.52	0.64	1.24	0.79	0.53	0.41
JAN	16-20	0.63	2.41	0.40	0.46	0.46	0.67	5.12	0.73	0.49	0.38
JAN	21-25	0.56	1.14	0.35	0.43	0.43	0.55	10.92	0.78	0.46	0.34
JAN	26-31	0.52	0.69	0.33	0.42	0.41	0.65	2.24	1.32	0.61	0.26
FEB	1-5	0.57	0.52	0.32	0.43	0.38	0.57	1.21	19.65	0.67	0.25
FEB	6-10	2.07	0.46	0.33	0.36	0.40	0.50	0.83	36.80	0.50	0.24
FEB	11-15	2.39	0.62	0.32	0.36	0.39	0.39	0.88	26.62	0.51	0.24
FEB	16-20	1.28	1.46	0.40	0.34	0.38	0.36	0.95	14.62	0.39	0.63
FEB	21-25	0.76	1.51	0.39	0.33	0.38	0.61	3.43	5.79	0.39	1.04
FEB	26-28	1.87	1.00	0.31	0.42	0.40	0.75	4.23	3.84	0.91	1.01
MAR	6-10	2.09	0.69	0.50	0.39	0.41	0.50	1.71	1.27	1.43	0.97
MAR	5-10	0.87	0.50	0.81	0.39	0.52	0.47	5.75	1.17	1.42	0.37
MAR	11-15	0.68	0.42	0.38	0.37	0.36	0.65	7.72	1.08	1.91	0.31
MAR	16-20	0.63	0.39	0.40	0.40	0.31	0.62	20.59	1.25	1.10	0.46
MAR	21-25	0.61	0.40	0.58	0.42	0.33	0.91	11.13	2.58	0.86	1.28
MAR	26-31	0.54	0.38	0.73	0.34	0.64	0.64	15.05	1.44	0.86	1.77
APR	1-5	0.51	0.33	1.21	0.40	0.54	0.75	17.94	4.22	0.43	4.57
APR	6-10	0.54	0.32	1.09	0.35	0.56	3.40	36.12	5.41	0.62	4.31
APR	11-15	0.82	0.36	3.76	0.51	1.09	14.90	27.25	5.13	1.13	23.28
APR	16-20	0.89	1.32	10.99	1.10	0.75	8.85	17.65	6.71	1.32	26.00
APR	21-25	0.81	0.89	6.06	2.08	0.52	3.15	2.30	8.99	3.42	3.37
APR	26-30	0.49	0.93	3.66	0.76	0.91	17.77	4.57	10.52	1.12	2.42
MAY	6-10	0.82	0.64	3.29	0.50	0.68	35.72	35.53	8.42	1.46	2.96
MAY	5-10	1.29	0.83	1.20	0.59	0.72	31.85	11.52	10.03	14.22	10.06
MAY	11-15	0.92	0.71	1.14	0.49	0.74	28.50	3.72	9.42	8.51	23.62
MAY	16-20	0.96	0.52	1.33	2.07	0.71	16.30	5.19	6.58	12.25	32.90
MAY	21-25	0.68	0.49	1.52	2.07	0.99	6.62	3.20	14.44	7.09	13.62
MAY	26-31	0.75	1.42	1.04	3.16	1.53	3.88	2.72	12.26	9.17	5.83
JUN	1-5	0.94	5.38	4.14	3.03	0.74	2.36	2.50	4.39	5.10	5.83
JUN	6-10	1.03	2.17	2.16	1.49	0.70	2.48	1.47	3.22	4.13	3.95
JUN	11-15	1.11	2.19	1.78	0.95	0.85	3.07	1.56	9.25	3.10	2.12
JUN	16-20	2.60	1.03	1.16	1.01	0.60	3.68	2.48	4.94	1.95	1.68
JUN	21-25	3.89	1.09	6.08	1.33	1.69	2.00	2.66	5.94	17.61	1.94
JUN	26-30	5.48	0.80	5.28	6.56	1.46	2.95	2.19	7.40	24.29	5.52
JUL	1-5	2.20	0.83	13.90	1.41	1.43	2.66	3.22	12.32	5.56	5.41
JUL	6-10	1.22	1.06	15.97	0.92	1.73	7.06	4.30	8.17	5.57	5.41
JUL	11-15	1.04	0.81	8.92	1.27	3.95	18.95	3.49	5.88	4.49	5.41
JUL	16-20	0.96	0.93	4.39	2.85	3.59	7.31	2.74	4.98	2.07	5.41
JUL	21-25	0.93	0.72	3.96	4.43	1.64	2.51	2.06	3.62	1.50	5.41
JUL	26-31	1.24	1.22	4.43	4.08	1.20	2.72	1.75	6.22	1.19	5.41
AUG	1-5	1.60	1.53	7.10	1.68	1.05	4.26	2.81	3.82	1.25	5.32
AUG	6-10	1.95	4.29	7.29	2.37	2.20	6.72	3.80	3.04	1.29	5.49
AUG	11-15	2.40	3.69	4.34	3.04	2.67	3.85	2.34	7.49	1.03	7.48
AUG	16-20	4.52	1.60	4.20	6.49	2.30	2.09	1.92	7.21	0.92	7.42
AUG	21-25	7.69	1.24	7.37	15.51	1.79	1.94	2.64	5.88	0.84	4.97
AUG	26-31	3.56	0.92	8.75	6.77	5.31	1.87	2.54	2.94	1.20	5.03
SEP	1-5	1.69	1.66	8.60	4.97	5.65	3.37	6.95	3.03	0.86	10.83
SEP	6-10	1.55	1.36	17.13	23.40	4.45	3.05	4.37	3.50	1.34	5.61
SEP	11-15	1.18	1.35	6.42	4.60	2.78	4.07	5.15	3.13	1.73	4.63
SEP	16-20	1.05	1.15	6.53	4.21	2.64	4.43	3.85	2.50	0.97	4.42
SEP	21-25	1.10	2.17	5.34	3.61	1.35	2.60	4.74	5.65	0.84	7.56
SEP	26-30	1.28	3.43	7.23	5.30	1.26	1.71	15.48	3.90	0.76	15.95
OCT	1-5	1.03	2.21	10.88	6.79	1.52	1.18	10.29	3.59	0.59	10.83
OCT	6-10	1.24	1.49	7.83	9.95	1.75	0.94	4.39	3.23	0.59	4.70
OCT	11-15	0.83	1.12	4.21	7.84	0.98	0.87	3.11	1.95	0.92	4.05
OCT	16-20	3.36	1.69	3.60	11.40	2.29	0.80	2.47	1.48	2.61	3.04
OCT	21-25	2.73	1.28	6.22	6.61	1.83	1.37	2.24	1.49	1.73	3.51
OCT	26-31	4.51	1.41	4.29	21.62	1.37	2.96	2.45	1.61	1.06	5.98
NOV	1-5	4.94	1.22	2.55	4.81	0.79	3.16	6.56	1.51	1.16	6.93
NOV	6-10	3.02	1.56	3.24	2.06	1.04	2.93	5.63	1.99	1.20	2.01
NOV	11-15	8.60	3.06	4.94	1.43	0.85	3.63	4.94	1.82	1.33	2.72
NOV	16-20	4.01	1.65	3.11	1.68	0.62	8.02	2.64	1.73	2.29	1.84
NOV	21-25	3.40	1.75	3.90	1.49	0.67	12.86	3.38	1.75	2.79	1.81
NOV	26-30	8.57	1.15	2.76	1.30	1.09	14.65	1.94	1.15	1.42	1.20
DEC	1-5	2.81	0.87	1.42	0.93	1.39	3.25	1.58	1.07	0.96	0.92
DEC	6-10	1.68	0.70	1.11	1.63	0.78	1.86	1.80	0.94	1.10	1.02
DEC	11-15	1.32	0.59	0.95	0.88	0.68	1.48	1.40	0.82	0.76	0.78
DEC	16-20	1.28	0.52	0.84	0.76	0.79	1.35	1.37	0.74	0.60	1.92
DEC	21-25	1.06	0.55	0.70	0.61	0.68	14.00	1.57	0.69	0.69	1.84
DEC	26-31	0.84	0.50	0.65	0.50	0.59	19.15	1.61	0.74	0.56	1.06
Mean		1.89	1.25	3.75	2.99	1.25	5.22	5.78	5.29	2.60	4.98

Table F.2.1 5-Day Runoffs at Malewa Damsite (4/4)

Unit : m3/s

Month	Date	1982	1983	1984	1985	1986	1987	1988
JAN	1-5	1.27	1.56	2.00	1.05	0.51	0.66	0.51
JAN	6-10	0.71	1.00	2.69	1.05	0.64	0.69	0.46
JAN	11-15	0.62	0.68	2.31	1.05	0.57	0.55	0.47
JAN	16-20	0.86	0.40	1.97	0.44	0.50	0.46	0.74
JAN	21-25	0.68	0.68	1.75	0.46	0.44	0.44	0.83
JAN	26-31	0.52	1.10	1.63	0.53	0.46	0.44	0.71
FEB	1-5	0.46	1.02	1.63	0.50	0.44	0.44	0.38
FEB	6-10	0.46	0.73	1.55	1.44	0.44	0.47	0.34
FEB	11-15	0.52	0.83	1.43	1.06	0.44	0.53	0.34
FEB	16-20	0.77	0.94	1.43	0.49	0.45	0.52	0.34
FEB	21-25	0.49	0.61	1.43	0.37	0.43	0.51	0.35
FEB	26-28	0.45	0.48	1.43	0.40	0.40	0.56	0.35
MAR	6-10	0.40	0.50	1.43	0.45	0.40	0.61	0.43
MAR	5-10	0.43	0.40	1.43	0.45	0.49	0.97	0.44
MAR	11-15	0.44	0.63	1.43	0.41	0.44	1.22	0.46
MAR	16-20	0.44	0.57	1.43	0.43	0.44	1.26	0.49
MAR	21-25	0.44	0.96	1.43	1.18	0.45	0.83	0.70
MAR	26-31	0.43	0.93	1.43	2.16	0.44	0.87	0.55
APR	1-5	0.59	2.10	1.07	1.76	0.44	0.94	0.85
APR	6-10	1.16	2.60	0.92	3.24	0.56	1.06	1.14
APR	11-15	0.84	1.44	0.73	4.08	0.65	0.83	22.03
APR	16-20	0.91	3.92	0.83	15.28	0.77	0.46	37.33
APR	21-25	1.84	6.02	0.70	10.40	2.31	0.57	53.32
APR	26-30	2.57	8.71	1.07	10.27	50.51	1.10	66.24
MAY	6-10	2.64	10.93	0.65	8.12	25.19	1.68	26.92
MAY	5-10	2.94	8.07	0.65	2.01	33.75	1.70	14.67
MAY	11-15	1.29	4.99	0.59	3.02	3.32	1.06	9.93
MAY	16-20	1.57	4.42	0.51	14.23	2.32	0.86	10.34
MAY	21-25	7.37	3.83	0.51	14.82	2.07	2.04	5.97
MAY	26-31	3.10	1.30	0.48	6.30	2.03	2.74	4.01
JUN	1-5	2.42	1.05	0.47	5.52	1.65	2.46	3.09
JUN	6-10	3.03	0.72	0.47	4.28	2.00	10.32	6.50
JUN	11-15	1.95	0.83	0.45	3.61	2.49	6.55	9.47
JUN	16-20	2.00	1.02	0.48	6.47	2.90	2.83	3.58
JUN	21-25	3.21	1.24	0.50	5.21	4.06	1.24	3.24
JUN	26-30	1.68	3.47	0.45	2.26	2.64	1.08	2.60
JUL	1-5	1.22	2.26	0.46	1.62	2.07	1.06	2.15
JUL	6-10	0.91	1.18	0.47	1.24	1.74	0.94	2.45
JUL	11-15	2.91	1.20	0.46	2.77	2.64	0.98	3.80
JUL	16-20	2.18	1.86	0.67	5.32	1.13	0.90	8.16
JUL	21-25	1.27	4.16	1.14	2.75	1.21	0.70	6.71
JUL	26-31	0.60	4.83	1.36	1.21	1.88	0.73	2.01
AUG	1-5	3.30	2.01	0.99	1.21	1.67	0.72	1.85
AUG	6-10	6.42	1.36	0.81	2.18	1.21	0.65	5.81
AUG	11-15	6.79	1.06	0.95	1.57	1.49	0.58	5.14
AUG	16-20	2.62	1.38	1.08	1.30	3.30	0.55	1.52
AUG	21-25	3.08	4.00	0.89	1.16	5.42	0.66	8.64
AUG	26-31	2.00	3.46	1.06	1.13	2.72	0.83	8.50
SEP	1-5	3.46	3.97	1.60	1.13	2.45	0.81	5.41
SEP	6-10	8.46	5.02	2.12	1.13	1.43	0.85	2.68
SEP	11-15	7.23	4.49	0.86	1.13	1.01	1.11	1.69
SEP	16-20	2.53	2.26	0.80	1.13	7.24	1.21	2.02
SEP	21-25	2.46	3.21	0.58	1.34	4.28	1.30	7.05
SEP	26-30	1.53	4.14	0.39	1.53	2.00	0.99	36.81
OCT	1-5	1.12	5.63	1.15	1.53	1.69	0.80	-
OCT	6-10	0.79	10.39	3.10	1.53	3.77	0.79	-
OCT	11-15	1.06	15.90	4.29	1.53	2.63	0.80	-
OCT	16-20	1.84	7.56	1.20	1.53	1.57	0.80	-
OCT	21-25	1.94	11.86	1.74	1.53	1.49	0.83	-
OCT	26-31	4.46	5.17	1.74	1.53	1.55	0.60	-
NOV	1-5	9.53	4.65	1.74	1.53	2.40	0.62	-
NOV	6-10	8.73	7.36	1.74	9.51	2.94	1.37	-
NOV	11-15	7.21	4.09	1.74	10.05	2.66	5.50	-
NOV	16-20	2.48	7.43	1.74	14.95	2.46	4.54	-
NOV	21-25	2.64	5.06	2.26	14.55	1.43	5.57	-
NOV	26-30	23.77	4.01	2.70	11.31	1.53	2.33	-
DEC	1-5	33.10	2.39	3.24	7.62	1.54	1.34	-
DEC	6-10	8.24	1.91	2.41	7.02	1.21	0.95	-
DEC	11-15	2.76	1.61	7.03	4.57	1.18	0.85	-
DEC	16-20	1.94	1.26	2.84	8.09	1.15	0.79	-
DEC	21-25	1.35	7.23	1.97	8.35	1.05	0.74	-
DEC	26-31	1.77	5.52	1.63	4.23	0.74	0.58	-
Mean		3.13	3.36	1.42	3.84	3.14	1.35	-

Table F.2.2 5-Day Runoffs at Turasha Damsite (1/4)

Unit : m3/s

Month	Date	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961
JAN	1-5	0.45	0.62	0.43	0.59	6.10	0.88	0.74	1.89	0.59	0.56
JAN	6-10	0.61	0.60	0.41	0.55	5.69	0.89	0.71	1.38	0.48	0.54
JAN	11-15	1.12	0.51	0.39	0.50	2.38	0.71	0.65	1.18	0.50	0.47
JAN	16-20	0.91	0.44	0.45	0.52	2.70	0.62	0.59	1.00	0.43	0.45
JAN	21-25	1.20	0.41	0.44	0.51	6.78	0.69	0.73	0.83	0.45	0.44
JAN	26-31	1.95	0.41	1.15	0.47	14.10	0.86	0.90	1.08	0.61	0.43
FEB	1-5	1.69	0.40	0.31	0.75	3.67	1.49	0.57	0.73	0.59	0.47
FEB	6-10	0.77	1.20	0.29	1.03	2.10	1.32	0.93	0.64	0.40	0.59
FEB	11-15	0.62	1.20	0.27	0.54	1.37	0.89	3.53	0.66	0.37	0.46
FEB	16-20	0.56	1.20	0.16	0.44	4.57	0.66	6.05	0.61	0.45	0.39
FEB	21-25	0.77	0.43	0.29	0.63	8.62	0.61	2.04	0.58	0.36	0.43
FEB	26-28	0.66	0.43	0.33	1.00	1.72	0.67	0.95	0.69	0.55	0.42
MAR	6-10	0.93	0.43	0.33	1.06	0.92	0.91	0.78	0.78	0.50	0.45
MAR	5-10	0.69	0.41	0.32	0.64	0.97	0.80	0.65	0.66	0.50	0.41
MAR	11-15	1.02	0.44	0.36	0.50	0.78	1.13	0.67	0.56	0.39	0.40
MAR	16-20	1.14	0.37	0.26	0.42	0.76	0.69	10.40	0.46	0.90	0.42
MAR	21-25	0.70	0.39	0.26	0.56	0.80	0.67	8.00	0.71	0.90	0.44
MAR	26-31	4.87	0.36	0.27	0.74	1.12	0.66	1.70	0.89	1.14	0.47
APR	1-5	7.93	1.23	0.55	0.60	1.94	0.73	1.14	0.71	1.30	0.49
APR	6-10	14.99	0.53	1.27	0.47	0.96	0.69	1.31	0.63	1.48	0.88
APR	11-15	5.78	0.89	2.08	1.83	1.63	1.42	0.98	0.92	1.22	1.21
APR	16-20	1.73	0.63	2.46	1.14	1.44	1.77	1.19	1.58	1.20	0.97
APR	21-25	17.00	0.66	1.04	1.00	1.91	3.86	1.25	1.29	1.13	0.85
APR	26-30	8.40	1.02	3.31	1.88	1.90	4.04	2.44	0.89	1.35	0.63
MAY	6-10	6.96	4.45	4.39	1.12	8.21	3.35	14.02	1.11	2.38	1.95
MAY	5-10	7.75	1.01	2.62	1.27	17.60	14.83	17.99	1.07	1.27	2.74
MAY	11-15	9.32	2.39	9.95	2.39	5.54	6.87	37.90	1.15	0.78	1.54
MAY	16-20	5.44	1.72	20.18	1.52	7.00	4.84	11.54	1.98	0.62	1.61
MAY	21-25	4.22	1.78	17.21	1.12	5.24	6.71	6.66	5.28	0.87	0.97
MAY	26-31	7.10	0.60	9.98	0.84	4.95	16.96	4.97	7.21	1.52	1.27
JUN	1-5	9.22	0.66	13.64	0.78	2.98	14.01	2.91	6.11	1.37	1.95
JUN	6-10	5.06	0.96	14.77	0.78	2.50	7.54	3.26	2.19	0.95	1.25
JUN	11-15	2.78	1.27	24.89	0.57	1.92	4.38	2.81	1.30	0.81	1.32
JUN	16-20	4.79	1.29	12.33	0.61	1.57	3.78	2.52	1.19	0.70	0.88
JUN	21-25	6.21	1.34	5.06	0.60	1.82	4.91	6.85	1.19	0.54	0.74
JUN	26-30	3.06	0.96	3.55	0.75	6.55	7.70	7.52	2.70	1.04	0.77
JUL	1-5	9.02	0.89	6.44	0.97	3.50	4.98	5.43	1.47	0.91	0.75
JUL	6-10	9.00	0.66	3.57	1.04	2.43	3.53	5.34	1.20	1.03	0.61
JUL	11-15	3.54	0.65	2.67	0.78	1.91	4.75	6.96	0.96	0.80	0.58
JUL	16-20	2.66	0.53	2.15	1.06	2.83	2.58	24.85	0.87	0.79	0.53
JUL	21-25	1.66	0.45	2.31	1.42	4.18	2.19	10.20	1.47	0.88	0.51
JUL	26-31	1.30	0.47	11.50	1.54	5.70	4.86	9.11	1.73	0.71	0.61
AUG	1-5	1.31	0.54	6.62	1.47	4.93	4.90	5.10	2.25	0.68	0.61
AUG	6-10	1.34	0.65	2.89	2.07	2.93	4.06	3.99	2.97	0.98	1.72
AUG	11-15	2.28	0.84	2.86	2.92	3.74	2.87	2.42	1.81	0.75	3.78
AUG	16-20	2.95	1.00	2.92	3.70	6.17	2.45	5.01	2.15	1.02	3.50
AUG	21-25	4.80	0.79	7.79	6.86	5.51	2.08	3.17	1.68	1.01	2.59
AUG	26-31	5.68	0.61	4.92	6.86	6.12	6.04	4.11	2.55	1.70	1.86
SEP	1-5	2.61	0.59	5.27	17.78	10.92	4.65	3.31	3.06	2.04	3.78
SEP	6-10	3.33	0.52	10.43	3.61	37.24	2.87	2.95	2.18	4.44	2.44
SEP	11-15	7.06	0.62	6.03	3.08	7.94	3.30	1.95	1.80	4.26	2.47
SEP	16-20	5.09	0.72	3.02	2.02	4.96	3.52	2.33	1.56	2.50	2.29
SEP	21-25	6.59	0.62	2.55	3.58	3.97	2.26	2.18	1.27	2.11	3.62
SEP	26-30	5.73	0.45	3.18	6.80	2.63	1.81	1.64	1.42	2.49	2.70
OCT	1-5	4.30	0.48	4.49	17.59	7.41	1.96	2.14	2.69	5.04	1.61
OCT	6-10	3.55	0.44	2.28	11.08	12.05	3.56	5.86	2.86	2.56	3.21
OCT	11-15	8.52	1.41	1.58	7.42	8.58	1.55	11.31	2.20	1.99	4.69
OCT	16-20	7.02	1.47	1.46	5.41	4.52	1.58	3.99	1.41	1.56	7.74
OCT	21-25	3.30	1.40	1.80	4.07	4.82	1.04	3.90	1.22	1.18	6.65
OCT	26-31	2.71	1.49	3.15	3.24	7.74	1.91	2.44	1.10	1.78	7.20
NOV	1-5	1.63	1.51	2.71	2.84	4.09	1.48	1.66	1.61	3.79	8.83
NOV	6-10	2.48	0.98	1.67	3.99	8.92	1.43	1.96	2.02	3.99	12.09
NOV	11-15	1.47	0.97	1.29	5.35	4.00	1.70	1.52	1.22	3.49	38.22
NOV	16-20	1.69	1.11	1.11	3.45	2.70	1.81	1.77	1.09	2.39	57.49
NOV	21-25	1.57	0.89	1.00	2.83	2.77	1.31	1.69	0.93	2.36	34.34
NOV	26-30	1.80	1.44	1.00	1.87	1.75	1.28	1.70	1.46	1.63	48.87
DEC	1-5	1.25	0.84	1.69	1.72	1.55	1.78	1.16	1.29	1.25	18.03
DEC	6-10	0.98	0.70	1.55	1.31	1.96	1.34	1.07	0.75	1.02	14.86
DEC	11-15	0.88	0.71	1.03	1.15	1.53	1.21	1.28	0.63	0.84	31.86
DEC	16-20	0.84	0.60	0.96	3.70	1.27	0.90	4.88	1.05	0.80	11.85
DEC	21-25	0.73	0.73	0.83	8.14	2.35	0.89	13.11	0.84	1.05	12.06
DEC	26-31	0.68	0.59	0.67	5.60	0.89	0.91	3.91	0.74	0.70	33.35
Mean		3.75	0.87	3.80	2.63	4.69	2.98	4.63	1.55	1.35	5.81

Table F.2.2 5-Day Runoffs at Turasha Damsite (2/4)

Unit : m3/s

Month	Date	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
JAN	1-5	22.05	2.92	1.52	1.63	0.72	0.71	0.83	0.55	0.45	0.78
JAN	6-10	22.86	2.53	2.40	2.50	0.64	0.59	0.77	0.46	0.61	0.60
JAN	11-15	8.81	2.50	1.61	1.29	0.65	0.53	0.66	0.42	1.12	0.55
JAN	16-20	6.17	5.93	1.26	0.94	0.58	0.52	0.60	0.39	0.91	0.91
JAN	21-25	3.79	2.88	1.18	0.86	0.74	0.51	0.60	0.55	1.20	0.65
JAN	26-31	2.84	2.19	0.94	0.94	0.78	0.48	0.57	1.09	1.95	0.58
FEB	1-5	1.91	1.42	0.73	0.74	0.64	0.43	0.55	2.60	1.69	0.57
FEB	6-10	1.43	1.45	0.76	0.81	0.56	0.47	0.62	1.62	0.77	0.52
FEB	11-15	1.02	1.85	0.81	0.67	0.79	0.49	0.64	1.57	0.62	0.45
FEB	16-20	0.88	1.52	0.66	0.58	0.79	0.40	0.81	1.28	0.56	0.43
FEB	21-25	0.79	1.01	0.69	0.55	0.61	0.34	1.44	1.04	0.77	0.41
FEB	26-28	0.76	1.18	0.73	0.53	0.68	0.33	1.75	1.29	0.66	0.36
MAR	6-10	0.91	1.18	1.71	0.55	0.66	0.49	7.66	1.32	0.93	0.36
MAR	5-10	0.80	1.10	2.36	0.64	0.69	0.52	8.50	1.10	0.69	0.34
MAR	11-15	0.76	0.92	0.99	0.53	0.60	0.43	3.62	0.96	1.02	0.38
MAR	16-20	1.41	2.42	0.97	0.56	0.82	0.60	2.09	0.73	1.14	0.40
MAR	21-25	1.35	1.32	1.72	0.60	1.10	0.48	7.01	0.79	0.70	0.40
MAR	26-31	0.99	1.31	2.41	0.93	0.95	0.39	5.25	1.00	4.87	0.42
APR	1-5	1.14	1.26	14.17	0.69	1.05	0.56	15.92	0.80	7.93	0.47
APR	6-10	1.57	0.83	1.64	0.94	1.55	0.81	6.94	0.69	14.99	0.52
APR	11-15	2.81	1.04	4.95	1.51	2.22	1.48	1.85	0.83	5.78	0.61
APR	16-20	1.84	3.61	4.88	1.42	3.82	1.48	2.08	0.93	1.73	1.43
APR	21-25	2.77	11.29	30.57	1.89	8.12	0.78	55.03	0.72	17.00	1.22
APR	26-30	4.24	43.42	19.64	3.00	9.71	1.17	103.63	0.59	8.40	2.15
MAY	6-10	11.70	23.72	9.66	4.39	13.47	1.44	18.83	2.37	6.96	4.35
MAY	5-10	39.28	16.79	10.74	6.95	6.32	10.49	7.88	3.38	7.75	4.18
MAY	11-15	24.42	23.78	16.96	4.91	1.95	33.59	4.52	7.80	9.32	4.51
MAY	16-20	11.55	24.15	13.22	4.78	1.35	4.72	2.07	6.78	5.44	9.75
MAY	21-25	4.70	19.44	6.85	9.04	1.47	7.72	1.55	1.79	4.22	3.86
MAY	26-31	5.84	41.67	3.03	2.71	1.56	6.64	1.80	1.40	7.10	6.79
JUN	1-5	3.66	24.91	3.17	1.48	1.13	6.87	2.20	0.89	9.22	10.08
JUN	6-10	3.38	28.94	3.75	1.21	1.01	3.81	1.43	0.83	5.06	12.17
JUN	11-15	4.41	9.58	3.04	0.97	1.93	6.43	1.59	0.83	2.78	3.85
JUN	16-20	7.63	4.19	5.80	0.80	2.10	4.94	4.02	0.82	4.79	2.04
JUN	21-25	8.51	2.45	1.79	1.19	1.36	4.59	3.02	0.72	6.21	1.48
JUN	26-30	8.58	2.12	2.09	2.01	1.07	3.42	1.80	0.64	3.06	1.66
JUL	1-5	5.28	2.21	3.11	1.63	0.87	2.90	1.18	0.65	9.02	3.14
JUL	6-10	4.74	2.05	2.59	2.50	0.92	3.17	1.23	0.82	9.00	3.16
JUL	11-15	3.18	1.61	2.05	1.29	1.04	3.75	1.10	0.90	3.54	4.59
JUL	16-20	3.10	1.26	2.14	0.94	1.04	6.20	0.89	0.75	2.66	6.77
JUL	21-25	3.00	1.10	1.99	0.86	1.05	10.43	0.82	0.72	1.66	3.78
JUL	26-31	2.41	1.19	5.22	0.94	2.01	3.91	1.17	0.71	1.30	2.61
AUG	1-5	2.09	1.21	5.41	0.74	1.49	2.44	1.08	0.76	1.31	3.36
AUG	6-10	2.45	1.33	11.72	0.81	1.36	2.92	1.13	0.64	1.34	4.56
AUG	11-15	2.48	1.45	5.71	0.67	1.36	2.55	1.15	0.64	2.28	6.65
AUG	16-20	2.53	2.68	3.43	0.58	1.36	2.22	2.22	0.84	2.95	8.09
AUG	21-25	1.99	2.57	2.90	0.55	1.26	3.61	2.11	0.82	4.80	11.28
AUG	26-31	2.77	3.32	3.14	0.53	3.62	2.18	1.69	0.71	5.68	17.79
SEP	1-5	2.61	2.60	3.61	0.55	10.18	1.70	1.08	1.29	2.61	9.75
SEP	6-10	5.31	1.95	2.58	0.64	6.70	1.56	0.85	1.33	3.33	5.04
SEP	11-15	12.19	1.38	2.34	0.53	6.65	1.28	0.74	2.39	7.06	4.05
SEP	16-20	13.36	1.17	3.67	0.56	2.23	1.39	0.82	3.02	5.09	2.75
SEP	21-25	11.86	1.14	5.28	0.60	1.57	1.41	0.68	2.09	6.59	2.74
SEP	26-30	14.55	1.05	4.13	0.93	2.58	2.08	0.64	1.34	5.73	2.93
OCT	1-5	5.85	1.13	6.01	0.69	2.13	1.55	0.62	1.02	4.30	3.75
OCT	6-10	4.11	1.08	7.53	0.94	3.20	1.25	0.65	0.85	3.55	2.77
OCT	11-15	4.39	1.61	8.94	1.51	4.09	1.26	0.62	1.19	8.52	2.00
OCT	16-20	12.89	1.45	7.61	1.42	1.77	3.15	0.61	3.99	7.02	1.73
OCT	21-25	18.61	0.80	3.88	1.89	1.68	5.37	0.54	0.91	3.30	1.50
OCT	26-31	16.33	0.68	3.10	3.00	1.59	4.75	1.48	0.68	2.71	2.40
NOV	1-5	6.45	1.01	2.22	4.39	5.93	2.17	1.52	0.83	1.63	2.48
NOV	6-10	5.15	0.94	2.02	6.95	10.54	1.70	1.91	0.67	2.48	1.66
NOV	11-15	2.89	0.70	2.42	4.91	6.37	1.33	1.17	0.72	1.47	1.64
NOV	16-20	2.22	0.93	2.99	4.78	3.34	2.57	1.08	0.79	1.69	1.18
NOV	21-25	2.13	1.81	1.85	9.04	5.07	3.25	2.77	1.25	1.57	1.07
NOV	26-30	4.25	1.92	2.01	2.71	3.82	4.35	2.46	0.97	1.80	1.24
DEC	1-5	5.40	3.79	1.34	1.48	1.81	6.26	3.49	0.86	1.25	1.18
DEC	6-10	2.68	25.65	1.62	1.21	1.41	3.00	2.02	0.64	0.98	0.88
DEC	11-15	1.95	23.13	1.29	0.97	1.15	1.49	1.15	0.62	0.88	0.76
DEC	16-20	1.64	4.74	1.24	0.80	1.07	1.18	0.86	0.52	0.84	1.00
DEC	21-25	1.30	2.90	1.28	1.19	0.86	1.00	1.25	0.49	0.73	1.68
DEC	26-31	4.15	17.98	1.27	2.01	0.69	1.02	0.60	0.45	0.68	1.82
Mean		5.91	6.14	4.29	1.83	2.47	2.94	4.52	1.24	3.75	2.97

Table F.2.2 5-Day Runoffs at Turasha Damsite (3/4)

Unit : m3/s

Month	Date	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
JAN	1-5	1.18	0.86	0.51	0.71	0.66	1.42	8.21	1.54	0.70	0.63
JAN	6-10	1.00	1.01	0.51	0.58	0.65	1.06	1.78	1.17	0.63	0.55
JAN	11-15	0.97	0.95	0.50	0.55	0.58	0.72	1.38	0.89	0.60	0.46
JAN	16-20	0.71	2.70	0.44	0.51	0.52	0.74	5.73	0.81	0.55	0.42
JAN	21-25	0.63	1.28	0.40	0.48	0.48	0.62	12.22	0.88	0.51	0.39
JAN	26-31	0.59	0.77	0.37	0.47	0.46	0.73	2.51	1.48	0.68	0.29
FEB	1-5	0.64	0.58	0.36	0.48	0.42	0.64	1.36	22.00	0.76	0.28
FEB	6-10	2.32	0.52	0.37	0.40	0.44	0.56	0.93	41.21	0.56	0.27
FEB	11-15	2.68	0.70	0.36	0.40	0.44	0.44	0.98	29.81	0.57	0.27
FEB	16-20	1.43	1.63	0.45	0.39	0.43	0.41	1.06	16.37	0.43	0.70
FEB	21-25	0.86	1.69	0.43	0.37	0.42	0.68	3.84	6.48	0.43	1.17
FEB	26-28	2.10	1.12	0.35	0.47	0.44	0.84	4.73	4.30	1.02	1.13
MAR	6-10	2.34	0.77	0.56	0.44	0.46	0.56	1.92	1.43	1.60	1.08
MAR	5-10	0.97	0.56	0.91	0.43	0.58	0.53	6.43	1.31	1.59	0.41
MAR	11-15	0.76	0.47	0.43	0.42	0.40	0.73	8.65	1.21	2.14	0.35
MAR	16-20	0.70	0.44	0.45	0.45	0.34	0.69	23.06	1.41	1.24	0.51
MAR	21-25	0.69	0.45	0.65	0.48	0.36	1.02	12.47	2.88	0.97	1.44
MAR	26-31	0.60	0.42	0.81	0.38	0.72	0.72	16.85	1.61	0.96	1.98
APR	1-5	0.57	0.37	1.35	0.44	0.60	0.84	20.09	4.72	0.48	5.12
APR	6-10	0.60	0.36	1.23	0.39	0.63	3.81	40.44	6.05	0.69	4.83
APR	11-15	0.92	0.40	4.21	0.57	1.22	16.68	30.51	5.74	1.27	26.06
APR	16-20	1.00	1.48	12.30	1.23	0.84	9.91	19.76	7.51	1.47	29.12
APR	21-25	0.90	1.00	6.78	2.33	0.58	3.53	2.58	10.07	3.83	3.77
APR	26-30	0.55	1.04	4.10	0.85	1.02	19.89	5.12	11.78	1.26	2.71
MAY	6-10	0.92	0.71	3.69	0.56	0.76	40.00	39.78	9.43	1.64	3.32
MAY	5-10	1.44	0.93	1.35	0.66	0.81	35.67	12.90	11.23	15.93	11.27
MAY	11-15	1.03	0.79	1.27	0.55	0.83	31.91	4.16	10.55	9.53	26.45
MAY	16-20	1.07	0.59	1.49	2.32	0.79	18.25	5.81	7.37	13.72	36.84
MAY	21-25	0.76	0.55	1.70	2.32	1.11	7.41	3.59	16.17	7.94	15.25
MAY	26-31	0.84	1.59	1.16	3.54	1.71	4.35	3.05	13.73	10.26	6.52
JUN	1-5	1.05	6.03	4.63	3.39	0.83	2.64	2.80	4.92	5.71	6.52
JUN	6-10	1.15	2.44	2.42	1.67	0.79	2.77	1.65	3.61	4.62	4.42
JUN	11-15	1.25	2.46	1.99	1.06	0.96	3.43	1.74	10.35	3.47	2.37
JUN	16-20	2.91	1.15	1.30	1.13	0.67	4.12	2.78	5.53	2.18	1.88
JUN	21-25	4.36	1.22	6.81	1.49	1.89	2.24	2.98	6.66	19.72	2.17
JUN	26-30	6.13	0.90	5.91	7.35	1.64	3.31	2.45	8.29	27.19	6.18
JUL	1-5	2.46	0.93	15.56	1.58	1.60	2.98	3.60	13.80	6.23	6.06
JUL	6-10	1.37	1.19	17.88	1.03	1.94	7.90	4.81	9.15	6.23	6.06
JUL	11-15	1.17	0.91	9.98	1.42	4.42	21.22	3.91	6.58	5.02	6.06
JUL	16-20	1.07	1.04	4.91	3.19	4.02	8.19	3.07	5.58	2.32	6.06
JUL	21-25	1.04	0.81	4.43	4.96	1.84	2.81	2.31	4.06	1.68	6.06
JUL	26-31	1.39	1.37	4.96	4.57	1.35	3.04	1.96	6.97	1.34	6.06
AUG	1-5	1.80	1.72	7.94	1.89	1.18	4.77	3.15	4.28	1.39	5.96
AUG	6-10	2.19	4.80	8.17	2.66	2.46	7.52	4.25	3.40	1.45	6.15
AUG	11-15	2.69	4.13	4.86	3.41	2.98	4.31	2.62	8.39	1.15	8.37
AUG	16-20	5.07	1.79	4.70	7.26	2.58	2.34	2.15	8.07	1.04	8.30
AUG	21-25	8.61	1.39	8.26	17.36	2.00	2.17	2.96	6.58	0.94	5.56
AUG	26-31	3.98	1.03	9.80	7.58	5.95	2.10	2.85	3.30	1.35	5.63
SEP	1-5	1.89	1.86	9.63	5.56	6.32	3.78	7.78	3.39	0.97	12.12
SEP	6-10	1.74	1.53	19.18	26.20	4.98	3.42	4.90	3.92	1.50	6.28
SEP	11-15	1.32	1.51	7.19	5.15	3.11	4.55	5.77	3.51	1.93	5.19
SEP	16-20	1.18	1.29	7.31	4.71	2.96	4.96	4.31	2.80	1.08	4.95
SEP	21-25	1.23	2.42	5.98	4.05	1.51	2.91	5.31	6.33	0.94	8.47
SEP	26-30	1.43	3.84	8.10	5.94	1.41	1.91	17.34	4.36	0.85	17.85
OCT	1-5	1.15	2.48	12.18	7.60	1.70	1.32	11.52	4.02	0.66	12.13
OCT	6-10	1.39	1.67	8.77	11.14	1.96	1.05	4.91	3.62	0.66	5.26
OCT	11-15	0.93	1.26	4.71	8.78	1.09	0.97	3.48	2.19	1.03	4.54
OCT	16-20	3.77	1.89	4.03	12.77	2.56	0.89	2.76	1.66	2.92	3.41
OCT	21-25	3.06	1.43	6.96	7.41	2.05	1.53	2.51	1.67	1.94	3.93
OCT	26-31	5.05	1.58	4.80	24.20	1.54	3.31	2.74	1.80	1.19	6.69
NOV	1-5	5.53	1.37	2.85	5.38	0.89	3.54	7.34	1.69	1.30	7.76
NOV	6-10	3.38	1.75	3.63	2.30	1.16	3.28	6.31	2.22	1.34	2.25
NOV	11-15	9.63	3.42	5.53	1.60	0.96	4.07	5.53	2.03	1.49	3.04
NOV	16-20	4.49	1.85	3.48	1.88	0.69	8.98	2.96	1.94	2.56	2.06
NOV	21-25	3.80	1.96	4.37	1.67	0.75	14.40	3.78	1.96	3.13	2.02
NOV	26-30	9.60	1.28	3.09	1.46	1.22	16.41	2.17	1.29	1.59	1.34
DEC	1-5	3.15	0.97	1.59	1.04	1.55	3.64	1.77	1.20	1.08	1.03
DEC	6-10	1.88	0.78	1.24	1.83	0.87	2.08	2.02	1.05	1.23	1.14
DEC	11-15	1.48	0.66	1.06	0.99	0.76	1.66	1.56	0.92	0.85	0.87
DEC	16-20	1.43	0.58	0.94	0.85	0.89	1.51	1.54	0.82	0.67	2.15
DEC	21-25	1.18	0.62	0.79	0.68	0.76	15.68	1.76	0.77	0.77	2.06
DEC	26-31	0.94	0.57	0.72	0.56	0.66	21.44	1.81	0.83	0.62	1.19
Mean		2.11	1.40	4.20	3.35	1.40	5.84	6.47	5.93	2.91	5.57

Table F.2.2 5-Day Runoffs at Turasha Damsite (4/4)

Unit : m3/s

Month	Date	1982	1983	1984	1985	1986	1987	1988
JAN	1-5	1.42	1.75	2.24	1.17	0.57	0.74	0.57
JAN	6-10	0.80	1.12	3.01	1.17	0.71	0.77	0.52
JAN	11-15	0.69	0.77	2.59	1.17	0.64	0.61	0.53
JAN	16-20	0.96	0.45	2.21	0.49	0.56	0.51	0.83
JAN	21-25	0.76	0.76	1.95	0.52	0.49	0.49	0.93
JAN	26-31	0.59	1.23	1.83	0.59	0.52	0.50	0.80
FEB	1-5	0.51	1.14	1.83	0.56	0.49	0.49	0.42
FEB	6-10	0.52	0.81	1.74	1.61	0.49	0.53	0.38
FEB	11-15	0.58	0.93	1.60	1.19	0.49	0.59	0.38
FEB	16-20	0.87	1.06	1.60	0.55	0.50	0.58	0.38
FEB	21-25	0.55	0.69	1.60	0.42	0.48	0.57	0.39
FEB	26-28	0.50	0.54	1.60	0.44	0.45	0.62	0.39
MAR	6-10	0.44	0.56	1.60	0.50	0.45	0.69	0.48
MAR	5-10	0.49	0.44	1.60	0.50	0.55	1.09	0.49
MAR	11-15	0.50	0.71	1.60	0.45	0.49	1.37	0.51
MAR	16-20	0.49	0.64	1.60	0.48	0.49	1.41	0.55
MAR	21-25	0.49	1.08	1.60	1.32	0.50	0.93	0.79
MAR	26-31	0.49	1.05	1.60	2.42	0.49	0.97	0.62
APR	1-5	0.66	2.35	1.20	1.97	0.49	1.06	0.95
APR	6-10	1.30	2.91	1.03	3.63	0.63	1.18	1.28
APR	11-15	0.94	1.61	0.82	4.57	0.73	0.93	24.67
APR	16-20	1.02	4.39	0.92	17.11	0.86	0.51	41.80
APR	21-25	2.06	6.74	0.78	11.64	2.58	0.64	59.70
APR	26-30	2.88	9.76	1.20	11.50	56.56	1.23	74.17
MAY	6-10	2.95	12.23	0.72	9.09	28.20	1.88	30.14
MAY	5-10	3.29	9.04	0.72	2.25	37.78	1.90	16.42
MAY	11-15	1.44	5.58	0.66	3.38	3.72	1.19	11.11
MAY	16-20	1.76	4.95	0.57	15.94	2.60	0.96	11.58
MAY	21-25	8.25	4.29	0.57	16.59	2.31	2.29	6.68
MAY	26-31	3.47	1.46	0.53	7.05	2.27	3.07	4.49
JUN	1-5	2.71	1.18	0.52	6.19	1.85	2.75	3.46
JUN	6-10	3.39	0.81	0.52	4.79	2.24	11.56	7.28
JUN	11-15	2.18	0.93	0.51	4.04	2.79	7.33	10.60
JUN	16-20	2.24	1.14	0.54	7.24	3.24	3.17	4.01
JUN	21-25	3.60	1.39	0.56	5.83	4.54	1.38	3.62
JUN	26-30	1.89	3.89	0.50	2.53	2.96	1.21	2.91
JUL	1-5	1.37	2.53	0.52	1.81	2.32	1.18	2.40
JUL	6-10	1.02	1.32	0.52	1.39	1.95	1.05	2.74
JUL	11-15	3.26	1.34	0.51	3.10	2.96	1.09	4.25
JUL	16-20	2.44	2.08	0.74	5.95	1.26	1.01	9.13
JUL	21-25	1.42	4.66	1.27	3.08	1.36	0.79	7.51
JUL	26-31	0.68	5.40	1.52	1.36	2.11	0.82	2.25
AUG	1-5	3.69	2.25	1.11	1.36	1.87	0.80	2.08
AUG	6-10	7.19	1.52	0.90	2.44	1.36	0.73	6.50
AUG	11-15	7.60	1.19	1.06	1.76	1.66	0.65	5.75
AUG	16-20	2.94	1.55	1.21	1.46	3.70	0.62	1.70
AUG	21-25	3.45	4.48	1.00	1.30	6.07	0.74	9.67
AUG	26-31	2.24	3.88	1.19	1.26	3.04	0.93	9.51
SEP	1-5	3.88	4.44	1.79	1.26	2.74	0.91	6.05
SEP	6-10	9.47	5.62	2.37	1.26	1.61	0.95	3.00
SEP	11-15	8.09	5.02	0.97	1.26	1.13	1.24	1.89
SEP	16-20	2.83	2.53	0.90	1.26	8.11	1.36	2.26
SEP	21-25	2.75	3.60	0.65	1.51	4.80	1.45	7.90
SEP	26-30	1.71	4.64	0.44	1.71	2.24	1.11	41.21
OCT	1-5	1.25	6.31	1.28	1.71	1.89	0.90	-
OCT	6-10	0.89	11.63	3.47	1.71	4.22	0.88	-
OCT	11-15	1.18	17.80	4.81	1.71	2.95	0.90	-
OCT	16-20	2.06	8.46	1.35	1.71	1.76	0.90	-
OCT	21-25	2.17	13.28	1.95	1.71	1.67	0.93	-
OCT	26-31	4.99	5.79	1.95	1.71	1.74	0.68	-
NOV	1-5	10.67	5.20	1.95	1.71	2.69	0.70	-
NOV	6-10	9.78	8.24	1.95	10.65	3.29	1.54	-
NOV	11-15	8.08	4.58	1.95	11.26	2.98	6.16	-
NOV	16-20	2.78	8.31	1.95	16.74	2.75	5.08	-
NOV	21-25	2.95	5.67	2.54	16.29	1.61	6.23	-
NOV	26-30	26.61	4.49	3.02	12.67	1.71	2.60	-
DEC	1-5	37.06	2.68	3.63	8.53	1.72	1.50	-
DEC	6-10	9.23	2.14	2.70	7.87	1.35	1.06	-
DEC	11-15	3.10	1.81	7.87	5.12	1.32	0.96	-
DEC	16-20	2.18	1.42	3.18	9.06	1.29	0.89	-
DEC	21-25	1.51	8.10	2.21	9.35	1.17	0.83	-
DEC	26-31	1.98	6.18	1.83	4.74	0.83	0.65	-
Mean		3.50	3.76	1.59	4.30	3.51	1.51	-

Table F.3.1 Annual Minimum Daily Runoffs

Hydrologic Year	Gage: 2GBI		Gage: 2GC4	
	Runoff	Recorded	Runoff	Recorded
1931	0.98	Jan. 9, 1932	-	-
1932	0.32	Apr. 23, 1933	-	-
1933	0.32	Apr. 2, 1934	-	-
1934	0.71	Apr. 6, 1935	-	-
1935	1.27	Jan. 20, 1936	-	-
1936	0.65	Feb. 21, 1937	-	-
1937	0.98	Mar. 20, 1938	-	-
1938	0.59	Mar. 28, 1939	-	-
1939	0.71	Jan. 2, 1940	-	-
1940	0.78	Jan. 25, 1941	-	-
1941	0.69	Feb. 6, 1942	-	-
1942	0.68	Jan. 25, 1943	-	-
1943	0.32	Feb. 29, 1944	-	-
1944	0.59	Feb. 24, 1945	-	-
1945	0.62	-	-	-
1946	0.59	Feb. 24, 1947	-	-
1947	0.56	Feb. 7, 1948	-	-
1948	0.56	Mar. 30, 1949	-	-
1949	0.68	Mar. 2, 1950	-	-
1950	0.62	Mar. 5, 1951	0.42	Feb. 11, 1951
1951	0.65	Mar. 22, 1952	0.38	Mar. 3, 1952
1952	0.68	Feb. 6, 1953	0.35	Mar. 26, 1953
1953	0.42	Feb. 10, 1954	0.13	Feb. 17, 1954
1954	0.59	Feb. 20, 1955	0.42	Mar. 15, 1955
1955	1.27	Mar. 23, 1956	0.68	Mar. 21, 1956
1956	1.09	Jan. 18, 1957	0.57	Feb. 23, 1957
1957	1.09	Jan. 22, 1958	0.56	Jan. 21, 1958
1958	0.88	Mar. 18, 1959	0.46	Mar. 17, 1959
1959	0.71	Feb. 128, 1960	0.33	feb. 25, 1960
1960	0.50	Feb. 1, 1961	0.38	Mar. 13, 1961
1961	0.98	Feb. 25, 1962	0.68	Mar. 14, 1962
1962	1.39	Feb. 26,. 1963	0.58	Mar. 3, 1963
1963	1.43	Feb. 18, 1964	0.67	Feb. 3, 1964
1964	0.98	Mar. 1, 1965	0.52	Mar. 17, 1965
1965	0.84	Feb. 8, 19^6	0.55	Jan. 21, 1966
1966	0.65	Feb. 28, 1967	0.32	Feb. 25, 1967
1967	0.87	Jan. 28, 1968	0.54	Feb. 1, 1968
1968	0.98	Jan. 8, 1969	0.38	Jan. 20, 1969
1969	0.81	dec. 30, 1969	0.43	Dec. 28, 1969
1970	0.62	Mar. 16, 1971	0.34	Mar. 10, 1971
1971	0.84	Apr. 4, 1972	0.52	Jan. 31, 1972
1972	0.56	Mar. 28, 1973	0.36	Apr. 3, 1973
1973	0.54	feb. 13, 1974	0.33	Mar. 1, 1974
1974	0.40	Mar. 6, 1975	0.37	Feb. 24, 1975
1975	0.59	Jan. 28, 1976	0.35	Mar. 16, 1976
1976	0.68	Jan. 20, 1977	0.40	Feb. 15, 1977
1977	0.78	Feb. 3, 1978	0.87	Feb. 11, 1978
1978	1.01	Jan. 25, 1979	0.83	Jan. 25, 1979
1979	0.48	Feb. 28, 1980	0.26	Feb. 22, 1980
1980	0.48	Mar. 7, 1981	0.26	Feb. 6, 1981
1981	0.56	Feb. 218, 1982	0.42	Mar. 3, 1982
1982	0.43	n.a.	0.29	Jan. 21, 1983
1983	0.65	Apr. 4, 1984	0.32	Apr. 23, 1984
1984	0.78	Feb. 22, 1985	0.42	Feb. 21, 1985
1985	-	-	0.36	Apr. 2, 1985
1986	-	-	0.46	Mar. 1, 1986
1987	-	-	0.39	Mar. 1, 1988

Note: Figure in parentheses is of estimated.
Data Source: (1) MOWD, (2) The Supplementary Report

Table F.3.2 Simulated Storage Requirements in Malewa and Turasha Reservoirs

Unit: Million cu.m

Year	Storage requirements in reservoirs Malewa reservoir	Turasha reservoir
1952	8.028	8.033
1953	-	-
1954	62.673	62.096
1955	27.021	27.137
1955	0.433	0.431
1955	3.95	3.938
1956	11.444	11.446
1957	14.964	14.825
1958	14.964	14.825
1059	-	-
1960	50.866	47.513
1961	5.408	5.775
1962	5.175	5.171
1963	5.174	1.171
1963	1.197	1.244
1963	5.517	5.28
1964	4.817	4.816
1965	-	-
1966	19.921	17.212
1966	0.12	0.376
1967	21.006	21.013
1967	0.883	0.29
1968	7.997	8.004
1969	-	-
1970	44.108	41.672
1970	0.503	0.465
1971	20.58	20.58
1972	20.797	20.772
1973	-	-
1974	34.829	33.737
1975	24.865	24.937
1976	-	-
1977	30.039	28.289
1977	1.716	1.691
1978	0.436	0.691
1978	1.395	1.396
1978	0.334	0.49
1979	2.895	2.959
1979	0.803	0.804
1980	16.684	17.23
1981	28.491	28.461
1982	18.584	18.778
1982	1.284	1.282
1983	8.722	8.725
1983	1.675	1.678
1983	0.661	0.636
1984	25.907	25.906
1985	2.035	2.038
1986	17.01	16.992
1986	0.256	0.256
1987	19.373	17.992

- : carry over

Table F.3.3 Rough Cost Estimate of Malewa Scheme and Turash Scheme

(Unit : Kshs. million)

Items	Malewa Scheme	Turash Scheme
1. Direct Constuction Cost		
1.1 Preparatory work	173.2	337.8
1.2 Water facilities		
- Diversion tunnel	63.5	189.7
- Cofferdam	18.2	15.9
- Main dam	259.3	885.9
- Spillway	216.3	210.5
1.3 Trans-basin tunnel		
- Intake & Outlet	5.7	5.7
- Pipeline	82.8	82.8
1.4 Raw water transmission system		
- Intake	21.9	85.9
- Pipeline	198.2	212.8
Sub-total	1,039.1	2,027.0
2. Indirect Construction Cost		
2.1 Land acquisition	8.2	5.5
2.2 Government administration	31.2	60.8
2.3 Engineering services	83.1	162.2
Sub-total	122.5	228.5
3. Physical Contingency	232.3	451.1
4. Interest during Construction	184.0	357.3
Total	1,577.9	3,063.9

Note : Government administration : Assumed at 3% of the direct cost
Engineering services : Assumed at 8% of the direct cost

Table F.4.1 Preliminary Cost Estimate for Varied Dam Height

(Unit: Kshs. million)

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Dam Crest	EL.2,135.00	EL.2,139.00	EL.2,144.00	EL.2,150.00	EL.2,154.00	EL.2,160.00
1. Direct Construction Cost						
a. Preparatory works	124.1	123.1	122.5	125.5	129.2	153.6
b. Diversion tunnel	63.5	63.5	63.5	63.5	63.5	59.7
c. Cofferdam	16.2	16.2	16.2	17.1	18.2	42.1
d. Main dam	121.7	141.3	170.2	220.3	259.3	334.5
e. Spillway	330.7	306.2	274.2	238.3	216.3	243.2
f. Trans-basin tunnel	88.5	88.5	88.5	88.5	88.5	88.5
Sub-total	744.7	738.8	735.1	753.2	775.0	921.6
2. Indirect Construction Cost						
Engineering services	59.6	59.1	58.8	60.3	62.0	73.7
Government administratior	22.3	22.2	22.1	22.6	23.3	27.6
Land aquisition	4.4	5.3	6.3	7.3	8.2	9.5
sub-total	86.3	86.6	87.2	90.2	93.5	110.8
3. Physical Contingency	166.2	165.1	164.5	168.7	173.7	206.5
4. Interest during Constructior	131.6	130.7	130.3	133.6	137.6	163.5
Total	1,128.8	1,121.2	1,117.1	1,145.7	1,179.8	1,402.4

Note : Engineering services : Assumed at 8 % of the direct cost
Government administration : Assumed at 3 % of the direct cost
Physical contingency : Assumed 20 % of the sum of the direct and indirect cost
Interest : Based on the following assumptions :
Interest rate per annum : 10 %
Construction period : 3 years

FIGURES

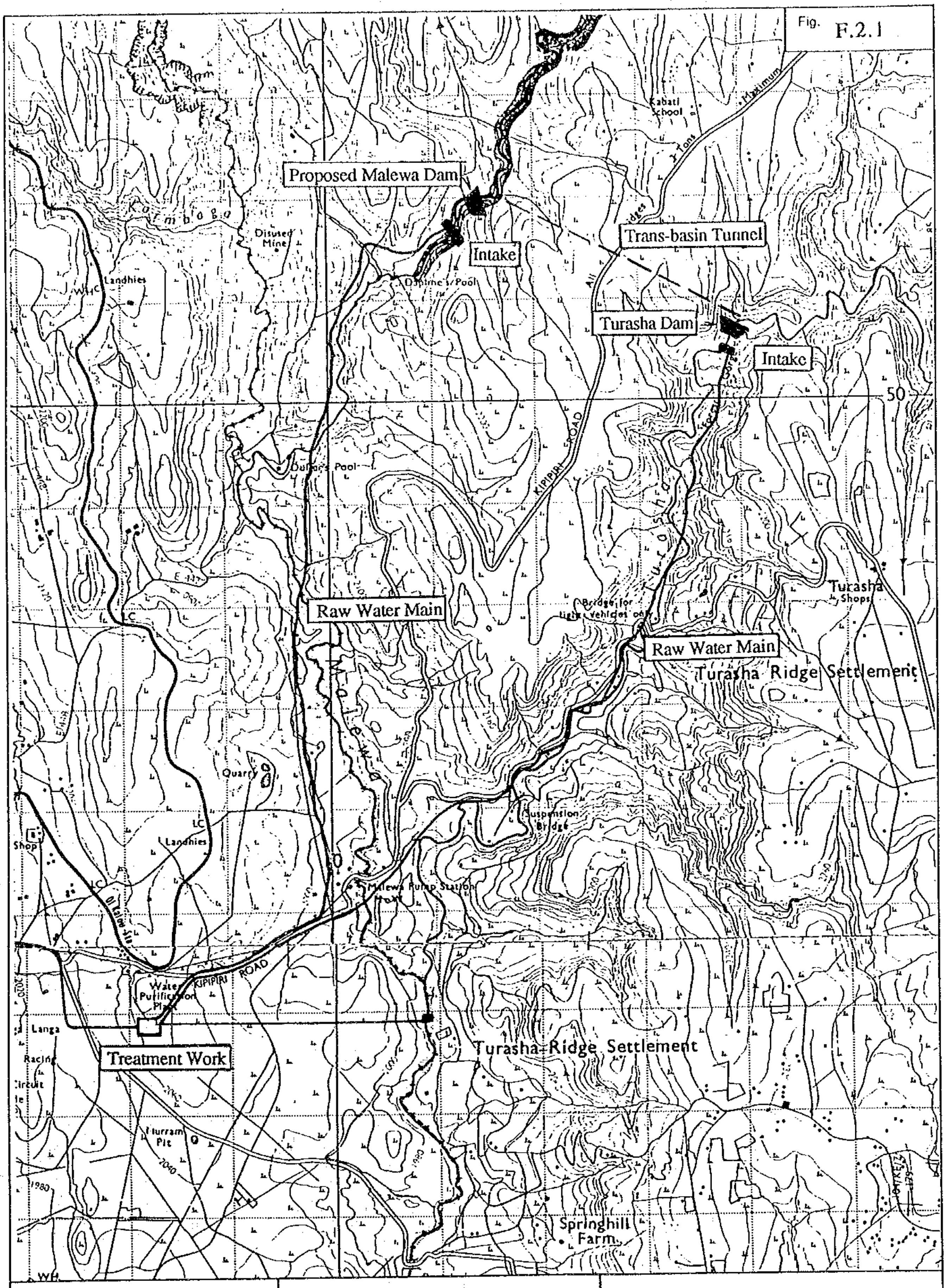
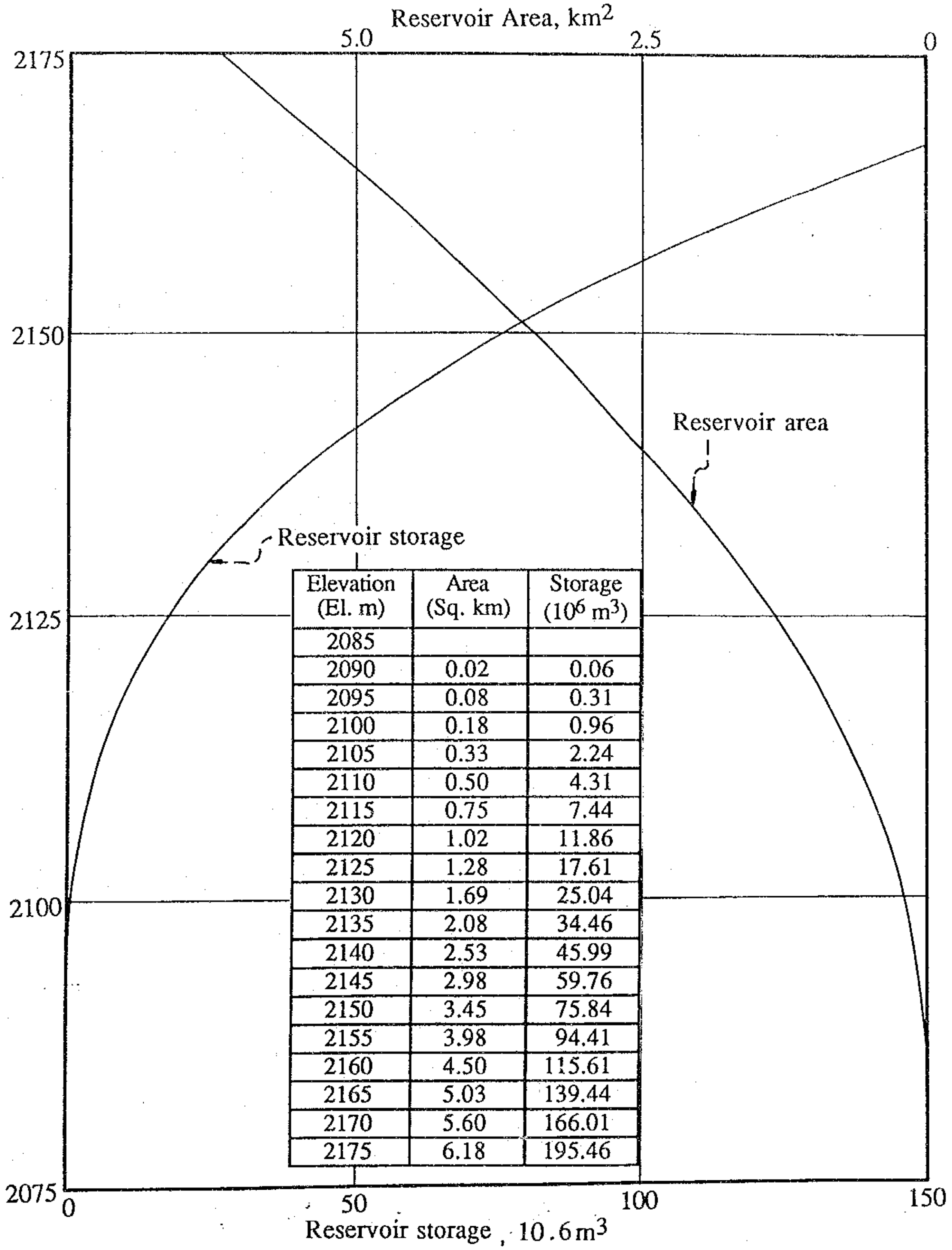


Fig. F.2.1

THE REPUBLIC OF KENYA MINISTRY OF WATER DEVELOPMENT NATIONAL WATER CONSERVATION AND PIPELINE CORPORATION	THE STUDY FOR CONSTRUCTION OF DAM IN MALEWA RIVER SYSTEM GREATER NAKURU WATER SUPPLY PROJECT EASTERN DIVISION JAPAN INTERNATIONAL COOPERATION AGENCY	TITLE Location Map of Damsites

Fig. F.2.2



Elevation (El. m)	Area (Sq. km)	Storage (10^6 m^3)
2085		
2090	0.02	0.06
2095	0.08	0.31
2100	0.18	0.96
2105	0.33	2.24
2110	0.50	4.31
2115	0.75	7.44
2120	1.02	11.86
2125	1.28	17.61
2130	1.69	25.04
2135	2.08	34.46
2140	2.53	45.99
2145	2.98	59.76
2150	3.45	75.84
2155	3.98	94.41
2160	4.50	115.61
2165	5.03	139.44
2170	5.60	166.01
2175	6.18	195.46

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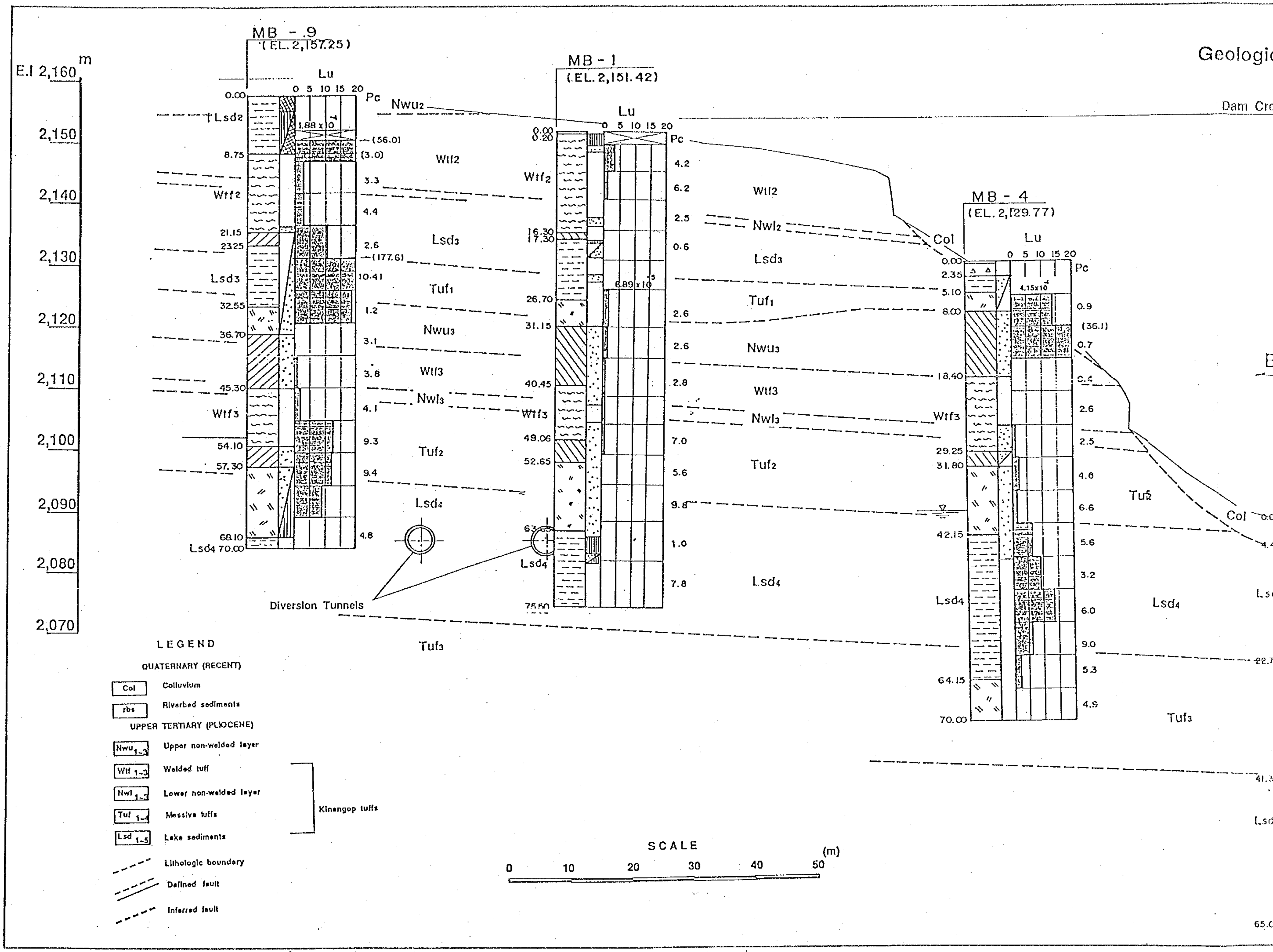
JAPAN INTERNATIONAL COOPERATION AGENCY

TITLE

Area-Storage Curve,

Malewa Reservoir



Geologic
Dam Cre
MB - 9
(EL. 2,157.25)
MB - 1
(EL. 2,151.42)
MB - 4
(EL. 2,129.77)
E.l 2,160 m
2,150
2,140
2,130
2,120
2,110
2,100
2,090
2,080
2,070
Lu
0 5 10 15 20
Pc
Nwu2
Wtf2
Lsd3
Tuf1
Nwu3
Wtf3
Nwl2
Nwl3
Tuf2
Lsd4
Tuf3
Col
Diversion Tunnels
LEGEND
QUATERNARY (RECENT)
Col Colluvium
rbs Riverbed sediments
UPPER TERTIARY (PLIOCENE)
Nwu 1-3 Upper non-welded layer
Wtf 1-3 Welded tuff
Nwl 1-3 Lower non-welded layer
Tuf 1-4 Massive tuffs
Lsd 1-5 Lake sediments
Kinangop tuffs
Lithologic boundary
Defined fault
Inferred fault
SCALE
0 10 20 30 40 50 (m)

Geological Profile (Dam Axis)

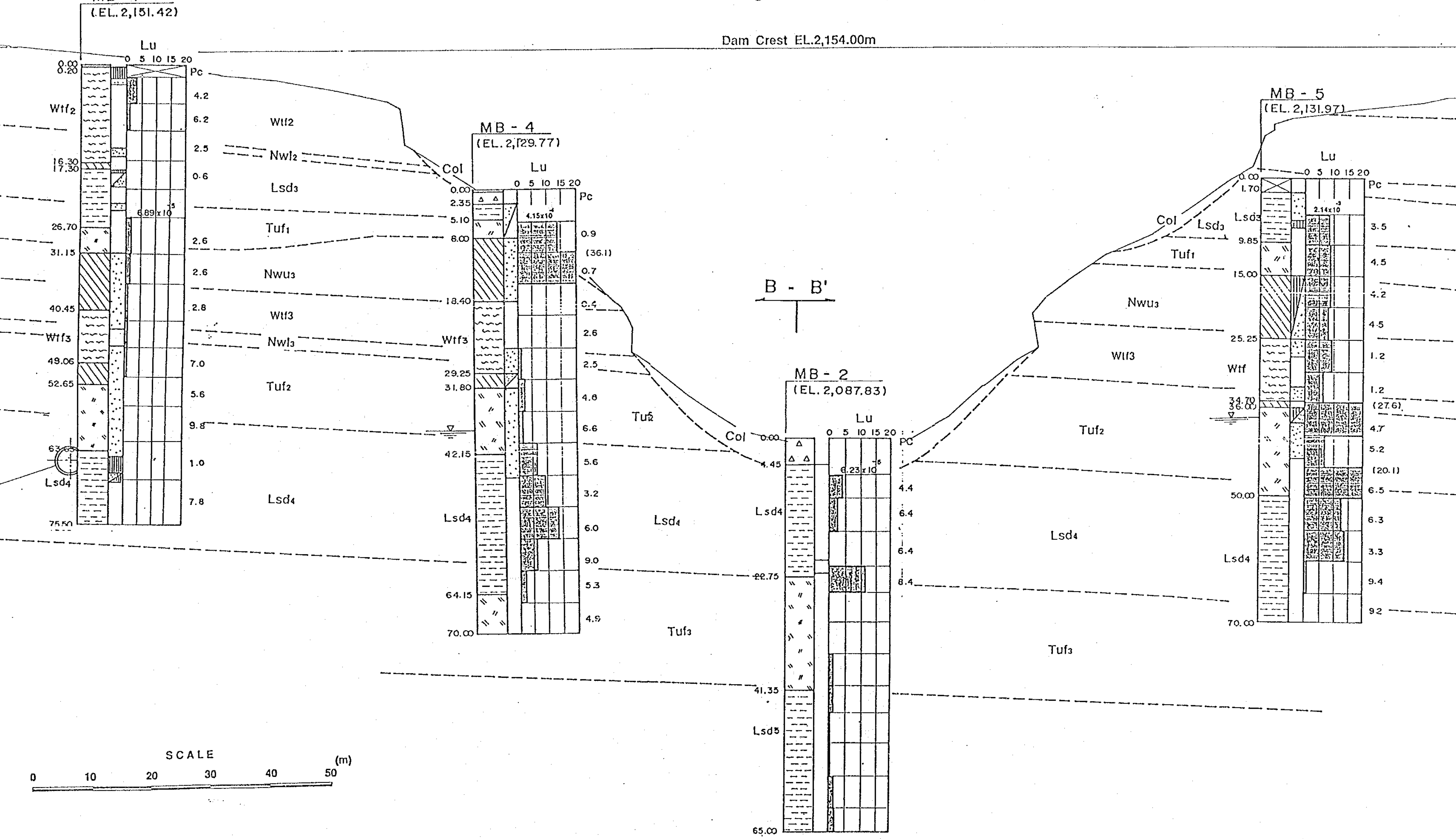


Fig F.2.3

ological Profile (Dam Axis)

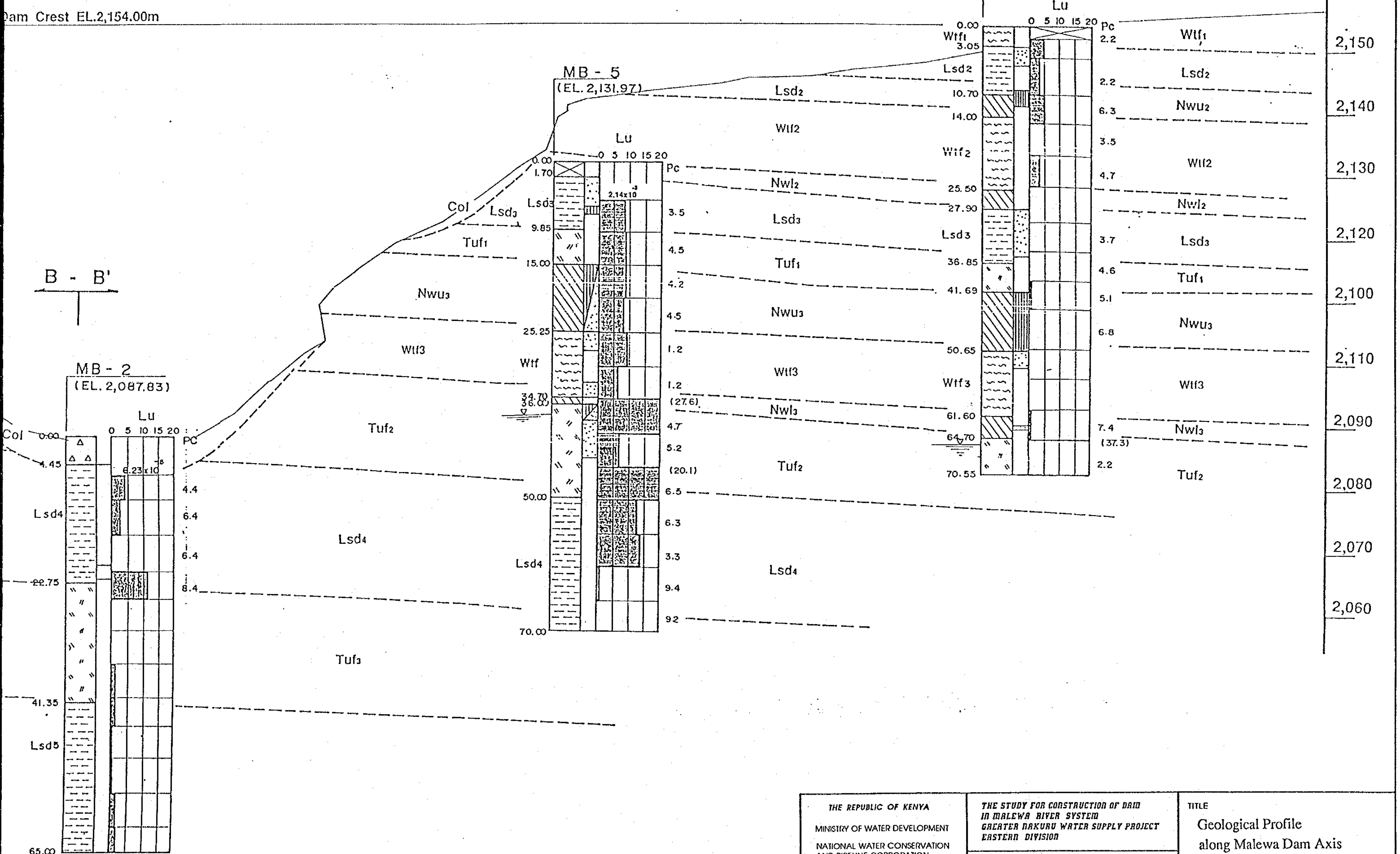


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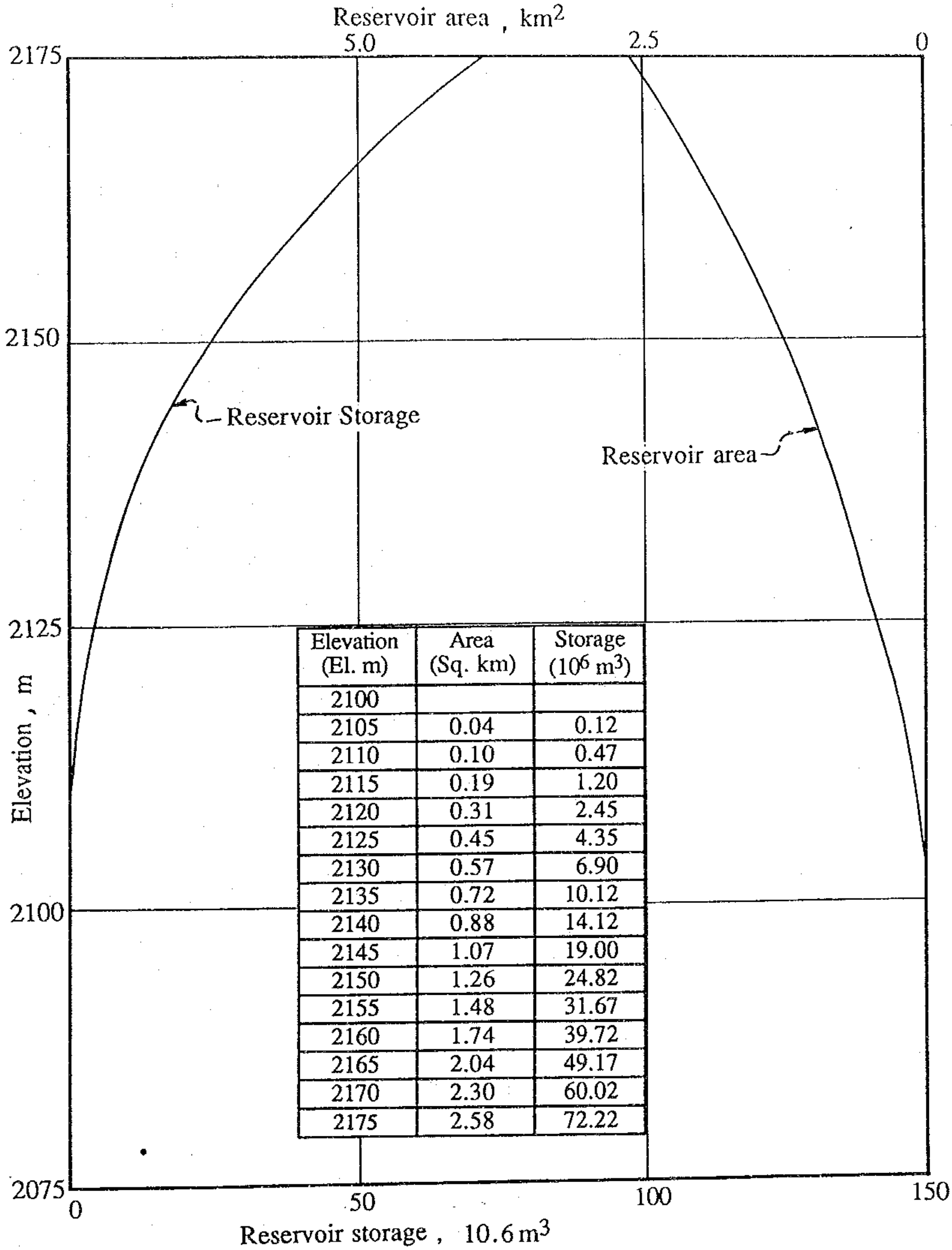
Fig. F.2.4



Elevation (El. m)	Area (Sq. km)	Storage (10^6 m^3)
2100		
2105	0.04	0.12
2110	0.10	0.47
2115	0.19	1.20
2120	0.31	2.45
2125	0.45	4.35
2130	0.57	6.90
2135	0.72	10.12
2140	0.88	14.12
2145	1.07	19.00
2150	1.26	24.82
2155	1.48	31.67
2160	1.74	39.72
2165	2.04	49.17
2170	2.30	60.02
2175	2.58	72.22

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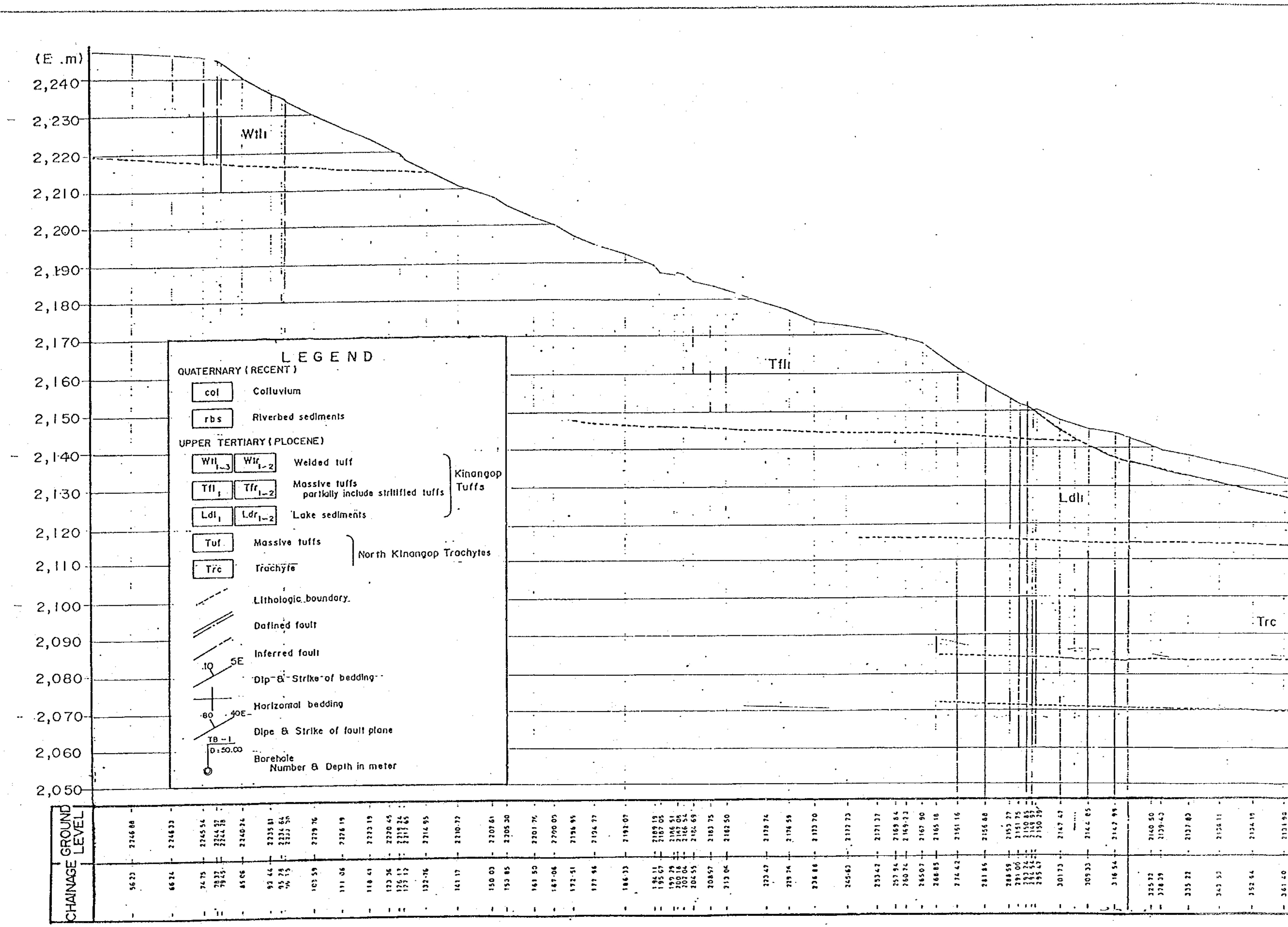
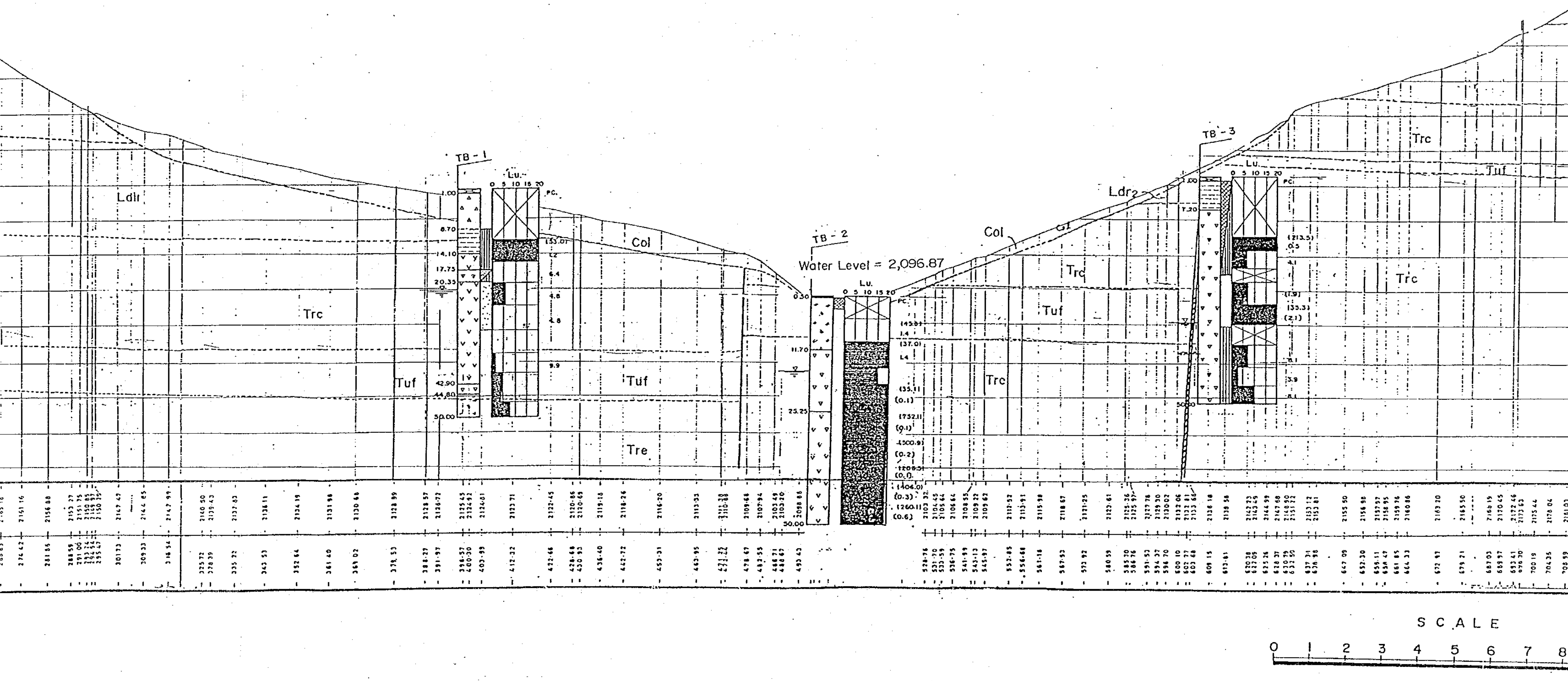

(E .m)
2,240
2,230
2,220
2,210
2,200
2,190
2,180
2,170
2,160
2,150
2,140
2,130
2,120
2,110
2,100
2,090
2,080
2,070
2,060
2,050
Wtl1
Tfl1
Ldl1
Trc
GROUND LEVEL
CHAINAGE
LEGEND
QUATERNARY (RECENT)
col Colluvium
rbs Riverbed sediments
UPPER TERTIARY (PLOCENE)
Wtl1-3 Wtr1-2 Welded tuff
Tfl1 Tfr1-2 Massive tuffs partially include stratified tuffs
Ldl1 Ldr1-2 Lake sediments
Kinangop Tuffs
Tuf Massive tuffs
Trc Trachyte
North Kinangop Trachytes
Lithologic boundary
Defined fault
Inferred fault
Dip & Strike of bedding
Horizontal bedding
Dipe & Strike of fault plane
TB-1 D:50.00
Borehole Number & Depth in meter



TB - 1
TB - 2
TB - 3
Lu.
Ldl1
Ldr2
Col
Trc
Tuf
Tre
Water Level = 2,096.87
SCALE
0 1 2 3 4 5 6 7 8

F.2.5

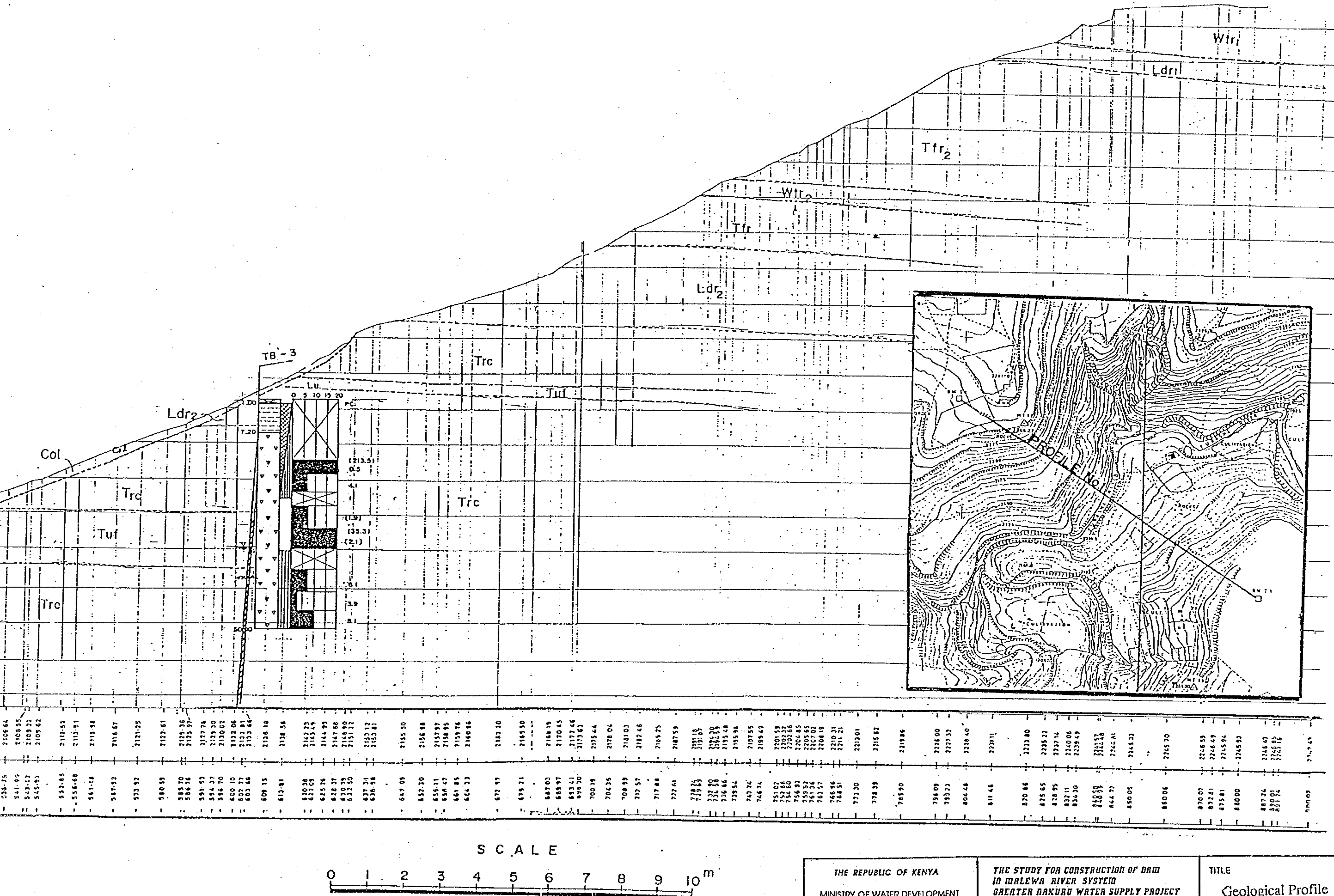


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Fig. F.2.6

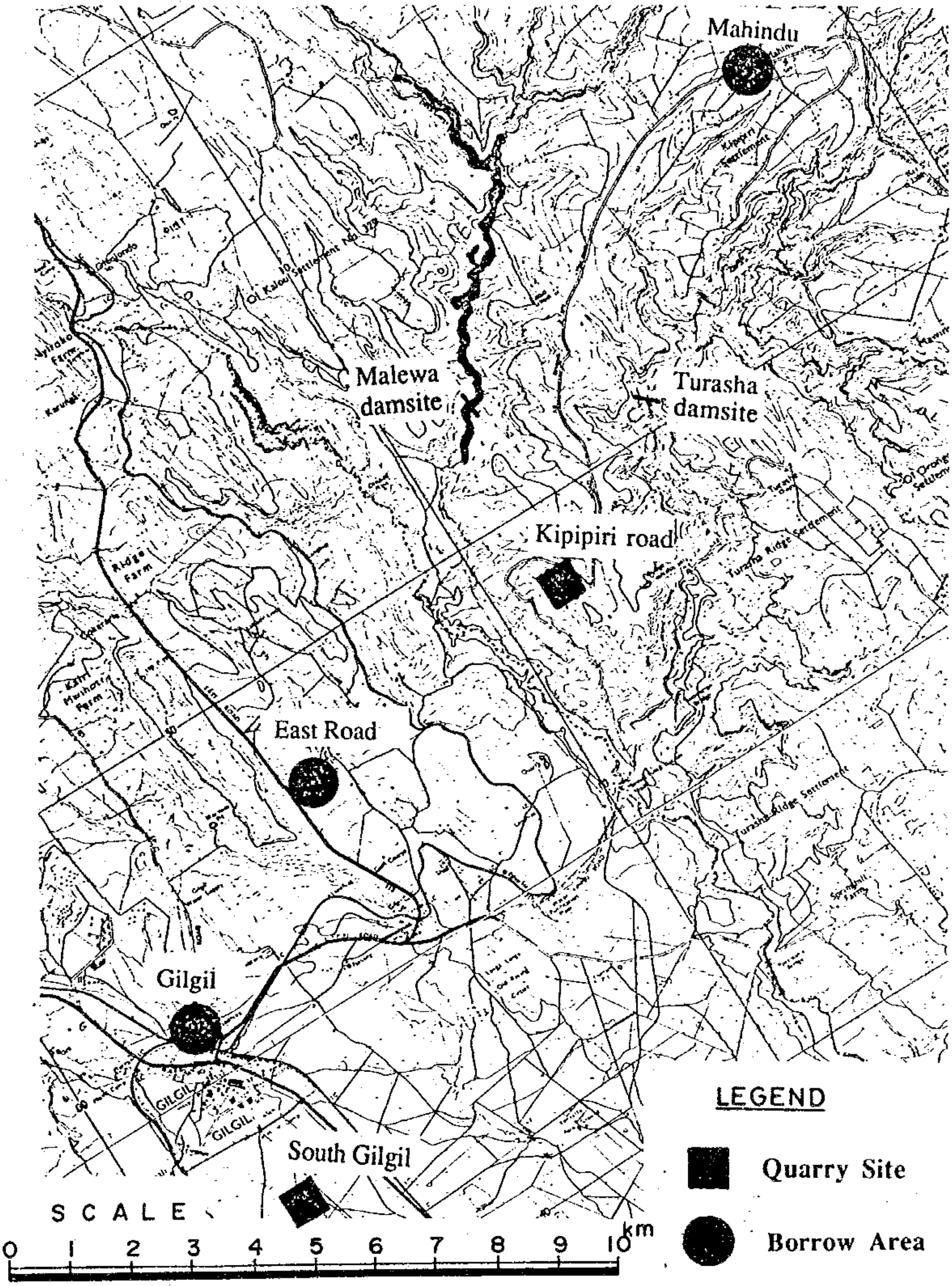

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Fig. F.2.7

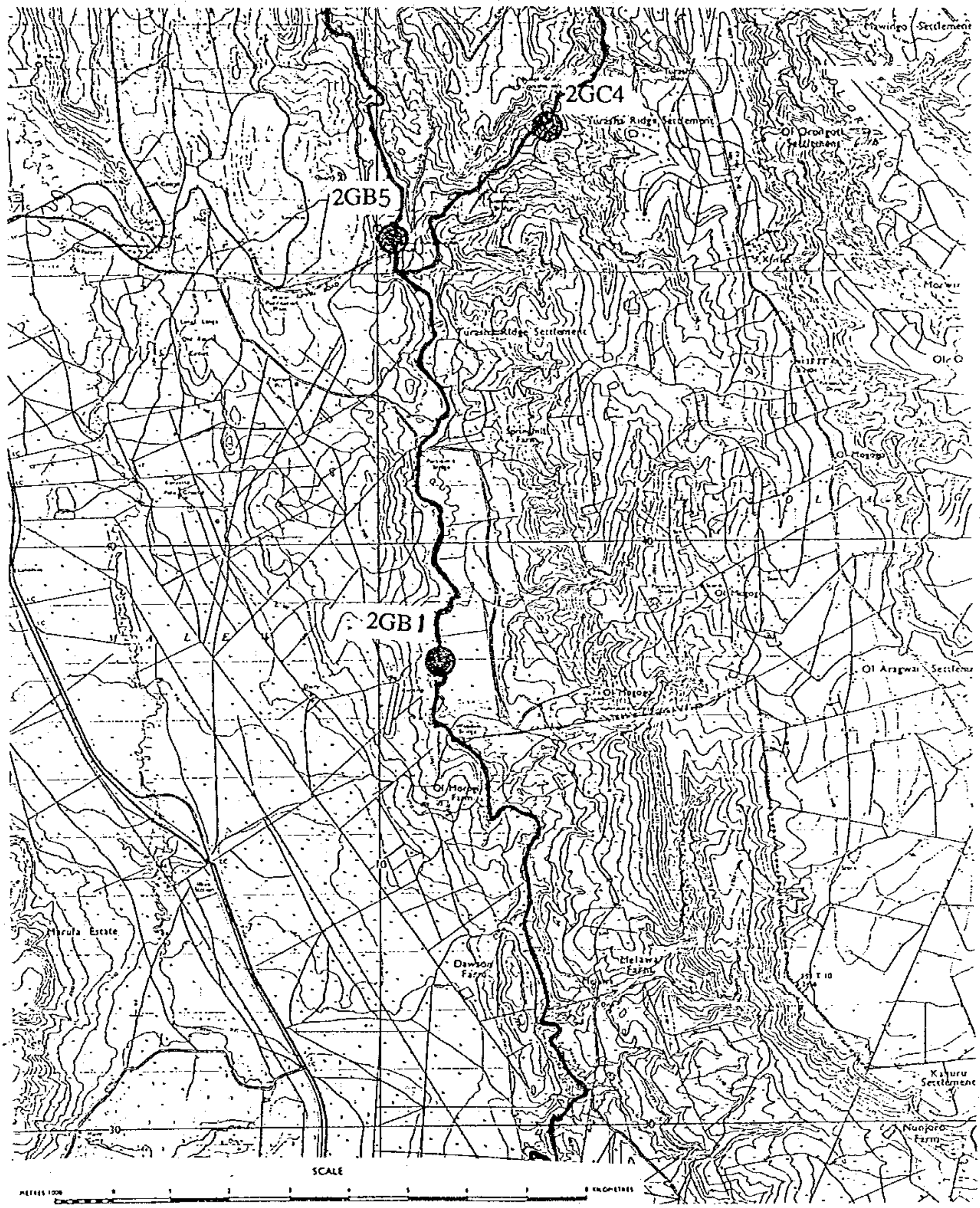

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Fig. F.2.8

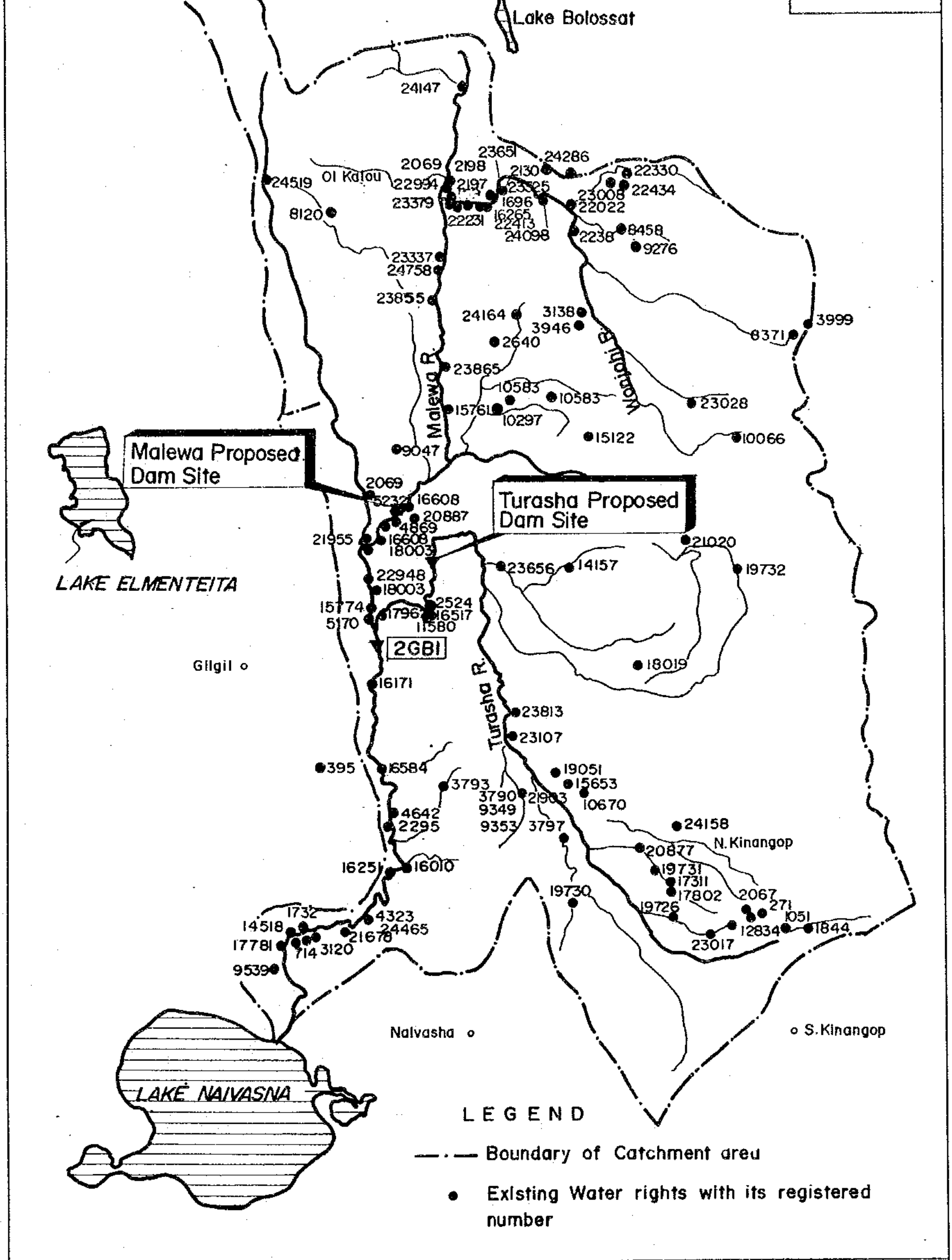

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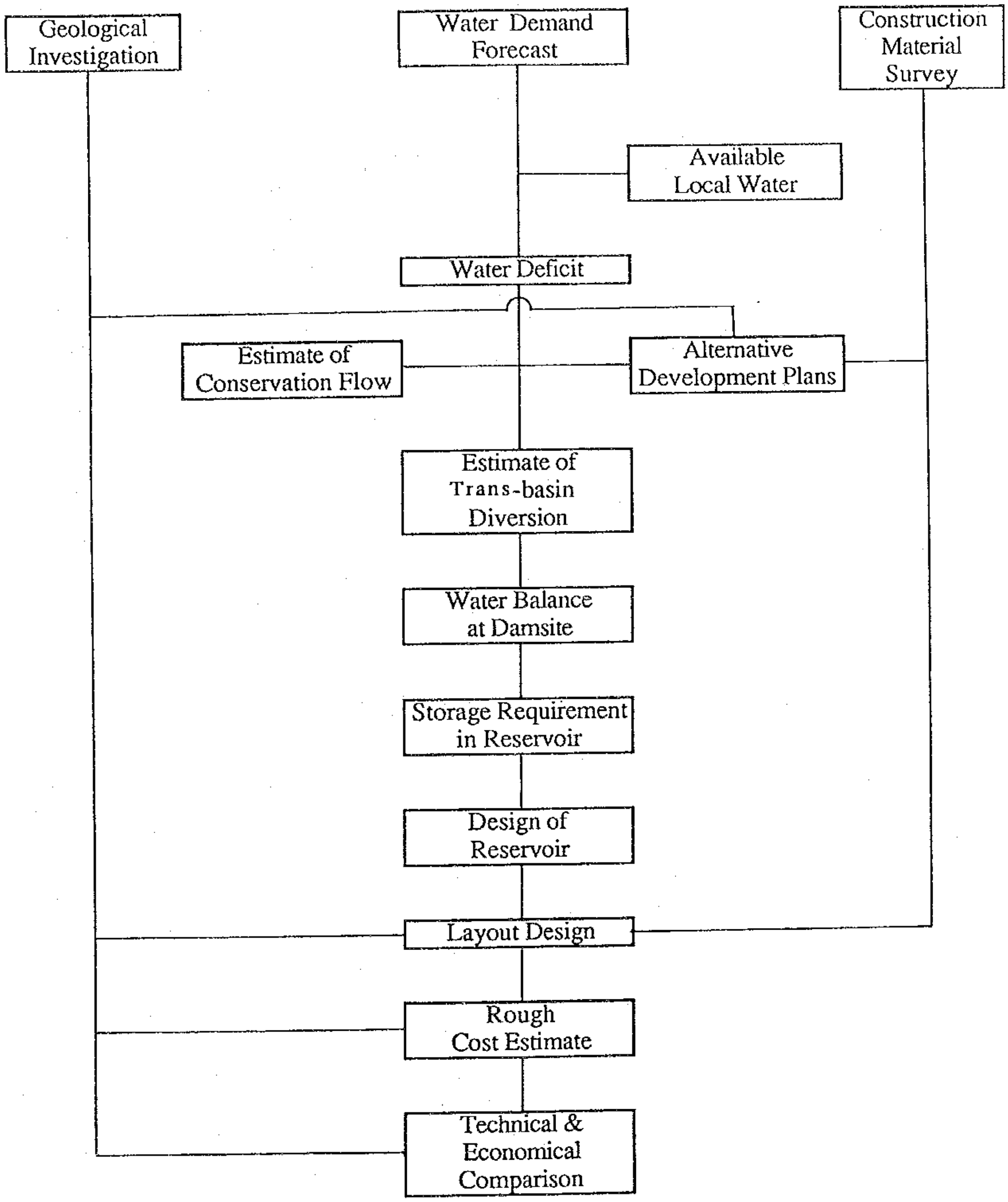
Fig. F.3.1



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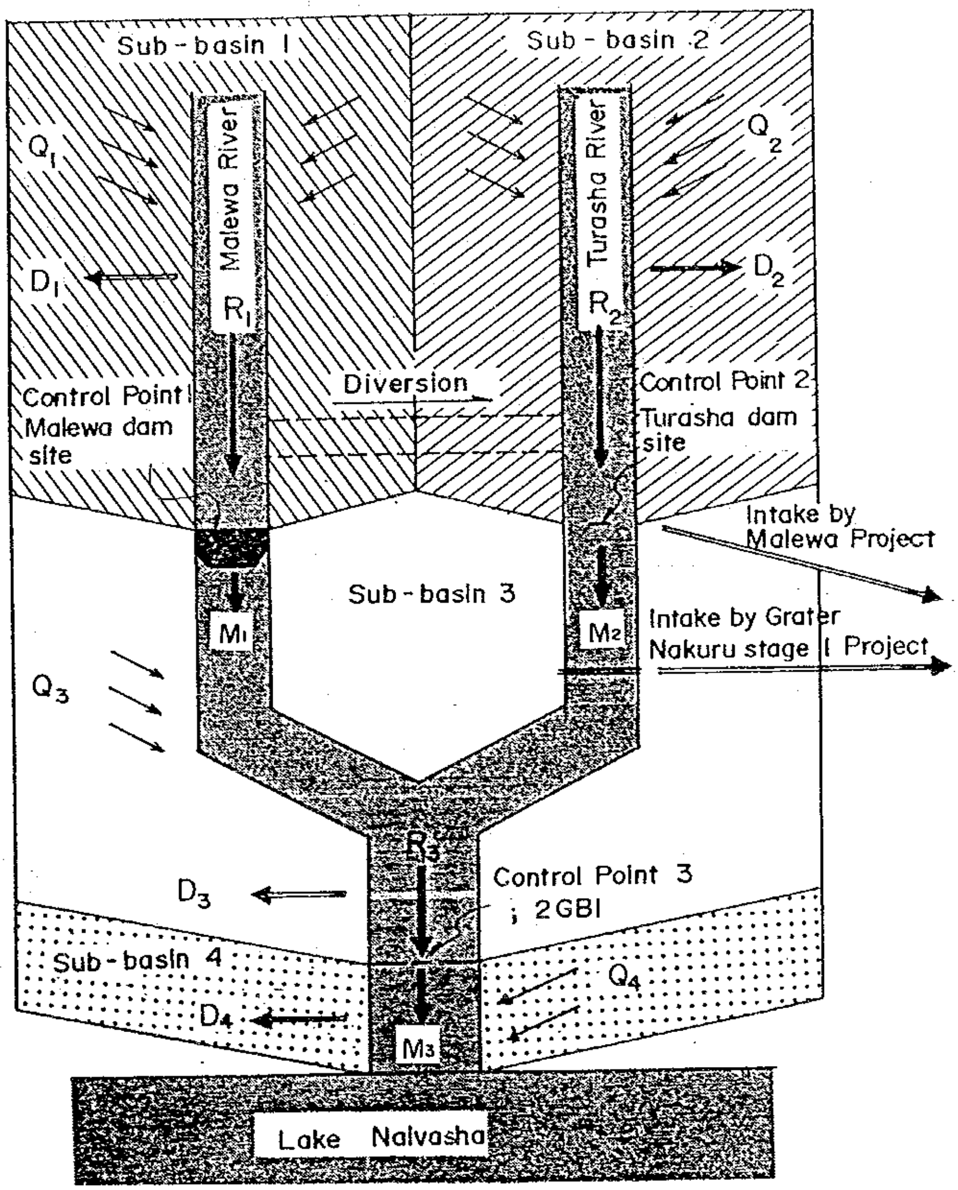
TITLE

Flow Chart for Selection Promising Damsite

Fig. F.3.2



Ri : Available runoff at control point i

Di : Water requirement for registered water right in sub - basin i

Qi : Natural runoff drained in sub-basin i

Mi : Conservation flow at control point i

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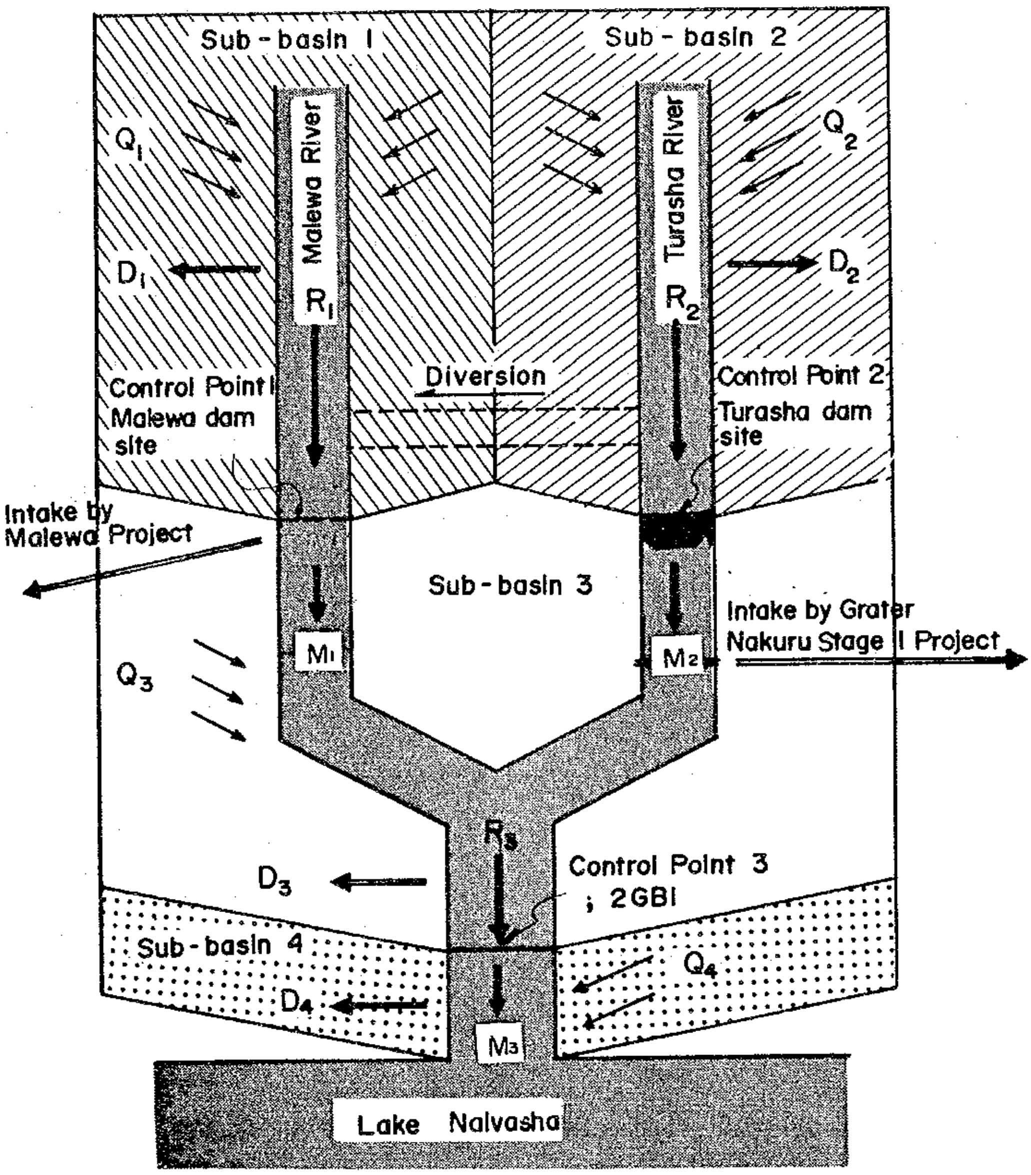
Fig. F.3.3



Ri : Available runoff at control point i

Di : Water requirement for registered water right in sub - basin i

Qi : Natural runoff drained in sub-basin i

Mi : Conservation flow at control point i

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