

*Japan International Cooperation Agency
(JICA)*

**Water Quality Survey Of the Addis Ababa
Drinking Water Supply System (Akaki,
Legedadi And Geferssa)**

**Water Works Design And
Supervision Enterprise
Addis Ababa Ethiopia**

WATER WORKS DESIGN AND SUPERVISION ENTERPRISE
LABORATORY

SELECTED PHYSICAL AND CHEMICAL WATER ANALYSIS RESULTS
Client - Japan International Cooperation Agency

WHO Guidelines

Nature of Sample					
Date of Collection	6/12/01	6/12/01	10/12/01	10/12/01	
Date Received	6/12/01	6/12/01	10/12/01	10/12/01	
Clients's ID . No.	LEGEDADI DAM	DIRE DAM	GEFERSSA DAM (# 3)	GEFFERSA DAM (1 & 2)	
Lab. ID. No.	039/94	040/94	041/94	042/94	
Colour (app.)	4410	301.0	123.0	151.0	15
Turbidity (NTU)	790.0	56.0	24.0	27.0	5
Total Diss. Solids, 105 ⁰ C (mg/l)	58.0	88.0	50.0	42.0	1000
Electrical Conductivity (us/cm)	84.0	117.0	67.0	60.0	
PH	7.63	7.74	7.31	7.52	6.5 - 8.5
Ammonia (mg/l NH ₄ ⁺)	0.70	1.15	0.37	0.17	
Sodium (mg/l Na ⁺)	5.0	7.0	4.0	4.0	200
Potassium (mg/l K ⁺)	2.1	2.1	1.7	1.7	
Total Hardness (mg/l as Ca CO ₃)	34.0	50.0	26.0	22.0	500
Calcium (mg/l Ca ²⁺)	10.4	14.4	8.0	6.4	200
Magnesium (mg/l Mg)	1.95	3.4	1.46	1.46	
Total Iron (mg/l Fe)	0.26	0.35	0.81	0.33	0.3
Manganese (mg/l Mn)	0.2	Nd	0.3	Nd	0.1
Fluoride (mg/l F)	0.02	0.2	0.09	0.09	1.5 - 2
Chloride (mg/l Cl)	0.87	0.87	0.87	0.87	250
Nitrite (mg/l NO ₂)	0.013	0.04	0.05	0.03	
Nitrate (mg/l NO ₃)	5.28	10.56	5.72	2.64	45
Alkalinity (mg/l CaCO ₃)	36.0	54.0	28.0	26.0	
Carbonate (mg/l CO ₃ ²⁻)	Nd	Nd	Nd	Nd	
Bicarbonate (mg/l HCO ₃)	43.92	65.88	34.16	31.72	
Sulphate (mg/l SO ₄ ²⁻)	4.0	7.0	5.0	6.0	
Phosphate (mg/l PO ₄ ³⁻)	0.07	0.10	0.05	0.03	400
COPPER (Mg/l Cu)	0.11	0.13	0.11	0.10	
Dissolved Oxygen (Mg/l)	7.98	5.86	5.40	5.96	
Dissolved Co ₂ (mg/l)	5.8	3.6	Nd	Nd	
Taste & odour	Moderately objectionable (muddy)	Very objectionable (earthy & musty)	Less objectionable	Less objectionable	unobjectionable

*Odour & Taste tests were carried out in the late morning hours and the results obtained are observed to be primarily of natural causes such as decaying vegetation, soil turnover, human and animal influences and all other conditions pertaining to a standing still water body.

Nature of Sample						
Date of Collection	6/12/01	6/12/01	6/12/01	6/12/01	12/12/01	12/12/01
Date Received	6/12/01	6/12/01	6/12/01	6/12/01	12/12/01	12/12/01
Clients's ID . No.	LEGEDADI TRANSMISSI ON LINE 1(900MM)	LEGEDADI TRANSMISSI ON LINE 2(1200mm)	LEGEDADI SURGE TANK	LEGEDADI TERMINAL RESVOIR	LEGDADI DESTRIBUTI ON LINE 1(JAN.MEDA)	LEGDADI DISTRIBUTION LINE 2(ENTOTO)
Lab. ID. No.	043/94	044/94	045/94	046/94	047/94	048/94
Colour (app.)	Nd	Nd	5.0	Nd	4	11
Turbidity (NTU)	Nd	Nd	2.0	Nd	1	2
Electical Conductivity (us/cm)	94.0	115.0	108.0	110.0	115	110
PH	7.11	7.36	7.55	7.47	7.49	7.66
Residual Chlorine mg/l	0.4	0.3	1.2	1.1	1.0	1.0
Remarks	Nd = None detected					

Nature of Sample						
Date of Collection	12/12/01	12/12/01	10/12/01	10/12/01	10/12/01	12/12/01
Date Received	12/12/01	12/12/01	10/12/01	10/12/01	10/12/01	12/12/01
Clients's ID . No.	LEGEDADI DISTRIBUTIO N LINE 3(BELAY ZELEKE)	LEGDADI TAP WATER (SHOLA)	GEFERSSA DISTRIBU TION LINE	GEFERSSA TERMINAL RESVOIR (RAS HAILU)	GEFERSSA TAP WATER (COLFE)	AKAKI DISTRIBUTE LINE
Lab. ID. No.	049/94	050/94	051/94	052/94	053/94	054/94
Colour (app.)	7	<4	2	0	2	<4
Turbidity (NTU)	2	Nd	0	0	1	Nd
Electical Conductivity (us/cm)	111	114	104.0	105.0	105.0	506
PH	7.61	7.55	7.32	7.25	7.22	7.77
Residual Chlorine (mg/l)	1.1	1.0	1.2	1.2	1.2	Nd
Disolved Co ₂ (mg/l)						14.8
Remarks	Nd = None detected					
	The electrical conductivity values for the Akaki distribution line and tap water do not match with each other, therefore, it needs to further be investigated					

Nature of Sample						
Date of Collection	12/12/01					
Date Received	12/12/01					
Clients's ID . No.	AKAKI TAP WATER (MEXICO SQ. CAFE)					
Lab. ID. No.	055/94					
Colour (app.)	<4					
Turbidity (NTU)	Nd					
Total Solids, 105 ⁰ C (mg/l)						
Total Diss. Solids, 105 ⁰ C (mg/l)						
Electical Conductivity (us/cm)	131					
PH	7.70					
Residual Chlorine	0.4					

Remarks

Nd = None detected

CHECKED BY Nezussio Z. 

Date 20/12/01

APPROVED BY 

Date 20/12/01

B. Bacteriological Results

No.	Lab. No.	Samling Location	Total Coliform count (No's/100 ml)	Fecal Coliform c (No's/100ml)
1	039/94	Legedadi Dam	2000	600
2	040/94	Dire Dam	600	50
3	041/94	Geferssa Dam # 3	500	200
4	042/94	Geferssa Dam (1 &2)	60	20
5	043/94	Legedadi Transmission Line 1 (900 mm)	Nd	Nd
6	044/94	Legedadi Transmission Line 2 (1200 mm)	Nd	Nd
7	045/95	Legedadi Surge Tank	Nd	Nd
8	046/94	Legedadi Terminal Reservoir	Nd	Nd
9	047/94	Legedadi Distribution Line 1 (Jan Meda)	Nd	Nd
10	048/94	Legedadi Distribution line 2 (Entoto)	Nd	Nd
11	049/94	Legedadi Distribution Line 3 (Belay Zeleke)	Nd	Nd
12	050/94	Legedadi tap water (Shola Area)	Nd	Nd
13	051/94	Geferssa Distribution Line	Nd	Nd
14	052/94	Geferssa Terminal Reservoir (Ras Hailu)	Nd	Nd
15	053/94	Geferssa Tap Water (Kolfe)	Nd	Nd
16	054/94	Akaki Distribution line	400	100
17	055/94	Akaki Tap Water (Mexico Sq. Cafe)	50	10

CHECKED BY Negussie Z.

Date 20/12/01

APPROVED BY 

Date 20/12/01

7.4 アディス・アベバ上下水道公団職員の数 (2006年)

	室長	副室長	秘書	事務員	技術者					職工	操作員	給水車 運転手	運転手	助手	連絡室	守衛	その他	計	備 考
					土木	機械	電気	水質	その他										
1 局長室	1		1									1						3	
2 監査部	1		1	6														8	
3 法務部	1		2	10														13	
4 計算情報部	1		1	2				12			2							18	
5 広報部	1		1	4				1										7	
維持管理室			1	1														2	
小計	1		2	6				1										9	
6 次官室 (技術)	1		1									1						3	
7 水道部	1		1	1							11		11	1				26	
レガディVTP	1	1		1		1	1	1			7		9	1	46	4		74	交代制
ガフェルサVTP	1	1		1		1	1	1			9		6	1	22	4		49	交代制
システム操作課	1		1		3													5	
配水池・ポンプ課	1					2					75		2		18			98	
送水管課	1				7					9		2	4	14				37	
漏水制御課	1			4	2							3	2					12	
衛生教育課	1			2	1			3					1					7	
表流水・副表流水部			1															2	
表流水課	1							6				1						8	
副表流水課	1							2		40		1						44	
8 材料管理部	1		1	1														3	
調達課	1		1															2	
国内調達課	1			3														4	
海外調達課	1			2														3	
倉庫課	1		1	2														4	
本局技術部品倉庫												3						3	
ミラカ技術部品倉庫												4		9				13	
中央供給倉庫												2						2	
中央燃料倉庫												6						6	
部品倉庫												3						3	
9 下水道部	1		1															2	
下水管課	1	1																2	
下水顧客課	1			1	8					2	1	2	2	11				28	
下水管維持課	1			1	8					2	3	2	18					35	
規画取締課	1				2								1					4	
汚水・汚泥課	1	1																2	
加圧汚水処理場	1																	1	
汚水処理班								1		9		1	2		15	3		31	
汚泥処理班				1	1							30						32	
コペ汚水処理場	1			1				1		1		1	4		6	3		18	
10 技術部	1		1	1														3	
計画基準課	1		1		4	1		2	2			1						12	
機械工場	1		1			3		2	7			1	6		9	2		32	
電気工場	1		1				3	2	2			1	2					12	
車両維持工場	1		1	1					1		1	1						7	
重車両班	1			1		5	1						3					11	
軽車両班	1			1		7	2			4			9					24	
車両維持班	1									7			2					10	
メカ検査修理工場	1			1						4			1	4				11	
11 研究室新部	1		1		1			1	1									6	
12 中央水質試験部	1		1					6					2	2				12	
小計	35	5	12	28	37	20	8	11	18	40	145	16	28	155	3	125	16	702	
13 計画部	1		1															2	
計画作成課	1		1						3									5	
計画監視・評価課	1		1	2	2			2				2						10	
小計	3		3	2	2			5				2						17	
14 財政部	1		1	1														3	
収入支出課	1			11														12	
記録課	1			11														12	
管理分析課	1			8														9	
保険課	1			1														2	
小計	5		1	32														38	
15 次官室 (管理)	1		1															3	
16 支所	5		5									5						15	5支所
技術サービス課	5				25			5	60			25	175					295	接統、維持部門
技術サービス課				5	5							26	52					88	下水サービス部門
技術サービス課					5				10			5	15					35	検針部門
顧客サービス課	5			25					10				48			17		105	
総務課	5			20									64					89	
総務課	5		5	15								5	15		30	15		90	
アキ支所	1		1															2	
顧客サービス課	1			2									3					10	
技術サービス課	1				2				4	6	2	2	8					25	
技術サービス課					6					1		1	7					15	検針部門
総務経理課	1			11								1	1			1	2	17	
17 管理部	1		1															2	
人事課	1		1	8														10	
人的資源開発課	1		1	1														3	
一般業務課	1		1	23	1	1		1	2	8	15	8	2	16	17		96		
小計	34		16	110	44	0	1	5	86	8	36	60	396	2	47	55	900		
合計	82	5	39	195	83	20	9	11	41	126	155	52	91	551	5	172	71	1,708	

7.5 原水供給可能量の検討

Review of Available Water Resources for the Legadadi Water Treatment Plan

This paper presents the preliminary and roughly review of the quantity of raw water resources for the Legadadi Water Treatment Plant in Addis ababa to confirm the possible expansion of the plant.

I. Conditions

The used data for this review are as follows but not be checked accuracy of these data by us. So that, the conditions in used data shall be regarded as the premise of this review.

Inflow to the reservoirs:

Applied the calculated mean monthly inflow to Legadadi and Dire Reservoirs (Table 8-12 and 8-13 of Chapter 8 “Hydrological Evaluation of Water Harvesting in the Three Catchment Areas”, Master Plan Study for Regedai, Dire and Geffersa Catchment Areas, 2000, AAWSA

Losses from reservoirs:

Assumed the evaporation from water surface, seepage to ground, leakage from dam body and others by the 80% of average monthly evaporation records (1974) at Addis Ababa Observatory, Table 8-2 of above report. Difference of water surface area in storage level of reservoirs is not applied. The water surface area used for calculation of losses is at maximum water level of reservoirs. It might give a safety factor for the evaluation of possible water resources.

Effective Reservoir Capacity:

The different reservoir capacities are reported in the previous study reports for the Legadadi reservoir and dire reservoir. The following lesser reservoir capacity of each reservoir is employed to calculation of water balance of reservoirs.

Legadadi Reservoir; Total Capacity is 38.71 MCM at El. 2,466m

Effective Storage Capacity is 35.8 MCM at EL 2,466 – 2446 m

(Study on the Problem Analysis of Means to control Water Quality Deterioration of Legadadi Reservoir, Final Report)

Dire Reservoir: Total Capacity is 19.0 MCM at EL. 2554.5 m

Effective Storage Capacity is 17.0 MCM at EL 2554.5 – 2532.0 m

(Area Capacity Curves of Dam Site 2, Dire Dam Design Report)

II. Simulation study of the Water Balance for both reservoirs are made and confirmed following points.

1. Legadadi Reservoir has the enough capacity of raw water for the production of treated water by 110,000 to 120,000 cu.m/day.

Refer Table-1.

2. The deliver of raw water from Dire Dam to Legadadi Water Treatment Plant is assumed by maximum 60,000 cu.m/day. During 8.5 months before rainy season (November to mid-July) may be reasonable delivering period.

Refer Table-2

3. If the raw water of 60,000 cu.m/day is delivered from Dire Dam in 8.5 months per year for the production of treated water at Legadadi Water Treatment Plant, the production of 170,000 cu.m/day will be available by means the possibility of expansion of plant by 20,000 cu.m/day capacity.

Refer Table-3

Year	Month	Inflow to Reservoir		Intake	Evaporation	Losses	Spilled Water	Total Out Flow	Balance of Reservoir	Remarks
		cu.m/s	MCM							
1992	Jan	0.08	0.21	3.91	160	0.58	0.00	4.48	20.59	
	Feb	0.09	0.23	3.65	137	0.49	0.00	4.15	16.67	
	Mar	0.07	0.19	3.91	141	0.51	0.00	4.41	12.44	
	Apr	0.05	0.13	3.78	134	0.48	0.00	4.26	8.31	
	May	0.04	0.11	3.91	136	0.49	0.00	4.40	4.02	
	Jun	0.07	0.18	3.78	105	0.38	0.00	4.16	0.05	
	Jul	2.17	5.81	4.09	101	0.36	0.00	4.46	1.40	
	Aug	16.84	45.10	4.09	126	0.45	6.16	10.71	35.80	
	Sep	8.60	22.29	3.96	110	0.40	17.94	22.29	35.80	
	Oct	0.59	1.58	3.91	176	0.63	0.00	4.54	32.84	
	Nov	0.32	0.83	3.78	186	0.67	0.00	4.45	29.22	
	Dec	0.02	0.05	3.91	158	0.57	0.00	4.47	24.80	
1993	Jan	0.12	0.32	3.91	160	0.58	0.00	4.48	20.64	
	Feb	0.06	0.15	3.53	137	0.49	0.00	4.02	16.76	
	Mar	0.04	0.11	3.91	141	0.51	0.00	4.41	12.46	
	Apr	0.11	0.29	3.78	134	0.48	0.00	4.26	8.48	
	May	0.10	0.27	3.91	136	0.49	0.00	4.40	4.35	
	Jun	0.38	0.98	3.78	105	0.38	0.00	4.16	1.18	
	Jul	7.64	20.46	4.09	101	0.36	0.00	4.46	17.19	
	Aug	18.82	50.41	4.09	126	0.45	27.25	31.79	35.80	
	Sep	11.43	29.63	3.96	110	0.40	25.27	29.63	35.80	
	Oct	2.10	5.62	3.91	176	0.63	1.09	5.62	35.80	
	Nov	0.30	0.78	3.78	186	0.67	0.00	4.45	32.13	
	Dec	0.19	0.51	3.91	158	0.57	0.00	4.47	28.16	
1994	Jan	0.08	0.21	3.91	160	0.58	0.00	4.48	23.89	
	Feb	0.03	0.07	3.53	137	0.49	0.00	4.02	19.95	
	Mar	0.04	0.11	3.91	141	0.51	0.00	4.41	15.64	
	Apr	0.05	0.13	3.78	134	0.48	0.00	4.26	11.51	
	May	0.06	0.16	3.91	136	0.49	0.00	4.40	7.27	
	Jun	0.27	0.70	3.78	105	0.38	0.00	4.16	3.81	
	Jul	4.71	12.62	4.09	101	0.36	0.00	4.46	11.97	
	Aug	12.72	34.07	4.09	126	0.45	5.70	10.24	35.80	
	Sep	5.69	14.75	3.96	110	0.40	10.39	14.75	35.80	
	Oct	0.97	2.60	3.91	176	0.63	0.00	4.54	33.86	
	Nov	0.26	0.67	3.78	186	0.67	0.00	4.45	30.08	
	Dec	0.14	0.37	3.91	158	0.57	0.00	4.47	25.98	
1995	Jan	0.11	0.29	3.91	160	0.58	0.00	4.48	21.80	
	Feb	0.05	0.12	3.53	137	0.49	0.00	4.02	17.90	
	Mar	0.05	0.13	3.91	141	0.51	0.00	4.41	13.62	
	Apr	0.13	0.34	3.78	134	0.48	0.00	4.26	9.69	
	May	0.15	0.40	3.91	136	0.49	0.00	4.40	5.70	
	Jun	0.13	0.34	3.78	105	0.38	0.00	4.16	1.88	
	Jul	4.32	11.57	4.09	101	0.36	0.00	4.46	8.99	
	Aug	11.72	31.39	4.09	126	0.45	0.04	4.58	35.80	
	Sep	3.83	9.93	3.96	110	0.40	5.57	9.93	35.80	
	Oct	0.49	1.31	3.91	176	0.63	0.00	4.54	32.57	
	Nov	0.26	0.67	3.78	186	0.67	0.00	4.45	28.80	
	Dec	0.14	0.37	3.91	158	0.57	0.00	4.47	24.70	
1996	Jan	0.13	0.35	3.91	160	0.58	0.00	4.48	20.56	
	Feb	0.09	0.23	3.65	137	0.49	0.00	4.15	16.64	
	Mar	0.09	0.24	3.91	141	0.51	0.00	4.41	12.47	
	Apr	0.08	0.21	3.78	134	0.48	0.00	4.26	8.41	
	May	0.07	0.19	3.91	136	0.49	0.00	4.40	4.21	
	Jun	0.92	2.38	3.78	105	0.38	0.00	4.16	2.43	
	Jul	11.32	30.32	4.09	101	0.36	0.00	4.46	28.30	

Year	Month		Inflow to Reservoir		Intake	Evaporation	Losses	Spilled Water	Total Out Flow	Balance of Reservoir	Remarks
			cu.m/s	MCM	MCM	mm	MCM	MCM	MCM	MCM	
	Apr	30	0.08	0.21	1.89	134	0.16	0.00	2.05	5.15	
	May	31	0.03	0.08	1.95	136	0.16	0.00	2.12	3.11	
	Jun	30	0.03	0.08	1.89	105	0.13	0.00	2.02	1.18	EL 2,535
	Jul	31	1.39	3.72	0.98	101	0.12	0.00	1.10	3.80	
	Aug	31	22.10	59.19	0.00	126	0.15	45.84	45.99	17.00	
	Sep	30	1.58	4.10	0.00	110	0.13	3.96	4.10	17.00	
	Oct	31	0.06	0.16	0.00	176	0.21	0.00	0.21	16.95	
	Nov	30	0.03	0.08	1.89	186	0.23	0.00	2.12	14.91	
	Dec	31	0.01	0.03	1.95	158	0.19	0.00	2.14	12.79	
1991	Jan	31	0.01	0.03	1.95	160	0.19	0.00	2.15	10.67	
	Feb	28	0.01	0.02	1.76	137	0.17	0.00	1.93	8.77	
	Mar	31	0.02	0.05	1.95	141	0.17	0.00	2.12	6.69	
	Apr	30	0.00	0.00	1.89	134	0.16	0.00	2.05	4.64	
	May	31	0.06	0.16	1.95	136	0.16	0.00	2.12	2.69	EL 2,538.4
	Jun	30	0.79	2.05	1.89	105	0.13	0.00	2.02	2.72	
	Jul	31	8.53	22.85	0.98	101	0.12	7.46	8.56	17.00	
	Aug	31	19.66	52.66	0.00	126	0.15	52.50	52.66	17.00	
	Sep	30	3.93	10.19	0.00	110	0.13	10.05	10.19	17.00	
	Oct	31	0.07	0.19	0.00	176	0.21	0.00	0.21	16.97	
	Nov	30	0.03	0.08	1.89	186	0.23	0.00	2.12	14.94	
	Dec	31	0.02	0.05	1.95	158	0.19	0.00	2.14	12.85	
1992	Jan	31	0.03	0.08	1.95	160	0.19	0.00	2.15	10.78	
	Feb	29	0.16	0.40	1.83	137	0.17	0.00	1.99	9.19	
	Mar	31	0.01	0.03	1.95	141	0.17	0.00	2.12	7.09	
	Apr	30	0.02	0.05	1.89	134	0.16	0.00	2.05	5.09	
	May	31	0.09	0.24	1.95	136	0.16	0.00	2.12	3.21	
	Jun	30	0.13	0.34	1.89	105	0.13	0.00	2.02	1.53	EL 2,536
	Jul	31	2.00	5.36	0.98	101	0.12	0.00	1.10	5.79	
	Aug	31	13.72	36.75	0.00	126	0.15	25.38	25.54	17.00	
	Sep	30	7.24	18.77	0.00	110	0.13	18.63	18.77	17.00	
	Oct	31	0.63	1.69	0.00	176	0.21	1.47	1.69	17.00	
	Nov	30	0.08	0.21	1.89	186	0.23	0.00	2.12	15.09	
	Dec	31	0.05	0.13	1.95	158	0.19	0.00	2.14	13.08	
1993	Jan	31	0.04	0.11	1.95	160	0.19	0.00	2.15	11.04	
	Feb	28	0.06	0.15	1.76	137	0.17	0.00	1.93	9.26	
	Mar	31	0.02	0.05	1.95	141	0.17	0.00	2.12	7.19	
	Apr	30	0.05	0.13	1.89	134	0.16	0.00	2.05	5.26	
	May	31	0.04	0.11	1.95	136	0.16	0.00	2.12	3.25	
	Jun	30	0.05	0.13	1.89	105	0.13	0.00	2.02	1.36	EL 2,535.5
	Jul	31	7.22	19.34	0.98	101	0.12	2.60	3.70	17.00	
	Aug	31	8.86	23.73	0.00	126	0.15	23.58	23.73	17.00	

Inflow Intake Losses Spill Total Out
41.19 16.22 2.03 23.48 41.73
18.65 days 0.54

Inflow Intake Losses Spill Total Out
88.71 16.22 2.03 57.26 75.51
43.10 days (13.20)

Inflow Intake Losses Spill Total Out
69.66 16.29 2.03 62.56 80.87
24.30 days 11.21

Inflow Intake Losses Spill Total Out
77.55 16.22 2.03 48.09 66.34
21.65 days (11.21)

Year	Month		Inflow to Reservoir		Intake	Evaporation	Losses	Spilled Water	Total Out Flow	Balance of Reservoir	Remarks
			cu.m/s	MCM	MCM	mm	MCM	MCM	MCM	MCM	
1994	Sep	30	7.95	20.61	0.00	110	0.13	20.47	20.61	17.00	
	Oct	31	0.50	1.34	0.00	176	0.21	1.13	1.34	17.00	
	Nov	30	0.10	0.26	1.89	186	0.23	0.00	2.12	15.14	
	Dec	31	0.06	0.16	1.95	158	0.19	0.00	2.14	13.16	
	Jan	31	0.05	0.13	1.95	160	0.19	0.00	2.15	11.15	
	Feb	28	0.03	0.07	1.76	137	0.17	0.00	1.93	9.29	
	Mar	31	0.04	0.11	1.95	141	0.17	0.00	2.12	7.27	
	Apr	30	0.03	0.08	1.89	134	0.16	0.00	2.05	5.30	
	May	31	0.02	0.05	1.95	136	0.16	0.00	2.12	3.23	
	Jun	30	0.06	0.16	1.89	105	0.13	0.00	2.02	1.37	EL 2,535.6
	Jul	31	5.46	14.62	0.98	101	0.12	0.00	1.10	14.90	
	Aug	31	11.34	30.37	0.00	126	0.15	28.12	28.27	17.00	
	Sep	30	2.81	7.28	0.00	110	0.13	7.15	7.28	17.00	
	Oct	31	0.15	0.40	0.00	176	0.21	0.19	0.40	17.00	
	Nov	30	0.03	0.08	1.89	186	0.23	0.00	2.12	14.96	
	Dec	31	0.02	0.05	1.95	158	0.19	0.00	2.14	12.87	
1995	Jan	31	0.01	0.03	1.95	160	0.19	0.00	2.15	10.75	
	Feb	28	0.01	0.02	1.76	137	0.17	0.00	1.93	8.84	
	Mar	31	0.06	0.16	1.95	141	0.17	0.00	2.12	6.88	
	Apr	30	0.03	0.08	1.89	134	0.16	0.00	2.05	4.91	
	May	31	0.01	0.03	1.95	136	0.16	0.00	2.12	2.82	
	Jun	30	0.02	0.05	1.89	105	0.13	0.00	2.02	0.85	EL 2534.5
	Jul	31	2.57	6.88	0.98	101	0.12	0.00	1.10	6.63	
	Aug	31	8.76	23.46	0.00	126	0.15	12.94	13.10	17.00	
	Sep	30	1.35	3.50	0.00	110	0.13	3.37	3.50	17.00	
	Oct	31	0.09	0.24	0.00	176	0.21	0.03	0.24	17.00	
	Nov	30	0.04	0.10	1.89	186	0.23	0.00	2.12	14.99	
	Dec	31	0.04	0.11	1.95	158	0.19	0.00	2.14	12.95	
1996	Jan	31	0.06	0.16	1.95	160	0.19	0.00	2.15	10.96	
	Feb	29	0.02	0.05	1.83	137	0.17	0.00	1.99	9.02	
	Mar	31	0.05	0.13	1.95	141	0.17	0.00	2.12	7.03	
	Apr	30	0.02	0.05	1.89	134	0.16	0.00	2.05	5.03	
	May	31	0.05	0.13	1.95	136	0.16	0.00	2.12	3.05	
	Jun	30	0.18	0.47	1.89	105	0.13	0.00	2.02	1.50	EL 2,536
	Jul	31	5.03	13.47	0.98	101	0.12	0.00	1.10	13.87	
	Aug	31	9.72	26.03	0.00	101	0.12	22.78	22.90	17.00	

Inflow	Intake	Losses	Spill	Total Out
61.32	16.22	2.03	45.18	63.42
21.76 days				2.10

Inflow	Intake	Losses	Spill	Total Out
45.44	16.22	2.03	35.45	53.70
13.49 days				8.26

Inflow	Intake	Losses	Spill	Total Out
41.88	16.29	2.03	16.34	34.65
23.74 days				(7.23)

Table-3 Monthly Water Requirement and Balance of Reservoir

- Legadadi Dam plus Dir's raw water of 60,000 cu.m/day for Treated Water Production of 170,000 cu.m/day -

Name of Reservoir : Legadadi Dam and Dire Dam

Catchment Area : 204.9 sq.km

Maximum Water Surface Area: 4.5 sq.km 0.8

From Dire: 60,000 cu.m/day

Intaked Water to WTP (Dry season): 178,500 cu.m/day

Durations Aug 1987 to Jul 1996

Intaked Water to WTP (Rainy season): 187,000 cu.m/day

HWL : 2,466.0

Effective Reservoir Capacity : 35.8 MCM

LWL : 2,446.0

Year	Month		Inflow to Reservoir		Delivered	Total	Intake	Evapratio	Losses	Spilled	Total Out	Balance	Remarks
			cu.m/s	MCM	form Dire	Inflow	MCM	n	MCM	Water	Flow	of Reservoir	
					MCM	MCM	MCM	mm	MCM	MCM	MCM	MCM	
1987	Aug.	31	13.12	35.14	0.00	35.14	5.80	126	0.45	28.89	35.14	35.80	
	Sep.	30	4.26	11.04	0.00	11.04	5.61	110	0.40	5.04	11.04	35.80	
	Oct.	31	0.66	1.77	0.00	1.77	5.53	176	0.63	0.00	6.17	31.40	
	Nov.	30	0.20	0.52	1.80	2.32	5.36	186	0.67	0.00	6.02	27.69	
	Dec.	31	0.15	0.40	1.86	2.26	5.53	158	0.57	0.00	6.10	23.85	
1988	Jan.	31	0.08	0.21	1.86	2.07	5.53	160	0.58	0.00	6.11	19.82	
	Feb.	29	0.07	0.18	1.74	1.92	5.18	137	0.49	0.00	5.67	16.06	
	Mar	31	0.06	0.16	1.86	2.02	5.53	141	0.51	0.00	6.04	12.04	
	Apr	30	0.04	0.10	1.80	1.90	5.36	134	0.48	0.00	5.84	8.11	
	May	31	0.05	0.13	1.86	1.99	5.53	136	0.49	0.00	6.02	4.08	
	Jun	30	0.05	0.13	1.80	1.93	5.36	105	0.38	0.00	5.73	0.28	
	Jul	31	6.35	17.01	0.93	17.94	5.80	101	0.36	0.00	6.16	12.05	
1989	Aug	31	18.90	50.62	0.00	50.62	5.80	126	0.45	20.63	26.88	35.80	
	Sep	30	11.51	29.83	0.00	29.83	5.61	110	0.40	23.83	29.83	35.80	
	Oct	31	1.53	4.10	0.00	4.10	5.53	176	0.63	0.00	6.17	33.73	
	Nov	30	0.32	0.83	1.80	2.63	5.36	186	0.67	0.00	6.02	30.34	
	Dec	31	0.24	0.64	1.86	2.50	5.53	158	0.57	0.00	6.10	26.74	
	Jan	31	0.10	0.27	1.86	2.13	5.53	160	0.58	0.00	6.11	22.75	
	Feb	28	0.11	0.27	1.68	1.95	5.00	137	0.49	0.00	5.49	19.21	
	Mar	31	0.09	0.24	1.86	2.10	5.53	141	0.51	0.00	6.04	15.27	
	Apr	30	0.11	0.29	1.80	2.09	5.36	134	0.48	0.00	5.84	11.52	
	May	31	0.06	0.16	1.86	2.02	5.53	136	0.49	0.00	6.02	7.51	
	Jun	30	0.07	0.18	1.80	1.98	5.36	105	0.38	0.00	5.73	3.76	
Jul	31	7.65	20.49	0.93	21.42	5.80	101	0.36	0.00	6.16	19.02		
1990	Aug	31	19.30	51.69	0.00	51.69	5.80	126	0.45	28.66	34.92	35.80	
	Sep	30	6.32	16.38	0.00	16.38	5.61	110	0.40	10.38	16.38	35.80	
	Oct	31	0.79	2.12	0.00	2.12	5.53	176	0.63	0.00	6.17	31.75	
	Nov	30	0.27	0.70	1.80	2.50	5.36	186	0.67	0.00	6.02	28.22	
	Dec	31	0.16	0.43	1.86	2.29	5.53	158	0.57	0.00	6.10	24.41	
	Jan	31	0.13	0.35	1.86	2.21	5.53	160	0.58	0.00	6.11	20.51	
	Feb	28	0.10	0.24	1.68	1.92	5.00	137	0.49	0.00	5.49	16.94	
	Mar	31	0.12	0.32	1.86	2.18	5.53	141	0.51	0.00	6.04	13.08	

7-27

Year	Month		Inflow to Reservoir		Delivered	Total	Intake	Evapratio	Losses	Spilled	Total Out	Balance	Remarks
			cu.m/s	MCM	form Dire	Inflow	MCM	n	MCM	Water	Flow	of	
					MCM	MCM	MCM	mm	MCM	MCM	MCM	MCM	
	Apr	30	0.17	0.44	1.80	2.24	5.36	134	0.48	0.00	5.84	9.48	
	May	31	0.10	0.27	1.86	2.13	5.53	136	0.49	0.00	6.02	5.59	
	Jun	30	0.09	0.23	1.80	2.03	5.36	105	0.38	0.00	5.73	1.89	
	Jul	31	2.99	8.01	0.93	8.94	5.80	101	0.36	0.00	6.16	4.67	
	Aug	31	20.72	55.50	0.00	55.50	5.80	126	0.45	18.11	24.36	35.80	
	Sep	30	8.66	22.45	0.00	22.45	5.61	110	0.40	16.44	22.45	35.80	
	Oct	31	1.76	4.71	0.00	4.71	5.53	176	0.63	0.00	6.17	34.35	
	Nov	30	0.30	0.78	1.80	2.58	5.36	186	0.67	0.00	6.02	30.90	
	Dec	31	0.16	0.43	1.86	2.29	5.53	158	0.57	0.00	6.10	27.09	
1991	Jan	31	0.16	0.43	1.86	2.29	5.53	160	0.58	0.00	6.11	23.27	
	Feb	28	0.11	0.27	1.68	1.95	5.00	137	0.49	0.00	5.49	19.72	
	Mar	31	0.14	0.37	1.86	2.23	5.53	141	0.51	0.00	6.04	15.91	
	Apr	30	0.08	0.21	1.80	2.01	5.36	134	0.48	0.00	5.84	12.08	
	May	31	0.00	0.00	1.86	1.86	5.53	136	0.49	0.00	6.02	7.92	
	Jun	30	0.11	0.29	1.80	2.09	5.36	105	0.38	0.00	5.73	4.27	
	Jul	31	6.11	16.37	0.93	17.30	5.80	101	0.36	0.00	6.16	15.41	
	Aug	31	19.01	50.92	0.00	50.92	5.80	126	0.45	24.27	30.52	35.80	
	Sep	30	9.75	25.27	0.00	25.27	5.61	110	0.40	19.27	25.27	35.80	
	Oct	31	0.56	1.50	0.00	1.50	5.53	176	0.63	0.00	6.17	31.13	
	Nov	30	0.24	0.62	1.80	2.42	5.36	186	0.67	0.00	6.02	27.53	
	Dec	31	0.15	0.40	1.86	2.26	5.53	158	0.57	0.00	6.10	23.69	
1992	Jan	31	0.08	0.21	1.86	2.07	5.53	160	0.58	0.00	6.11	19.65	
	Feb	29	0.09	0.23	1.74	1.97	5.18	137	0.49	0.00	5.67	15.95	
	Mar	31	0.07	0.19	1.86	2.05	5.53	141	0.51	0.00	6.04	11.96	
	Apr	30	0.05	0.13	1.80	1.93	5.36	134	0.48	0.00	5.84	8.05	
	May	31	0.04	0.11	1.86	1.97	5.53	136	0.49	0.00	6.02	3.99	
	Jun	30	0.07	0.18	1.80	1.98	5.36	105	0.38	0.00	5.73	0.24	
	Jul	31	2.17	5.81	0.93	6.74	5.80	101	0.36	0.00	6.16	0.82	
	Aug	31	16.84	45.10	0.00	45.10	5.80	126	0.45	3.88	10.13	35.80	
	Sep	30	8.60	22.29	0.00	22.29	5.61	110	0.40	16.29	22.29	35.80	
	Oct	31	0.59	1.58	0.00	1.58	5.53	176	0.63	0.00	6.17	31.21	
	Nov	30	0.32	0.83	1.80	2.63	5.36	186	0.67	0.00	6.02	27.82	
	Dec	31	0.02	0.05	1.86	1.91	5.53	158	0.57	0.00	6.10	23.63	
1993	Jan	31	0.12	0.32	1.86	2.18	5.53	160	0.58	0.00	6.11	19.70	
	Feb	28	0.06	0.15	1.68	1.83	5.00	137	0.49	0.00	5.49	16.04	
	Mar	31	0.04	0.11	1.86	1.97	5.53	141	0.51	0.00	6.04	11.96	
	Apr	30	0.11	0.29	1.80	2.09	5.36	134	0.48	0.00	5.84	8.21	
	May	31	0.10	0.27	1.86	2.13	5.53	136	0.49	0.00	6.02	4.31	
	Jun	30	0.38	0.98	1.80	2.78	5.36	105	0.38	0.00	5.73	1.37	
	Jul	31	7.64	20.46	0.93	21.39	5.80	101	0.36	0.00	6.16	16.60	
	Aug	31	18.82	50.41	0.00	50.41	5.80	126	0.45	24.95	31.21	35.80	

Year	Month		Inflow to Reservoir		Delivered	Total	Intake	Evapratio	Losses	Spilled	Total Out	Balance	Remarks
			cu.m/s	MCM	MCM	MCM	MCM	mm	MCM	MCM	MCM	MCM	
1994	Sep	30	11.43	29.63	0.00	29.63	5.61	110	0.40	23.62	29.63	35.80	
	Oct	31	2.10	5.62	0.00	5.62	5.53	176	0.63	0.00	6.17	35.26	
	Nov	30	0.30	0.78	1.80	2.58	5.36	186	0.67	0.00	6.02	31.81	
	Dec	31	0.19	0.51	1.86	2.37	5.53	158	0.57	0.00	6.10	28.08	
	Jan	31	0.08	0.21	1.86	2.07	5.53	160	0.58	0.00	6.11	24.04	
	Feb	28	0.03	0.07	1.68	1.75	5.00	137	0.49	0.00	5.49	20.30	
	Mar	31	0.04	0.11	1.86	1.97	5.53	141	0.51	0.00	6.04	16.23	
	Apr	30	0.05	0.13	1.80	1.93	5.36	134	0.48	0.00	5.84	12.32	
	May	31	0.06	0.16	1.86	2.02	5.53	136	0.49	0.00	6.02	8.32	
	Jun	30	0.27	0.70	1.80	2.50	5.36	105	0.38	0.00	5.73	5.09	
Jul	31	4.71	12.62	0.93	13.55	5.80	101	0.36	0.00	6.16	12.47		
1995	Aug	31	12.72	34.07	0.00	34.07	5.80	126	0.45	4.49	10.74	35.80	
	Sep	30	5.69	14.75	0.00	14.75	5.61	110	0.40	8.74	14.75	35.80	
	Oct	31	0.97	2.60	0.00	2.60	5.53	176	0.63	0.00	6.17	32.23	
	Nov	30	0.26	0.67	1.80	2.47	5.36	186	0.67	0.00	6.02	28.68	
	Dec	31	0.14	0.37	1.86	2.23	5.53	158	0.57	0.00	6.10	24.81	
	Jan	31	0.11	0.29	1.86	2.15	5.53	160	0.58	0.00	6.11	20.86	
	Feb	28	0.05	0.12	1.68	1.80	5.00	137	0.49	0.00	5.49	17.17	
	Mar	31	0.05	0.13	1.86	1.99	5.53	141	0.51	0.00	6.04	13.12	
	Apr	30	0.13	0.34	1.80	2.14	5.36	134	0.48	0.00	5.84	9.42	
	May	31	0.15	0.40	1.86	2.26	5.53	136	0.49	0.00	6.02	5.66	
Jun	30	0.13	0.34	1.80	2.14	5.36	105	0.38	0.00	5.73	2.06		
Jul	31	4.32	11.57	0.93	12.50	5.80	101	0.36	0.00	6.16	8.40		
1996	Aug	31	11.72	31.39	0.00	31.39	5.80	126	0.45	0.00	6.25	33.54	
	Sep	30	3.83	9.93	0.00	9.93	5.61	110	0.40	1.66	7.67	35.80	
	Oct	31	0.49	1.31	0.00	1.31	5.53	176	0.63	0.00	6.17	30.95	
	Nov	30	0.26	0.67	1.80	2.47	5.36	186	0.67	0.00	6.02	27.39	
	Dec	31	0.14	0.37	1.86	2.23	5.53	158	0.57	0.00	6.10	23.53	
	Jan	31	0.13	0.35	1.86	2.21	5.53	160	0.58	0.00	6.11	19.63	
	Feb	29	0.09	0.23	1.74	1.97	5.18	137	0.49	0.00	5.67	15.92	
	Mar	31	0.09	0.24	1.86	2.10	5.53	141	0.51	0.00	6.04	11.98	
	Apr	30	0.08	0.21	1.80	2.01	5.36	134	0.48	0.00	5.84	8.15	
	May	31	0.07	0.19	1.86	2.05	5.53	136	0.49	0.00	6.02	4.18	
Jun	30	0.92	2.38	1.80	4.18	5.36	105	0.38	0.00	5.73	2.63		
Jul	31	11.32	30.32	0.93	31.25	5.80	101	0.36	0.00	6.16	27.72		
Aug	31	11.72	31.39	0.00	31.39	5.80	101	0.36	17.15	23.31	35.80		

7.6 ディレダムからの導水管能力の検討

$$H=10.666*C^{-1.85}*D^{-4.87}*Q^{1.85}*L$$

C= Velocity factor

Q= Discharge (m3/s)

D= Pipe diameter (m)

L= Pipe length (m)

700 mm L= 3,060 m

600 mm L= 7,200 m

(1) In case Q= 56,600 m3/day , C=100

0.655 m3/s

			Dire Dam LWL= 2,532.50 m	
Q ₇₀₀ =	0.655 m3/s	V= 1.7024 m/s	H= 16.901 m	
Q ₆₀₀ =	0.655 m3/s	V= 2.3171 m/s	H= 84.249 m	
			Total H= 101.150 m	
			LWL= 2,431.35 m	Balance
			Regadadi intake HWL= 2,431.35 m	0.000 m

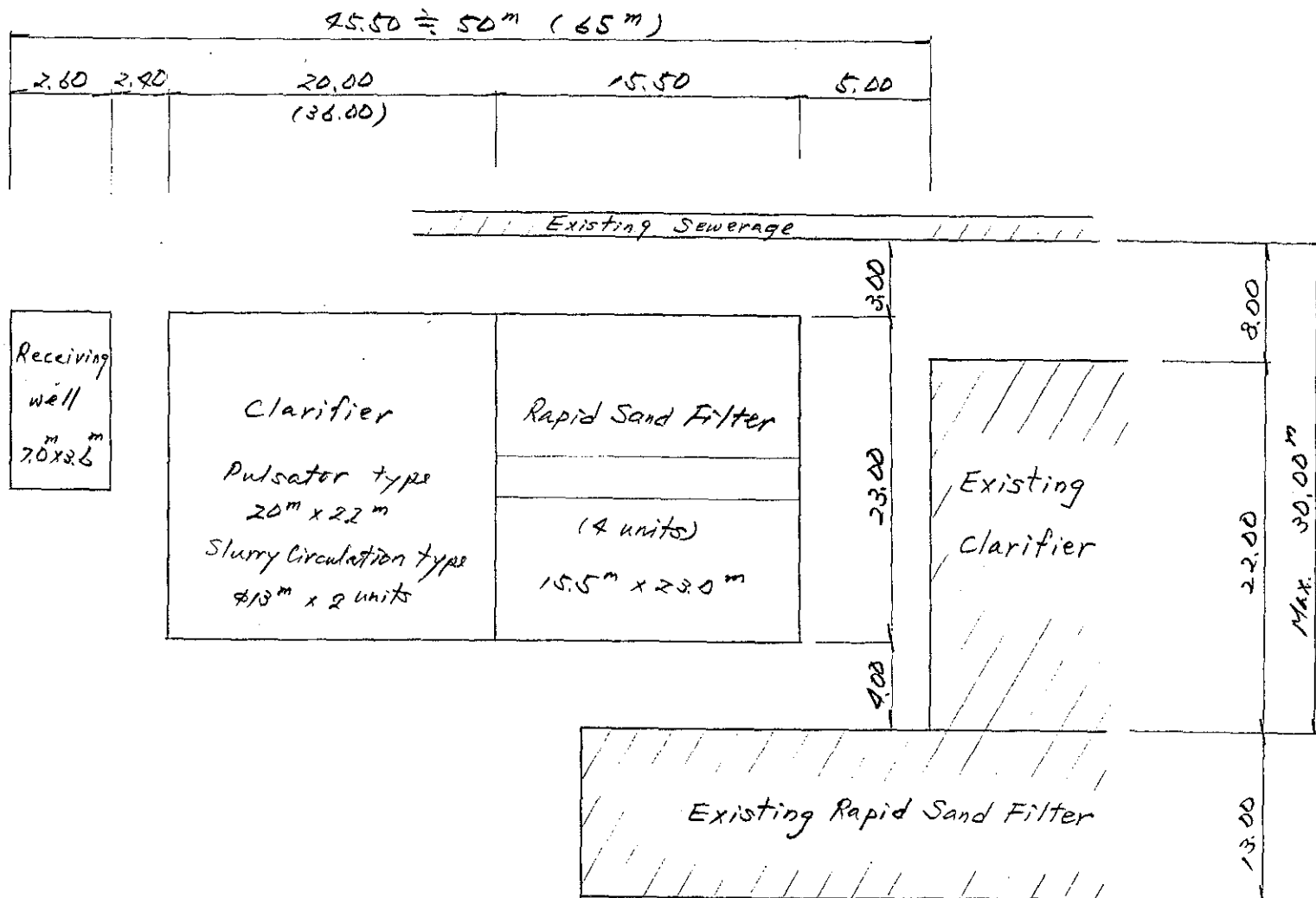
(2) In case Q= 62,200 m3/day , C=110

0.720 m3/s

			Dire Dam LWL= 2,532.50 m	
Q ₇₀₀ =	0.720 m3/s	V= 1.8726 m/s	H= 16.901 m	
Q ₆₀₀ =	0.720 m3/s	V= 2.5488 m/s	H= 84.249 m	
			Total H= 101.150 m	
			LWL= 2,431.35 m	Balance
			Regadadi intake HWL= 2,431.35 m	0.000 m

7.7 浄水場敷地の検討

Layout for Expansion



() : Slurry Circulation type

7.8 送水管能力の検討

$$H=10.666*C^{-1.85}*D^{-4.87}*Q^{1.85}*L$$

C= Velocity factor C=100

Q= Discharge (m³/s)

D= Pipe diameter (m)

L= Pipe length (m)

1400 mm L= 6,887 m

900 mm L= 6,887 m

1200 mm L= 11,514 m

900 mm L= 11,514 m

(1) In case Q= 140,000 m³/day

1.620 m³/s

Head Tank LWL= 2,426.76 m

Q₁₄₀₀= 1.144 m³/s H= 3.652 m

Q₁₂₀₀= 1.144 m³/s H= 12.935 m

Total H= 16.587

Q₉₀₀= 0.476 m³/s H= 6.208 m

Q₉₀₀= 0.476 m³/s H= 10.379 m

Total H= 16.587

LWL= 2,410.17 m Balance

Terminal Reservoir LWL= 2,408.80 m 1.37 m

(2) In case Q= 150,000 m³/day

1.736 m³/s

Head Tank LWL= 2,426.76 m

Q₁₄₀₀= 1.226 m³/s H= 4.149 m

Q₁₂₀₀= 1.226 m³/s H= 14.696 m

Total H= 18.845

Q₉₀₀= 0.510 m³/s H= 7.053 m

Q₉₀₀= 0.510 m³/s H= 11.792 m

Total H= 18.845

LWL= 2,407.92 m Balance

Terminal Reservoir LWL= 2,408.80 m -0.88 m

(3) In case Q= 170,000 m³/day

1.968 m³/s

Head Tank LWL= 2,426.76 m

Q₁₄₀₀= 1.389 m³/s H= 5.230 m

Q₁₂₀₀= 1.389 m³/s H= 18.525 m

Total H= 23.755

Q₉₀₀= 0.578 m³/s H= 8.891 m

Q₉₀₀= 0.578 m³/s H= 14.864 m

Total H= 23.755

LWL= 2,403.01 m Balance

Terminal Reservoir LWL= 2,408.80 m -5.79 m

$$H = 10.666 * C^{-1.85} * D^{-4.87} * Q^{1.85} * L$$

C = Velocity factor C=100 (1400mm & 1200mm) , C=90 (900mm)

Q = Discharge (m³/s)

D = Pipe diameter (m)

L = Pipe length (m)

1400 mm L = 6,887 m

900 mm L = 6,887 m

1200 mm L = 11,514 m

900 mm L = 11,514 m

(4) In case Q = 140,000 m³/day

1.620 m³/s

Head Tank LWL = 2,426.76 m

Q₁₄₀₀ = 1.179 m³/s H = 3.859 m

Q₁₂₀₀ = 1.179 m³/s H = 13.669 m

Total H = 17.528

Q₉₀₀ = 0.442 m³/s H = 6.560 m

Q₉₀₀ = 0.442 m³/s H = 10.968 m

Total H = 17.528

LWL = 2,409.23 m Balance

Terminal Reservoir LWL = 2,408.80 m 0.43 m

(5) In case Q = 150,000 m³/day

1.736 m³/s

Head Tank LWL = 2,426.76 m

Q₁₄₀₀ = 1.263 m³/s H = 4.385 m

Q₁₂₀₀ = 1.263 m³/s H = 15.529 m

Total H = 19.914

Q₉₀₀ = 0.473 m³/s H = 7.453 m

Q₉₀₀ = 0.473 m³/s H = 12.461 m

Total H = 19.914

LWL = 2,406.85 m Balance

Terminal Reservoir LWL = 2,408.80 m -1.95 m

(6) In case Q = 170,000 m³/day

1.968 m³/s

Head Tank LWL = 2,426.76 m

Q₁₄₀₀ = 1.431 m³/s H = 5.527 m

Q₁₂₀₀ = 1.431 m³/s H = 19.576 m

Total H = 25.103

Q₉₀₀ = 0.536 m³/s H = 9.395 m

Q₉₀₀ = 0.536 m³/s H = 15.707 m

Total H = 25.103

LWL = 2,401.66 m Balance

Terminal Reservoir LWL = 2,408.80 m -7.14 m

7.10 新規ダムによる水源代替え案の検討

Alternative Study to Increase Water Supply Capacity

The new Lege Hola Dam and Reservoir at about 5 km downstream of Dire Dam was proposed by in the 9.7 of Chapter 9 (Master Plan Study for Regedai, Dire and Geffersa Catchment Areas) for the effective utilization of spilled water from the Dire Dam that is estimated by 23 MCM per annum in average.

Simulation of water balance using above mentioned data is shown the possible production capacity of new water treatment plant from 53,000 to 85,000 cu.m/day, but more study have to be done.

Water flows among the Dire Dam, Legadadi Dam and WTP and New Lege Hola Reservoir are shown as follows;

Lege Hola Dam and Reservoir

Effective Capacity	Estimated Production	Note
11.0 MCM	53,000 cu.m/day	Proposed by M/P, almost not utilized spilled water from Dire Dam due to less capacity of reservoir
16.5 MCM	70,000 cu.m/day	Occasional use of spilled water at drought years, but possibility of such dam should be confirmed.
22.0 MCM	85,000 cu.m/day	Effective use of spilled water, but the possibility of such dam should be confirmed

Water Allocation and Flow

