activities which are already over have been taken as per actuals while the activities which are yet to take place are projected taking into consideration the most probable period required. It will be seen that while working out the actual activities completed, the time durations for certain items are much higher than the normal which happened in this case due to the delays mentioned earlier. For examples, the activity (14) viz. working plans and estimates for raw and clear water pumping machinery should not have taken 73 weeks. A realistic figure would be around 20 to 30 weeks depending upon several factors like availability of staff etc. Therefore while drawing up the CPM chart at the beginning stages itself, it may be necessary to assume more rational figures of time duration based on the experience of the department and not providing for any delays. The charts can , however, be updated periodically. The following 11 major components of the scheme are further sub-divided into 102 activities to complete the project. The number of the activities on the network diagram is also shown in brackets for ready reference.

Major Components	Activity			Time Duration (weeks)
		Item	No.	
I. Head Works (including Raw Water Rising Main)	(i)	Working plans & estimates	(2)	43
	(ii)	Sanction	(3)	7
	(iii)	Draft tender papers	(4)	2
	(iv)	Receiving tenders	(5)	6
	(v)	Evaluate tenders &award of contract	(6)	10
				68
	(vi)	Execution work		
	(a)	Intake well connecting pipe, twin jack well	(10)	78
	(b)	Pump house	(73)	26
	(c)	Approach bridge with approach road and fencing to head works	(11)	78
	(d)	Part excavation of raw water rising main	(7)	20
	(e)	Part laying of raw water rising main	(9)	36

Major Components	Activity			Time Duration (weeks)
		Item	No.	
	(f)	Excavation of balance raw water rising main	(8)	20
	(g)	Laying balance length of rising main	(72)	36
	(h)	Fixing specials and valves constructing chambers on the rising main	(73)	12
II Pumping machinery for raw water and clear water group I	(i)	Working plans and estimates	(14)	73
	(ii)	Sanction	(15)	10
	(iii)	Draft tender papers	(16)	4
	(iv)	Receive tenders	(17)	8
	(v)	Evaluate tender & award of contract	(70)	12
	(vi)	Deliveries of pumping machinery,	(74)	48
		C.I pipes, specials, valves,	(88)	48
		gantry girders, etc	(87)	48
	(vii)	Erection works	(101)	12
			(101)	
			(83)	
	(viii)	Trial run	(102)	4
III Clear Water Pumping Machinery Group II	(i)	Working plans and estimates	(43)	73
	(ii)	Sanction	(44)	10
	(iii)	Draft tender papers	(45)	4

Major Components	Activity			Time Duration (weeks)
		Item	No.	
	(iv)	Receive tenders	(46)	6
	(v)	Evaluate tenders & award of contract	(64)	4
	(vi)	Delivery of pumping machinery, C.I pipes, specials, valves, gantry girders etc.	(69)	32
			(68)	32
	(vii)	Erection work	(100)	8
			(100)	8
	(viii)	Trial run	(102)	4
IV Treatment Works	(i)	Draft tender papers	(18)	62
	(ii)	Receive tenders	(19)	6
	(iii)	Evaluate tenders & award of contract	(76)	16
	(iv)	Execution work		84
	(a)	Supply of mechanical and electrical equipment for clariflocculator.	(79)	44
	(b)	Supply of mechanical and electrical equipment for filters.	(81)	60
	(c)	Erection of all equipment upto clariflocculator	(80)	8
	(d)	Erection of all equipment upto filters	(82)	14
	(e)	Civil works for clariflocculator	(77)	44

Major Components		Activity					Time Duration (weeks)	
			Item		No.			
		(f)	Civil works for filters		(78)		55	
		(g)	Trial run of filters		(102)		4	
V.	Clear Water Reservoir And Pump House	(i)	Working plans & estimates		(20)		78	
		(ii)	Approval		(21)		3	
		(iii)	Draft tender papers		(22)		3	
		(iv)	Receive tenders		(23)		6	
		(v)	Evaluate tenders and award of contract		(85)		8	
		(vi)	Execution		(86)		35	
				Group I			Group II	
				At treatment works at point A			At points B & C	
VI	R.C.C. Service Reservoirs	(i)	Working plans B&C	(24)	80		(36)	80
		(ii)	Approval	(25)	6		(37)	6
		(iii)	Draft tender papers	(26)	8		(38)	8
		(iv)	Receive tenders	(27)	6		(39)	6
		(v)	Evaluate tenders and award of contract	(89)	8		(70)	8
		(vi)	Execution	(90)	65		(98)	65
				(91)	65		(99)	65
VII	Clear Water Rising Mains and Gravity Mains	(a)	Rising Main to S.R. at treatment works					
		(b)	Rising Main to S.R. Point A					

Major Components		Activity			Time Duration (weeks)
			Item	No.	
		(c)	Booster main to Point B		
		(d)	Booster main to Point C		
		(e)	Gravity main from S.R. at Point A to Point B.		
		(i)	Working plans and estimates	(31)	73
		(ii)	Approval	(32)	10
		(iii)	Draft tender papers	(33)	4
		(iv)	Receive tenders	(34)	6
		(v)	Evaluate tenders and of contract award	(92)	4
		(vi)	Execution	(93,94, 95,96,97)	24
VIII	Booster Pumping stations		At Point B and C		
		(i)	Working plans and estimates and approval	(40)	90
		(ii)	Draft tender papers	(41)	4
		(iii)	Receive tenders	(42)	4
		(iv)	Evaluate tenders and contract award	(65)	2
		(v)	Execution	(66,67)	24

Major Components		Activity			Time Duration (weeks)
			Item	No.	
IX	Nalla Diversion Nalla to be diverted to Downstream of Head Works to control pollution	(i)	Working Plans and estimates	(48)	97
		(ii)	Approval	(49)	4
		(iii)	Draft tender papers	(50)	2
		(iv)	Receive tenders	(51)	4
		(v)	Evaluate tenders and contract award	(52)	2
		(vi)	Execution	(53)	20
X.	Staff Quarters	At Head Works, Treatment Works, etc.			
		(i)	Working plans and estimates	(54)	93
		(ii)	Approval	(55)	6
		(iii)	Draft tender papers	(56)	4
		(iv)	Receive tenders	(57)	6
		(v)	Evaluate tenders	(58)	8
		(vi)	Execution	(59)	52
XI	Miscellaneous Works		(a) i) Land acquisition for head works and booster pumping stations including barbed wire fencing.	(60)	140
			ii) Providing internal roads, external W.S and drainage arrangements to quarters, etc.	(61)	32
		(iii)	Providing electrical installation to staff quarters, pump house, boosting stations and at headworks &	(62)	32

Major Components	Activity			Time Duration (weeks)
		Item	No.	
		treatment works premises.		
	(b)	Telephone connections	(63)	155
	(c)	C.I pipes, valves, specials		
		(New order to be placed)		
		(i) Indent	(12)	77
		(ii) Supply order by S.E	(13)	4
		(iii) Delivery	(71)	65
	(d)	C.I pipes against old order placed by S.E on 31-5-1973		
		(i) Supply order	(29)	37
		(ii) Delivery	(30)	65
	(e)	Final transfer of Govt. land for treatment works, clear water reservoir and pump house and S.R at Treatment works.	(75)	85
	(f)	Obtaining permission of B & C Deptt. for crossing NH for clear water rising main to S.R at point A.	(28)	130
	(g)	Obtaining permission of Railways for crossing railway track for	(35)	130

2962 UA&E/97—39A

Major Components	Activity			Time Duration (weeks)
		Item	No.	
		clear water gravity main from S.R to Lane at Point A.		
	(h)	Erecting transmission lines & transformers at headworks, treatment works and booster pumping station.	(47)	130

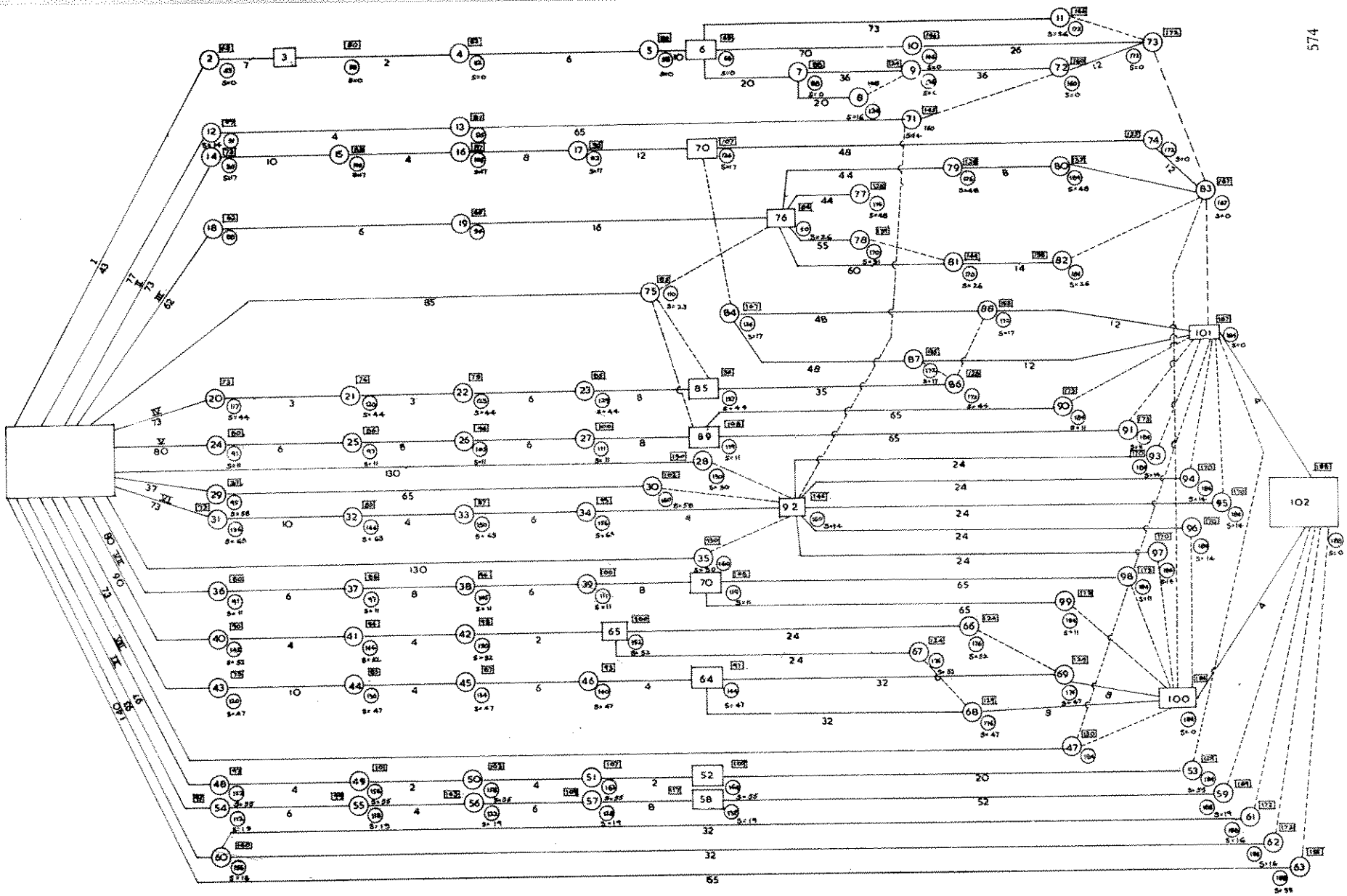
From the Network Diagram, it may also be seen that the Prime Critical Path is through the Headworks and covering the activities 1-2-3-4-5-6-10-73-83-101-102 as shown and the time of completion is 188 weeks. Since 4 weeks of testing for all pumping plant and machinery and 12 weeks for erection of raw water pump set are included in this 188 week periods the time duration for the different major components could be summarized as:

I	Headworks including Raw Water Rising Main	172 Weeks
II	Raw Water and Clear Water Pumping Machinery	167 weeks
III	Treatment works	
(a)	Clariflocculators	136 weeks
(b)	Filters	158 weeks
IV	Clear Water Sump and Pump House	128 weeks
V.	R.C.C. Services Reservoirs	173 Weeks
VI	Clear Water Rising and Gravity Mains	128 weeks
VII	Booster Pump Stations	124 weeks
VIII	Nallah Diversion	129 weeks
IX.	Staff Quarters	169 weeks
X.	Miscellaneous Works	

2962 UA&E/97—39B

(a)	Land acquistion for head works and provisions of barbed wire fencing, internal roads, etc.	172 weeks
(b)	Transfer of Government land for treatment works, etc.	85 weeks
(c)	Telephone connections	155 weeks
(d)	Supply of C.I. pipes and specials	
(i)	New order to be Placed	146 weeks
(ii)	Orders already placed	102 weeks
(e)	Obtaining permission of PWD for National Highway crossing of the rising main	130 weeks
(f)	Obtaining permission of Railways for crossing railway tracks	130 weeks

By proper advance planning and continuous persuasive efforts, it should be possible that the salient works are completed in 188 weeks which is the critical period for the major items of headworks, raw water mains and treatment works so that water could be made available to the consumers even if the scheme is not complete in all respects.



C.P.M. NET-WORK DIAGRAM FOR A TYPICAL WATER SUPPLY AUGMENTATION SCHEME

APPENDIX 5.1

MASS DIAGRAM FOR IMPOUNDING STORAGE

PROBLEM

Draw the mass diagram and compute the storage needed for an impounding reservoir for a constant draft of 23 ml/sqkm/month of 30.4 days with the following recorded mean monthly run of values.

Order of month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Observed monthly mean run off, million litres per square Kilometers	94	122	45	5	5	2	0	2	16	7	72	92	21	55	33

SOLUTION

Methodology

The mass diagram is obtained by plotting the time interval (order of the month) as abscissa and the cumulative run off and cumulative draft up to the corresponding time interval as calculated in table below as ordinates.

TABLE SHOWING CALCULATION OF REQUIRED STORAGE

(Volume of water in million liters per square kilometre)

Order of month	Recorded run-off Q	Estimated draft D	Comul-ative run-off ΣQ	Deficiency D-Q	Cumula-tive deficiency Σ(D-Q)	Reservoir state
(1)	(2)	(3)	(4)=Σ(2)	(5)=(3)-(2)	(6)=Σ(5)	(7)
1	94	23	94	-71	0(192)	
2	122	23	216	-99	0(121)	
3	45	23	261	-22	0(22)	Reservoir full at the beginning dry period
4	5	23	266	18	18*	
5	5	23	271	18	36	
6	2	23	273	21	57	*Reservoir empties
7	0	23	273	23	80	

Order of month	Recorded run-off Q	Estimated draft D	Comul-ative run-off ΣQ	Deficiency D-Q	Cumula-tive deficiency Σ(D-Q)	Reservoir state
8	2	23	275	21	101	
9	16	23	291	7	108	
10	7	23	298	16	124	Maximum deficiency at end of dry period
11	72	23	370	-49	75	
12	92	23	462	-69	6	
13	21	23	483	2	8	
14	55	23	538	-32	0(24)	Reservoir refilled
15	33	23	571	-10	0(34)	

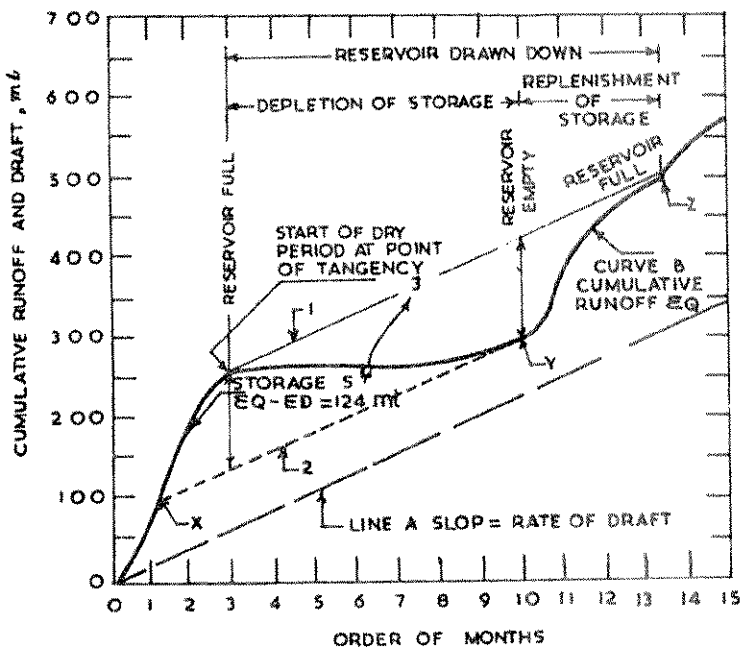
Col 3 Constant rate of draft = 23 mL/ sq km for an average month of 30.4 days.

Col. 5. Negative value indicates surplus.

Col. 6. Negative values are not included in Σ (D-Q) until the beginning of dry period i.e. until water is lost from storage and there is room to store incoming flows. The surplus preceding the dry period, however, must equal or exceed the preceding maximum deficiency; otherwise the reservoir will not be full at the beginning of dry period. The cumulative surplus, calculated backwards from the beginning of dry period, is shown in brackets in column 6 and is seen to exceed 124 mL/sq km of catchment area. The cumulative run-off curve 'B' has been drawn as shown in the figure.

The cumulative draft line for the area under consideration is also plotted in the same scale (line A) assuming constant draft of 23 mL/sq km of catchment area for a month of 30.4 days. The slope of line 'A' indicates the rate of draft.

The maximum deficit of run off from the draft is obtained by drawing a straight line parallel to the cumulative draft curve at the crest and through the cumulative run-off curve tangentially. The vertical ordinate length intercepted between two such parallel lines tangential to the crest and trough gives the maximum deficit for the period between the points of intersection of the parallel line with the mass curve. The maximum cumulative deficiency as observed from the mass curve (which could also be determined analytically as shown in the table) is 124 mL/sq km of catchment area. For the constant rate of draft of 23 mL/sq km of catchment area for a month of 30.4 days and for this cycle of runoff values , the impounded storage needed is for (124/23)x 30.4 i.e 165 days (almost half a year).



1. DRAW CUMULATIVE DRAFT ΣD PARALLEL TO RATE OF DRAFT A AND TANGEN TO CURVE B
2. DRAW PARALLEL TO LINE A AND TANGENT TO CURVE B
3. MEASURE MAXIMUM DEFICIENCY CUMULATIVE
   ΣD − ΣQ = 124 ml

X. MUST INTERSECT RUNOFF CURVE, IF RESERVOIR IS TO BE FULL AT START OF DRY PERIOD.

Y. END OF DRY PERIOD AT POINT OF TANGENCY.

Z. MUST INTERSECT RUNOFF IF RESERVOIR IS TO REFILL.

MASS—DIAGRAM FOR IMPOUNDING STORAGE

APPENDIX 5.2

GROUND WATER RESOURCES AND IRRIGATION POTENTIAL

(Provisional)

States/ Uts	Total Replenshi-ble Ground Water Resource	Provision For Drinking Industrial & Other Uses	Utilisable Ground Water Resources For Irrigation	Net Draft	Balance Available For Irrigation	Net Irrigation Require-ments	Ultimate Irrigation Potential	Potential Utilised	Balance Irr. Pot. To Be Developed
	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(Range) (m)	(m ha)	(m ha)	(m ha)
1	2	3	4	5	6	7	8	9	10
STATES									
Andhra Pradesh	4.34	0.65	3.69	0.74	2.95	(0.558-.0909)	5.19	1.04	4.15
Arunachal Pradesh	0.14	0.02	0.12	0.00	0.12		0.002		0.02
Assam	2.35	0.35	2.00	0.05	1.95	1.280	1.56	0.04	1.52
Bihar	3.38	0.51	2.87	0.68	2.19	0.400	7.18	1.70	5.48
Goa	0.061	0.015	0.046	0.0040	0.0420	0.600	0.076	0.006	0.070

States/ Uts	Total Replenshi-ble Ground Water Resource	Provision For Drinking Industrial & Other Uses	Utilisable Ground Water Resources For Irrigation	Net Draft	Balance Available For Irrigation	Net Irrigation Require-ments	Ultimate Irrigation Potential	Potential Utilised	Balance Irr. Pot. To Be Developed
	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(Range) (m)	(m ha)	(m ha)	(m ha)
1	2	3	4	5	6	7	8	9	10
Gujrat									
Confined	0.22	0.03	0.19	0.11	0.08	(0.0364 - 0.500)	0.44	0.25	0.19
Un-confined	2.04	0.31	1.73	0.53	1.20	(.0315 -0.500)	4.37	1.37	3.00
Haryana	0.85	0.13	0.72	0.51	0.21	0.385	1.88	1.32	0.56
Himachal Pradesh	0.036	0.007	0.029	0.006	0.023	0.385	0.074	0.016	0.088
Jammu & Kashmir	0.44	0.07	0.37	0.005	0.365	(0.385 -0.600)	0.783	0.012	0.771
Karnataka	1.62	0.24	1.38	0.50	0.88	(0.350 - 0.360)	3.12	0.70	2.420
Kerala	0.81	0.12	0.69	0.07	0.62	0.690	0.99	0.09	0.90
Madhya Pradesh	5.97	0.89	5.08	0.60	4.48	0.400	12.70	1.50	11.20
Mahara-shtra	3.38	0.67	3.20	0.70	2.50	(0.400 -0.750)	5.84	1.32	4.52
Manipur	0.012	0.002	0.010	0.00	0.01	0.650	0.016		0.016

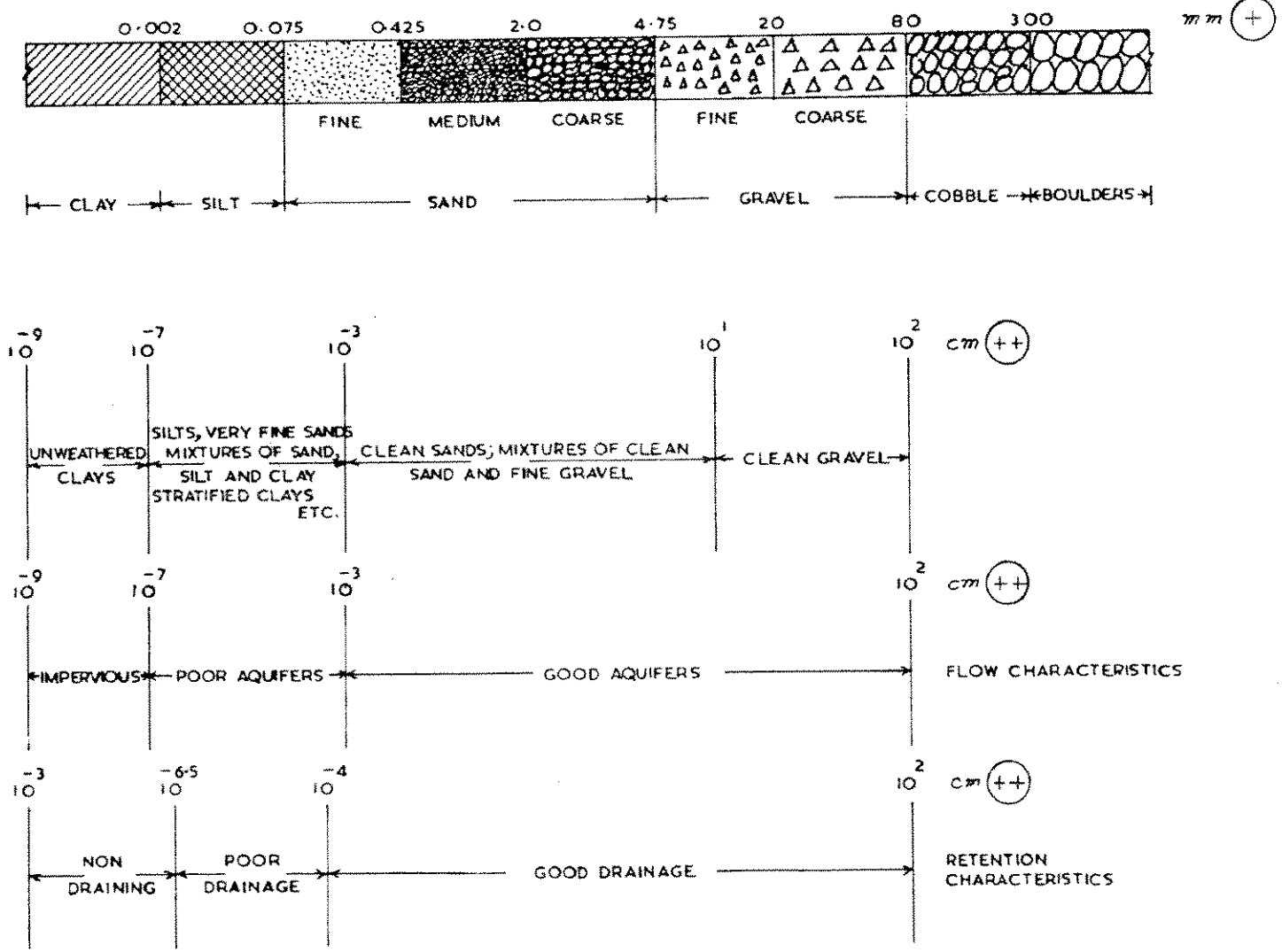
States/ Uts	Total Replenshi-ble Ground Water Resource	Provision For Drinking Industrial & Other Uses	Utilisable Ground Water Resources For Irrigation	Net Draft	Balance Available For Irrigation	Net Irrigation Require-ments	Ultimate Irrigation Potential	Potential Utilised	Balance Irr. Pot. To Be Developed
	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(Range) (m)	(m ha)	(m ha)	(m ha)
1	2	3	4	5	6	7	8	9	10
Meghal-aya	0.043	0.007	0.036	0.000024	0.035976	0.650	0.056	0.00004	0.05596
Mizoram					Not Assessed				
Nagaland	0.006	0.001	0.004	0.00	0.004				
Orissa	2.33	0.35	1.98	0.10	1.88	(0.34 - 0.44)	5.40	0.25	5.15
Punjab	1.80	0.27	1.53	1.52	0.01	0.400	3.82	3.80	0.02
Rajasthan	1.62	0.29	1.33	0.50	0.83	(0.39- 0.42)	3.44	1.26	2.18
Sikkim					Not Assessed				
Tamilnadu	3.02	0.46	2.56	1.20	1.36	(0.360 -0.937)	3.35	1.45	1.90
Tripura	0.06	0.01	0.05	0.005	0.045	0.630	0.06	0.008	0.072
Uttar pradesh	8.05	1.21	6.84	2.50	4.34	.360	18.00	11.50	6.50
West Bengal	2.07	0.31	1.76	0.29	1.47	(0.6-1.67)	1.88	0.23	1.65
Total states	45.147	6.922	38.225	10.620	27.605		80.265	27.862	52.40296

States/ Uts	Total Replenshi-ble Ground Water Resource	Provision For Drinking Industrial & Other Uses	Utilisable Ground Water Resources For Irrigation	Net Draft	Balance Available For Irrigation	Net Irrigation Require-ments	Ultimate Irrigation Potential	Potential Utilised	Balance Irr. Pot. To Be Developed
	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(Range) (m)	(m ha)	(m ha)	(m ha)
1	2	3	4	5	6	7	8	9	10
Say	45.15	6.92	38.23	10.62	27.61		80.27	27.86	52.41
UNION TERRI-TORIES									
Andam-an & Nicobar									
Chandi-garh	0.0035		0.0035	0.0059	0.0024				
Dadra & Nagar Haveli	0.0075	0.0023	0.0062	0.005	0.0047	0.6500	0.0080	0.0007	0.0073
Delhi	0.0604	0.0076	0.0428	0.0287	0.0141	0.3850	0.1112	0.0745	0.0367
Daman & Diu					Not Assessed				
Laksha-dweep					Not Assessed				
Pondic-herry	0.0175	0.0026	0.0149	0.0204	-0.0055	0.0000	0.0000	0.0000	0.0000

States/ Uts	Total Replenshi-ble Ground Water Resource	Provision For Drinking Industrial & Other Uses	Utilisable Ground Water Resources For Irrigation	Net Draft	Balance Available For Irrigation	Net Irrigation Require-ments	Ultimate Irrigation Potential	Potential Utilised	Balance Irr. Pot. To Be Developed
	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(m ha m/Yr)	(Range) (m)	(m ha)	(m ha)	(m ha)
1	2	3	4	5	6	7	8	9	10
Total UTs	0.0789	0.0125	0.0664	0.0555	0.0109	1.0350	0.1192	0.0752	0.0440
Say	0.08	0.01	0.07	0.06	0.01		0.12	0.08	0.04
Total All India	45.2259	6.9345	38.2914	10.6755	27.6159		80.3842	27.9372	52.4469
Say	45.23	6.93	38.30	10.68	27.62		80.38	27.94	52.44

*The estimates of ground Water Resources and as per the norms and guidelines laid down by the Ground Water Estimation Committee (1984) assessed by the working group based by the state Irrigation Secretary incharge of Ground Water Department and comprised of the head of the Ground Water Organisation in the State Director of State Agricultural Department and representative from Agriculture Universities and the regional Director of Control Ground Water Board as the convenor.

APPENDIX 5.3



(+) EFFECTIVE SIZE IN *MM*

(++) CO-EFFICIENT OF PERMEABILITY *CM*/SEC. AT UNIT HYDRAULIC GRADIENT CLASSIFICATION OF SOIL

APPENDIX 5.4

VALUES OF THE WELL FUNCTION F(U) FOR VARIOUS VALUES OF U

N	N x 10^{-15}	N x 10^{-14}	N x 10^{-13}	N x 10^{-12}	N x 10^{-11}	N x 10^{-10}	N x 10^{-9}	N x 10^{-8}
1	2	3	4	5	6	7	8	9
1.0	33.96	31.66	29.36	27.05	24.75	22.45	20.15	17.84
1.5	33.56	31.25	28.95	26.65	24.35	22.04	19.74	17.44
2.0	33.27	30.97	28.66	26.36	24.06	21.76	19.45	17.15
2.5	33.05	30.74	28.44	26.14	23.83	21.53	19.23	16.93
3.0	32.86	30.56	28.26	25.96	23.65	21.53	19.05	16.75
3.5	32.71	30.41	28.10	25.80	23.50	21.20	18.69	16.59
4.0	32.57	30.27	27.97	25.67	23.36	21.06	18.76	16.46
4.5	32.46	30.15	27.85	25.55	23.25	20.94	18.64	16.34
5.0	32.35	30.05	27.75	25.44	23.14	20.84	18.54	16.23
5.5	32.26	29.95	27.65	25.35	23.05	20.74	18.44	16.14
6.0	32.17	29.87	27.56	25.26	22.96	20.66	18.35	16.05
6.5	32.09	29.79	27.48	25.18	22.88	20.58	18.27	15.97
7.0	32.02	29.71	27.41	25.11	22.81	20.50	18.20	15.90
7.5	31.95	29.64	27.34	25.04	22.74	20.43	18.13	15.83
8.0	31.88	29.58	27.28	24.97	22.67	20.37	18.07	15.76
8.5	31.82	29.52	27.22	24.91	22.61	20.31	18.01	15.70
9.0	31.76	29.46	27.16	24.86	22.55	20.25	17.95	15.65
9.5	31.71	29.41	27.11	24.86	22.50	20.20	17.89	15.59