Sl. No	Chemical	Common Name	Formula	Use	Available Forms	Commercial Strength	Appearance And Properties	Usual Solution or Suspension Strength	Method of Feeding	Materials Used For Handling Solution	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12
18.	Ferric chloride	Chloride of iron	$FeCl_2 .6H_2O$	Coagulant	Lump sticks crystals	60 % $FeCl_3$	Yellow brown highly hygroscopic, very corrosive	3-5 %	Wet, proportion-ating pump	Rubber lined tank or stoneware containers plastic	-
19.	Ferric chloride (solution)	Do	$FeCl_2$	do	Solution	30-40 % $FeCl_3$	Brown solution, very corrosive	3-5 %	Wet proportion-ating pump	do	-
20.	Ferric sulphate	Iron sulphate, ferrifloc	$Fe_2(SO_4)_3 . H_2O$	Coagulant	Granules crystals lumps	18.5-0.1 % Fe	Red brown or grey crystals mildly hygroscopic	3-5 %	wet	Dry; iron stainless steel and concrete wet : lead or stainless steel plastics	Solution is corrosive
21.	Ferrous sulphate	Copperas, green vitriol;sugar sulphate	$FeSO_4 7H_2O$	do	do	20 % Fe	Green to brownish yellow crystals hygroscopic	4-8 %	Wet	do	Cakes in storage above 20 °C lime addition necessary plastics
22.	Hydrazine hydrate	-	$H_2H_4H_2O$	Deoxygena-tion	Solid powder	64 %	White powder	-	Wet, proportion-ating	Stainless steel pump	
23.	Hydroch-loric acid	Muriatic acid	HCl	in cation exchange	Regenerant	Liquid	30 % HCl liquid	5 – 10%	Wt. Pump	Glass rubber lined	Dangerous chemical

Sl. No	Chemical	Common Name	Formula	Use	Available Forms	Commercial Strength	Appearance And Properties	Usual Solution or Suspension Strength	Method of Feeding	Materials Used For Handling Solution	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12
				operation						tanks	
24.	Potassium aluminium sulphate	Potash alum	K_2SO_4 $Al_2(SO_4)_3$ $24H_2O$	Coagulant	Lump, powder, blocks	8-11 % Al_2O_3	White crystalline, acidic corrosive hygroscopic	1 %	Wet or dry	-	Generally used in business filters
25.	Sodium aluminate	Soda alum	$Na_2Al_2O_3$	Coagulant	Crystalline flakes,solution	43-45 % Al_2O_2	White to grey crystal, liquid caustic, alkaline	5 %	Wet and dry	Cast iron mild steel concrete	Generally used along with filter alum
26.	Sodium carbonate	Soda ash	Na_2CO_3	pH adjustment softening	Dense crystals; powder	98-99 % Na_2CO_3	White powder, caustic	1-10 %	Dry or wet proportion-ating pumps	-	Dangerous chemical
27.	Sodium chloride	Common salt	NaCl	Softening regenerant	Crystals	90-95 % NaCl	Colourless crystals	8-10 %	Wet, fed through, injection nozzles	Bitumen or epoxy coated M.S. tanks	-
28.	Sodium chromate	Chromate	$NaCrO_4$	Corrosion prevention anodic inhibition	Crystals	80-90 % Na_2CrO_4	Yellow/ brown crystals	-	Wet, proportion-ating pump	Stainless steel, plastic	Dangerous chemical, harmful to eyes. Used in combination with sodium silicate

Sl. No	Chemical	Common Name	Formula	Use	Available Forms	Commercial Strength	Appearance And Properties	Usual Solution or Suspension Strength	Method of Feeding	Materials Used For Handling Solution	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12
29.	Sodium hexameta phosphate	Calgan, glassy phosphate	$(NaPO_2)_4$	Scale and corrosion prevention	Powder, flakes	60-63 % P_2O_2	Like broken glass	0.25	Wet proportiona ting pump	Stainless steel, plastic, hard rubber	Holds up ppm of Fe, Mn,Ca and Mg ;for M.S. protective coating
30.	Sodium hydroxide	Caustic soda	NaOH	pH adjustment, softening and filter cleaning	Flakes lumps, pellets, powder	96-99 %	Alkaline, corrosive, hygroscopic	1-10 %	Wet, proportiona ting pumps, orifices box; rotameter	Cast iron; mild steel; rubber lined	Dangerous chemical
31.	Sodium hydroxi-de(solut-ion)	Caustic soda, iye	NaOH	do	solution	10-40 % NaOH	Syrupy solution	do	do	do	do
32.	Sodium sulphate	-	Na_2SO_4	Deoxygena-tion	Powder lumps	90-99 % Na_4SO_2	White powder	1 %	Wet, proportion-ating pump	Satinless steel plastics	8mg/l sodium sulphate required to remove 1 mg/l O_2
33.	Sulphur dioxide	-	SO_2	Dechlorinati on or filter cleaning	Gas	100 %	Colourless pungent	-	Dry	Steel	-

Sl. No	Chemical	Common Name	Formula	Use	Available Forms	Commercial Strength	Appearance And Properties	Usual Solution or Suspension Strength	Method of Feeding	Materials Used For Handling Solution	REMARKS
1	2	3	4	5	6	7	8	9	10	11	12
34.	Sulphuric acid	Vitriol	H_2SO_4	pH adjustment, lowering of alkalinity	Liquid	60-90 % (commercial H_2SO_4)	Syrupy ; corrosive; hygroscopic	1-2 %	Wet, dilute solution, orifice box rotameter	Lead, porcelain or rubber	Always add acid to water ; dangerous chemical
35.	Sulphuric acid	do	do	Regenerant cation exchange operation	do	98 %H_2SO_4	do	do	Wet, pumping	Lead, glass or rubber lined tank	do

APPENDIX 9.1

COMPUTATION OF CHEMICAL DOSAGES IN WATER SOFTENING TREATMENT PROCESS USING LIME SODA PROCESS

1. Problem Statement

The water with following chemical constituents is to be softened using Lime Soda Process.Compute the quantities of chemicals required to treat 250 m^3/hr of water flow assuming practical units of removal for $CaCO_3$ to be 30 mg/l and for $Mg(OH)_2$ as 10 mg/l.

CO_2	= 9.9 mg/l	Alkalinity (CO_3)	= 175 mg/l
Ca^{++}	= 100 mg/l	SO_4^{2-}	= 107 mg/l
Mg^{++}	= 8.9 mg/l	Cl^-	= 17.8 mg/l
Na^+	= 11.5 mg/l		

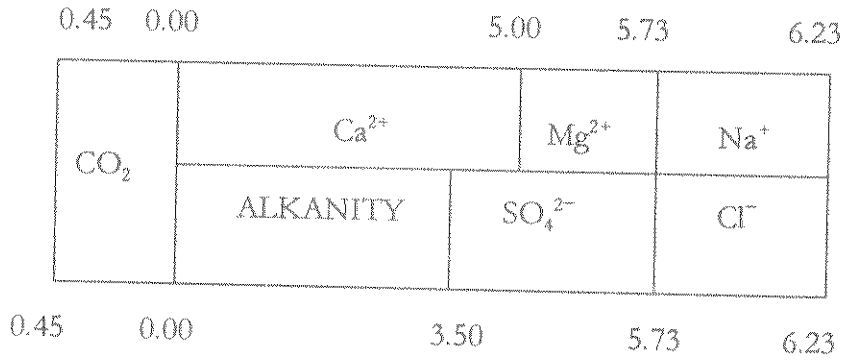
2. Solution

1. Compute me/l of all components present in water.

Sl.No.	Component	Concentration mg/l	Equivalent weight	Conc. me/l.
1	CO_2	9.9	22.0	0.45
2	Ca^{2+}	100.0	20.0	5.00
3	Mg^{2+}	8.9	12.2	0.73
4	Na^+	11.5	23.0	0.50
5	Alkalinity	175.0	50.0	3.50
6	SO_4^{2-}	107.0	48.0	2.23
7	Cl^-	17.8	35.5	0.50

2. Prepare a me/l bar graph of raw water with hypothetical combination.

In preparing such a bar graph , the concentration of cations is usually arranged left to right starting with Ca2+ followed by Mg^{2+}, Na^+ etc. in that order . Similarly, below the cations, anions are arranged left to right commencing with alkalinity followed by SO_4^{2-}, Cl^- etc.The CO2 being a molecule is conventionally shown to the left of zero mark .



Graph

3. Compute the quantities of chemicals required.

(a) Chemical reactions:

$$CO_2 + Ca(OH)_2 \rightleftharpoons CaCO_3 + H_2O \quad (1)$$
$$Ca(HCO_3)_2 + Ca(OH)_2 \rightleftharpoons 2CaCO_3 + 2H_2O \quad (2)$$
$$MgSO_4 + Ca(OH)_2 \rightleftharpoons Mg(OH)_2 + CaSO_4 \quad (3)$$
$$CaSO_4 + Na_2CO_3 \rightleftharpoons CaCO_3 + Na_2SO_4 \quad (4)$$

It may be noted that it is necessary to add excess lime, usually a surplus of 35 mg/l as CaO or 1.25 me/l above stoichiometric requirement, to raise pH for precipitation of Magnesium by reaction at (3)

No.	Components	Conc. me/l	Lime required me/l	Soda ash Required me/l	Remarks
1	CO_2	0.45	0.45	-	Reaction(1)
2	$Ca(HCO_3)_2$	3.50	3.50	-	(2)
3	$CaSO_4$	1.50	-	1.50	(4)
4	$MgSO_4$	0.73	0.73	0.73	(3) & (4)
			4.68	2.23	

Lime required = Stiochiometric quantities + excess lime
= 4.68 + 1.25 = 5.93 me/l
= 166.04 mg /l as CaO
= 219.41 mg/l as $Ca(OH)_2$

Soda Ash required = 2.23 me/l.
= 118.19 mg/l as Na_2CO_3

Annual consumption of lime as CaO

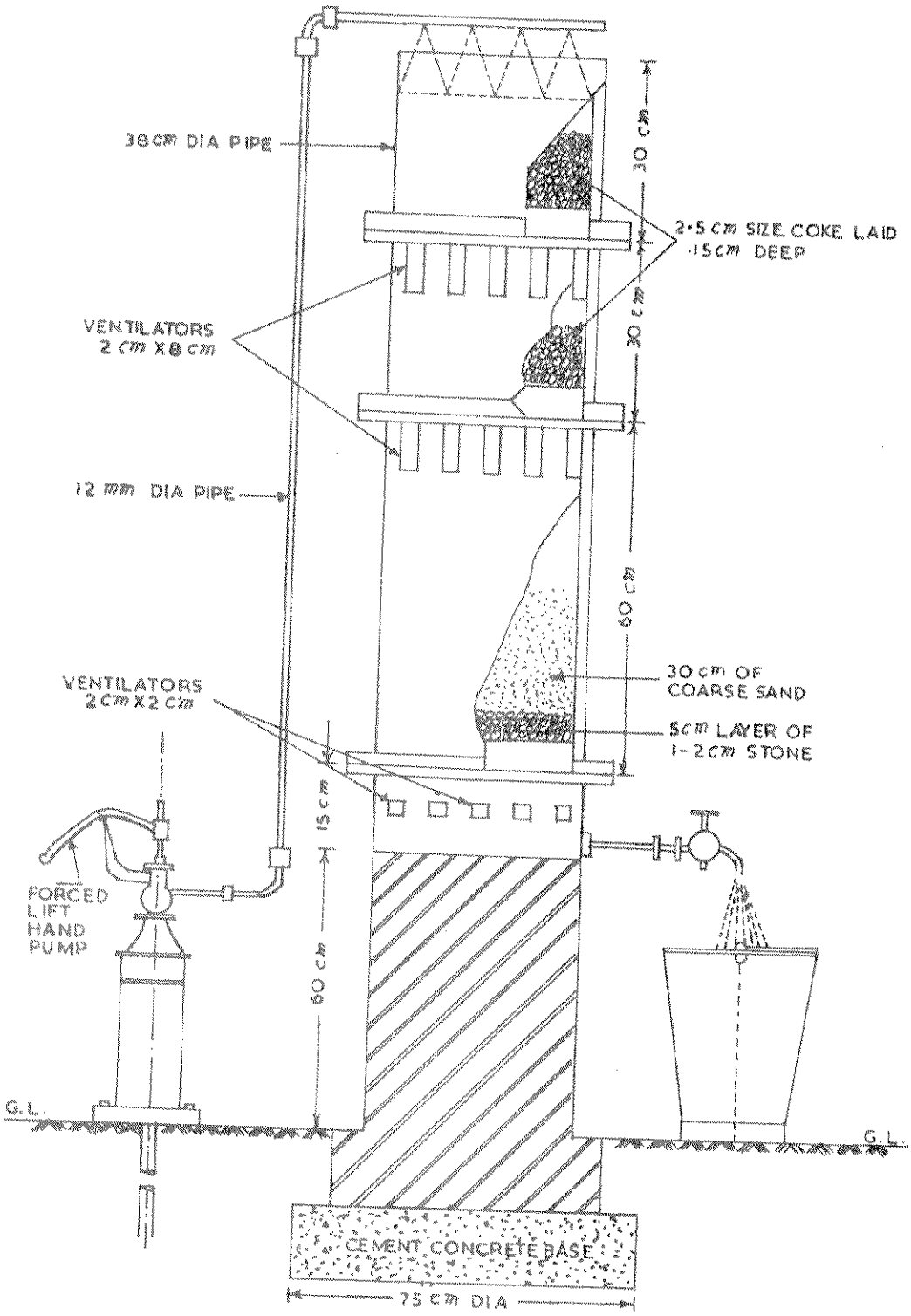
$$= (166.04 \times 250 \times 24 \times 10^3 \times 365) / (10^6 \times 10^3)$$
$$= 363.63 \text{ metric tons}$$

Annual consumption of Soda ash as Na_2CO_3

$$= (118.19 \times 250 \times 24 \times 10^3 \times 365) / (10^6 \times 10^3) \quad \text{metric tons}$$
$$= 258.84 \text{ metric tons}$$

2962 UA&E/97—44A

APPENDIX 9.2



TYPE DESIGN OF IRON REMOVAL PLANT

(CAPABLE OF GIVING 200 LITRES PER HOUR)

2962 UA&E/97—44B

APPENDIX 9.3

DESIGN OF IRON REMOVAL UNITS

Typical designs of iron removal units for 5,10 and 20 m^3/h follow.

DESIGN CONSIDERATIONS

- Schemes have been designed for 5, 10 and 20 m^3/h flow and 10 % extra water quantity to provide for sedimentation bleed losses and filter back wash requirements.
- Power shut-downs are frequent and rarely more than two hours supply is available in the morning and evening. Accordingly, raw water pumping hours assumed to be 2 hours in the morning and two hours in the evening. During these four hours pumping period, total daily requirements of water are to be pumped to elevated storage tank to draw water by gravity flow to the treatment unit(s).
- To avoid extra cost for additional overhead tank for filtered water, it is assumed that the filtered water from the sump-well will be directly pumped for the distribution. The distribution of treated water would follow the same time schedule as contemplated for pumping raw water.
- Backwashing of the sand filter would be carried out by using raw water from the overhead tank.

DESIGN CRITERIA

- Water consumption — 40 lpcd
- Tray aerator
  - Spacing of Trays — 0.3 m.
  - Aeration Rate — 1.26 $m^3/m^2/h$
- Sedimentation Basin
  - Detention Period — 2.5 h
- Sand Filter
  - Effective Size — 0.6-0.8 mm
  - Uniformity Coefficient — 1.3 to 1.7
  - Sand Depth — 1.2 m
  - Total head above sand — 1.35 m
  - Rate of Filtration — 4.88 $m^3/m^2/h$
  - Minimum Backwash Rate — 35 $m^3/m^2/h$
  - Total Head for Filter Wash — 12 m
  - Gravel Depth — 0.39-0.62 m

Gravel Size

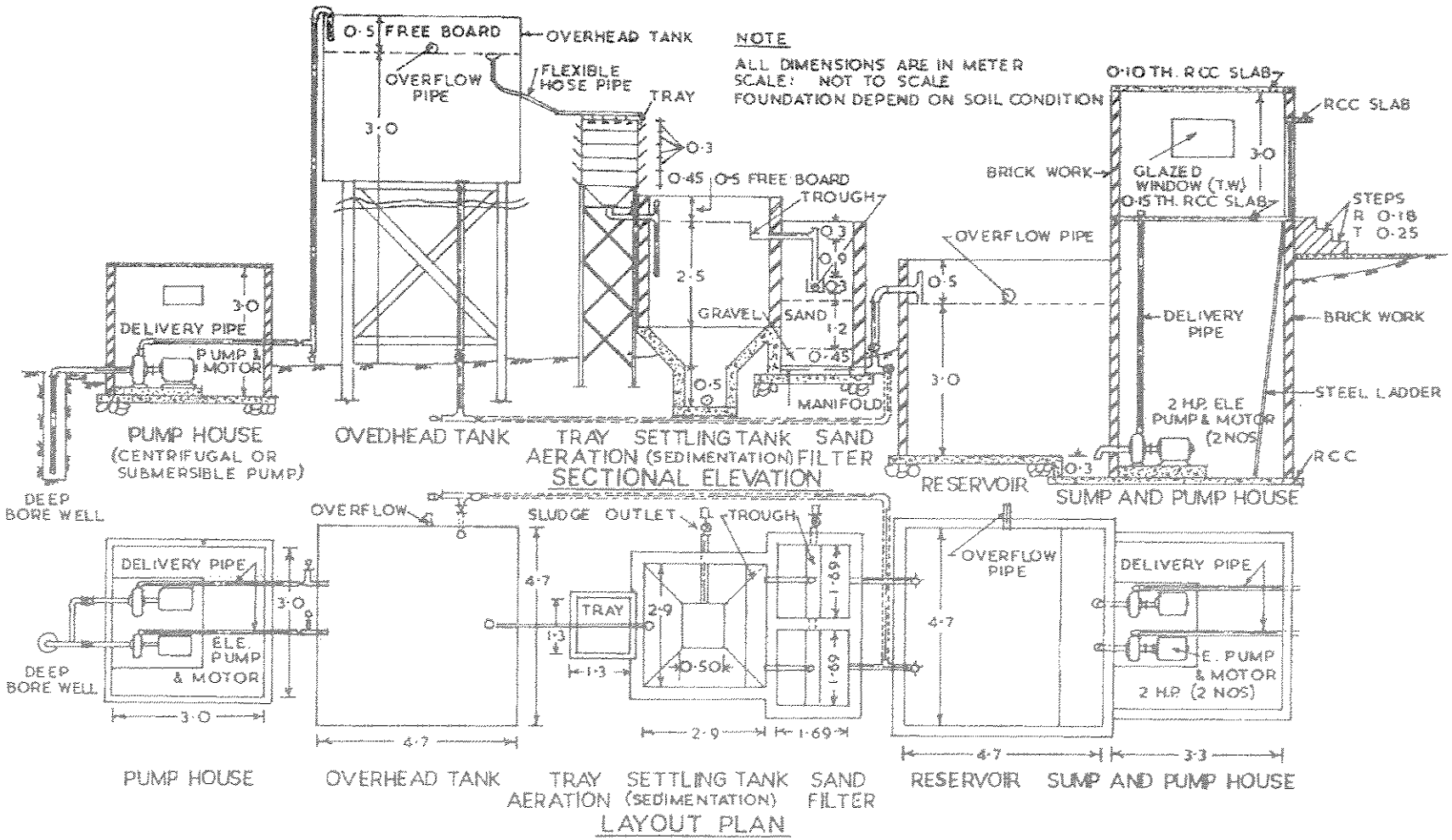
65-38 mm	13-20 cm
38-20 mm	8-13 cm
20-12 mm	8-13 cm
12-5 mm	5- 8 cm
5- 2 mm	5- 8 cm

specifications of units are detailed in the following Table and the arrangements are as shown in Fig. 9.8 to 9.10.

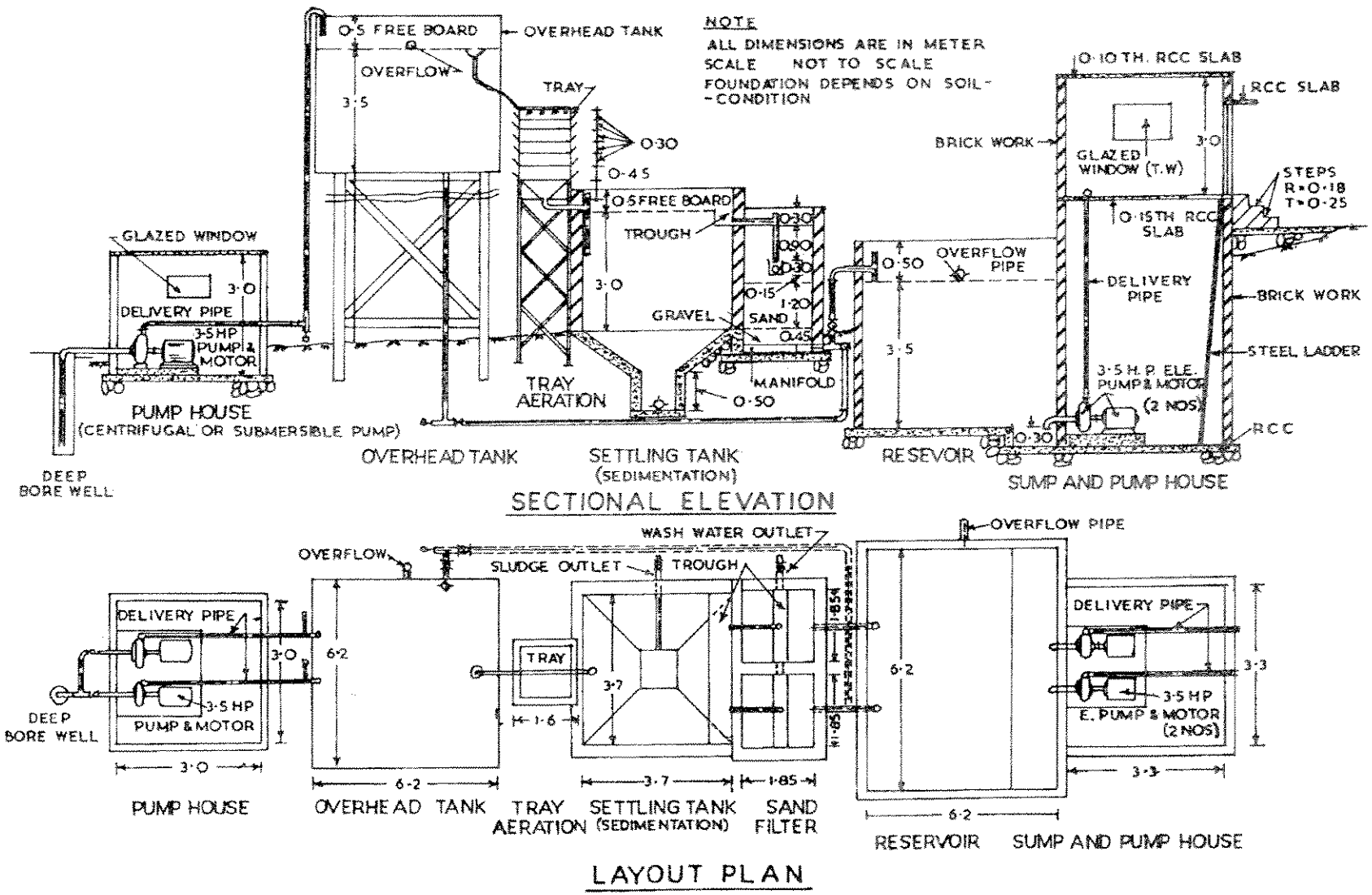
TABLE

DESIGN SPECIFICATIONS FOR CONTINUOUS IRON REMOVAL UNIT FOR COMMUNITY WATER SUPPLY

Design capacity, m^3/h	5	10	20
Raw water Pump, hp	2.0, 2 Nos	3.4, 2 Nos	7, 2Nos
Overhead Reservoir			
Capacity, m^3	66	132	264
Size	4.7m x 4.7m x 3m	6.2m x 6.2m x 3.5m	8.7m x 8.7m x 3.5m
Tray Aerators			
No. of Trays	4	5	6
Collection trough	1	1	1
Tray size	1.3 m x 1.3m	1.6 m x 1.6m	2.lm x 2. lm
Height of each tray	.03 m	0.3m	0.3 m
Sedimentation Tank			
Size	2.9m x 2.9 m x 2.5m	3.7m x 3.7m x 3.0m	5.25m x 5.25m x 3.0m
Sand Filter			
Size	1.69 m x 1.69m	1.85m x 1.85 m, 2 Nos	2.6m x 2.6 2 Nos
Clear Water Storage Tank	4.7m x 4.7m x 3m	6.2m x 6.2m x 3.5m	8.7m x 8.7m x 3.5m



CONTINUOUS IRON REMOVAL FOR COMMUNITY WATER SUPPLY CAPACITY 5 m^3/h



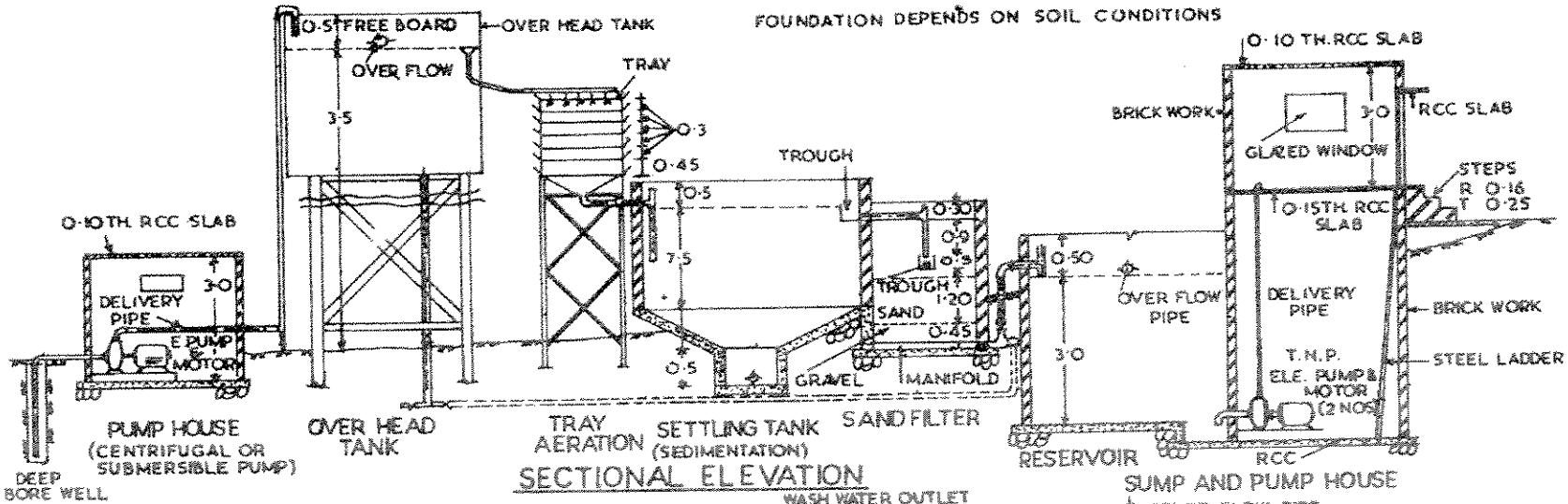
CONTINUOUS IRON REMOVAL FOR COMMUNITY WATER SUPPLY CAPACITY 10 m³/h

NOTE :-

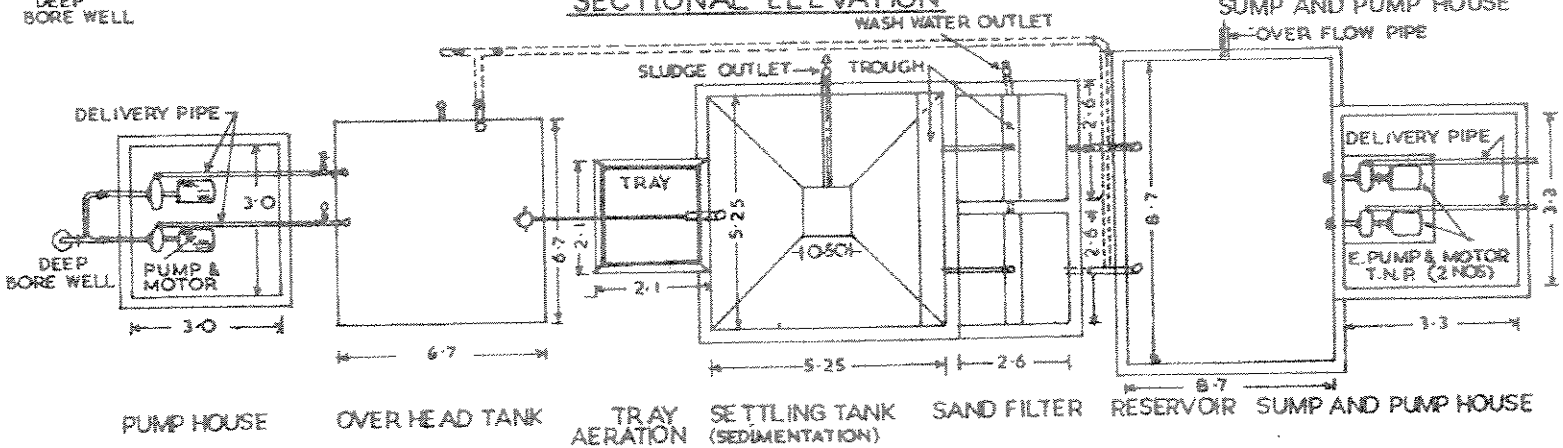
ALL DIMENSIONS ARE IN METER

SCALE – NOT TO SCALE

FOUNDATION DEPENDS ON SOIL CONDITIONS



SECTIONAL ELEVATION



LAYOUT PLAN

CONTINUOUS IRON REMOVAL FOR COMMUNITY WATER SUPPLY CAPACITY 20 m^3/h

APPENDIX 9.4

SOLAR RADIATION

North range Lat.		Probable average values of insolation - Direct and Diffused on a Horizontal surface at sea level at Langley's per day.							
		January		February		March		April	
0		Visible	Total	Visible	Total	Visible	Total	Visible	Total
34	Max[e]	114	360	160	450	204	553	254	659
	Min[f]	53	155	78	215	118	320	141	385
32	Max	126	380	169	450	212	570	258	663
	Min	63	180	87	240	126	340	146	395
30	Max	136	400	176	490	218	587	261	875
	Min	76	220	96	260	134	362	151	405
28	Max	146	420	184	510	224	603	264	683
	Min	87	250	106	290	142	373	156	415
26	Max	156	440	192	530	230	615	266	690
	Min	99	280	114	310	149	390	160	425
24	Max	166	460	200	545	236	625	268	697
	Min	111	310	123	340	156	410	164	433
22	Max	174	480	206	560	241	644	270	701
	Min	123	355	132	370	162	426	167	440
20	Max	183	500	213	575	246	652	271	703
	Min	134	360	140	390	168	440	170	447
18	Max	192	515	220	590	250	664	272	705
	Min	144	380	150	410	174	459	174	452
16	Max	200	530	226	610	255	670	272	707
	Min	154	400	159	430	180	473	177	456
14	Max	208	555	233	630	258	680	271	709
	Min	163	430	167	450	184	487	179	400
12	Max	216	572	239	645	262	690	271	710
	Min	172	455	176	450	189	500	181	462
10	Max	223	595	244	655	264	694	271	711
	Min	179	475	184	490	193	513	183	464
8	Max	230	610	249	665	267	700	270	709
	Min	187	495	192	510	196	523	185	467

APPENDIX 9.4 (Continued)

SOLAR RADIATION

North range Lat.		Probable average values of insolation - Direct and Diffused on a Horizontal surface at sea level at Langley's per day.							
		May		June		July		August	
	0	Visible	Total	Visible	Total	Visible	Total	Visible	Total
34	Max[e]	290	743	297	775	289	763	267	696
	Min[f]	176	462	168	439	178	472	159	448
32	Max	290	744	296	772	289	761	269	700
	Min	181	475	166	731	178	472	163	458
30	Max	290	744	296	768	289	759	271	702
	Min	184	490	163	425	178	469	166	462
28	Max	289	743	294	764	288	755	272	704
	Min	187	506	161	418	178	467	169	466
26	Max	288	741	292	760	288	749	273	706
	Min	189	518	158	409	177	463	172	169
24	Max	288	738	290	753	287	742	273	708
	Min	191	525	155	403	176	459	174	471
22	Max	286	734	286	747	285	736	273	707
	Min	193	530	152	392	173	454	176	472
20	Max	284	730	284	738	282	729	272	706
	Min	194	532	148	383	172	450	177	472
18	Max	282	723	280	728	280	723	272	705
	Min	194	530	145	375	170	442	177	471
16	Max	279	718	276	720	277	715	270	702
	Min	194	528	141	363	167	435	177	469
14	Max	276	710	272	710	273	708	265	700
	Min	194	524	137	354	164	429	177	467
12	Max	273	702	267	700	269	700	267	697
	Min	193	518	133	343	161	421	176	464
10	Max	270	694	262	688	265	690	266	693
	Min	192	512	129	330	158	414	176	460
8	Max	266	685	258	678	260	680	263	688
	Min	191	506	124	320	154	405	174	456

APPENDIX 9.4 (Continued)

SOLAR RADIATION

North range Lat.		Probable average values of insolation - Direct and Diffused on a Horizontal surface at sea level at Langley's per day.							
		September		October		November		December	
	0	Visible	Total	Visible	Total	Visible	Total	Visible	Total
34	Max[e]	221	602	178	490	128	380	101	338
	Min[f]	134	368	96	250	70	202	47	158
32	Max	226	615	185	510	138	400	114	360
	Min	140	385	104	270	80	221	60	184
30	Max	321	625	192	524	148	420	126	380
	Min	147	399	113	290	90	256	70	210
28	Max	236	635	119	537	157	440	138	400
	Min	154	415	120	310	99	278	80	236
26	Max	240	652	205	552	166	460	149	420
	Min	160	429	128	332	109	300	90	260
24	Max	244	659	212	568	175	480	101	440
	Min	165	443	136	360	119	326	101	280
22	Max	248	668	218	582	183	500	172	460
	Min	170	455	143	380	128	350	110	300
20	Max	252	674	224	596	190	520	182	480
	Min	176	467	150	400	138	370	120	320
18	Max	256	680	229	605	198	538	192	500
	Min	180	479	157	418	146	390	129	340
16	Max	259	684	234	615	206	554	200	520
	Min	185	489	164	434	154	410	138	300
14	Max	262	688	240	627	214	567	209	530
	Min	189	496	170	449	162	430	146	380
12	Max	264	691	244	640	221	585	217	550
	Min	193	502	176	462	169	446	154	400
10	Max	266	693	248	650	228	600	225	570
	Min	196	510	181	474	176	462	102	420
8	Max	267	695	252	660	234	616	231	590
	Min	200	518	186	468	182	478	169	440

EXPLANATORY NOTE

(a) Calculated from data published by the United States Weather Bureau

(b) Gram Calories per square cm = Langley

(c) "Visible" Radiation of wavelengths of $4000A^0$ to $7000A^0$ penetrating a smooth water surface .

(d) Total Radiation of all wavelengths in solar spectrum .

(e) Value which will not normally be exceeded .

(f) Value based on or extrapolated from lowest values observed for indicated month and latitude during 10 years of record.

Approximate corrections for elevation upto 3000m

Total radiation = Total(1+0.6105El)

Visible radiation = Vis.(1+0.03053El) where El.is in thousands of metres.

Correction for cloudiness (approx.) = Min+[(Max-Min) Cl.]Where Cl is fraction of time weather is clear.

APPENDIX 10.1

CALCULATION OF CAPACITY OF SERVICE RESERVOIR

PROBLEM

Find out capacity of storage reservoir for the following two situations viz.,

(i) Power is not available from 6a.m.to 10a.m. daily

(a) 16 hrs. of pumping during 10p.m. to 6a.m. and 10a.m.to 6p.m..

(b) 8 hrs.of pumping during 4a.m. to 6a.m. and 12 noon to 6p.m.

(ii) Power is available throughout 24 hrs.

(a) 16 hrs.of pumping during 4a.m.to 12 noon and 1p.m.to 9p.m.

(b) 8 hrs. of pumping during 4a.m. to 8p.m. and 2p.m. to 6p.m.

Data given are:

1. Design population-24,000
2. Per Capita water supply-90 lpd
3. Peak factor-2.25
4. Peak hours: 6a.m. to 10a.m.,1p.m.to 2p.m.,5p.m.to 6p.m.
5. Other than peak hours, hourly demands are as follows:
   - (i) 20% of average hourly demand:11p.m. to 4a.m..
   - (ii) 40% of.average hourly demand: 4 a.m. to 5 a.m. and 10 p.m. to 11 p.m.
   - (iii) 60% of average hourly demand: 12 noon to 1 p.m.
   - (iv) 70% of average hourly demand: 2p.m. to 5 p.m. and 8 p.m. to 10 p.m.
   - (v) 80% of hourly demand: 5 a.m. to 6 a.m.
   - (vi) 90% of hourly demand: 6p.m. to 8p.m.
   - (vii) 100% of hourly demand: 10a.m. to 12 noon
6. Water supply is continuous.

SOLUTION

1. Total demand = 24000 x 90lpd = 2.16 mld
2. Average hourly demand = 2.16/24 = 0.09ml = a
3. Peak hourly demand = 2.25 x average hourly demand = 2.25a

Tables 1 and 2 show the compilation for arriving at the capacity of the service reservoir, for 16 and 8hours of pumping.

In Table 1 data from cols.1 to 3 are applicable for both the given situations (i) and (ii). Computed data for situation (i) and (ii) are given in cols. 4,5,6,7, those inside the brackets referring to situation (ii)

Similarly in Table 2 computed data outside the brackets from cols. 2 to 5 refer to the situation (i) while those inside the brackets are for the situation (ii).

Storage required under situations:

(i) (a) 0.8460 mL or 39% of daily demand.

(b) 0.9900 mL or 46% of daily demand.

(ii) (a) 0.3285 mL or 15% of daily demand.

(b) 0.7065 mL or 33% of daily demand.

TABLE 1

SHOWING COMPUTATION FOR CAPACITY OF SERVICE RESERVOIR

Given data			16 hours pumping; pumping rate: =24xa/6		8hours pumping; pumping rate = 24xa / 8 = 3a	
Period in hours	Hourly demand	Cumulative demand	Cumulative pumping	Cumulative deficit or surplus	Cumulative pumping	Cumulative deficit or surplus
(1)	(2)	(3) = Σ {2}	(4)	(5) = (4) - (3)	(6)	(7) = (6) - (3)
04-05	0.400a	0.40a	1.50a(1.50a)	+1.10a(+1.10a)	3.00a(3.00a)	+2.60a(+2.60a)
05-06	0.80a	1.20a	3.00a(3.00a)	+1.80a(1.80a)	6.00a(6.00a)	+4.80a(+4.80a)
06-10	2.25a	10.20a	3.00a(9.00a)	-7.20a(-1.20a)	6.00a(12.00a)	-4.20a(+1.80a)
10-12	A	12.20a	6.00a(12.00a)	-6.20a(-0.20a)	6.00a(12.00a)	-6.20a(-0.20a)
12-13	0.60a	12.80a	7.50a(12.00a)	-5.30a(-0.08a)	9.00a(12.00a)	-3.80a(-0.80a)
13-14	2.25a	15.05a	9.00a(13.50a)	-0.05a(-1.55a)	12.00a(12.00a)	-3.05a(-3.05a)
14-17	0.70a	17.15a	13.50a(18.00a)	-3.65a(0.85a)	21.00a(21.00a)	-3.85a(+3.85a)
17-18	2.25a	19.40a	15.00a(19.50a)	-4.40a(-0.10a)	24.00a(24.00a)	+4.60a(+4.60a)
18-20	0.90a	21.20a	15.00a(22.50a)	-6.20(+1.30a)	24.00a(24.00a)	+2.80a(+2.80a)
20-21	0.70a	21.90a	15.00a(24.00a)	-6.90a(+2.10a)	24.00a(24.00a)	+2.10a(-2.10a)
21-22	0.70a	22.60a	15.00a(24.00a)	-7.60a(+1.40a)	24.00a(24.00a)	+1.40a(+1.40a)
22-23	0.40a	23.00a	16.50a(24.00a)	-6.50a(+1.00a)	24.00a(24.00a)	+1.00a(+1.00a)
23-01	0.20a	23.40a	19.50a(24.00a)	-3.90a(+0.60a)	24.00a(24.00a)	+0.60a(+0.60a)
01-04	0.20a	24.00a	24.00a(24.00a)	0.00a(0.00a)	24.00a(24.00a)	0.00a(+0.00a)