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Water Purification System Based on Rapid Gravity System and City Supply (Raw Water from River Hooghly)

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Abstract: The present study is aimed to develop an understanding on the principles and working of a Rapid Gravity Water Treatment Plant with River Hooghly as its source. The following project gives us an insight to the relative workings of the various parts of the Water Treatment Plant from source to distribution. This also includes detailed design of each of the components of the system.

I. INTRODUCTION

Water, without any doubt, is a basic human need. Providing safe and adequate quantities of the same for all rural and urban communities is perhaps one of the most important undertakings, for the public works dept. Indeed, the well planned water supply scheme is a prime and vital element of a country's infrastructures as on this peg hangs the health and wellbeing of its people.

The population in India is likely to be in excess of hundreds of cores by the turn of this decade with an estimated 40% of urban population. This goes on to say that a very large demand of water supply, for domestic, industrial, fire-fighting, public uses, etc; will have to be in accordance with the rising population hence, identification of source of water supply, there conservation and optimum utilization is of paramount importance. The supplied water should be 'potable' and 'wholesome'. Absolute pure water is never found in nature, but invariable contains certain suspended, colloidal, and dissolved impurities (organic and inorganic in nature, generally called solids), in varying degree of concentration depending upon the source. Hence treatment of water to mitigate and for absolute removal of these impurities (which could be; solids, pathogenic microorganism, odour and taste generators, toxic substances, etc.) become indispensable. Untreated or improperly treated water becomes unfit for intended use and proves to be detrimental for life.

The designed water treatment plant has a perennial river as the basic source of water. The type of treatment to be given depends upon the given quality of water available and the quality of water to be served. Our project deals with the rapid gravity filtration system of 60 MLD capacity.

II. PRESENTATION

A. Basic Data For The Design Of Water Supply System

The following project includes the design of water treatment plant and distribution system and also the preparation of its Technical Report and Engg. drawings showing the required details of collection and treatment units. The following Table gives the basic necessary data required for the design of water treatment plant.

(Table No. 2.1)

No.	Description	
1.	Name of the place	Barrackpore
2.	District	North 24 pgns
3.	Location	(a) About 5 km from Barrackpore Railway Station (b) On the bank of river Hooghly
4.	Latitude (Lat.)	22.78 N
5.	Longitude (Lon.)	88.34 E

(Table No. 2.2)

Sl No.	Design Considerations	Values
1.	Design period (years)	30
2.	Average rate of water supply (LPCD)	135
3.	Industrial demand (MLD)	20%
4.	Quality of raw water • Ph • Turbidity • Total Hardness (mg/L) [as CaCo3] • Chlorides(ppm) • Iron(ppm) • Manganese(ppm) • M.P.N.(No./100ml)	 7 to 7.9 30 to 1200 0 200 0 to 0.03 0.03 to 0.04 3.5
5.	Population of past four decades: • 1980 • 1990 • 2000 • 2010	 65000 85000 100000 125000
6.	F.S.L. of river (R.L. in mts.)	101.1
7.	Invert level of raw material gravity intake pipe (R.L. in mts.)	100
8.	Length of raw water rising main (mts.)	100
9.	Source supply: A river with sufficient perennial flow to satisfy the required demand.	
12.	Bed level of river (m)	115
13.	H.F.L. of river (m)	117

Population of the town

Year 1980 : 65000 (Census data)

Year 2040 : 240000

1) Average daily draft (M.L.D.) : 38.4
2) Maximum daily draft (M.L.D.) : 57.6
3) Design period (Years) : 30

Design data and parameters are collected and incorporated from the generation and supply station of drinking water for Kolkata and used accordingly

B. Components of Water Supply System

Intake Works

Intake well

1. No. of units : 1
2. Dia. of well (m) : 5.5 m
3. Ht. of intake well : 20 m
4. R.L. of bottom well (m) : 97 m
5. R.L. of top of well (m) : 117 m
6. Detention time (min.) : 10 min

Gravity Main

1. No. of units : 1
2. Dia.(m) : 0.85 m
3. Invert level (m) : 100.75
4. Slope : 1 in 300

Jack Well

1. No. of units : 1
2. Dia.(m) : 7.5 m
3. Depth of water (min) : 101.6
4. Detention time (min.) : 2 min

Rising main and pumping units

Rising:

1. Dia.(m) : 0.9m
2. Velocity of flow (m/s) : 1.1 m/s

Pumping unit:

1. Capacity of each pump (HP) : 127 HP
2. No. of pumps : 2

Treatment works

Chemical storage house:

1. Length (m) : 15 m
2. Breadth (m) : 40 m
3. Height (m) : 6 m

Chemical Dissolving Tank:

1. No. of Tank : 2
2. Length (m) : 4 m
3. Breadth (m) : 1.5 m
4. Depth (m) : 1 m

Flash Mixer:

1. No. of units : 1
2. Dia. (m) : 3 m
3. Detention time (min) : 30 sec
4. Height (m) : 9 m
5. Depth of water (m) : 6 m

Clariflocculation

Flocculator:

1. No. of units : 6
2. Dia. (m) :8 m
3. Dia. Of inlet pipes (m) : 0.6m
4. Depth of water flow (m) : 4m
5. Velocity of flow (m/s) : 1 m/s

Clarifier:

1. No. of units : 6
2. Dia. (m) : 20 m
3. Depth of water (m) : 4m
4. Overall max depth of tank at the partition wall (m) : 5.4 m
5. Slope of bottom : 8% of 4m

Rapid Sand Filter:

1. No. of units : 10
2. Surface area (Sq. m) : 66 m^2
3. Dimension of unit (m x m) : 7.4 m x 9.3 m
4. Thickness of sand bed (cm) : 60 cm
5. Thickness of gravel bed (cm) : 50 cm
6. Dia. Of manifold (m) : 125 cm
7. Laterals
   a) Nos : 94
   b) Dia.(mm) : 80 mm
   c) Length (m) : 3.1 m
   d) Spacing (cm) : 20 cm
8. No. of perforations per lateral : 13
9. Dia. Of perforations (mm) : 15 mm
10. Wash water trough : 5 nos of 0.4 m x 0.5 m

Disinfection House:

1. Chlorine required/day (kg) : 107.52 kg
2. Cylinder required/day (no.) : 2 of 100 kg each

Storage Units

Underground Reservoir:

1. No. of units : 1 reservoir with 10 compartments
2. Length (m) : 21 m
3. Breadth (m) : 21 m
4. Depth (m) : 3.5 m

Elevated Service Reservoir:

1. No. of units : 5
2. Dia. (m) : 17 m
3. Depth (m) : 6 m
4. Capacity (Cum) : 1280 m^3

C. Population Forecasting

1) *Design Period:* Water supply project may be designed normally to meet the requirements over a 30 years period after their completion. The time lag between design and completion should be also taken into account. It should not ordinarily exceed 2 years and 5 years even in exceptional circumstances. The 30 years period may however be modified in regard to specific components of the project particularly the conveying mains and trunk mains of the distribution system depending on their useful life or the facility for carrying out extension when required, so that expenditure far ahead of utility is avoided. However in our case the design period has been considered as 30 years per given data.

2) *Population Forecast*

a) *General Considerations:* The population to be served during such period will have to be estimated with due regard to all the factors governing the future growth and development of the city in the industrial, commercial, educational, social and administrative spheres. Special factors causing sudden immigration or influx of population should also be considered.

Calculation of Population with Different Methods
(Table No. 4.1)

Sr. No.	Year	Population (thousand)	Increase (thousand)	Increase %	Incremental increase (thousand)	Decrease in %increase
1	2	3	4	5	6	7
1.	1980	65				
2.	1990	85	20	30.8		
3.	2000	100	15	17.5	-5	13.12
4.	2010	125	25	25	10	-7.75
Total			60	73.42	5	-6.63
Average			20	Rg = 24	i = 2.5	-3.315

b) Arithmetical Increase Method

Using the relation:

$$Pn = Po + nc$$

Where:

Po = Initial population
Pn = Population in nth decade
n = No. of decade
c = Average increase (refer table 2.1, col. 4)

P2040 = 125000 + (3 x 20000)
= 185000

c) *Geometrical Increase Method*

Using the relation:

$$Pn = Po\,(1 + Rg / 100)^n$$

Where:

Pn = Population in the nth decade
Pn = Population of any decade
Rg = Percentage increase (Ref. Table 4.1, col. 5)
N = No. of decade

$$P = 125000 \times [\ \{ 1 + (24 / 100) \}^3]$$
= **240000**

d) Incremental Increase Method

Using the relation:

$$P_n = P_o + (r + i)n$$

Where: r = Average rate of increase in population per decade (Ref. Table 4.1, Col. 4)

i = Average rate of incremental increase per decade

Po = Population in any decade;

Pn = Population in n decade;

$$P = P_o + nx + [\{n(n+1)\}/2] \times i$$

$$= 125000 + (3 \times 20000) + [\{3(3+1)\}/2] \times 2500$$

$$= 200000$$

D. Description of The Various Methods

1) *Arithmetic Increase Method:* This method is based upon assumption that the population increases at a constant rate and rate of growth slowly decreases. In our case also population is increasing at a constant rate with slight decrease in growth rate. Also this method is more suitable for very big and older cities whereas in our case it is smaller and new town. So result by this is although good but not as accurate as desired.
2) *Geometrical Increase Method:* In this method the per decade growth rate is assumed to be constant and which is average of earlier growth rate. The forecasting is done on the basis that the percentage increases per decade will remain same. This method would apply to newer cities with large scope for expansion.
3) *Incremental Increase Method:* This method is an improvement over the above two methods. The average increase in the population is determined by the arithmetical increase method and to this is added the average of the net incremental increase, once for each future decade. This method would apply to cities, likely to grow with a progressively increasing or decreasing rate rather than constant rate.
4) *Decreasing Rate of Growth Method:* As in our case the city is reaching towards saturation as obvious from the graph and it can be seen that rate of growth is also decreasing. Thus this method which makes use of the decrease in the percentage increases is more suitable. This method consists of deduction of average decrease in percentage increase from the latest percentage increase. Thus this gives weightage to the previous data as well as the latest trends. Decrease in percentage increase is worked out average thus giving importance to whole data.
5) *Logical Curve Method:* This is suitable in cases where the rate of increase of decrease of population with the time and the population growth is likely to reach a saturation limit ultimately because of special local factor. The city shall grow as per the logistic curve, which will plot as a straight line on the arithmetic paper with the time intervals plotted against population in percentage of solution.
6) *Simple Graphical Method:* Since the result obtained by this method is dependent upon the intelligence of the designer, this method is of empirical nature and not much reliable. Also this method gives very approximate results. Thus this method is useful only to verify the data obtained by some other method.

E. Calculation of Water Demand

1) Calculation of Different Drafts

Expected population after 30 years = 240000

Average rate of water supply = 135 LPCD

(Including domestic, commercial, public and wastes)

(It can be assumed that city is a residential town i.e low rise buildings)

1. Water required for above purposes for whole town: = 240000 X 135
= 32 MLD

2. Adding Industrial demand @ 20%: = 32 + (0.2 x 32)
= 38.4 MLD

3. Adding fire demand @ 5%: = 38.4 + (38.4 x 0.05)
= 40.3 MLD

- Average daily draft = 38.4 MLD
- Maximum daily draft = 1.5 x 38.4
  = 57.6 MLD
- Coincident draft = maximum daily draft + fire demand
  =57.6+(0.05x38.4)
  = 59.5 MLD

2) Design Capacity for Various Components

a) Intake structure daily draft = 57.6 MLD (max daily draft)

b) Pipe main = maximum daily draft = 57.6 MLD (max daily draft)

c) Filters and other units at treatment plant
= 2 x average daily demand
= 2 x 38.4
= 76.8 MLD

d) Lift pump = 2 x average daily demand
= 2 x 38.4
= 76.8 MLD

F. Physical and Chemical Standards Of Water

Ref: IS 10500 2012

(Table no. 5.1**)**

Sr. no.	Characteristics	Acceptable	Cause of Rejection
1.	Turbidity (units on J.T.U. scale)	1	5
2.	Colour(units on platinum cobalt scale)	5	15
3.	Taste and odour		
4.	PH	6.5 to 8.5	Greater or less
5.	Total dissolved solids (mg/l)	500	2000
6.	Total hardness(mg/l as CaCo3)	200	600
7.	Chlorides(mg/l as C1)	250	1000
8.	Sulphates(mg/l as SO4)	200	400
9.	Fluorides'(mg/l as F)	1.0	1.5
10.	Nitrates(mg/l as NO3)	45	45
11.	Calcium(mg/l as Capacity)	75	200
12.	Magnesium(mg/l Mg)	30	100
13.	Iron(mg/l as Fe)	0.1	0.3
14.	Manganese(mg/l as Mn)	0.05	0.5
15.	Copper(mg/l as Cu)	0.05	1.5
16.	Zinc(mg/l as Zn)	5.0	15.0
17.	Phenolic Compounds(mg/l as phenol)	0.001	0.002
18.	Anionic Detergents(mg/l as MBAS)	0.2	1.0
19.	Mineral oil (mg/l)	0.01	0.3
TOXIC MATERIALS			
20.	Arsenic (mg/l)	0.05	0.05
21.	Cadmium(mg/l)	0.01	0.01
22.	Chromium (mg/l as Hexavalent Cr)	0.05	0.05
23.	Cyanides(mg/l as Cn)	0.05	0.05
24.	Lead (mg/l as Pb)	0.1	0.1
25.	Selenium (mg/l as Se)	0.01	0.01
26.	Mercury(mg/l as Hg)	0.001	0.001
27.	Polynuclear Aromatic Hydrocarbons (mg/l)	0.2	0.2
RADIO ACTIVITY			
28.	GROSS Alpha Activity in pico Curie (pCi/L)	3	3
29.	Gross Beta Activity (pCi/L)	30	30

Comparison Of Given Data and Standard Data

(Table No. 5.2)

Sr. No.	Particulars	Actual	Standard	Difference	Means for Treatment
1.	pH	7.0 to 7.9	7 to 8.5	OK	Not necessary
2.	Turbidity (NTU)	30 to 1200	1 to 4	29 to 1196	Clarifier and RG filter
3.	Total Hardness(mg/l)	0	1	OK	Not necessary
4.	Chlorides(mg/l)	200	200	OK	Not necessary
5.	Iron(mg/l)	0.00 to 0.03	0.1	OK	Not necessary
6.	Manganese(mg/l)	0.03 to 0.04	0.05	OK	Not necessary
7.	MPN (No. 100)	3.5	0.0	3.5	Chlorination

G. Suggested Units of Treatment Plant

Due to previous analysis following units are required to be designed for water treatment plant.

1) Intake Structure

a) Intake well
b) Gravity main
c) Jack well
d) Rising main
e) Pumping System

2) Treatment Unit

a) Coagulant dose
b) Chemical dissolving tank
c) Chemical house
d) Flash mixer
e) Clariflocculator
f) Rapid Gravity filter
g) Chlorination unit

3) Storage Unit

a) Underground storage tank
b) Elevated storage

H. Design Of Units

1) Intake Structures

Design Of Intake Well

Intake well: Intake consists of the opening, strainer or grating through which the water enters, and the conduit conveying the water, usually by gravity to a well or sump. From the well, the water is pumped to the mains or treatment plants. Intakes should also be so located and designed that possibility of interference with the supply is minimized and where uncertainty of continuous serviceability exits, intakes should be duplicated. The following must be considered in designing and locating the intakes:

- The location with respect to the sources of population.
- The prevalence of floating materials, such as ice, logs and vegetation.

Types of Intakes:

- Wet intakes: Water is up to source of supply.
- Dry intakes: No water inside it other than in the intake pipe.

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- Submerged intakes: Entirely under the water.
- Movable and Floating intakes: Used where wide variation in surface elevation with sloping blanks.

Location of Intakes:

- The location of the best quality of water available.
- Currents that might threaten the safely of the intake structure.
- Navigation channels should be avoided.
- Ice flows and other difficulties.
- Formation of shoals and bars.
- Fetch of the wing and other condition affection the weight of waves.
- Ice storm.
- Floods.
- Power availability and reliability.
- Accessibility.
- Distance from pumping station.
- Possibilities of damage by moving objects and hazards.

The intake structure used intake our design is wet-type.

a) Design Criteria

Detention time	= 5 to 10 min
Diameter	= 5 to 10 m
Depth	= 10 m to 30 m
Velocity of flow	= 0.6 to 0.9 m/s
Number of units	= 1 to 3 (4 max)
Freeboard	= 1 to 3 m

b) Design Calculation:

R.L. of River Bed	= 100 m
R.L. of Lowest water level	= 102 m
R.L. of Normal water level	= 110 m
R.L. of High Flood Level (HFL)	= 115 m
Detention Time	= 10 min

Flow of water required i.e

Volume of water entering per second	= [(57.6 x 10^6)/ (24 x 3600 x 1000)]
	= 0.67 m^3/s
Volume of well	= 0.67 x 10 x 60
	= 402 m^3
Cross-sectional area of intake well	= 402/20
	= 20.1 m^2
Diameter of intake well	= 5.5 m
Freeboard given	= 2m

c) Summary

1.	Number of intake wells	1
2.	Diameter of intake well	5.5m
3.	Height of well	20m
4.	R.L. of bottom of well	97 m

Design of Bar Screen

a) Bar screen

River water enters into the intake well through the openings or ports, which are left in the wall steining, and fitted with vertical bar screens. These screens may be made of vertical iron bars of 20mm dia, placed vertically @ 30mm to 50mm horizontal clear spacing and fitted to an angle iron frame, which may be fixed properly in the opening. Depending upon the discharge, the total area of such openings are worked out. Such ports or openings are usually provided at 2 to 3 levels in the well, thus providing one or more ports at each level, depending on the pumping rate. Lower layer ports permit the direct entry of water at the low flow stage of the river, while the upper ports meet requirement at the high flood level. The middle ports are provided at the normal river level.

b) Design Criteria

Diameter of each steel bar = 20mm
Velocity of flow = 0.15 to 0.3 m/sec
Spacing between bars = 30 to 50 mm

c) Design Calculation

20mm diameter steel bars @50 mm spacing are considered
Velocity = 0.25 m/s
Area of openings at each level = 0.67 / 0.25
= 2.68 m^2
Height of screen = 1 m
No of openings = 2.68 / (0.05 x 1)
= 54 nos
No of bars = 53 nos
Length occupied by 50mm bars = 53 x 0.02
= 1.06 m
Total screen length = {1.06 + (2.68 m^2 x 1 m)}
= 3.8 m
Providing 2 ports at each river water level of size = 1m x 1.9m

d) Summary

e)

1.	Total number of bar screen	6
2.	At each level	2
3.	Size of each bar screen	1m x 1.9m
4.	R.L. s of bar screen pairs	102m, 105m, & 115m

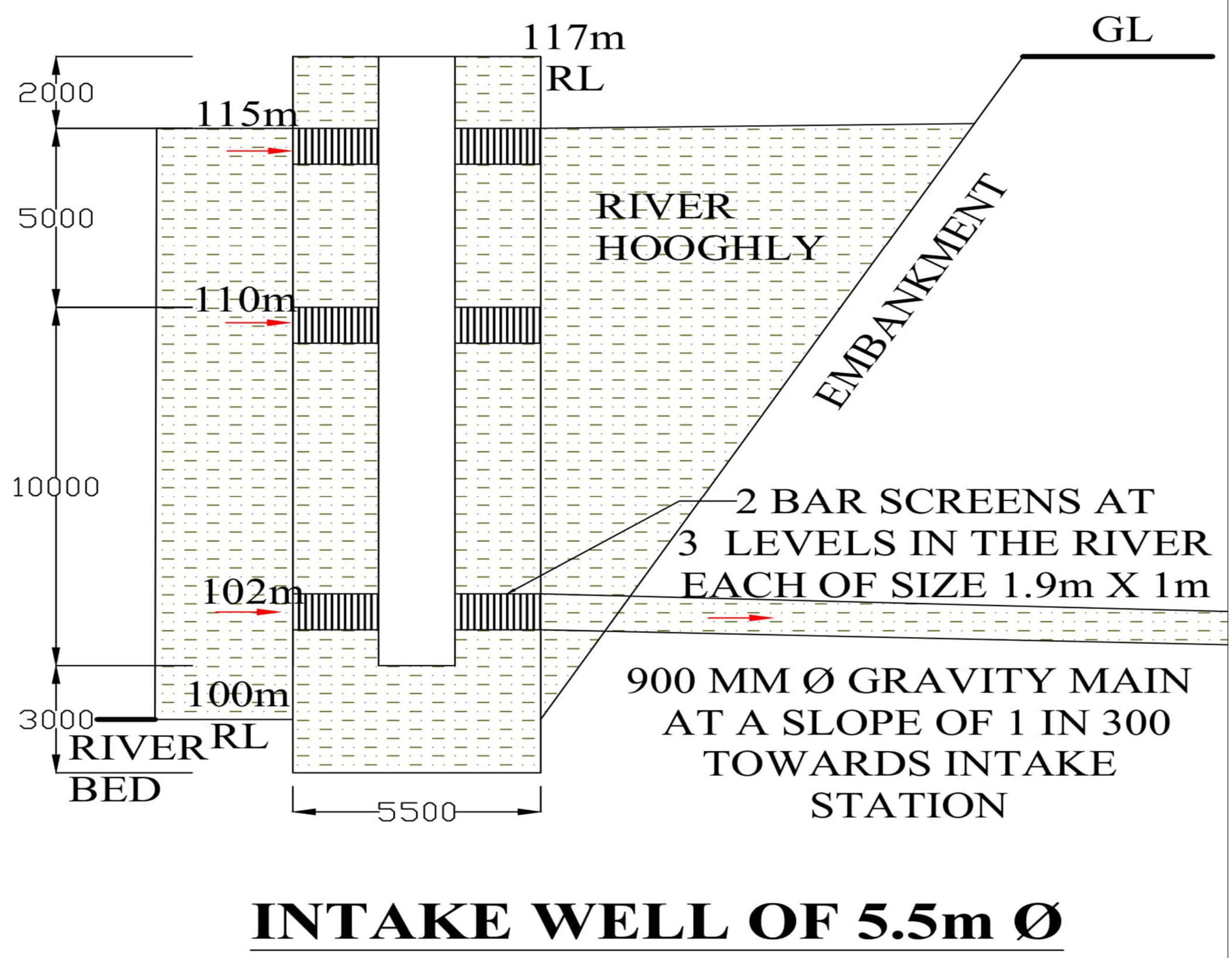
117m
RL
GL
2000
115m
5000
RIVER
HOOGHLY
EMBANKMENT
110m
10000
2 BAR SCREENS AT
3 LEVELS IN THE RIVER
EACH OF SIZE 1.9m X 1m
102m
900 MM Ø GRAVITY MAIN
AT A SLOPE OF 1 IN 300
TOWARDS INTAKE
STATION
100m
3000
RIVER
BED
RL
5500
INTAKE WELL OF 5.5m Ø

Figure 1

Design of Gravity Main

a) *Gravity Main:* The gravity main connects the intake well to the jack well and water flows though it by gravity. To secure the greatest economy the diameter of a single pipe through which water flows by gravity should be such that all the head available to cause flow is consumed by friction. The available fall from the intake well to the jack well and the ground profile in between should generally help to decide if a free flow conduit is feasible. Once this is decided the material of the conduit is to be selected keeping in view the local cost and the nature of the terrain to be traversed. Even when a fall is available, a pumping or force main, independently or in combination with a gravity main could also be considered. Gravity pipelines should be laid below the hydraulic gradient.

b) *Design Criteria*

Diameters of gravity main = 0.3m to 1m
Velocity of water = 0.5 m/s to 2.0 m/s
Number of gravity main = number of intake well = 1
Assumption velocity = 1.2 m/s

c) *Design Calculation*

R.C.C. Circular pipe is used.
Conduit velocity = 1.2 m/s
Area of conduit required = $(0.67\ m^3/s) / (1.2\ m/s)$
$= 0.56\ m^2$
Diameter of the conduit = 0.85 m
For this dia pipe velocity is = $0.67 / \{(3.147/4) \times 0.85^2\}$
$= 1.18$ m/s
Using Manning's formula $V = (1/n) \times R^{2/3} \times S^{1/2}$
$1.18 = (1/0.017) \times (0.85/4)^{2/3} \times (S^{1/2})$
$S = 3.3 \times 10^{-3}$
S = 1 in 300

d) *Summary*

1.	Number of gravity main	1
2.	Diameter of gravity main	0.85 m
3.	Slope of gravity main	1 in 300

Design of Jack Well

a) *Jack Well:* This structure serves as a collection of the sump well for the incoming water from the intake well from where the water is pumped through the rising main to the various treatment units. This unit is more useful when number of intake wells are more than one, so that water is collected in one unit and then pumped for purification. The jack well is generally located away from the shore line, so that the installation of pumps, inspection maintenance is made easy.

b) *Design Criteria*

- Suction head < 10 m.
- Diameter of well < 20 m.

c) *Design Calculation*

Detention time = 2 min
Assuming suction head = 8 m
Bottom clearance = 2 m
Maximum depth of water that can be stored in condition when water is minimum in river
101.6 – 99.6 = 2 m
Capacity of well = 0.67 x 2 x 60
$= 80.4\ m^3$

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C/S area of well = 80.4 / 2

= 40.2 m^2

Diameter of well = 7.5 m

R.L. of bottom of jack well = 99.6 m

R.L. of bottom of jack well when full = 109.6 m

d) Summary

1.	Diameter of jack well	7.5 m
2.	R.L. of bottom of jack well	99.6 m
3.	R.L. top of jack well	109.6 m
6.	Bottom clearance	2 m

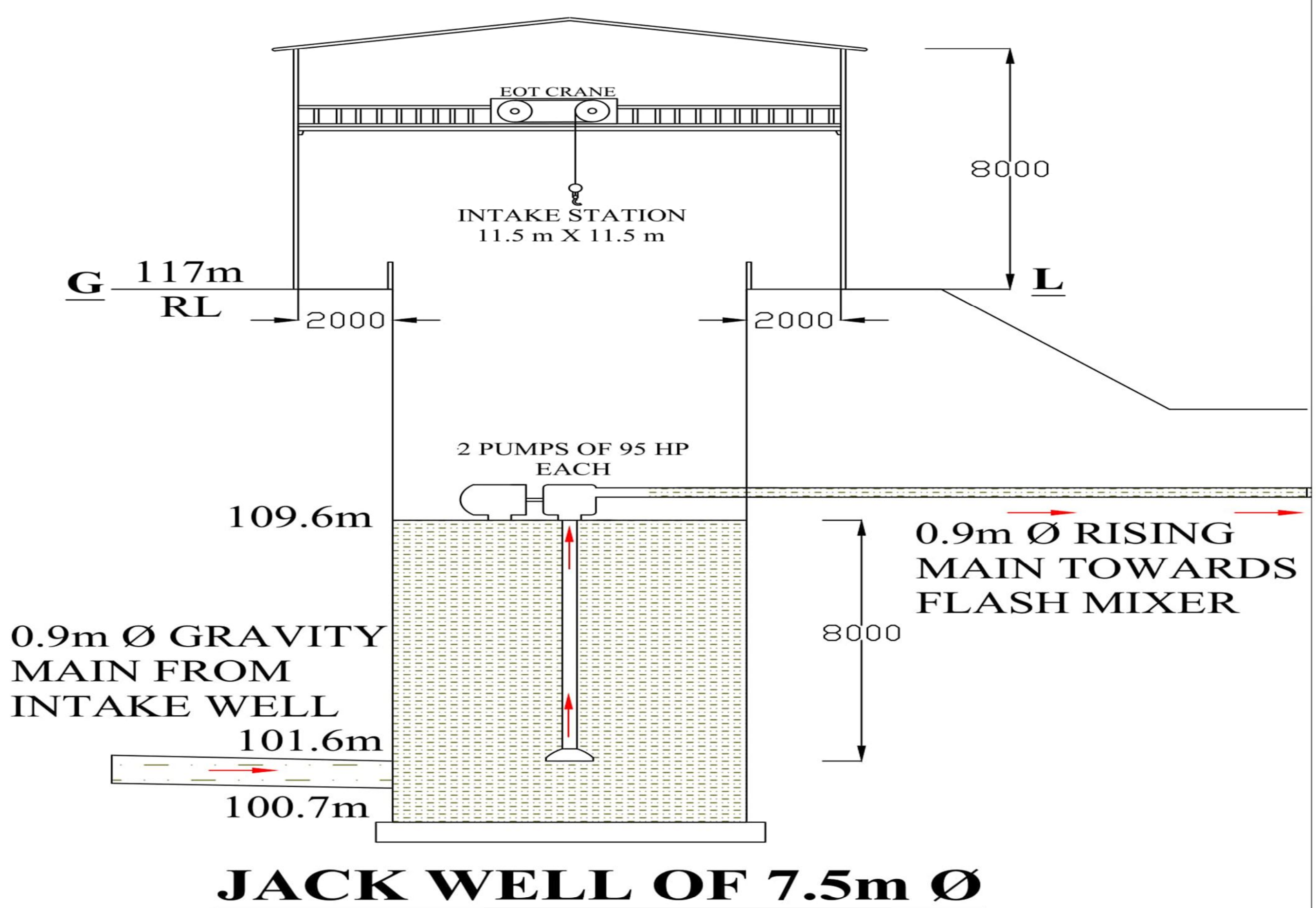

Figure 2

Design of Pumping System

a) Pumps

- In the water treatment plant, pumps are used to boost the water from the jack well to the aeration units.
- The following points are to be stressed upon.
- The suction pumping should be as short and straight as possible. It should not be greater than 10m for centrifugal pump. If head is more than 10 m, water is converted into vapour and thus in spite of creating water head, vapour head is created and pump ceases to function.
- The suction pipe should be of such size that the velocity should be about 2 m/sec.
- The delivery pipe should be of such size that the velocity should be about 2.5 m/sec.

The following criteria govern pump selection.

- Buoyancy operated pumps
- Impulse operated pumps
- Positive displacement pumps
- Velocity adoptions pumps

The following criteria govern pump selection.

- Type of duty required.
- Present and projected demand and pattern and change in demand.
- The details of head and flow rate required.
- Selection the operating speed of the pump and suitable drive.
- The efficiency of the pumps and consequent influence on power consumption and the running costs.

b) Diameter Of Rising Main

Q = $0.67\ m^3/s$

Economical diameter = $0.97\ (Q)^{1/2}$ to $1.22\ (Q)^{1/2}$

= 0.8 m to 1m

Provided D = 0.9 m

c) Design Criteria

Suction head should not be greater than 10 m.

Velocity of flow length = 0.7 to 1.5 m/s

Top clearance = 0.5 m

Bottom clearance = 2 m

d) Design Calculation

Frictional losses in rising main:

Velocity = Q / area = $0.67 / \{(3.14/4) \times 0.9^2\} = 1.1$ m/s

$4f = f' = 0.02 \times [1 + (1 / 35 \times d)] = 0.02$

$Hf = (f' \times L \times v^2) / (2 \times g \times d)$

$= (0.02 \times 200 \times 1.1^2) / (2 \times 9.81 \times 0.9)$

= 0.27 m

Hs + Hd = total lift including suction and delivery

= 8m + 1m + 0.27m (loss)

= 9.27m

WHP (water horse power) = (W X Q X H) / 0.735
= (9.81 x 0.67 x 9.27) /0.735
= 83 HP

W = unit weight of water
Q = discharge
H = total head against which pump works
1 HP = 735 W = 0.735 kW

BHP (Brake horse power) = WHP/ Nm x Np
= 83 / (0.85 x 0.77)
= 127 HP

e) *Summary*

Provide 2 pumps in parallel

Ref page 306 of "water supply engineering" by SK Garg

Design of Rising Main

a) *General:* These are the pressure pipes used to convey the water from the jack well to the treatment units. The design of rising main is dependent on resistance to flow, available head, allowable velocities of flow, sediment transport, quality of water and relative cost. Various types of pipes used are cast iron, steel, reinforced cement concrete, pre-stressed concrete, asbestos cement, polyethylene rigid PVC, ductile iron fibre glass pipe, glass reinforced plastic, fibre reinforced plastic. The determination of the suitability in all respects of the pipe of joints for any work is a matter of decision by the engineer concerned on the basis of requirements for the scheme.

b) Design Criteria
Velocity = 0.9 to 1.5 m/sec.

c) *Design Calculation*

Economical diameter, D $=0.97(Q)^{1/2}$ to $1.22\ (Q)^{1/2}$
= 0.8 m to 1m

Provided Diameter = 0.9 m

Velocity = Q / area = $0.67 / \{(3.14/4) \times 0.9^2\}$
= 1.1 m/s

d) *Summary*

1.	Diameter of pipe	0.9m

- *Treatment units*

The aim of water treatment is to produce and maintain water that is hygienically safe, aesthetically attractive and palatable; in an economical manner. Albeit the treatment of water would achieve the desired quality, the evaluation of its quality should not be confined to the end of the treatment facilities but should be extended to the point of consumer's use. The method of treatment to be employed depends on the characteristics of the raw water and the desired standards of water quality. The unit operation and unit processes in water treatment constitute aeration flocculation (rapid and slow mixing) and clarification, filtration, softening, defluoridization, water conditioning and disinfection and may take many different combinations to suit the above requirements.

In the case of ground water and surface water storage which are well protected, where the water has turbidity below 10 JTU (Jackson Candle Turbidity Units) and is free from odour and color, only disinfection by chlorination is adopted before supply.

Where ground water contains excessive dissolved carbon dioxide and odorous gases, aeration followed by flocculation and sedimentation, rapid gravity or pressure filtration and chlorination may be necessary.

Conventional treatment including pre-chlorination, aeration, flocculation and sedimentation, rapid gravity filtration and post-chlorination are adopted for highly polluted surface waters laden with algae or microscopic organism.

2) *Design of Chemical House and Calculation of Chemical Dose*

The space for storing the chemicals required for the subsequent treatment of water consists of determining space required for storing the most commonly used coagulant alum, lime, chlorine, etc. for the minimum period of three months.

The size of unit also depends upon the location, transport facilities, weather conditions. Chemical house should be designed to be free from moisture, sap, etc. there should be sufficient space for handling and measuring chemicals and other related operations.

It should be located near to the treatment plant and chemicals should be stored in such size of bags that can be handled easily.

Alum bags being used is of size = 600 x 400

Alum bags stack size

10 bags stacked horizontally in each of 8 layers = 6 m x 400 mm

15 stacks breadth wise is stored in the storage with 500 mm spacing in between stacks and 1 m spacing of the end stacks from wall

6 stacks length wise is stored in the storage with 2 m spacing from the walls

Alum dose

Coagulation

Coagulation describes the effect produced by the addition of a chemical to a colloidal dispersion resulting in particle destabilization. Operationally, this is achieved by the addition of appropriate chemical and rapid intense mixing for obtaining uniform dispersion of the chemical.

The coagulant dose in the field should be judiciously controlled in the light of the jar test values. Alum is used as coagulant.

Design Criteria for alum dose

Alum required for particular seasons is given below:

Monsoon = 50 mg/l

Winter = 20 mg/l

Summer = 5 mg/l

Alum required:

$(76.8 \times 10^6) / 24 = 32 \times 10^5$

Per day alum required for worst season for intermediate stage

$= 50 \times 10^{-6} \times 32 \times 10^5 \times 24$

$= 3840$ kg/day

For 3 months (90days) = 3840 x 90

= 345600 kg

Number of bags where 1 bag is containing 50kg = 345600 / 50

= 7000 bags

For 1 day no of bags being used = 7000 / 90

= 78 bags

Hence 8 layers of bags 10 bag in each row for 1 day

1 heap = 78 bags

No of heaps to be stored = 90

Chemical dissolving tank:

1 day = 78 bags

78 bags = 50kg x 78

= 3900 kg

Density of alum = 1710 kg / m^3

Volume of 78 bags = 3900 / 1710

= 2.5 m^3

Volume of dissolving tank = 4 m x 1.5 m x 1 m

= 6 m^3

2 tanks each of 6m^3 volume. 1 always on standby for next day out of the 2 tanks

Chemical solution tank

Total alum = 3900 kg / day

Solution required per day = 3900 / 1.7

=2294 lit / day
= 1.6 lit /min

Quantity of solution for 24 hours = 1.6 x 24 x 60
= 2.3 m^3

Tank dimensions = 1.5 m x 1m x 1m

1 tank of 2.5 m^3 volume

Design of mechanical Rapid Mix Unit

a) Flash Mixer

Rapid mixing is an operation by which the coagulation is rapidly and uniformly dispersed throughout the volume of water to create a more or less homogeneous single or multiphase system.

This helps in the formation of micro flocs and results in proper utilization of chemical coagulant preventing localization of connection and premature formation of hydroxides which lead to less effective utilization of the coagulant. The chemical coagulant is normally introduced at some point of high turbulence in the water. The source of power for rapid mixing, to create the desired intense turbulence is gravitational and pneumatic.

The intensity of mixing is dependent upon the temporal mean velocity gradient ‘G’. This is defined as the rate of change of velocity per unit distance normal to the section. The turbulence and resultant intensity of mixing is based on the rate of power input to the water.

Flash mixture is one of the most popular methods in which the chemicals are dispersed. They are mixed by the impeller rotating at high speeds.

b) Design Criteria For Mechanical Rapid Mix Unit

- Detention time = 30 to 120 secs (pg 424)
- Velocity of flow = 4 to 9 m/sec
- Power required = 2 to 5 kW/m^3/sec
- Impeller speed = 100 to 120 rpm
- Loss of head = 0.4 to 1.0
- Ratio of impeller diameter to tank diameter = 0.2:1 to 0.4:1
- Ratio of tank height to diameter = 1:1 to 3:1

c) Design calculation

- Design flow = 76.8 MLD
  = 76800 m^3/day
- Detention time = 30 sec
- Ratio of tank height to diameter = 2:1
- Rotational speed of the impeller = 120 rpm
- Assume temperature = 20 ^oC

- *Dimension of tank*

  Volume = 0.67 m^3/sec x 30 sec
  = 21 m^3
  Diameter = (3.14 / 4) x d^2 x h
  = (3.14 / 4) x d^2 x 2d
  = 3 m
  Height = 6 m
  Total height of tank = 6 m + 1 m
  = 7 m

- *Power Requirement*

  Power spent = (2Kw/m^3/min) x (21m^3) x (30/60)min
  = 21 kW

- *Dimension of flat blade and Impeller*

  Diameter of impeller = 0.3 x 3

  = 0.9 m

  Velocity of tip impeller(Vt) = (2 x 3.14 x r x n) / 60

  = (2 x 3.14 x 0.45 x 120) / 60

  = 5.6 m^3/sec

Let Cd = 1.8 flat blades

Vt / 2 = Vd

- Area of blade = (0.5 x Cd x A x P x V^3)

  (power spent) 21 x 10^3 = {0.5 x 1.8 x A x 1000 x $(5.6/2)^3$}

  A = 1.1 m^2

8 blades of 0.37 m x 0.37 m
Provide 4 numbers of length 1.5 m and projecting 0.2 m from the wall

- *Provide inlet and outlet pipes of 900 mm Diameter.*

d) Summary

1.	Detention time	30 sec
2.	Speed of impeller	120 rpm
3.	Height of tank	7 m
4.	Power required	21 kW
5.	Number of blade	8 blades
6.	Number of baffles	4
7.	Diameter of inlet and outlet	900 mm

Ref IS 7090:1985

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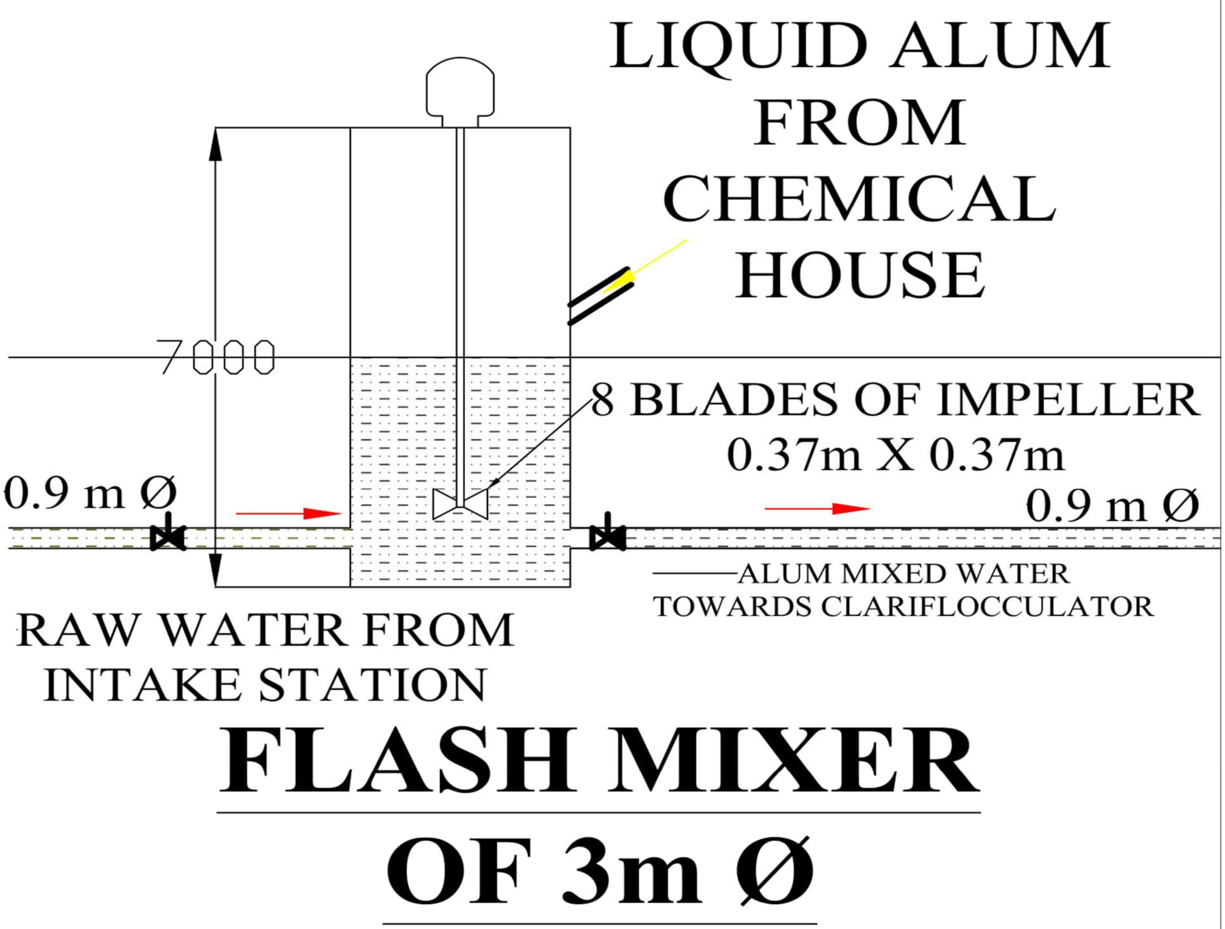


Figure 3

Design of Clariflocculator

a) *Clariflocculation:* The coagulation and sedimentation processes are effectively incorporated in a single unit in the clariflocculator. Sometimes clarifier and clariflocculator are designed as separate units. All these units consist of 2 or 5 flocculating paddles placed equidistantly. These paddles rotate on their vertical axis. The flocculating paddles may be of rotor-stator type rotating in opposite direction above the vertical axis. The clarification unit outside the flocculation compartment is served by inwardly raking rotating blades. The water mixed with chemical is fed in the flocculator compartment fitted with paddles rotating at low speeds thus forming flocs. The flocculated water passes out from the bottom of the flocculation tank to the clarifying zone through a wide opening. The areas of the opening being large enough to maintain a very low velocity. Under quiescent conditions, in the annular settling zone the floc embedding the suspended particles settle to the bottom and the clear effluent overflows into the peripheral launder.

b) *Design criteria: (flocculator)*
- Depth of tank = 3 to 5 m
- Detention time = 30 to 60 min
- Velocity of flow = 0.2 to 0.8 m/s
- Total area of paddles = 10 to 25% of the tank c/s
- Range of peripheral velocities of blades = 0.2 to 0.6 m/s
- Velocity gradient (G) = 10 to 75
- Dimension less factor GL = 10^4 to 10^5
- Power consumption = 10 to 36 kW/MLD
- Outlet velocity = 0.15 to 0.25 m/sec

c) *Design Criteria: (Clarifier)*
- Surface overflow rate = 40 m^3/m^2/day
- Depth of water = 3 to 4.5
- Weir loading = 300 m^3/m^2/day
- Storage of sludge = 25%
- Floor slope = 1 in 12 or 8% for mechanically cleaned tank
- Slope for sludge hopper = 1.2 : 1
- Scrapper velocity = 1 revolution in 45 to 80 mins
- Velocity of water at outlet chamber = not more than 40 m/sec

d) *Design of Influent Pipe*
- Exit velocity from flash mixer = 1.0 m/s
- Discharge = $(76.8 \times 10^6) / (24 \times 3600)$
  = 0.89 m^3/s
- c/s Area of the pipe = (0.89 m^3/s) / (1 m/s)
  = 0.89 m^2
- diameter of influent pipe = 0.6 m

Provide a 0.6 m dia influent pipe for each clariflocculator

e) *Design of the Floccualtor Zone*
- Detention time = 30 min
- Depth = 4 m
- Discharge = 0.67 m^3/sec
- Total volume of 6 flocculators = 0.67 x 30 x 60
  = 1206 m^3
- Volume of each flocculator = 201 m^3
- Area = 50.3 m^2
- Diameter of the flocculator zone = 8 m

f) Dimension of Paddles

Ref IS 7208 : 1992

- Power input = G^2 x u x (vol)
  = 40^2 x 0.89 x 10^{-3} x (3.14/4 x 8^2 x 4)
  = 286.3
- (Drag coefficient) C_d = 1.8
- P = 995 kg/m^3 at 25^{o}C
- V=velocity of tip of blade = 0.4 m/s
- v =velocity of water at tip of the blade= 0.25 x 0.4 m/s = 0.1 m/s

Power input = 0.5 x { Cd x p x A x $(V-v)^3$}

- Ap = 11.8
- Ratio of paddles : c/s of
  Flocculater =[(11.8) / {3.14 x (8 – 0.75) x 4}]
  = 13 % (within 10 % to 25 %)

Provide 5 nos of paddles of 3m height and 0.8 m width One shaft will support 5 paddles. Paddles will rotate at 4 RPM

V = (2 X 3.14 X r x n) / 60 (2 x π x r x n / 60)

0.4 = (2 x 3.14 x r x 4) / 60

r = 1 m

distance of paddle from centre of vertical shaft = r = 1m

Let velocity of water below the partition wall between the flocculator and clarifier be 0.3 m/s

- Area = (0.89 m^3/sec) / (0.3 m/s)
  = 3m^2
- Depth below the partition wall = 3 / (3.14 x 8)
  = 0.12 m
- Provide 25% for storage of sludge = (25/100) x 4m
  = 1 m
- Provide 8% slope for the bottom = 0.3 m
- Total depth of tank at the partition wall= 0.3 m + 4 m + 0.12 m + 1 m
  = 5.4 m

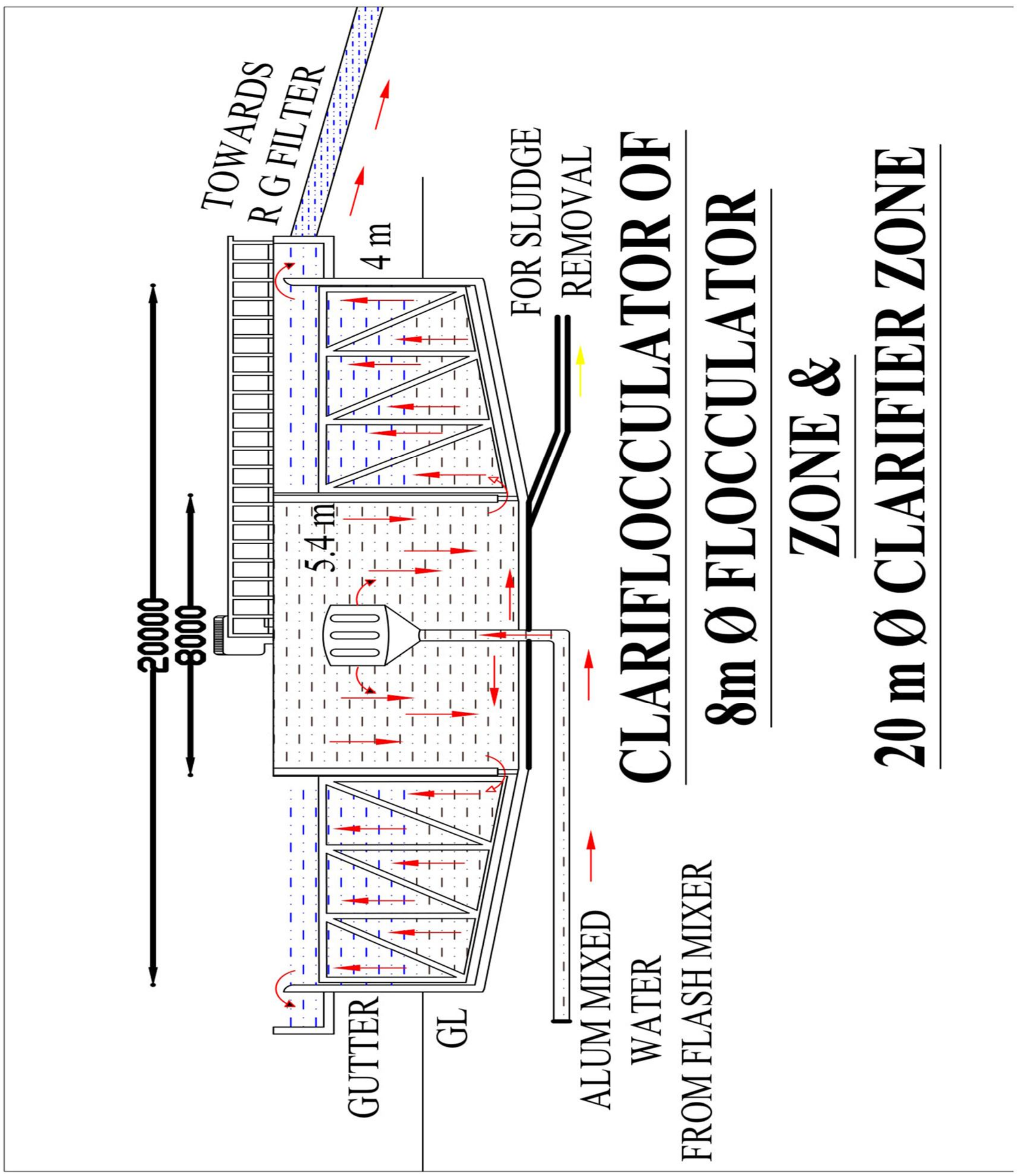
g) Design of Clarifier

- Surface overflow rate = 40 m^3/m^2/day
- Surface area of 6 clariflocculator = (0.89 m^3/s) / {40/(3600 x 24)}
  = 2000 m2
- Surface area of 1 clariflocculator = 333.33 m2
- D_{cf} = diameter OF Clariflocculator = 20 m
- Length of weir = 3.14 x 20 m
  = 62.8 m
- Weir loading = 76.8 x 10^3 m^3/day / 62.8 m
  = 1223 m^3/day/m

According to the manual of Govt of India. If it is a well type clarifier. It can exceed upto 1500 m^3/day/m

h) Summary (Clariflocculator)

1.	Detention period	30 min
2.	Diameter of influent pipes	0.6 m
3.	Overall depth of flocculator	4 m
4.	Diameter of flocculator	8 m
5.	No. of paddles	5
6.	Paddles rotation(RPM)	4
7.	Distance of paddle from C.L. of vertical shaft	1 m
8.	Slope of bottom (%)	8
9.	Total depth of partition wall	5.4
10.	Diameter of clarifier	20



Design Of Rapid Gravity Filter

a) *Rapid Sand Filter:* The rapid sand filter comprises of a bed of sand serving as a single medium granular matrix supported on gravel overlying an under drainage system, the distinctive features of rapid sand filtration as compared to slow sand filtration include careful pre-treatment of raw water to effective flocculate include colloidal particles, use of higher filtration rates and coarser but more uniform filter media to utilize greater depths of filter media to trap influent solids without excessive head loss and back washing of filter bed by reversing the flow direction to clear the entire depth of river. The removal of particles within a deep granular medium filter such as rapid sand filter occurs primarily within the filter bed and is referred to as depth filtration. Conceptually the removal of particles takes place in two distinct slips as a transport and as attachment step. In the first step the impurity particles must be brought from the bulk of the liquid within the pores close to the surface of the medium of the previously deposited solids on the medium. The transport step may be accompanied by straining gravity, setting, impaction interception, hydrodynamics and diffusion and it may be aided by flocculation in the interslices of the filter.

b) *Design Criteria : (Rapid Sand Filter)*

Rate of filtration = 5 to 7.5 $m^3/m^2/hr$
Max surface area of one bed = 100 m^2
Min overall depth of filter unit including a
Free board of 0.25 m = 3 m
Effective size of sand =0.35 to 0.55 (pg 440)
Uniformity co-efficient for sand = 1.3 to 1.7 (pg 441)
Ignition loss should not exceed 0.7% by weight
Silica content should not be less than 90%
Specific gravity = 2.55 to 2.65
Wearing loss is not greater than 3%
Minimum number of units = 2
Depth of sand = 0.6 to 0.75
Standing depth of water over the filter = 1 to 2 m
Free board is not less than 0.5m

c) *Problem Statement*

Net filtered water = $0.89 m^3/sec$
Quantity of backwash water used = 2% (SK GARG pg 446)
Time lost during backwash = 30 min
Design rate of filtration = $5 m^3/m^2/hr$ (pg 450)
Length-Width ratio = 1.25:1 to 1.33:1 (nptel website)
Under drainage system = 3 mm
Size of perforation = 15 mm

d) *Design Calculation*

Solution: required flow water = $0.89 m^3/sec$
Design flow for filter = 0.89 + (0.89x2%)
= 0.91 m^3/sec
Plan area for filter = (0.91 m^3) / (5 $m^3/m^2/hr$) x 3600
= 655 m^2
Using 10 units,
Plan area = 66 m^2
Length (L) x Width = 66 m^2
As Width = 1.3 L, Length = 7.4 m and Width = 9.3 m
Provide 10 filter units each with a dimension of 7.4 m x 9.3 m

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Estimation of Sand depth:

It is checked against breakthrough of floc.
Using Hudson Formula :
Q x d x h/L = B x 293223/1
Where Q, d, h and l are in m^3/m^2/hr, mm, and m respectively.
B = 4 x 10^{-4} (poor response) < avg degree of pre treatment
h = 2.5m (terminal head loss)
Q = 5 x 2 (FOS) m^3/m^2/hr (assuming 100% overload of filter)
d = 0.6 mm (mean dia)
10 x $(0.6)^3$ x (2.5/l) = 4 x 10^{-4} x 29323
l (depth) = 60 cm (60cm to 90 cm, pg 440)

Provide depth of sand bed = 60 cm

Estimation of Gravel and size Gradation:

Size gradation of 2 mm at to 40 mm at bottom using empirical formula:
P = 2.54 x R (log d)
Where R = 12 (10 to 14)
The units of L and d are cm and mm respectively.

Size	2	5	10	20	40
Depth(cm)	9.2	21.3	30.5	40	49
Increment	9.2	12.1	9.2	9.5	9

Provide 50 cm depth of 40 mm gravel.

Design of Under Drainage system:

Plan area of each filter = 7.4 m x 9.3 m
= 68.82 m^2
Total area of perforation = 0.3 % x 68.82 m^2
= 2048.4 cm^2
Total cross section area of laterals = 3 x area of perforations
= 3 x 2048.4
= 6145.2 cm^2
Area of central manifold =2 x area of lateral
(pg 452) = 12290.4 cm^2
Diameter of central manifold =√{12290.4 x (4 / 3.14)}
= 125 cm
Assuming spacing for laterals = 20 cm (8cm to 20cm)
Number of laterals = 9.3 m x (100/20)
= 47 on each side

Hence, 94 laterals in total in each unit

Length of each lateral = (width of filter / 2) – (diameter of manifold / 2)
= (7.4 / 2) – (1.25 / 2)
= 3.1 m

Adopt 15mm dia perforations in the laterals

Total area of perforations = 2048.4 cm^2

$(3.14 / 4) \times (15/10)^2 \times n$ = 2048.4 cm^2

n = 1160

no of perforations per lateral = 1160 / 94

= 13

Area of perforations per lateral = $13 \{(3.14/4) \times 1.5^2\}$

= 23 cm^2

Area of each lateral = 2 x area of perforations per lateral

= 2 x 23

= 46 cm^2

Diameter of each lateral = $\{46 \times (4/3.14)\}^{1/2}$

= 80 mm

Spacing for perforations = {(3.1 x 100)/13}

= 24 cm c/c

Provide 94 laterals each of 80 mm diameter @ 20 cm c/c, each having 13 perforations of 15 mm size @24 cm c/c with 125 cm diameter manifold.

Computation of Wash Water Troughs

Wash water rate = 36 $m^3/m^2/hr$

Wash water discharge for one filter = 36 x 68.82 m^2

= 0.6882 m^3/sec

Spacing for troughs = 1.8 m (1.5m to 2m)

No of troughs per filter unit = 7.4 / 1.8 = 5

Discharge per unit trough = 0.6882 / 5

= 0.1376 m^3/sec

Dimension of a trough is given by the empirical formula:

$Q = 1.376 \times B \times h^{3/2}$ (pg 453)

Assume B = 0.4 m

Hence, $0.1376 = 1.376 \times 0.4 \times h^{3/2}$

h = 0.4 m

Freeboard = 0.1 m

Provide 5 troughs of 0.4 m wide and 0.5 m deep in each filter.

Total Depth of Filter Box:

Depth of filter box = depth of under drainage + gravel+ sand + water depth (1 to 2 m) + freeboard

= 800 (dia of laterals) + 500 + 600 + 1200 + 300

= 3400mm (2.5 m to 3.5 m, pg 439)

Design of Filter Air Wash:

Assume rate at which air is supplied = 1.5 m3/m2/min

Duration of air wash = 3 min

Total quantity of air required per unit bed = 1.5 x 3 x 7.4 x 9.3

= 309.69 m^3

e) Summary

Number of units	10
Size of unit	7.4 m x 9.3 m
Depth of Sand bed	60 cm
Depth of gravel	50 cm
Diameter of perforation	15 mm
Diameter of central manifold	125 cm
Spacing for laterals	20 cm
Number of laterals	94
Diameter of laterals	80 mm
Number of perforations per lateral	13
Number of troughs	5
Size of troughs	0.4 m x 0.5 m
Total depth of filter box	3.4 m
Duration of air wash	3 min
Total quantity of air required per unit bed	309.69 m^3

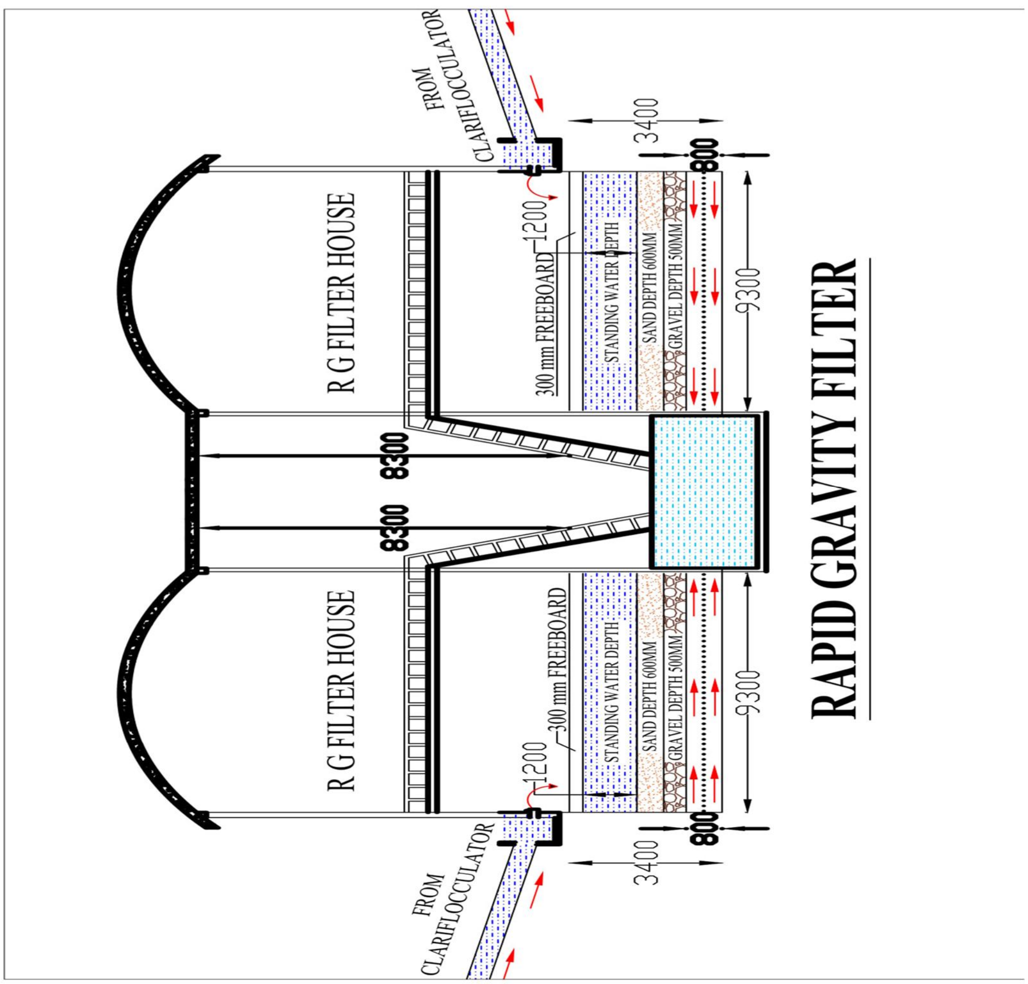


Figure 5

Disinfection Unit

a) *Chlorination:* Treatment method such as aeration, plain sedimentation, coagulation, sedimentation filtration, would render the water chemically and aesthetically acceptable with some reduction in the pathogenic bacteria content. However, the foregoing treatment methods do not ensure 100% removal of pathogenic bacteria and hence it becomes necessary to disinfect the water to kill the pathogenic bacteria. Disinfection should not only remove the existing bacteria from the water but also ensure their immediate killing even afterwards, in the distribution system. The chemical which is used as a disinfectant must therefore be able to give the residual disinfection effect for a long period, thus affording some protection against recontamination.

b) *Design Criteria (Chlorination)*

Chlorine dose = 1.4 mg/L (rainy season)
= 1 mg/L (winter season)
= 0.6 mg/L (summer season)
Residual Chlorine = 0.2 mg/L (minimum)
Contact period = 20 min to 30 min (pg 482)

c) *Design Calculation*

Chlorine required per day $=76.8 \times 10^{6} \times 1.4 \times 10^{-6}$
$= 107.52$ kg
Number of cylinder used per day $= 107.52 / 100$
= 2 cylinders of 100 kg each
(pg 482 & 481)

d) *Summary*

Chlorine required per day	107.52 kg
Number of cylinder required per day	2

Storage tank

- *General:* Distribution reservoirs also called service reservoir are the storage reservoir which store the treated water for supplying the same during and also help in absorbing the hourly fluctuations in water demand.
- *Storage Capacity:* Ideally the total storage capacity of a distribution reservoir is the summation of (1) balancing reserve (2) breakdown reserve (3) fire reserve. The balancing storage capacity of a reservoir can be worked out from the data of hourly consumption of water for the town by either the mass curve method or analytic method. In absence of availability of the data of hourly demand of water the capacity of reservoir is usually ¼ to 1/3 of the daily average supply.

Underground Storage Reservoir (U.S.R.)

a) *General:* The reservoir is used for storing the filtered water which is now fit for drinking. From this, the water is pumped to E.S.R. normally the capacity of this type of reservoir depends upon the capacity of the pumps and hours of pumping during a day. If the pump works for 24mins then the capacity of the reservoir may be between 30 mins to 1hour.

1	2	3	4
6 am to 8 am	**12pm to 2pm**	**6pm to 8pm**	**12am to 2am**

b) *Design Calculations (U.S.R.)*

4 pumps working continuously for 2 hrs duration at a time per day

76.8 MLD = 3200 m^3/hr

As the flow chart above 4 hrs max storage has to be stored

Total volume of tank $= 3200 \times 4$
$= 12800\ m^3$

Taking 3.5 m depth

Total area $= 12800 / 3$
$= 4267\ m^2$

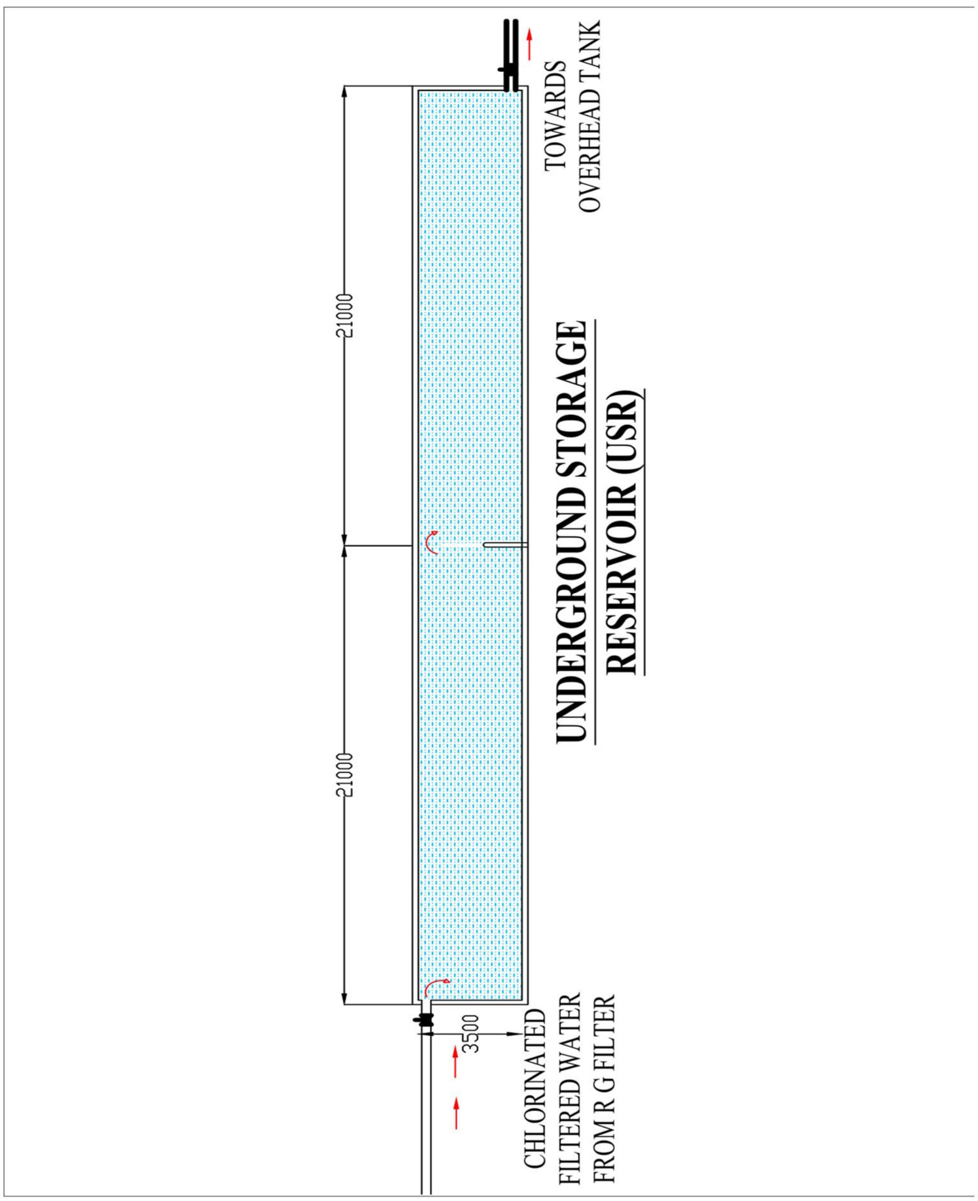
10 compartments are present in the tank

Each compartment area = 426.7 m^2

Dimensions of each compartment with 0.5 m freeboard = 21 m x 21 m x 3.5 m

c) Summary

Capacity of reservoir	12800 m3
Total depth	3.5 m
Compartments	10
Size	21 m x 21 m x 3.5 m
Max detention time	4 hrs



3) *Elevated Service Reservoir (E.S.R.)*

a) *General:* Where the areas to be supplied with treated water at the higher elevation than the treatment plant site, the pressure requirements of the distribution system necessitates the construction of ESR.

b) *Design Calculations*

Elevated service reservoir has to store 2 hrs worth of water

Volume = 3200 x 2

= 6400 m^3

Depth = 6 m (for each tank)

Total area = 6400 / 6

= 1067 m^2

Taking 5 nos of elevated service reservoirs

Area of each reservoir = 213.4 m^2

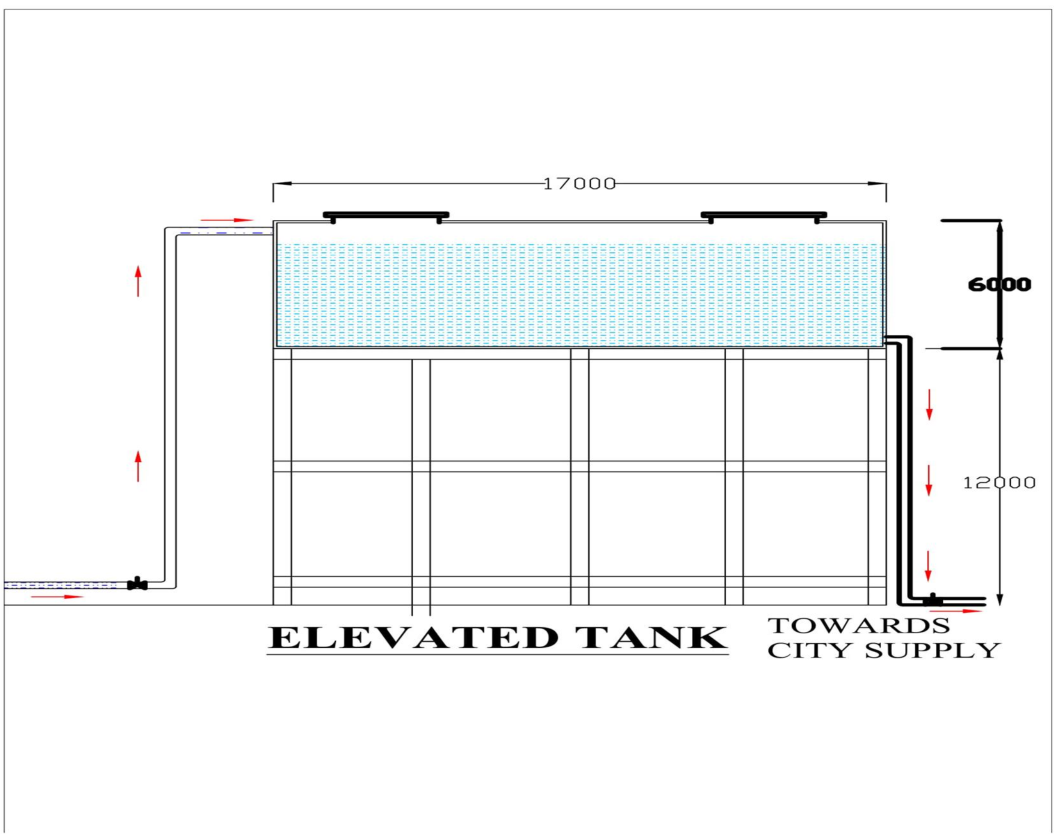
Dimensions of each reservoir = $(213.4)^{1/2}$

= 17 m

5 ESR with diameter of 17 m and depth of 6 m

c) *Summary*

Number of tanks	5
Depth of tank	6 m
Diameter of tank	17 m



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I. *Typical Design Of An Underground Storage Reservoir*

Figure shows the proposed arrangement for the retaining walls of the tank.
Stability of the wall per meter run.

1) *Case 1. When only water pressure acts.*

The relevant stability calculations are shown in the table as below:

Load due to load	Magnitude of load (N)	Distance from a (m)	Moment about 'a' (Nm)
Stem 0.2×3.5×25000	17500	2.9	50750
$0.2\times\frac{3.5}{2}\times25000$	8750	2.73	23887
Wt. of water $\frac{3\times0.2}{3.5}\times\frac{3}{2}\times9810$	2522	$2.6+\frac{1}{3}\left(\frac{3\times0.2}{3.5}\right)=2.66$	6708
2.60×3×9810	76518	1.30	99473
Base slab 4×0.4×25000	40000	2	80000
Moment of water pressure $9810\times3^3/6$			44145
Total	145290		304963

Z $=\frac{304963}{145290}=2.10$m

Eccentricity

$e= z-\frac{b}{2}=2.10-2=0.10$m

Maximum and minimum pressures at the base are given by

P $=\frac{W}{b}[1\pm\frac{6e}{b}]$

p $=\frac{145290}{4}[1\pm\frac{6\times0.10}{4}]$ N/m^2

p_{max} = 41770N/m^2

p_{min} = 30870N/m^2

Total horizontal exerted by water

P $=wh^2/2=9810\times3^2/2N=44145N$

Maximum available friction=μW=0.5×145290=72645N

Factor of safety $=\frac{\mu W}{P}=\frac{72645}{44145}=1.6$ (greater than 1.5)

2) *Case 2. When the tank is empty.*

The relevant stability calculations are shown in the table below.

Z $=\frac{297909}{122250}=2.44$m

Eccentricity

E $=z-\frac{b}{2}=2.44-2=0.44$m

Load due to	**Magnitude of load(N)**	**Distance from a (m)**	**Moment about 'a' (Nm)**
Stem	17500	2.9	50750
	8750	2.73	23887
Base slab	40000	2	80000
Wt. of soil 1×3.5×16000	56000	3.5	196000
Total	122250		350637
Deduct for moment of lateral pressure $16000\times(3.9^3/6)\times\frac{1-sin30°}{1+sin30°}$			52728
Net moment about a			297909

Reinforcements

CASE 1 : Maximum bending moment at the bottom of the stem due to water pressure alone
= 9810*(27/6) = 44145 Nm
This bending moment produces tension on the water face, adopting
C=7 N/MM^2, t=100 N/mm^2, m=13
Equating, MR to BM
1.41*1000D^2=44145*1000, D=177 mm.
Providing, an effective cover of 40 mm, the effective depth available = 400-40
= 360m
Ast = (44145*1000)/(100*0.84*360) mm^2= 1460 mm^2
Spacing of 16mm diameter bars = (201*1000)/1460 = 138 mm say 130 mm centers.

CASE 2 : Maximum bending moment at the bottom of the stem due to lateral soil pressure alone
= 16000*((3.5) ^3/6) * (1-sin 30)/(1+sin 30) Nm = 38110 Nm.
This bending moment produces tension away from the water face.
Hence, adopting c = 7 N/mm^2, t = 125 N/mm^2 , m = 113
At = (38110*1000)/ (125*0.86*360) = 985 mm^2
Spacing of 12 mm diameter bars =(113*1000)/9.85 = 115 mm say 110 mm centers.
Distribution steel = 0.3% of gross area = (0.3*400*1000)/100 = 1200 mm^2
Spacing of 10 mm diameter bars = (79*1000) /1200 = 66 mm say 60 mm centers.
If the distribution steel be provided near both the faces then the spacing will be at 120 mm centers near each face.

III. CONCLUSION

The project deals with the design of a conventional Rapid Gravity water treatment plant having a perennial river (Hooghly River) as the source. The design has been done for a periodic population of 240000 expected in the year 2040. This project educates the reader about the process through which Raw Turbid River Water is treated to make the same drinkable. It will also help us when we may come across any of the above design in future.

The above treatments of the water make it possible to safe guard the health of the people and make water potable for public use.

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BIBLIOGRAPHY

We would like to infer the names of the following books and sites that has helped us and guided us towards our attempt in designing the water distribution system for our final year project –

[1] S.K GARG – Water Supply Engineering
[2] IS 10500:2012 (DRINKING WATER SPECIFICATION)
[3] IS 7090:1985 (GUIDLINE FOR RAPID MIXING DEVICES)
[4] IS 7208 :1992 (GUIDLINE FOR FLOCCULATOR DEVICES)
[5] NPTEL WEBSITE

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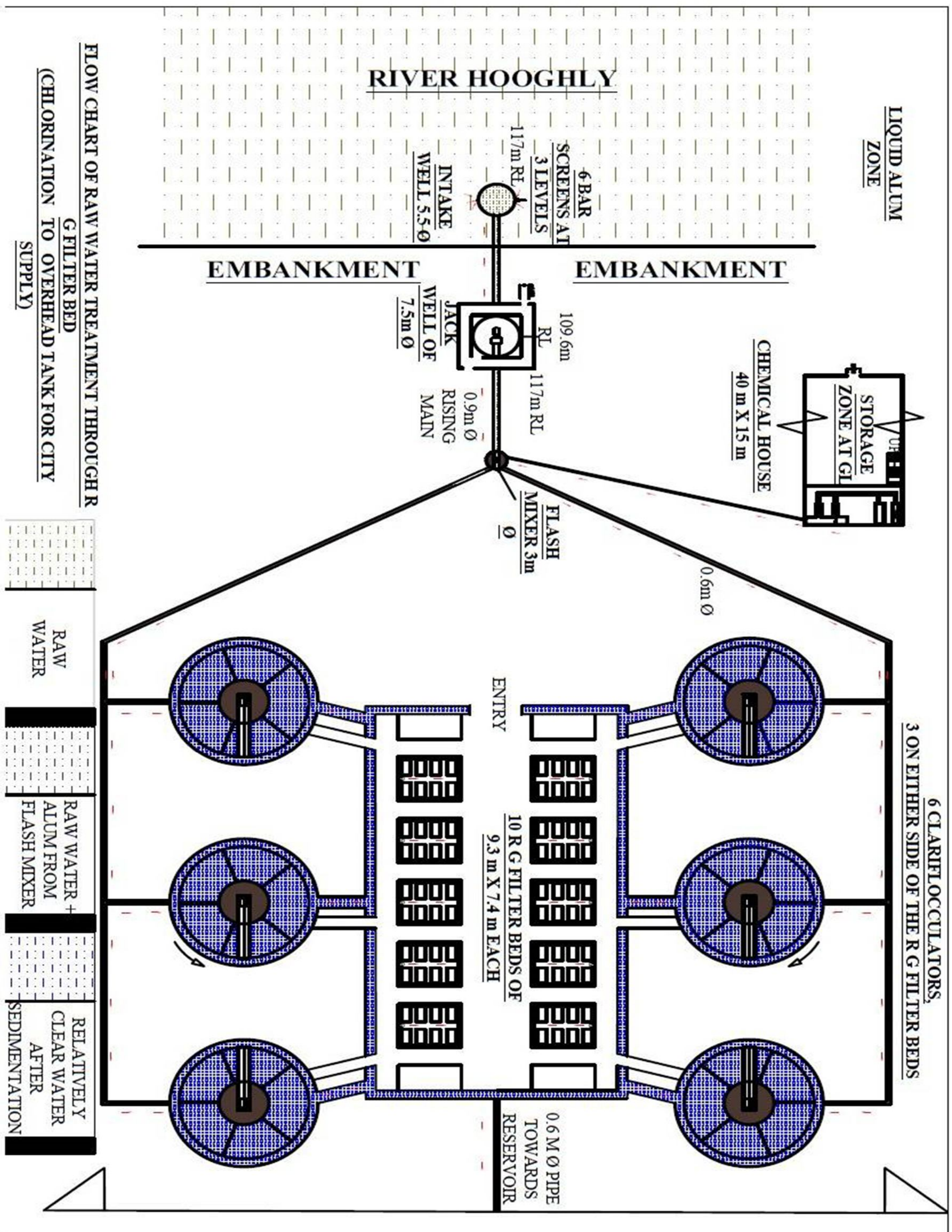
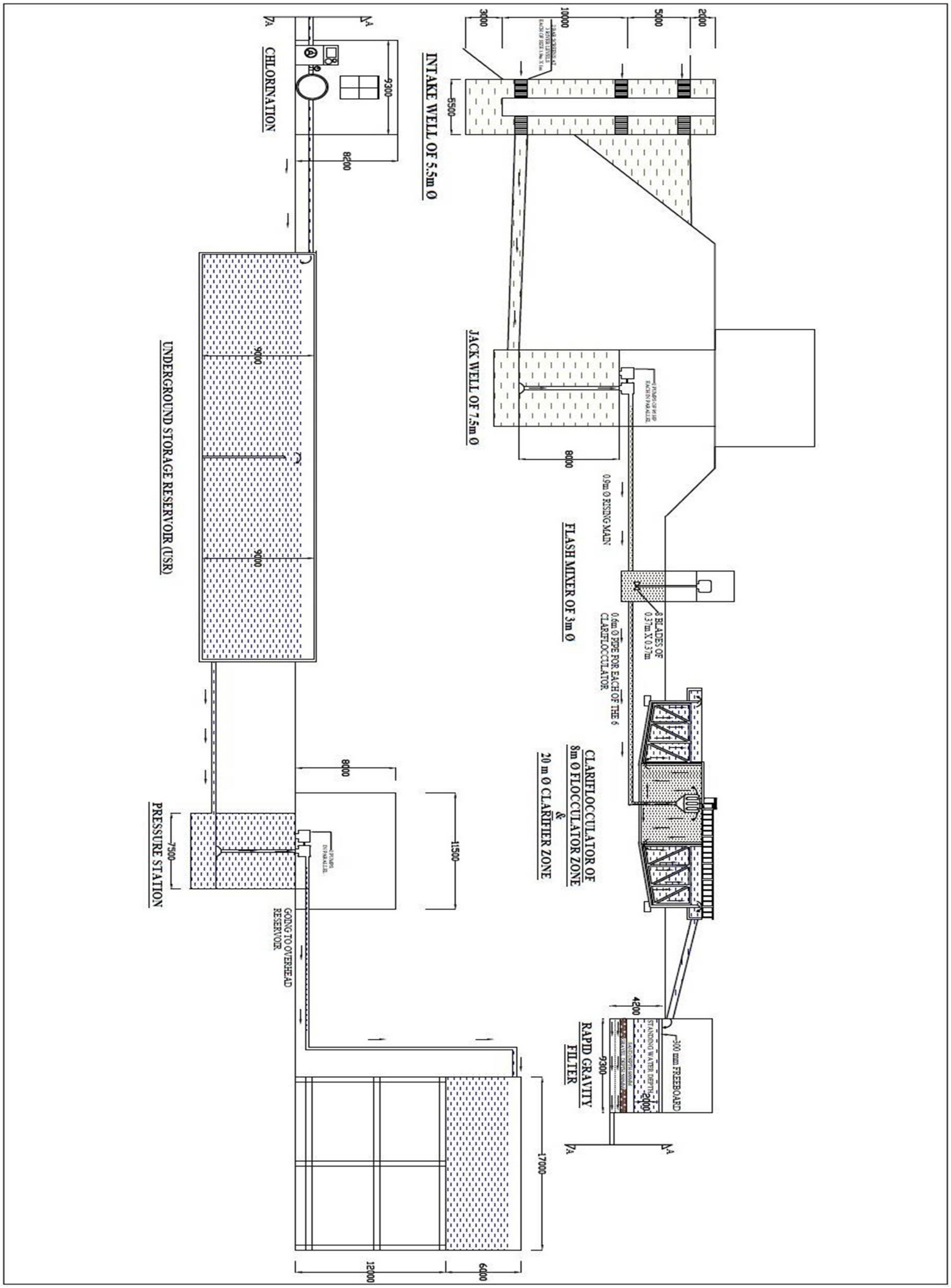
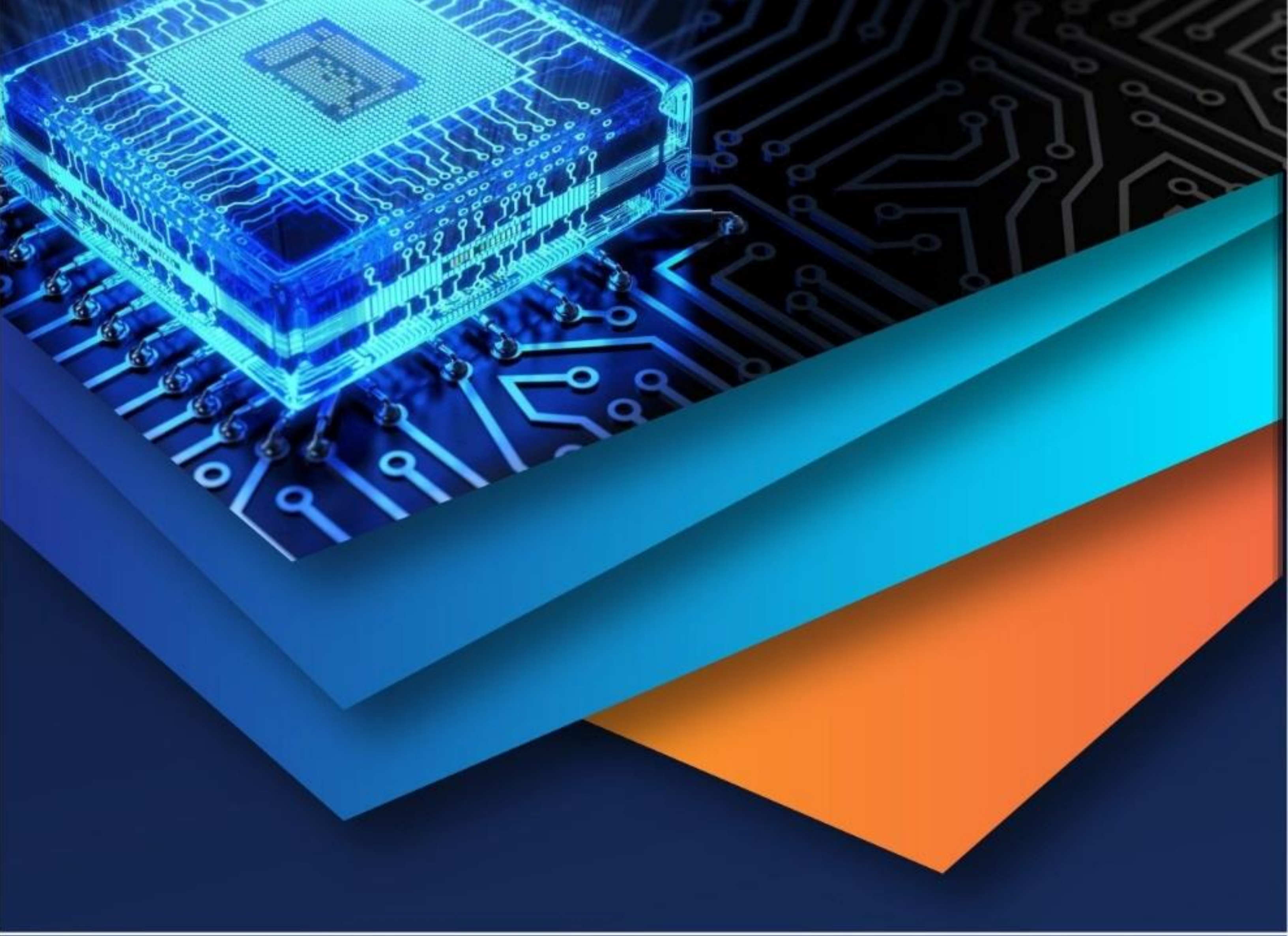
ANNEXURE

In this section there are two figures for the total Rapid Gravity system to get a complete view.

- Figure 8: Top down view of the whole system
- Figure 9: Sectional view of the whole system




INTAKE WELL OF 5.5m Ø
CHLORINATION
JACK WELL OF 7.5m Ø
0.9m Ø RISING MAIN
FLASH MIXER OF 3m Ø
CLARIFLOCCULATOR OF
8m Ø FLOCCULATOR ZONE
&
20 m Ø CLARIFIER ZONE
RAPID GRAVITY
FILTER
300 mm FREEBOARD
UNDERGROUND STORAGE RESERVOIR (USR)
PRESSURE STATION
GOING TO OVERHEAD
RESERVOIR



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