HYDRAULIC DESIGN
OF
WATER TREATMENT PLANT
CAPACITY - 40 MLD
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<th>Page</th>
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<td>1. Flocculator And Clarifier</td>
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<td>2. Collection Launder</td>
<td>81</td>
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<td>Head Losses And Reduced Levels (Channel)</td>
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<tr>
<td>Head Losses And Reduced Levels (Filter Inlet Channel)</td>
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<td>Head Losses And Reduced Levels (Rapid Sand Gravity Filter)</td>
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<td>Head Losses And Reduced Levels (Pure Water Channel)</td>
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</tbody>
</table>
ANNEXURE - I

STANDARD TABLES
**STANDARD DIMENSIONS FOR PARSHALL FLUME**

(*Reference Manual on Sewerage and Sewerage Treatment- Table 5.5*)

<table>
<thead>
<tr>
<th>Flow Range $Q_{max}$ (MLD)</th>
<th>W</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
<th>G</th>
<th>K</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 5</td>
<td>75</td>
<td>460</td>
<td>450</td>
<td>175</td>
<td>255</td>
<td>150</td>
<td>300</td>
<td>25</td>
<td>56</td>
</tr>
<tr>
<td>5 to 30</td>
<td>150</td>
<td>610</td>
<td>600</td>
<td>315</td>
<td>391</td>
<td>300</td>
<td>600</td>
<td>75</td>
<td>113</td>
</tr>
<tr>
<td>30 to 45</td>
<td>225</td>
<td>865</td>
<td>850</td>
<td>375</td>
<td>566</td>
<td>300</td>
<td>750</td>
<td>75</td>
<td>113</td>
</tr>
<tr>
<td>45 to 170</td>
<td>300</td>
<td>1350</td>
<td>1322</td>
<td>600</td>
<td>831</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>170 to 250</td>
<td>450</td>
<td>1425</td>
<td>1357</td>
<td>750</td>
<td>1010</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>250 to 350</td>
<td>600</td>
<td>1500</td>
<td>1472</td>
<td>900</td>
<td>1188</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>350 to 500</td>
<td>900</td>
<td>1650</td>
<td>1619</td>
<td>1200</td>
<td>1547</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>500 to 700</td>
<td>1200</td>
<td>1800</td>
<td>1766</td>
<td>1500</td>
<td>1906</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
<tr>
<td>700 to 850</td>
<td>1500</td>
<td>2100</td>
<td>2060</td>
<td>2100</td>
<td>2625</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
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<tr>
<td>850 to 1400</td>
<td>2400</td>
<td>2400</td>
<td>2353</td>
<td>2700</td>
<td>3344</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
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## STANDARD POWER REQUIREMENT

(*Reference IS 7090 - 4985)

<table>
<thead>
<tr>
<th>Detention Time</th>
<th>Velocity Gradient</th>
<th>Net Power Input per Unit Volume</th>
<th>Net power Input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sec</td>
<td>S(^{-1})</td>
<td>Watts/m(^3) Volume</td>
<td>Watts/m(^3) of flow per hr</td>
</tr>
<tr>
<td>60</td>
<td>300</td>
<td>72</td>
<td>1.2</td>
</tr>
<tr>
<td>50</td>
<td>360</td>
<td>104</td>
<td>1.4</td>
</tr>
<tr>
<td>40</td>
<td>450</td>
<td>162</td>
<td>1.8</td>
</tr>
<tr>
<td>30</td>
<td>600</td>
<td>288</td>
<td>2.4</td>
</tr>
<tr>
<td>25</td>
<td>720</td>
<td>415</td>
<td>2.9</td>
</tr>
<tr>
<td>20</td>
<td>900</td>
<td>648</td>
<td>3.6</td>
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</tbody>
</table>

**Calculations based on water temperature of 30 °C**
ANNEXURE - II

HYDRAULIC DESIGN CALCULATIONS
### TABLE NO.1 - DESIGNED FLOWS AND CAPACITIES FOR VARIOUS ELEMENTS

<table>
<thead>
<tr>
<th>SR NO.</th>
<th>ELEMENT</th>
<th>FLOW</th>
<th>NO. OF UNITS</th>
<th>OVERLOADING</th>
<th>LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MLD</td>
<td>NOS.</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>Cascade Aerator</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Parshall Flume</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Flash Mixer (Square DC)</td>
<td>40</td>
<td>2</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Pipe</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Clariflocculator (Radial flow)</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Channel</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Rapid Sand Gravity Filter</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Pure Water Channel</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Pipe</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Circular Sump</td>
<td>40</td>
<td>1</td>
<td>20</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SR NO.</th>
<th>ELEMENT</th>
<th>DESIGNED FLOW / UNIT</th>
<th>CAPACITY / UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>MLD</td>
<td>m³/day</td>
</tr>
<tr>
<td>1</td>
<td>Cascade Aerator</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>2</td>
<td>Parshall Flume</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>3</td>
<td>Flash Mixer (Square DC)</td>
<td>25.000</td>
<td>25,000,000.00</td>
</tr>
<tr>
<td>4</td>
<td>Pipe</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>5</td>
<td>Clariflocculator (Radial flow)</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>6</td>
<td>Channel</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>7</td>
<td>Rapid Sand Gravity Filter</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>8</td>
<td>Pure Water Channel</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>9</td>
<td>Pipe</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
<tr>
<td>10</td>
<td>Circular Sump</td>
<td>50.000</td>
<td>50,000,000.00</td>
</tr>
</tbody>
</table>

**Formula Used:**

1. **Designed Flow in MLD**

   \[ \text{Designed Flow Per Unit} = \left( \frac{\text{Flow} \times \left( \frac{\text{Overloading}}{100} + \frac{\text{Loss}}{100} \right)}{\text{No. of Units}} \right) + \text{Flow} \]

2. **Capacity in m³/day**

   \[ \text{Capacity} (Q) = \text{Designed Flow Per Unit} \times 10^3 \]

3. **Capacity in m³/hr**

   \[ \text{Capacity} (Q) = \frac{\text{Designed Flow Per Unit} \times 10^3}{24} \]

4. **Capacity in m³/sec**

   \[ \text{Capacity} (Q) = \frac{\text{Designed Flow Per Unit} \times 10^3}{24 \times 60 \times 60} \]
HYDRAULIC DESIGN

- INLET SHAFT
- STEPS AND PLANNER
- COLLECTION LAUNDER
HYDRAULIC DESIGN OF CASCADE AERATOR

The role of Aeration is to remove undesirable dissolved gases in water and to add oxygen to water to convert undesirable substances to a more manageable form.

1. INLET SHAFT
(Reference Table No. 1)

✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50 MLD
✓ Designed Capacity in m³/sec = 0.579 m³/sec

1.1 ASSUMPTIONS & CALCULATIONS:

➢ Assumed velocity of flow through Inlet Shaft = 0.65 m/sec

\[
\text{Diameter of Inlet Shaft Required} = \left( \frac{4 \times \text{Designed Flow (m}^3/\text{sec)}}{\pi \times \text{Velocity (m/s)}} \right)^{0.5}
\]

\[
\text{Diameter of Inlet Shaft Required} = \left( \frac{4 \times 0.579}{3.14 \times 0.65} \right)^{0.5} = 1.065 \text{ m}
\]

Provided Internal Diameter of Inlet Shaft = 1.1 m

➢ Assumed thickness of Inlet Shaft = 0.1 m

Hence, Outer Diameter = 1.300 m

1.2 VALIDATION CHECKS:

1. Provided Diameter 1.1 m > Required Diameter = 1.065 m

Diameter Provided > Diameter Required.

2. Velocity Achieved = 0.610 m/sec

Hence, Velocity achieved is within the permissible Range (0.6 -1.25 m/sec)

DESIGN SUMMARY - INLET SHAFT

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>0.610 m/sec</td>
</tr>
<tr>
<td>Internal Diameter of Inlet Shaft</td>
<td>1.1 m</td>
</tr>
<tr>
<td>Thickness of Inlet Shaft</td>
<td>0.1 m</td>
</tr>
<tr>
<td>Outer Diameter of Inlet Shaft</td>
<td>1.300 m</td>
</tr>
</tbody>
</table>

2. STEPS AND PLANNER
(Reference Table No. 1)

✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50 MLD
✓ Designed Capacity in m³/hr = 2,083.333 m³/hr

2.1 ASSUMPTIONS & CALCULATIONS:

➢ Assumed criteria for area of Aerator = 0.015 m²/m³/h

\[
\text{Area of Aerator Required} = \text{Designed Flow (m}^3/\text{hr}) \times \text{Criteria (m}^2/\text{m}^3/\text{h)}
\]
\[
\text{Area}_{\text{Required}} = 31.250 \text{ m}^2
\]

**Provide Area of Aerator = 32 m}^2**

\[
\text{Diameter of Aerator} = \sqrt{\frac{4}{\pi} \times A + O.D^2}
\]
\[
= \sqrt{\frac{4}{\pi} \times 32 + 1.300^2}
\]
\[
\text{Diameter of Aerator} = 6.516 \text{ m}
\]

▷ Assumed Number of steps = 5 NOS
▷ Assumed Rise of each step = 0.3 m

\[
\text{Size of Tread} = \frac{\text{Diameter of Aerator} - O.D_{\text{Shaft}}}{2 \times \text{No. of Steps}}
\]
\[
= \frac{6.516 - 1.300}{2 \times 5}
\]
\[
\text{Size of Tread} = 0.522 \text{ m}
\]

**Provided Tread= 0.6 m**

\[
\text{Actual Diameter of Aerator} = \text{Tread}_{\text{Provided}} \times (2 \times \text{No. of Steps}) + O.D_{\text{Shaft}}
\]
\[
= 0.6 \times (2 \times 5) + 1.300
\]
\[
\text{Actual Diameter of Aerator} = 7.300 \text{ m}
\]

\[
\text{Total Height of Rise} = \text{Rise} \times \text{No. of Steps}
\]
\[
= 0.3 \times 5
\]
\[
\text{Total Height of Rise} = 1.5 \text{ m}
\]

**VALIDATION CHECKS:**

Actual Area Criteria = 0.020 m}^2/m}^3/h

\[
\text{Actual Area Criteria achieved is within the permissible Limit (0.015 to 0.045 m}^2/m}^3/h)
\]

**DESIGN SUMMARY - STEPS & PLANNER**

<table>
<thead>
<tr>
<th>Actual Area Criteria</th>
<th>0.020 m}^2/m}^3/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter of Aerator</td>
<td>7.300 m</td>
</tr>
<tr>
<td>Number of Steps</td>
<td>5 NOS</td>
</tr>
<tr>
<td>Tread Size</td>
<td>0.6 m</td>
</tr>
<tr>
<td>Rise Size</td>
<td>0.3 m</td>
</tr>
<tr>
<td>Total Rise height</td>
<td>1.5 m</td>
</tr>
</tbody>
</table>

**3. COLLECTION LAUNDER**

✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50 MLD
3.1 ASSUMPTIONS & CALCULATIONS:

- Assumed velocity of flow = 0.65 m/sec
- Assumed width of collecting Launder = 0.6 m
- Assumed Free Board = 0.3 m

\[
\text{Side Water Depth of Collection Launder} = \frac{\text{Design Flow (m}^3/\text{sec)}}{2 \times \text{Velocity} \times \text{Width of Launder}}
\]

\[
= \frac{0.579}{2 \times 0.65 \times 0.6} = 0.742 \text{ m}
\]

\[
\text{Total Depth of Collection Launder} = \text{SWD}_{\text{Launder}} + \text{Free Board}
\]

\[
= 0.742 + 0.3 = 1.042 \text{ m}
\]

**DESIGN SUMMARY - COLLECTION LAUNDER**

- Velocity = 0.65 m/sec
- Width = 0.6 m
- Side water Depth (SWD) = 0.742 m
- Free Board = 0.3 m
- Total Depth of Launder = 1.042 m

---

**Figure - Cascade Aerator Details**

*For Schematic purpose only*
HYDRAULIC DESIGN

- PARSHALL FLUME
- UPSTREAM CHANNEL
- DOWNSTREAM CHANNEL
The role of Parshall Flume (U/S & D/S Channel) is to measure the flow and convey water from Aerator to Flash mixer. Parshall Flume is a type of standing wave flume which is widely used. It can measure discharges varying from 0.001 m$^3$/sec to 100 m$^3$/sec.

1. PARSHALL FLUME
(Reference Table No. 1)
✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50 MLD

1.1 STANDARD DIMENSIONS:

All above mentioned dimensions are in mm.

1.2 DIMENSIONS OF PARSHALL FLUME:

(*Reference Manual on Sewerage and Sewerage Treatment- Table 5.5)

<table>
<thead>
<tr>
<th>W</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>F</th>
<th>G</th>
<th>K</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>1350</td>
<td>1322</td>
<td>600</td>
<td>831</td>
<td>600</td>
<td>900</td>
<td>75</td>
<td>225</td>
</tr>
</tbody>
</table>

*All above mentioned dimensions are in mm.

2. UPSTREAM CHANNEL
(Reference Table No. 1)
✓ Designed Capacity in m$^3$/sec = 0.579 m$^3$/sec

2.1 ASSUMPTIONS & CALCULATIONS:
✓ Assumed Velocity of Flow = 0.65 m/sec
✓ Assumed Free Board = 0.3 m
✓ Assumed Length of Channel = 2.5 m
SOME PAGES ARE KEPT BLANK INTENTIONALLY
HYDRAULIC DESIGN

- CENTRAL SHAFT
- FLOCCULATOR
- POWER REQUIREMENT
- CLARIFIER
- WEIR
- NOTCHES
- PERIPHERAL LAUNDER
**TYPICAL CLARIFLOCULATOR SKETCH**

- **CENTRAL SHAFT DIAMETER** = 1.1 m
- **CLARIFIER DIAMETER** = 50
- **FLOCCULATOR DIAMETER** = 15 m
- **FREE BOARD** = 0.3
- **TYPICAL CLARIFLOCULATOR SKETCH**
- **Blade Height** = 1.4 m
- **Blade Width** = 0.3 m
- **SWD** = 3
- **SWD** = 4.5 m
- **SWD** = 4.8 m

*For Schematic purpose only.*
1 CENTRAL SHAFT
The role of Central Shaft is to convey water to the clariflocculator.
(Reference Table No. 1)
✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50.000 MLD
✓ Designed Capacity in m$^3$/sec = 0.579 m$^3$/sec

1.1.1 ASSUMPTIONS & CALCULATIONS:
➢ Assumed velocity of flow through Central Shaft = 0.65 m/sec

\[
\text{Diameter Of Central Shaft Required} = \left[ \frac{4 \times \text{Designed Flow (m}^3/\text{sec)}}{\pi \times \text{Velocity (m/s)}} \right]^{0.5}
\]

\[
= \left[ \frac{4 \times 0.579}{3.14 \times 0.65} \right]^{0.5}
\]

Diameter Of Central Shaft Required = 1.065 m

Provide Internal Diameter of Central Shaft = 1.1 m

➢ Assumed thickness of Central Shaft = 0.15 m

Hence, Outer Diameter = 1.400 m

1.1.2 VALIDATION CHECKS:
1. Provided Diameter = 1.1 m    >    Required Diameter = 1.065 m
Hence, Diameter provided of Central Shaft is Sufficient.

2. Velocity Achieved = 0.610 m/s
Hence, Velocity achieved is within the permissible Range(0.6-1.2m/sec).

DESIGN SUMMARY - CENTRAL SHAFT
Velocity = 0.610 m/sec
Internal Diameter of Central Shaft = 1.1 m
Thickness of Central Shaft = 0.15 m
Outer Diameter of Central Shaft = 1.400 m

1.2 PORTS
Ports are being provided at the top portion of the Central shaft with the purpose for outlet of water.
(Reference Table No. 1)
✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50.000 MLD
✓ Designed Capacity in m$^3$/sec = 0.579 m$^3$/sec

1.2.1 ASSUMPTIONS & CALCULATIONS:
➢ Assumed velocity of flow through Ports = 0.65 m/sec

\[
\text{Area of Openings of Ports} = \frac{\text{Design Flow (m}^3/\text{sec)}}{\text{Velocity (m/sec)}}
\]
Area of Openings of Ports = \frac{0.579}{0.65} = 0.891 \text{ m}^2

\triangleright Assumed Number of Rows = 1 \text{ Nos.}
\triangleright Assumed Number of Ports per Rows = 5 \text{ Nos.}
\triangleright Assumed width of port = 0.541 \text{ m}
\triangleright Assumed Clear Spacing of Ports = 0.150 \text{ m}

\text{Area of each port required} = \frac{\text{Area of Openings of Ports}}{\text{Nos. of Rows} \times \text{Nos. of Ports per Row}}
= \frac{0.891}{1 \times 5} = 0.178 \text{ m}^2

\text{Height of port} = \frac{\text{Area of port required}}{\text{width of port}}
= \frac{0.178}{0.541} = 0.329 \text{ m}

Provide height of port = 0.35 \text{ m}

Actual Clear Spacing of Ports
= \frac{(\pi \times \text{I.D}) - (\text{Width of Port} \times \text{No. of Ports per Row})}{\text{No. of Ports per Row}}
= \frac{(3.14 \times 1.1) - (0.541 \times 5)}{5} = 0.150 \text{ mm c/c}

\text{NOTE: For ease in construction of ports, clear spacing is maintained as a standard value and thereby width of port is calculated accordingly}

1.2.2 VALIDATION CHECKS:
1. Provided Area of Ports = 0.189 \text{ m}^2 > Required Area = 0.178 \text{ m}^2

Hence, Dimensions of Ports are Sufficient.

\text{DESIGN SUMMARY - PORTS}

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity through Ports</td>
<td>0.65 \text{ m/sec}</td>
</tr>
<tr>
<td>No. of Rows</td>
<td>1 \text{ Nos.}</td>
</tr>
<tr>
<td>Number of Ports per Row</td>
<td>5 \text{ Nos.}</td>
</tr>
<tr>
<td>Height of Port</td>
<td>0.35 \text{ m}</td>
</tr>
<tr>
<td>Width of Port</td>
<td>0.541 \text{ m}</td>
</tr>
<tr>
<td>Actual Clear Spacing Between Ports</td>
<td>0.150 \text{ m}</td>
</tr>
</tbody>
</table>

2. FLOCCULATOR

The role of flocculator is to agglomerate the macroflocs generated in the Flash Mixer. The agglomeration helps to build large size and dense flocs which are effectively removed in the Clarifier/Sedimentation Tank.
(Reference Table No. 1)
Number of Units = 1 Nos
Designed Flow Per Unit = 50,000 MLD
Designed Capacity in m³/sec = 0.579 m³/sec

2.1 ASSUMPTIONS & CALCULATIONS:
- Assumed Detention Time in Flocculator = 20 minutes
- Assumed SWD in Flocculator = 4.5 m

\[
\text{Volume of Flocculator} = Design\ Flow \times Detention\ Time \times 60
\]
\[
= 0.579 \times 20 \times 60
\]

\[
\text{Volume of Flocculator} = 694.800\ m^3
\]

\[
\text{Diameter of Flocculator Required} = \left[ \frac{4}{\pi} \times \left( \frac{Volume (m^3)}{SWD (m)} + O.\ D_{shaft}^2 \right) \right]^{0.5}
\]
\[
= \left[ \frac{4}{3.14} \times \left( \frac{694.800}{4.5} + 1.400^2 \right) \right]^{0.5}
\]

\[
D_F,\text{Required} = 14.091\ m
\]

Provide Diameter of Flocculator (Dₚ) = 15 m

2.2 VALIDATION CHECKS:
1. Actual Detention Time Maintained = 22.891 > Assumed Detention time = 20 min

Actual Detention Time Maintained > Assumed Detention Time.

DESIGN SUMMARY - FLOCCULATOR
- Detention Time = 20 min
- Side Water Depth (SWDₚ) = 4.5 m
- Diameter of Flocculator (Dₚ) = 15 m

3. POWER REQUIREMENT
- Assumed Velocity Gradient = 30 sec⁻¹
- Assumed absolute Viscosity of Water = 0.00089 kg/m.s

\[
\text{Power Required} = G^2 \times \mu \times \frac{\pi}{4} \times \left( D_p^2 - O.D_{shaft}^2 \right) \times SWD_F
\]
\[
= 30^2 \times 0.00089 \times \frac{3.14}{4} \times \left( 15^2 - 1.400^2 \right) \times 4.5
\]

\[
\text{Power Required} = 0.631\ kw
\]

3.1 PADDLE & BLADE REQUIREMENT:
- Assumed Drag Coefficient = 1.1
- Assumed Density of Water = 997 kg/m³
- Assumed Paddle Tip Velocity = 0.5 m/sec
- Assumed Water Velocity at Paddle Tip = 0.125 m/sec
  (*As per CPEEHO Manual Water Velocity at Paddle tip should be 25% of Paddle tip Velocity.)
- Assumed Number of Drive Units = 2 Nos.
- Assumed Number of Arms per Drive Unit = 4 Nos.
- Assumed Number of Blades = 4 Nos.
Area of Paddles Required

\[ \text{Area of Paddles Required} = \frac{2P}{C_D \times \rho \times (V - v)^3} \]

\[ = \frac{2 \times 0.631 \times 10^3}{1.1 \times 997 \times (0.5 - 0.125)^3} \]

\[ A_P = 21.821 \text{ m}^2 \]

Area of Blades/Drive Unit

\[ \text{Area of Blades/Drive Unit} = \frac{A_P}{\text{Number of Drives}} \]

\[ = \frac{21.821}{2} \]

\[ \text{Area of Blades/Drive Unit} = 10.911 \text{ m}^2 \]

*Note: For Detail Calculation & Diagram Refer Annexure III*

- Assumed Height of Blades = 1.4 m
- Assumed Width of Blades = 0.3 m
- Assumed rpm of Blade = 3 rpm

Area of Each Blade

\[ \text{Area of Each Blade} = \text{Height of Blade} \times \text{Width of Blade} \]

\[ = 1.4 \times 0.3 \]

\[ \text{Area of Each Blade} = 0.420 \text{ m}^2 \]

3.2 VALIDATION CHECKS:

1. Ratio of \( A_{\text{blades}} \) to C/S Area of Flocculator = 10.980 %

   \[ \text{The Ratio is in between 10 to 25% which is permissible Limit.} \]

### DESIGN SUMMARY - POWER, PADDLE & BLADES

- **Velocity Gradient** = 30 sec\(^{-1}\)
- **Power Required** = 0.631 kw
- **Drag Coefficient** = 1.1
- **Paddle Tip Velocity** = 0.5 m/sec
- **Water Velocity at Paddle Tip** = 0.125 m/sec
- **No. of Drive Units** = 2 Nos.
- **No. of Arms per Drive Units** = 4 Nos.
- **No of Blade per Arm** = 4 Nos.
- **Height of Blade** = 1.4 m
- **Width of Blade** = 0.3 m
- **rpm of Blade** = 3 rpm
4. CLARIFIER
The role of Clarifier is very similar of that of sedimentation tank. Clarifier is the unit in between Flocculator and Filtration Unit.
(Reference Table No. 1)
✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50.000 MLD
✓ Designed Capacity in m³/hr = 2,083.333 m³/hr

4.1 ASSUMPTIONS & CALCULATIONS:
➢ Assumed Slope to Horizontal = 1 in 11
➢ Assumed Detention Time in Flocculator = 2.5 hours
➢ Assumed SWD in Clarifier = 3 m
➢ Assumed Thickness of partition = 0.2 m
➢ Assumed Surface Overflow Rate (SOR) = 30 m³/m²·d

\[
\text{Volume of Clarifier} = \text{Designed Capacity} \times \text{Detention Time} = 2,083.333 \times 2.5
\]

\[
\text{Volume of Clarifier} = 5,208.333 \text{ m}^3
\]

\[
\text{Area Of Clarifier} = \frac{Q}{\text{SWD}} = \frac{5208.333}{3} = 1,736.111 \text{ m}^2
\]

\[
\text{Diameter of Clarifier Required} = \left[ \frac{4}{\pi} \times A + D_f^2 \right]^{0.5} = \left[ \frac{4}{3.14} \times 1,736.111 + 15^2 \right]^{0.5} = 49.21 \text{ m}
\]
SOME PAGES ARE KEPT BLANK INTENTIONALLY
HYDRAULIC DESIGN

- FILTER BED
- SAND AND GRAVEL
- DEPTH OF WATER
- UNDER DRAIN SYSTEM
- BACKWASHING OF FILTER
- WASH WATER THROUGH
- GULLET/GUTTER
- WASH WATER TANK
Figure - Rapid Sand Gravity
1. FILTER BEDS

(Reference Table No. 1)

- Number of Units = 1 Nos.
- Designed Flow Per Unit = 50,000 MLD

1.1 ASSUMPTIONS & CALCULATIONS:

- Assumed Water for Backwashing = 5%
- Cumulative Time for Backwashing = 10 min
- Assumed Number of Filter Beds = 2 Nos.
- Assumed Rate of Filtration in 20 m³/m².h
- Assumed Ratio of Length to Width = 1.3

\[
\text{Total Water to be Filtered} = \text{Designed Capacity} + \text{Water for Backwashing}
\]

\[
= 50,000 + \left[ \frac{5 \times 50,000}{100} \right] \times 10^3
\]

\[
\text{Total Water to be Filtered} = 52,500,000 \text{ m}^3/\text{day}
\]

\[
\text{Actual Time for Filtration} = 24 - \frac{\text{Time for Backwashing}}{60}
\]

\[
= 24 - \frac{10}{60}
\]

\[
\text{Actual Time for Filtration} = 23.833 \text{ Hours}
\]

\[
\text{Flow per Bed} = \frac{\text{Total Water to be Filtered}}{\text{Actual Time for Filtration}}
\]

\[
= \frac{52,500,000}{23.833}
\]

\[
\text{Flow per Bed} = 2,202.797 \text{ m}^3/\text{hr}
\]

\[
\text{Area Required for each Bed} = \frac{\text{Flow per Bed} (\text{m}^3/\text{hr})}{\text{Rate of Filtration} (\text{m}^3/\text{m}^2.\text{hr}) \times \text{No of Beds}}
\]

\[
= \frac{2202.797}{20 \times 2}
\]

\[
\text{Area Required for each Bed} = 55.070 \text{ m}^2
\]

\[
\text{Length of Bed Required} = \left[ \frac{\text{Area Required} (\text{m}^2)}{1/(\text{L/W Ratio})} \right]^{0.5}
\]

\[
= \left[ \frac{55.070}{1/1.3} \right]^{0.5}
\]

\[
\text{Length of Bed Required} = 8.461 \text{ m}
\]

Provide Length of Bed = 8.5 m
Width of Bed Required = \frac{\text{Length Required}}{\text{Ratio}}

= \frac{8.461 \text{ m}}{1.3}

Width of Bed Required = 6.509 \text{ m}

Provide Width of Bed = 6.6 \text{ m}

1.2 VALIDATION CHECKS:
1. Area Provided = 56.100 \text{ m}^2 > Area Required = 55.070 \text{ m}^2

Area Provided > Area Required

2. Actual L/W ratio maintained is 1.288

Actual L/W ratio maintained is within the permissible range.(1.11 to 1.66)

DESIGN SUMMARY - FILTER BED

Water for Backwashing = 5 \%
Time for Backwashing = 10 \text{ min}
Number of Filter Beds = 2 \text{ Nos.}
Rate of filtration = 20 \text{ m}^3/\text{m}^2\cdot \text{h}
L/W ratio = 1.288
Length of filter bed = 8.5 \text{ m}
Width of filter Bed = 6.6 \text{ m}

2. DEPTH OF SAND AND GRAVEL

DESIGN SUMMARY - SAND

Depth of Sand = 0.6 \text{ m}
d_{10} Size = 0.6 \text{ mm}
d_{60} Size = 0.75 \text{ mm}

<table>
<thead>
<tr>
<th>SR.NO</th>
<th>RANGE IN SIZE (mm)</th>
<th>RANGE IN DEPTH (mm)</th>
<th>PROVIDED DEPTH (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 to 5</td>
<td>50 to 80</td>
<td>70</td>
</tr>
<tr>
<td>2</td>
<td>5 to 12</td>
<td>50 to 80</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>12 to 20</td>
<td>80 to 130</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>20 to 38</td>
<td>80 to 130</td>
<td>120</td>
</tr>
<tr>
<td>5</td>
<td>38 to 65</td>
<td>130 to 200</td>
<td>160</td>
</tr>
</tbody>
</table>

DESIGN SUMMARY - GRAVEL

Depth of Gravel = 500 \text{ mm}

3. DEPTH OF WATER

3.1 ASSUMPTIONS & CALCULATIONS:

\( \triangleright \) Assumed Depth of water above sand = 1 \text{ m}
\( \triangleright \) Assumed Free Board = 0.5 \text{ m}

\[
\text{Total Depth of Filter Box} = D_{\text{Sand}} + D_{\text{Gravel}} + D_{\text{Water}} + \text{Free Board}
\]

= 0.6 + 0.5 + 1 + 0.5

Total Depth of Filter Box = 2.600 \text{ m}
DESIGN SUMMARY - DEPTH OF WATER

Depth of Water = 1 m
Free Board = 0.5 m
Total Depth of Filter Box = 2.600 m

4. UNDER DRAIN SYSTEM
(Reference from Filter Bed Design)
✓ Provided Length of Filter Bed = 8.5 m
✓ Provided Width of Filter Bed = 6.6 m

4.1 ASSUMPTIONS & CALCULATIONS:
> Assumed Sections per filter bed = 2 Nos.
> Assumed Ratio of Filter to Perforations = 0.3 %
> Assumed Ratio of Laterals to Area of Orifice = 4
> Assumed Ratio of Area of Manifolds to Area of Laterals = 1.5

Area of filter per underdrain section = \( \frac{\text{Length of Filter} \times \text{Width of Filter}}{\text{No. of Underdrain sections/Filter Bed}} \)

Area of filter per underdrain section = \( \frac{8.5 \times 6.6}{2} \)

Area of filter per underdrain section = 28.050 m²

Area of Orifice Required = \( \frac{\text{Ratio of Filter to Perforations} \times \text{Area of Filter/Underdrain Section}}{100} \)

Area of Orifice Required = \( \frac{0.3 \times 28.050}{100} \)

Area of Orifice Required = 0.084 m²

Area of Lateral Required = \( \frac{\text{Ratio of Lateral to Area of Orifice} \times \text{Area of Orifice}}{4} \)

Area of Lateral Required = \( \frac{4 \times 0.084}{1} \)

Area of Lateral Required = 0.336 m²

Area of Manifold Required = \( \frac{\text{Ratio of Area of Manifold to Area of Lateral} \times \text{Area of Lateral}}{1.5} \)

Area of Manifold Required = \( \frac{1.5 \times 0.336}{1} \)

Area of Manifold Required = 0.504 m²

Diameter of Manifold Required = \( \left( \frac{4 \times A_{\text{Manifold}}}{\pi} \right)^{0.5} \)

Diameter of Manifold Required = \( \left[ \frac{4 \times 0.504}{3.14} \right]^{0.5} \)

Diameter of Manifold Required = 0.801 m

Provide Diameter of Manifold = 0.85 m

> Assumed width of Pit for Manifold = 0.9 m
> Assumed height of Pit for Manifold = 0.9 m
Assumed Diameter of Laterals = 50 mm

\[
\text{Area of each Lateral} = \frac{\pi}{4} \times D_{\text{Lateral}}^2
\]
\[
= \frac{3.14}{4} \times 50^2
\]
\[
\text{Area of each Lateral} = 0.00196 \text{ m}^2
\]

\[
\text{Number of Laterals Required} = \frac{\text{Area of Laterals}}{\text{Area of Each Lateral}}
\]
\[
= \frac{0.336}{0.00196}
\]
\[
\text{Number of Laterals Required} = 171 \text{ Nos}
\]

Provide Number of Laterals = 172 Nos

Number of Laterals on each side of Manifold = \( \frac{\text{Number of Lateral}}{2} \)
\[
= \frac{171}{2}
\]
Number of Laterals on each side of Manifold = 85.500 Nos

\[
\text{Length of Each Lateral} = \frac{\text{Width of Filter Bed}}{2} - \frac{D_{\text{Manifold}}}{2}
\]
\[
= \frac{6.6}{2} - \frac{0.85}{2}
\]
\[
\text{Length of Each Lateral} = 1.225 \text{ m}
\]

\[
\text{Ratio} = \frac{\text{Length of Each Lateral}}{\text{Diameter of Lateral}}
\]
\[
= \frac{1225}{50}
\]
\[
\text{Ratio} = 24.500 < 60
\]

\[
\text{Required Spacing of Lateral} = \frac{\text{Length of Filter Bed}}{(\text{Number of Lateral}/2)}
\]
\[
= \frac{8.5}{(172/2)}
\]
\[
\text{Required Spacing of Lateral} = 100 \text{ mm}
\]

Provide Spacing of Lateral = 100 m c/c
Assumed diameter of Orifice = 7 mm

\[
\text{Area of each Orifice} = \frac{\pi}{4} \times D_{\text{Orifice}}^2
\]

\[
= \frac{3.14}{4} \times 7^2
\]

Area of each Orifice = 0.0000385 m²

Number of Orifices per Lateral Required = \frac{\text{Area of Orifice}}{\text{No of Laterals} \times \text{Area of Each Orifice}}

= \frac{0.084}{171 \times 0.0000385}

Number of Orifices per Lateral Required = 14 Nos

Provide Number of Orifices = 15 NOS

Required Spacing of Orifice = \frac{\text{Length of Each Lateral}}{(\text{No of Orifice}/2)}

= \frac{1.225}{(15/2)}

Required Spacing of Orifice = 165 mm c/c

Provide Spacing of Orifice = 140 mm c/c

4.2 VALIDATION CHECKS:
1. Diameter of Manifold Provided = 0.85 m > Diameter of Manifold required = 0.801 m

Spacing of Manifold Provided > Spacing of Manifold Required

2. Ratio of Length of Laterals to Spacing of Lateral = 24.500

Ratio of Length of Laterals to Spacing of Lateral < 60, Hence Okay.

DESIGN SUMMARY - UNDER DRAIN SYSTEM

<table>
<thead>
<tr>
<th>Section</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections per filter bed</td>
<td>2 Nos</td>
</tr>
<tr>
<td>Ratio of Filter to Perforation</td>
<td>0.3 %</td>
</tr>
<tr>
<td>Ratio of Area of Manifolds to Area of Laterals</td>
<td>1.5</td>
</tr>
<tr>
<td>Diameter of Manifold</td>
<td>0.85 m</td>
</tr>
<tr>
<td>Width of Manifold Pit</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Depth of Manifold Pit</td>
<td>0.9 m</td>
</tr>
<tr>
<td>Diameter of Lateral</td>
<td>50 m</td>
</tr>
<tr>
<td>Number of Laterals</td>
<td>172 Nos</td>
</tr>
<tr>
<td>Diameter of Orifice</td>
<td>7 mm</td>
</tr>
<tr>
<td>Spacing of Lateral</td>
<td>100 mm c/c</td>
</tr>
<tr>
<td>Spacing of Orifice</td>
<td>140 mm c/c</td>
</tr>
</tbody>
</table>

5. BACKWASHING OF FILTER
SOME PAGES ARE KEPT BLANK INTENTIONALLY
HYDRAULIC DESIGN

- PURE WATER CHANNEL
HYDRAULIC DESIGN OF PURE WATER CHANNEL

The role of Pure Water Channel is to convey water from one element to the another.

(Reference Table No. 1)
- Number of Units = 1 Nos
- Designed Flow Per Unit = 50 MLD
- Designed Capacity in m³/sec = 0.579 m³/sec

1.1 ASSUMPTIONS & CALCULATIONS:
- Assumed velocity of flow through Pure Water Channel = 0.6 m/sec
- Assumed Width of Pure Water Channel = 2 m
- Assumed Free Board = 2 m
- Assumed Length of Pure Water Channel = 3 m

\[
\text{Side Water Depth of Pure Water Channel} = \frac{\text{Designed Capacity} (m^3/\text{sec})}{\text{Velocity} \times \text{Width of Channel}} = \frac{0.579}{0.6 \times 2} = 0.482 \text{ m}
\]

\[
\text{Side Water Depth of Pure Water Channel} = 0.482 \text{ m}
\]

\[
\text{Total Depth of Pure Water Channel} = \text{SWD}_{\text{Channel}} + \text{Free Board} = 0.482 + 2 = 2.482 \text{ m}
\]

1.2 VALIDATION CHECKS:
1. Velocity Achieved = 0.6 m/s

Hence, Velocity achieved is within the permissible Range (0.6 - 1.2 m/sec)

DESIGN SUMMARY - CHANNEL
- Velocity = 0.6 m/sec
- Width = 2 m
- Side water Depth (SWD) = 0.482 m
- Length = 3 m
- Free Board = 2 m
- Total Depth of Pure Water Channel = 2.482 m

Figure - Pure Water Channel Details
HYDRAULIC DESIGN

PIPE
HYDRAULIC DESIGN OF PIPE

The role of Pipe is to convey water from one element to another.

(Reference Table No. 1)
✓ Number of Units = 1 Nos
✓ Designed Flow Per Unit = 50 MLD
✓ Designed Capacity in m³/sec = 0.579 m³/sec

1.1 ASSUMPTIONS & CALCULATIONS:
➤ Assumed velocity of flow through Pipe = 0.6 m/sec

\[
\text{Diameter of Pipe Required} = \left( \frac{4 \times \text{Designed Flow} (\text{m}^3/\text{sec})}{\pi \times \text{Velocity} (\text{m/s})} \right)^{0.5} \\
= \left[ \frac{4 \times 0.579}{3.14 \times 0.6} \right]^{0.5} \\
= 1.108 \text{ m}
\]

Provide Standard D.I Pipe of Internal Diameter = 1.200 m

➤ Corresponding thickness of Pipe (K7) = 0.01530 m

Hence, Outer Diameter = 1.231 m

1.2 VALIDATION CHECKS:
1. Provided Diameter 1.200 m > Required Diameter = 1.108 m

Hence Diameter provided of Pipe is Sufficient.

2. Velocity Achieved = 0.512 m/s

DESIGN SUMMARY - PIPE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Velocity</td>
<td>0.512 m/s</td>
</tr>
<tr>
<td>Internal Diameter of Pipe</td>
<td>0.512 m</td>
</tr>
<tr>
<td>Thickness of Pipe</td>
<td>0.01530 m</td>
</tr>
<tr>
<td>Outer Diameter of Pipe</td>
<td>1.231 m</td>
</tr>
</tbody>
</table>

Figure - Pipe Details
*For Schematic purpose only.*
HYDRAULIC DESIGN

- PURE WATER SUMP (CIRCULAR)
SOME PAGES ARE KEPT BLANK INTENTIONALLY
ANNEXURE - II

- HYDRAULIC HEAD LOSSES AND REDUCED LEVELS
## HYDRAULIC HEAD LOSSES AND REDUCED LEVELS

<table>
<thead>
<tr>
<th>NOTATION</th>
<th>ABBREVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL</td>
<td>Head Loss</td>
</tr>
<tr>
<td>TWL</td>
<td>Total Water Level</td>
</tr>
<tr>
<td>FSL</td>
<td>Full Supply Level</td>
</tr>
<tr>
<td>RL</td>
<td>Reduced Level</td>
</tr>
<tr>
<td>$h_e$, $h_f$</td>
<td>Frictional Loss</td>
</tr>
<tr>
<td>g</td>
<td>Gravitational Acceleration</td>
</tr>
<tr>
<td>C</td>
<td>Manning's Coefficient</td>
</tr>
<tr>
<td>f</td>
<td>Hazen William Coefficient</td>
</tr>
<tr>
<td>R</td>
<td>Hydraulic Radius</td>
</tr>
<tr>
<td>S</td>
<td>Hydraulic Gradient</td>
</tr>
<tr>
<td>$h_{en}$</td>
<td>Head Loss at Entry</td>
</tr>
<tr>
<td>$h_{ex}$</td>
<td>Head Loss at Exit</td>
</tr>
<tr>
<td>$h_b$</td>
<td>Head Loss due to Bend</td>
</tr>
<tr>
<td>$h_{se}$</td>
<td>Head Loss due to Sudden Expansion</td>
</tr>
<tr>
<td>$h_{sc}$</td>
<td>Head Loss due to Sudden Contraction</td>
</tr>
<tr>
<td>$K_{en}$</td>
<td>Entry Head Loss Coefficient</td>
</tr>
<tr>
<td>$K_{ex}$</td>
<td>Exit Head Loss Coefficient</td>
</tr>
<tr>
<td>$K_b$</td>
<td>Bend Head Loss Coefficient</td>
</tr>
<tr>
<td>$K_{se}$</td>
<td>Expansion Head Loss Coefficient</td>
</tr>
<tr>
<td>$K_{sc}$</td>
<td>Contraction Head Loss Coefficient</td>
</tr>
<tr>
<td>Q</td>
<td>Discharge in m$^3$/sec</td>
</tr>
<tr>
<td>v</td>
<td>Velocity in m/sec</td>
</tr>
<tr>
<td>SWD or d</td>
<td>Side Water Depth in m</td>
</tr>
<tr>
<td>b</td>
<td>Width in m</td>
</tr>
<tr>
<td>d</td>
<td>Diameter in m</td>
</tr>
<tr>
<td>L</td>
<td>Length in m</td>
</tr>
</tbody>
</table>

### Formulae Used for Calculating Head Losses:

**1. Frictional Losses in Open Channels:**

Using Manning's Formula

\[
(S) = \left[ \frac{\text{Velocity} \times n}{R^{1/3}} \right]^{1/(n+1)}
\]
n = Manning's Coefficient

\[ \text{Hydraulic Radius (R)} = \frac{\text{Cross Sectional Area}}{\text{Wetted Perimeter}} = \frac{b \times d}{b + 2d} \]

Frictional Loss = \( \text{Hydraulic Gradient (S)} \times \text{Length} \)

II. Frictional Losses in Pipes:

a. Frictional Losses by Hazen William Equation:

\( h_{fr} = C \left( \frac{\text{Velocity}}{0.85 \times C \times R^{0.63}} \right)^{1/0.54} \times \text{Length of Pipe} \)

Where, \( C \) = Hazen William Coefficient (Refer Table No.)

\( R \) = Hydraulic Radius

\( = \frac{\text{Diameter}}{4} \)

b. Frictional Losses by Darcy Weisbach Equation:

\( h_f = f \left( \frac{f \times L \times Q^2}{12.1 \times d^5} \right) \)

Where, \( f \) = Darcy Weisbach Coefficient (Refer Table No.)

\( L \) = Length of Pipe in m

\( Q \) = Discharge in \( m^3/\text{sec} \)

\( d \) = Diameter of Pipe in m

III. Minor Head Losses in Pipes:

a. Loss at Entry:

\( h_{en} = \frac{K_{en} \times V^2}{2 \times g} \)

b. Loss at Exit:

\( h_{ex} = \frac{K_{ex} \times V^2}{2 \times g} \)

c. Loss due to Bend:

\( h_b = \frac{K_b \times V^2}{2 \times g} \)
d. Loss due to Sudden Enlargement:

\[ h_{se} = \frac{K_{se} \times V_1^2}{2 \times g} \]

e. Loss due to Sudden Contraction:

\[ h_{sc} = \frac{K_{sc} \times V_2^2}{2 \times g} \]

Where \( K_{en}, K_{ex}, K_{iu}, K_{se}, K_{sc} \) are Head Loss Coefficients

For Coefficient Details refer Table No.

\( v \) = velocity in m/sec

\( g \) = Gravitational Acceleration

**Formulae Used for Calculating Water and Reduced Levels:**

- TWL at Start of an Element = \( \text{Previous TWL}_{Element} - \text{Assumed Drop}_{Element} \)
- TWL at End of an Element = \( \text{TWL}_{Element \ at \ start} - \text{Total Head Loss}_{Element} \)
- RL at Start of an Element = \( \text{TWL}_{Element \ at \ start} - \text{SWD}_{Element} \)
- RL at End of an Element = \( \text{TWL}_{Element \ at \ End} - \text{SWD}_{Element} \)
HEAD LOSSES

- REDUCED LEVELS
HEAD LOSSES AND REDUCED LEVELS
(CASCADE AERATOR)

1. STEPS AND PLANNER
   ✓ No. of Steps = 5 Nos.
   ✓ Rise of Steps = 0.3 m
   ✓ Diameter of Aerator = 7.3 m

2. COLLECTION LAUNDER
   ✓ Velocity in Launder = 0.65 m/sec
   ✓ Width of Launder = 0.6 m
   ✓ SWD = 0.742
   ✓ Free Board = 0.3 m

HEAD LOSS CALCULATIONS AND LEVELS:

- R.L at Lip of Aeration Fountain = 150 m
- Free Fall from last step to collection launder = 0.01 m

Total Loss from lip of fountain = (No of Steps \times \text{Rise}_{\text{Step}}) + \text{Free Fall}
= (5 \times 0.3) + 0.01

Total Loss from Lip of Fountain = 1.510 m

- Assumed Total Loss from Lip of Fountain = 1.510 m

TWL of Collection Launder at start = R.L of Lip - (Total Loss + Additional Losses)
= 150 - (1.510 + 0.01)

TWL of Collection Launder at start = 148.480 m

R.L of Collection Launder Bottom at start = TWL of Collection Launder at start - SWD of Launder
= 148.480 - 0.742

R.L of Collection Launder Bottom at start = 147.738 m

R.L of Collection Launder Top at start = TWL of Collection Launder at start + Free Board
= 148.480 + 0.3

R.L of Collection Launder Top at start = 148.038 m

Length of Launder = \frac{5}{2} \times (\text{Diameter}_{\text{Aerator}} + \text{Width}_{\text{Launder}})
= \frac{3.14}{2} \times (7.3 + 0.6)

Length of Launder = 12.40 m

- Frictional Loss in Launder, Using Manning's Formula and taking Manning's Coefficient for R.C.C as n = 0.13

Hydraulic Gradient \( S \) = \left[ \frac{\text{Velocity} \times n}{R^{\frac{1}{3}}} \right]^{\frac{1}{2}}
\[ \frac{0.6 \times 0.013}{0.21363} \left( \frac{1}{L} \right) \]

**Hydraulic Gradient (S)** = 0.00056

**Frictional Loss in Launder** = \( \text{Hydraulic Gradient} \times \text{Length of Launder} \)
= 0.00056 \times 12.40
= 0.007 m

**TWL of Collection Launder at End** = \( \text{TWL of Launder at Start} - (\text{Frictional Loss} + \text{Additional Loss}) \)
= 148.480 - (0.007 + 0.005)
= 148.468 m

**R.L of Collection Launder Bottom at End** = \( \text{TWL of Collection Launder at End} - \text{SWD}_{\text{Launder}} \)
= 148.468 - 0.742
= 147.726 m
SOME PAGES ARE KEPT BLANK INTENTIONALLY
HEAD LOSSES AND REDUCED LEVELS
(PURE WATER CHANNEL)

✓ Velocity of Flow in Channel = 0.6 m/sec
✓ Depth of Water (SWD) = 0.482 m
✓ Length of Channel = 3 m
✓ Width of Channel = 2 m

HEAD LOSS CALCULATIONS AND LEVELS:

ゝ TWL of Rapid Sand Gravity Filter at end = 146.435 m
ゝ Assumed Drop in Channel = 0 m

\[
\begin{align*}
\text{TWL of Channel at start} &= \text{TWL of Launder at End} - \text{Drop} \\
&= 146.435 - 0 \\
&= 146.435 \text{ m}
\end{align*}
\]

\[
\begin{align*}
\text{RL of Channel at Start} &= \text{TWL of Channel at Start} - \text{SWD}_{\text{Channel}} \\
&= 146.435 - 0.482 \\
&= 145.953 \text{ m}
\end{align*}
\]

ゝ Frictional Loss in Channel, Using Manning's Formula and taking Manning's Coefficient for R.C.C as \( n = 0.13 \)

\[
\begin{align*}
\text{Hydraulic Gradient (S)} &= \left[ \frac{\text{Velocity} \times n}{R^{\frac{1}{3}}} \right]^{\frac{1}{2}} \\
&= \left[ \frac{0.6 \times 0.13}{0.32524^{\frac{1}{3}}} \right]^{\frac{1}{2}} \\
&= 0.00027
\end{align*}
\]

\[
\begin{align*}
\text{Frictional Loss in Channel} &= \text{Hydraulic Gradient} \times \text{Length of Channel} \\
&= 0.00027 \times 3.00 \\
&= 0.00081 \text{ m}
\end{align*}
\]

ゝ Assumed Frictional Loss in Channel = 0.00081 m
ゝ Assumed Additional Head Losses Remark = 0 m

\[
\begin{align*}
\text{TWL of Channel at End} &= \text{TWL of Channel at Start} - (\text{Frictional Loss} + \text{Additional Loss}) \\
&= 146.435 - (0.00081 + 0) \\
&= 146.434 \text{ m}
\end{align*}
\]

\[
\begin{align*}
\text{R.L of Channel Bottom at End} &= \text{R. L of Channel Bottom at Start} \\
&= 145.953 \text{ m}
\end{align*}
\]
HEAD LOSSES AND REDUCED LEVELS
(PIPE)

✓ Designed Flow = 0.579 m³/sec
✓ Velocity of water in Pipe = 0.6 m/sec
✓ Diameter of Pipe = 1.200 m
✓ Length of Pipe = 3 m

HEAD LOSS CALCULATIONS AND LEVELS:

➢ TWL of Channel at end = 146.434 m

\[
\begin{align*}
\text{Total Head Losses in Pipe} & \quad = \quad A_{HL} \\
& \quad = \quad 0 \\
\text{Total Head Losses in Pipe} & \quad = \quad 0.000 \text{ m}
\end{align*}
\]

\[
\begin{align*}
\text{TWL at the start of Pure Water Sump} & \quad = \quad \text{TWL of Pure Water Channel at end} \quad - \quad \text{Total Head Losses in Pipe} \\
& \quad = \quad 146.434 \quad - \quad 0.000 \\
\text{TWL at the start of Pure Water Sump} & \quad = \quad 146.434 \text{ m}
\end{align*}
\]
HEAD LOSSES AND REDUCED LEVELS
(PURE WATER SUMP)

Water Depth (SWD) = 3 m

HEAD LOSS CALCULATIONS AND LEVELS:
TWL of Pure Water Sump at the start = 146.434 m

\[
\begin{align*}
FSL \text{ in Sump} &= TWL \text{ at Start} - (Drop + Free \ Fall) \\
               &= 146.434 - (0.050 \ m + 0.300 \ m) \\
               &= 146.084 \ m
\end{align*}
\]

\[
\begin{align*}
RL \text{ of Sump Bottom} &= FSL \text{ in Sump} - SWD_{\text{sump}} \\
                          &= 146.084 - 3 \\
                          &= 143.084 \ m
\end{align*}
\]
## TOTAL WATER LEVEL AND REDUCED LEVELS

**AVERAGE GL OR RL AT START = 150 m**

<table>
<thead>
<tr>
<th>SR NO.</th>
<th>ELEMENT</th>
<th>CUMULATIVE HEAD LOSS</th>
<th>TOTAL WATER LEVEL</th>
<th>REDUCED LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CASCADE AERATOR</td>
<td>1.532 m</td>
<td>150</td>
<td>148.468</td>
</tr>
<tr>
<td>2</td>
<td>PARSHALL FLUME</td>
<td>1.991 m</td>
<td>148.468</td>
<td>148.009</td>
</tr>
<tr>
<td>3</td>
<td>FLASH MIXER</td>
<td>1.996 m</td>
<td>148.009</td>
<td>148.004</td>
</tr>
<tr>
<td>4</td>
<td>PIPE</td>
<td>2.011 m</td>
<td>148.004</td>
<td>147.989</td>
</tr>
<tr>
<td>5</td>
<td>PIPE</td>
<td>2.011 m</td>
<td>147.989</td>
<td>147.989</td>
</tr>
<tr>
<td>6</td>
<td>CLARIFLOCCULATOR</td>
<td>2.056 m</td>
<td>147.989</td>
<td>147.944</td>
</tr>
<tr>
<td>7</td>
<td>CHANNEL</td>
<td>2.061 m</td>
<td>147.944</td>
<td>147.939</td>
</tr>
<tr>
<td>8</td>
<td>FILTER INLET CHANNEL</td>
<td>2.062 m</td>
<td>147.939</td>
<td>147.938</td>
</tr>
<tr>
<td>9</td>
<td>RAPID SAND GRAVITY FILTER</td>
<td>3.565 m</td>
<td>147.938</td>
<td>146.435</td>
</tr>
<tr>
<td>10</td>
<td>PURE WATER CHANNEL</td>
<td>3.566</td>
<td>146.435</td>
<td>146.434</td>
</tr>
<tr>
<td>11</td>
<td>PIPE</td>
<td>3.566 m</td>
<td>146.434</td>
<td>146.434</td>
</tr>
<tr>
<td>12</td>
<td>PURE WATER SUMP</td>
<td>3.916 m</td>
<td>146.434</td>
<td>144.34</td>
</tr>
</tbody>
</table>

**Diagram**

- **TWL**: Total Water Level
- **RL**: Reduced Level
- **F.L IN SUMP**: F.L at the Sump
- **F.L IN FILTER AT END**: F.L at the End of the Filter
- **F.L IN CLARIFIER**: F.L at the Clarifier
- **F.L IN CHANNEL**: F.L at the Channel
- **F.L IN LAUNDER AT END**: F.L at the End of the Launder
- **F.L IN FLASH MIXER**: F.L at the Flash Mixer
- **F.L IN D.S AT START**: F.L at the Start of the D.S
- **F.L IN LAUNDER AT START**: F.L at the Start of the Launder
- **F.L IN COLLECTION LAUNDER**: F.L at the Collection Launder
- **RL AT LIP OF AERATION FOUNTA**: Reduced Level at the Lip of Aeration Founta