## 3. Hydraulic Profile

### 3.1 Plant Capacity

| | | | |
|---|---|---|---|
| Production Flow | | | 45,460 m3/d |
| Treatment Flow | Loss in preatment process | 5 % | 47,900 m3/d |
| | | | 0.554 m3/s |

### 3.2 Raw Water Intake

#### 1) Water Level of RBC

| | | |
|---|---|---|
| HWL | + | 184.71 |
| LWL | + | 184.26 |
| Bed EL | + | 183.92 |

#### 2) Head Loss of Intake

| **Intake Mouth** | | | LWL | HWL |
|---|---|---|---|---|
| Number of mouth | | | 1 | 1 |
| width | 1.600 | | 1.6 | 1.6 |
| water depth (LWL) | (intake level + 184.26, bed level + 183.92) | | 0.34 | 0.79 |
| Inlet loss: hi = | (1 + fe) x v^2/2g = | | 0.063 | 0.012 |
| where, | fe = coefficient | | 0.2 | 0.2 |
| | v = | | 1.018 | 0.438 |
| | a = opening area (w1.0 x h0.50 x 2 nos) | | 0.544 | 1.264 |
| | | WL + | 184.20 | 184.70 |

**Raw Water Main and Branch Pipe** (Raw Water Main to RW Storage Tank)

| | | | | |
|---|---|---|---|---|
| Dimensions of Raw Water Main | | | | |
| diameter: | for both main and branch pipes | ND | 800 mm | |
| length | Main: 21, Branch 31m | | 52 m | |
| Head loss: Raw Water Main | | | LWL | HWL |
| | Diameter (mm) | | 800 | 800 |
| | Length (m) | | 21 | 21 |
| | Velocity (m/s) | | 1.103 | 1.103 |
| | Hydraulic Gradient (i) C = 130 | | 1.30 | 1.30 |
| | Friction Loss (hf) | | 0.027 | 0.027 |
| | Minor loss | | 0.093 | 0.093 |
| | Total head loss | | 0.120 | 0.120 |
| | | WL + | 184.08 | 184.58 |
| Caorse Screen: | | | | |
| hscr = | C x v^2/2g = | | 0.0003 | 0.0002 |
| wgere, | C = c x (s/b)^4/3 x sin Θ = | | 0.23 | 0.23 |
| | c: shape factor (rectangular) | | 2.42 | 2.42 |
| | s: thickness of screen bar (flat bar) | mm | 9 | 9 |
| | b: net clearance between screen bars | mm | 51 | 51 |
| | v: approach velocity | m/s | 0.148 | 0.117 |
| | Θ: slope to horizontal | deg. | 70 | 70 |
| | a: opening area (w2.00 x h1.87) | m2 | 3.740 | 4.740 |
| | w: width | m | 2.00 | 2.00 |
| | h: water depth (0.50-0.005) | m | 1.87 | 2.37 |
| | α: opening ratio due clogging by debris | % | 20% | 20% |
| | head loss of coarse screen is set at | m | 0.006 | 0.004 |
| | | assumed | 0.02 | 0.02 |
| | | WL + | 184.06 | 184.56 |

| | | | | |
|---|---|---|---|---|
| Raw Water Branch | | | | |
| (one only tank used) | | | | |
| Diameter (mm) | | 800 | 800 | |
| Length (m) | | 31 | 31 | |
| Velocity (m/s) | | 1.103 | 1.103 | |
| Hydraulic Gradient (i) | C = 130 | 1.30 | 1.30 | |
| Friction Loss (hf) | | 0.040 | 0.040 | |
| Minor loss | (fraction fr = 0.99, valve fv =0.2, bend fb = 0.3, outlet fo = 1.0) | 0.154 | 0.154 | |
| Total head loss | | 0.195 | 0.195 | |
| | WL + | 183.86 | 184.36 | |
| | FGL + | 185.00 | 185.00 | |
| | Free board | 1.14 | 0.64 | |

| | | | |
|---|---|---|---|
| Summary | RW Main | 0.120 | m |
| | Coarse Screen | 0.020 | m |
| | RW Branch | 0.195 | m |
| | Total loss | 0.335 | m |

## 3) Water Level of Raw Water Storage Tank

| | | | | |
|---|---|---|---|---|
| HWL | water depth: | 3.5 m | + | 184.36 |
| LWL | | 3.0 m | + | 180.86 |

note: when canal becomes LWL, effective water depth of tank becomes 3.0m

| | | | | |
|---|---|---|---|---|
| Raw Water Outflow pipe (RW PS Inlet) | | | | |
| Diameter (mm) | | 800 | | |
| Length (m) | | 36 | | |
| Velocity (m/s) | | 1.103 | | |
| Hydraulic Gradient (i) | | 1.30 | | |
| Friction Loss (hf) | | 0.047 | | |
| Minor loss (fi 0.5, BV 0.24, fo 1.0) | | 0.108 | | |
| Total head loss | | 0.155 | | |

| | | | | | |
|---|---|---|---|---|---|
| Interconnecting Pipe (RW Tank - RW PS Inlet) | | | | | |
| Flow rate | | Q = | 0.554 | m3/s | |
| Size | | | 800 | mm | |
| Length | | | 36 | m | |
| Velocity | | v = | 1.103 | m/s | |
| Hydraulic Gradient | C = 130 | i = | 1.30 | ‰ | |
| Friction loss | | hf = | 0.047 | m | |
| Monor loss | Σf = 1.5 | hm = | 0.093 | m | |
| Valve loss | fv = 0.24 | hvm = | 0.015 | m | |
| | | Hrwm = | 0.155 | m | |

## 4) Raw Water Pump Station

| | | | | | |
|---|---|---|---|---|---|
| Pump Suction Well | HWL | loss of fine screen | 0.1 | + | 184.11 |
| | LWL | | | + | 180.61 |

| | | | | |
|---|---|---|---|---|
| Raw Water Pump Head | LWL of Suction Well | | + | 180.61 |
| | Head loss of Raw Water Main | 0.66 | | |
| | Inlet gate loss of Receiving tank | 0.08 | | |
| | WL of Receiving Tank | | + | 188.86 |
| | Static head | 8.26 | | |
| | Loss of RW main and inlet gate of Receiving Tank | 0.74 | | |
| | Loss of piping around pumps | 1.00 | | |
| | Flow controller included in RWM | - | | |
| | Pump Head | 10.00 | | |

## 3.3 Water Treatment Plant

### 1) Receiving / Distribution Tank

| | | | | | |
|---|---|---|---|---|---|
| Flow Rate | | | | 47,900 | m3/d |
| | | | | 0.554 | m3/s |
| Head Loss | | | | | |
| Loss of piping around pump | | | Hp = | 1.500 | m |
| Raw Water Main | Size | | | 700 | mm |
| | Length | | | 55 | m |
| | Fittings | 90 bend: 3 | | | |
| | Valve | BV: 1 | Controler: 1 | | |
| | Velocity | C = 130 | v = | 1.440 | m/s |
| | Hydraulic Gradient | | i = | 2.50 | ‰ |
| | Friction loss | | hf = | 0.137 | m |
| | Minor loss | Σf = 1.9 | hm = | 0.201 | m |
| | Valbe loss (maintenanc | fv = 0.24 | hvm = | 0.004 | m |
| | (controller) | fc = 3.0 | hc = | 0.318 | m |
| | | | Hrwm = | 0.660 | m |
| Receiving Tank | Number of Compartments | | | 2 | nos. |
| | Flow per Unit | | | 0.277 | m3/s |
| | Inlet Gate Loss | size: | | 600 x 600 | mm |
| | | | v = | 0.769 | m/s |
| | | fg = 2.78 | hg = | 0.084 | m |
| | | Water level of Receiving Tank | | WL + | 188.86 |
| | Overflow weir | L = 3 m | hw = | 0.123 | m |
| | Free fall | W = 3.5m | hd = | 0.067 | m |
| | | | Hw = | 0.190 | m |
| | Interconnecting gate loss | size of gate | | 600 x 600 | mm |
| | | | hg = | 0.084 | m |

### 2) Flash Mixing Tank

| | | | | | |
|---|---|---|---|---|---|
| Number of Tanks | | | | 2 | tanks |
| Head Loss | | | | | |
| Interconnection Pipe | Flow rate | | | 0.277 | m3/s |
| | Size of pipe | | | 500 | mm |
| | Length | | | 10 | m |
| | Fittings | 90 bend: 1 | | | |
| | Valve | BV: 1 | | | |
| | Velocity | | v = | 1.411 | m/s |
| | Hydraulic gradient | | i = | 3.56 | ‰ |
| | Friction loss | C = 130 | hf = | 0.036 | m |
| | Minor loss | Σf = 1.8 | hm = | 0.183 | m |
| | Valve loss | fv = 0.24 | hv = | 0.024 | m |
| | | | Hp = | 0.243 | m |
| | | Water level of Flash Mixing Tank | | WL + | 188.35 |
| Flash Mixing tank | Overflow Weir Loss | L = 3m | hw = | 0.136 | m |
| | | free fall | hd = | 0.464 | m |
| | | total loss | Ht = | 0.600 | m |

### 3) Flocculation Tank

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of Tanks | | | | 4 | tanks | |
| Head Loss | Flow rate | | | 0.139 | m3/s | |
| Inlet gate of Flocc. Tank | | | | | | |
| | Size of inlet gate | | | 450 x 450 | mm | |
| | Velocity | | v = | 0.684 | m/s | |
| | Gate loss | C = 2.78 | hg = | 0.066 | m | |
| | | Water level of Flocculation Tank Tank (first raw) | | | WL + | 187.68 |
| Flocculation | Slow Mixing | (refer to process design | hmix = | 0.358 | m | |
| | Perforated wall | v = 0.2 m/s | hor = | 0.005 | m | |

### 4) Settling Tank

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of Tanks | | | | 4 | tanks | |
| | | | Water level of Settling Tank Tank | | WL + | 187.32 |
| Head Loss | Flow rate | | | 0.139 | m3/s | |
| Crified water collection | (refer to process design) | | | | PCL + | 187.20 |
| | Collector | | hs = | 0.306 | m | |
| | Effluent launder | | hl = | 0.110 | m | |
| | Total loss | | Hc = | 0.415 | m | |

### 5) Rapid Sand Filter

| | | | | | | |
|---|---|---|---|---|---|---|
| Number of Filter | | | | 8 | filters | |
| Flow rate | | | Q = | 46,870 | m3/d | |
| | | | q = | 0.068 | m3/s | |
| Head Loss | | | Water level of header channel | | WL + | 186.90 |
| Inlet Loss | Inlet gate | gate size: 300 x 300 | velocity: | 0.753 | m/s | |
| | | | hg = | 0.080 | m | |
| | Inlet weir | width (m): 0.9 | hw = | 0.119 | m | |
| | | | free fall hd: | 0.097 | m | |
| | Inlet pipe | (ND 300 mm x L 1.8m) | | 0.076 | m | |
| | Inlet loss | | | 0.372 | m | |
| | | | Water level of Filter | | WL + | 186.53 |
| Loss of Filtration | for clean filter sand, gravel and underdrain | | | 0.328 | m | |
| | clogging loss | | | 1.300 | m | |
| | | | | 1.628 | m | |

**Filtration Loss**

| | | | | |
|---|---|---|---|---|
| Number of filters | | | 8 | units |
| Flow rate | loss: | 3% | 46,900 | m3/d |
| | per filter | | 5,900 | m3/d |
| | | | 0.068287 | m3/s |
| Filter Area | width | | 5.2 | m |
| | length | | 8.1 | m |
| | area | | 42.12 | m2 |

Sand Layer

$hs = 0.178 * Cd/g * v^2/p^4 * h$ = 0.326 m

where,

| | | | |
|---|---|---|---|
| Cd : | Drag coefficient | | |
| g : | Acceleration of gravity | 980 | $cm/s^2$ |
| v : | Filtration rate (cm/s) | 0.162 | cm/s |
| p : | Void ration of sand layer | 0.4 | |
| A : | Surface area of sand particle | | |
| V : | Volume of sand particle | | |
| h : | Thickness of sand layer | 100 | cm |

$A/V = 6/\sigma d = 6/(0.81*0.09) =$ 82.3

where,

| | | | |
|---|---|---|---|
| σ: | Spericity of sand particle | 0.81 | |
| d : | Effective size of filter sand | 0.09 | cm |

$Cd = 24/Re + 3/\sqrt{Re} + 0.34$ = 17.5

where,

| | | | |
|---|---|---|---|
| Re : | Reynol's number ( = v*d/n) | 1.620 | |
| n : | Kinematic viscoursity (at 25℃) | 0.009 | |

$= 58.4\ Cd * v^2$

Gravel Layer 0.001 m

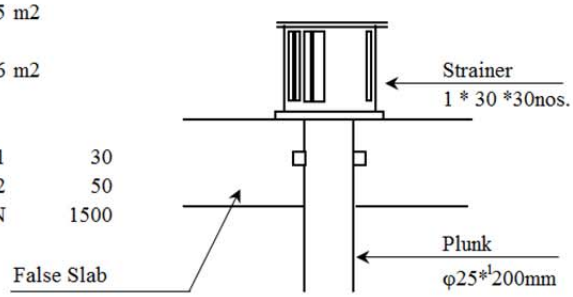
Underdrain (Nozzle Type)

Nozzle Dimensions

Area of strainer: 1.35 m2

Area of plunk pipe : 0.736 m2

| | | | |
|---|---|---|---|
| B | 5.2 | n1 | 30 |
| L | 8.1 | n2 | 50 |
| | | N | 1500 |




Layout of Nozzle

| | | |
|---|---|---|
| Spacing | 150 mm | |
| number of nozzle per filter | 1500 nos | (30*50) |

Filtration Loss (continued)

$hu = (fi + f*d/l + fo) *vp^2/2g + 1/c^2 * vs/2g$

where,

| | | | |
|---|---|---|---|
| fi : | inlet loss coeefficient | 0.5 | |
| f*l/d : | friction loss coefficient (124.5*0.01^2/0.025^1/3 * 0.2/0.02 | 0.43 | |
| fo : | outlet loss coefficient | 1.0 | |
| vp : | velocity of plunk | 0.0928 | m/s |
| c : | orifice coeeficient | 0.6 | |
| vs : | velocity of strainer | 0.0506 | |

$= 1.9 * 0.094\ q^2 + 2.78 * 0.028\ q^2$

$= 0.259\ q^2$ 0.001 m

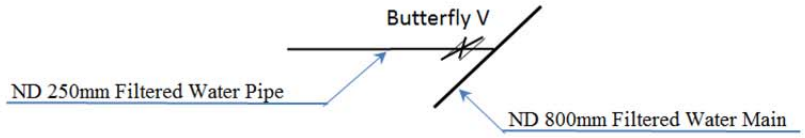
Filtration loss total (clean sand) 0.328 m

Loss of filtered water pipe and main (refer to below analysis) 0.643 m

WL + 184.26

**Loss of Filtered Water Pipes**

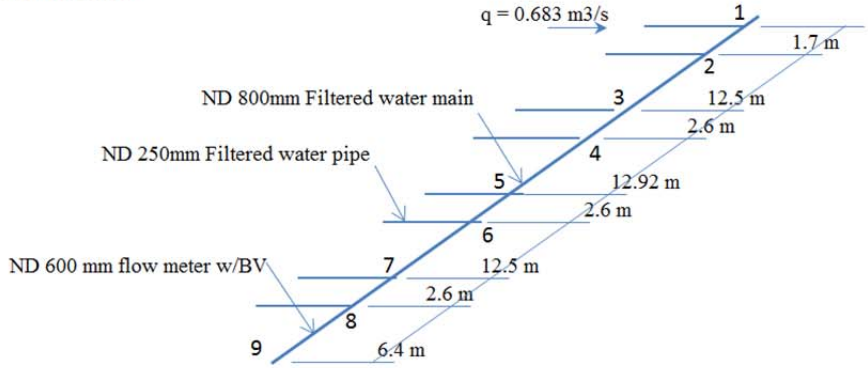
Fileted water pipe




hp1 = (fi + fv + fo + f*l/d) * v^2/2g = 0.323 m

| | | | | |
|---|---|---|---|---|
| where, | fi : | inlet coefficient | 0.5 | |
| | fv : | valve coefficient | 0.3 | |
| | fo : | outlet coefficient | | (calculate separately: refer attached table) |
| | f*l/d-1 : | friction coefficient (400 | 0.54 | ((124.5*0.012^2/0.2^1/3) * (3.5/0.2)) |
| | v : | velocity | 2.175 | (0.0683/(0.785*(0.2^2)) |

Filtered water main



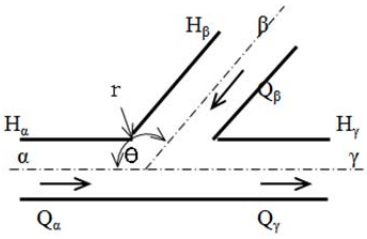

| | friction loss | | | minor loss | | | | | total loss |
|---|---|---|---|---|---|---|---|---|---|
| section | f*l/d | q | v | hf | hβ | hα | hv & hge | ho | Σh |
| 1 ~ 2 | 0.41 | 0.0683 | 0.136 | 0.000 | 0.068 | - | - | - | 0.07 |
| 2 ~ 3 | 0.30 | 0.1366 | 0.272 | 0.001 | 0.072 | 0.003 | - | - | 0.08 |
| 3 ~ 4 | 0.06 | 0.2049 | 0.408 | 0.001 | 0.078 | 0.004 | - | - | 0.08 |
| 4 ~ 5 | 0.31 | 0.2731 | 0.544 | 0.005 | 0.086 | 0.006 | - | - | 0.10 |
| 5 ~ 6 | 0.06 | 0.3414 | 0.680 | 0.001 | 0.096 | 0.007 | - | - | 0.10 |
| 6 ~ 7 | 0.30 | 0.4097 | 0.816 | 0.010 | 0.107 | 0.009 | - | - | 0.13 |
| 7 ~ 8 | 0.06 | 0.4780 | 0.951 | 0.003 | 0.120 | 0.010 | - | - | 0.13 |
| 8 ~ 9 | 0.23 | 0.5463 | 1.087 | 0.014 | 0.135 | 0.011 | - | 0.060 | 0.22 |
| 8 ~ 9 | - | 0.5463 | 1.933 | - | - | - | 0.095 | - | 0.10 |

| | | | | |
|---|---|---|---|---|
| where, | fv : | valve loss (BV) | 0.30 | |
| | fge : | gradual expansion | 0.2 | (Θ = 12 deg.) |
| | fo : | outlet | 1.0 | |

Summary loss of Filtered Water Pipe and Main

| filter | filtered water pipe | | filtered water main | | loss of outlet section | | total |
|---|---|---|---|---|---|---|---|
| | hp1 | hp2 | hf | hm | hv & he | ho | loss |
| 1 | 0.323 | 0.068 | 0.035 | 0.049 | 0.095 | 0.060 | 0.631 |
| 2 | 0.323 | 0.072 | 0.035 | 0.049 | 0.095 | 0.060 | 0.635 |
| 3 | 0.323 | 0.078 | 0.034 | 0.047 | 0.095 | 0.060 | 0.638 |
| 4 | 0.323 | 0.086 | 0.033 | 0.042 | 0.095 | 0.060 | 0.641 |
| 5 | 0.323 | 0.096 | 0.028 | 0.037 | 0.095 | 0.060 | 0.640 |
| 6 | 0.323 | 0.107 | 0.027 | 0.030 | 0.095 | 0.060 | **0.643** |
| 7 | 0.323 | 0.120 | 0.017 | 0.021 | 0.095 | 0.060 | 0.637 |
| 8 | 0.323 | 0.135 | 0.014 | 0.011 | 0.095 | 0.060 | 0.639 |

**Loss of Confluence**




$H_\beta - H\gamma = f_\beta \times V_\gamma^2/2g$

$f_\beta = -q_\beta^2 \times \{1.2x(1/\varphi - 1) + 0.8(1-1/\varphi^2)\} - (1-q_\beta) \times \{0.92 + q_\beta(2.92-\varphi)\}$

$H_\alpha - H\gamma = f_\alpha \times V_\gamma^2/2g$

$f\alpha = -q_\beta^2 \times \{2.59-1.62) - 0.62\varphi\} - q_\beta(1.94-\varphi) + 0.03$

where,
- $H_\alpha$: Pressure of main pipe before confluence
- $H_\beta$: Pressure of branch pipe
- $H_\gamma$: Pressure of main pipe after confluence
- $q_\beta$: $-Q_\beta/Q\gamma$
- Θ: Angle of branch to main pipe (90 deg)
- φ: Section area of Main/Section area of Branch
- ρ: r/D (0)
- r: Radius of pipe connection between main and branch pipes (0)

**Loss of Confluence** Main pipe: 800 mm Branch pipe: 250 mm

**Loss of Branch Pipe:** $\mathbf{H_\beta - H\gamma} = f_\beta \times V_\gamma^2/2g$

| node | Qα | Qβ | Qγ | qβ | φ | fβ | vγ | hβ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.0683 | 0.0683 | 1.00 | 0.097656 | -72 | 0.136 | -0.068 |
| 2 | 0.0683 | 0.0683 | 0.1366 | 0.50 | 0.097656 | -19.2 | 0.272 | -0.072 |
| 3 | 0.1366 | 0.0683 | 0.2049 | 0.33 | 0.097656 | -9.2 | 0.408 | -0.078 |
| 4 | 0.2049 | 0.0683 | 0.2732 | 0.25 | 0.097656 | -5.7 | 0.544 | -0.086 |
| 5 | 0.2732 | 0.0683 | 0.3415 | 0.20 | 0.097656 | -4.07 | 0.680 | -0.096 |
| 6 | 0.3415 | 0.0683 | 0.4098 | 0.17 | 0.097656 | -3.16 | 0.816 | -0.107 |
| 7 | 0.4098 | 0.0683 | 0.4781 | 0.14 | 0.097656 | -2.60 | 0.952 | -0.120 |
| 8 | 0.4781 | 0.0683 | 0.5464 | 0.13 | 0.097656 | -2.24 | 1.088 | -0.135 |

**Loss of Main Pipe:** $\mathbf{H_\alpha - H\gamma}$ $f_\alpha \times V_\gamma^2/2g$

| node | Qα | Qβ | Qγ | qβ | φ | fγ | vγ | hα |
|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0.0683 | 0.0683 | 1.00 | 0.097656 | - | - | - |
| 2 | 0.0683 | 0.0683 | 0.1366 | 0.50 | 0.097656 | -0.66 | 0.272 | -0.003 |
| 3 | 0.1366 | 0.0683 | 0.2049 | 0.33 | 0.097656 | -0.48 | 0.408 | -0.004 |
| 4 | 0.2049 | 0.0683 | 0.2732 | 0.25 | 0.097656 | -0.37 | 0.544 | -0.006 |
| 5 | 0.2732 | 0.0683 | 0.3415 | 0.20 | 0.097656 | -0.30 | 0.680 | -0.007 |
| 6 | 0.3415 | 0.0683 | 0.4098 | 0.17 | 0.097656 | -0.25 | 0.816 | -0.009 |
| 7 | 0.4098 | 0.0683 | 0.4781 | 0.14 | 0.097656 | -0.21 | 0.952 | -0.010 |
| 8 | 0.4781 | 0.0683 | 0.5464 | 0.13 | 0.097656 | -0.19 | 1.088 | -0.011 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Loss of Outlet Weir | Weir length | | | l = | 8.1 m | | |
| | overflow height | C = | 1.84 | hw = | 0.110 m | | |
| | Weir crest | | | | | EL + | 184.15 |
| | Free fall | | | hd = | 0.190 m | | |
| | Weir loss | | | | 0.300 m | | |
| | | | | Water level of Filter effluent | | WL + | 183.960 |

## 6) Clear Water reservoir

Head Loss

Interconnection Pipe

| | | | | | | |
|---|---|---|---|---|---|---|
| Main Pipe | Flow rate | | | | 0.542 | m3/s |
| | Size of pipe | | | | 800 | mm |
| | Length | | | | 20 | m |
| | Fittings | 90 bend: 2 | | | | |
| | Velocity | | | v = | 1.080 | m/s |
| | Hydraulic gradient | | C = 130 | i = | 1.25 | ‰ |
| | Friction loss | | | hf = | 0.025 | m |
| | Minor loss | | Σf = 0.6 | hm = | 0.036 | m |
| | | | | Hp1 = | 0.061 | m |
| Branch | Flow rate | | | | 0.271 | m3/s |
| | Size of pipe | | | | 600 | mm |
| | length | | | | 30 | m |
| | Fittings | 90 bend: 1 | Diversion: 1 | | | |
| | Valve | BV: 1 | | | | |
| | Velocity | | | v = | 0.960 | m/s |
| | Hydraulic gradient | | C = 130 | i = | 1.41 | ‰ |
| | Friction loss | | | hf = | 0.042 | m |
| | Minor loss | | Σf = 1.64 | hm = | 0.077 | m |
| | | | | Hp2 = | 0.119 | m |
| Total loss | | | | Hp = | 0.180 | m |

| | | |
|---|---|---|
| Water level of reservoir | HWL + | 183.78 |
| | LWL + | 179.28 |

## Summary of Hydraulic Analysis – Profile of Water Treatment Plant

| | Facilities | | Head Loss (m) | | Key Elevation | Flow ($m^3/s$) | Water Level |
|---|---|---|---|---|---|---|---|
| 1 | **Receiving/Distribution Tank** | | loss in treatment process | | 5% | 0.554 | |
| | Receiving Level | | | | | | + 188.86 |
| | Weir | hw | 0.123 | + | 188.74 | | |
| | | hd | 0.067 | | | | |
| | Effluent | hg | 0.084 | | | | |
| | Interconencting Pipe | | 0.243 | | | | |
| 2. | **Flash Mixing Tank** | | | | | 0.554 | |
| | Water Level | | | | | | + 188.35 |
| | Weir | hw | 0.136 | + | 188.21 | | |
| | | hd | 0.464 | | | | |
| 3. | **Flocculation Tank** | | | | | 0.554 | |
| | Influent Gate | hg | 0.066 | | | | |
| | Water Level | | | | | | + 187.68 |
| | Baffle Plate | hor1 | 0.358 | | | | |
| | Perforated Wall | hor2 | 0.005 | | | | |
| 4. | **Settling Tank** | | | | | 0.554 | |
| | Water Level | | | | | | + 187.32 |
| | Clarified Water Collector (pipe center) | | | + | 187.20 | | |
| | Loss of Collector | hcor+d+hd | 0.306 | | | | |
| | Effluent Launder | ho-hc | 0.110 | | | | |
| | Total Loss | hf | 0.415 | | | | |
| 5. | **Filter** | | loss in treatment process | | 3% | 0.544 | |
| | Water Level (header channel) | | | | | | + 186.90 |
| | Inlet loss | hi | 0.372 | | | | |
| | Water level (filter) | | | | | | 186.53 |
| | Filter Loss | h | 1.628 | including sand cloggong loss | | | |
| | Filtered pipe and main | hp | 0.643 | | | | |
| | Effluent Weir (Crest) | hw | 0.110 | + | 184.15 | | |
| | Effluent Chamber | | | | | | + 184.26 |
| | | hd | 0.190 | | | | |
| 6. | **Clear Water Reservoir** | | | | | 0.544 | |
| | Interconencting Pipe | | 0.180 | | | | |
| | Water Level | HWL | | | | | + 183.78 |
| | | LWL | 4.50 | | | | + 179.28 |

## AB7.1.2 Transmission and Distribution System

### 1. Service Area

Service area under the Priority Project includes three distribution zones (DZs). These service areas are supplied by the Water Treatment Plant to be constructed at the Existing Jhak Khanuane Water Treatment Plant through three Distribution Centers. General plan of the project area is shown on the following figure.

The distribution center is composed of a ground reservoir (GR) and a Overhead Reservoir (OHR). They are planned to be constructed at the existing OHR sites, namely Abudur Pur (DZ I), Madina Town No.2 (DZ II) and Peoples Colony No.3 (DZ III).

Finished water of Jhal Khanuana WTP (rated capacity of 45,500 m3/d or 10 mgd) is transmitted by pumps to the above three DZs, where recived water in each GR is pumped up to OHR for gravity distribution to respective service area. Flow meters are provided for control of inflow into GR and distribution flow from OHR to monitor distribution flow.

DZ is further divided into multiple district meter areas (DMAs). At the inflow point of DMA, district meter is provided to monitor distribution flow. Pressure gauge is also provided there for monitor of pressure conditions of DMA. The flow monitoring facilitateto grasp the tendency of demand and status of physical loss to compare consumption in respective DMA for loss abatement actions required. The electro-magnetic flow meter is planned taking the necessity of accurate flow measureing.

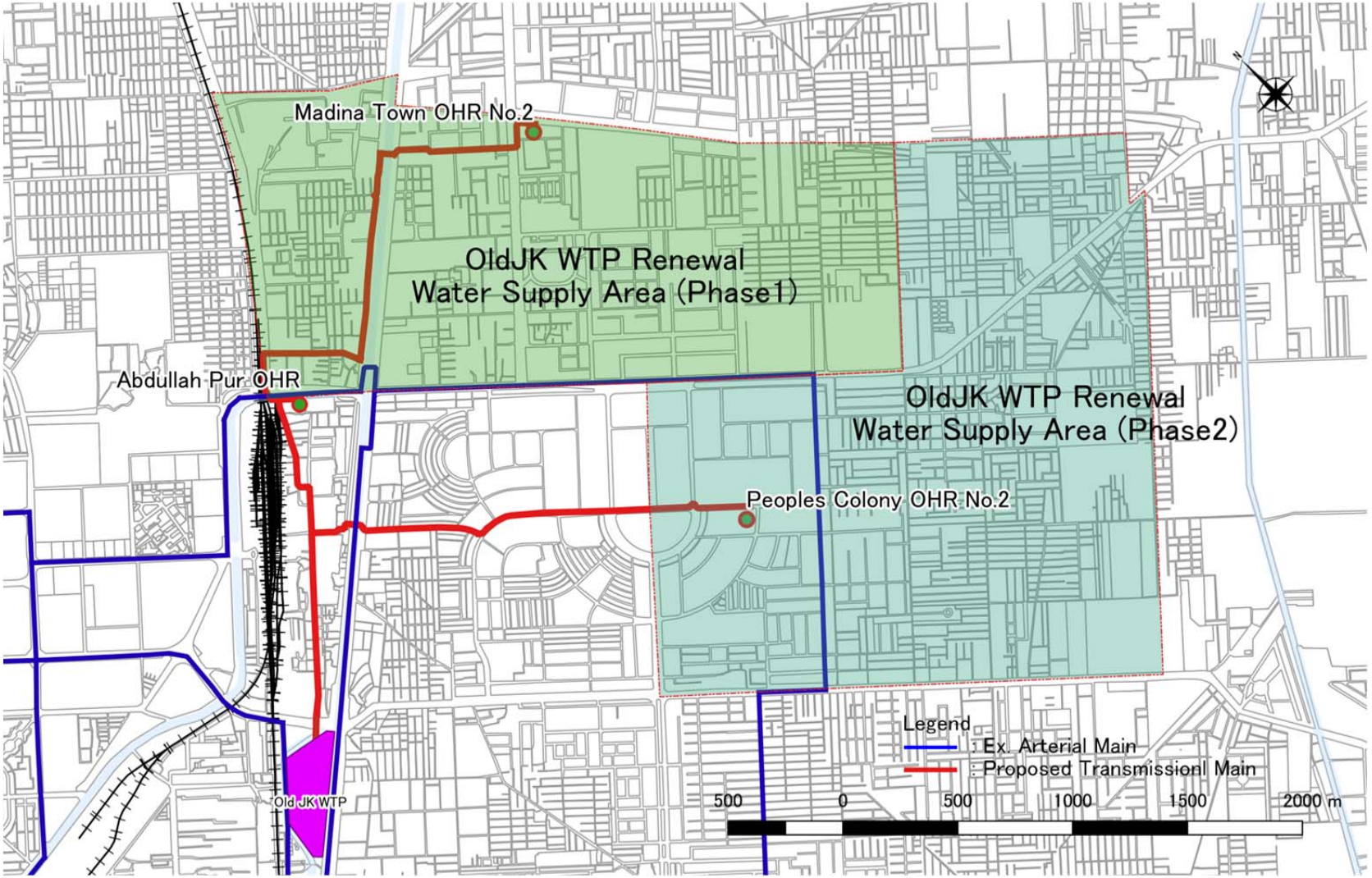
The size of DMA is set at approximately 2000 service connection. The number of DMAs from the said connection numbers, is presented in the below table.

**Service Connections and Water Demand (Day Maximum) in Distribution Zone (DZ) and Distribution Meter Area (DMA)**

| Zone | DMA | 2023 | | 2028 | | 2033 | | 2038 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Connection | Demand | Connection | Demand | Connection | Demand | Connection | Demand |
| | | unit | $m^3/d$ | unit | $m^3/d$ | unit | $m^3/d$ | unit | $m^3/d$ |
| DZ I | I-1 | 970 | 2,460 | 1,300 | 3,100 | 1,670 | 3,710 | 2,010 | 4,190 |
| (DC22) | I-2 | 890 | 2,270 | 1,200 | 2,860 | 1,540 | 3,430 | 1,850 | 3,860 |
| | subtotal | 1,860 | 4,730 | 2,500 | 5,960 | 3,210 | 7,140 | 3,860 | 8,050 |
| | II-1 | 1,200 | 3,050 | 1,590 | 3,770 | 2,010 | 4,460 | 2,350 | 4,910 |
| DZ II | II-2 | 700 | 1,770 | 920 | 2,180 | 1,170 | 2,590 | 1,370 | 2,820 |
| (DC21) | II-3 | 740 | 1,860 | 980 | 2,360 | 1,240 | 2,770 | 1,450 | 3,050 |
| | II-4 | 1,140 | 2,910 | 1,510 | 3,590 | 1,910 | 4,230 | 2,230 | 4,680 |
| | subtotal | 3,780 | 9,590 | 5,000 | 11,900 | 6,330 | 14,050 | 7,400 | 15,460 |
| | III-1 | 820 | 2,080 | 1,090 | 2,610 | 1,380 | 3,070 | 1,610 | 3,360 |
| | III-2 | 970 | 2,470 | 1,280 | 3,030 | 1,620 | 3,630 | 1,900 | 3,960 |
| DZ III | III-3 | 790 | 2,000 | 1,040 | 2,460 | 1,320 | 2,940 | 1,540 | 3,230 |
| (DC18) | III-4 | 790 | 2,000 | 1,040 | 2,500 | 1,320 | 2,910 | 1,550 | 3,230 |
| | III-5 | 1,170 | 2,960 | 1,550 | 3,680 | 1,960 | 4,360 | 2,290 | 4,770 |
| | III-6 | 1,060 | 2,730 | 1,400 | 3,360 | 1,780 | 3,960 | 2,080 | 4,320 |
| | subtotal | 5,600 | 14,240 | 7,400 | 17,640 | 9,380 | 20,870 | 10,970 | 22,870 |
| | Total | 11,240 | 28,560 | 14,900 | 35,500 | 18,920 | 42,060 | 22,230 | 46,380 |

note *1: above figures are based on the demand projection in respective DZs

*2: number of service connection is for domestic users estimated using household size of 7.15, 7.10, 7.0 in year 2023, 2028 and 2038 respectively




GENERAL PLAN OF PRIORITY PROJECT AREA

## 2. Design Criteria

### 2.1 Definitions

The system is composed of treated water transmission main and distribution main which is further divided into three categories of primary, secondary and tertiary mains.

The difinitions of above categories of pipelines are as follows:

Transmission main: The transmission main is pipeline only to transmit finished water from WTP to above mentioned three distribution centers. Therefore, no tapping water from the transmission main is allowed.

Distribution main:

Primary main: The primary main covers entire area of respective DZ.

Secondary main: The secondary main covers entire area of respective DMA.

tertiary main: In general, tapping to consumer's connection is allowed from the tertiary main.

### 2.2 Hydraulic Criteria

#### 1) Design Flow

The flow of transmission main is based on the day maximum demand, on the other hand the distribution flow is based on the peak hourly demand.

Regarding peak hourly or peak flow is defined for categories of distribution mains as follows:

| | |
|---|---|
| Primary main: | 1.5 times of day maximum demand |
| Secondary main: | 1.7 times of day maximum demand |
| Tertiary main: | Simultaneous tapping rate by tapping of connections as 80%, where unit flow is set at 18 l/min. |

#### 2) Head Loss Analysis

Head loss of pipelines is calculated based on Hazen-William formula, where the following loss co-efficient factor (C-value) is used.

| | |
|---|---|
| Transmission Main: | 130 |
| Distribution Mains: | 120 |

#### 3) Minimum Pressure of Distribution System

The pressure of distribution system is determined so as to supply directly up to three stories buildings and houses in consideration that three stories houses and apartments are prevailing in Faisalabad-MC. The minimum pressure of each category of distribution main is presented as follows:

| | | |
|---|---|---|
| Tapping at Tertiary main: | 12 m | |
| Secondary main: | 14 m | (head loss of tertiary main as approx. 2m) |
| Primary main: | 18 m | (head loss of secondary network as 4~5m) |

#### 4)

### 2.3 Transmission and Distribution Pipeline

For design bases of transmission and distribution pipelines, the following criteria are set-up:

### 1) Pipe Materials

The type of pipe materials is determined taking characteristice of pipe materials, cost and importance of pipelines as follows:

| | | |
|---|---|---|
| Transmission main: | DCIP | (considering importance to maintain transmission flow, size of pipeline will be in the range of 250mm to 600mm) |
| Distribution main: | HDPE | (taking advantage of low friction loss, high efficiency of pipe installation works and less cost comparing to DCIP for smaller size of pipeline, size of pipe line will be in the range 80mm to 500mm) |

### 2) Type of Valves

Following types of valve is preferable to be used by size of pipelines.

| Size of pipeline | Type of valve |
|---|---|
| ND 80 ~ 250 mm (Tertiary and Secondary mains) | Gate valve (non-rising stem) |
| ND 300mm or larger (Primary and Transmission mains) | Butterfly valve (short body) |

### 3) Earth Cover

The earth cover by size and category of pipeline is determined as follows:

| | |
|---|---|
| Transmission main (generally 500mm and smaller) | 1.2 m |
| Distribution primary main (generally 300 ~ 500mm) | 1.2 m |
| Distribution secondary main (generally 150 ~ 250mm) | 0.9 m |
| Distribution tertiary main (generally 80 ~ 100mm) | 0.6 m |

### 4) Ground Reservoir and Overhead Reservoir

The structure, detension time and effective depth of reservoir is as follows:

| | | |
|---|---|---|
| Ground Reservoir (GR) | Structure: | RC |
| | Detention time: | 4 hrs |
| | Effective Water depth: | 4 ~ 6 m |
| Overhead Reservoir (OHR) | Structure: | RC |
| | Detention time: | 1.5 hrs |
| | Effective Water depth: | max. 6 m |

note 1: Detention time of reservoir of 4 hours is determined based on the peak hour factor of 1.5 of day max. demand

2: Detention time of OHR as 1.5 hours is determined based on capacity of lift pump from GR as peak hourly demand with power suply failure of one hour.

## 3. Transmission Facilities

## 3.1 Transmission Main

### 1) Pipeline Routes

Transmission main starts from WTP boundary. The pipeline crosses firstly trunk road with fly over named ……..., where space is availabe under the the fly over to cross it. The night work will be required to cross this trunk road.

After crossing the above Fly over, the pipeline enter into local road where only limited traffic is observed. The road (road name is not shown on Google earth) is unpaved one with enough width to install pipeline at it road shoulder. after 900m along from starting point, the branch is provoded toward fo the Canal Road along Rakh Branch Canal (RBC).

The pipline continues run along the local raod for about 200m, then turns to the left toward rail way along the local road. Ater turn to the right the pipeline continued to Jhamura Road for about 440 m long. The branch pipe is provided at Jhamura Road along its south-west up to the Distribution Center 1 for about 70m.

At the Jhamura Road, the pipeline turns to the left toward railway for about 30m then runs toward North-east direction along Jhamura Road for about 200m, where the pipeline turns to the right toward the Canal Road. The pipeline runs along the service road of the Canal Road for abou 900m long toward the north-east, then turns to the right toward the Distribution Center 2.

The pipeline crosses RBC and Canal Roads at its both sides, then reached to trunk road of madina town area named Suzan Road for about 600m. From the suzan road for about 230m the pipeline arrives at the Distribution Center 2 located along Green Belt Road.

Branch pipeline to the Distribution Center 3 crosses RBC and Canal Road at its both sides, then runs to the Distribution Center for about 1800m along Shalah-e-Faisal Link Road.

## 2) Hydraulic Analysis and Sizing of Transmission Main

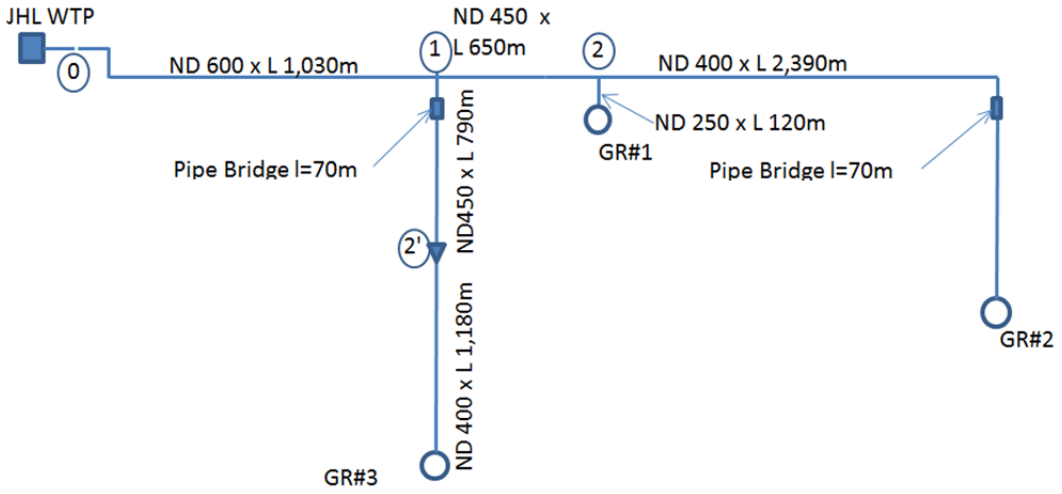
Finished water in Jhal Khanuana Water Treatment Plant (JK WTP) is transferred to three distribution centers (DCs). Design parameters of each DC is summarized as follows:

| DZ / Parameter | | DZ I Abudullah Pur | | DZ II Madina Town No.2 | | DZ III Peoples Colony No.2 | |
|---|---|---|---|---|---|---|---|
| JK WTP: | Water level of CW Reservoir | | | HWL + | | 183.78 | |
| | | | | LWL + | | 179.28 | |
| | Designed Delivery Head | | | Pump head + | | 35 | m |
| | | | | Loss in WTP | | 2.5 | m |
| | | | | Delivery head + | | 211.78 | m |
| Distribution Center | | | | | | | |
| Levels | Ground Level (FGL) | 186.10 | m | 188.20 | m | 186.20 | m |
| | Water Level of GR | | | | | | |
| | HWL + | 187.60 | m | 189.70 | m | 187.70 | m |
| | LWL + | 181.60 | m | 185.20 | m | 182.20 | m |
| | | | | | | | |
| Distribution Capacity (Day max.) | | 8,050 | $m^3/d$ | 15,460 | $m^3/d$ | 22,870 | $m^3/d$ |
| (demand for year 2038) | | 0.093 | $m^3/s$ | 0.179 | $m^3/s$ | 0.265 | $m^3/s$ |
| | | | | | | | |
| Peak Flow (hourly max.) | | 503 | $m^3/hr$ | 966 | $m^3/hr$ | 1,429 | $m^3/hr$ |
| (for primary network) | | 0.140 | $m^3/s$ | 0.268 | $m^3/s$ | 0.397 | $m^3/s$ |

Pipeline route and approximate length of transmission main with elevations of Distribution Centers are as shown in the following figures:

| District Zone | | DZ I | DZ II | DZ III |
|---|---|---|---|---|
| Flow (m3/s) | | 0.093 | 0.179 | 0.265 |
| Sevice Area | GL + | 187~189 | 186~188 | 184~187 |
| GR (m) | GL + | 186.10 | 188.20 | 186.20 |
| | HWL + | 187.60 | 189.70 | 187.70 |
| | LWL + | 181.60 | 185.20 | 182.20 |
| OHR (m) | HWL + | 216.60 | 218.70 | 216.70 |
| | LWL + | 211.10 | 213.20 | 211.20 |

**Configulation of Transmission Main**




Diameter of each section of transmission main is calculated as shown in the following table, where friction loss co-efficient (C-value) of 130 is used.

| Section | GL *3 | WL *1 | ND | L | q | v | ‰ | hf | Dinamic H *2 | Res. Head |
|---|---|---|---|---|---|---|---|---|---|---|
| | | m | mm | m | m3/s | m/s | | m | m | m |
| 0 | 185.0 | 181.53 | | | | | | | 214.03 | 29.0 |
| 1 | 184.2 | 179.28 | 600 | 1,030 | 0.537 | 1.90 | 4.99 | 5.14 | 208.89 | 24.7 |
| 2 | 185.8 | | 450 | 650 | 0.272 | 1.71 | 5.76 | 3.74 | 205.15 | 19.3 |
| GR1 | 185.5 | 187.00 | 250 | 120 | 0.093 | 1.90 | 13.83 | 1.66 | 203.49 | 16.5 |
| | | | | | | | | | | |
| GR2 | 185.4 | 186.90 | 400 | 2,390 | 0.179 | 1.43 | 4.71 | 11.26 | 193.89 | 7.0 |
| | | | | | | | | | | |
| 2' | 185.0 | | 450 | 790 | 0.265 | 1.67 | 5.48 | 4.33 | 204.56 | 19.6 |
| GR3 | 184.8 | 186.30 | 400 | 1,180 | 0.265 | 2.11 | 9.73 | 11.48 | 193.07 | 6.8 |

note 1: Design water level of Clear Water Reservoir of WTP is taken as mid water level (+183.78-4.5/2)
Design water level of Ground Reservoir is set at 1.5 m higher than FGL
GL is Formation Ground Level (FGL)
2: Pump head is designed as 35m, Piping loss around pumps is set at 1.6m,Pipeline loss in WTP is set at 0.8m
3: GL of DC is Planned GL (FGL) which is about 1 m higher from GL of the Road

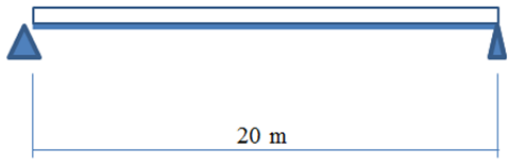
## 3.2 Special Construction

Special construction required is only pipe bridge construction to cross RBC. The pipe beam method for pipe bridge construction is desiged using mild steel pipe with diameter of 500mm from span length at about 20m.

## Tentative Analysis of Pipe Bridge at RBC

**Upper Structure**

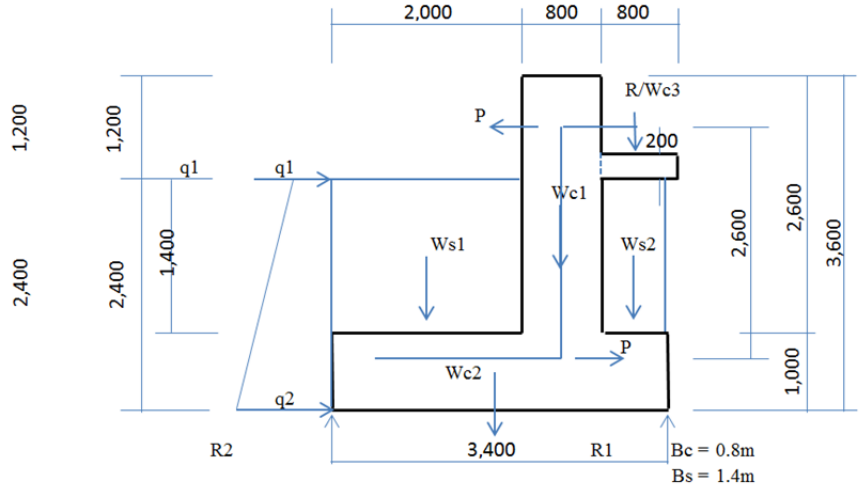
1 Upper Structure




| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | expansion | |
| | | | | | Δt | 60 ℃ |
| | | | | | | 10 ℃ |
| | | | | | | 50 ℃ |
| | | | | | Δl | 8.4 mm |
| Pipe: Diameter | OD | | | | 508 | mm |
| | t | | | | 6 | mm |
| | A | | | | 94.58 | cm2 |
| | Z | | | | 374 | cm3 |
| | I | | | | 9,489 | cm4 |
| Loading | pipe: ND | | | | 500 | mm |
| | w: pipe | OD: | 508 mm | | 74.3 | kg/m |
| | water | | | | 196.3 | kg/m |
| | ll | | | | 100 | kg/m |
| | | | | total | 371 | kg/m |
| Moment | | | | | 1.85 | t-m |
| | σs: | | | | 496 | kg/cm2 |
| | | | | | | 33750 |
| Shear | | | | | 3,706 | kg 23.4375 |
| | τ: | | | | 39.2 | kg/cm2 |
| Defection | | | | | < 1/200 | |
| | y: | | | | 4.8 | cm |
| | S: | | | 1/ | 415 | ok |

2 Sub-Structure - Abutment

1) Dimensions




2) Stability Analysis

a. Loading

| | | |
|---|---|---|
| P = | | 6.87 t |
| Wc1 = | Concrete | 3.83 t |
| Wc2 = | Concrete | 10.95 t |
| Wc3 = | Concrete | 0.29 t |
| Ws1 = | Soil | 3.81 t |
| Ws2 = | Soil | 1.14 t |
| Ws3 = | Soil | 4.86 t |
| q1 = | surcharge | 1.20 t |
| q2 = | Earth Pressure + Surcharge | 3.26 t |
| R = | Reaction of Pipes | 3.71 t |

b. Stability Analysis

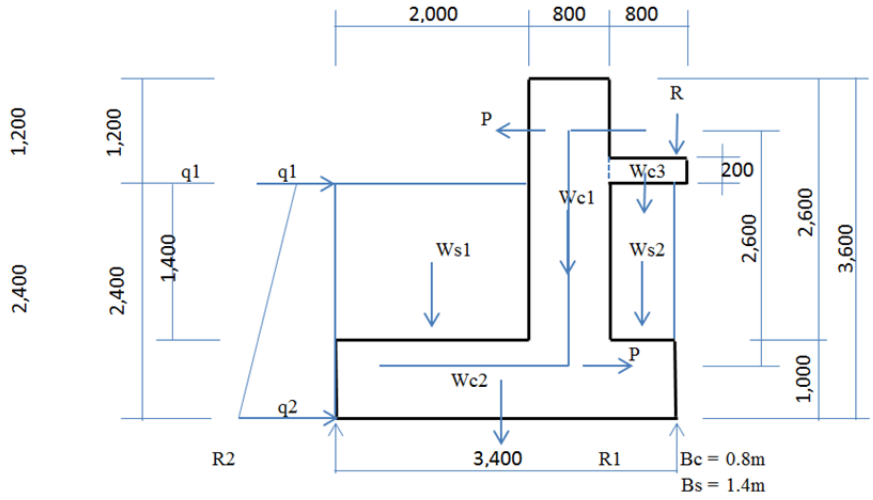
| | V. Loads ton | H. Loads ton | Arm L. m | Moment t-m |
|---|---|---|---|---|
| Wc1 | 3.83 | | 2.90 | 11.11 |
| Wc2 | 10.95 | | 1.70 | 18.62 |
| Wc3 | 0.29 | | 1.60 | 0.46 |
| Ws1 | 3.81 | | 3.60 | 13.72 |
| Ws2 | 1.14 | | 0.47 | 0.53 |
| Ws3 | 4.86 | | 1.70 | |
| q1 | | 1.20 | 1.20 | 1.44 |
| q2 | | 2.06 | 0.80 | 1.65 |
| R | 3.71 | | 3.80 | 14.08 |
| P | | 6.87 | 2.60 | -17.86 |
| Σ | 28.59 | 3.26 | | 43.74 |

ΣW = 28.59 ΣM = 43.74 X = 1.53 e = -0.17

| | | |
|---|---|---|
| Rotation: | due to pressure of pipeline | 17.86 t |
| | due to weight of abutment | 61.60 t |
| | safety factor | 3.4 ok |
| Sliding: | Horizontal Force | 3.26 t |
| | Friction (50% of weight) | 14.29 t |
| | Safety factor | 4.4 ok |
| Reaction: | R1 = | 4.91 t/m2 |
| | R2 = | 9.11 t/m2 |
| | allowable bearing capacity of soil | 15.0 t/m2 |

2.2 Without Operation

1) Dimensions




2) Stability Analysis

a. Loading

| | | |
|---|---|---|
| P = | | 0.00 t |
| Wc1 = | Concrete | 3.83 t |
| Wc2 = | Concrete | 10.95 t |
| Wc3 = | Concrete | 0.29 t |
| Ws1 = | Soil | 3.81 t |
| Ws2 = | Soil | 1.14 t |
| Ws3 = | Soil | 4.86 t |
| q1 = | surcharge | 1.20 t |
| q2 = | Earth Pressure + Surcharge | 3.26 t |
| R = | Reaction of Pipes | 3.71 t |

b. Stability Analysis

| | V. Loads ton | H. Loads ton | Arm L. m | Moment t-m |
|---|---|---|---|---|
| Wc1 | 3.83 | | 2.40 | 9.19 |
| Wc2 | 10.95 | | 1.70 | 18.62 |
| Wc3 | 0.29 | | 3.20 | 0.93 |
| Ws1 | 3.81 | | 1.00 | 3.81 |
| Ws2 | 1.14 | | 3.10 | 3.53 |
| Ws3 | 4.86 | | 1.70 | 8.26 |
| q1 | | 1.20 | 1.20 | 1.44 |
| q2 | | 2.06 | 0.80 | 1.65 |
| R | 3.71 | | 3.40 | 12.60 |
| P | | 0.00 | 2.60 | 0.00 |
| Σ | 28.59 | 3.26 | | 60.03 |

ΣW = 28.59 ΣM = 60.03 X = 2.10 e = 0.40

| | | | |
|---|---|---|---|
| Rotation: | due to pressure of pipeline | 0.00 t | |
| | due to weight of abutment | 60.03 t | |
| | safety factor | | ok |
| Sliding: | Horizontal Force | 3.26 t | |
| | Friction (50% of weight) | 14.29 t | |
| | Safety factor | 4.4 | ok |
| Reaction: | R1 = | 11.95 t/m2 | |
| | R2 = | 2.06 t/m2 | |
| | allowable bearing capacity of soil | 15.0 t/m2 | |

## 4. Distribution Facilities

### 4.1 Distribution Zone I

#### 1) Water Demand

| | | | | |
|---|---|---|---|---|
| - Water demand | Day maximum demand | | 8,050 | $m^3/d$ |
| | Peak hourly demand | for Primary Network | 503 | $m^3/hr$ |
| | | for Secondary Network | 570 | $m^3/hr$ |
| - Service connection | Unit consumption | | 2.1 | m3/d/conn |
| | Number | | 3,800 | units |

#### 2) Distribution Cemter

| | | | | | |
|---|---|---|---|---|---|
| - Name of DC: | | | | Abdullah Pur OHR No.1 | |
| - Area and Size of DC site: | Area | | | 768 | m2 |
| | Size | width : | | 16 | m |
| | | length : | | 48 | m |
| - Facilities: | Civil Construction: | | | | |
| | Ground Reservoir (GR) | detention time : | | 4 | hrs |
| | | volume : | | 1,350 | m3 |
| | Number | | | 2 | units |
| | Dimensions | width : | @4.0*2 | 7.5 | m |
| | | length : | @4.0*4 | 15.5 | m |
| | | w. depth : | | 6 | m |
| | | volume : | | 1,395 | m3 |
| | Overhead Reservoir (OHR) | detention time : | | 1.5 | hrs |
| | | volume : | | 503 | m3 |
| | Number | | | 1 | unit |
| | Dimensions | Dia. : | | 10.8 | m |
| | | w. depth : | | 5.5 | m |
| | | volume : | | 504 | m3 |
| | | height: | (LWL) | 25 | m |
| | Mechanical Equipment | | | | |
| | Lift Pump | total capacity : | | 503 | m3/hr |
| | | type of pump : | | Double suction volute pump | |
| | | number : | duty | 3 | units |
| | | | standby | 1 | unit |
| | | Dimensios : | | Q2.8m3/min x H32m x 22kW, 400V | |
| | Piping | Ground Reservoir: | inlet | 250 | mm |
| | | | overflow | 250 | mm |
| | | | drain | 200 | mm |
| | | | float valve | 250 | mm |
| | | Overhead Reservoir: | inlet | 350 | mm |
| | | | outlet | 350 | mm |
| | | | overflow | 200 | mm |
| | | | drain | 150 | mm |
| | | lift pump: | Suction | 250 | mm |
| | | | delivery | 200 | mm |
| | | | Check Valve | high toruque spring type | |
| | | | delivery Valve | Butterfly V. (short body) | |

Distribution Center -1 (continued)

| | | | | |
|---|---|---|---|---|
| Crane (pump room) | type: | traveling girder w/electric chain hoist | | |
| | capacity: | | 2 | ton |
| Flow meter (inflow and outflow) | type: | Electro-magnetic | | |
| | diameter: | inflow | 200 | mm |
| | | outflow | 300 | mm |
| Flow control valve (inflow) | type: | Teeth vane Butterfly valve | | |
| | diameter: | | 200 | mm |
| Chlorine Dosage | chemical: | Hypochlorite or Breaching powder | | |
| | type: | Drip type | | |
| | dosage rate: | max. | 1 | mg/l |
| | capacity: | | 0.3 | l/hr |

Electrical Equipment

| | | | | |
|---|---|---|---|---|
| Power Receiving | source: | FESCO | | |
| | number of incoming: | | 1 | |
| | incoming voltage: | | 400 | V |
| | transformer: | FESCO | | |
| | type | Oil Immersed Type | | |
| | capacity | | 150 | kVA |
| | primary voltage | | 11,000 | V |
| | secondary voltage | | 400 | V |
| Emergency Generator | type: | Diesel | | |
| | capacity: | | 150 | kVA |
| | voltage: | | 400 | V |
| | main fuel tank; | (45 hrs op.) | 2,000 | l |
| | service fuel tank: | | 400 | l |
| Instrumentation | | | | |
| field instrumentation: | GR water level: | ultrasonic | 2 | units |
| | PHR water level: | ultrasonic | 1 | unit |
| instrumentation panel: | | | 1 | lot |
| UPS: | no. of unit: | | 1 | unit |
| | backup time : | | 30 | min |

### 3) Distribution Network

| | | | | |
|---|---|---|---|---|
| - Primary Network | Distribution Flow | (peak hourly flow) | | 503 $m^3$/hr |
| | Number of DMAs | | | 2 nos. |
| | Primary mains | | materials: | HDPE |
| | | size: (mm) | | 300~350 |
| | | length: (m) | | 2,600 |
| - Secondary network | Distribution Flow | (peak hourly fow) | | 570 $m^3$/hr |
| | District Meter | | pipe size: | 250 mm |
| | (for each) | | flow meter: type | electro magnetic |
| | | | size | 200 mm |
| | Secondary Main | | materials: | HDPE |
| | | | size: | 150~250 mm |
| | | | length: | 3,320 m |

note: Detailes of network analysis is refered to Annex 1 for Primary network and 2 for Secondary Network

## 4.2 Distribution Zone II

### 1) Water demand

| | | | |
|---|---|---|---|
| - Water demand | Day maximum demand | | 15,460 $m^3$/d |
| | Peak hourly demand | for Primary Network | 966 $m^3$/hr |
| | | for Secondary Network | 1,095 $m^3$/hr |
| - Service connection | Unit consumption | | 2.1 m3/d/conn |
| | Number | | 7,400 units |

### 2) Distribution Center

| | | | | |
|---|---|---|---|---|
| - Name of DC: | | | | Madina Town No.2 |
| - Area and Size of DC site: | Area | | | 2,560 m2 |
| | Size | | width : | 40 m |
| | | | length : | 64 m |
| - Facilities: | Civil Construction: | | | |
| | Ground Reservoir (GR) | | detention time : | 4 hrs |
| | | | volume : | 2,580 m3 |
| | | Number | | 2 units |
| | | Dimensions | width : @4.5*3 | 13.1 m |
| | | | length : @4.3*5 | 21.1 m |
| | | | w. depth : | 4.8 m |
| | | | volume : | 2,654 m3 |
| | Overhead Reservoir (OHR) | | detention time : | 1.5 hrs |
| | | | volume : | 970 m3 |
| | | Number | | 1 unit |
| | | Dimensions | Dia. : | 14.7 m |
| | | | w. depth : | 5.5 m |
| | | | volume : | 933 m3 |
| | | | height: (LWL) | 25 m |

Distribution Center II (continued)

Mechanical Equipment

| | | | | |
|---|---|---|---|---|
| Lift Pump | total capacity : | | 966 | m3/hr |
| | type of pump : | Double suction volute pump | | |
| | number : | duty | 3 | units |
| | | standby | 1 | unit |
| | Dimensios : | $^{Q}$5.1m3/min x $^{H}$30m x 45kW, 400V | | |
| Piping | Ground Reservoir: | inlet | 300 | mm |
| | | overflow | 300 | mm |
| | | drain | 200 | mm |
| | Overhead Reservoir: | inlet | 450 | mm |
| | | outlet | 450 | mm |
| | | overflow | 300 | mm |
| | | drain | 150 | mm |
| | lift pump: | Suction | 300 | mm |
| | | delivery | 250 | mm |
| | | Check Valve | high toruque spring type | |
| | | delivery Valve | Butterfly V. (short body) | |
| Crane (pump room) | type: | traveling girder w/chain hoist | | |
| | capacity: | | 2 | ton |
| Flow meter (inflow and outflow) | type: | Electro-magnetic | | |
| | diameter: | inflow | 350 | mm |
| | | outflow | 400 | mm |
| Flow control valve (inflow) | type: | Teeth vane Butterfly valve | | |
| | diameter: | | 350 | mm |
| Chlorine Dosage | chemical: | Hypochlorite or Breaching powder | | |
| | type: | Drip type | | |
| | dosage rate: | max. | 1 | mg/l |
| | capacity: | | 0.17 | l/hr |

Electrical Equipment

| | | | | |
|---|---|---|---|---|
| Power Receiving | source: | FESCO | | |
| | number of incoming: | | 1 | |
| | incoming voltage: | | 400 | V |
| | transformer: | FESCO | | |
| | | type | Oil Immersed Type | |
| | | capacity | 300 | kVA |
| | | primary voltage | 11,000 | V |
| | | secondary voltage | 400 | V |
| Emergency Generator | type: | Diesel | | |
| | capacity: | | 300 | kVA |
| | voltage: | | 400 | V |
| | main fuel tank; | (45 hrs op.) | 4,000 | l |
| | service fuel tank: | | 400 | l |
| Instrumentation | | | | |
| field instrumentation: | GR water level: | ultrasonic | 2 | units |
| | PHR water level: | ultrasonic | 1 | unit |
| instrumentation panel: | | | 1 | lot |
| UPS: | no. of unit: | | 1 | unit |
| | backup time : | | 30 | min |

### 3) Distribution Network

| | | | | |
|---|---|---|---|---|
| - Primary Network | Distribution Capacity | (peak hourly flow) | | 966 $m^3$/hr |
| | Number of DMAs | | | 4 nos. |
| | Primary mains | | materials: | HDPE |
| | | | size: | 300~450 mm |
| | | | length: | 8,000 m |
| - Secondary | Distribution Capacity | (peak hourly flow) | | 1,095 $m^3$/hr |
| | Secondary mains | | materials: | HDPE |
| | | | size: | 150~250 mm |
| | | | length: | 16,840 m |

note: Detailes of network analysis is refered to Annex 1 for Primary network and 2 for Secondary Network

## 4.3 Distribution Zone III

### 1) Water Demand

| | | | |
|---|---|---|---|
| - Water demand | Day maximum demand | | 22,890 $m^3$/d |
| | Peak hourly demand | for Primary Network | 1,431 $m^3$/hr |
| | | for Secondary Network | 1,621 $m^3$/hr |
| - Service connection | Unit consumption | | 2.1 m3/d/conn |
| | Number | | 10,900 units |

### 2) Distribution Center

| | | | | | |
|---|---|---|---|---|---|
| - Name of DC: | | | | Peoples Colony No.2 | |
| - Area and Size of DC site: | Area | | | | 2,501 m2 |
| | Size | | width : | | 41 m |
| | | | length : | | 61 m |
| - Facilities: | Civil Construction: | | | | |
| | Ground Reservoir (GR) | | detention time : | | 4 hrs |
| | | | volume : | | 3,820 m3 |
| | | Number | | | 2 units |
| | | Dimensions | width : | @3.9*4 | 15.1 m |
| | | | length : | @4.0*6 | 23.5 m |
| | | | w. depth : | | 5.5 m |
| | | | volume : | | 3,903 m3 |
| | Overhead Reservoir (OHR) | | detention time : | | 1.5 hrs |
| | | | volume : | | 1,430 m3 |
| | | Number | | | 1 unit |
| | | Dimensions | Dia. : | | 18.2 m |
| | | | w. depth : | | 5.5 m |
| | | | volume : | | 1,430 m3 |
| | | | height: | (LWL) | 25 m |

Distribution Center III (continued)

Mechanical Equipment

| | | | | |
|---|---|---|---|---|
| Lift Pump | total capacity : | | 1,431 | m3/hr |
| | type of pump : | Double suction volute pump | | |
| | number : | duty | 3 | units |
| | | standby | 1 | unit |
| | Dimensios : | Q7.9m3/min x H31m x 75kW, 400V | | |
| Piping | Ground Reservoir: | inlet | 350 | mm |
| | | overflow | 350 | mm |
| | | drain | 200 | mm |
| | Overhead Reservoir: | inlet | 500 | mm |
| | | outlet | 500 | mm |
| | | overflow | 350 | mm |
| | | drain | 150 | mm |
| | lift pump: | Suction | 350 | mm |
| | | delivery | 300 | mm |
| | | Check Valve | high toruque spring type | |
| | | delivery Valve | Butterfly V. (short body) | |
| Crane pump room | type: | traveling girder w/chain hoist | | |
| | capacity: | | 2 | ton |
| Flow meter (inflow and outflow) | type: | Electro-magnetic | | |
| | diameter: | inflow | 350 | mm |
| | | outflow | 400 | mm |
| Flow control valve (inflow) | type: | Teeth vane Butterfly valve | | |
| | diameter: | | 350 | mm |
| Chlorine Dosage | chemical: | Hypochlorite or Breaching powder | | |
| | type: | Drip type | | |
| | dosage rate: | max. | 1 | mg/l |
| | capacity: | | 0.24 | l/hr |

Electrical Equipment

| | | | | |
|---|---|---|---|---|
| Power Receiving | source: | FESCO | | |
| | number of incoming: | | 1 | |
| | incoming voltage: | | 400 | V |
| | transformer: | FESCO | | |
| | | type | Oil Immersed Type | |
| | | capacity | 500 | kVA |
| | | primary voltage | 11,000 | V |
| | | secondary voltage | 400 | V |
| Emergency Generator | type: | Diesel | | |
| | capacity: | | 500 | kVA |
| | voltage: | | 400 | V |
| | main fuel tank; | (45 hrs op.) | 6,000 | l |
| | service fuel tank: | | 400 | l |
| Instrumentation | | | | |
| field instrumentation: | GR water level: | ultrasonic | 2 | units |
| | PHR water level: | ultrasonic | 1 | unit |
| instrumentation panel: | | | 1 | lot |
| UPS: | no. of unit: | | 1 | unit |
| | backup time : | | 30 | min |

**3) Distribution Network**

| | | | |
|---|---|---|---|
| - Primary Network | Distribution Capacity | (peak hourly flow) | 1,431 $m^3$/hr |
| | Number of DMAs | | 6 nos. |
| | Primary mains | materials: | HDPE |
| | | size: | 300~500 mm |
| | | length: | 12,080 m |
| - Secondary | Distribution Capacity | (peak hourly flow) | 1,621 $m^3$/hr |
| | Secondary mains | materials: | HDPE |
| | | size: | 150~250 mm |
| | | length: | 28,780 m |

note: Detailes of network analysis is refered to Annex 1 for Primary network and 2 for Secondary Network

## Annex 1 to Appendix 7.1.2 Power Receiving and Emergency Power Supply

### 1. Distribution Center I (Abudullar Pur)

### 1.1 Power Demand

The maximum demand of the Distribution Center I is estimated as 115kW. Load list is shown below.

| Name of Equipment | kW | Q'ty | Total kW |
|---|---|---|---|
| Lift Pump No.1 to 4 | 30 | 4 (3) | 90 |
| Lift Pump Discharge Valve No.1 to 4 | 0.2 | 4 (3) | 0.6 |
| Distribution Inlet Flow Control Valve | 0.4 | 1 | 0.4 |
| Overhead crane (Traveling Girder w/Chain hoist) | 5.5 | 1 | 5.5 |
| Monorail Hoist | 4.5 | 1 | 4.5 |
| Floor drain pump No.1 | 1.5 | 2 (1) | 1.5 |
| Chlorine injector | 2.2 | 1 | 2.2 |
| Building Lighting and other miscellaneous load | 10% | 1 | 10.5 |
| **Total [kW]** | | | **115** |

### 1.2 Power Receiving

Electric power will be supplied from FESCO by one circuit of low voltage line. General features of the supplied power are as follows:

- Power Source: FESCO
- Tariff Category: B2
- Voltage System: 400V AC, 50Hz, 3 phase 3wire

The required capacity of main transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [\text{kVA}]$$

Where,

| | | |
|---|---|---|
| $\varphi$ | : total power factor | 0.85 |
| $\eta$ | : total load efficiency | 0.85 |
| $\beta$ | : demand factor | 1.0 |
| $\alpha$ | : allowance rate | 1.1 |
| $\Sigma P$ | : sum of the load [kW] | 115 |

Required capacity of transformer

$$\frac{115}{0.85 \times 0.85} \times 1.0 \times 1.1 = 175[\text{kVA}]$$

Therefore, **200 [kVA] x 1** is selected.

### 1.3 Emergency Power Supply

The same criteria as French project will also be applied to DC I. That is, the target load for generator = 100% of total load. The capacity of generator is determined using following formulas.

**a) $PG_1$** is the capacity necessary for all load operation

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

$\Sigma P_0$ : sum of the load 115 [kW]

$\eta_L$ : total load efficiency 0.85

$\varphi_L$ : total power factor 0.8

$\alpha$ : demand factor 1.0

$S_f$ : the increase coefficient of electric current by unbalanced load 1.0

$$= \frac{115}{0.85 \times 0.8} \times 1.0 \times 1.0 = \mathbf{169\ [kVA]}$$

**b) $PG_2$** is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

$P_m$ : maximum motor capacity 30 [kW]

$\beta$ : starting kVA per 1kW of maximum motor capacity 1.2

C : coefficient by starter 1

$X_d'$ : generator's constant 0.25

$\Delta E$ : allowable voltage drop rate 0.25

$$= 30 \times 1.2 \times 1 \times 0.25 \times \frac{1 - 0.25}{0.25} = 27\ \mathbf{[kVA]}$$

**c) $PG_3$** is the capacity necessary for starting maximum motor

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

$f_{v1}$ : decrease coefficient of loading 1.0

$\Sigma P_0$ : sum of the load 115 [kW]

$\eta_L$ : total load efficiency 0.85

$\alpha$ : demand factor 1.0

$P_m$ : maximum motor capacity 30 [kW]

$\beta$ : starting kVA per 1kW of max.motor capacity 1.2

C : coefficient by starter 1

$\gamma_G$ : generator strength against momentary overload 1.5

$$= \frac{1}{1.5} \{ (115 - 30) \times \frac{1.0}{0.85 \times 0.8} + 30 \times 1.2 \times 1 \} = \mathbf{107\ [kVA]}$$

**d) Generator Capacity**

$PG_1 =$ 169

$PG_2 =$ 27

$PG_3 =$ 107 **(MAXIMUM)**

Therefore, **<u>200</u> [kVA]** is selected.

## 2. Distribution Center II (Madina Town No.2)

### 2,1 Power Demand

The maximum demand of the Distribution Center II is estimated as 165kW. Load list is shown below.

| Name of Equipment | kW | Q'ty | Total kW |
|---|---|---|---|
| Lift Pump No.1 to 4 | 45 | 4 (3) | 135 |
| Lift Pump Discharge Valve No.1 to 4 | 0.2 | 4 (3) | 0.6 |
| Distribution Flow Control Valve | 0.4 | 1 | 0.4 |
| Overhead crane (Traveling Girder w/Chain hoist) | 5.5 | 1 | 5.5 |
| Monorail Hoist | 4.5 | 1 | 4.5 |
| Floor drain pump No.1 | 1.5 | 1 | 1.5 |
| Chlorine injector | 2.2 | 1 | 2.2 |
| Building Lighting and other miscellaneous load | 10% | 1 | 15.0 |
| **Total [kW]** | | | **165** |

### 2.2 Power Receiving

Electric power will be supplied from FESCO by one circuit of low voltage line. General features of the supplied power are as follows:

- Power Source: FESCO
- Tariff Category: B2
- Voltage System: 400V AC, 50Hz, 3 phase 3wire

The required capacity of main transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \ [\text{kVA}]$$

Where,

| | | |
|---|---|---|
| $\varphi$ | : total power factor | 0.85 |
| $\eta$ | : total load efficiency | 0.85 |
| $\beta$ | : demand factor | 1.0 |
| $\alpha$ | : allowance rate | 1.1 |
| $\Sigma P$ | : sum of the load [kW] | 165 |

Required capacity of transformer

$$\frac{165}{0.85 \times 0.85} \times 1.0 \times 1.1 = 251[\text{kVA}]$$

### 2.3 Emergency Power Supply

The same criteria as French project will also be applied to DC II. That is, the target load for generator = 100% of total load. The capacity of generator is determined using following formulas.

**a) $PG_1$** is the capacity necessary for all load operation

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \ [\text{kVA}]$$

Where,

$\Sigma P_0$ : sum of the load 165 [kW]

$\eta_L$ : total load efficiency 0.85

$\varphi_L$ : total power factor 0.8

$\alpha$ : demand factor 1.0

$S_f$ : the increase coefficient of electric current by unbalanced load 1.0

$$= \frac{165}{0.85 \times 0.8} \times 1.0 \times 1.0 = \mathbf{242\ [kVA]}$$

**b) $PG_2$** is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

$P_m$ : maximum motor capacity 45 [kW]

$\beta$ : starting kVA per 1kW of maximum motor capacity 1.2

C : coefficient by starter 1

$X_d'$ : generator's constant 0.25

$\Delta E$ : allowable voltage drop rate 0.25

$$= 45 \times 1.2 \times 1 \times 0.25 \times \frac{1 - 0.25}{0.25} = \mathbf{40\ [kVA]}$$

**c) $PG_3$** is the capacity necessary for starting maximum motor

[

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

$f_{v1}$ : decrease coefficient of loading 1.0

$\Sigma P_0$ : sum of the load 165 [kW]

$\eta_L$ : total load efficiency 0.85

$\alpha$ : demand factor 1.0

$P_m$ : maximum motor capacity 45 [kW]

$\beta$ : starting kVA per 1kW of maxi.motor capacity 1.2

C : coefficient by starter 1

$\gamma_G$ : generator strength against momentary overload 1.5

$$= \frac{1}{1.5} \{ (165 - 45) \times \frac{1.0}{0.85 \times 0.8} + 45 \times 1.2 \times 1 \} = \mathbf{153\ [kVA]}$$

**d) Generator capacity**

$PG_1 =$ 242 **(MAXIMUM)**

$PG_2 =$ 40

$PG_3 =$ 153

Therefore, **250 [kVA] is** selected.

## 3 Distribution Center III (Peiples Colony No.2)

### 3.1 Power Demand

The maximum demand of Distribution Center III is estimated as 264kW. Load list is shown below.

| Name of Equipment | kW | Q'ty | Total kW |
|---|---|---|---|
| Lift Pump No.1 to 4 | 75 | 4 (3) | 225 |
| Lift Pump Discharge Valve No.1 to 4 | 0.2 | 4 (3) | 0.6 |
| Distribution Flow Control Valve | 0.4 | 1 | 0.4 |
| Overhead crane (Traveling Girder w/Chain hoist) | 5.5 | 1 | 5.5 |
| Monorail Hoist | 4.5 | 1 | 4.5 |
| Chlorine injector | 1.5 | 1 | 1.5 |
| Floor drain pump No.1 | 2.2 | 1 | 2.2 |
| Building Lighting and other miscellaneous load | 10% | 1 | 24.0 |
| **Total [kW]** | | | **264** |

### 3.2 Power Receiving

Electric power will be supplied from FESCO by one circuit of low voltage line. General features of the supplied power are as follows:

- Power Source: FESCO
- Tariff Category: B2
- Voltage System: 400V AC, 50Hz, 3 phase 3wire

The required capacity of main transformer is calculated using following formula.

$$\text{Capacity of transformer} = \frac{\Sigma P}{\eta \times \varphi} \times \beta \times \alpha \text{ [kVA]}$$

Where,

| | | |
|---|---|---|
| $\varphi$ | : total power factor | 0.85 |
| $\eta$ | : total load efficiency | 0.85 |
| $\beta$ | : demand factor | 1.0 |
| $\alpha$ | : allowance rate | 1.1 |
| $\Sigma P$ | : sum of the load [kW] | 165 |

$$\frac{264}{0.85 \times 0.85} \times 1.0 \times 1.1 = 401\text{[kVA]}$$

Therefore, **500 [kVA] x 1** is selected.

### 3.3 Emergency Power Supply

The same criteria as French project will also be applied to Distribution Center III. That is, the target load for generator = 100% of total load. The capacity of generator is determined using following formulas.

**a) $PG_1$** is the capacity necessary for all load operation

$$PG_1 = \frac{\Sigma P_0}{\eta_L \times \varphi_L} \times \alpha \times S_f \quad [kVA]$$

Where,

$\Sigma P_0$ : sum of the load 264 [kW]

$\eta_L$ : total load efficiency 0.85

$\varphi_L$ : total power factor 0.8

$\alpha$ : demand factor 1.0

$S_f$ : the increase coefficient of electric current by unbalanced load 1.0

$$= \frac{264}{0.85 \times 0.8} \times 1.0 \times 1.0 = \mathbf{388\ [kVA]}$$

**b) $PG_2$** is the capacity necessary against voltage drop

$$PG_2 = P_m \times \beta \times C \times X_d' \times \frac{1 - \Delta E}{\Delta E} \quad [kVA]$$

Where,

$P_m$ : maximum motor capacity 75 [kW]

$\beta$ : starting kVA per 1kW of maximum motor capacity 1.2

C : coefficient by starter 1

$X_d'$ : generator's constant 0.25

$\Delta E$ : allowable voltage drop rate 0.25

$$= 75 \times 1.2 \times 1 \times 0.25 \times \frac{1 - 0.25}{0.25} = \mathbf{68\ [kVA]}$$

**c) $PG_3$** is the capacity necessary for starting maximum motor

$$PG_3 = \frac{f_{v1}}{\gamma_G} \{ (\Sigma P_0 - P_m) \times \frac{\alpha}{\eta_L \times \varphi_L} + P_m \times \beta \times C \} \quad [kVA]$$

Where,

$f_{v1}$ : decrease coefficient of loading 1.0

$\Sigma P_0$ : sum of the load 264 [kW]

$\eta_L$ : total load efficiency 0.85

$\alpha$ : demand factor 1.0

$P_m$ : maximum motor capacity 75 [kW]

$\beta$ : starting kVA per 1kW of max. motor capacity 1.2

C : coefficient by starter 1

$\gamma_G$ : generator strength against momentary overload 1.5

$$= \frac{1}{1.5} \{ (264 - 75) \times \frac{1.0}{0.85 \times 0.8} + 75 \times 1.2 \times 1 \} = \mathbf{245\ [kVA]}$$

**d) Generator capacity**

$PG_1$ = 388 **(MAXIMUM)**

$PG_2$ = 68

$PG_3$ = 245

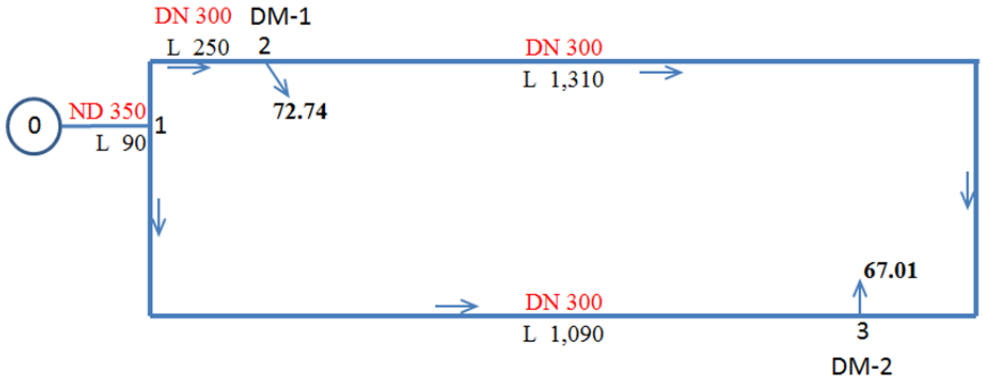
Therefore, **<u>500</u> [kVA] is** selected.

## Annex 2 to Appendix B7.1.2 Network Analysis of Primary Main

### 1. Distribution Zone I

| | | unit | Zone I | DMA I-1 | DMA I-2 |
|---|---|---|---|---|---|
| Design Flow: | Day maximum Demand | $m^3/d$ | 8,050 | 4,190 | 3,860 |
| | Peak Hourly Demand | $m^3/hr$ | 503 | 262 | 241 |
| | | l/s | 139.76 | 72.74 | 67.01 |

Skelton




Node Dat

| Node No. | Type | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|---|
| | | l/sec | m | m | m |
| 0 | | 139.75 | 211.10 | 186.1 | 25.00 |
| 1 | | 0 | 210.51 | 188.0 | 22.51 |
| 2 | | 72.74 | 208.91 | 188.0 | 20.91 |
| 3 | | 67.01 | 208.45 | 190.0 | 18.45 |

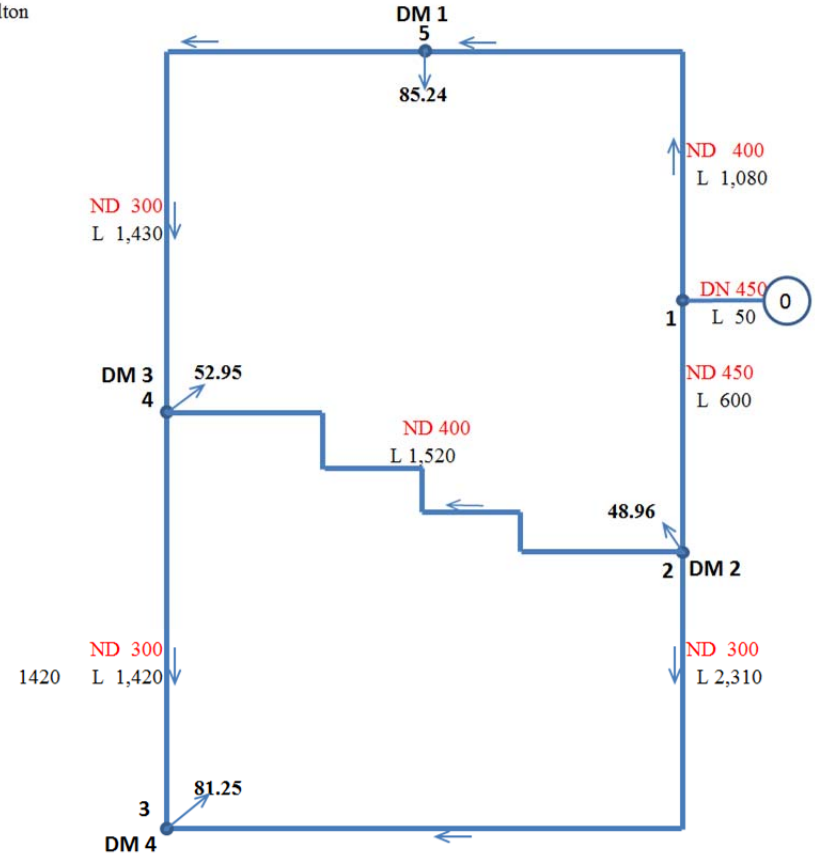
Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H. gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 350 | 90 | 120 | 0.59 | 139.75 | 1.45 | 6.54 |
| 1 | 2 | 300 | 250 | 120 | 1.60 | 92.05 | 1.30 | 6.39 |
| 2 | 3 | 300 | 1310 | 120 | 0.47 | 19.31 | 0.27 | 0.36 |
| 1 | 3 | 300 | 1090 | 120 | -2.06 | -47.70 | -0.68 | -1.89 |

## 2. Distribution II

| Design Flow: | unit | Zone II | DMA II-1 | DMA II-2 | DMA II-3 | DMA II-4 |
|---|---|---|---|---|---|---|
| Day maximum Demand | $m^3/d$ | 15,460 | 4,910 | 2,820 | 3,050 | 4,680 |
| Peak Hourly Demand | $m^3/hr$ | 966 | 307 | 176 | 191 | 293 |
| | l/s | 268.40 | 85.24 | 48.96 | 52.95 | 81.25 |

Skelton




Node Data

| Node No. | Type | Flow | WL | GL | Eff. Head | Note |
|---|---|---|---|---|---|---|
| | | l/sec | m | m | m | |
| 0 | | -268.40 | 213.20 | 188.2 | 25.0 | |
| 1 | | 0.00 | 212.88 | 186.0 | 26.9 | |
| 2 | | 48.96 | 221.39 | 196.0 | 25.4 | DM 2 |
| 3 | | 81.25 | 204.28 | 186.0 | 18.3 | DM 3 |
| 4 | | 52.95 | 204.78 | 186.0 | 18.8 | DM 4 |
| 5 | | 85.24 | 210.61 | 188.0 | 22.6 | DM 1 |

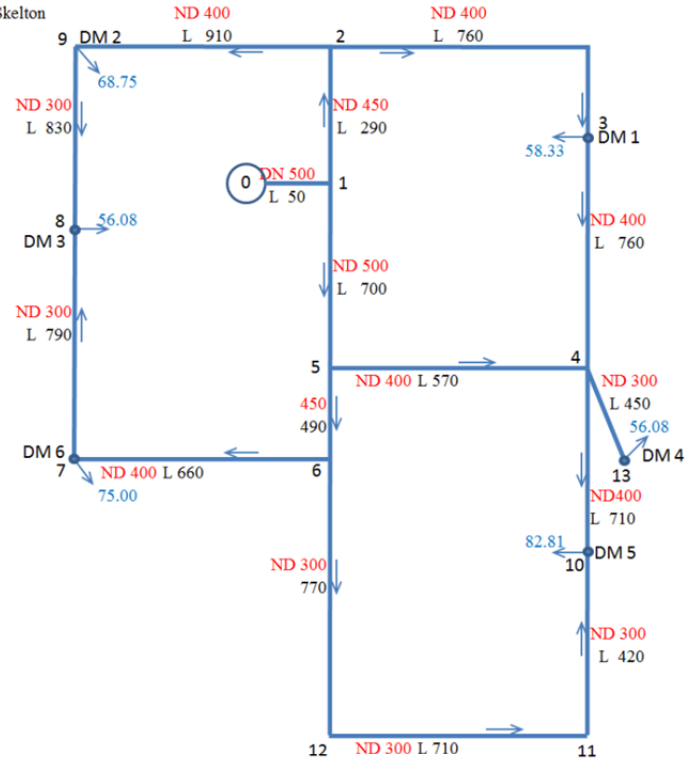
Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H. gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 450 | 50 | 120 | 0.32 | 268.40 | 1.69 | 6.44 |
| 1 | 2 | 450 | 600 | 120 | 1.50 | 160.88 | 1.01 | 2.50 |
| 2 | 3 | 300 | 2310 | 120 | 7.10 | 62.00 | 0.88 | 3.07 |
| 3 | 4 | 300 | 1420 | 120 | -0.50 | -19.26 | -0.27 | -3.54 |
| 4 | 5 | 300 | 1430 | 120 | -5.83 | -72.21 | -1.02 | -4.08 |
| 5 | 1 | 400 | 1080 | 120 | -2.27 | -107.53 | -0.86 | -2.10 |
| 2 | 5 | 400 | 1520 | 120 | 0.77 | 49.92 | 0.40 | 0.51 |

## 3. Distribution Zone III

| Design Flow: | unit | Zone III | DMA III-1 | DMA III-2 | DMA III-3 | DMA III-4 | DMA III-5 | DMA III-6 |
|---|---|---|---|---|---|---|---|---|
| Day maximum Demand | $m^3/d$ | 22,870 | 3,360 | 3,960 | 3,230 | 3,230 | 4770 | 4320 |
| Peak Hourly Demand | $m^3/hr$ | 1,429 | 210 | 248 | 202 | 202 | 298 | 270 |
| | l/s | 239.24 | 58.33 | 68.75 | 56.08 | 56.08 | 82.81 | 75.00 |

Skelton




Node Data

| Node No. | Type | Flow l/sec | WL m | GL m | Eff. Head m | Note |
|---|---|---|---|---|---|---|
| 0 | | -397.23 | 211.20 | 186.2 | 25.00 | |
| 1 | | 0.00 | 210.80 | 186.0 | 24.80 | |
| 2 | | 0.00 | 209.77 | 186.0 | 23.77 | |
| 3 | | 58.33 | 208.60 | 186.0 | 22.60 | DM 1 |
| 4 | | 0.00 | 208.43 | 185.0 | 23.43 | |
| 5 | | 0.00 | 209.21 | 186.0 | 23.21 | |
| 6 | | 0.00 | 208.53 | 185.0 | 23.53 | |
| 7 | | 77.43 | 207.37 | 186.0 | 21.37 | DM 6 |
| 8 | | 56.08 | 207.05 | 185.0 | 22.05 | DM 3 |
| 9 | | 68.75 | 207.96 | 186.0 | 21.96 | DM 2 |
| 10 | | 80.56 | 207.89 | 187.0 | 20.89 | DM 5 |
| 11 | | 0.00 | 208.03 | 187.0 | 21.03 | |
| 12 | | 0.00 | 208.27 | 186.0 | 22.27 | |
| 13 | | 56.08 | 207.28 | 186.0 | 21.28 | DM 4 |

Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H. gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 500 | 0 | 120 | 0 | 0.00 | 0 | 0.00 |
| 1 | 2 | 450 | 230 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 2 | 3 | 400 | 570 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 3 | 4 | 400 | 140 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 4 | 5 | 400 | 830 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 5 | 6 | 400 | 550 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 6 | 7 | 450 | 460 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 7 | 8 | 400 | 690 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 8 | 9 | 300 | 720 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 9 | 10 | 300 | 750 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 10 | 2 | 400 | 910 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 5 | 11 | 300 | 660 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 11 | 12 | 300 | 420 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 12 | 13 | 300 | 670 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 13 | 7 | 300 | 740 | 120 | 0.00 | 0.00 | 0 | 0.00 |
| 5 | 14 | 300 | 390 | 120 | 1.01 | 56.08 | 0.794 | 2.59 |

## Annex 3 to Appendix B7.1.2 Network Analysis of Secondary Main

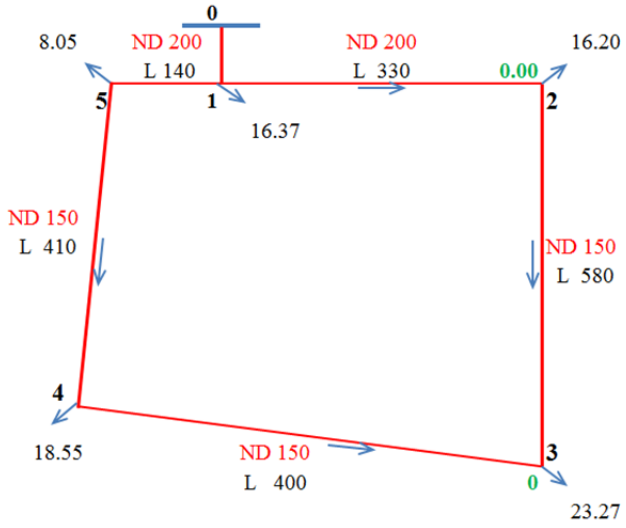
# 1. Distribution Zone I

## 1.1 District Meter Area I-1

Design Flow

| | | | |
|---|---|---|---|
| Day maximum Demand | 4,190 $m^3/d$ | | |
| Peak Hourly Demand | 297 $m^3/hr$ | = | 82.4 l/s |

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | 82.44 | 208.91 | 188.0 | 20.91 |
| 1 | 16.37 | 208.15 | 188.0 | 20.15 |
| 2 | 16.20 | 206.49 | 187.0 | 19.49 |
| 3 | 23.27 | 204.12 | 187.0 | 17.12 |
| 4 | 18.55 | 204.50 | 188.0 | 16.50 |
| 5 | 8.05 | 206.89 | 188 | 18.89 |

Pipeline Data

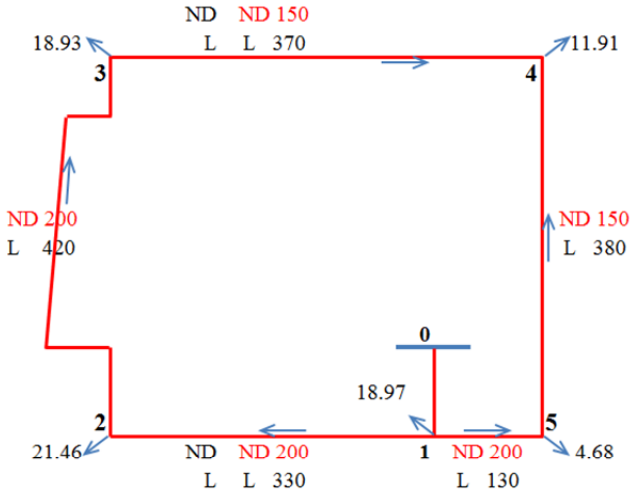
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.76 | 82.44 | 1.68 | 12.67 |
| 1 | 2 | 200 | 330 | 120 | 1.66 | 27.87 | 0.89 | 5.04 |
| 2 | 3 | 150 | 580 | 120 | 2.37 | 11.67 | 0.66 | 4.08 |
| 3 | 4 | 200 | 380 | 120 | -0.38 | -11.60 | -0.37 | -0.99 |
| 4 | 5 | 200 | 410 | 120 | -2.39 | -30.15 | -0.96 | -5.83 |
| 5 | 1 | 200 | 140 | 120 | -1.26 | -38.20 | -1.22 | -9.03 |

## 1.2 District Meter Area I-2

Design Flow  Day maximum Demand  3,860 $m^3/d$

Peak Hourly Demand  273 $m^3/hr$ =  75.95 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | 75.95 | 208.45 | 190.0 | 18.45 |
| 1 | 18.97 | 207.80 | 188.0 | 19.80 |
| 2 | 21.46 | 205.37 | 187.0 | 18.37 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 3 | 18.93 | 203.37 | 187.0 | 16.37 |
| 4 | 11.91 | 203.84 | 187.0 | 16.84 |
| 5 | 4.68 | 207.34 | 188.0 | 19.34 |

Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.65 | 75.95 | 1.55 | 10.89 |
| 1 | 2 | 200 | 330 | 120 | 2.43 | 34.17 | 1.09 | 7.35 |
| 2 | 3 | 150 | 420 | 120 | 2.01 | 12.71 | 0.72 | 4.78 |
| 3 | 4 | 150 | 370 | 120 | -0.47 | -6.22 | -0.35 | -1.27 |
| 1 | 5 | 150 | 380 | 120 | -3.51 | -18.13 | -1.03 | -9.23 |
| 5 | 4 | 200 | 130 | 120 | -0.45 | -0.73 | -0.02 | -3.48 |

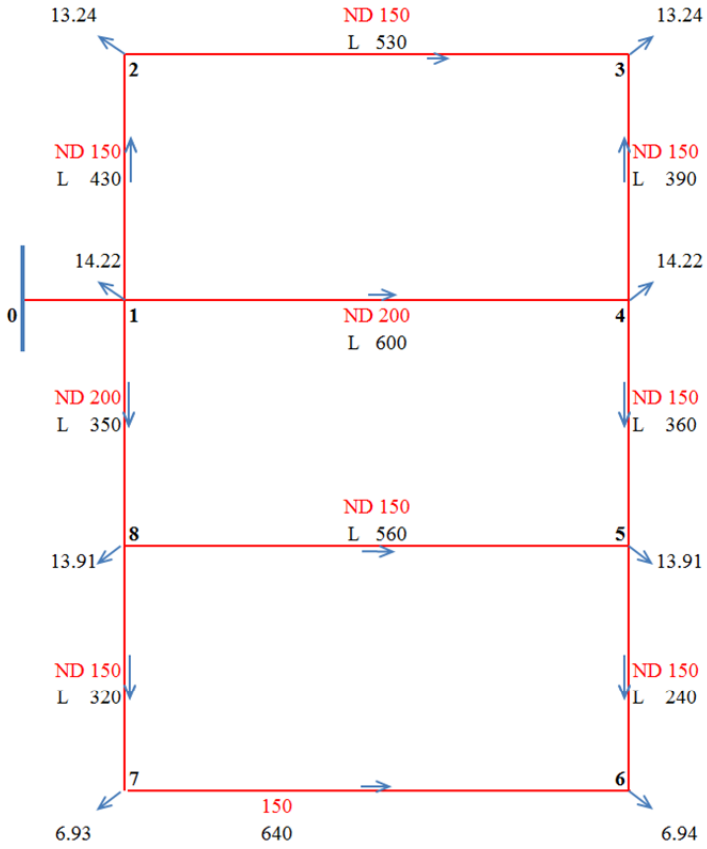
## 2. Distribution Zone II

### 2.1 District Meter Area II-1

Design Flow  Day maximum Demand  4,910 $m^3/d$

Peak Hourly Demand  348 $m^3/hr$ =  96.61 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -96.61 | 210.61 | 187.0 | 23.61 |
| 1 | 14.22 | 209.59 | 187.0 | 22.59 |
| 2 | 13.24 | 205.66 | 186.0 | 19.66 |
| 3 | 13.24 | 205.24 | 187.0 | 18.24 |
| 4 | 14.22 | 206.12 | 186.0 | 20.12 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 5 | 13.91 | 205.49 | 188.0 | 17.49 |
| 6 | 6.94 | 205.42 | 187.0 | 18.42 |
| 7 | 6.93 | 205.81 | 188.0 | 17.81 |
| 8 | 13.91 | 207.00 | 187.0 | 20.00 |

Pipeline Data

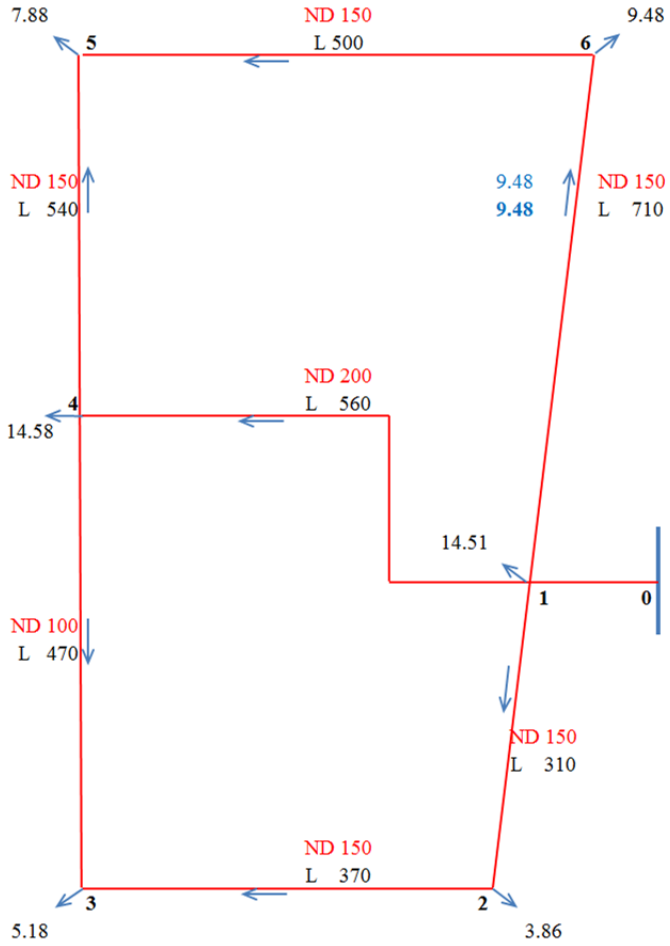
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 1.002 | 96.61 | 1.969 | 17.00 |
| 1 | 2 | 150 | 430 | 120 | 3.93 | 18.04 | 1.021 | 9.14 |
| 2 | 3 | 150 | 530 | 120 | 0.42 | 4.80 | 0.272 | 0.79 |
| 3 | 4 | 150 | 390 | 120 | -0.87 | -8.44 | -0.48 | -2.24 |
| 4 | 5 | 150 | 360 | 120 | 0.63 | 7.37 | 0.42 | 1.74 |
| 5 | 6 | 150 | 240 | 120 | 0.07 | 2.78 | 0.16 | 0.29 |
| 6 | 7 | 150 | 640 | 120 | -0.39 | -4.16 | -0.24 | -0.61 |
| 7 | 8 | 150 | 320 | 120 | -1.19 | -11.09 | -0.63 | -3.72 |
| 8 | 1 | 200 | 350 | 120 | -2.59 | -34.32 | -1.09 | -7.41 |
| 8 | 5 | 150 | 560 | 120 | 1.51 | 9.32 | 0.53 | 2.69 |
| 1 | 4 | 200 | 600 | 120 | 3.47 | 30.03 | 0.96 | 5.79 |

## 2.2 District Meter Area II-2

Design Flow　　Day maximum Demand　　2,820 $m^3/d$

Fire Flow　　200 $m^3/min$ =　　55.49 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -55.49 | 211.38 | 180.0 | 31.38 |
| 1 | 14.51 | 211.02 | 186.0 | 25.02 |
| 2 | 3.86 | 210.00 | 186.0 | 24.00 |
| 3 | 5.18 | 209.50 | 184.0 | 25.50 |
| 4 | 14.58 | 209.46 | 184.0 | 25.46 |
| 5 | 7.88 | 208.63 | 186.0 | 22.63 |
| 6 | 9.48 | 208.65 | 188.0 | 20.65 |

Pipeline Data

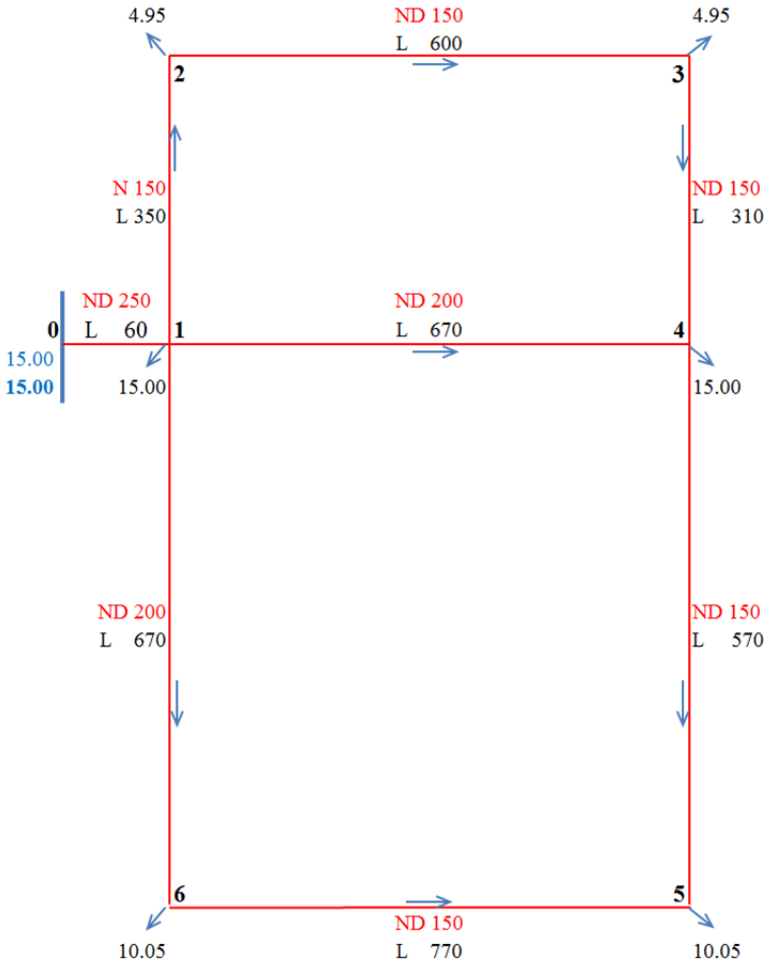
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.37 | 55.49 | 1.13 | 6.09 |
| 1 | 2 | 150 | 310 | 120 | 1.01 | 10.34 | 0.59 | 3.26 |
| 2 | 3 | 150 | 370 | 120 | 0.51 | 6.48 | 0.37 | 1.37 |
| 3 | 4 | 150 | 470 | 120 | 0.03 | 1.30 | 0.07 | 0.07 |
| 4 | 5 | 150 | 540 | 120 | 0.83 | 6.90 | 0.39 | 1.54 |
| 5 | 6 | 150 | 500 | 120 | -0.02 | -0.98 | -0.06 | -0.04 |
| 6 | 1 | 150 | 710 | 120 | -2.37 | -10.46 | -0.59 | -3.33 |
| 1 | 4 | 200 | 560 | 120 | 1.55 | 20.18 | 0.64 | 2.77 |

## 2.3 District Meter Area II-3

Design Flow  Day maximum Demand  3,050 $m^3/d$

Peak Hourly Demand  216 $m^3/hr$ =  60.0 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -60.00 | 204.28 | 186.0 | 18.28 |
| 1 | 15.00 | 203.86 | 186.0 | 17.86 |
| 2 | 4.95 | 202.75 | 187.0 | 15.75 |
| 3 | 202.20 | 202.20 | 187.0 | 15.20 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 4 | 15.00 | 202.19 | 186.0 | 16.19 |
| 5 | 10.05 | 201.83 | 184.0 | 17.83 |
| 6 | 10.05 | 202.68 | 184.0 | 18.68 |

Pipeline Data

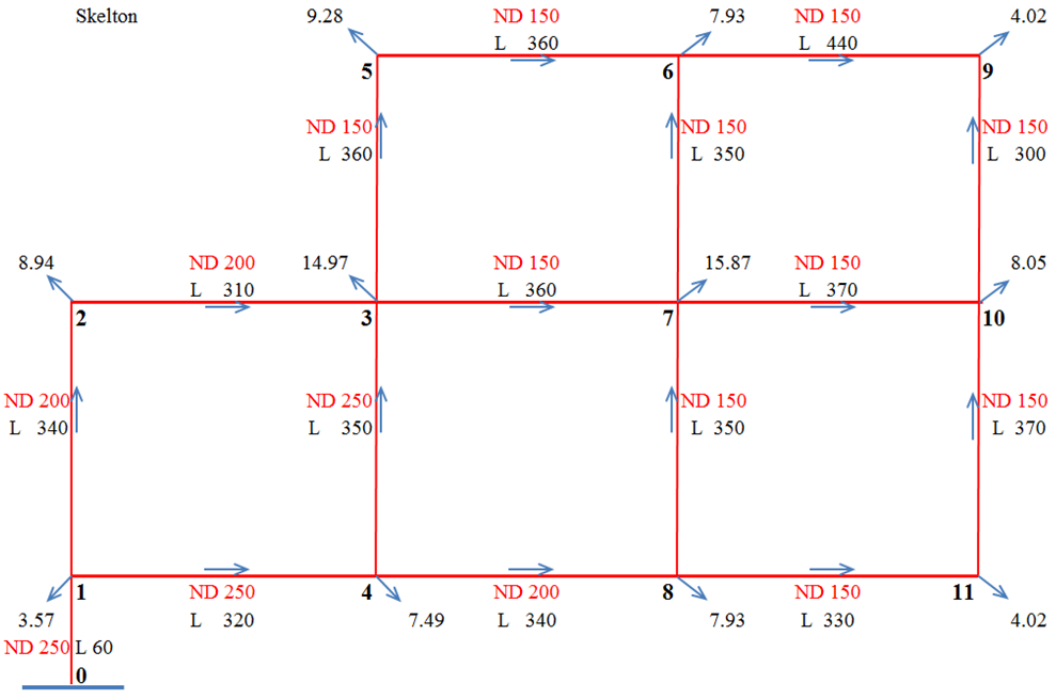
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.42 | 60.00 | 1.22 | 7.04 |
| 1 | 2 | 150 | 350 | 120 | 1.11 | 10.18 | 0.58 | 3.17 |
| 2 | 3 | 150 | 600 | 120 | 0.55 | 4.23 | 0.24 | 0.92 |
| 3 | 4 | 150 | 310 | 120 | 0.00 | 0.28 | 0.02 | 0.00 |
| 4 | 5 | 150 | 570 | 120 | 0.37 | 4.30 | 0.24 | 0.64 |
| 5 | 6 | 150 | 770 | 120 | -0.85 | -5.75 | -0.33 | -1.10 |
| 6 | 1 | 200 | 670 | 120 | -1.18 | -15.80 | -0.50 | -1.76 |
| 1 | 4 | 200 | 670 | 120 | 1.66 | 19.02 | 0.61 | 2.48 |

## 2.4 District Meter Area II-4

Design Flow  Day maximum Demand  4,680 $m^3/d$

Peak Hourly Demand  332 $m^3/hr$ =  92.08 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -92.07 | 204.78 | 187.0 | 17.78 |
| 1 | 3.57 | 203.85 | 187.0 | 16.85 |
| 2 | 8.94 | 202.01 | 186.0 | 16.01 |
| 3 | 14.97 | 201.63 | 185.0 | 16.63 |
| 4 | 7.49 | 201.63 | 187.0 | 14.63 |
| 5 | 9.28 | 198.95 | 185.0 | 13.95 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 6 | 7.93 | 198.61 | 184.0 | 14.61 |
| 7 | 15.87 | 198.86 | 184.0 | 14.86 |
| 8 | 7.92 | 199.94 | 184.0 | 15.94 |
| 9 | 4.02 | 198.54 | 185.0 | 13.54 |
| 10 | 8.05 | 198.60 | 185.0 | 13.60 |
| 11 | 4.02 | 198.99 | 185 | 13.99 |

Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.93 | 92.07 | 1.88 | 15.55 |
| 1 | 2 | 200 | 340 | 120 | 1.84 | 28.95 | 0.92 | 5.41 |
| 2 | 3 | 200 | 310 | 120 | 0.85 | 20.01 | 0.64 | 2.73 |
| 3 | 4 | 250 | 350 | 120 | -0.47 | -24.41 | -0.50 | -1.33 |
| 4 | 1 | 250 | 320 | 120 | -2.22 | -59.55 | -1.21 | -6.94 |
| 3 | 5 | 150 | 360 | 120 | 2.22 | 14.57 | 0.83 | 6.16 |
| 5 | 6 | 150 | 360 | 120 | 0.34 | 5.29 | 0.30 | 0.94 |
| 6 | 7 | 150 | 350 | 120 | -0.25 | -4.55 | -0.26 | -0.71 |
| 7 | 3 | 150 | 360 | 120 | -2.31 | -14.89 | -0.84 | -6.41 |
| 7 | 8 | 150 | 350 | 120 | -1.08 | -10.05 | -0.57 | -3.10 |
| 8 | 4 | 200 | 340 | 120 | -1.69 | -27.65 | -0.88 | -4.97 |
| 6 | 9 | 150 | 440 | 120 | 0.06 | 1.91 | 0.11 | 0.14 |
| 9 | 10 | 150 | 300 | 120 | -0.05 | -2.11 | -0.12 | -0.17 |
| 10 | 7 | 150 | 370 | 120 | -0.26 | -4.52 | -0.26 | -0.70 |
| 10 | 11 | 150 | 370 | 120 | -0.39 | -5.65 | -0.32 | -1.06 |
| 11 | 8 | 150 | 330 | 120 | -0.95 | -9.67 | -0.55 | -2.88 |

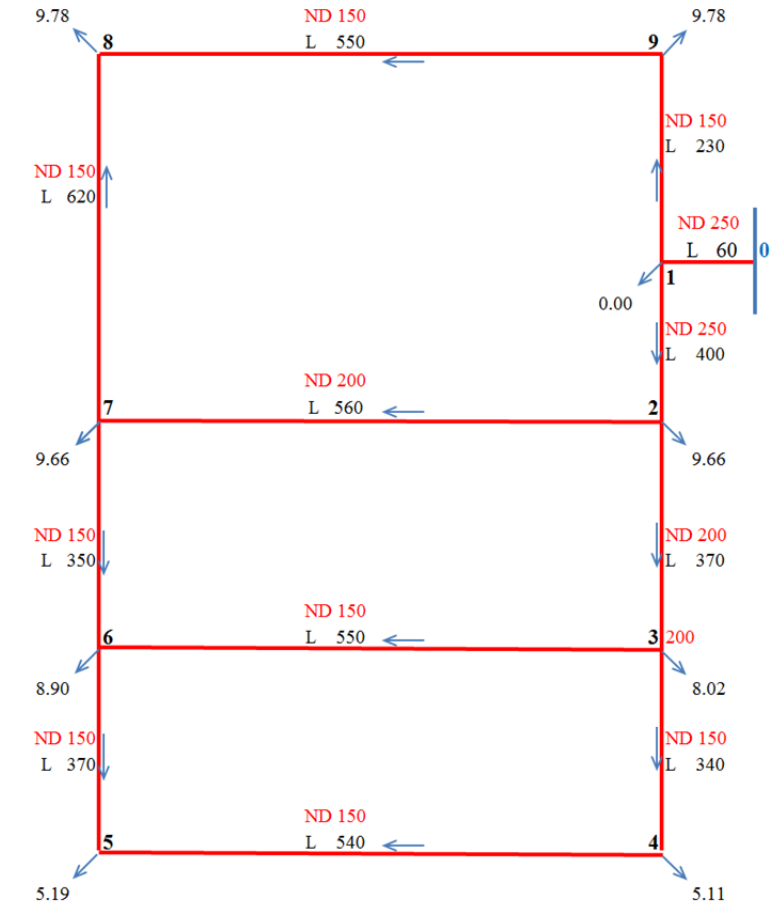
## 3. Distribution Zone III

### 3.1 District Meter Area III-1

Design Flow  Day maximum Demand  3,360 $m^3/d$

Peak Hourly Demand  238 $m^3/hr$ =  66.1 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -66.10 | 208.6 | 186.0 | 22.60 |
| 1 | 0.00 | 208.1 | 184.0 | 24.10 |
| 2 | 9.66 | 206.2 | 186.0 | 20.21 |
| 3 | 8.02 | 205.11 | 186.0 | 19.11 |
| 4 | 5.11 | 204.53 | 187.0 | 17.53 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 5 | 5.19 | 204.42 | 186.0 | 18.42 |
| 6 | 8.90 | 204.54 | 186.0 | 18.54 |
| 7 | 9.66 | 205.00 | 186.0 | 19.00 |
| 8 | 9.78 | 204.92 | 189.0 | 15.92 |
| 9 | 9.78 | 206.04 | 186.0 | 20.04 |

Pipeline Data

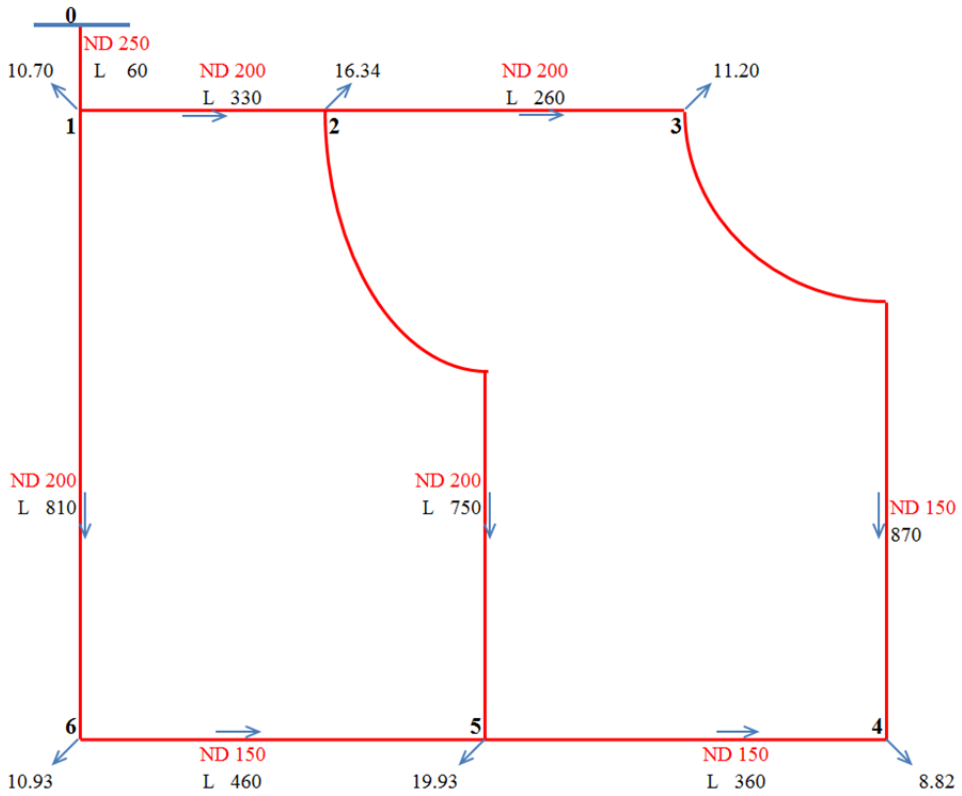
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.51 | 66.10 | 1.35 | 8.42 |
| 1 | 2 | 250 | 400 | 120 | 1.88 | 48.30 | 0.98 | 4.71 |
| 2 | 3 | 200 | 370 | 120 | 1.10 | 20.94 | 0.67 | 2.97 |
| 3 | 4 | 150 | 340 | 120 | 0.59 | 7.34 | 0.42 | 1.73 |
| 4 | 5 | 150 | 540 | 120 | 0.10 | 2.23 | 0.13 | 0.19 |
| 5 | 6 | 150 | 370 | 120 | -0.12 | -2.96 | -0.17 | -0.32 |
| 6 | 3 | 150 | 550 | 120 | -0.57 | -5.58 | -0.32 | -1.04 |
| 6 | 7 | 150 | 350 | 120 | -0.45 | -6.28 | -0.36 | -1.30 |
| 7 | 2 | 200 | 560 | 120 | -1.22 | -17.70 | -0.56 | -2.17 |
| 7 | 8 | 150 | 620 | 120 | 0.08 | 1.76 | 0.10 | 0.12 |
| 8 | 9 | 150 | 550 | 120 | -1.12 | -8.03 | -0.454 | -2.04 |
| 9 | 1 | 150 | 230 | 120 | -2.05 | -17.81 | -1.01 | -8.93 |

## 3.2 District Meter Area III-2

Design Flow  Day maximum Demand  3,960 $m^3/d$

Peak Hourly Demand  281 $m^3/hr$ =  77.92 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -77.92 | 207.96 | 186.0 | 21.96 |
| 1 | 10.70 | 207.28 | 186.0 | 21.28 |
| 2 | 16.34 | 203.39 | 186.0 | 17.39 |
| 3 | 11.20 | 202.9 | 186.0 | 16.94 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 4 | 8.82 | 202.31 | 187.0 | 15.31 |
| 5 | 19.93 | 202.54 | 187.0 | 15.54 |
| 6 | 10.93 | 204.59 | 185.0 | 19.59 |

Pipeline Data

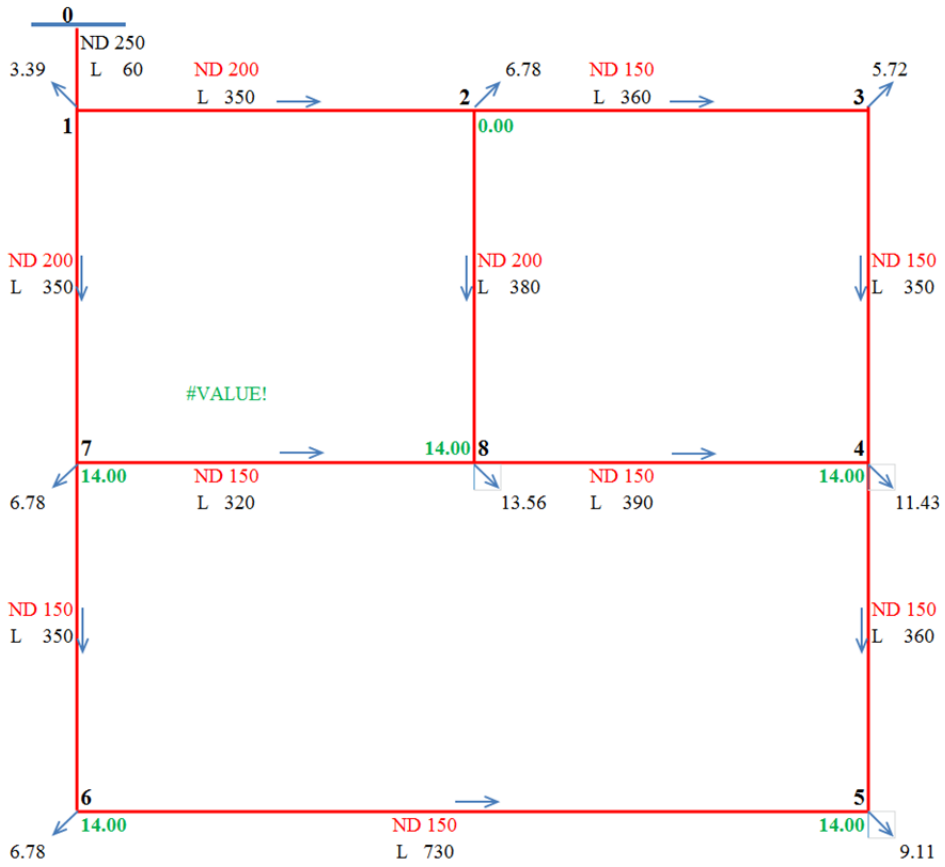
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.68 | 77.92 | 1.59 | 11.41 |
| 1 | 2 | 200 | 330 | 120 | 3.88 | 44.05 | 1.40 | 11.77 |
| 2 | 3 | 200 | 260 | 120 | 0.46 | 15.80 | 0.50 | 1.75 |
| 3 | 4 | 150 | 870 | 120 | 0.62 | 4.56 | 0.26 | 0.72 |
| 4 | 5 | 150 | 360 | 120 | -0.23 | -4.26 | -0.24 | -0.63 |
| 5 | 6 | 150 | 460 | 120 | -2.05 | -12.24 | -0.69 | -4.46 |
| 5 | 2 | 200 | 810 | 120 | -0.85 | -11.95 | -0.38 | -1.05 |
| 6 | 1 | 200 | 750 | 120 | -2.69 | -23.17 | -0.74 | -3.58 |

## 3.3 District meter Area III-3

Design Flow  Day maximum Demand  3,230 $m^3/d$

Peak Hourly Demand  229 $m^3/hr$ =  63.55 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -63.55 | 207.05 | 185.0 | 22.05 |
| 1 | 3.39 | 206.58 | 185.0 | 21.58 |
| 2 | 6.78 | 204.35 | 187.0 | 17.35 |
| 3 | 5.72 | 203.01 | 186.0 | 17.01 |
| 4 | 11.43 | 202.68 | 186.0 | 16.68 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 5 | 9.11 | 202.50 | 186.0 | 16.50 |
| 6 | 6.78 | 203.20 | 186.0 | 17.20 |
| 7 | 6.78 | 204.74 | 186.0 | 18.74 |
| 8 | 13.56 | 203.83 | 186.0 | 17.83 |

Pipeline Data

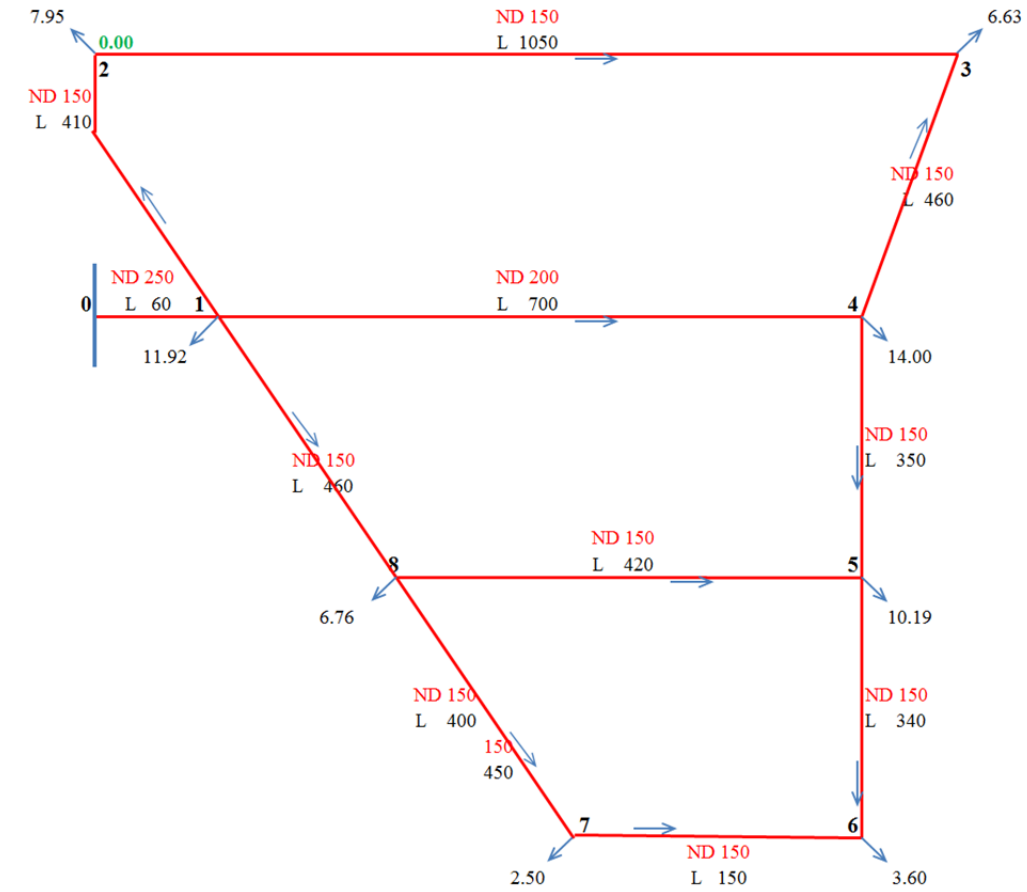
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 1.00 | 63.55 | 1.30 | 7.83 |
| 1 | 2 | 200 | 350 | 120 | 2.23 | 31.64 | 1.01 | 6.38 |
| 2 | 3 | 150 | 360 | 120 | 1.34 | 11.08 | 0.63 | 3.71 |
| 3 | 4 | 150 | 350 | 120 | 0.34 | 5.36 | 0.30 | 0.97 |
| 4 | 5 | 150 | 360 | 120 | 0.18 | 3.75 | 2.62 | 0.50 |
| 5 | 6 | 150 | 730 | 120 | -0.71 | -5.36 | -0.30 | -0.97 |
| 6 | 7 | 150 | 350 | 120 | -1.54 | -12.14 | -0.69 | -4.39 |
| 7 | 1 | 200 | 350 | 120 | -1.84 | -28.52 | -0.91 | -5.26 |
| 7 | 8 | 150 | 320 | 120 | 0.91 | 9.60 | 0.54 | 2.84 |
| 8 | 2 | 200 | 380 | 120 | -0.52 | -13.78 | -0.44 | -1.37 |
| 8 | 4 | 150 | 390 | 120 | 1.15 | 9.81 | 0.56 | 2.96 |

## 3.3 District Meter Area III-4

Design Flow  Day maximum Demand  3,230 $m^3$/d

Peak Hourly Demand  229 $m^3$/hr =  63.55 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -63.55 | 207.28 | 186.0 | 21.28 |
| 1 | 11.92 | 206.81 | 187.0 | 19.81 |
| 2 | 7.95 | 204.91 | 184.0 | 20.91 |
| 3 | 6.63 | 204.12 | 184.0 | 20.12 |
| 4 | 14.00 | 204.18 | 184.0 | 20.18 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 5 | 10.19 | 203.50 | 184.0 | 19.50 |
| 6 | 3.60 | 203.46 | 186.0 | 17.46 |
| 7 | 2.50 | 203.48 | 186.0 | 17.48 |
| 8 | 6.76 | 203.74 | 185.0 | 18.74 |

Pipeline Data

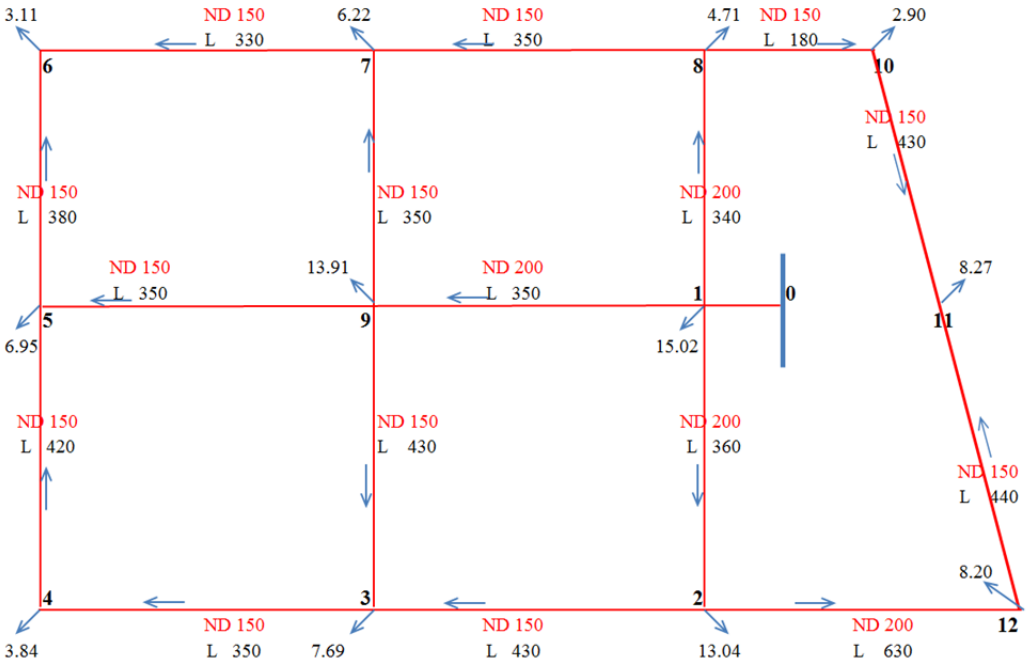
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 1.00 | 63.55 | 1.30 | 7.83 |
| 1 | 2 | 150 | 400 | 120 | 1.90 | 12.66 | 0.72 | 4.74 |
| 2 | 3 | 150 | 1050 | 120 | 0.80 | 4.71 | 0.27 | 0.76 |
| 3 | 4 | 150 | 460 | 120 | -0.07 | -1.93 | -0.11 | -0.15 |
| 4 | 5 | 150 | 350 | 120 | 0.68 | 7.84 | 0.00 | 1.95 |
| 5 | 6 | 150 | 340 | 120 | 0.04 | 1.73 | 0.10 | 0.12 |
| 6 | 7 | 150 | 150 | 120 | -0.02 | -1.87 | -0.11 | -0.14 |
| 7 | 8 | 150 | 400 | 120 | -0.26 | -4.37 | -0.25 | -0.66 |
| 8 | 5 | 150 | 420 | 120 | 0.24 | 4.08 | 0.23 | 0.58 |
| 8 | 1 | 150 | 460 | 120 | -3.07 | -15.21 | -0.86 | -6.67 |
| 1 | 4 | 200 | 700 | 120 | 2.63 | 23.77 | 0.76 | 3.75 |

## 3.5 District Meter Area III-5

Design Flow  Day maximum Demand  4,770 $m^3/d$

Peak Hourly Demand  338 $m^3/hr$ =  93.9 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -93.86 | 207.89 | 187.0 | 20.89 |
| 1 | 15.02 | 206.92 | 187.0 | 19.92 |
| 2 | 13.04 | 205.11 | 187.0 | 18.11 |
| 3 | 7.69 | 204.72 | 184.0 | 20.72 |
| 4 | 3.84 | 204.63 | 186.0 | 18.63 |
| 5 | 6.95 | 204.66 | 186.0 | 18.66 |
| 6 | 3.11 | 204.7 | 185.0 | 19.71 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 7 | 6.22 | 205.00 | 184.0 | 21.00 |
| 8 | 4.71 | 205.76 | 187.0 | 18.76 |
| 9 | 13.91 | 205.11 | 187.0 | 18.11 |
| 10 | 2.90 | 205.24 | 187.0 | 18.24 |
| 11 | 8.27 | 204.61 | 185.0 | 19.61 |
| 12 | 8.20 | 204.65 | 186.0 | 18.65 |

Pipeline Data

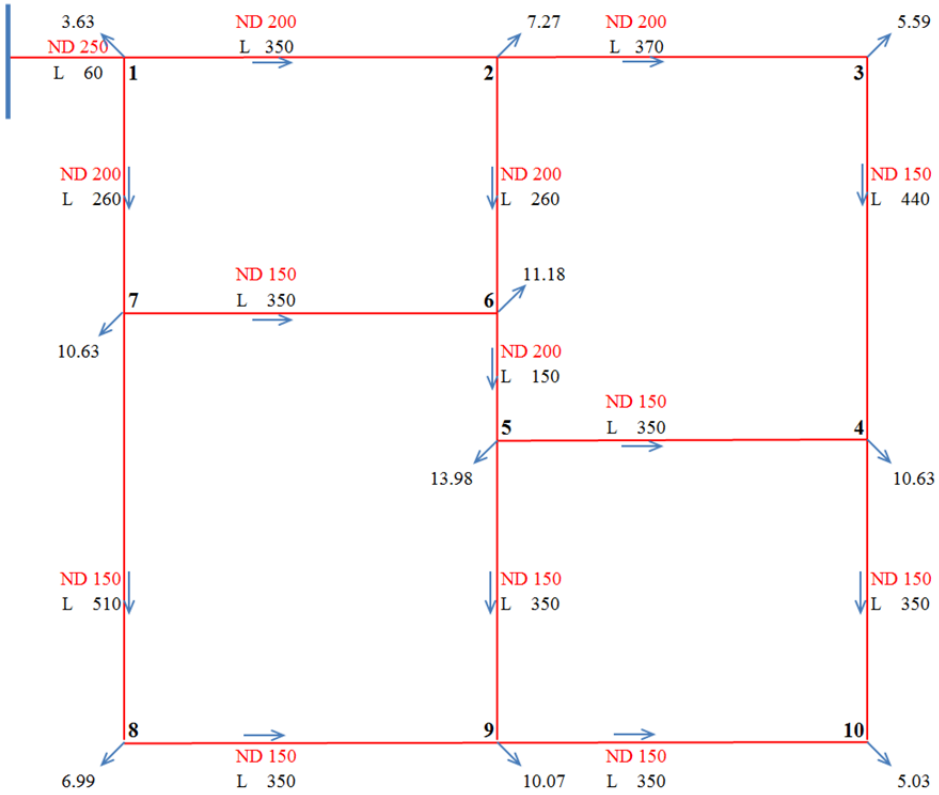
| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.97 | 93.86 | 1.91 | 16.11 |
| 1 | 2 | 200 | 360 | 120 | 1.82 | 27.91 | 0.89 | 5.05 |
| 2 | 3 | 150 | 430 | 120 | 0.38 | 5.12 | 0.29 | 0.89 |
| 3 | 4 | 150 | 350 | 120 | 0.09 | 2.61 | 0.15 | 0.26 |
| 4 | 5 | 150 | 420 | 120 | -0.03 | -1.23 | 1.07 | -0.06 |
| 5 | 6 | 150 | 380 | 120 | -0.06 | -1.92 | -0.11 | -0.15 |
| 6 | 7 | 150 | 330 | 120 | -0.28 | -5.03 | -0.29 | -0.86 |
| 7 | 8 | 150 | 350 | 120 | -0.76 | -8.30 | -0.47 | -2.17 |
| 8 | 1 | 200 | 340 | 120 | -1.17 | -22.64 | -0.72 | -3.43 |
| 1 | 9 | 200 | 350 | 120 | 1.81 | 28.29 | 0.90 | 5.18 |
| 9 | 5 | 150 | 350 | 120 | 0.45 | 6.26 | 0.35 | 1.29 |
| 9 | 7 | 150 | 350 | 120 | 0.11 | 2.95 | 0.17 | 0.32 |
| 9 | 3 | 150 | 430 | 120 | 0.39 | 5.17 | 0.29 | 0.90 |
| 8 | 10 | 150 | 180 | 120 | 0.51 | 9.63 | 0.55 | 2.86 |
| 10 | 11 | 150 | 430 | 120 | 0.63 | 6.73 | 0.38 | 1.47 |
| 11 | 12 | 150 | 440 | 120 | -0.04 | -1.54 | -0.09 | -0.10 |
| 2 | 12 | 200 | 630 | 120 | -0.45 | -9.74 | -0.31 | -0.72 |

## 3.6 District Meter Area III-6

Design Flow  Day maximum Demand  4,320 $m^3/d$

Peak Hourly Demand  306 $m^3/hr$ =  85.00 l/s

Skelton




Node Data

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 0 | -85.00 | 207.37 | 186.0 | 21.37 |
| 1 | 3.63 | 206.57 | 186.0 | 20.57 |
| 2 | 7.27 | 202.70 | 185.0 | 17.70 |
| 3 | 5.59 | 202.15 | 185.0 | 17.15 |
| 4 | 10.63 | 201.06 | 185.0 | 16.06 |
| 5 | 13.98 | 201.35 | 184.0 | 17.35 |

| Node No. | Flow | WL | GL | Eff. Head |
|---|---|---|---|---|
| | l/sec | m | m | m |
| 6 | 11.18 | 201.94 | 184.0 | 17.94 |
| 7 | 10.63 | 204.15 | 186.0 | 18.15 |
| 8 | 6.99 | 201.46 | 188.0 | 13.46 |
| 9 | 10.07 | 200.99 | 184.0 | 16.99 |
| 10 | 5.03 | 200.94 | 186.0 | 14.94 |

Pipeline Data

| Node Number | | Dia. | Length | Friction | Head Loss | Flow | Velocity | H.Gradient |
|---|---|---|---|---|---|---|---|---|
| Up-stream | Dn-stream | m | m | Co-efficient | m | l/sec | m/sec | ‰ |
| 0 | 1 | 250 | 60 | 120 | 0.80 | 85.00 | 1.73 | 13.41 |
| 1 | 2 | 200 | 350 | 120 | 3.87 | 42.57 | 1.36 | 11.04 |
| 2 | 3 | 200 | 370 | 120 | 0.55 | 14.48 | 0.46 | 1.50 |
| 2 | 6 | 200 | 260 | 120 | 0.76 | 20.82 | 0.66 | 2.94 |
| 3 | 4 | 150 | 440 | 120 | 1.08 | 8.89 | 0.50 | 2.47 |
| 4 | 5 | 150 | 350 | 120 | -0.28 | -4.88 | 0.00 | -0.81 |
| 5 | 6 | 200 | 150 | 120 | -0.59 | -24.41 | -0.78 | -3.94 |
| 6 | 7 | 150 | 350 | 120 | -2.21 | -14.77 | -0.84 | -6.32 |
| 7 | 1 | 200 | 260 | 120 | -2.42 | -38.80 | -1.24 | -9.30 |
| 7 | 8 | 150 | 510 | 120 | 2.69 | 13.40 | 0.76 | 5.28 |
| 8 | 9 | 150 | 350 | 120 | 0.47 | 6.41 | 0.36 | 1.35 |
| 9 | 5 | 150 | 350 | 120 | -0.36 | -5.55 | -0.31 | -1.03 |
| 4 | 10 | 150 | 350 | 120 | 0.13 | 3.14 | 0.18 | 0.36 |
| 10 | 9 | 150 | 350 | 120 | -0.05 | -1.89 | -0.11 | -0.14 |

## AB7.2 Cost Estimation for Priority Project

1. Unit cost used for cost estimation

Pipe

| Pipe | Unit Price | |
|---|---|---|
| HDPE100 | 3,081 | Rs./m |
| HDPE150 | 5,726 | Rs./m |
| HDPE200 | 8,586 | Rs./m |
| HDPE250 | 19,638 | Rs./m |
| HDPE300 | 23,565 | Rs./m |
| HDPE350 | 27,492 | Rs./m |
| HDPE400 | 33,956 | Rs./m |
| HDPE450 | 37,904 | Rs./m |
| HDPE500 | 42,045 | Rs./m |

Note: Multiplied unit costs for M/P by 1.5

District Meter

| Unit Cost | |
|---|---|
| 3,000,000 | Rs./unit |

Tertiary Branch

| Item | Unit Cost | |
|---|---|---|
| Valve | 60,500 | Rs./unit |
| Valve Box | 57,400 | Rs./unit |
| Pipe (HDPE 100) | 19,300 | Rs./unit |
| Fitting | 19,300 | Rs./unit |
| **Total** | **156,500** | **Rs./unit** |

Note: Other unit costs related to Priority Project are equivalent to that of M/P

# APPENDIX FOR CHAPTER B8 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

## AB8.1 Photos of Surroundings of Proposed Water Supply Facilities

TR1 candidate site
Private agricultural land.

TR1 candidate site

Water distribution center-7 candidate site
The land belongs to WASA-F.

Water distribution center-7 candidate site

Water distribution center-5 candidate site
Private agricultural land. Sewerage pipe is installed on the route of planned arterial main.

Water distribution center-5 candidate site

Water distribution center-6 candidate site

Vacant private land. Due to the lower ground level, rain and sewage flow in during rainy season.

Water distribution center-6 candidate site

Arterial main route

The pipe will be installed in the center of road, therefore no effect to the housing structures.

Arterial main route

TR3, WTP1, WTP2, WTP3 candidate site

Belongs to the Public health department. In the north, there is water supply system for school and health facility.

TR3, WTP1, WTP2, WTP3 candidate site

WTP1 will be implemented by French project.

Transmission main candidate site
Pipe will be installed along the irrigation canal.

Transmission main candidate site

Water distribution center-36 candidate site
The agricultural land over the canal and road is proposed.
Around 2m lower than surrounding area.

Water distribution center-36 candidate site

Water distribution center-36 candidate site
Football/cricket ground.

Water distribution center-36 candidate site

TR2 candidate site

Both sides along the road are candidate. Both lands are private agriculture lands.

TR2 candidate site

New Abdullah Pur

Existing OHR site. Limited land area shall be considered in the design and layout of new reservoirs.

New Abdullah Pur

Peoples Colony OHR

Existing OHR500,000G and GR250,000G.

Peoples Colony OHR

Water Distribution Center-44 candidate site
Private land adjacent to a mosque. It becomes a puddle pond and waste disposal area.

Water Distribution Center-44 candidate site

Waris Pura OHR
Existing OHR site, currently utilized under the Pilot Project. Water cut is anticipated during construction.


Waris Pura OHR

Water Distribution Center-48 candidate site
Private land with large area. Currently it becomes an illegal waste disposal site.

Water Distribution Center-48 candidate site

Madina Town OHR No.1

Belongs to local authority. There are houses of WASA-F and FDA staff on the premises.

Mdina Town OHR No.1

Water Distribution Center-37 candidate site

Private land. Both sides of the road are vacant.

Water Distribution Center-37 candidate site

Water Distribution Center-32 candidate site

Private vacant land. There are some vacant lands in the neighbors.

Water Distribution Center-32 candidate site

## AB8.2 Environmental Standards in Pakistan

### (1) Water Quality

1) National Environmental Quality Standards (NEQS) for Municipal and Liquid Industrial Effluents[1, 2]

(mg/L, unless otherwise defined)

| | Parameter | Standards | | |
|---|---|---|---|---|
| | | Into Inland Waters | Into Sewage Treatment[3] | Into Sea[4] |
| 1 | Temperature increase[5] | =<3˚C | =<3˚C | =<3˚C |
| 2 | pH | 6-9 | 6-9 | 6-9 |
| 3 | Biochemical-Oxygen Demand (BOD)[6] | 80 | 250 | 80[7] |
| 4 | Chemical oxygen demand (COD) | 150 | 400 | 400 |
| 5 | Total suspended solids (TSS) | 200 | 400 | 200 |
| 6 | Total dissolved solids (TDS) | 3,500 | 3,500 | 3,500 |
| 7 | Grease and oil | 10 | 10 | 10 |
| 8 | Phenolic compounds (as phenol) | 0.1 | 0.3 | 0.3 |
| 9 | Chlorides (as $Cl^-$) | 1,000 | 1,000 | SC[8] |
| 10 | Fluorides (as $F^-$) | 10 | 10 | 10 |
| 11 | Cyanide total (as $CN^-$) | 1.0 | 1.0 | 1.0 |
| 12 | Anionic detergents (as MBAS)[9] | 20 | 20 | 20 |
| 13 | Sulfates ($SO_4$) | 600 | 1,000 | SC[8] |
| 14 | Sulfides ($S^-$) | 1.0 | 1.0 | 1.0 |
| 15 | Ammonia ($NH_3$) | 40 | 40 | 40 |
| 16 | Pesticides[10] | 0.15 | 0.15 | 0.15 |
| 17 | Cadmium (Cd)[11] | 0.1 | 0.1 | 0.1 |
| 18 | Chromium (trivalent and hexavalent, Cr) | 1.0 | 1.0 | 1.0 |
| 19 | Copper (Cu)[4] | 1.0 | 1.0 | 1.0 |
| 20 | Lead (Pb)[4] | 0.5 | 0.5 | 0.5 |
| 21 | Mercury (Hg)[4] | 0.01 | 0.01 | 0.01 |
| 22 | Selenium (Se)[4] | 0.5 | 0.5 | 0.5 |
| 23 | Nickel (Ni)[4] | 1.0 | 1.0 | 1.0 |
| 24 | Silver (Ag)[4] | 1.0 | 1.0 | 1.0 |
| 25 | Total toxic metals | 2.0 | 2.0 | 2.0 |
| 26 | Zinc (Zn) | 5.0 | 5.0 | 5.0 |
| 27 | Arsenic (As)[4] | 1.0 | 1.0 | 1.0 |
| 28 | Barium (Ba)[4] | 1.5 | 1.5 | 1.5 |
| 29 | Iron (Fe) | 8.0 | 8.0 | 8.0 |
| 30 | Manganese (Mn) | 1.5 | 1.5 | 1.5 |
| 31 | Boron (B)[4] | 6.0 | 6.0 | 6.0 |
| 32 | Chlorine | 1.0 | 1.0 | 1.0 |

1. The dilution of liquid effluents with fresh water to adjust them to within the NEQS limits is not permissible before discharge into the environment.
2. The concentrations of pollutants in water used will be subtracted from the effluent in the calculations of the NEQS limits.
3. Applicable only when and where sewage treatment is operational and BOD = 80 mg/L is achieved by the sewage treatment system.
4. Provided the discharge is not at shore and not within 10 miles of mangrove or other important estuaries.
5. The effluent should not result in a temperature increase of more than 3˚C at the edge of the zone where the initial mixing and dilution take place in the receiving body. If no zone is defined, use 100 m from the point of discharge.
6. Assuming a minimum discharge dilution of 1:10, a lower ratio would invite the determination of progressively more stringent standards by the Federal Environmental Protection Agency. A 1:10 dilution means, for example, that a water body receiving 1 cubic meter of treated effluent would have to contain at least 10 cubic meter of water for dilution of the effluent.
7. The value for industry is 200 mg/L.
8. Discharge concentration at or below sea concentration (SC).
9. Methylene Blue Active Substances: assuming the surfactant is biodegradable.
10. Pesticides include herbicides, fungicides, and insecticides.
11. Provided that the total toxic metals discharge does not exceed the level given at No. 25.

SOURCE: National Environmental Quality Standards (NEQS), 2000

2) National Standard for Drinking Water Quality (NSDWQ)[1, 2]

(mg/L, unless otherwise defined)

| Parameter | | Standard Values for Pakistan | WHO Guidelines (2011) | Remarks |
|---|---|---|---|---|
| **Bacterial** | | | | |
| 1 | E. Coli (Drinking water) | ND/100 ml sample | ND/100 ml sample | Most Asian countries also follow WHO Guidelines |
| | E. Coli (Treated water entering the distribution system) | ND/100 ml sample | ND/100 ml sample | |
| | E. Coli (Distribution system) | ND/100 ml sample | ND/100 ml sample | |
| **Physical** | | | | |
| 2 | Color | ≤ 15 TCU | ≤ 15 TCU | |
| 3 | Taste | Non objectionable/ Acceptable | Non objectionable/ Acceptable | |
| 4 | Odor | Non objectionable/ Acceptable | Non objectionable/ Acceptable | |
| 5 | Turbidity | < 5 NTU | < 5 NTU | |
| 6 | Total hardness as $CaCO_3$ | < 500 mg/L | — | |
| 7 | Total Dissolved Solids (TDS) | < 1,000 mg/L | — | <1,000 mg/L (WHO guideline value in the year 1984) |
| 8 | pH | 6.5-8.5 | — | 6.5-8.5 (the range recommended by WHO for the purpose of corrosion control in pipelines) |
| **Chemical** | | | | |
| | ***Essential Inorganic*** | ***mg/L*** | ***mg/L*** | |
| 9 | Aluminum (Al) | ≤ 0.2 | 0.2 | |
| 10 | Antimony (Sb) | ≤ 0.005(P) | 0.02 | |
| 11 | Arsenic (As) | ≤ 0.05(P) | 0.01 | |
| 12 | Barium (Ba) | 0.7 | 0.7 | |
| 13 | Boron (B) | 0.3 | 2.4 | 0.5 mg/L (WHO guideline value in the year 2004) |
| 14 | Cadmium (Cd) | 0.01 | 0.003 | Standard for Pakistan; similar to most Asian developing countries |
| 15 | Chloride (Cl) | < 250 | — | 250 mg/L (the value recommended by WHO for the purpose of taste) |
| 16 | Chromium (Cr) | ≤ 0.05 | 0.05 | |
| 17 | Copper (Cu) | 2 | 2 | |
| | ***Toxic Inorganic*** | ***mg/L*** | ***mg/L*** | |
| 18 | Cyanide (CN) | ≤ 0.05 | — (0.07, 2004) | Standard for Pakistan; similar to most Asian developing countries |
| 19 | Fluoride (F)[1] | ≤ 1.5 | 1.5 | |
| 20 | Lead (Pb) | ≤ 0.05 | 0.01 | Standard for Pakistan; similar to most Asian developing countries |
| 21 | Manganese (Mn) | ≤ 0.5 | — (0.4, 2004) | |
| 22 | Mercury (Hg) | ≤ 0.001 | 0.006 | 0.001 mg/L (WHO guideline value in the year 2004) |
| 23 | Nickel (Ni) | ≤ 0.02 | 0.07 | 0.02 mg/L (WHO guideline value in the year 2004) |
| 24 | Nitrate ($NO_3$)[1] | ≤ 50 | 50 | |
| 25 | Nitrite ($NO_2$)[1] | ≤ 3(P) | 3 | |
| 26 | Selenium (Se) | 0.01(P) | 0.01 | |
| 27 | Residual chlorine | 0.2-0.5 at consumer end<br>0.5-1.5 at source | — | |
| 28 | Zinc (Zn) | 5.0 | — (levels above 3 mg/L may not be acceptable to consumers) | Standard for Pakistan; similar to most Asian developing countries |

| | Parameter | Standard Values for Pakistan | WHO Guidelines (2011) | Remarks |
|---|---|---|---|---|
| | ***Organic*** | | | |
| 29 | Pesticides mg/L | PSQCA No. 4639-2004, Page No. 4 Table No. 3 Serial No. 20- 58 may be consulted.[2] | | Pakistan Standard Specification for Bottled Drinking Water |
| 30 | Phenolic compounds (as Phenols) mg/L | | ≤ 0.002 | |
| 31 | Poly-nuclear aromatic hydrocarbons (as PAH) g/L | | 0.01 (by the GC/MS method) | |
| | ***Radioactive*** | ***Bq/L*** | ***Bq/L*** | |
| 32 | Alpha emitters | 0.1 | 0.5 | |
| 33 | Beta emitters | 1 | 1 | |

1. Indicates priority health-related inorganic constituents that require regular monitoring.
2. PSQCA: Pakistan Standards Quality Control Authority.
3. ND: Not Detected

SOURCE: Pakistan Environmental Protection Agency (EPA)

## (2) Air Quality

1) National Environmental Quality Standards (NEQS) for Ambient Air

(μg/m$^3$)

| | Pollutants | Time-weighted Average | Concentration in Ambient Air | | Method of Measurement |
|---|---|---|---|---|---|
| | | | Effective from 1st July 2010 | Effective from 1st January 2013 | |
| 1 | Sulphur Dioxide ($SO_2$) | Annual Average[1] | 80 | 80 | Ultraviolet Fluorescence Method |
| | | 24 hours[2] | 120 | 120 | |
| 2 | Oxides of Nitrogen as (NO) | Annual Average[1] | 40 | 40 | Gas Phase Chemiluminescence |
| | | 24 hours[2] | 40 | 40 | |
| 3 | Oxides of Nitrogen as ($NO_2$) | Annual Average[1] | 40 | 40 | Gas Phase Chemiluminescence |
| | | 24 hours[2] | 80 | 80 | |
| 4 | Ozone ($O_3$) | 1 hour | 180 | 130 | Non Dispersive UV Absorption Method |
| 5 | Suspended Particle Matter (SPM) | Annual Average[1] | 400 | 360 | High Volume Sampling (Average flow rate not less than 1.1m$^3$/min) |
| | | 24 hours[2] | 550 | 500 | |
| 6 | Respirable Particle Matter ($PM_{10}$) | Annual Average[1] | 200 | 120 | β Ray Absorption Method |
| | | 24 hours[2] | 250 | 150 | |
| 7 | Respirable Particle Matter ($PM_{2.5}$) | Annual Average[1] | 15 | 15 | β Ray Absorption Method |
| | | 24 hours[2] | 40 | 35 | |
| | | 1 hour | 25 | 15 | |
| 8 | Lead (Pb) | Annual Average[1] | 1.5 | 1 | ASS Method after sampling using EPM2000 or equivalent Filter pater |
| | | 24 hours[2] | 2.0 | 1.5 | |
| 9 | Carbon Monoxide (CO) | 8 hours[2] | 5 | 5 | Non Dispersive Infra Red (NDIR) Method |
| | | 1 hour | 10 | 10 | |

1. Annual arithmetic mean of minimum 104 measurements in a year taken twice a week hourly at uniform interval.
2. 24 hourly or 8 hourly values should be met 98% of the standard value in a year, 2% of the time. It may exceed but not on two consecutive days.

SOURCE: National Environmental Quality Standards (NEQS) for Ambient Quality, 2010

2) National Environmental Quality Standards (NEQS) for Industrial Gaseous Emission

(mg/Nm$^3$, unless otherwise defined)

| Parameter | | Source of Emission | Standards in 1993 | Revised Standards in 2000 |
|---|---|---|---|---|
| 1 | Smoke | Smoke opacity not exceed: | 40% or 2 (Renglemann Scale) | 40% or 2 (Renglemann Scale) or equivalent smoke number |
| 2 | Particulate Matter[1] | (a) Boilers and fumaces: | | |
| | | (i) Oil fired | 300 | 300 |
| | | (ii) Coal fired | 500 | 500 |
| | | (iii) Cement Kilns | 200 | 300 |
| | | (b) Grinding, crushing, coolers and related processes, metallurgical processes, convertors, blast fumaces and cupolas. | 500 | 500 |
| 3 | Hydrogen Chloride[2] | Any | 400 | 400 |
| 4 | Chlorine[2] | Any | 150 | 150 |
| 5 | Hydrogen Fluoride[2] | Any | 150 | 150 |
| 6 | Hydrogen Sulphide[2] | Any | 10 | 10 |
| 7 | Sulphur Oxides | Sulfuric Acid / Sulfuric Acid plants. | 400 | 5000 |
| | | Other plants[3]. | 400 | 1700 |
| 8 | Carbon Monoxide[4] | Any | 800 | 800 |
| 9 | Lead[2] | Any | 50 | 50 |
| 10 | Mercury[2] | Any | 10 | 10 |
| 11 | Cadmium[2] | Any | 20 | 20 |
| 12 | Arsenic[2] | Any | 20 | 20 |
| 13 | Copper[2] | Any | 50 | 50 |
| 14 | Antimony[2] | Any | 20 | 20 |
| 15 | Zinc[2] | Any | 200 | 200 |
| 16 | Antimony Zinc Oxides of Nitrogen (NOx)[4] | (i) Nitric Acid manufacturing unit | 400 | 400 |
| | | (ii) Gas fired | 400 | 400 |
| | | (iii) Oil fired | — | 600 |
| | | (iv) Coal fired | — | 1200 |

1. Based on the assumption that the size of the particles is 10 microns or more.
2. Any source.
3. Based on 1% sulphure content in fuel oil. Higher content of sulphure will cause standards to be pro-rated.
4. In respect of emissions of sulphure dioxide and nitrogen oxides, the power plants operating on oil or coal as fuel shall, in addition to National Environmental Quality Standards (NEQS) specified above, comply with the following standards.

SOURCE: National Environmental Quality Standards (NEQS) for Industrial Gaseous Emission, 2000

### (3) Noise

1) National Environmental Quality Standards (NEQS) for Noise

(Limit in dB (A) Leq[4])

| Category of Area/Zone | | Effective from 1st July 2010 | | Effective from 1st July 2012 | |
|---|---|---|---|---|---|
| | | Day time[1] | Night time[2] | Day time[1] | Night time[2] |
| 1 | Residential Area (A) | 65 | 50 | 55 | 45 |
| 2 | Commercial Area (B) | 70 | 60 | 65 | 55 |
| 3 | Industrial Area (C) | 80 | 75 | 75 | 65 |
| 4 | Silence Zone[3] (D) | 55 | 45 | 50 | 45 |

1. Day time hours: 6.00 am to 10.00 pm
2. Night time hours: 10.00 pm to 6.00 am
3. Silence zone: Zones which are declared as such competent authority. An area comprising mot less than 100 meters around hospitals, edictional institutions and courts.
4. dB (A) Leq: Time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

Source: National Environmental Quality Standards (NEQS) for Noise, 2010

## AB8.3 Stakeholder Meeting Report

### (1) Proceedings of 1st Stakeholder Meeting (SHM-1)

Initial Environmental Examination (IEE) process forms a part of the JICA-WASA M/P Project. Under this component, the first stakeholder meeting (SHM) was organized by JICA Mission Team (JMT). The date, venue, objectives the meeting are as under:

Date : 28th September, 2017
Venue : Conference Room, WASA Faisalabad.
List of participants: Attached as **Annex-1**.

The objectives of the SHM are:

- To provide key stakeholders with information regarding the findings of the study and proposed long-term plan of water supply and sewerage in Faisalabad under the project.
- To provide an overview of the environmental and social assessment and Public Participation Process (PPP) being followed for the proposed project.
- To provide an opportunity for key stakeholders to seek clarity and provide input into the project.
- To record comments raised and include them in the Interim Report of the project.

Agenda of the meeting including presentations made are as under:

- Overview/ Scope of M/P
- Environmental and Social Considerations
- Discussion
- way forward

**1) Summary of Presentation in SHM-1**

An overview of M/P for formulating a strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad was presented in the meeting. The information provided is summarized as under:

***Water Supply***

Water supply sources comprise of ground water and surface water in Faisalabad. The sources of ground water are government owned tube wells/ private wells and river water (Chenab River/RBC, JBC and GBC). WASA-F is responsible for delivery, maintenance and management of water supply system. The current water supply situation is highlighted below:

- Actual Water Supply in 2017 : 247000 m3 /day
- Total Water Demand in 2015 : 287000 m3 /day
- Current Water supply service: 6 hours or less from
- Insufficient water quantity with low pressure

*Issues*

- Over/illegal pumping from tube wells causes groundwater depletion
- Mostly pipes do not have water meters
- Water containing high salinity content
- Low operation rate of water treatment plants (JKWTP-empty filters)
- Intermittent low operation of pumps (6hr/day) at terminal reservoir & pumping station along with Inability of manage water distribution

*Targets Proposed in M/P*

- Total Water Demand estimated in 2038: 1252000 m3/day
- Water supply service/operation : 24/7
- Sufficient water pressure : 12m
- Sufficient water quantity: 145litres/capita/day
- Safe water quality: WHO guidelines by establishing water quality system in WASA
- Step-wise development (groundwater + surface water) based on the future demand

Considering the above planning, two scenarios were studied for the development of water sources to achieve the future demand & other targets in the M/P. Scenario-1 mostly provides for short and medium terms proposals which mainly aims at development of well fields and canals (JBC, RBC, GBC), whilst Scenario-2 apart from taking intake from canal water on short term basis, primarily focuses on development of well field, of Chenab River. In financial terms Scenario-1 is cost effective, whereas Scenario-2 involves huge investment.

*Environmental & Social Considerations*

- Environmental Impacts
  - Water usage or water right
  - Depletion of groundwater
  - Generation of sludge & wastewater from WTPs
- Social Impacts
  - Land acquisition for the TR & OHR/GR sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

***Sewerage & Drainage***

The vast majority of industrial effluent is discharged "raw" without any treatment into two main drains that are Paharang drain to the North West and Madhuana drain to the South East. Paharang Drain eventually discharges to the Chenab River and Madhuana Drain to the Ravi River; both drains are managed by the Irrigation Department.

In order to assess the quality of water being discharged into Main Drains and to estimate the results of planned sewerage system on reduction of pollution loads, a survey along Main Drains within target area of the project and that of Chenab & Ravi Rivers is conducted. Sampling method and flow rate measurement to estimate the pollution loads is summarized as under:

- Water Quality Analysis on Main Drains
  - Sampling points: Madhuana Drain 4, Paharang Drain 10
  - Parameters: Temp, pH, SS, BOD, COD, SS, NO2-, NO3-, NH4+, T-N, T-P, Oil, SO4-, CN-, Phenol, Cu, Zn, As, Cr, Pb, Cr, Hg, Ni, Coliform (total 24)
- Water Quality Analysis on Main Rivers
  - Sampling points: Chenab River 2, Ravi River 2
  - Parameters: Temp, pH, EC, SS, DO, BOD, COD, SS, NH4+, Coliform (total 8)
- Flow rate Measuring (to estimate the pollution loads)
  - Velocity & Section area at drains and rivers
  - Pumping operation at pump stations

Major Conclusions of the survey:

- Water quality of Main drains as well as that of rivers exceeds NEQS/WHO guidelines.
- Drain and river water is heavily polluted with domestic & industrial waste water.

*Planning Proposed for Domestic Waste Water in M/P*

- Basic Planning
  - Expansion of sanitary sewer network
  - On-site sanitation facilities for the low populated areas
- Sewers & Pumping Stations
  - Increase of the capacity of sewers
  - Installation of sewer pipes collecting WW instead of open drainage channels
- Wastewater Treatment Plants (WWTP)
  - Renovation of Chokera WWTP
  - Preparation of appropriate sites for new WWTPs
  - Treated WW shall be used for agricultural purposes

*Planning Proposed for Industrial Waste Water in M/P*

- Main issues
  - Acceptance of industrial WW to sewerage system of WASA-F
  - Installation/operation of pre-treatment facilities in factories
- Regulation to control the IWW quality
  - Strengthening regulations & observing compliance
  - COD, TDS & toxics shall be reduced by pre-treatment
  - Dedicating penalty for violation
- Monitoring of IWW
  - Data collection for enhanced registration & inspection system
  - Improvement of WASA-F lab to analyze key parameters
  - Establishment of sustainable monitoring system

*Environmental & Social Considerations*

- Environmental Impacts
  - Hydrological situation/water quality (to be improved)
  - Generation of sludge from WWTPs
- Social Impacts
  - Land acquisition for the WWTP sites
  - Evacuation & demolition during construction stage
- Other considerations
  - Traffic congestion during construction stage
  - Noise & vibration
  - Air pollution

**2) Discussion/ Minutes of SHM-1**

Questions & Answer including observations/clarifications made in the meeting are summarized as under:

**Mr. Rohan Javed (DDT), WASA**

Mr. Rohan shared his opinion on the two scenarios discussed in the presentation. According to him, for Scenario-1 (JBC, RBC, GB), the proposal has to be first discussed with the Irrigation department because the rights of canal water belongs to them. Also, Scenario-1 will solve the problem of water supply for only 20

years. Whereas, the cost of Scenario-2 is much higher than the Scenario-1 as it provides one-time investment and long-term solution catching the need of the Faisalabad for 50 years. Also, the water from the Chenab River can be supplied in accordance to the demand and volume can be increased with the increase in requirement. So, in the light of explanation provided by him, he supported the Scenario-2 to be opted.
MD, WASA, responded that the Scenario-2 is very costly as the investment required for long term to solve the water issue. However, the final decision will depend upon the availability of finances for this project. He also mentioned that east zone of the Faisalabad city possesses more pollution as compared to the west zone and there is more need to establish waste water treatment plant in east zone as compared to west zone. He requested JICA Study Team to verify their results in east and west zone.
JICA Study Team Member, Ms. Takamizawa, however informed that Scenario-1 is better because of low cost as compared to Scenario-2. Also, the feasibility of Scenario-2 depends upon the construction of Chiniot dam. She said that the JICA Study Team will further examine the Scenario-2 in detail after verifying the feasibility of Chiniot dam.

**Rana Kashif Ali, S.D.O, Irrigation Department**
Irrigation department highlighted their concerns about the installation of Water Pumping Radar (WPR) on the canals as proposal would require the redesigning of that part of the canal where WPR are to be installed. He was of the view that installation of WPR equipment should be undertaken under a separate project.
MD, WASA, said that in order to resolve this issue, detailed discussion would need to be held with Irrigation department.

**Gul Hafeez, SIDS, The Urban Unit, Govt. of Punjab**
Mr. Gul highlighted the issue regarding the institutional capacity building of WASA and suggested that the JICA Study Team should consider it while finalizing their proposal/ recommendation in the report.
JICA Study Team ensured that the strengthening of WASA is included in the scope of work of M/P.
Mr. Hafeez further states that the capacity of water supply system is proposed to be raised from 63 MGD in 2015 to 275 MGD in 2038. WASA would not be able to handle this capacity. JICA Study Team clarified that the water supply system of Faisalabad would be upgraded/ developed to cope with the augmentation of the capacity.
For the industrial waste disposal and the environmental issues, WASA should setup their Non-Environmental Cell.
Mr. Shahid Iqbal from FINITE highlighted that firstly priority projects under Master Plan would be identified, then the requirement to mitigate the environmental issues would be incorporated in the IEE/ EIA reports to be submitted for the approval of EPA which supervises/ oversees every environmental issue.
When the Master Plan will be completed, then EIA and IEE reports will be prepared and will be submitted to EPA for their approval.

**Asif Kiyani (EPA)**
Mr. Asif Kiyani supports the Scenario-2 and appreciates Mr. Rohan observations on both scenarios. He raised a question about how to control pollution including solid waste.
JICA Study Team states that existing solid waste management is not included in their scope of work. But they will give comments and provide guidance to manage it. They also emphasize to educate the citizens about solid waste management.

**Ms. Takamizawa (JICA Study Team)**
Ms. Takamizawa mentioned the stakeholders to whom she wants to discuss the details of the Master Plan Project. MD, WASA assisted her on that question.

**Closing Remarks from Mr. Irfan (Vice Chairman, WASA)**
Mr. Irfan pays his tribute to JICA, Government of Japan for conducting this Master Plan Project and for looking after the needs of Faisalabad city and regards their spirit. He emphasized on the importance of the Faisalabad city as one of the major Industrial city of Pakistan. He also mentioned another Tender for up gradation of Terminal Reservoir in Faisalabad City, worth 1.6 billion Pak Rupees. He discussed the installation of new public stations and lines in the city. After the construction of 2nd Treatment Plant, WASA will be able to provide 100% potable water to the local people of the city. Mr. Irfan also emphasize on the installation of waste water treatment plant on both east and west side of the city.

**Way Forward**
- Finalization of Interim Report
- Planning & design of priority project
- Cost estimation of M/P & priority project
- Financial evaluation
- IEE level survey of priority project
- Stakeholder & public consultation
- Completion of Draft Final Report

**(2) Proceedings of Workshop/ 2nd Stakeholder Meeting (WS/SHM-2)**

JICA Mission Team (JMT) in consultation with all the concerned departments and stakeholders involved in the formulation of Master Plan has prepared an Interim Report in November 2017. The Interim Report provided an overall overview of M/P and divulged upon priority projects for planned development and improvement of water supply, sewerage and drainage facilities in the city.
In order to update all the concerned departments, one day workshop together with second SHM was organized by WASA-F/JMT.

Date : 20th December, 2017
Venue : Serena Hotel Faisalabad.
List of participants: Attached as **Annex-2**.

The objectives of the Workshop/ SHM are:
- To provide information regarding findings of M/P & proposed long term plan of water supply, sewerage and drainage in Faisalabad.
- To provide an overview of the environmental and social assessment and public participation process for proposed projects.
- To provide clarification to queries of participants & seek their contribution for the improvement of Master Plan.
- To record comments raised & incorporate them in the draft Final Report of M/P project.

Agenda of the meeting including presentations made are as under:
- Overview/Scope of M/P relating to
  - Water Supply
  - Sewerage & drainage
- Environmental and Social Considerations
- Discussion

**(1) Summary of Presentation in the WS/SHM-2**

Master Plan including ensuing strategy for the development/improvement of water supply services and sewerage/drainage system in Faisalabad presented in the first SHM already was also discussed in the workshop/second SHM (herein after called as second meeting). Besides the information regarding existing situation, planned proposals in M/P etc.as provided above in para 6.1, following additional details have been divulged in the second meeting.

*Direction of Water Supply planning*

- Securing Water Resources
  - Step-wise development (ground & water) considering the future demand
- Improvement of Water Supply Services
  - Supply zones, transmission & distribution network, distribution centers
  - Method for improvement of service level, from vicious to virtuous cycle
- Proposed Priority Project to be initiated in three areas; Sitara Sapna city, Sarfaraz colony and Medina Town. This includes:
  - Old Jhal Khaluana WTP Renewal (10 MGD) with New DCs Construction
  - New Transmission and Distribution Network with Water Meter Procurement
  - Stepwise Development: Phase 1 (5 MGD) and Phase 2 (5 MGD)

*Planned Water Supply Service (2038)*

Current (2015) Target (2038)

- Served Population (domestic): 4,146,000
- Connection (domestic): 572,000
- Water Demand: 275 MGD
- Production Capacity: 277 MGD
- Coverage Area: 2 360 km2
- Use of Groundwater: 16%

*Key Features:*

- Step-wised development of new water sources based on short term plan for 2023, midterm plan for 2023-2028/2033 & long term plan for 2028/33-2038
- Service area divided into seven (7) supply zones with respect to water source. This includes :
  - 4 Zones from Terminal Reservoirs (TRs):
  - 1 existing TR & 3 new TRs
  - 1 Zone from RBC
  - 1 Zone from New JK WTP
  - 1 Zone from Old JK WTP
- 56 water distribution centers (WDC) are proposed to be established serving respective Administrative Zones (including 20 on private land) with OHR of 25m height & capacity=2000$m^3$
- Utilization of ground water would be substantially reduced from present 85% to 16% in 2038
- Components of priority projects proposed in above three areas include WDC, Water Treatment Plant, Distribution & Transmission Main Lines, & Meters

*Direction of Sewerage/Drainage planning*

Domestic WW Management

**Basic Planning Policy**

- Domestic wastewater to be collected by sewer pipes and conveyed to
- WWTP not discharged to the open drainage channels.
- Installation of interceptor sewers to maximize the capacity of sewerage network

**Improvement of Sewer Network & Pumping Stations**

- Increase of the capacity of sewer network
- Minimizing the number of pumping stations by deeper pipe installations
- Use of existing disposal pumps as storm-water pumps where possible

**Wastewater Treatment Plants (WWTP)**

- Renovation of Chokera WWTP
- Preparation of appropriate sites for new WWTPs
- Industrial WW to be treated separately

*Planned Sewerage/Drainage Service (2038)*

**Domestic**

| | |
|---|---|
| Served Population: | 4,292,000 (Including FDA City, Sadar & Khurrianwala) |
| Wastewater Flow: | 130 MGD |
| Pollution Load: | 242 ton/d-BOD |

**Industrial**

| | |
|---|---|
| Wastewater Flow: | 646 MGD |
| Pollution Load: | 584 – 659 ton/d-BOD |
| Design Sewer Flow: | 190 MGD |
| Capacity of WWTP: | 190 MGD |
| Water Quality (BOD): | 80 mg/l |
| Coverage Area: | 2 379 km2 |

**Key Features:**

- Industrial Wastewater Volume to be accepted by the WASA-F Sewerage System:
  - About 20% of Total Design Ave. Daily Flow in 2038

Industrial WW Management

**Acceptance of Industrial WW to WASA-F Sewerage System**

- Current ratio of Total volume of Industrial WW to non-industrial WW is 1:3 in WASA area.
- Installation/operation of pre-treatment facilities in factories

**Regulations to Control Industrial WW Quality**

- Strengthening regulations & observing compliance
- COD, TDS & toxics shall be reduced by pre-treatment
- Enforcement of penalty for violation

**Monitoring of Industrial WW**

- Data collection for enhanced registration & inspection system
- Improvement of WASA-F lab to analyze key parameters
- Establishment of sustainable monitoring system

**Recommendations for Industrial WW management**

- Industrial WW is harmful to biological WW treatment process. It is very difficult for WASA-F Sewerage System to accept all amount of industrial WW. It is therefore recommended:
- Separate Industrial WWTP for Khurrianwala
- Shifting of major Industrial Estates to M3 in future
- Large sized factories should treat their own Industrial WW in compliance with NEQS
- WASA-f may accept industrial WW once their effluent quality is complied with quality agreed to by the WASA-F.
- To establish the **Industrial Wastewater Management Unit in WASA-F-** responsible for application, monitoring and inspection of industrial units served by WASA-F sewerage under **the Sewerage and Drainage Faisalabad Regulation (2015).**

*Environmental & Social Considerations*

In addition to the impacts described in the above section (first SHM proceedings), it is worthwhile to state that land would be required for Construction of:

- OHRs proposed on public/private land with area of one Centre amounts to 1500m$^2$
- TR near Narwala Road Bypass Satiana Road with area of one reservoir of 10000m$^2$
- Gugera WTP &TR & Jhang WTP with area for one WTP of 10acre
- Chokera WWTP with 550 acres & Mew West WWTP with 710 acres
- Eastern WWTP with required area of 1100 acres

It is also imperative to carry out effective coordination with stakeholders for

- Identification of Project Affected Persons (PAPs)
- Public consultation and compensation where necessary
- Permissions regarding road & transport, canal, environment
- Arrangement of construction waste & sludge disposal
- Technical assistance from universities
- Scarcity of water resources in Faisalabad
- Importance of water saving
- Proper disposal of waste no to sewerage or drainage
- Enforcement of regulations and observation of compliance

**Discussion/ Minutes of Work-Shop & SHM-2**

A gist of discussions in the form of Questions & Answers including observations/clarifications made as well as input provided by the participants in the workshop is presented below:

**Q.1**
Whether or not any study has been undertaken to assess/examine the extent of contamination both in surface water (S/W), & underground water (U/G) because of presence of lot of Silt, toxic industrial effluent, particularly Arsenic particles. If not, it would be more appropriate to carry out a detailed study before the installation of Water Treatment Plant (WTP).
**Answer**
Mostly the U/G water was found to be contaminated with chemical including Arsenic particles. It is planned to provide WTP for S/W while WTP has not been considered to be installed for U/G water. It is, however, agreed to incorporate the proposal to conduct a detailed study before installation of WTP, in the Master Plan (M/P).

**Q.2**
Treatment of surface water containing Industrial Waste/toxic material is a major problem which has become very severe in intensity in the city. The presentation made by DD WASA-F does not indicate as to how many treatment plants are required. Is there any plan for a specified number of treatment plants proposed to be installed in M/P for Faisalabad?
**Answer**
It was informed that M/P has proposed stage-wise development schemes under Scenario-1 including priority projects for the rehabilitation & improvement of existing old WTP and the installation of new WTP. Under Scenario-1, the water Supply Service system is proposed to the developed through integration of canal water while the system under Scenario-II is based on the use of Chenab river water. The Scenario-I, being cost effective, is proposed in the development of water supply service system as under:

| Water Source/Development Project | Design Capacity (MGD) | Name of Water Sources | Term | Target Year |
|---|---|---|---|---|
| **Surface Water** | | | | |
| Renewal of Old JKWTP | 10 | RBC | Short Term | 2023 |
| New JKWTP | 05 | RBC | Short Term | 2020/ 2023 |
| Jhang WTP-1 | 20 | JBC(upper) | Mid Term | 2028 |
| Jhang WTP-2 | 40 | JBC (upper) | Long Term | 2038 |
| Gugera WTP-1 | 25 | GBC(lower) | Mid Term | 2023 |
| Gugera WTP-2 | 25 | GBC(lower) | Mid Term | 2028 |
| Gugera WTP-3 | 25 | GBC (Lower) | Long Term | 2033 |
| **Ground Water** | | | | |
| JBC new well | 10 | JBC (Upper) | Mid Term | 2028 |
| JBC exp-well | 10 | JBC (Upper) | Mid Term | 2033 |
| Gugera-1-well | 05 | GBC (Lower) | Mid Term | 2023 |
| Gugera-2-well | 05 | GBC(Lower) | Mid Term | 2028 |

Under the priority projects, the existing old JKWTP constructed in 1935 with slow sand filtration plant having original capacity of 3.5 MGD, is proposed to be rehabilitated /renewed through installation of rapid sand filtration system. This would augment the capacity from 3.5 MGDE to 10 MGD, to cater for the consumer demand which has been growing rapidly manifold since then.

**Q.3**
Water of Gugera Branch Canal (GBC) is highly contaminated. What measures are being proposed to resolve this problem?
**Answer**
Both surface water and ground water have been proposed to be purified through rapid sand filtration system. A total of three (3) WTP for surface water and two WTP for ground water are proposed to be constructed at GBC (Lower), as evident from the above table.

**Q.4**
Water supply gets affected or suspended during the closure of canals. How the demand would be met during this period. What proposals are being made to ensure sustainable operations of the water treatment plant during the closing period of canals? Haphazard
**Answer**
Irrigation Canal is an important source of surface water. Being a direct source of irrigation water, the maintenance of canals is considered imperative. Three (3) branches of canal water, (JBC-upper, RBC & GBC-lower) are affected due to the closure of LCC feeder and lower channel canals respectively. Considering the standard closing period, the effect of canal closure can be minimized through construction of water supply network so as to complement each other for the closure period of few days. To ensure the stability in the flow of surface water and to meet the required demand during the canal closure period, the option is to develop surface water source by constructing new water treatment plants facilities by acquiring direct intake water from an irrigation canal. However, the direct intake solution may involve constraints like incurring high cost and taking long time to negotiate with the Irrigation Department. Furthermore, the duration of standard closing period is at least 18 days which has increased to almost one month in recent years. This period needs to be reduced to minimum of 15-18 days. It was informed that adjustment needs to be made to avoid overlapping of the closing periods of two canals JBC & GBC, which can be made by shifting/staggering the closing period of JBC and GBC.

It may be proposed to Irrigation Department that more water can be withdrawn from canals like JBC during the closing period of other canals such as GBC. The negotiation for procuring direct intake of water of 25 MGD from GBC and 20 MGD from others with the Irrigation Department is in progress. It was further pointed out that reuse of waste water after treatment is also under consideration. An agreement with Government of Denmark has been signed for carrying out a feasibility study in this regard.

**Comment**
There is no procedure/method that can be followed medically for extracting Arsenic from the human body if water containing Arsenic is used. It would be more appropriate to eliminate Arsenic contents in the drinkable underground or surface water.
**Answer**
As compared to Lahore, no such problem exists in Faisalabad. The Arsenic contents amount to 10 microgram/liter in the water in Faisalabad city which is below than the WHO standard.
Installation of RO plants is under way to overcome this problem in Lahore.

**Comment/Question 5**
Competition seems to be observed between Agriculture and Water Irrigation sectors in Punjab/Pakistan. With the increase in population this competition also increased while the quality of drinking water is continued deteriorating which is of major concern for the public/water users. The question is to what extent the treatment should be carried out for the improvement of quality of the canal water.
**Answer**
Regarding the quality of the surface water through canals, it was clarified that water treatment is being carried out following the WHO standards which are being used all over the world and provide robust criteria for checking the quality of water taken from the surface water sources i.e. canals, rivers etc. It was further divulged that treated canal water is being used for both drinking and irrigation purpose. An example of Vietnam was quoted, where treatment is performed for drinking water only. Regarding contamination in water being used for household purposes, efforts are being made to supply clean/treated water on regular basis. The performance of WASA-F in this regard is being improved on sustainable basis and day by day.

**Comments**
In the use of water resources, preference/priority seems to be given to the surface water sources, which are estimated to be gradually depleting. The sustainability of water supply sources especially that of surface water, is considered to be a real challenge. The Irrigation Department had not been able to supply water for drinking and even for irrigation purposes on sustainable basis. Whether any Risk Analysis has been undertaken in the M/P, to ensure sustainability?
**Answer**
Team leader of JICA study team responded that there was a scarcity of water resources in Pakistan including Punjab/Faisalabad as compared to the other countries like Thailand, Laos etc. where rivers are large and water is abundantly available. In Pakistan the availability of water on sustainable basis is a critical issue and poses big challenge. The Risk Analysis is a theoretical matter; however, the M/P underscores the need of backup support for the sustainable water supply from the surface water sources especially the canal water. Referring to planned water intake from canals, about 160MGD of treated water has been proposed to be taken from three branches of canals (Jhang BC, Rakh BC & Gugera BC), which amount to 5% of total canal water in 20 years. It was further brought out that an agreement with Irrigating Department was reached to supply 20 MGD waste water after treatment.

**Q.6**
Weather, WASA-F possesses, their own water distribution centers (WDC) if so, how many are owned by WASA in Faisalabad.

**Answer**
A water distribution center consists of Overhead Reservoir (OHR) + Ground Reservoir (GR). Currently Seven (7) WDCs are functioning at following sites in the Faisalabad city:

| | | |
|---|---|---|
| Abdullah pur | : | 1 |
| Medina Town | : | 2 |
| People's Colony | : | 3 |
| Head water works | : | 1 |
| Total | : | 7 |

A total 56 WDCs are planned to be established with each OHR is 25 m in height. Of these, 20 WDCs (OHR/GR) are proposed to set up on private land, while the rest would be constructed on public land. Explaining the water supply facilities, WASA-F apprised the participants, with the aim of producing portable water to each and every home situated within its operational area. WASA-F has been suffering from the budgetary constraints for implementing the water source development projects for drinking purpose. The network has been developed whose O& M cost is on high side but the revenue fell short of the cost because of low/poor recovery of outstanding dues. At present, the water requirement of Faisalabad City stands at 130 gallons per person per day and WASA-F has not been able to meet this demand. Nor is WASA-F now maintaining 24/7 water supply in the city. This can only be accomplished with the cooperation of water users who would be willingly paying water charges on regular basis.

**Q.7**
Is the saline/waste water acceptable after treatment for drinking?
**Answer**
It was explained that after proper treatment through water treatment plant as well as following RO method for eliminating Chemical/toxic elements, the water can be used for drinking, other household activities and irrigation purposes.

**Q.8**
Water contamination issue exists due to mixing of water supply and drainage/ sewerage pipe lines. The reason among others is that two pipelines are laid very close to each other and that too on one side of the streets. This issue needs to be resolved on priority basis.
**Answer**
It was responded that both water supply lines and sewerage pipes are very old and laid very close to each other. Due to lack of maintenance and wear & tear, the condition of pipe lines has deteriorated with the passage of time, consequently the contents of the pipes got intermingled with each other. WASA-F is striving hard to get rid of this problem and it is expected to resolve this issue in a period of six months.

**Comments/Question 9**
It appeared from the presentation that M/P has emphasized to follow projects with proper engineering design/techniques for the provision of clean water to the city. No mention regarding Water Quality Index seems to be made in the M/P. Water Quality Index, being an important issue especially in view of the fact that quality of water is changed on hourly basis, needs to be addressed in the M/P.
**Answer**
It was clarified that water Quality Index depends upon a number of items. WASA-F has already been affiliated with American Association regarding clean water supply system. In this regard WASA-F is following the parameters presented by the American Association and shares information with them. However, considering the importance attached to assessment of water quality, it was agreed to incorporate the Water Quality index in the final report of M/P.

**Q.10**
There are many industries situated in and around Faisalabad. How many industries have installed the treatment plants for processing the industrial effluent/waste water?
**Answer**
It was elaborated that the issue regarding availability of treatment plant and its operation in the industries has been studied in detail and included in the Interim Report of M/P. Majority of the industries (about 70%) have been shifted to Industrial Estate and few (i.e. 30%) are still working in and around city.
Most of the Industries have their own treatment plants, which are not operating most of the time. No proper monitoring system has been established so far to judge the performance of treatment plants owned by the industries.
It was informed that WASA-F (Government of Punjab) have signed an agreement with Government of Denmark to undertake a Feasibility study of processing / treatment of industrial waste water and its disposal through drainage. The study is estimated to cost Rs 15 billion, of which 35% would be provided as a grant and remaining 65% loan by the Danish Government.

**Comment**
In order to derive the desired benefits from the project for providing water supply, sewerage & drainage system in Faisalabad as identified in M/P, it is imperative to ensure implementation of projects & recommendations as planned both for long term and short-term solutions.
**Answer**
WASA-F Authorities ensured that with the support of government, other organizations, public representatives and academic institutions, every effort would be made to arrange and provide finances required for the implementation of projects recommended in the M/P.
Moreover, WASA-F invited the participants of workshop particularly the professionals from the Agricultural University, WWF, etc., to share information regarding studies (to be carried out or already completed). The case in point is the provision of comprehensive treatment plant for Kurianwala city, for which concept paper is required to be shared with the WASA-F for review/examination.
It was also revealed that the Geo-Tag study regarding sewerage system for Faisalabad has been prepared by the Agricultural University of Faisalabad. WASA-F while appreciating the technical input being made for the sewerage/drainage development in the city, requested the concerned organization to share a copy of this study with JICA study team as the very objective of this meeting is to share views and, disseminate knowledge for the improvement and development of water supply, sewerage in Faisalabad.
Regarding the participation of public Representation in the workshop, it was explained that Vice Chairman WASA-F is a public representative and attending the workshop. In this regard it was informed that design of Dhoriwala Nula has been remodeled to overcome the problem of choking of sewerage system in the area during monsoon. Similarly, the sewerage system of Khannawala which becomes choked during monsoon has been planned to be improved on priority basis to overcome the problem.

**FINDINGS OF SHM'S/ WORKSHOPS**

- The most important stakeholders are mainly governmental Departments, such as WASA-F, Irrigation Department, CDGF/District Offices, FDA, EPD, Concerned Provincial Departments/Punjab EPA etc. Many have been deeply involved in the planning process and contributed towards the formulation of M/P. The stakeholders include the sectors that would influence the implementation of M/P. For example, EPD/Punjab EPA would evaluate the environmental management of the projects although it did not participate in the planning process, and FDA would review the management of land use of the M/P project. In nutshell, it is preempted that all of these stakeholders would be able to greatly gain from the meetings/ workshop.
- Feedback received from the stakeholders/ participants would largely contribute towards the better improvement and development of M/P in the planning process/stage. The suggestions/proposals

made by the stakeholders especially professionals/ professors from WASA-F, Irrigation Department and Faisalabad Agricultural university would not only help formulating the practical approach for implementation of M/P recommendations but also provide short/medium term plans to meet the ever-growing water demand.

- In conclusion, the SHM/ workshop has provided good opportunity to integrate the opinions of the stakeholders into decision making.

Water Sources Development Plan, two alternative scenarios of water source development plan were examined: Scenario-1) development of well field and canals (JBC, RBC, GBC), and Scenario-2) development of well field, canal and Chenab River.

**ANNEX-1 List of Participants SHM-1**

**Stakeholder Meeting on Master Plan of WASA Faisalabad**
**JICA Master Plan Study Team**
**28 September 2017**
**Conference Room, WASA - F**

| Sr. No | Name | Designation & Department |
|---|---|---|
| 1 | Faqir Muhammad Ch. | MD - WASA |
| 2 | Khalid Javed | Municipal Officer (Infrastructures) |
| 3 | Dr. Haroon Rashid | Lecturer Dept of Struct & Env. Engg Uni of Agri. Fsd. |
| 4 | M. Naeem | MSE Specialist (The Urban Unit) |
| 5 | Gul Hafeez | SIDS The Urban Unit |
| 6 | Rana Kashif Ali | S.D.O Irrigation Dept |
| 7 | Asif Gillani | Environment Specialist (The Urban Unit, FSD) |
| 8 | Shaukat Hayat | DD EPA FSD |
| 9 | Waseem Ahmad Hashmi | DMD (S) WASA |
| 10 | Muhmmad Khalid | DMD € Wasa |
| 11 | Adnan Nisar | Director P&D Wasa |
| 12 | Shoaib Rashid | Director RMO 1 |
| 13 | Zahid Pervez | Director (Admin.) |
| 14 | Ejaz Latif | Dir (ODM) W |
| 15 | Ryunan Matsue | JICA Mission Team |
| 16 | Harutoshi UCHIDA | JICA Mission Team |
| 17 | Kiyoko Takamizawa | JICA Mission Team |
| 18 | Naoto Takatoi | JICA Mission Team |
| 19 | Kaora Suzuki | JICA Mission Team |
| 20 | Itsuro Matsubara | JICA Mission Team |
| 21 | Yasuhiro Matsuoka | JICA Mission Team |
| 22 | Akira Kohara | JICA Mission Team |
| 23 | Dr. Shahid Nasir | Finite Engineering |
| 24 | Hafiz M. Awais | Asst. Director |
| 25 | Roohan | DD (Tech)/ W. R |
| 26 | Asad Ali | Deputy Director (FFP) |
| 27 | Sultan Azam | JMT |
| 28 | Kamran Raza | (O&M) E |
| 29 | Syed Shujja Haider | Project Coordinator JMT |
| 30 | Shahid Iqbal | Finite Engineering |
| 31 | Irfan Mannan | V. Chairman WASA |
| 32 | Ishtiaq Ahmad Khan | IRC Specialist (The Urban Unit) |

**ANNEX-2 List of Participants WS/SHM-2**

**2nd Workshop/ Stakeholder Meeting on Master Plan of WASA**
**JICA Master Plan Study Team**
**12/20/2017**
**Conference Hall, Serena Hotel Faisalabad**

| Sr. No. | Name | Designation & Department |
|---|---|---|
| 1 | Muhammad Shabbir Afzal | Deputy Director Agriculture (Ext) Faisalabad |
| 2 | Prof Dr. M Arshad | Chairman Department of Irrigation & Drainage University of Agriculture FSD (UAF) |
| 3 | Dr. R Naiz Ahmed | Director, Water Management UAF |
| 4 | Dr. Lubna Anjum | Lecturer, Dept. of Irrigation & Drainage Agri. Engg. UAF |
| 5 | Engr. Wajeeha Qamer | Assistant Professor, Civil Engineering Dept. NFC IEFR FSD |
| 6 | Engr. Abubaker Ijaz | Duty Director (Tech), Energy Management Cell Water Resources, WASA FSD |
| 7 | Abul Ghaffar Naveed | Deputy Director, WASA, FSD |
| 8 | Aamer Aziz | Additional DG FDA |
| 9 | Dr. Muhammad Asif Shazad | District Health Officer, Preventive Services, FSD |
| 10 | Muhammad Saleem Bhathi | SE LCC East Irrigation, FSD |
| 11 | Dr. Shaid Nasir | Director Finite Engineering, (Pvt) ltd. |
| 12 | Ms Kiyoko Akamizawa | JICA M/P Mission Team |
| 13 | Shujjaa Haider | Project Coordinator, JICA Mission Team |
| 14 | Sultan Azam | JICA M/P Team |
| 15 | Ghulam Murtaze | SELCC West Irrigation, FSD |
| 16 | Syed Faisal Hassan | Engr. Operation & Maintenance SNGPL |
| 17 | Kamran Raza | WASA (O&M), FSD |
| 18 | M Farhan Akram | DD WASA, FSD |
| 19 | M Abdullah | Project Coordinator, WWF |
| 20 | Ali Shan Arif Makhdum | Environmental Officer, WWF |
| 21 | Mubasher Ahmad Cheema | Technical Skills Training Specialist (check department/ Address) |
| 22 | Zia Mustafa | Water Specialist, Aljagdi Academy, Urban Unit (Check Aljagdi) |
| 23 | Ejaz Latif | Director (O&M) WASA, FSD |
| 24 | Muhammad Ali | Deputy Director (Tech), P&D Department |
| 25 | G. Mustafa | Psychologist (Check designation & department) |
| 26 | Faqir Hussain Babar | Director, PHS, WASA FSD |
| 27 | Shahbaz latif | DDR (I&C), WASA FSD |
| 28 | Zahid Pervaiz | Director Rev (IDL), WASA FSD |
| 29 | Burira Anam (check name) | AD (GIS), WASA, FSD |
| 30 | Samreen Ashraf | AD (GIS), WASA, FSD |
| 31 | Farhat Adibbia (check name) | SRO, WASA, FSD |
| 32 | Shahida Rehman | AD, WASA, FSD |
| 33 | Muhammad Shaukat Ali | Ex DMD, WASA, FSD |
| 34 | Shoaib Rashid | Director Rev (Domestic), WASA FSD |

| Sr. No. | Name | Designation & Department |
|---|---|---|
| 35 | Haroon Rasheed | Director Admin, WASA FSD |
| 36 | Muhammad Khalid | DMD, WASA, FSD |
| 37 | Waseem Ahmed Hashmi | DMD.D.(S) WASA, FSD |
| 38 | Adnan Nisar Khan | Director, WASA, FSD |
| 39 | Rana Asif Muhmood | Chief Engineer, Irrigation Dept. FSD ZONE |
| 40 | Faqir Muhammad CH | MD-WASA, FSD |
| 41 | Irfan Mannan | Vice Chairman - WASA, FSD |
| 42 | Hoshino Takashi | Team Leader, JICA Mission Team |
| 43 | M.Riaz Kamoka | U-C Chairman |
| 44 | Gul Hafeez | SIDS - Urban Unit |
| 45 | Hafiz M.Awais Jamal | Asst. Director (Project), WASA, FSD |
| 46 | Saqib Raza | WASA, FSD |
| 47 | Usman Latif | WASA, FSD |
| 48 | M.Maqsood Ahmed | WASA, FSD |
| 49 | Atiq-ur-Rehman | WASA, FSD |
| 50 | Abdul Raouf Butt | WASA, FSD |
| 51 | Muhammad Ashraf | Resident Engineer |
| 52 | Muhammad Nouman Noor | Assistant Director (Tech), water Resources Directorate, WASA FSD |
| 53 | M.Farhan ali | Deputy Director, I.T, WASA, FSD |
| 54 | M.Fasial Mirza | Research Associate |
| 55 | Azhar Azeez | PRO, WASA, FSD |
| 56 | Laiba Tanveer | Survey-Assistant, JICA Mission team |
| 57 | Asad Ali | Deputy director, (FFP), WASA Faisalabad |
| 58 | Ghulam Shabbir | Deputy Director (P&D) |
| 59 | Umar Iftikhar Khan | DD (Admin) WASA, FSD |
| 60 | Shahid Iqbal | Consultant, Finite Engg. (pvt.) Ltd, Islamabad |