

APPENDIX 4

Calculation of friction losses **and local losses in pumping** **mains**

Pressure Pipe DN 350- Rising Main from Simunye to Nduma Booster Station

Pumping Main runs from a the pump station at the Treatment Plant to Nduma Booster Station

Inlet Level at Reservoir 310.000 [m.a.s.l.]

Energy level at sump 196.000 [m.a.s.l.]

Discharge Rate Q 69.00 [l/s]
Pipe Diameter d 0.3400 [m]

Flow area A 0.091 [m²]
Flow velocity v 0.760 [m/s]

Lenght of pipe L 20500.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
cinematic viscosity ν 1.3E-6 [m²/s]

Reynolds number 198864 [-]

Coefficient of resistance λ 0.019936 [-]

hydraulic gradient I_v 1.7278 [‰]
Friction loss 35.4201 [m]

local head losses

	number	coefficient ζ	sum
inlet	4	0.50	2.00
bend 90°	6	0.15	0.90
bend 45°	12	0.10	1.20
valve	2	0.30	0.60
exit	1	1.00	1.00
Sum ζ			5.70

local head losses

$\zeta_{tot} * v^2 / 2g$ 0.1680 [m]

friction head losses

$\lambda * L/d * v^2 / 2g$ 35.4201 [m]

total head loss

35.5881 [m]

Static Head Difference

114.000 [m]

Head loss

35.588 [m]

Manometric Head

149.588 [m]

Efficiency of the Pump η

=

0.6

Power demand P

=

$\rho * g * H_{man} * Q / \eta$

168.76 [kW]

Pressure Pipe DN 200- Rising Main from Ka-Shewula Booster Station to Ka-Shewula Reservoir

Pumping Main runs from Ka-Shewula booster station to Ka-Shewula Reservoir

Inlet Level at Reservoir 526.000 [m.a.s.l.]

Energy level at sump 455.000 [m.a.s.l.]

Discharge Rate Q 20.70 [l/s]
Pipe Diameter d 0.2000 [m]

Flow area A 0.031 [m²]
Flow velocity v 0.659 [m/s]

Length of pipe L 7700.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
cinematic viscosity ν 1.3E-6 [m²/s]

Reynolds number 101421 [-]

Coefficient of resistance λ 0.022946 [-]

hydraulic gradient I_v 2.5413 [‰]
Friction loss 19.5683 [m]

local head losses

	number	coefficient ζ	sum
inlet	1	0.50	0.50
bend 90°	3	0.15	0.45
bend 45°	7	0.10	0.70
valve	2	0.30	0.60
exit	1	1.00	1.00
Sum ζ			3.25

local head losses $\zeta_{tot} * v^2 / 2g$ 0.0720 [m]
friction head losses $\lambda * L / d * v^2 / 2g$ 19.5683 [m]
total head loss 19.6403 [m]

Static Head Difference 71.000 [m]
Head loss 19.640 [m]

Manometric Head 90.640 [m]

Efficiency of the Pump η = 0.6
Power demand $P = \rho * g * H_{man} * Q / \eta$ 30.68 [kW]

Pressure Pipe DN 250- Rising Main from Treatment Plant to Lomahasha Booster

Pumping Main runs from a the pump station at the Treatment Plant to Lomahasha Booster Station

Inlet Level at Reservoir 526.000 [m.a.s.l.]

Energy level at sump 455.000 [m.a.s.l.]

Discharge Rate Q 28.50 [l/s]
Pipe Diameter d 0.2500 [m]

Flow area A 0.049 [m²]
Flow velocity v 0.581 [m/s]

Lenght of pipe L 7700.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
cinematic viscosity ν 1.3E-6 [m²/s]

Reynolds number 111710 [-]

Coefficient of resistance λ 0.021942 [-]

hydraulic gradient I_v 1.5095 [‰]
Friction loss 11.6228 [m]

local head losses

	number	coefficient ζ	sum
inlet	1	0.50	0.50
bend 90°	3	0.15	0.45
bend 45°	8	0.10	0.80
valve	3	0.30	0.90
exit	1	1.00	1.00
Sum ζ			3.65

local head losses

$\zeta_{\text{tot}} * v^2 / 2g$ 0.0628 [m]

friction head losses

$\lambda * L / d * v^2 / 2g$ 11.6228 [m]

total head loss

11.6856 [m]

Static Head Difference

71.000 [m]

Head loss

11.686 [m]

Manometric Head

82.686 [m]

Efficiency of the Pump η

=

0.6

Power demand P

=

$\rho * g * H_{\text{man}} * Q / \eta$

38.53 [kW]

Pressure Pipe DN 315- Rising Main from Mbuluzi River to Nduma Booster Station

Pumping Main runs from a the pump station at the Treatment Plant to Nduma Booster Station

Inlet Level at Reservoir 310.000 [m.a.s.l.]

Energy level at sump 145.000 [m.a.s.l.]

Discharge Rate Q 69.00 [l/s]
Pipe Diameter d 0.3050 [m]

Flow area A 0.073 [m²]
 Flow velocity v 0.945 [m/s]

Lenght of pipe L 5500.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
 cinematic viscosity ν 1.3E-6 [m²/s]

Reynolds number 221685 [-]

Coefficient of resistance λ 0.019936 [-]

hydraulic gradient I_v 1.7278 [‰]
 Friction loss 9.5030 [m]

local head losses

	number	coefficient ζ	sum
inlet	1	0.50	0.50
bend 90°	2	0.15	0.30
bend 45°	4	0.10	0.40
valve	2	0.30	0.60
exit	1	1.00	1.00
Sum ζ			2.80

local head losses

$\zeta_{tot} * v^2 / 2g$ 0.1274 [m]

friction head losses

$\lambda * L / d * v^2 / 2g$ 9.5030 [m]

total head loss

9.5855 [m]

Static Head Difference

165.000 [m]

Head loss

9.585 [m]

Manometric Head

174.585 [m]

Efficiency of the Pump η

η

=

0.6

Power demand

P

=

$\rho * g * H_{man} * Q / \eta$

196.96 [kW]

Pressure Pipe DN 315- Rising Main from Nduma Booster Station to Lomahasha Booster

Pumping Main runs from Nduma Booster Station to Lomahasha booster station

Inlet Level at Reservoir 455.000 [m.a.s.l.]

Energy level at sump 310.000 [m.a.s.l.]

Discharge Rate Q 40.50 [l/s]
Pipe Diameter d 0.3000 [m]

Flow area A 0.071 [m²]
 Flow velocity v 0.573 [m/s]

Length of pipe L 5800.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
 cinematic viscosity ν 1.3E-6 [m²/s]
 Reynolds number 132288 [-]
 Coefficient of resistance λ 0.021340 [-]
 hydraulic gradient I_v 2.9645 [‰]
 Friction loss 17.1944 [m]

local head losses

	number	coefficient ζ	sum
inlet	1	0.50	0.50
bend 90°	2	0.15	0.30
bend 45°	7	0.10	0.70
valve	2	0.30	0.60
exit	1	1.00	1.00
Sum ζ			3.10

local head losses $\zeta_{tot} * v^2 / 2g$ 0.0519 [m]
 friction head losses $\lambda * L / d * v^2 / 2g$ 17.1944 [m]
 total head loss 17.3020 [m]

Static Head Difference 145.000 [m]
 Head loss 17.302 [m]

Manometric Head 162.302 [m]

Efficiency of the Pump η = 0.6
Power demand $P = \rho * g * H_{man} * Q / \eta$ 107.47 [kW]

Pressure Pipe DN 250- Rising Main from Lomahasha Booster Station to Lomahasha Reservoir

Pumping Main runs from the Treatment Plant to Lomahasha Booster Station at Mbokojwane

Inlet Level at Reservoir 630.000 [m.a.s.l.]

Energy level at sump 455.000 [m.a.s.l.]

Discharge Rate Q 40.50 [l/s]
Pipe Diameter d 0.2500 [m]

Flow area A 0.049 [m²]
Flow velocity v 0.825 [m/s]

Length of pipe L 2500.00 [m]

Friction losses

operational roughness k_b 0.25 [mm]
cinematic viscosity ν 1.3E-6 [m²/s]

Reynolds number 158746 [-]

Coefficient of resistance λ 0.021340 [-]

hydraulic gradient I_v 2.9645 [‰]
Friction loss 7.4114 [m]

local head losses

	number	coefficient ζ	sum
inlet	1	0.50	0.50
bend 90°	2	0.15	0.30
bend 45°	6	0.10	0.60
valve	2	0.30	0.60
exit	1	1.00	1.00
Sum ζ			3.00

local head losses

$\zeta_{\text{tot}} * v^2 / 2g$ 0.1042 [m]

friction head losses

$\lambda * L/d * v^2 / 2g$ 7.4114 [m]

total head loss

7.5156 [m]

Static Head Difference

175.000 [m]

Head loss

7.516 [m]

Manometric Head

182.516 [m]

Efficiency of the Pump

η

=

0.6

Power demand

P

=

$\rho * g * H_{\text{man}} * Q / \eta$

120.86 [kW]