(4) Calculation Sheets of Facility Design

1. Hydraulic calculation of pipeline

1.1. Hydraulic calculation of transmission pipeline

(1) NGWAZINI COMMUNITY

Flow required··· Design flow

Daily average	Qave.	= 152.0	m^3/day
Daily maximum	Qmax.	= 197.6	m^3/day
Hourly maximum	Qhr-max.	= 14.8	m^3/hour
Yield water capacity of borehole	Qmax.	= 197.6	m^3/day
		2.29	ℓ/sec.
Supply water capacity	Qhr-max.	= 14.8	m^3/hour
		= 247.0	ℓ/min.

① From the intake well to the distribution reservoir

Head loss of transmission pipeline

A) Head loss of straight pipeline $\Delta H = f1 \times L/D \times V^2/2g$

ΔH ;Head loss in the pipeline

f1 = 0.02+0.0005/D ;The head loss coefficient

L ;Length of the pipeline (m)

D ;Diameter of pipe (m)

V ;Flow velocity (m/s)

$= Q/(60 \times 3.14/4 \times D^2)$

Pipe dia.	25	32	40	50	65	80	100	125	150
f1	0.040	0.036	0.033	0.030	0.028	0.026	0.025	0.024	0.023

Pipe dia. $D = 146\sqrt{Q/V}$

Q					V = 1.0 m/s
Qave.	152.0	m^3/d =	0.106	m^3/min.	
Qmax.	197.6	m^3/d	0.137	m^3/min.	
Qhr-max.	14.8	m^3/hr=	0.247	m^3/min.	

Well pump specification

Qmax. 197.6m^3/d÷20hr = 9.88m^3/hr = 0.165m^3/min ——→ 0.165m^3/min

$D = 146\sqrt{0.165/1.0}$ = 59.3mm 65mm < over

Flow velocity

(D=100mm) (D=80mm) (D=65mm) (D=50mm)

$V(d.max.) = 0.165/(60\times3.14/4\times D^2) = 0.350\ m/s = 0.548\ m/s = 0.829\ m/s = 1.398\ m/s$

$\Delta H1(100)(d.max) = 0.025\times790/0.1 \times(0.350)^2/19.6 = 1.234$ m
$(80)(d.max) = 0.026\times790/0.08 \times(0.548)^2/19.6 = 3.934$ m
$(65)(d.max) = 0.028\times790/0.065\times(0.829)^2/19.6 = 11.932$ m
$(50)(d.max) = 0.030\times45/0.05 \times(1.398)^2/19.6 = 2.692$ m(Well Pump)

B) Head loss of elbow pipe

$\Delta H2 = f\times V^2/2g\times Q'ty$ f = 0.2 100mm Q'ty=7pcs 50 mm Q'ty 1 pc.
$\Delta H2(100)(d.max.) = 0.2\times(0.350)^2/19.6\times7 = 0.009$ m
$(80)(d.max.) = 0.2\times(0.548)^2/19.6\times7 = 0.021$ m
$(65)(d.max.) = 0.2\times(0.829)^2/19.6\times7 = 0.049$ m
$(50)(d.max.) = 0.2\times(1.398)^2/19.6\times1 = 0.020$ m

C) Head loss of gate valve

$\Delta H3 = f\times V^2/2g\times Q'ty$ 100mm Q'ty=1pc 50 mm Q'ty 1 pc.

Pipe dia. (mm)	50	65	80	100	125	150
f	0.175	0.172	0.168	0.164	0.150	0.145

$\Delta H3(100)(d.max.) = 0.164\times(0.350)^2/19.6\times1 = 0.001$ m
$(80)(d.max.) = 0.168\times(0.548)^2/19.6\times1 = 0.003$ m
$(65)(d.max.) = 0.172\times(0.829)^2/19.6\times1 = 0.006$ m
$(50)(d.max.) = 0.175\times(1.398)^2/19.6\times1 = 0.017$ m

D) Head loss of check valve

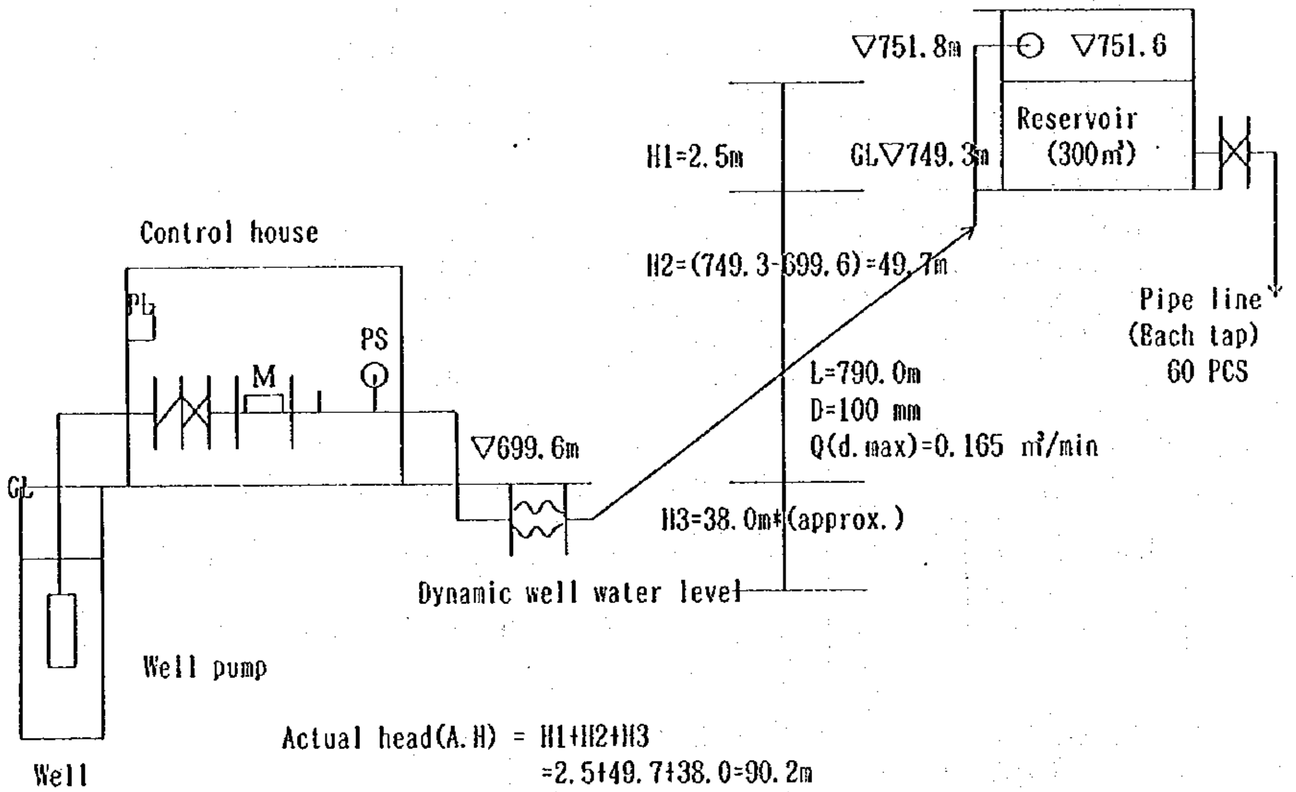
$\Delta H4 = f\times V^2/2g\times Q'ty$ $f = 0.8 \sim 1.2$ 50 mm Q'ty = 1 pc.
$\Delta H4(50)(h.max.) = 1.2\times(1.398)^2/19.6 \times1 = 0.120$ m

Pipeline dia.			100 mm	80 mm	65 mm	50 mm
Head loss of straight pipe Head loss of elbow Head loss of gate valve Head loss of check valve	790 m 7 pcs 1 pc. 1 pc.	ΔH1 ΔH2 ΔH3 ΔH4	1.234 m 0.009 m 0.001 m -	3.934 m 0.021 m 0.003 m -	11.932 m 0.049 m 0.006 m -	2.692 m 0.020 m 0.017 m 0.120 m
Total head loss Actual head		ΔH A.H	1.244 m 90.2 m	3.958 m 90.2 m	11.987 m 90.2 m	2.849 m
Total head (AH+H+H50mm)		T.H	94.293 m	97.007 m	105.036 m	

(Result) ··· Best pipe dia. ——→ 100 mm
Required head of well pump ——→ 100 m
Discharge pipe dia. of well pump ——→ 50 mm

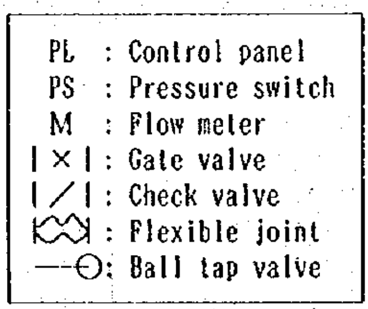
Hydraulic calculation chart of transmission pipeline

(1) NGWAZINI COMMUNITY



Actual head(A.H) = H1+H2+H3
=2.5+49.7+38.0=90.2m

LEGENT



(2) BEKHINKOSI COMMUNITY .

Flow required··· Design flow

Daily average	Qave.	= 83.8	m^3/day
Daily maximum	Qmax.	= 108.9	m^3/day
Hourly maximum	Qhr-max.	= 8.2	m^3/hour
Yield water capacity of borehole	Qmax.	= 108.9	m^3/day
		1.3	ℓ/sec.
Supply water capacity	Qhr-max.	= 8.2	m^3/hour
		= 136.7	ℓ/min.

① From the intake well to the distribution reservoir

Head loss of transmission pipeline

A) Head loss of straight pipeline $\Delta H = f1 \times L/D \times V^2/2g$

ΔH ;Head loss in the pipeline

f1 = 0.02+0.0005/D ;The head loss coefficient

L ;Length of the pipeline (m)

D ;Diameter of pipe (m)

V ;Flow velocity (m/s)

$=Q/(60 \times 3.14/4 \times D^2)$

Pipe dia	25	32	40	50	65	80	100	125	150
f1	0.040	0.036	0.033	0.030	0.028	0.026	0.025	0.024	0.023

Pipe dia. $D = 146\sqrt{Q/V}$

Q V = 1.0 m/s

Qave. 83.8 m^3/d = 0.058 m^3/min.

Qmax. 108.9 m^3/d = 0.076 m^3/min.

Qhr-max 8.2 m^3/hr= 0.1367 m^3/min.

Well pump specification (Spare pump = NGWAZINI well pump)

Qmax. = 108.9 ÷20 hr = 5.445m^3/min = 0.091m^3/min ——→ 0.165m^3/min

$D = 146\sqrt{0.165/1.0} = 59.3$ mm ——→ 65 mm<

Flow velocity = m/s

(100mm) (80mm) (65mm) (50mm)

$V(d.max.) = 0.165/(60 \times 3.14/4 \times D^2)$ = 0.350 0.548 0.829 1.398

L = 1.140 m Well pump discharge pipe lenglgh L =35.0 m

$\Delta H1(100)(d.max) = 0.025 \times 1.140/0.1 \times (0.350)^2/19.6 = 1.781$ m

$(80)(d.max) = 0.026 \times 1.140/0.08 \times (0.548)^2/19.6 = 5.677$ m

$(65)(d.max) = 0.028 \times 1.140/0.065 \times (0.829)^2/19.6 = 17.219$ m

$(50)(d.max) = 0.030 \times 35/0.05 \times (1.398)^2/19.6 = 2.094$ m

B) Head loss of elbow pipe

$\Delta H2 = f \times V^2/2g \times Q'ty$ f = 0.2 100mm Q'ty=7pcs 50mm Q'ty 1 pc.

$\Delta H2(100)(d.max.) = 0.2 \times (0.350)^2/19.6 \times 7 = 0.009$ m

$(80)(d.max.) = 0.2 \times (0.548)^2/19.6 \times 7 = 0.021$ m

$(65)(d.max.) = 0.2 \times (0.829)^2/19.6 \times 7 = 0.049$ m

$(50)(d.max.) = 0.2 \times (1.398)^2/19.6 \times 1 = 0.020$ m

C) Head loss of gate valve

$\Delta H3 = f \times V^2/2g \times Q'ty$ 125mm or 100mm or 80 mm Q'ty 1 pc. 50mm Q'ty 1 pc.

$\Delta H3(100)(d.max.) = 0.164 \times (0.350)^2/19.6 \times 1 = 0.001$ m

$(80)(d.max.) = 0.168 \times (0.548)^2/19.6 \times 1 = 0.003$ m

$(65)(d.max.) = 0.172 \times (0.829)^2/19.6 \times 1 = 0.006$ m

$(50)(d.max.) = 0.175 \times (1.398)^2/19.6 \times 1 = 0.017$ m

D) Head loss of check valve

$\Delta H4 = f \times V^2/2g \times Q'ty$ $f = 0.8 \sim 1.2$ 50mm Q'ty 1 pc.

$\Delta H4(50)(d.max.) = 1.2 \times (1.398)^2/19.6 \times 1 = 0.120$ m

Pipe dia.			100 mm	80 mm	65 mm	50 mm
Head loss of straight pipe	1.140 m	ΔH1	1.781 m	5.677 m	17.219 m	2.094 m
Head loss of elbow	7 pcs	ΔH2	0.009 m	0.021 m	0.049 m	0.020 m
Head loss of gate valve	1 pc.	ΔH3	0.001 m	0.003 m	0.006 m	0.017 m
Head loss of check valve	1 pc.	ΔH4	-	-	-	0.120 m
Total head loss		ΔH	1.791 m	5.701 m	17.274 m	2.251 m
Actual head		A.H	52.5 m	52.5 m	52.5 m	
Total head (AH+H+H50mm)			56.542 m	60.452 m	72.025 m	

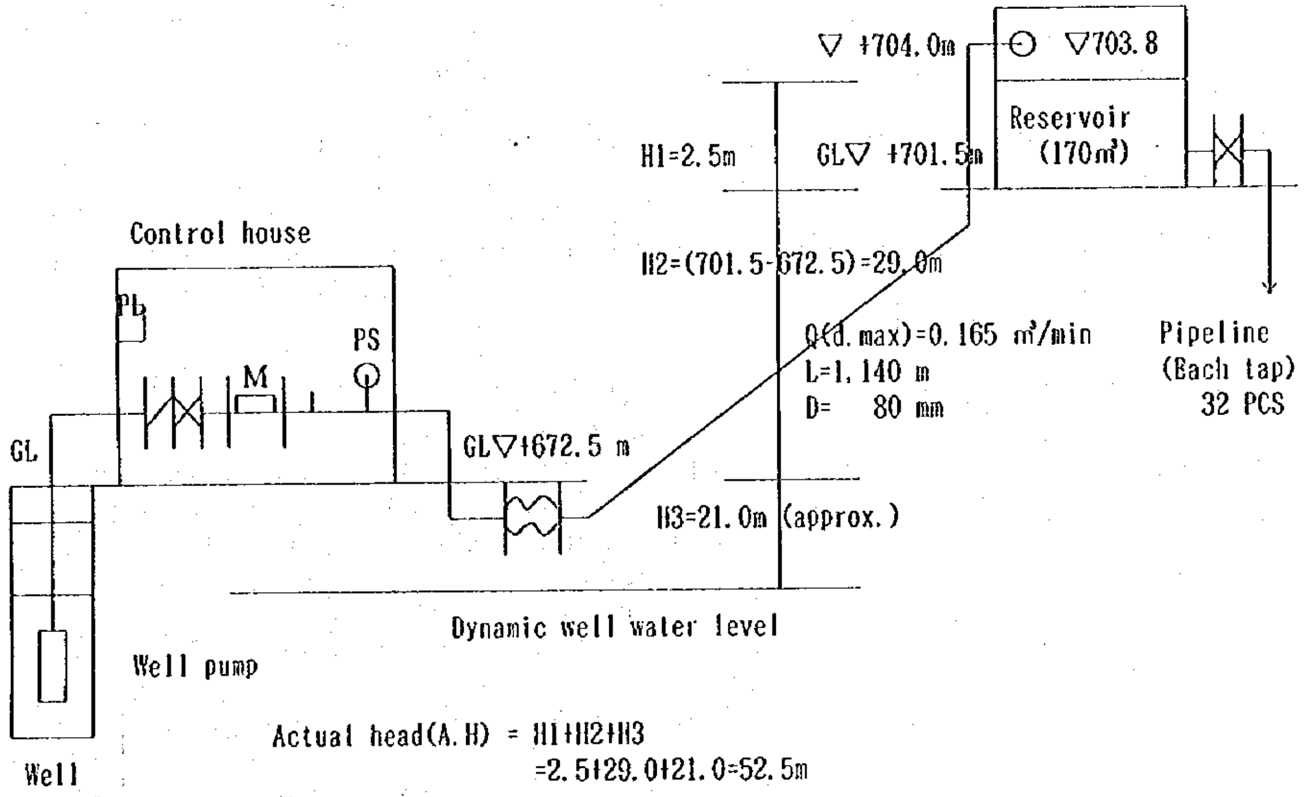
(Result) ··· Best pipe dia. ⟶ 80 mm

Required head of well pump ⟶ 100 m

Discharge pipe dia. of well pump ⟶ 50 mm

Hydraulic calculation chart of transmission pipeline

(2) BEKHINKOSI COMMUNITY



Actual head(A.H) = H1+H2+H3
=2.5+29.0+21.0=52.5m

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PL	: Control panel
PS	: Pressure switch
M	: Flow meter
|×|	: Gate valve
|/|	: Check valve
(symbol)	: Flexible joint
—⊖	: Ball tap valve

(3) MSUMPB COMMUNITY

Flow required··· Design Flow

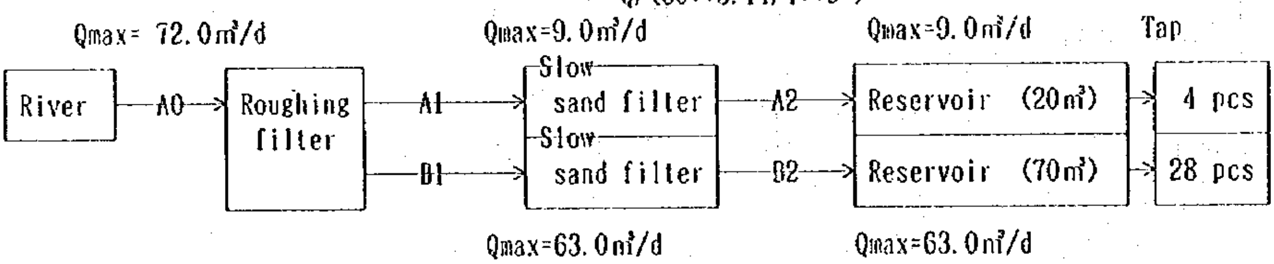
Daily average	Qave.	=	55.4	m^3/day
Daily maximum	Qmax.	=	72.0	m^3/day
Hourly maximum	Qhr-max.	=	5.4	m^3/hour
Yield water capacity of borehole	Qmax.	=	72.0	m^3/day
			0.83	ℓ/sec.
Supply water capacity	Qhr-max.	=	5.4	m^3/hour
		=	90.0	ℓ/min.

① From the intake wair to the distribution reservoirs ··· A line(20m^3 Res)
··· B line(70m^3 Res)

Head loss of pipeline

A)Head loss of straight pipe $\Delta H = f1 \times L/D \times V^2/2g$

ΔH ;Head loss of pipeline
f1 ;0.02+0.0005/D ;The head loss coefficient
L ;Length of the pipeline (m)
D ;Diameter of pipe (m)
V ;Velocity (m/s)
= $Q/(60 \times 3.14/4 \times D^2)$



Flow = Tap ratio
A line flow (Qd.max) = 72.0m^3/d× 4/32 = 9.0m^3/d
B line flow (Qd.max) = 72.0m^3/d×28/32 = 63.0m^3/d

A0 pipe dia. $D = 146\sqrt{Q/V}$ Q(d.max.) = 71.9m^3/d = 0.050m^3/min V = 0.6 m/s
$146\sqrt{(0.050)/(0.6)}$ = 42.2 mm ⟶ 65 mm

Flow velocity
V(d-max.) = $0.050/(60 \times 3.14/4 \times D^2)$ = 0.251 m/s

					9/PVC ID	OD
Pipe diameter	$D = 146\sqrt{Q/V}$					
A0 Line	$D = 146\sqrt{(0.050)/(0.6)}$	= 42.2 mm	9PVC		68.4mm	75mm
A1 Line	$D = 146\sqrt{(0.0063)/(0.6)}$	= 14.9 mm	9PVC		45.6mm	50mm
A2 Line	$D = 146\sqrt{(0.0063)/(0.6)}$	= 14.9 mm	9PVC		45.6mm	50mm
B1 Line	$D = 146\sqrt{(0.0438)/(0.6)}$	= 39.4 mm	12PVC		50.0mm	60.5mm
B2 Line	$D = 146\sqrt{(0.0438)/(0.6)}$	= 39.4 mm	9PVC		45.6mm	50mm

Flow velocity $V = Q(d.max)/(60\times3.14/4\times D^2)$

A0 Line (65mm) $V = (0.050\ )/(60\times3.14/4\times D^2) = (0.050\ )/(0.199) = 0.251$ m/s

A1 Line (50mm) $V = (0.0063)/(60\times3.14/4\times D^2) = (0.0063)/(0.118) = 0.053$ m/s

A2 Line (50mm) $V = (0.0063)/(60\times3.14/4\times D^2) = (0.0063)/(0.118) = 0.053$ m/s

B1 Line (50mm) $V = (0.0436)/(60\times3.14/4\times D^2) = (0.0438)/(0.118) = 0.371$ m/s

B2 Line (50mm) $V = (0.0436)/(60\times3.14/4\times D^2) = (0.0438)/(0.118) = 0.371$ m/s

Head loss of pipeline $\Delta H1 = f1\times L/D\times V^2/2g$

A0 Line $f1 = 0.028$ L= 10m

$\Delta H1 = 0.028\times\ 10/0.065\times(0.252)^2/19.6 = 0.014$ m

A1 Line $f1 = 0.030$ L=140m

$\Delta H1 = 0.030\times\ 140/0.05\ \times(0.053)^2/19.6 = 0.012$ m

A2 Line $f1 = 0.030$ L=800m

$\Delta H1 = 0.030\times\ 800/0.05\ \times(0.053)^2/19.6 = 0.069$ m

B1 Line $f1 = 0.030$ L=10,135m

$\Delta H1 = 0.030\times10,135/0.05\ \times(0.371)^2/19.6 = 42.704$ m

B2 Line $f1 = 0.030$ L=265m

$\Delta H1 = 0.030\times\ 265/0.05\ \times(0.371)^2/19.6 = 1.117$ m

Head loss of Elbow $\Delta H2 = f1\times V^2/2g\times Q'ty$ $f = 0.2$

A0 Line $\Delta H2 = 0.2\times(0.251)^2/19.6\times1 = 0.001$ m

A1 Line $\Delta H2 = 0.2\times(0.053)^2/19.6\times2 = 0.001$ m

A2 Line $\Delta H2 = 0.2\times(0.053)^2/19.6\times8 = 0.001$ m

B1 Line $\Delta H2 = 0.2\times(0.371)^2/19.6\times2 = 0.003$ m

B2 Line $\Delta H2 = 0.2\times(0.371)^2/19.6\times8 = 0.011$ m

Head loss of gate valve $\Delta H3 = f \times V^2/2g \times Q'ty$

A0 Line(65mm)	$\Delta H3 = 0.172 \times (0.251)^2/19.6 \times 1$	= 0.001 m
A1 Line(50mm)	$\Delta H3 = 0.175 \times (0.053)^2/19.6 \times 2$	= 0.001 m
A2 Line(50mm)	$\Delta H3 = 0.175 \times (0.053)^2/19.6 \times 2$	= 0.001 m
B1 Line(50mm)	$\Delta H3 = 0.175 \times (0.371)^2/19.6 \times 2$	= 0.002 m
B2 Line(50mm)	$\Delta H3 = 0.175 \times (0.371)^2/19.6 \times 2$	= 0.002 m

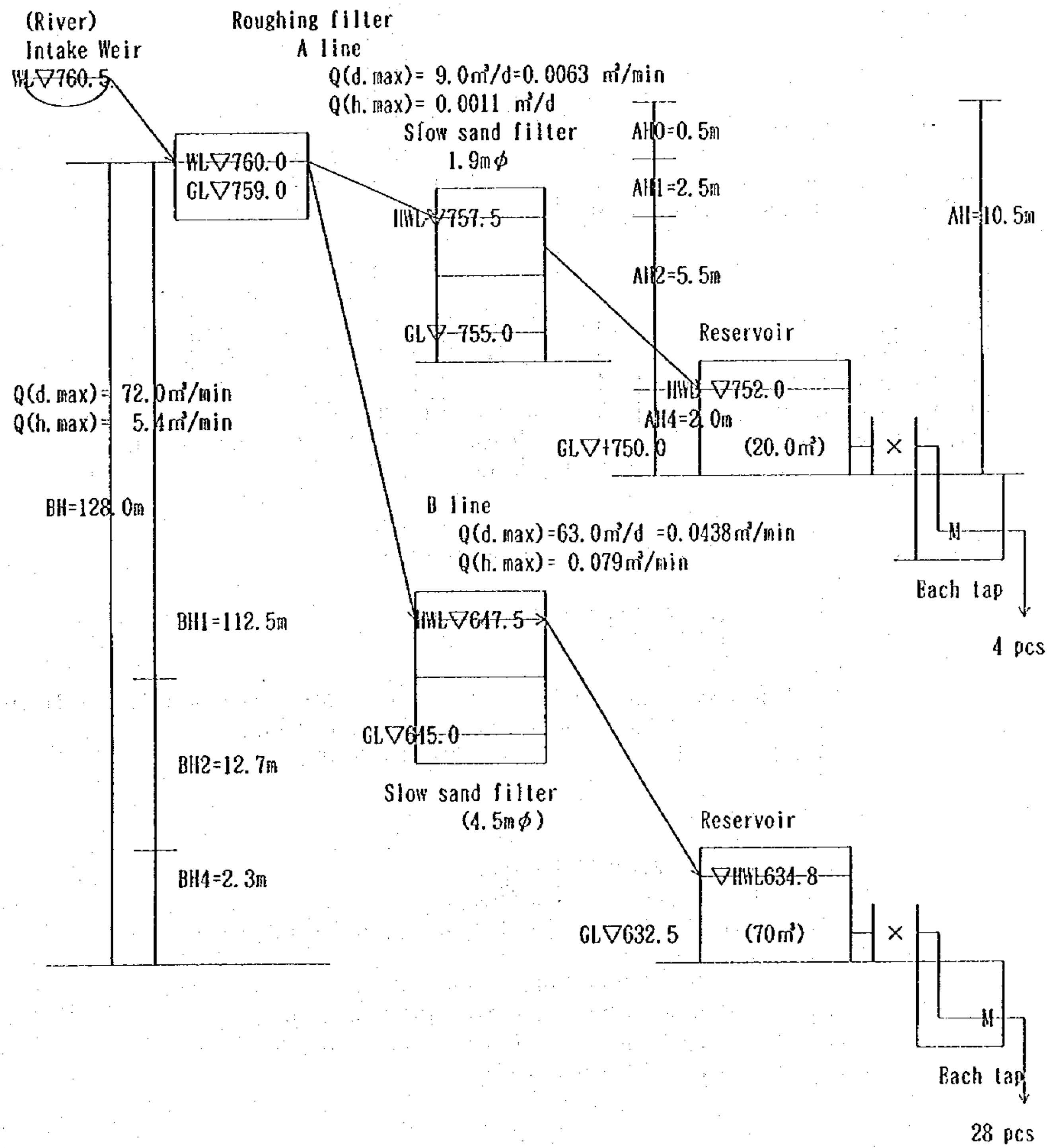
MSUMPE COMMUNITY Calculation of aqueduct pipeline & transmission pipeline

		A pipeline			B pipeline	
Line		A0	A1	A2	B1	B2
Pipe length	(m)	10 m	140 m	800 m	10,135 m	265 m
Flow Q(h.max.)	(m^3/min)	0.050	0.0063	0.0063	0.0438	0.0438
Pipe dia.(ID)	(m)	0.065	0.05	0.05	0.05	0.05
Velocity	(m/s)	0.251	0.053	0.053	0.371	0.371
Elbow	pc.	1	2	8	2	8
Gate valve	pc.	1	2	2	2	2
Head loss of pipe	ΔH1(m)	0.014	0.012	0.069	42.704	1.117
Head loss of elbow	ΔH2(m)	0.001	0.001	0.001	0.003	0.011
Head loss of gate V	ΔH3(m)	0.001	0.001	0.001	0.002	0.002
Total head loss	ΔH (m)	0.016	0.014	0.071	42.709	1.130
Actual head	A.H (m)	0.5	2.5	5.5	112.5	12.7
Result		OK	OK	OK	OK	OK

A0-Line ··· 75/ 9PVC(I.D 65mm)
A1-Line ··· 63/ 9PVC(I.D 50mm)
A2-Line ··· 63/ 9PVC(I.D 50mm)
B1-Line ··· 63/12PVC(I.D 50mm)
B2-Line ··· 63/ 9PVC(I.D 50mm)

Hydraulic calculation chart of aqueduct pipeline & transmission pipeline

(3) MSUMPE COMMUNITY … Gravity flow



(4) SOMNTONGO COMMUNITY

Flow required··· Design flow

Daily average	Qave.	= 174.3 m³/day
Daily maximum	Qmax.	= 226.5 m³/day
Hourly maximum	Qhr-max.	= 17.0 m³/hour
Yield water capacity of borehole	Qmax.	= 226.5 m³/day
		2.6 ℓ/sec.
Supply water capacity	Qhr-max.	= 17.0 m³/hour
		= 283.4 ℓ/min.

Water to be transmitted to two separate distribution reservoirs
(Tap ratio = 10 Taps ; 30 taps) Total=40 taps

	A line	B line	Total
Daily average(Qd.ave.)	43.6 m³/day	130.7 m³/day	174.3 m³/day
Daily maximum(Qd.max.)	56.6 m³/day	169.9 m³/day	226.5 m³/day
Hourly maximum(Qh-max.)	4.25 m³/hour	12.75 m³/hour	17.0 m³/hour
Transmission pump(Qd.max.)	56.6 m³/day	169.9 m³/day	226.5 m³/day
Supply water capacity(Qh-max.)	4.25 m³/hour = 0.071 m³/min.	12.75 m³/hour = 0.213 m³/min.	17.0 m³/hour = 0.284 m³/min.

① From the intake well to the distribution reservoir

[A-line] Head loss of transmission pipeline

A) Head loss of straight pipeline

$\Delta H = f1 \times L/D \times V^2/2g$

ΔH ;Head loss in the pipeline f1 = 0.02+0.0005/D ;The head loss coefficient

L ;Length of the pipeline (m) D ;Diameter of pipe (m)

V ;Flow velocity (m/s) = $Q/(60 \times 3.14/4 \times D^2)$

Pipe dia. $D = 146\sqrt{Q/V}$

Q V = 1.0 m/s

Qmax. 226.5 m³/d = 0.1573 m³/min.

Qhr-max. 17.0 m³/hr= 0.2834 m³/min.

Well pump spec. Qmax. = 226.5 m³/d÷20hr/d = 11.33m³/h = 0.189m³/min.

Pipe dia of A and B line

A-line 0.189m³/min.×10tap/40tap = 0.0473m³/min.

B-line 0.189m³/min.×30tap/40tap = 0.1418m³/min.

A-line $D = 146\sqrt{0.0473/1.0}$ = 31.7mm 50mm <

B-line $D = 146\sqrt{0.1418/1.0}$ = 55.0mm 80mm <

Flow velocity(m/s) = A-line = B-line ··· = Flow velocity A-line and B-line spare pump of A-line can be used for B-line

150mm 125mm 100mm 80mm

$V = (0.1418\ m^3/min)/(60\times 3.14/4\times D^2) = (0.134)(0.193)(0.301)(0.471)$

A) A-line head loss of straight pipe L = 3,200m

$\Delta H1(150)(d.max.) = 0.023\times 3,200/0.15\times (0.134)^2/19.6 = 0.450$ m

$(125)(d.max.) = 0.024\times 3,200/0.125\times (0.191)^2/19.6 = 1.168$ m

$(100)(d.max.) = 0.025\times 3,200/0.1\times (0.299)^2/19.6 = 3.698$ m

$(80)(d.max.) = 0.026\times 3,200/0.08\times (0.468)^2/19.6 = 11.771$ m

B-line head loss of straight pipe L = 4,270m

$\Delta H1(150)(d.max.) = 0.023\times 4,270/0.15\times (0.133)^2/19.6 = 0.600$ m

$(125)(d.max.) = 0.024\times 4,270/0.125\times (0.191)^2/19.6 = 1.558$ m

$(100)(d.max.) = 0.025\times 4,270/0.1\times (0.299)^2/19.6 = 4.935$ m

$(80)(d.max.) = 0.026\times 4,270/0.08\times (0.468)^2/19.6 = 15.707$ m

B) Head loss of elbowpipe A-line = B-line

$\Delta H2 = f\times V^2/2g\times Q'ty$ f = 0.2 Q'ty 11 pcs.

$\Delta H2(150)(d.max.) = 0.2\times (0.134)^2/19.6\times 11 = 0.002$ m

$(125)(d.max.) = 0.2\times (0.193)^2/19.6\times 11 = 0.004$ m

$(100)(d.max.) = 0.2\times (0.301)^2/19.6\times 11 = 0.010$ m

$(80)(d.max.) = 0.2\times (0.471)^2/19.6\times 11 = 0.025$ m

C) Head loss of gate valve A-line = B-line

$\Delta H3 = f\times V^2/2g\times Q'ty$ Q'ty 3 pcs

$\Delta H3(150)(d.max.) = 0.145\times (0.134)^2/19.6\times 4 = 0.001$ m

$(125)(d.max.) = 0.150\times (0.193)^2/19.6\times 4 = 0.001$ m

$(100)(d.max.) = 0.164\times (0.301)^2/19.6\times 4 = 0.003$ m

$(80)(d.max.) = 0.168\times (0.471)^2/19.6\times 4 = 0.008$ m

D) Head loss of check valve

$\Delta H4 = f\times V^2/2g\times Q'ty$ f = 0.8 ～1.2 Q'ty 1 pc.

$\Delta H4(150)(d.max.) = 1.2\times (0.134)^2/19.6\times 1 = 0.001$ m

$(125)(d.max.) = 1.2\times (0.193)^2/19.6\times 1 = 0.002$ m

$(100)(d.max.) = 1.2\times (0.301)^2/19.6\times 1 = 0.005$ m

$(80)(d.max.) = 1.2\times (0.471)^2/19.6\times 1 = 0.014$ m

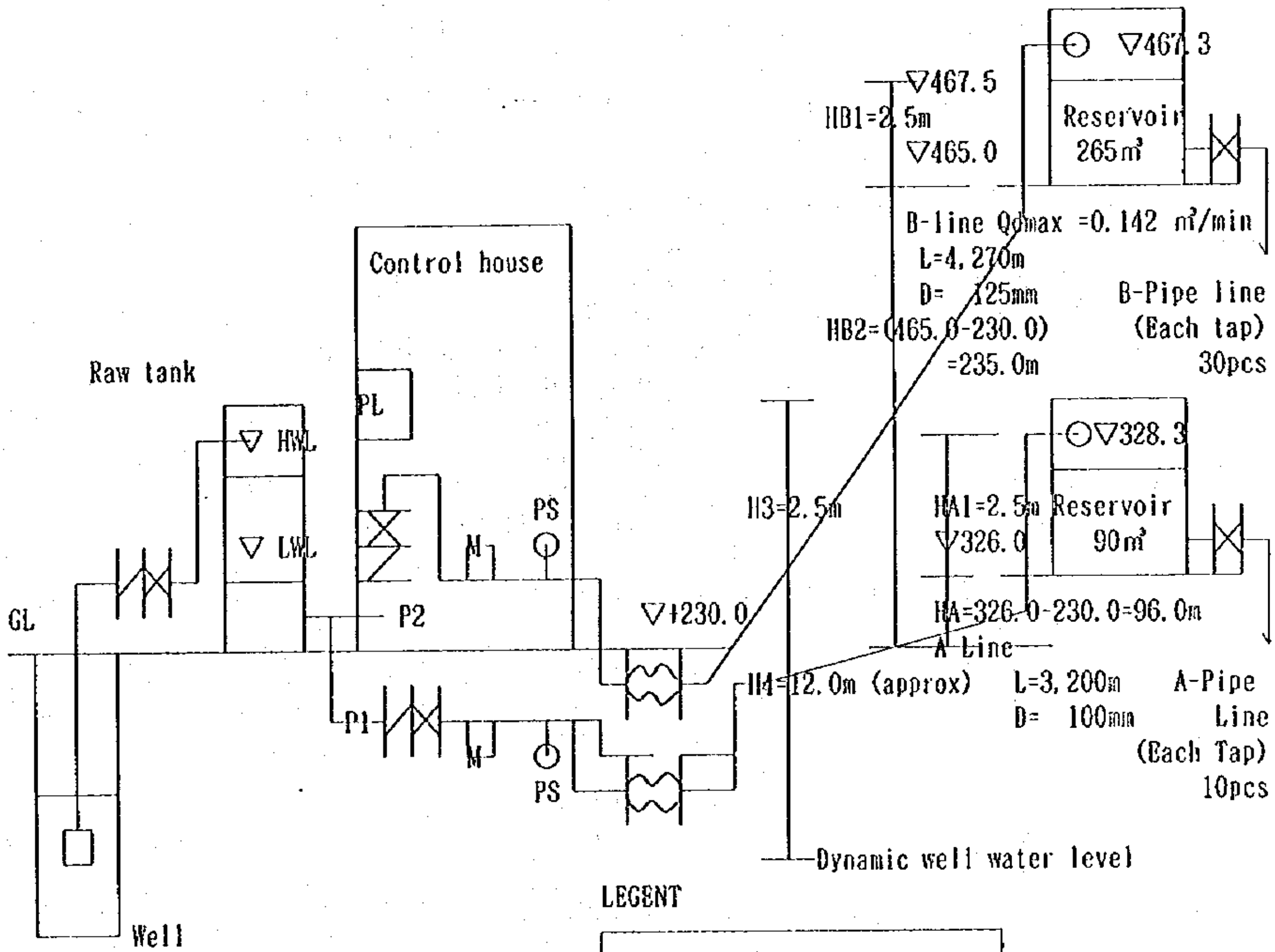
Well pump Qd.max. = 0.189 m³/min. Discharge pipe length 35.0m
Discharge pipe dia. 50mm V = Q/(60×3.14/4×D²) = 1.602 m/sec
A)Head loss of straight pipe ΔH1 = 0.03 ×35.0/0.05×(1.602)²/19.6 = 2.750m
B)Head loss of elbow ΔH2 = 0.2 ×(1.602)²/19.6×4 pcs. = 0.105m
C)Head loss of gate valve ΔH3 = 0.175×(1.602)²/19.6×1 pc. = 0.023m
D)Head loss of check vavle ΔH4 = 1.2 ×(1.602)²/19.6×1 pc. = 0.157m

	A-line				B-line				Well.p.-L
Q'ty	Transmission pump A				Transmission pump B				Well pump
Pipe dia.	(150mm)	(125mm)	(100mm)	(80mm)	(150mm)	(125mm)	(100mm)	(80mm)	(50mm)
	m	m	m	m	m	m	m	m	m
ΔH1 3,200 m	0.450	1.168	3.698	11.771					
ΔH1 4,270 m					0.600	1.558	4.935	15.707	2.750
ΔH2 11 pc.	0.002	0.004	0.010	0.025	0.002	0.004	0.010	0.025	0.105
ΔH3 4 pc.	0.001	0.001	0.003	0.008	0.001	0.001	0.003	0.008	0.023
ΔH4 1 pc.	0.001	0.002	0.005	0.014	0.001	0.002	0.005	0.014	0.157
Total loss (H)	0.454	1.175	3.716	11.818	0.604	1.565	4.953	16.754	3.035
Actual head(A.H)	98.5	98.5	98.5	98.5	237.5	37.5	237.5	237.5	14.5
Total head = H+AH	98.954	99.675	102.216	110.318	238.104	239.065	242.453	254.254	17.535

(Result) ··· Best pipe dia. A-line 100 mm
B-line 125 mm
Transmission pump required head A-line 110 m
B-line 245 m
Intake Well pump required head 30 m
Discharge pipe diameter intake well pump 50 mm

Hydraulic calculation chart of transmission pipeline

(4) SOMNTONGO COMMUNITY



Well pump
Actual head (W.P.A.H) = H3 + H4
=2.5 + 12.0 = 14.5m

Transmission pump
A-line actual head (A-A.H) = HA1 + HA2
= 2.5 + 96.0 = 98.5m
B-line actual head (B-A.H) = HB1 + HB2
= 2.5 +235.0 =237.5m

LEGENT

PL	: Control panel
PS	: Pressure switch
M	: Flow meter
|×|	: Gate valve
|/|	: Check valve
(flexible joint symbol)	: Flexible joint
P1	: A-l. Transmission P.
P2	: B-l. Transmission P.
—⊙	: Ball tap valve

1.2 Calculation of Supply Water Pipeline

(1) NGWAZINI COMMUNITY

①Flow Required … Design Flow

Daily Average	Qave.	= 152.0	m³/day
Daily Maximum	Qmax.	= 197.6	m³/day
Hourly Maximum	Qhr-max.	= 14.8	m³/hour
Yield Water Capacity of Borehole	Qmax.	= 197.6	m³/day
		2.29	ℓ/sec.
Supply Water Capacity	Qhr-max.	= 14.8	m³/hour
		= 247.0	ℓ/min

② From the reservoir tank to the each tap

1) Pipe diameter $D = 146\sqrt{Q/V}$

2) Pipe head loss $\Delta H = f1 \times L/D \times V^2/2g$

ΔH = Loss head in the pipe line (m)

f1 = 0.02 + 0.0005/D

L ; Pipe Length (m)

D ; Pipe Dia. (m)

V ; Velocity (m/sec)

$= (60 \times 3.14/4 \times D^2)$

D(150)	= $(60 \times 3.14/4 \times D^2)$	= 1.060
D(125)	=	= 0.736
D(100)	=	= 0.471
D(80)	=	= 0.301
D(65)	=	= 0.199
D(50)	=	= 0.118
D(40)	=	= 0.075
D(32)	=	= 0.048
D(25)	=	= 0.029
D(20)	=	= 0.019

3) Tap Q'ty 60 pcs.

per 1 tap flow = 247(ℓ/min) ÷ 60 (tap) = 4.12 ℓ/min

= 0.247 m³/min ÷ 60 (tap) = 0.00412 m³/min

Ngwazini Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00412 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
RES	J50		49			0.2019	0.125	140/9PVC	158.0	0.274	749.3	732.5	-16.8	0.116	0.116	749.184	16.684
J50	SP14	1	1	R (1)	5.0	0.0041	0.020	25/10HDP	718.0	0.216	732.5	680.0	-52.5	3.846 50.000	53.962	695.338	15.338
J50	J51	0	15			0.0618	0.065	75/9PVC	368.0	0.311	732.5	725.0	-7.5	0.774	0.890	748.410	23.410
J51	SP12	1	1			0.0041	0.020	25/10HDP	316.0	0.216	725.0	700.0	-25.0	1.692	2.582	746.718	46.718
J51	J52	0	14			0.0577	0.065	75/9PVC	210.0	0.290	725.0	722.5	-2.5	0.384	1.274	748.026	25.526
J52	SP10	1	1			0.0041	0.020	25/10HDP	105.0	0.216	722.5	725.5	3.0	0.562	1.836	747.464	21.964
J52	J53	0	13			0.0536	0.065	75/9PVC	110.0	0.269	722.5	711.0	-11.5	0.173	1.447	747.853	36.853
J53	SP9	1	1			0.0041	0.020	25/10HDP	126.0	0.216	711.0	700.0	-11.0	0.675	2.122	747.178	47.178
J53	J55	0	12			0.0494	0.065	75/9PVC	315.0	0.248	711.0	707.5	-3.5	0.421	1.868	747.432	39.932
J55	J551	0	4			0.0165	0.032	40/10HDP	247.0	0.344	707.5	710.0	2.5	1.659	3.527	745.773	35.773
J551	SP72	1	1			0.0041	0.020	25/10HDP	10.0	0.216	710.0	710.0	0.0	0.054	3.581	745.719	35.719
J551	SP74	1	3			0.0124	0.032	40/10HDP	431.0	0.258	710.0	710.0	0.0	1.628	5.155	744.145	34.145
SP74	J552	0	2			0.0082	0.025	32/10HDP	15.0	0.283	710.0	715.0	5.0	0.098	5.253	744.047	29.047
J552	SP75	1	1			0.0041	0.020	25/10HDP	346.0	0.216	715.0	727.5	12.5	1.853	7.106	742.194	14.694
J552	SP77	1	1			0.0041	0.025	32/10HDP	841.0	0.141	715.0	719.0	4.0	1.365	6.618	742.682	23.682
J55	J56	0	8			0.0330	0.057	63/9PVC	85.0	0.280	707.5	707.5	0.0	0.179	2.047	747.253	39.753
J56	SP78	1	1			0.0041	0.020	25/10HDP	53.0	0.216	707.5	708.0	0.5	0.284	2.331	746.969	38.969
J56	J57	0	7	R (2)	5.0	0.0288	0.057	63/9PVC	683.0	0.244	707.5	682.5	-25.0	1.092 50.000	53.139	696.161	13.661
J57	SP7	1	1			0.0041	0.020	25/10HDP	305.0	0.216	682.5	675.0	-7.5	1.634	54.773	694.527	19.527
J57	J58	0	6			0.0247	0.045	50/9PVC	242.0	0.329	682.5	665.0	-17.5	0.965	54.104	695.196	30.196
J58	SP6	1	1			0.0041	0.020	25/10HDP	126.0	0.216	665.0	670.0	5.0	0.675	54.779	694.521	24.521
J58	J59	0	5			0.0206	0.045	50/9PVC	458.0	0.275	665.0	665.0	0.0	1.276	55.380	693.920	28.920

Ngwazini Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00412 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J59	SP5	1	1	R (3)	4.0	0.0041	0.020	25/10HDP	221.0	0.216	665.0	637.5	-27.5	1.184 40.000	96.564	652.736	15.236
J59	J60	0	4	R (4)	4.0	0.0165	0.032	40/10HDP	189.0	0.344	665.0	640.0	-25.0	1.269 40.000	96.649	652.651	12.651
J60	SP4	1	1			0.0041	0.020	25/10HDP	105.0	0.216	640.0	635.0	-5.0	0.562	97.211	652.089	17.089
J60	J61	0	3			0.0124	0.032	40/10HDP	900.0	0.258	640.0	625.0	-15.0	3.400	100.049	649.251	24.251
J61	SP81	1	2	R (5)	3.0	0.0082	0.025	32/10HDP	998.0	0.283	625.0	595.0	-30.0	6.525 30.000	136.574	612.726	17.726
SP81	SP82	1	1			0.0041	0.020	25/10HDP	473.0	0.216	595.0	572.5	-22.5	2.533	139.107	610.193	37.693
J61	SP83	1	1			0.0041	0.020	25/10HDP	210.0	0.216	625.0	610.0	-15.0	1.125	101.174	648.126	38.126
RES	J65	0	11			0.0453	0.065	75/9PVC	170.0	0.228	749.3	741.0	-8.3	0.192	0.192	749.108	8.108
J65	SP2	1	1			0.0041	0.020	25/10HDP	21.0	0.216	741.0	740.8	-0.2	0.112	0.304	748.996	8.196
J65	J67	0	10	R (6)	3.5	0.0412	0.057	63/9PVC	367.0	0.349	741.0	705.0	-36.0	1.200 35.000	36.392	712.908	7.908
J67	SP16	1	1			0.0041	0.020	25/10HDP	158.0	0.216	705.0	705.0	0.0	0.846	37.238	712.062	7.062
J67	J69	0	9			0.0371	0.057	63/9PVC	567.0	0.314	705.0	690.0	-15.0	1.501	37.893	711.407	21.407
J69	SP19	1	1	R (7)	3.0	0.0041	0.020	25/10HDP	263.0	0.216	690.0	670.0	-20.0	1.409 30.000	69.302	679.998	9.998
J69	SP18	1	1			0.0041	0.020	25/10HDP	21.0	0.216	690.0	690.0	0.0	0.112	38.005	711.295	21.295
J69	SP20	1	7	R (8)	3.5	0.0288	0.057	63/9PVC	462.0	0.244	690.0	663.0	-27.0	0.739 35.000	73.632	675.668	12.668
SP20	SP21	1	6			0.0247	0.045	50/9PVC	390.0	0.329	663.0	663.0	0.0	1.556	75.188	674.112	11.112
SP21	J70	0	5			0.0206	0.045	50/9PVC	168.0	0.275	663.0	652.5	-10.5	0.468	75.656	673.644	21.144
J70	SP22	1	2	R (9)	3.5	0.0082	0.025	32/10HDP	630.0	0.283	652.5	625.0	-27.5	4.119 35.000	114.775	634.525	9.525
SP22	SP24	1	1	R (10)	4.5	0.0041	0.020	25/10HDP	673.0	0.216	625.0	572.5	-52.5	3.605 45.000	163.380	585.920	13.420
J70	SP25	1	3			0.0124	0.032	40/10HDP	336.0	0.258	652.5	640.0	-12.5	1.269	76.925	672.375	32.375
SP25	SP27	1	2	R (11) (12)	10.5	0.0082	0.025	32/10HDP	1040.0	0.283	640.0	555.0	-85.0	6.799 105.000	188.724	560.576	5.576
SP27	SP84	1	1	R (13)	3.5	0.0041	0.020	25/10HDP	998.0	0.216	555.0	512.5	-42.5	5.345 35.000	229.069	520.231	7.731

Ngwazini Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00412 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J50	J80	0	33			0.1360	0.100	110/9PVC	390.0	0.289	732.5	730.5	-2.0	0.415	0.531	748.769	18.269
J80	SP29	1	2			0.0082	0.025	32/10HDP	105.0	0.283	730.5	730.0	-0.5	0.686	1.217	748.083	18.083
SP29	SP31	1	1	R (14)	4.0	0.0041	0.020	25/10HDP	746.0	0.216	730.0	695.0	-35.0	3.996 40.000	45.213	704.087	9.087
J80	J81	0	31			0.1277	0.100	110/9PVC	315.0	0.271	730.5	725.0	-5.5	0.295	0.826	748.474	23.474
J81	SP85	1	9			0.0371	0.057	63/9PVC	116.0	0.314	725.0	717.5	-7.5	0.307	1.133	748.167	30.667
SP85	J100	0	8			0.0330	0.057	63/9PVC	650.0	0.280	717.5	720.0	2.5	1.368	2.501	746.799	26.799
J100	J101	0	2			0.0082	0.025	32/10HDP	190.0	0.283	720.0	722.5	2.5	1.242	3.743	745.557	23.057
J101	SP87	1	1			0.0041	0.020	25/10HDP	158.0	0.216	722.5	720.0	-2.5	0.846	4.589	744.711	24.711
J101	SP88	1	1			0.0041	0.020	25/10HDP	105.0	0.216	722.5	707.5	-15.0	0.562	4.305	744.995	37.495
J100	J102	0	6			0.0247	0.045	50/9PVC	158.0	0.329	720.0	720.5	0.5	0.630	3.131	746.169	25.669
J102	SP89	1	1			0.0041	0.020	25/10HDP	53.0	0.216	720.5	720.0	-0.5	0.284	3.415	745.885	25.885
J102	SP90	1	5			0.0206	0.045	50/9PVC	495.0	0.275	720.5	727.5	7.0	1.379	4.510	744.790	17.290
SP90	J103	0	4			0.0165	0.032	40/10HDP	10.0	0.344	727.5	727.5	0.0	0.067	4.577	744.723	17.223
J103	JSP91	0	1			0.0041	0.025	32/10HDP	210.0	0.141	727.5	722.5	-5.0	0.341	4.918	744.382	21.882
JSP91	SP92	1	1			0.0041	0.025	32/10HDP	630.0	0.141	722.5	727.5	5.0	1.022	5.940	743.360	15.860
J103	J105	0	3			0.0124	0.032	40/10HDP	578.0	0.258	727.5	711.0	-16.5	2.184	6.761	742.539	31.539
J105	SP96	1	1			0.0041	0.020	25/10HDP	840.0	0.216	711.0	701.5	-9.5	4.499	11.260	738.040	36.540
J105	J106	0	2			0.0082	0.025	32/10HDP	30.0	0.283	711.0	711.0	0.0	0.196	6.957	742.343	31.343
J106	SP94	1	1			0.0041	0.020	25/10HDP	11.0	0.216	711.0	711.0	0.0	0.059	7.016	742.284	31.284
J106	SP95	1	1	R (15)	4.0	0.0041	0.020	25/10HDP	980.0	0.216	711.0	685.0	-26.0	5.249 40.000	52.206	697.094	12.094
J81	J82	0	22			0.0906	0.080	90/9PVC	263.0	0.301	725.0	725.0	0.0	0.400	1.226	748.074	23.074
J82	SP34	1	1	R (16)	4.5	0.0041	0.020	25/10HDP	462.0	0.216	725.0	691.0	-34.0	2.474 45.000	48.700	700.600	9.600

Ngwazini Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00412 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J82	J822	0	21	R (17)	2.5	0.0865	0.080	90/9PVC	263.0	0.287	725.0	710.0	-15.0	0.363 25.000	26.589	722.711	12.711
J822	SP36	1	1			0.0041	0.020	25/10HDP	6.0	0.216	710.0	710.0	0.0	0.032	26.621	722.679	12.679
J822	J83	0	20			0.0824	0.080	90/9PVC	105.0	0.274	710.0	707.5	-2.5	0.132	26.721	722.579	15.079
J83	SP37	1	1			0.0041	0.020	25/10HDP	210.0	0.216	707.5	705.0	-2.5	1.125	27.846	721.454	16.454
J83	J85	0	19			0.0783	0.080	90/9PVC	201.0	0.260	707.5	700.0	-7.5	0.228	26.949	722.351	22.351
J85	SP39	1	1			0.0041	0.020	25/10HDP	105.0	0.216	700.0	700.0	0.0	0.562	27.511	721.789	21.789
J85	J86	0	18			0.0742	0.080	90/9PVC	315.0	0.247	700.0	712.0	12.0	0.322	27.271	722.029	10.029
J86	J862	0	5			0.0206	0.045	50/9PVC	610.0	0.275	712.0	702.5	-9.5	1.700	28.971	720.329	17.829
J862	SP42	1	1			0.0041	0.020	25/10HDP	6.0	0.216	702.5	702.5	0.0	0.032	29.003	720.297	17.797
J862	J87	0	4	R (18)	3.0	0.0165	0.032	40/10HDP	610.0	0.344	702.5	675.0	-27.5	4.097 30.000	63.068	686.232	11.232
J87	J871	0	2			0.0082	0.025	32/10HDP	10.0	0.283	675.0	675.0	0.0	0.065	63.133	686.167	11.167
J871	SP45	1	1			0.0041	0.020	25/10HDP	6.0	0.216	675.0	675.0	0.0	0.032	63.165	686.135	11.135
J871	SP46	1	1			0.0041	0.020	25/10HDP	600.0	0.216	675.0	650.0	-25.0	3.214	66.347	682.953	32.953
J87	J872	0	2			0.0082	0.025	32/10HDP	494.0	0.283	675.0	652.5	-22.5	3.230	66.298	683.002	30.502
J872	SP48	1	1			0.0041	0.020	25/10HDP	53.0	0.216	652.5	650.0	-2.5	0.284	66.582	682.718	32.718
J872	SP49	1	1	R (19)	3.0	0.0041	0.020	25/10HDP	105.0	0.216	652.5	640.0	-12.5	0.562 30.000	96.860	652.440	12.440
J86	J863	0	13			0.0536	0.065	75/9PVC	10.0	0.269	712.0	712.0	0.0	0.016	27.287	722.013	10.013
J863	SP40	1	1			0.0041	0.020	25/10HDP	126.0	0.216	712.0	705.0	-7.0	0.675	27.962	721.338	16.338
J863	J88	0	12			0.0494	0.065	75/9PVC	850.0	0.248	712.0	701.0	-11.0	1.137	28.424	720.876	19.876
J88	SP51	1	1			0.0041	0.020	25/10HDP	379.0	0.216	701.0	685.0	-16.0	2.030	30.454	718.846	33.846
J88	SP52	1	11			0.0453	0.065	75/9PVC	50.0	0.228	701.0	701.0	0.0	0.057	28.481	720.819	19.819
SP52	J90	0	10			0.0412	0.057	63/9PVC	444.0	0.349	701.0	685.0	-16.0	1.452	29.933	719.367	34.367

Ngwazini Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00412 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J90	SP53	1	1			0.0041	0.020	25/10HDP	420.0	0.216	685.0	690.0	-5.0	2.249	32.182	717.118	27.118
J90	J91	0	9			0.0371	0.057	63/9PVC	42.0	0.314	685.0	686.0	1.0	0.111	30.044	719.256	33.256
J91	J92	0	6			0.0247	0.045	50/9PVC	210.0	0.329	686.0	685.0	-1.0	0.838	30.882	718.418	33.418
J92	SP54	1	1			0.0041	0.020	25/10HDP	6.0	0.216	685.0	685.0	0.0	0.032	30.914	718.386	33.386
J92	J94	0	5			0.0206	0.045	50/9PVC	494.0	0.275	685.0	685.0	0.0	1.377	32.259	717.041	32.041
J94	SP57	1	1	R (20)	3.5	0.0041	0.020	25/10HDP	473.0	0.216	685.0	665.0	-20.0	2.533 35.000	69.792	679.508	14.508
J94	J96	0	4	R (21)	3.5	0.0165	0.032	40/10HDP	252.0	0.344	685.0	675.0	-10.0	1.693 35.000	68.952	680.348	5.348
J96	SP67	1	1			0.0041	0.020	25/10HDP	158.0	0.216	675.0	670.0	-5.0	0.846	69.798	679.502	9.502
J96	J98	0	3			0.0124	0.032	40/10HDP	620.0	0.258	675.0	660.0	-15.0	2.342	71.294	678.006	18.006
J98	SP59	1	1			0.0041	0.020	25/10HDP	6.0	0.216	660.0	660.0	0.0	0.032	71.326	677.974	17.974
J98	SP60	1	2			0.0082	0.025	32/10HDP	210.0	0.283	660.0	657.5	-2.5	1.373	72.667	676.633	19.133
SP60	SP62	1	1			0.0041	0.020	25/10HDP	1060.0	0.216	657.5	650.0	-7.5	5.677	78.344	670.956	20.956
J91	J99	0	3			0.0124	0.032	40/10HDP	872.0	0.258	686.0	680.0	-6.0	3.295	33.339	715.961	35.961
J99	J992	0	3			0.0124	0.032	40/10HDP	193.0	0.258	680.0	675.0	-5.0	0.729	34.068	715.232	40.232
J992	SP64	1	1			0.0041	0.020	25/10HDP	210.0	0.216	675.0	687.5	12.5	1.125	35.193	714.107	26.607
J992	SP65	1	2	R (22)	4.0	0.0082	0.025	32/10HDP	630.0	0.283	675.0	663.0	-12.0	4.119 40.000	78.187	671.113	8.113
SP65	SP66	1	1			0.0041	0.020	25/10HDP	315.0	0.216	663.0	652.5	-10.5	1.687	79.874	669.426	16.926
		60							34,852.0								

(2) BHEKIKHOSI COMMUNITY

①Flow Required … Design Flow

Daily Average	Qave.	= 83.8	m³/day
Daily Maximum	Qmax.	= 108.9	m³/day
Hourly Maximum	Qhr-max.	= 8.2	m³/hour
Yield Water Capacity of Borehole	Qmax.	= 108.9	m³/day
		1.3	ℓ/sec.
Supply Water Capacity	Qhr-max.	= 8.2	m³/hour
		= 136.7	ℓ/min

②From the reservoir tank to the each tap

1) Pipe diameter $D = 146\sqrt{Q/V}$

2) Pipe head loss $\Delta H = f1 \times L/D \times V^2/2g$

ΔH = Loss head in the pipe line (m)

$f1 = 0.02 + 0.0005/D$

L ; Pipe Length (m)

D ; Pipe Dia. (m)

V ; Velocity (m/sec)

$= (60 \times 3.14/4 \times D^2)$

D(150) =	$(60 \times 3.14/4 \times D^2)$	= 1.060
D(125) =		= 0.736
D(100) =		= 0.471
D(80) =		= 0.301
D(65) =		= 0.199
D(50) =		= 0.118
D(40) =		= 0.075
D(32) =		= 0.048
D(25) =		= 0.029

3) Tap Q'ty 32 pcs.

per 1 tap flow = 136.7(ℓ/min) ÷ 32 (tap) = 4.272 ℓ/min

= 0.1367m³/min ÷ 32 (tap) = 0.00427m³/min

Bhekinkosi Community Supply Water Pipe Line　　1 Tap Flow (Q) = 0.00427 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
RES	J1	0	9			0.0384	0.057	63/9PVC	105.0	0.325	701.5	695.0	-6.5	0.298	0.298	701.202	6.202
J1	J2	0	3			0.0128	0.032	40/10HDP	315.0	0.267	695.0	690.0	-5.0	1.275	1.573	699.927	9.927
J2	SP5	1	1			0.0043	0.020	25/10HDP	42.0	0.226	690.0	690.0	0.0	0.246	1.819	699.681	9.681
J2	J4	0	2			0.0085	0.032	40/10HDP	1072.0	0.177	690.0	675.0	-15.0	1.906	3.479	698.021	23.021
J4	SP2	1	1			0.0043	0.020	25/10HDP	158.0	0.226	675.0	672.5	-2.5	0.926	4.405	697.095	24.595
J4	SP1	1	1			0.0043	0.020	25/10HDP	420.0	0.226	675.0	680.0	5.0	2.463	5.942	695.558	15.558
J1	J5	0	6			0.0256	0.045	50/9PVC	10.0	0.341	695.0	695.0	0.0	0.043	0.341	701.159	6.159
J5	J6	0	3			0.0128	0.032	40/10HDP	366.0	0.267	695.0	670.0	-25.0	1.481	1.822	699.678	29.678
J6	SP12	1	1			0.0043	0.020	25/10HDP	137.0	0.226	670.0	667.0	-3.0	0.803	2.625	698.875	31.875
J6	SP13	1	2	R (1)	5.0	0.0085	0.025	32/10HDP	709.0	0.293	670.0	632.5	-37.5	4.969 50.000	56.791	644.709	12.209
SP13	SP14	1	1			0.0043	0.020	25/10HDP	536.0	0.226	632.5	607.5	-25.0	3.143	59.934	641.566	34.066
J5	SP6	1	3			0.0128	0.032	40/10HDP	368.0	0.267	695.0	684.0	-11.0	1.489	1.830	699.670	15.670
SP6	SP8	1	2			0.0085	0.032	40/10HDP	683.0	0.177	684.0	682.5	-1.5	1.215	3.045	698.455	15.955
SP8	SP10	1	1	R (2)	4.0	0.0043	0.020	25/10HDP	788.0	0.226	682.5	645.0	-37.5	4.620 40.000	47.665	653.835	8.835
RES	SP15	1	23			0.0982	0.080	90/9PVC	158.0	0.326	701.5	675.0	-26.5	0.282	0.282	701.218	26.218
SP15	J9	0	22	R (3)	3.5	0.0939	0.080	90/9PVC	709.0	0.312	675.0	656.0	-19.0	1.158 35.000	36.440	665.060	9.060
J9	SP17	1	1	R (4)	3.5	0.0043	0.020	25/10HDP	524.0	0.226	656.0	620.0	-36.0	3.072 35.000	74.512	626.988	6.988
J9	SP18	1	21			0.0897	0.080	90/9PVC	262.0	0.298	656.0	647.5	-8.5	0.390	36.830	664.670	17.170
SP18	J10	0	20			0.0854	0.080	90/9PVC	116.0	0.284	647.5	643.0	-4.5	0.157	36.987	664.513	21.513
J10	SP20	1	2	R (5)	4.0	0.0085	0.025	32/10HDP	773.0	0.293	643.0	605.0	-38.0	5.417 40.000	82.404	619.096	14.096
SP20	SP21	1	1			0.0043	0.020	25/10HDP	462.0	0.226	605.0	592.0	-13.0	2.709	85.113	616.387	24.387
J10	J11	0	18			0.0769	0.065	75/9PVC	105.0	0.386	643.0	642.5	-0.5	0.340	37.327	664.173	21.673

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Bhekinkosi Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00427 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J11	SP22	1	1			0.0043	0.020	25/10HDP	147.0	0.226	642.5	630.0	-12.5	0.862	38.189	663.311	33.311
J11	J12	0	17			0.0726	0.065	75/9PVC	347.0	0.365	642.5	630.0	-12.5	1.005	38.332	663.168	33.168
J12	SP24	1	3			0.0128	0.032	40/10HDP	315.0	0.267	630.0	632.5	2.5	1.275	39.607	661.893	29.393
SP24	SP26	1	2	R (6)	5.0	0.0085	0.025	32/10HDP	945.0	0.293	632.5	577.5	-55.0	6.623 50.000	96.230	605.270	27.770
SP26	SP28	1	1	R (7) (8)	8.5	0.0043	0.020	25/10HDP	928.0	0.226	577.5	500.0	-77.5	5.441 85.000	186.671	514.829	14.829
J12	SP23	1	14	R (9)	3.5	0.0598	0.065	75/9PVC	168.0	0.301	630.0	620.0	-10.0	0.331 35.000	73.663	627.837	7.837
SP23	J13	0	13			0.0555	0.065	75/9PVC	473.0	0.279	620.0	597.5	-22.5	0.801	74.464	627.036	29.536
J13	SP47	1	1	R (10)	5.0	0.0043	0.020	25/10HDP	683.0	0.226	597.5	562.5	-35.0	4.005 50.000	128.469	573.031	10.531
J13	SP29	1	12			0.0512	0.065	75/9PVC	105.0	0.257	597.5	592.5	-5.0	0.151	74.615	626.885	34.385
SP29	SP32	1	11	R (11)	3.5	0.0470	0.065	75/9PVC	1166.0	0.236	592.5	580.0	-12.5	1.412 35.000	111.027	590.473	10.473
SP32	SP34	1	10			0.0427	0.057	63/9PVC	536.0	0.362	580.0	577.5	-2.5	1.886	112.913	588.587	11.087
SP34	J15	0	9			0.0384	0.057	63/9PVC	237.0	0.325	577.5	566.0	-11.5	0.672	113.585	587.915	21.915
J15	SP35	1	1			0.0043	0.020	25/10HDP	105.0	0.226	566.0	555.0	-11.0	0.616	114.201	587.299	32.299
J15	J16	0	8			0.0342	0.057	63/9PVC	168.0	0.290	566.0	565.0	-1.0	0.379	113.964	587.536	22.536
J16	SP37	1	1	R (12)	4.0	0.0043	0.020	25/10HDP	557.0	0.226	565.0	535.0	-30.0	3.266 40.000	157.230	544.270	9.270
J16	SP38	1	7			0.0299	0.057	63/9PVC	410.0	0.253	565.0	564.0	-1.0	0.705	114.669.	586.831	22.831
SP38	SP40	1	6			0.0256	0.045	50/9PVC	767.0	0.341	564.0	555.0	-9.0	3.286	117.955	583.545	28.545
SP40	J17	0	5	R (13)	4.0	0.0214	0.045	50/9PVC	184.0	0.285	555.0	532.5	-22.5	0.551 40.000	158.506	542.994	10.494
J17	SP41	1	3			0.0128	0.032	40/10HDP	389.0	0.267	532.5	525.0	-7.5	1.574	160.080	541.420	16.420
SP41	J19	0	2			0.0085	0.025	32/10HDP	63.0	0.293	525.0	525.0	0.0	0.442	160.522	540.978	15.978
J19	SP42	1	1	R (14)	3.5	0.0043	0.020	25/10HDP	525.0	0.226	525.0	495.0	-30.0	3.078 35.000	198.600	502.900	7.900
J19	SP46	1	1			0.0043	0.020	25/10HDP	525.0	0.226	525.0	525.0	0.0	3.078	163.600	537.900	12.900
J17	J18	0	2			0.0085	0.025	32/10HDP	168.0	0.293	532.5	530.0	-2.5	1.177	159.683	541.817	11.817

Bhekinkosi Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00427 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water H. (m)	Total. H. (m)
J18	SP44	1	1	R (15)	4.0	0.0043	0.020	25/10HDP	441.0	0.226	530.0	492.5	-37.5	2.586 40.000	202.269	499.231	6.731
J18	SP45	1	1			0.0043	0.020	25/10HDP	263.0	0.226	530.0	525.0	-5.0	1.542	161.225	540.275	15.275
		32							19,433.0								

(3) MSUMPE COMMUNITY

Flow Required··· Design Flow

Daily Average	Qave.	=	55.3	m^3/day
Daily Maximum	Qmax.	=	71.9	m^3/day
Hourly Maximum	Qhr-max.	=	5.4	m^3/hour
Yield Water Capacity of Borehole	Qmax.	=	71.9	m^3/day
			0.83	ℓ/sec.
Supply Water Capacity	Qhr-max.	=	90.0	ℓ/min

Flow Rate = Tap Ratio

A Line Tap Q'ty = 4 pcs. Qh.max. = 0.090m^3/min× 4/32 = 0.01125m^3/min

B Line Tap Q'ty = 28 pcs. Qh.max. = 0.090m^3/min×28/32 = 0.07875m^3/min

② From A Line Reservoir Tank to the each Tap (4 Taps)
From B Line Reservoir Tank to the each Tap (28 Taps)

1) Pipe Diameter D = $146\sqrt{Q/V}$

2) Pipe head Loss $\Delta H = f1 \times L/D \times V^2/2g$

ΔH = Loss head in the pipe line (m)

f1 = 0.02 + 0.0005/D

L ; Pipe Length (m)

D ; Pipe Dia. (m)

V ; Velocity (m/sec)

= $(60 \times 3.14/4 \times D^2)$

D	125	100	80	65	50	40	32	25	20
$60 \times 3.14/4 \times D^2$	0.736	0.471	0.301	0.199	0.118	0.075	0.048	0.029	0.019

3) Tap Q'ty 4 pcs. (A Line) + 28 pcs. (B Line) = 32 pcs.

per 1 Tap Flow = 0.090 m^3/min÷32(Tap) =0.00281.m^3/min

A Line 0.090 m^3/min× 4 /32 =0.01125 m^3/min

B Line = 0.090 m^3/min×28/32 =0.07875 m^3/min

Msumpe Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00281 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
RES	SP51	1	4	R (1) (2)	10.0	0.0112	0.032	40/10HDP	1313.0	0.233	750.0	630.0	-120.0	4.046 100.000	104.046	645.954	15.954
SP51	SP53	1	3			0.0084	0.025	32/10HDP	730.0	0.290	630.0	630.0	0.0	5.012	109.058	640.942	10.942
SP53	SP55	1	2			0.0056	0.020	25/10HDP	736.0	0.295	630.0	592.5	-37.5	7.353	116.411	633.589	41.089
SP55	SP57	1	1	R (3)	4.0	0.0028	0.020	25/10HDP	872.0	0.147	592.5	575.0	-17.5	2.163 40.000	158.574	591.426	16.426
RES	J1	0	28			0.0787	0.065	75/9PVC	5.0	0.395	632.5	632.0	-0.5	0.017	0.017	632.483	0.483
J1	J2	0	10	R (4)	4.5	0.0281	0.040	50/12PVC	1103.0	0.375	632.0	517.5	-114.5	6.430 45.000	51.447	581.053	63.553
J2	SP7	1	1			0.0028	0.020	25/12HDP	263.0	0.147	517.5	518.0	0.5	0.652	52.099	580.401	62.401
J2	SP6	1	9			0.0253	0.040	50/12PVC	42.0	0.337	517.5	520.0	2.5	0.198	51.645	580.855	60.855
SP6	J3	0	8			0.0225	0.040	50/12PVC	473.0	0.300	520.0	542.5	22.5	1.765	53.410	579.090	36.590
J3	SP4	1	1			0.0028	0.020	25/10HDP	158.0	0.147	542.5	560.0	17.5	0.392	53.802	578.698	18.698
J3	J4	0	3			0.0084	0.025	32/10HDP	368.0	0.290	542.5	547.5	5.0	2.526	55.936	576.564	29.064
J4	SP17	1	1			0.0028	0.020	25/10HDP	189.0	0.147	547.5	527.5	-20.0	0.469	56.405	576.095	48.595
J4	J5	0	2			0.0056	0.020	25/10HDP	21.0	0.295	547.5	547.5	0.0	0.210	56.146	576.354	28.854
J5	SP3	1	1			0.0028	0.020	25/10HDP	132.0	0.147	547.5	565.5	18.0	0.327	56.473	576.027	10.527
J5	SP1	1	1			0.0028	0.020	25/10HDP	368.0	0.147	547.5	547.5	0.0	0.913	57.059	575.441	27.941
J3	J6	0	4			0.0112	0.032	40/10HDP	357.0	0.233	542.5	549.0	6.5	1.100	54.510	577.990	28.990
J6	SP8	1	1			0.0028	0.020	25/10HDP	158.0	0.147	549.0	565.0	16.0	0.392	54.902	577.598	12.598
J6	J7	0	3			0.0084	0.025	32/10HDP	1024.0	0.290	549.0	527.5	-21.5	7.030	61.540	570.960	43.460
J7	SP10	1	1			0.0028	0.020	25/10HDP	132.0	0.147	527.5	545.0	17.5	0.327	61.867	570.633	25.633
J7	J8	0	2			0.0056	0.025	32/10HDP	552.0	0.193	527.5	529.0	1.5	1.678	63.218	569.282	40.282
J8	SP12	1	1			0.0028	0.020	25/10HDP	210.0	0.147	529.0	555.0	26.0	0.521	63.739	568.761	13.761
J8	SP13	1	1			0.0028	0.020	25/10HDP	105.0	0.147	529.0	526.0	-3.0	0.260	63.478	569.022	43.022

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Msumpe Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00281 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
J1	J9	0	18	R (5)	4.0	0.0506	0.065	75/12PVC	630.0	0.254	632.0	560.0	-72.0	0.884 40.000	40.901	591.599	31.599
J9	SP20	1	1			0.0028	0.020	25/10HDP	137.0	0.147	560.0	572.0	12.0	0.340	41.241	591.259	19.259
J9	JP19	0	17			0.0478	0.065	75/9PVC	221.0	0.240	560.0	557.5	-2.5	0.277	41.178	591.322	33.822
JP19	J10	0	17			0.0478	0.065	75/12PVC	242.0	0.240	557.5	532.5	-25.0	0.303	41.481	591.019	58.519
J10	SP28	1	1	R (6)	6.0	0.0028	0.020	25/12HDP	189.0	0.147	532.5	517.5	-15.0	0.469 60.000	101.950	530.550	13.050
J10	JP15	0	10			0.0281	0.040	50/12PVC	237.0	0.375	532.5	537.5	5.0	1.382	42.863	589.637	52.137
JP15	SP16	1	10			0.0281	0.040	50/9PVC	200.0	0.375	537.5	560.0	22.5	1.166	44.029	588.471	28.471
SP16	J11	0	9			0.0253	0.040	50/9PVC	105.0	0.337	560.0	570.0	10.0	0.494	44.523	587.977	17.977
J11	SP14	1	1	R (7)	4.0	0.0028	0.020	25/10HDP	420.0	0.147	570.0	535.0	-35.0	1.042 40.000	85.565	546.935	11.935
J11	J12	0	8			0.0225	0.040	50/9PVC	263.0	0.300	570.0	544.0	-26.0	0.981	45.504	586.996	42.996
J12	SP30	1	1	R (8)	4.5	0.0028	0.020	25/10HDP	137.0	0.147	544.0	535.0	-9.0	0.340 45.000	90.844	541.656	6.656
J12	J13	0	7	R (9)	5.0	0.0197	0.040	50/9PVC	200.0	0.263	544.0	527.5	-16.5	0.573 50.000	96.077	536.423	8.923
J13	SP35	1	1			0.0028	0.020	25/10HDP	631.0	0.147	527.5	500.0	-27.5	1.565	97.642	534.858	34.858
J13	SP37	1	6			0.0169	0.032	40/10HDP	357.0	0.352	527.5	508.0	-19.5	2.511	98.588	533.912	25.912
SP37	J14	0	5	R (10)	3.0	0.0141	0.032	40/10HDP	515.0	0.294	508.0	495.0	-13.0	2.527 30.000	131.115	501.385	6.385
J14	SP38	1	2			0.0056	0.020	25/10HDP	5.0	0.295	495.0	495.0	0.0	0.050	131.165	501.335	6.335
SP38	SP39	1	1			0.0028	0.020	25/10HDP	599.0	0.147	495.0	482.5	-12.5	1.486	132.651	499.849	17.349
J14	SP41	1	3			0.0084	0.025	32/10HDP	305.0	0.290	495.0	487.5	-7.5	2.094	133.209	499.291	11.791
SP41	J15	0	2			0.0056	0.020	25/10HDP	263.0	0.295	487.5	488.0	0.5	2.627	135.836	496.664	8.664
J15	SP42	1	1			0.0028	0.020	25/10HDP	158.0	0.147	488.0	482.5	-5.5	0.392	136.228	496.272	13.772
J15	SP43	1	1			0.0028	0.020	25/10HDP	473.0	0.147	488.0	470.0	-18.0	1.173	137.009	495.491	25.491
J10	SP22	1	6			0.0169	0.032	40/12HDP	242.0	0.352	532.5	530.0	-2.5	1.702	43.183	589.317	59.317
SP22	J16	0	5			0.0141	0.032	40/12HDP	189.0	0.294	530.0	515.0	-15.0	0.927	44.110	588.390	73.390

Msumpe Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00281 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
J16	SP23	1	1			0.0028	0.020	32/12HDP	158.0	0.147	515.0	522.0	7.0	0.392	44.502	587.998	65.998
J16	SP25	1	4			0.0112	0.032	40/10HDP	295.0	0.233	530.0	540.0	10.0	0.909	45.019	587.481	47.481
SP25	J17	0	3			0.0084	0.025	32/10HDP	84.0	0.290	540.0	540.0	0.0	0.577	45.596	586.904	46.904
J17	SP27	1	1			0.0028	0.020	25/10HDP	368.0	0.147	535.0	517.5	-17.5	0.913	46.509	585.991	68.491
J17	J18	0	2			0.0056	0.025	32/10HDP	1176.0	0.193	550.0	560.0	10.0	3.576	49.172	583.328	23.328
J18	SP45	1	1			0.0028	0.020	25/10HDP	52.0	0.147	560.0	565.0	5.0	0.129	49.301	583.199	18.199
J18	SP46	1	1			0.0028	0.020	25/10HDP	604.0	0.147	560.0	567.5	7.5	1.498	50.670	581.830	14.330
		32							18766.0								

(4) SOMNTONGO COMMUNITY

Flow Required… Design Flow

Daily Average	Qave.	= 174.3	m³/day
Daily Maximum	Qmax.	= 226.5	m³/day
Hourly Maximum	Qhr-max.	= 17.0	m³/hour
Yield Water Capacity of Borehole	Qmax.	= 226.5	m³/day
		2.6	ℓ/sec.
Supply Water Capacity	Qhr-max.	= 17.0	m³/hour
		= 283.3	ℓ/min

Separated 2 Water Supply Line (= 2 supply water line)

	A Line Tap (10pcs)	B Line Tap (30pcs)	C Line Tap (40pcs)
Daily Average(Qave.)	44.3 m³/day	130.0 m³/day	174.3 m³/day
Daily Maximum(Qmax.)	57.6 m³/day	168.9 m³/day	226.5 m³/day
Hourly Maximum(Qh-max.)	4.32 m³/hour	12.68 m³/hour	17.0 m³/hour
Yeild water capacity(Qmax) of Transmission Pump	57.6 m³/day 0.66 ℓ/sec	168.9 m³/day 1.94 ℓ/sec	226.5 m³/day 2.6 ℓ/sec
Supply Water Capacity(Qh-max.)	4.32 m³/hour = 0.072 m³/min	12.68 m³/hour 0.212 m³/min	17.0 m³/hour 0.28 m³/min

② From the Reservoir Tank to the each Tap

1) Pipe Diameter $D = 146\sqrt{Q/V}$

2) Pipe Loss $\Delta H = f1 \times L/D \times V^2/2g$

ΔH ; Loss head in the pipe line (m)

$f1 = 0.02 + 0.0005/D$

L ; Pipe Length (m)

D ; Pipe Dia. (m)

V ; Velocity (m/sec)

$= Q/(60 \times 3.14/4 \times D^2)$

D	20	25	32	40	50	65	80	100	125	150
$60 \times 3.14/4 \times D^2$	0.019	0.029	0.048	0.075	0.118	0.199	0.301	0.471	0.736	1.060

3) Tap Q'ty 40 pcs.

per 1 Tap Flow = 0.2833m³/min ÷ 40(Tap) = 0.00708 m³/min

A Line = 0.00708m³/min × 30(Tap) = 0.2124 m³/min

B Line = 0.00708 m³/min × 10(Tap) = 0.0708 m³/min

Somntongo Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00708 m3/min

Pipe Line From	Pipe Line To	Tap pc	Tap pcs	Reducing Tank No.	Reducing Tank kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	Ground Level To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
RES	J1	0	30	R (1)	3.0	0.2124	0.100	110/12PVC	525.0	0.451	465.0	393.0	-72.0	1.362 30.000	31.362	433.638	40.638
J1	SP1	1	2			0.0142	0.032	40/10HDP	205.0	0.296	393.0	395.0	2.0	1.019	32.381	432.619	37.619
SP1	SP3	1	1	R (2) (3)	6.0	0.0071	0.020	25/10HDP	971.0	0.374	395.0	343.0	-52.0	15.592 60.000	107.973	357.027	14.027
J1	SP4	1	28			0.1982	0.100	110/12PVC	357.0	0.421	393.0	363.0	-30.0	0.807	32.169	432.831	69.831
SP4	J2	0	27			0.1912	0.100	110/12PVC	11.0	0.406	363.0	363.0	0.0	0.023	32.192	432.808	69.808
J2	SP6	1	1			0.0071	0.020	25/10HDP	1155.0	0.374	363.0	365.0	2.0	18.546	50.738	414.262	49.262
J2	J3	0	26			0.1841	0.100	110/12PVC	394.0	0.391	363.0	368.0	5.0	0.768	32.960	432.040	64.040
J3	SP8	1	1	R (4) (5)	8.5	0.0071	0.020	25/10HDP	1418.0	0.374	368.0	307.0	-61.0	22.769 85.000	140.729	324.271	17.271
J3	SP9	1	25			0.1770	0.100	110/12PVC	132.0	0.376	368.0	360.0	-8.0	0.238	33.198	431.802	71.802
SP9	SP11	1	24			0.1699	0.100	110/12PVC	1156.0	0.361	360.0	357.0	-3.0	1.922	35.120	429.880	72.880
SP11	SP12	1	23			0.1628	0.100	110/12PVC	578.0	0.346	357.0	377.0	20.0	0.883	36.003	428.997	51.997
SP12	J4	0	22			0.1558	0.100	110/12PVC	126.0	0.331	377.0	378.0	1.0	0.176	36.179	428.821	50.821
J4	SP14	1	3	R (6)	5.0	0.0212	0.040	50/9PVC	1035.0	0.283	378.0	349.0	-29.0	3.436 50.000	89.615	375.385	26.385
SP14	J5	0	2			0.0142	0.032	40/10HDP	588.0	0.296	349.0	338.0	-11.0	2.924	92.539	372.461	34.461
J5	SP16	1	1			0.0071	0.020	25/10HDP	394.0	0.374	338.0	337.0	-1.0	6.327	98.866	366.134	29.134
J5	SP17	1	1			0.0071	0.020	25/10HDP	179.0	0.374	338.0	325.0	-13.0	2.874	95.413	369.587	44.587
J4	J6	0	19			0.1345	0.100	110/9PVC	121.0	0.286	378.0	387.0	9.0	0.126	36.305	428.695	41.695
J6	SP18	1	1			0.0071	0.020	25/10HDP	1365.0	0.374	387.0	367.0	-20.0	21.918	58.223	406.777	39.777
J6	SP20	1	18			0.1274	0.100	110/9PVC	752.0	0.270	387.0	410.0	23.0	0.699	37.004	427.996	17.996
SP20	J7	0	17			0.1204	0.100	110/9PVC	11.0	0.256	410.0	420.0	10.0	0.009	37.013	427.987	7.987
J7	SP21	1	3	R (8)	3.0	0.0212	0.040	50/9PVC	814.0	0.283	420.0	383.0	-37.0	2.702 30.000	69.715	395.285	12.285
SP21	SP22	1	2	R (9)	5.0	0.0142	0.032	40/10HDP	1313.0	0.296	383.0	328.0	-55.0	6.530 50.000	126.245	338.755	10.755

Somntongo Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00708 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
SP22	SP24	1	1	R (10)	2.0	0.0071	0.020	25/10HDP	1051.0	0.374	328.0	295.0	-33.0	16.876 20.000	163.121	301.879	6.879
J7	SP25	1	14	R (11)	2.0	0.0991	0.080	90/9PVC	431.0	0.329	420.0	380.0	-40.0	0.782 20.000	57.795	407.205	27.205
SP25	J8	0	13			0.0920	0.080	90/9PVC	394.0	0.306	380.0	373.0	-7.0	0.619	58.414	406.586	33.586
J8	SP27	1	3	R (12)	4.0	0.0212	0.040	50/9PVC	1219.0	0.283	373.0	343.0	-30.0	4.047 40.000	102.461	362.539	19.539
SP27	SP28	1	2			0.0142	0.032	40/10HDP	552.0	0.296	343.0	348.0	5.0	2.745	105.206	359.794	11.794
SP28	SP30	1	1			0.0071	0.020	25/10HDP	857.0	0.374	348.0	327.0	-21.0	13.761	118.967	346.033	19.033
J8	J9	0	10			0.0708	0.065	75/9PVC	589.0	0.356	373.0	365.0	-8.0	1.623	60.037	404.963	39.963
J9	SP32	1	1			0.0071	0.025	32/10HDP	473.0	0.245	365.0	383.0	18.0	2.318	62.355	402.645	19.645
J9	J10	0	9			0.0637	0.065	75/9PVC	294.0	0.320	365.0	393.0	28.0	0.655	60.692	404.308	11.308
J10	SP33	1	2			0.0142	0.032	40/10HDP	90.0	0.296	393.0	393.0	0.0	0.448	61.140	403.860	10.860
SP33	SP34	1	1	R (13) (14)	7.0	0.0071	0.020	25/10HDP	1838.0	0.374	393.0	298.0	-95.0	29.513 70.000	160.653	304.347	6.347
J10	SP35	1	7			0.0496	0.065	75/9PVC	473.0	0.249	393.0	385.0	-8.0	0.638	61.330	403.670	18.670
SP35	J11	0	6	R (15)	2.0	0.0425	0.050	63/9PVC	1277.0	0.360	385.0	363.0	-22.0	5.066 20.000	86.396	378.604	15.604
J11	SP37	1	1			0.0071	0.020	25/10HDP	48.0	0.374	363.0	364.0	1.0	0.771	87.167	377.833	13.833
J11	J12	0	5			0.0354	0.050	63/9PVC	604.0	0.300	363.0	343.0	-20.0	1.664	88.060	376.940	33.940
J12	SP38	1	1			0.0071	0.025	32/10HDP	751.0	0.245	343.0	357.0	14.0	3.680	91.740	373.260	16.260
J12	SP39	1	1	R (16)	4.0	0.0071	0.020	25/10HDP	184.0	0.374	343.0	320.0	-23.0	2.955 40.000	131.015	333.985	13.985
J12	J13	0	3			0.0212	0.040	50/9PVC	688.0	0.283	343.0	359.0	16.0	2.284	90.344	374.656	15.656
J13	SP41	1	1			0.0071	0.020	25/10HDP	79.0	0.374	359.0	345.0	-14.0	1.269	91.613	373.387	28.387
J13	J14	0	2			0.0142	0.032	40/10HDP	405.0	0.296	359.0	355.0	-4.0	2.014	92.358	372.642	17.642
J14	SP42	1	1			0.0071	0.020	25/10HDP	58.0	0.374	355.0	340.0	-15.0	0.931	93.289	371.711	31.711
J14	J15	0	1	R (17)	3.0	0.0071	0.020	25/10HDP	368.0	0.374	355.0	324.0	-31.0	5.909 30.000	128.267	336.733	12.733
J15	SP44	1	1			0.0071	0.020	25/10HDP	594.0	0.374	324.0	303.0	-21.0	9.538	137.805	327.195	24.195

Somntongo Community Supply Water Pipe Line

1 Tap Flow (Q) = 0.00708 m3/min

Pipe Line From	To	Tap pc	pcs	Reducing Tank No.	kg/cm2	Flow(Q) (m3/min)	Dia. (m)	Material	Length (m)	Velocity (m/s)	Ground Level From (m)	To (m)	Actual. H. (m)	Loss. H. (m)	Acc. Loss (m)	Water Level (m)	Total. H. (m)
RES2	J16	0	10			0.0708	0.080	90/9PVC	521.0	0.235	326.0	320.0	-6.0	0.483	0.483	325.517	5.517
J16	SP46	1	1			0.0071	0.020	25/10HDP	132.0	0.374	320.0	306.0	-14.0	2.120	2.603	323.397	17.397
J16	J17	0	9			0.0637	0.065	75/9PVC	289.0	0.320	320.0	308.0	-12.0	0.643	1.126	324.874	16.874
J17	SP47	1	1			0.0071	0.020	25/10HDP	163.0	0.374	308.0	305.0	-3.0	2.617	3.743	322.257	17.257
J17	SP49	1	8	R (18)	1.8	0.0566	0.065	75/9PVC	426.0	0.284	308.0	281.0	-27.0	0.747 18.000	19.873	306.127	25.127
SP49	J18	0	7			0.0496	0.065	75/9PVC	163.0	0.249	281.0	275.0	-6.0	0.220	20.093	305.907	30.907
J18	J19	0	3			0.0212	0.040	50/9PVC	305.0	0.283	275.0	275.0	0.0	1.013	21.106	304.894	29.894
J19	SP50	1	2			0.0142	0.032	40/10HDP	121.0	0.296	275.0	275.0	0.0	0.602	21.708	304.292	29.292
SP50	SP52	1	1			0.0071	0.020	25/10HDP	746.0	0.374	275.0	258.0	-17.0	11.979	33.687	292.313	34.313
J19	SP53	1	1			0.0071	0.020	25/10HDP	195.0	0.374	275.0	271.0	-4.0	3.131	24.237	301.763	30.763
J18	J21	0	4			0.0283	0.040	50/9PVC	1140.0	0.377	275.0	257.0	-18.0	6.717	26.810	299.190	42.190
J21	SP55	1	1			0.0071	0.025	32/10HDP	893.0	0.245	257.0	284.0	27.0	4.376	31.186	294.814	10.814
J21	SP56	1	3			0.0212	0.040	50/9PVC	1418.0	0.283	257.0	265.0	8.0	4.708	31.518	294.482	29.482
SP56	J22	0	2			0.0142	0.032	40/10HDP	48.0	0.296	265.0	266.0	1.0	0.239	31.757	294.243	28.243
J22	SP57	1	1			0.0071	0.025	32/10HDP	1024.0	0.245	266.0	275.0	9.0	5.018	36.775	289.225	14.225
J22	SP59	1	1			0.0071	0.032	40/10HDP	1707.0	0.148	266.0	286.0	20.0	2.122	33.879	292.121	6.121
		40							36208.0								

2. Calculation of equipment capacity

2.1. Calculation of capacity for each tank

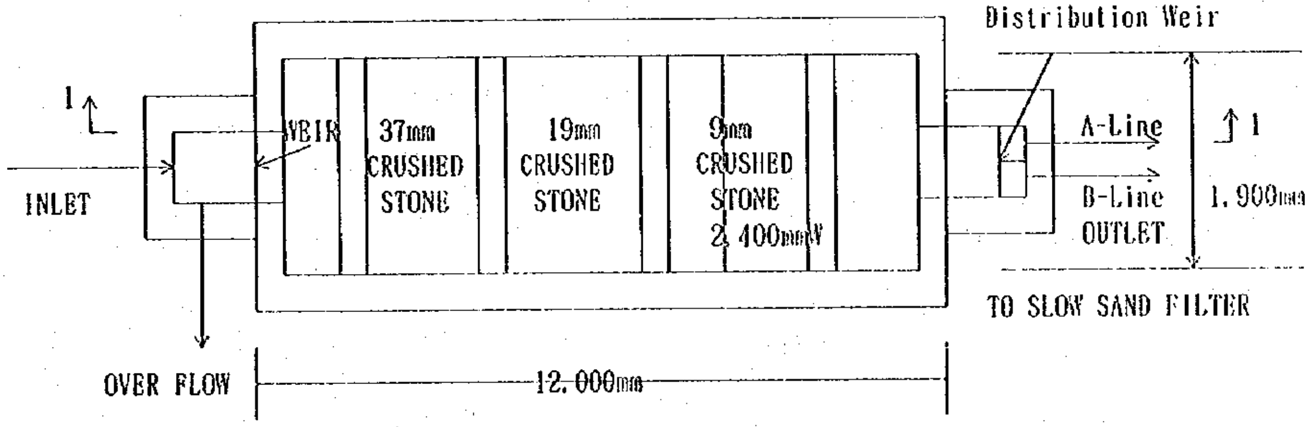
Community name	NGWAZINI	BEKHINKOSI	MSUMPE		SOMNTONGO	
Intake	Ground water	Ground water	Surface water		Ground water	
	(Well)	(Well)	(River)		(Well)	
Q(d.ave) Q(d.max) Q(h-max)	152.0 m^3/d 197.6 m^3/d 14.8 m^3/h	83.0 m^3/d 108.9 m^3/d 8.2 m^3/h	55.4 m^3/d 72.0 m^3/d 5.4 m^3/h		174.3 m^3/d 226.5 m^3/d 17.0 m^3/h	
Raw water tank	-	-	-		Q(d.max)×15min = 2.4 m^3(5.0 m^3) 1.7mφ×2.3mH=5.2 m^3/R	
Roughing filter	-	-	Retention time Q(d.max)×7hr=21.0 m^3 12.0m ×1.9m×1.0mH		-	
Distribution Q(d.max.)(m^3/d) Q(h.max.)(m^3/h) Q(h.max.)(m^3/min)			Tap ratio(4;28)		Tap ratio(10;30)	
			9.0 m^3/d 0.675 m^3/h 0.011 m^3/m	63.0 m^3/d 4.725 m^3/h 0.079 m^3/m	56.6 m^3/d 4.25 m^3/h 0.072 m^3/m	169.9 m^3/d 12.75 m^3/h 0.212 m^3/m
Slow sand filter LV=4m/d	-	-	Q(d.max) 9.0/4.0 =2.25 m^2 = 1.9mφ 2 Sets	LV = 4m/d 63.0/4.0 =15.75 m^2 = 4.5mφ 2 Sets	-	-
Reservoir tank	197.6 m^3/d ×1.5day = 296.4 m^3	108.9 m^3/d ×1.5day = 163.35 m^3	9.0 m^3/d ×1.5day = 13.5 m^3	63.0 m^3/d ×1.0day = 63.0 m^3	56.6 m^3/d ×1.5day = 84.9 m^3	169.9 m^3/d ×1.5day = 254.85 m^3
Required volume	= 300.0 m^3	= 170.0 m^3	= 20.0 m^3	= 70.0 m^3	= 90.0 m^3	≒ 265.0 m^3
Type Dimension	RC□Type (5.75 ×11.75) ×2.3 ×2 = 310.4 m^3 = 310.4 m^3	RC□Type (4.3×8.85) ×2.3 ×2 = 175.0 m^3 = 175.0 m^3	○ Type 3.8mφ × 2.0 = 22.6 m^3 - (0.3×0.3) ×2.3 = 0.2 m^3 = 22.4 m^3	○ Type 6.4mφ × 2.3 = 73.9 m^3 - (0.3×0.3) ×2.3 = 0.2 m^3 = 73.7 m^3	○ Type 7.15m φ ×2.3 = 92.3 m^3 - (0.3×0.3) ×2.3 = 0.2 m^3 = 92.1 m^3	RC□Type (5.4×11.5 ×2.3 ×2 = 274.4 m^3 = 274.4 m^3

2.2 Calculation of water Treatment Facility

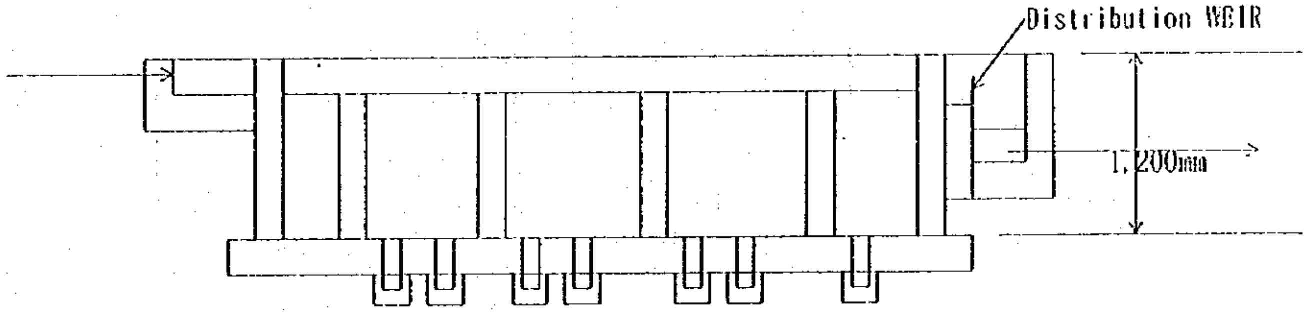
MSUMPB COMMUNITY

(1) Roughing filter

Flow (Qd.max) = 72.0 m³/d = 3.0m³/hr = 0.050m³/min = 0.83 ℓ/sec
Retention time ; Q(d.max)×7hour = 21.0m³
= (12.0L×1.9W×1.0)/(0.83 ℓ/s×1/1000×3600)
= approx. 7.0hr



HORIZONTAL ROUGHING FILTER FOR 0.83 ℓ/sec OVER FLOW



(2) Slow sand filter .

	A line	B line
Q(d.max) Filter Speed S Dimension	= 9.0 m³/d LV = 4.0 m/d S = 9.0 m³/d÷4.0m/d = 2.25m² = 1.9 mφ = 0.95×0.95×3.14 = 2.833 m²	= 63.0 m³/d LV = 4.0 m/d S = 63.0 m³/d÷4.0m³/d = 15.75m² = 4.5 mφ = 2.25×2.25×3.14 = 15.8 m²
Q'ty	= 2(1 stand-by)	= 2(1 stand-by)

(3) Reservoir tank

	A line	B line
Q(d.max)	= 9.0 m³/d	= 63.0 m³/d
Retention time Safety Ratio	= Q(d.max) ×1.0 ×α α= 1.5 = 9.0 m³/d×1.0 ×1.5 = 13.5 m³ = 20.0 m³	= Q(d.max) ×1.0 = 63.0 m³/d×1.0 = 63.0 m³ = 70.0 m³
Dimension Volume	= 3.8 mφ×2.0mh = 1.9m × 1.9m ×3.14 ×2.0mh = 22.67m³ (20m³)	= 6.4 mφ×2.3mh = (3.2m×3.2m×3.14 ×2.3mh) -(0.3m×0.3m×2.3mh) = 73.9 m³-0.21 m³ = 73.69m³
Q'ty	1	1

2.3. Power calculation of pump

1. Shaft power calculation for well pump and transmission pump

Shaft power required to operate pump is given in the following calculation

$P = Pw/\eta P = (0.163 \times \gamma \times Q \times H)/\ \eta P$ (1)

P	: Pump shaft power	(kw)
Pw	: Theoretic power	
γ	: Specific gravity of the liquid	1.0
Q	: Pump discharge rate	(m^3/min)
H	: Total head of pump	(m)
ηP	: Effective of pump	(%)

(NGWAZINI COMMUNITY well pump)

Q(d.max) = (197.6m^3/d)÷20hr/d = 9.88m^3/hr = 0.165 m^3/min ————> 0.165m^3/min

H = 100.0m ηP = 60%

P = (0.163×1.0×0.165×100.0)/0.60 = 4.483 kw

(BEKHINKOSI COMMUNITY well pump)

Q(d.max) = (108.9m^3/d)÷20hr/d = 5.445m^3/hr = 0.091m^3/min ————> 0.165m^3/min

H = 100.0m ηP = 60%

P = (0.163×1.0×0.165×100.0)/0.60 = 4.483 kw

(SOMNTONGO COMMUNITY well pump)

Q(d.max) = (226.5m^3/d)÷20hr/d = 11.33m^3/hr = 0.189 m^3/min

H = 30.0m ηP = 50%

P = (0.163×1.0×0.189×30.0)/0.50 = 1.848 kw

Shaft power calculation for transmission pump

Q(d.max) = (226.5m^3/d)÷20hr/d = 11.33m^3/hr = 0.189 m^3/min

Separated 2 line (Tap Raitio = A-line 10 taps ; B-line 30 Taps)

A-line Q = 0.048m^3/min. → 0.05m^3/min. H = 110.0m ηP = 45%

P = (0.142×1.0×0.05×110.0)/0.45 = 1.993 KW

B-line Q = 0.142m^3/min. H = 245.0m ηP = 50%

P = (0.163×1.0×0.142×245.0)/0.50 = 11.342 KW

2. Motor output calculation

Motor output is determined by the calculation shown in (2) considering a safety factor.

$$R = \{P \times (1+\alpha)\} / \eta t \qquad (2)$$

R	:Motor output	kw
P	:Shaft out of motor	kw
α	:Shaft factor	0.15
ηt	:Conductivity efficiency	Direct connection = 1

(NGWAZINI COMMUNITY well pump)

P = 4.483 kw

R = {4.483 ×(1+0.15)} /1 = 5.155 kw ——→ 5.5 kw

(BEKHINKOSI COMMUNITY well pump)

P = 4.483 kw

R = {4.483 ×(1+0.15)} /1 = 5.155 kw ——→ 5.5 kw

(SOMNTONGO COMMUNITY well pump)

P = 1.848 kw

R = {1.848 ×(1+0.15)} /1 = 2.125 kw ——→ 3.7 kw

(SOMNTONGO COMMUNITY transmission pump)

A-line P = 1.993 kw

R = {1.993 ×(1+0.15)} /1 = 2.292 kw ——→ 3.7 kw

B-line P =11.342 kw

R = {11.342×(1+0.15)} /1 =13.043 kw ——→ 15.0 kw

3. Water Hammer Analysis for Water Transmission Pipeline

A. NGWAZINI COMMUNITY

From well pump check valve to the reservoir

(1) Well pump data

Power of motor		5.5	kw
Cycle		50	hz
Actual head (Ha)		52.2	m
Loss head		4.093	m
Total head	(Ht)	56.293	m
Flow	Q(d.max)	0.165	m^3/min (= 197.0m^3/d ÷ 20hr ≒ 0.165m^3/min)
			ηP = 0.6
rpm	N	2,900	rpm
pump set	n	1	set

(2) Transmission pipeline deta

Pipe length (100 mm) 790 m (From well side check valve to reservoir)
PVC Pipe(110/12) t = 6.3 mm

(50 mm) 45 m (Discharge pipe of Well Pump)
Carbon steel pipe(SGP) t = 3.8 mm

(3) Calculation

GD^2 = 0.05 ×5.5×2 pole = 0.55 kg- m^2

Inertia coefficient k = $(1.79\times10^6\times56.3\times0.165)/(60\times0.6\times0.55^2\times2900^2\times1)$
= 0.182

Loss percentage R = (56.293 - 52.2)/56.293×100 = 7.27%

Pressure propagation speed a = $(1420)/\sqrt{1+(0.69\times100/6.3)}$
≒ 411

Inner pipe velocity V = $0.165/(60\times3.14/4\times0.1^2)$
= 0.350 m/sec

Conduit constant 2ρ = (411×0.350)/(9.8 ×56.3) = 0.26

Surge coefficient S = 0.182×(2×790/411) = 0.7

Therefore, the followings are given by the water hammer effect calculation of Parmakian.

From (a)	Pressure drop just after the water well.	-50%×56.3 m = -28.2 m
From (b)	Pressure drop at the center of conduit.	-30%×56.3 m = -10.9 m
From (c)	Pressure rise just after the water well.	+10%×56.3 m = + 5.6 m
From (d)	Pressure rise at the center of conduit.	+ 7%×56.3 m = + 3.9 m

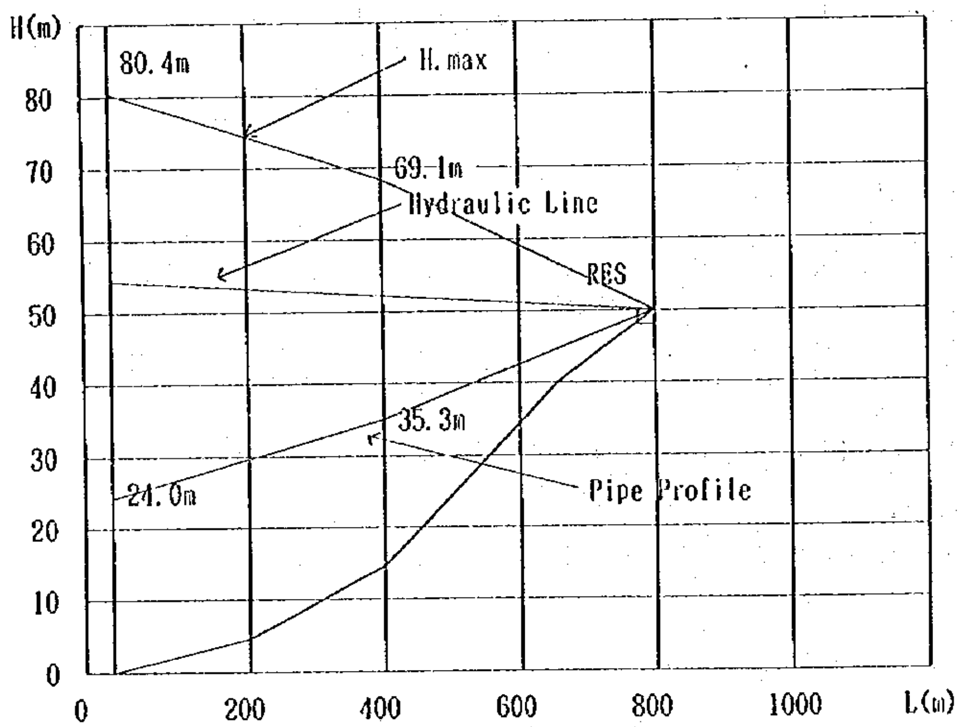
The above calculation is subject to no provision of check valve .

Lowest pressure just after the well = 52.2 - 28.2 = 24.0 m
Highest pressure just after the well = 52.2 + 5.6 = 57.8 m

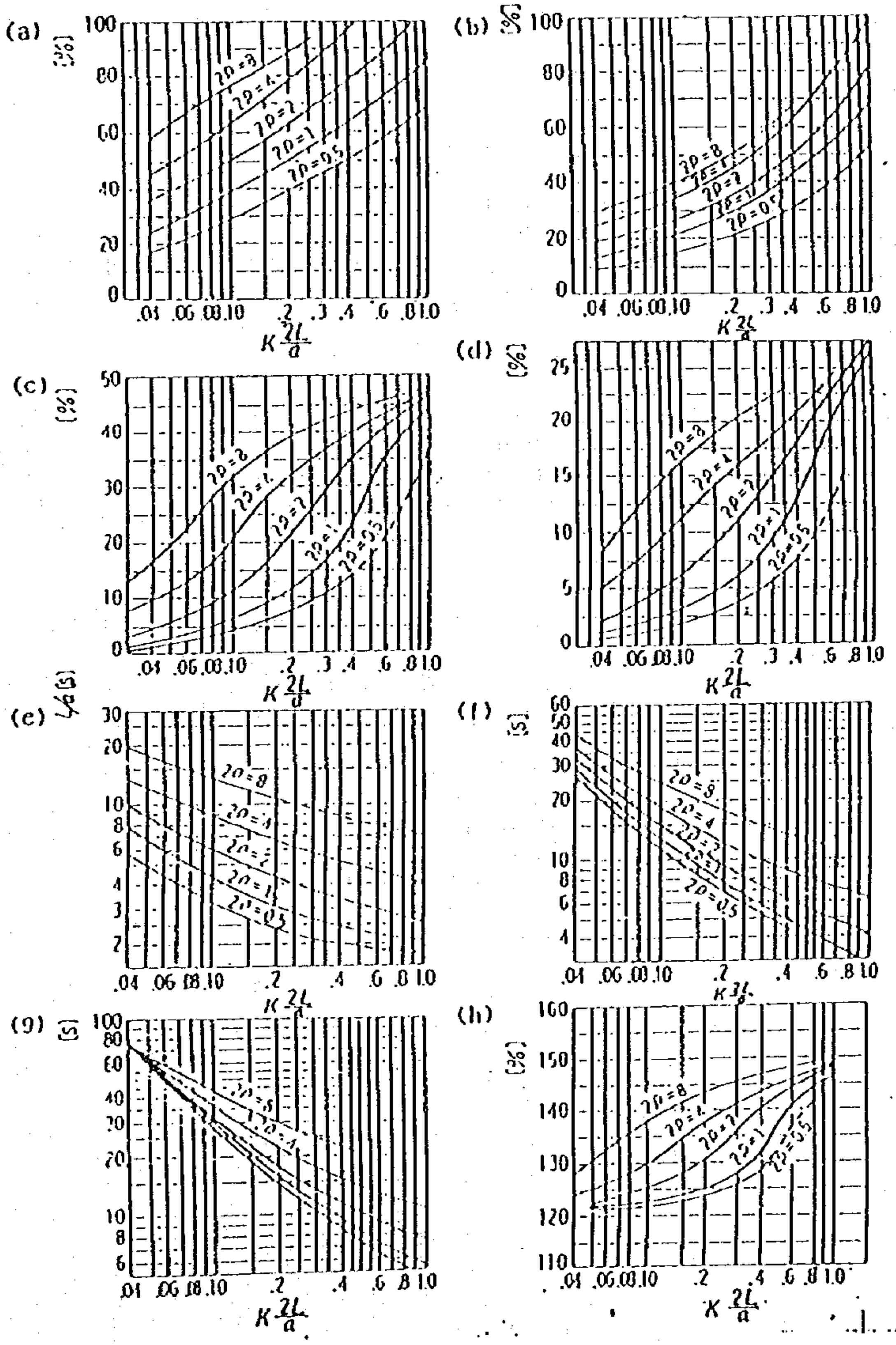
In case of the check valve provided, the pressure rises by dropped pressure.

Lowest pressure just after the well = 52.2 - 28.2 = 24.0 m
Highest pressure just after the pump = 52.2 + 28.2 = 80.4 m
Lowest pressure at the center of conduit = 52.2 - 16.9 = 35.3 m
Highest pressure at the center of conduit = 52.2 + 16.9 = 69.1 m

WATER HAMMER PRESSURE CURVE (NGWAZINI COMMUNITY)



1. Can the conduit stand against the highest pressure?
   … PVC Pipe(110/12) of 8kg/ cm² approx. is to be installed.
2. The water hammer resistant check valve is to be installed.


(a)
(b)
(c)
(d)
(e)
(f)
(g)
(h)
K 2L/a

B. BEKHINKOSI COMMUNITY .

From well pump check valve to the reservoir tank

(1) Well pump data

Power of motor		5.5	kw
Cycle		50	hz
Actual head (Ha)		31.5	m
Loss head		6.807	m
Total head	(Ht)	39.452	m
Flow	Q(max)	0.165	m^3/min (= 83.8m^3/d÷20h = 0.091m^3/min)
	ηP	0.6	(=NGWAZINI Well Pump ———→0.165m^3/min)
rpm	N	2,900	rpm
pump set	n	1	set

(2) Transmission pipeline data

Pipe length 1,140 m

Pipe diameter 80 mm 90/12PVC Pipe t = 5.1 mm

(From the well side check valve to the reservoir tank)

(3) Calculation

GD^2 = 0.05 ×5.5×2 pole = 0.55 kg-m^2

Inertia coefficient k = $(1.79\times10^6\times39.5\times0.165)/(60\times0.6\times0.55^2\times2900^2\times1)$

= 0.127

Loss percentage R = (39.452 - 31.5)/39.452×100 = 20.2%

Pressure propagation speed a = $(1420)/\sqrt{1+(1\ (0.69\times80/5.1)}$

= 413

Inner pipe velocity V = $0.165/(60\times3.14/4\times0.08^2)$

= 0.548 m/sec

Conduit constant 2ρ = (413×0.548)/(9.8×39.5) = 0.58

Surge coefficient S = 0.127 ×(2×1,140/413) = 0.7

Therefore, the followings are given by the water hammer effect calculation of Parmakian.

From (a)	Pressure drop just after the water well.	-60%×39.5	= -23.7 m
From (b)	Pressure drop at the center of conduit.	-40%×39.5	= -15.8 m
From (c)	Pressure rise just after the water well.	+25%×39.5	= + 9.9 m
From (d)	Pressure rise at the center of conduit.	+15%×39.5	= + 5.9 m

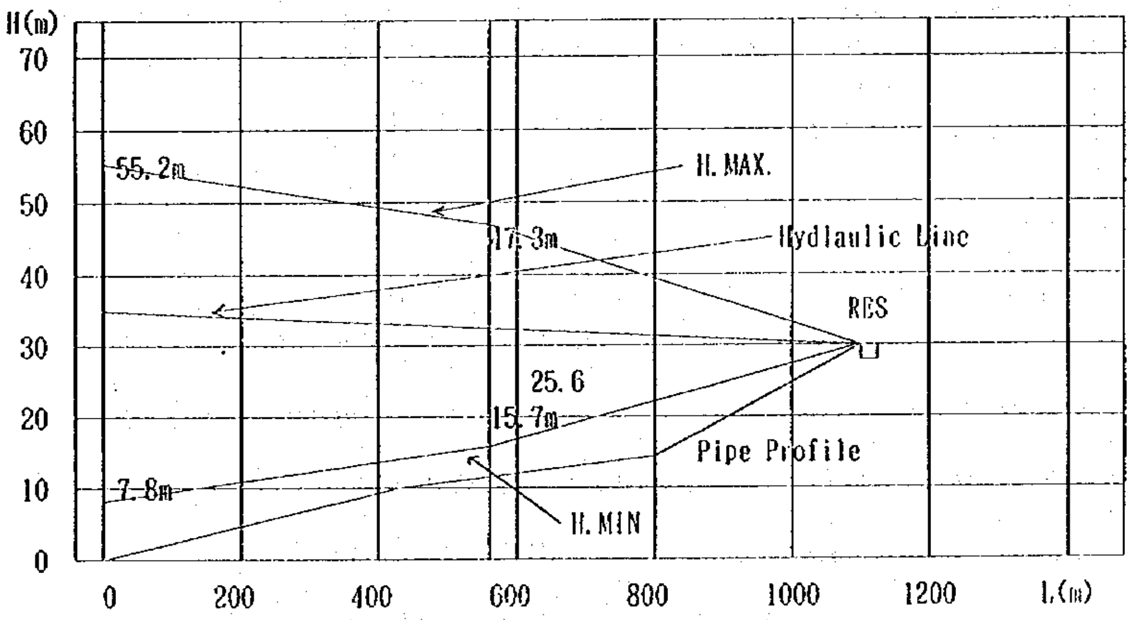
The above calculation is subject to no provision of check valve .

Lowest pressure just after the well = 31.5 -23.7 = 7.8 m
Highest pressure just after the well = 31.5 + 9.9 = 41.4 m

In case of the check valve provided, the pressure rises by dropped pressure.

Lowest pressure just after the well = 31.5 - 23.7 = 7.8 m
Highest pressure just after the pump = 31.5 + 23.7 = 55.2 m
Lowest pressure at the center of conduit = 31.5 -15.8 = 15.7 m
Highest pressure at the center of conduit = 31.5 +15.8 = 47.3 m

WATER HAMMER PRESSURE CURVE (BEKHINKOSI COMMUNITY)



1. Since the highest pressure is not more than 6kg/ cm² and 110/12PVC pipe is to be installed and ordinary check valve can be used.

C. SOMNTONGO COMMUNITY

(1) B-line (265m^3 reservoir) transmission pump data

Power of motor		15.0 kw
Cycle		50 hz
Actual head (Ha)		237.5 m
Loss head		1.565 m
Total head	(Ht)	239.065 m
Flow	Q(d.max)	0.142 m^3/min ηP ;50%
rpm	N	2,900 rpm
pump set	n	2 set (1 set stand-by)

(2) B-line feeding pipe line data

Pipe total length 4,270 m (From booster pump to reservoir)

Diameter of pipe 125 mm STPG38 sch-80 t = 9.5 mm

(3) Each coefficient

k ;	Cubical elasticity of water	kg/mm^2
E ;	Sub-elasticity coefficient of piping material	kg/mm^2
t ;	Thickness of pipe	9.5 mm
g ;	Acceleration of gravity	9.8 m/sec^2
K/E;	Steel pipe	0.01

(4) Calculation

GD^2	= 0.05×15.0×2 poles = 1.5kg-m^2 GD^2 : Flywheel effect of rotation part kg-m^2
Inertia coefficient k	$k = (1.79 \times 10^6 \times Ht \times Qo)/(60 \times \eta P \times GD^2 \times N^2 \times n)$
Loss percentage R(%)	$R = (Ht-Ha)/Ht \times 100$
Pressure propagation speed a(m/sec)	$a = (1420)/(\sqrt{1 + k/E \times D/t})$
Inner conduit water velocity V(m/sec	$V = Qo/(60 \times 3.14/4 \times D^2)$
Conduit constant 2ρ	$2\rho = (a \times V)/(g \times Ht)$
Surge coefficient S	$S = k \times (2L/a)$

(Calculation result)

Inertia coefficient k = $(1.79\times10^6\times239.0\times0.142)/(60\times0.50\times1.5^2\times2,900^2\times1)$
= 0.106

Loss percentage R = $(239.0-237.5)/(239.0)\times100$
= 0.63%

Pressure transmission speed a = $1420/\sqrt{1+0.01\times125/9.5}$
= 1,335 m/sec

Water velocity in pipe V = $0.142/(60\times3.14/4\times0.125^2)$
= 0.192 m/sec

Conduit constant 2 ρ = $(1,335\times0.192)/(9.8\times239.0)$
= 0.11

Surge coefficient S = $0.106\times(2\times4,270/1,335)$
= 0.678

① Pressure rise when the valve is quickly closed $\triangle h$m

$\triangle h = (a\ V)/g$ subject to ($T\leqq 2L/a$ ··· $2\times4270/1335 = 6.4$ sec)

a ; Transmission speed of pressure wave m/sec
V ; Water velocity in pipe (Reverse flow velocity just before valve is closed) = 1.1 m/s
T ; Closing time of valve S
L ; Conduit length m

$\triangle h = (1,335\times1.1)/9.8 = 149.8$ m

② Pressure rise when the valve is slowly closed $\triangle h$m

$\triangle h = 1/2\times n(n+\sqrt{n^2+4})\times Ht$

n = LV/gTHt subject to ($T\geqq 2L/a$··· = $2\times4270/1335 = 6.4$ sec)

Ht = Height from the valve to water tank = total head 243 m

V = Water velocity just before the valve is closed. V = 1.3 m/s T = 5 sec

$n = 4,270\times0.192/9.8\times5\times239.0 = 0.07$

$\triangle H = 1/2\times0.07\ (0.07+\sqrt{(0.07)^2+4})\times239.0 = 16.74$ m

③ Calculation of pressure rise by the water hammer calculation in Parmakian.

Turnaround time of pressure wave μ = 2L/a (sec)

Conduit coefficient 2ρ = aV/gHt = (1335 ×0.192)/9.8×239.0 = 0.11
(Pressure rise ratio in case of the valve quickly closed)

Inertia effect coefficient of rotating part K

$K = (187.5M_0)/(GD^2\ N_0)$ sec^{-1}

$M_0 = 972\times(P_0/N_0)$

M_0 ; Torque while normally operating kg-m

P_0 ; Shaft power while normally operating kw

GD^2 ; Flywhile effect of rotating part kg-m²

N_0 ; Rotation 2,900 rpm

P_0 = 0.163 ×(0.142×239.0)/0.50 = 10.99 kw

M_0 = 972 × 10.99/2,900 = 3.68 kg-m

L = 4,270 m a = 1,335 m/s V = 0.192 m/s

GD^2 = 1.5 kg-m²

μ = (2×4,270)/1,335 = 6.297 sec

2ρ = (1,335×0.192)/(9.8×239.0) = 0.11

K = (187.5×3.68)/(1.5² ×2,900) = 0.106 sec-1

S = K(2L/a) = 0.106×(2×4,270)/1,335 = 0.678

Therefore, water hammer effect in Parmakian is given as follows.

From (a)	Pressure drop just after the pump.	-50% ×239.0	= -119.5 m
From (b)	Pressure drop at the center of conduit.	-30% ×239.0	= -71.7 m
From (c)	Pressure rise just after the pump.	+15% ×239.0	= +35.9 m
From (d)	Pressure rise at the center of conduit.	+10% ×239.0	= +23.9 m
From (e)	Time required until reverse flow starts.	1×L/a = 1 ×4270/1335	= 3.2sec
From (f)	Time required until the pump stops.	2×L/a = 2 ×4270/1335	= 6.4sec
From (g)	Time required until the pump reaches at maximum reverse.	4×L/a = 4 ×4270/1335	= 12.8sec
From (h)	Maximum reverse rotation of the pump.	130%×N = 1.3×2900	= 3,770 rpm

The above calculation is subject to no provision of check valve with the pump.

Lowest pressure just after the pump = 237.5 - 119.5 = 118.0 m

Lowest pressure at the center of conduit = 237.5 - 71.7 = 165.8 m

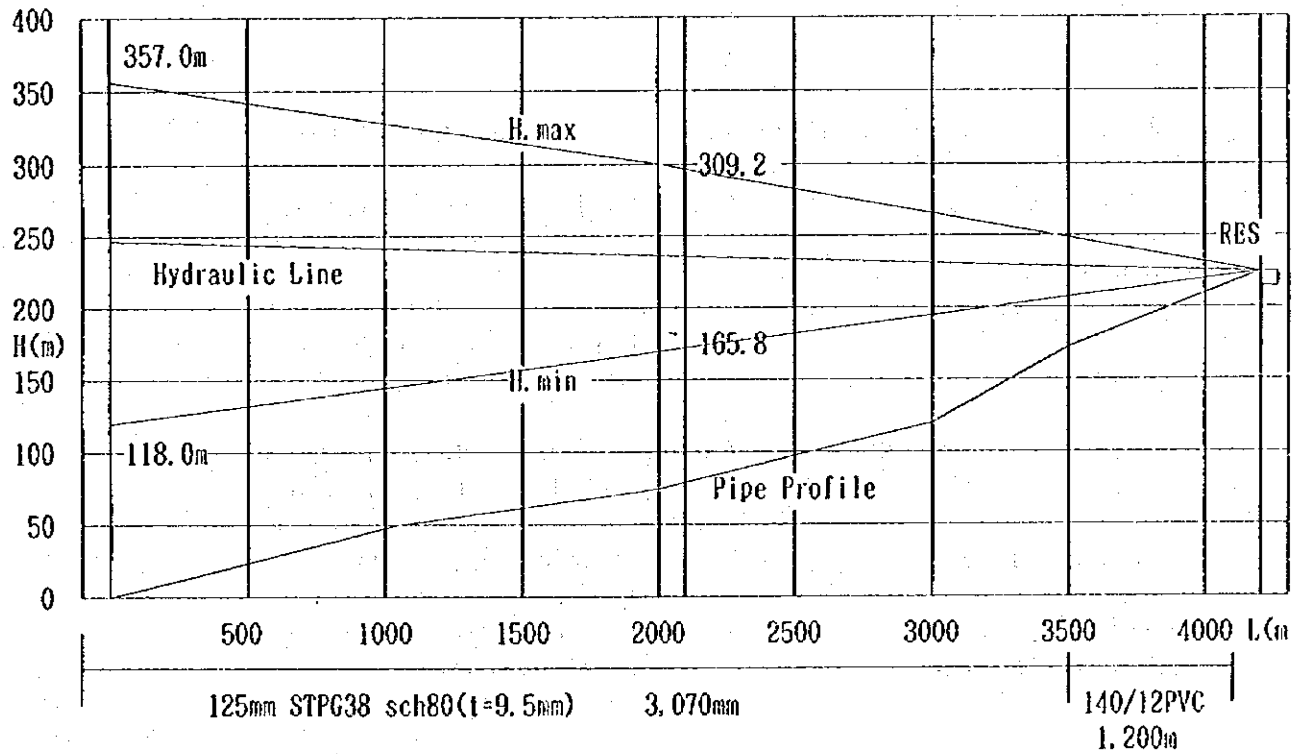
Highest pressure just after the pump = 237.5 + 35.9 = 273.4 m

Highest pressure at the center if conduit = 237.5 + 23.9 = 261.4 m

In case of the check valve provided, the pressure rises by dropped pressure if the valve is quickly closed simultaneously when the back flow starts (which means back flow never happens.)

Lowest pressure just after the pump 237.5 - 119.5 = 118.0 m
Lowest pressure at the center of conduit 237.5 - 71.7 = 165.8 m
Highest pressure just after the pump 237.5 + 119.5 = 357.0 m
Highest pressure at the center of conduit 237.5 + 71.7 = 309.2 m

WATER HAMMER PRESSURE CURVE (SOMUNTOGO COMMUNITY B-Line)



1. Can the conduit stand against the maximum pressure?
   In order for steel pipe to stand against the max. pressure of about 36.0kg/cm², pressure resistant steel pipe (STPG38-sch80) is to be installed by 3,070m from the pump and PVC pipe(140/12)is to be installed for the rest.
2. The water hammer resistant check valve is to be provided.

D. SOMTONGO COMMUNITY

(1) A-line Transmission Pump data (*1;Calculation = Case of used spare pump)

Power of motor			15.0 kw (*1)
Cycle			50 hz
Actual head (Ha)			98.5 m
Loss head			3.716 m
Total head			102.216 m
Flow	(Q)	*1	0.142 m³/min ηP ;50% *1;Spare pump flow
rpm	N		2,900 rpm
pump set	n		1 set

(2) A-line Transmission pipeline data (From transmission Pumpp to reservoir)

Pipe total length	1,200 m		
Diameter of pipe	100 mm	110/12PVC	t = 6.3 mm

(3) Calculation

GD^2 $= 0.05 \times 15.0 \times 2$ poles $= 1.5$ kg-m²

Inertia coefficient k $k = (1.79 \times 10^6 \times 102.2 \times 0.142)/(60 \times 0.5 \times 1.5^2 \times 2900^2 \times 1)$
$= 0.045$

Loss percentage R(%) $R = (102.216 - 98.5)/102.216 \times 100 = 3.64\%$

Pressure propagation speed $a = (1420)/\sqrt{1 + (0.69 \times 100/6.0)}$
$= 402$

Inner conduit water velocity $V = 0.142/(60 \times 3.14/4 \times 0.1^2)$
$= 0.301$ m/sec

Conduit constant $2\rho = (402 \times 0.301)/(9.8 \times 102.2) = 0.12$

Surge coefficient $S = 0.045 \times (2 \times 3,200/402)$
$= 0.72$

Therefore, water hammer effect in Parmakian is given as follows.

From (a)	Pressure drop just after the pump.	-50% ×102.2 = -51.1 m
From (b)	Pressure drop at the center of conduit.	-30% ×102.2 = -30.7 m
From (c)	Pressure rise just after the pump.	+15% ×102.2 = +15.3 m
From (d)	Pressure rise at the center of conduit.	+10% ×102.2 = +10.2 m

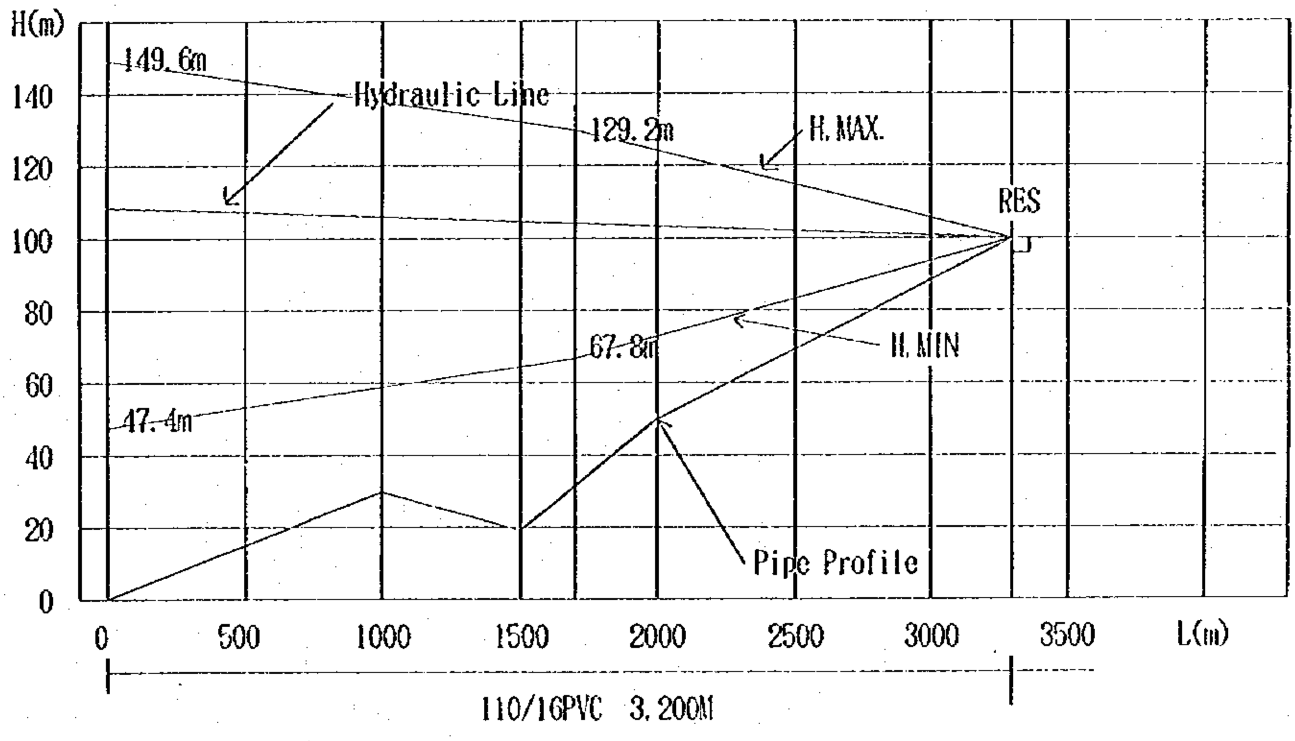
The above calculation is subject to no provision of check valve with the pump.

Lowest pressure just after the pump = 98.5 - 51.1 = 47.4 m
Highest pressure just after the pump = 98.5 + 15.3 = 113.8 m

In case of the check valve provided, the pressure rises by dropped pressure.

Lowest pressure just after the pump	98.5 - 51.1 = 47.4 m
Lowest pressure at the center of conduit	98.5 + 51.1 = 149.6 m
Highest pressure just after the pump	98.5 - 30.7 = 67.8 m
Highest pressure at the center of conduit	98.5 + 30.7 = 129.2 m

WATER HAMMER PRESSURE CURVE (SOMNTOGO COMMUNIY A-Line)



1. Can the conduit stand against the maximum pressure?
   In order for steel pipe to stand against the max. pressure of about 15.0kg/cm², PVC pipe(110/16) is to be installed.
   Ordinary galvanized steel pipe is to be installed in the house.
2. The water hammer resistant check valve is to be provided.

7. REFERENCES

List of Collected Material

1.Maps

1-1 Geographical Map (1:250,000)
1-2 Geological Map (1:250,000)
1-3 Hydrogeological Map (1:250,000)
1-4 Hydrogeological Map (Sheet 1-31) (1:50,000)
1-5 Topographical Map (Sheet 1-31) (1:50,000)
1-6 Borehole Location Map (1:250,000)
1-7 Reticulation Map (1:250,000)

2.General Conditions

2-1 Development Plan (1994/95-1996/97)
2-2 Metorological Data (Extracts)
2-3 Report on the 1986 Swaziland Population Census (Vol.3,4)
2-4 Report on the Swaziland Population Projections (1986-2016)
2-5 National Income and Expenditure Survey 1985 (抜粋)
2-6 Report on the 1991 Demographic and Housing Survey (Vol.1)

3.Rural Water Supply

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3-2 Water Act (1967)
3-3 Guidelines for Drinking Water Quality in Swaziland (1984)
3-4 Guidelines and Procedures for Approval of Rural Water Supplies (1986)
3-5 RWSB Satndard Design
3-6 Breakdown of Recurrent Budget and Expenditure of RWSB (1991/92-1993/94)
3-7 Inventory of RWSB Water Supply Facility (1975-1991)
3-8 Review on Progress towards "Sustainable Manitenance System for Rural Water Supplies in Swaziland" (1993)
3-9 Report from the Participatory Evaluation of the Government of Swaziland/UNDP, Rural Water Supply and Sanitnaion (1994)
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3-12 Rural Water Supply (EU/LomeⅢ) Report on Third Community Training Seminar (1991)

3-13 Financing Agreement between the European Economic Community and the Kingdome of Swaziland (1988)

3-14 Tender Documents for Rural Water Supply Scheme I (EU/1990) (Extracts)

3-15 Groundwater Resources of Swaziland (CIDA & Geology/1992)

3-16 Groundwater Resources Unit Annual Report (1993)

3-17 Development, South Africa & the European Union (1994)

3-18 H_2O Drilling Cost Estimation

3-19 Swaziland Groundwater Cost Estimation

3-20 GEOTECH Cost Estimation

3-21 Afridev Handpump Specification

4.Hygiene

4-1 Hygiene and Environmental Education and Implementation Project (UNICEF/1994)

4-2 Government of the Kingdom of Swaziland and UNICEF Programme of Cooperation 1996-2000 (Draft)

4-3 How to Build a Pit Latrine

4-4 Outpatient Annual Statistical Report 1992

4-5 Outpatient Monthly Summary 1994

4-6 Inpatient Information 1993

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