THE HORTICULTURAL DEVELOPMENT PROJECT
IN
THE KINGDOM OF NEPAL

DESIGN CALCULATION NOTE
ON
THE CONSTRUCTION
OF
DEMONSTRATION FARMS
IN
NEPALGUNJ AND SINDHULI SUB-CENTERS

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

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I. GENERAL

This note presents the design calculations made for designs of the demonstration farms for the Nepalgunj Sub-center and the Sindhuli Sub-center. The note is to be read in conjunction with Design Report, Design Drawings and Tender Documents for the project.

II. IRRIGATION WATER REQUIREMENTS

2.1 Calculation Procedures

Irrigation water requirements for grapes and junar are estimated in the following manner by using the methods which are suggested in "Crop Water Requirements" published by FAO of the United Nations, 1977.

(1) Calculate potential evapotranspiration (ETo) by using Blaney-Criddle Method, Radiation Method, Modified Penman Method and Pan Evaporation Method, and employ the mean value of their results.

(2) Multiply ETo by crop factors to obtain crop evapotranspirations.

(3) Deduct the effective rainfall from the crop evapotranspiration to obtain the crop water requirements.

(4) Divide the crop water requirements by field efficiency to obtain field water requirements.

(5) Estimate application interval from relationship of crop water requirement and readily available soil water.

2.2 Crop Water Requirements

Calculation of the potential evapotranspiration is carried out by using the following methods.

(1) Blaney-Criddle method

$$ETo = C[P(0.46T + 8)] \quad mm/day$$

Where, T : Mean temperature (°C)

P : Mean daily percentage of total annual day time hours

(2) Radiation Method

$$ETo = C(W \cdot Rs) \quad \text{mm/day}$$

Where, Rs : Solar radiation in equivalent evaporation

W : Weighting factor which depends on temperature and altitude

C : Adjustment factor

$$Rs = (0.25 + 0.50n/N)Ra$$

Where, n/N : Ratio between actual measured bright sunshine hours and maximum possible sunshine hours

Ra : Amount of radiation received at the top of the atmosphere

(3) Modified Penman Method

$$ETo = C[W \cdot Rn + (1-W) \cdot f(u) \cdot (ea-ed)]$$

Where, ETo : Potential evapotranspiration, mm/day

W : Temperature-related weighting factor

Rn : Net radiation in equivalent evaporation, mm/day

f(u): Wind-related function

(ea-ed): Difference between the saturation vapour pressure at mean air temperature and the mean actual vapour pressure of the air, mbar

C : Adjustment factor to compensate for the effect of day and night weather conditions

(4) Pan Evaporation Method

$$ETo = Kp \cdot Epan$$

Where, Epan : Pan evaporation, mm/day

Kp : Pan coefficient

Crop factor (Kc) for grapes and citras (Junar) is quoted from "Crop Water Requirements", FAO paper No. 24.

2.3 Irrigation Efficiency

Irrigation efficiency for sprinkler irrigation and furrow irrigation is estimated as follows:

Irrigation Efficiency

Description	Sprinkler Irrigation	Furrow Irrigation
	(%)	(%)
1) Field efficiency	85	65
2) Conveyance efficiency	90	80
3) Irrigation efficiency 1) x 2) x 1/100	76.5	52

Irrigation water requirements of grapes and junar are estimated as shown in Tables 2.1 and 2.2.

2.4 Application Interval

Application interval is estimated in following equation:

$$I = \frac{(P \cdot Sa) \cdot D}{ETcrop}$$

Where, I : Application Interval, days

P : Fraction of available soil water, 0.35

Sa : Available soil water, mm
Sa = Sfc - Sfw

Sfc : Field capacity, mm

Sfw : First wilting point, mm

P·Sa : Readily available soil water, mm/m

D : Rooting depth, m

ETcrop: Peak crop water requirement

Calculation results are shown in Table 2.3.

Table 2.1 Irrigation Water Requirements for Grapes

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
	Initial	leave											
				Flowering		Harvesting							
1. Crop Coefficient, Kc	0.25	0.45	0.60	0.70	0.70	0.65	0.55	0.45	0.35	-	-	-	-
2. Potential Evapotranspiration, ETo (mm/day)	2.30	3.40	4.60	6.10	7.10	6.00	4.90	4.50	4.20	4.10	3.10	2.50	52.80
3. Crop Water Requirements ETcrop = Kc·ETo (mm/day)	0.58	1.53	2.76	4.27	4.97	3.90	2.70	2.03	1.47	-	-	-	24.21
4. Effective Rainfall (mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Field Efficienty (%)	85	85	85	85	85	85	85	85	85	85	85	85	-
6. Field Water Requirement F.W.R = ETcrop/0.85 (mm/day)	0.68	1.80	3.25	5.02	5.84	4.59	3.18	2.39	1.73	-	-	-	28.48
7. Conveyance Efficiency (%)	90	90	90	90	90	90	90	90	90	90	90	90	-
8. Irrigation Water Requirement I.W.R. = F.W.R./0.90 (mm/day)	0.76	2.00	3.61	5.58	6.50	5.10	3.53	2.66	1.92	-	-	-	31.66
" (l/s/ha)	0.09	0.23	0.42	0.65	0.75	0.59	0.41	0.31	0.22	-	-	-	-

Table 2.2 Irrigation Water Requirements for Junar Nursery

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1. Crop Coefficient, Kc	0.55	0.55	0.50	0.50	0.50	0.45	0.45	0.45	0.45	0.45	0.50	0.50	-
2. Potential transpiration, ETo (mm/day)	2.00	2.60	3.60	4.50	5.20	4.50	4.00	4.00	3.50	3.50	2.70	2.10	42.20
3. Crop Water Requirements ETcrop = Kc·ETo (mm/day)	1.10	1.40	1.80	2.30	2.60	2.00	1.80	1.80	1.60	1.60	1.40	1.10	20.50
4. Effective Rainfall (mm/day)	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Field Efficiency (%)	65	65	65	65	65	65	65	65	65	65	65	65	-
6. Field Water Requirement F.W.R. = ETcrop/0.65 (mm/day)	1.70	2.15	2.77	3.54	4.00	3.08	2.77	2.77	2.46	2.46	2.15	1.70	31.54
7. Conveyance Efficiency (%)	80	80	80	80	80	80	80	80	80	80	80	80	-
8. Irrigation Water Requirement I.W.R. = F.W.R./0.80 (mm/day)	2.13	2.69	3.46	4.43	5.00	3.85	3.46	3.46	3.08	3.08	2.69	2.13	39.42
" (l/sec/ha)	0.25	0.31	0.40	0.51	0.58	0.45	0.40	0.40	0.36	0.36	0.31	0.25	-

Table 2.3 Application Interval

	GRAPES (Nepalgunj Sub-center)	JUNAR (Sindhuli Sub-center)
1. Field capacity, Sfc (mm)	130	130
2. First wilting point, Sfw (mm)	50	50
3. Available soil water, Sa (mm)	80	80
4. Readily available soil water, P·Sa (mm/m)	28	28
5. Rooting depth, D (m)	1.0	0.5
6. Peak crop water requirement (mm/day)	4.97	2.6
7. Application interval, I (days)	5.63	5.38

III. DRAINAGE WATER REQUIREMENT

3.1 Calculation Procedures

Drainage water requirements of Nepalgunj Sub-center and Sindhuli Sub-center are estimated by using MacMath's formula suggested in "Drainage Manual", USBR. Calculation is carried out by the following manner.

(1) Estimate the daily rainfall with 5-year return period.

(2) Estimate the rainfall intensity for the time of flood concentration.

(3) Estimate the darinage water requirement by using MacMath's formula.

3.2 Design Rainfall

Daily rainfalls with 5-year return period at the Nepalgunj Sub-center and the Sindhuli Sub-center are estimated at 200mm/day and 150mm/day, respectively by using Tomas plots and Hazen plots methods on the basis of daily rainfall records observed at the Nepalgunj Agricultural Station and the Tulsi Meteorological Station which is located near the Sindhuli Sub-center.

Rainfall intensity for the time of flood concentration is calculated by the following equations:

$$I = \frac{R_{24}}{24}\left(\frac{24}{T}\right)^{\frac{2}{3}}$$

$$T = L/W$$

$$W = 72(H/L)^{0.6}$$

Where, I : Rainfall intensity, mm/hr

R_{24}: Daily rainfall with 5-year return period, mm/day

T : Time of flood concentration, hr

L : Length of channel, m

H : Fall between the farthest contributing point and the point of concentration, m

3.3 Drainage Water Requirements

MacMath's formula is defined as follows:

$$Q = 9.15 \times 10^{-3} \times C \times I \times S^{\frac{1}{5}} \times A^{\frac{4}{5}}$$

Where, Q : Flood discharge, m^3/sec

C : Coefficient representing the basin characteristics

I : Rainfall intensity for the time of flood concentration, mm/hr

S : Slope between the furthest contributing point and the point of concentration

A : Area of basin, ha

Weighted drainage basin factors for determining C

Runoff conditions	Vegetation	Soils	Topography
Low	0.08 (well grassed)	0.08 (sandy)	0.04 (flat)
Moderate	0.12 (good coverage)	0.12 (light)	0.06 (gently sloping)
Average	0.16 (good to fair)	0.16 (medium)	0.08 (sloping to hilly)
High	0.22 (fair to sparse)	0.22 (heavy)	0.11 (hilly to steep)
Extreme	0.30 (sparse to bare)	0.30 (heavy to rock)	0.15 (steep)

(1) Nepalgunj Sub-center

a) Drainage requirement for the Belhaniya stream

Drainage area and fall of the Belhaniya stream are 13.45Km^2 and 4.5m per 9.5Km, respectively. The rainfall intensity for the stream is calculated to be 12.52mm/hr as shown below:

$$W = 72 \times (4.5 \times 10^{-3}/9.5)^{0.6}$$
$$= 0.729 \quad \text{Km/hr}$$

$$T = 9.5/0.729$$
$$= 13.03 \quad \text{hr}$$

$$I = \frac{200}{24}\left(\frac{24}{13.03}\right)^{\frac{2}{3}}$$
$$= 12.52 \quad \text{mm/hr}$$

Therefore, the drainage requirement of the Belhaniya stream is calculated to be 2.37m^3/sec applying the above McMath's formula.

$$Q = 9.15 \times 10^{-3} \times 0.3 \times 12.52 \times (4.7 \times 10^{-4})^{\frac{1}{5}} \times 1345^{\frac{4}{5}}$$
$$= 2.37\text{m}^3/\text{sec}$$

b) Drainage requirement for the project area

The drainage requirement for the project area of Nepalgunj Sub-center is calculated at 0.30m^3/sec assuming that the time of concentration is 1.0 hr as summarized in the attached Table 3.1.

(2) Sindhuli Sub-center

The drainage requirement of the Sindhuli Sub-center is estimated dividing the drainage area into steep portion of about 0.866 ha located west adjacent to the proposed farm and rather flat portion of about 1.58 ha. The drainage requirement for each portion is calculated to be 0.159m^3/sec for the steep portion and 0.065m^3/sec for the flat portion assuming that the time of concentration is 1.0 hr as summarized in the attached Table 3.1.

3.4 Design Drainage Discharge

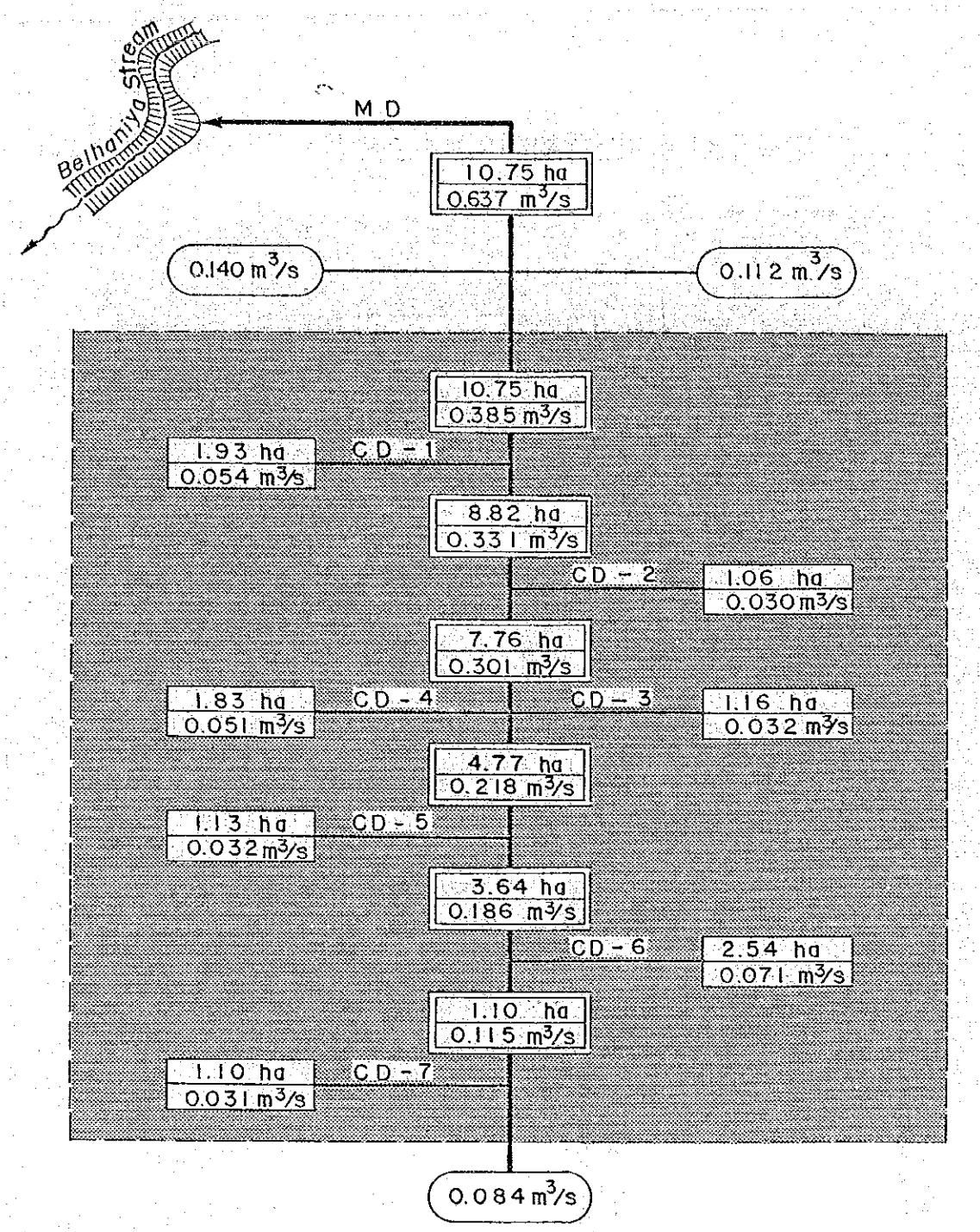
The design drainage discharge for both area is calculated based on the calculated drainage requirement. The calculated design drainage discharge for each drainage canal is illustrated in the attached Fig. 3.1 and Fig. 3.2. The unit drainage requirement is tabulated below.

Area	Unit Drainage Requirement (m^3/sec/ha)
1) Nepalgunj Sub-center (10.750 ha)	0.028
2) Sindhuli Sub-center	
Steep Portion (0.866 ha)	0.184
Flat Portion (1.580 ha)	0.041

Table 3.1 Calculation of Drainage Requirement

	Description	C	R_{24}	t	i	S	A	Q
			(mm/day)	(hr)	(mm/day)		(ha)	(m^3/sec)
1)	Nepalgunj Sub-center	0.20	200	1.0	69.34	1/177	10.750	0.301
2)	Sindhuli Sub-center (Steep Portion)	0.43	150	1.0	52.00	1/2	0.866	0.159
3)	" (Flat Portion)	0.20	150	1.0	52.00	1/42	1.550	0.065

Note: $Q = 9.15 \times 10^{-3} \; C \cdot I \cdot S^{\frac{1}{5}} \cdot A^{\frac{4}{5}}$



LEGEND

a / b : Main Drain (MD)

a / b : Collector Drain (CD)

b : Direct Flow-in

a : Catchment Area (ha), b : Design Discharge (m^3/sec)

Fig. 3.1 Drainage Diagram for Nepalgunj Sub-center

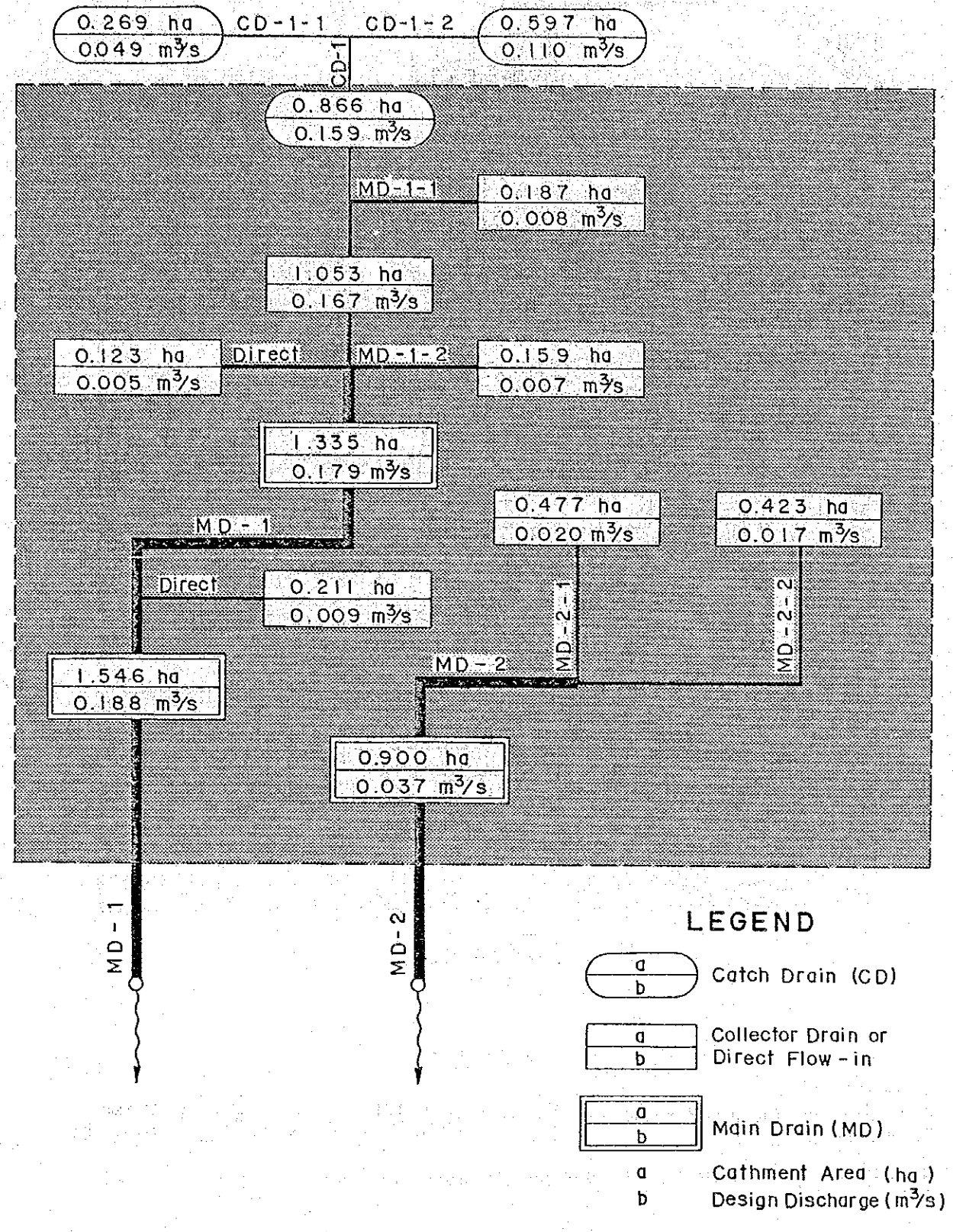


Fig. 3.2 Drainage Diagram for Sindhuli Sub-center

IV. HYDRAULIC CALCULATIONS FOR PIPELINE SYSTEM

4.1 Hydraulic Formula

The closed pipeline system is applied for irrigating both farms. For the hydraulic calculations of pipelines, the following Hazen William's formula is employed:

$$V = 0.35464 \times C \times D^{0.63} \times I^{0.54}$$

$$Q = 0.27853 \times C \times D^{2.63} \times I^{0.54}$$

$$D = 1.6258 \times C^{-0.38} \times Q^{0.38} \times I^{-0.205}$$

$$I = \frac{hf}{L} = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$$

Where, V : Velocity, m/sec

Q : Discharge, m^3/sec

D : Diameter of pipe, m

I : Hydraulic gradient

hf : Friction loss of head, m

L : Length of pipeline, m

C : Coefficient of roughness

4.2 Nepalgunj Sub-center

4.2.1 Sprinklers

(1) Principal features of sprinkler

Principal features of sprinkler system are summarized as follows:

Crops	:	Grapes
Peak value of Crop water requirement	:	4.97 mm/day
Field efficiency	:	85%

Field water requirement : $\frac{4.97\text{mm/day}}{85} \times 100 = 5.85\text{mm/day}$

Application interval : 5 days

Field water requirement for once irrigation : 5 x 5.85 = 29.2mm

Typical size of farm plot : 80 x 60m = 0.48 ha

Number of plots : 18 plots

Irrigated plots per day : 4 plots

Sprinkler head

Spacing, L x B : 10 x 20m
L = Distance of sprinkler head
B = Distance of sprinkler lines

Discharge : 21.2ℓ/min

Pressure : 2.5kg/cm^2

Diameter of irrigation area : 21.0m

Nozzle size : 4 x 2.4mm

Trajectory angle : 10°

Irrigation intensity : $I = \frac{21.2\ell/\text{min} \times 60\ \text{sec}}{10 \times 20\text{m}} = 6.36\text{mm/hr}$

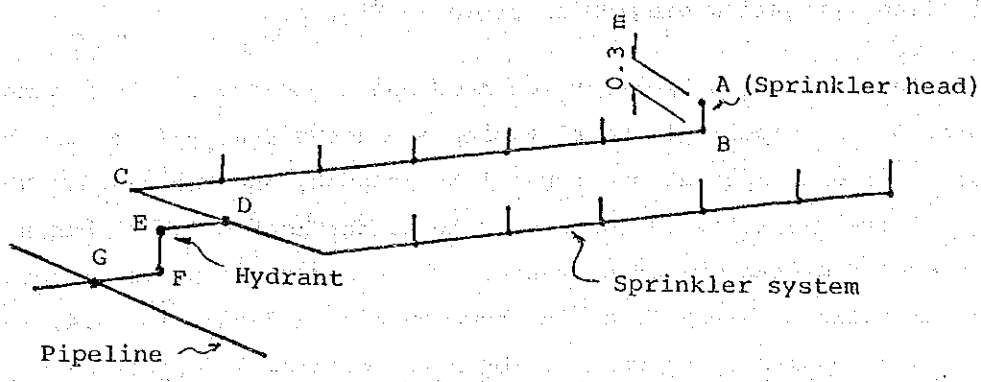
Irrigation hour : $T = FWR/I = \frac{29.2}{6.36} = 4.60\ \text{hr}$

(2) Layout of sprinkler system

Irrigation water is applied to the field by a sprinkler system with an application interval of 5 days and an irrigation hour of 4.6 hours.

One sprinkler set has two lines and 12 sprinkler heads covering the application area of 0.48 ha. Two splinkler sets are therefore necessary for irrigating one plot of about 0.5 ha shifting the sets twice a day. Daily operation hour is 9.2 hours at peak irrigation period. Layout of the sprinkler system is shown in Fig. 4.1.

(3) Total head of sprinkler system is calculated at 27.7m as shown below:



Node	Line	Length (L)	Diameter (D)	Discharge (Q)	Velocity (V)	Loss (Hf)	Head (H)
		(m)	(mm)	(ℓ/min)	(m/sec)	(m)	(m)
A	-	-	-	-	-	-	25.00
B	A-B	0.3	20	21.2	1.1	0.04	25.04
C	B-C	60	50	21.2-127.2	0.2-1.1	0.98	26.02
D	C-D	10	50	127.2	1.1	0.37	26.39
E	D-E	1	50	254.4	2.2	0.10	26.49
F	E-F	0.6	50	254.4	2.2	0.11	26.60
G	F-G	6	50	254.4	2.2	0.61	27.20

4.2.2 Pipeline System

(1) Pipeline

Design discharge for pipeline at each hydrant is calculated as below:

Required discharge for one sprinkler system : 254.4ℓ/min. (4.24ℓ/sec)

Design discharge for pipeline at each hydrant : 254.4ℓ/min/Conveyance efficiency

= 254.4/0.90 = 282.67ℓ/min. (4.71ℓ/sec)

Four plots are irrigated a day by four sprinkler sets, with one set covering half a plot. The sprinkler set is shifted twice a day. Pipeline irrigation diagram is shown in Fig. 4.2.

In determining the required head and discharge at the beginning point of the pipeline, the elevation and the distance (from the beginning point) of each hydrant are taken into account, and the Hydrant No. 15 and No. 11 are respectively considered to be the most critical cases in such factors of elevation and distance. The schematic pipeline layout and the calculated energy line are shown on Fig. 4.3 and Fig. 4.4, respectively. The results of calculation by Hazen William's formula is presented in Table 4.1.

Required head for main irrigation pipeline and discharge at the beginning point of pipeline are calculated to be 31.5 m and 1.13 m^3/min. (18.84 ℓ/sec), respectively.

(2) Delivery pump

Head loss of delivery pipes around the pump is calculated to be 4.5 m. Total required head for delivery pump is 36 m.

Required horse power of pump is estimated as follows:

$$P = \frac{0.163 \times \gamma \times Q \times H}{\eta} \times (1 + \alpha)$$

where, P : Horse power, kW

γ : Specific gravity of water, 1.0

Q : Discharge = [Design discharge] + [Pump Allowance 0.12 m^3/min]

H : Total head, 36 m

η : Pump efficiency, 61%

α : Allowance, 0.1

$$P = \frac{0.163 \times 1.0 \times 1.25 \times 36}{0.61} \times (1 + 0.1) = 13.22 \text{ kW}$$

Principal features of the delivery pump are summarized below:

Power	:	15 kW
Diameter	:	80 x 65 mm
Discharge	:	1.25 m^3/min.
Total head	:	36.0 m
Rating speed	:	2,900 r.p.m.
Frequency	:	50 Hz

(3) Kind of pipes

The pipes used for the pipeline system will be polyvinyl chloride pipe (P.V.C. pipe) considering its economic advantage and workability during the construction.

(4) Farm pond

Effective storage capacity is so determined as to ensure the irrigation for one day without pumping operation even during emergency.

Effective storage capacity = 1.13 m^3/min.x 60 x 4.6 x 2 = 625 m^3

4.2.3 Submergible Pump

(1) Design discharge

The peak design discharge of submergible pump is calculated to be 0.65 m^3/min. based on the operation hour of 16 hr.

[Design discharge] = [Effective storage]/(16 x 60)
= 625/(16 x 60) = 0.65 m^3/min.

(2) Drawdown of deep well

Drawdown of deep well is calculated as below based on the result of the pumping up test which was carried out by the Indian firm in 1980. The result of the pumping up test is shown in Fig. 4.5:

$$K = \frac{2.3 \times Q}{2\pi \times D \cdot h} \log \frac{R}{r}$$

Where, K : Permiability coefficient, 1.81×10^{-4} m/sec

Q : Design discharge, $0.65 m^3/min = 0.0108 m^3/sec$

D : Length of strainer, 21.2m

h : Drawdown depth, m

R : Circle of influence, 100m

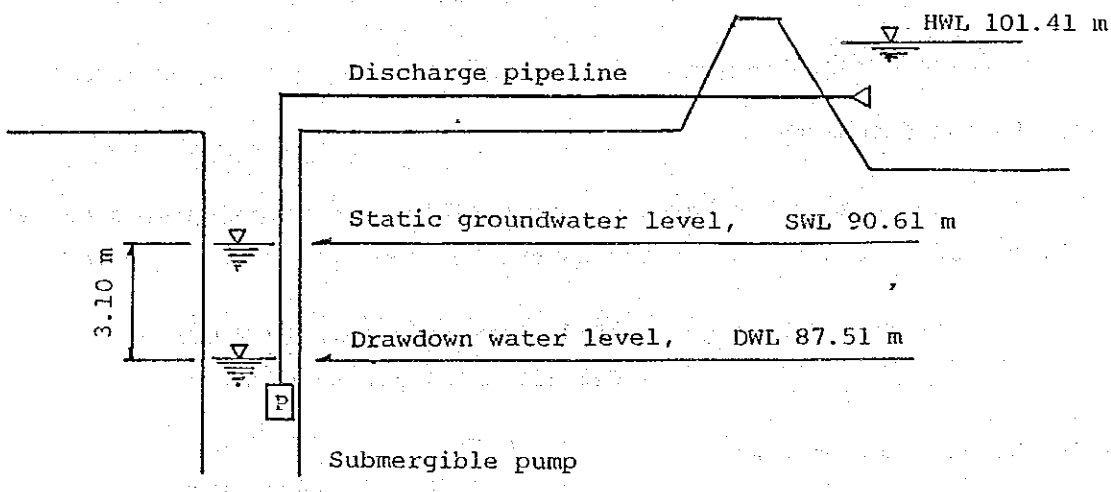
r : Radius of deep well, 0.1m

$$1.81 \times 10^{-4} = \frac{2.3 \times 0.0108}{2\pi \times 21.2 \times h} \log \frac{100}{0.1}$$

$$h = 3.10m$$

(3) Submergible pump

To calculate required horse power of submergible pump necessary for lifting up a discharge of 0.65 m^3/min., water head required for operation of the pump is estimated at 19.0 m as follows:



$$H = H_1 + H_2$$

Where, H : Total water head, m

H_1 : Actual head, m

(HWL - DWL = 101.41 - 87.51 = 13.9m)

H_2 : Head loss by discharge pipe, m

H_2 is calculated at 4.55m by using said Hazan William's formula.

$H = 13.9 + 4.55 = 18.45 \doteq 19.0m$

Required horse power of the submergible pump is calculated as follows:

$$P = \frac{0.163 \times \gamma \times Q \times H}{\eta} \times (1 + \alpha)$$

Where, P : Required horse power, KW

γ : Specific gravity of water, 1.0

Q : Design discharge, $0.65m^3/min$

H : Total head, 19.0m

η : Pump efficiency, 60%

α : Allowance, 0.1

$$P = \frac{0.163 \times 1.0 \times 0.65 \times 19}{0.6} \times (1 + 0.1)$$

$= 3.7KW$

Principal features of the submergible pump are itemized below:

Power	:	3.7KW
Diameter	:	80mm
Discharge	:	$0.65m^3/min$
Total head	:	19.0m
Rating speed	:	2,900r.p.m
Frequency	:	50Hz

4.3 Sindhuli Sub-center

4.3.1 Pipeline system

(1) Pipeline

Irrigation water is applied from each hydrant to the field by the furrow or basin irrigation method. Irrigation area is devided into

16 blocks, of which eight blocks are irrigated in a day with 8-hours irrigation. Principal features of pipeline system are itemized as follows:

Crop	:	Junar Nursery
Field water requirement	:	4.0 mm/day
Application interval	:	5 days
Field water requirement	:	5 x 4.0 = 20 mm
Diversion water requirement	:	FWR/Conveyance efficiency = 20/0.80 = 25 mm
Discharge for each hydrant	:	0.69 ℓ/sec
Discharge of beginning point of pipeline	:	0.69 x 8 = 5.51 ℓ/sec

Pipeline irrigation diagram is shown in Fig. 4.6.

The design of pipeline system is made in the same way as that for the Nepalgunj Sub-center.

4.3.2 Intake Pump

(1) Design discharge

The operation of the intake pump is six hours at the peak time. Design discharge for the pump is calculated below:

$$[\text{Design discharge}] = \frac{[\text{Irrigation water in a day}]}{[\text{Operation hour of the pump}]}$$

$$= \frac{158.75}{6 \times 60} = 0.44 \text{ m}^3/\text{min.}$$

$$[\text{Irrigation water in a day}] = \text{DWR} \times [\text{Irrigation area in a day}]$$

$$= 25 \times 10^3 \times 1.27 \times 10^4 \times 1/2$$

$$= 158.75 \text{ m}^3$$

(2) Drawdown of shallow well

Shallow well will be constructed on the riverbed of the Gwang river. The riverbed material consists of fine or medium sand and cobble stones, and permiability coefficient is assumed at 3.5×10^{-4} m/sec. Drawdown of well is calculated below:

$$Q = \frac{4\pi K(H - ho)}{\{4.6/hs \cdot \log (\pi hs/2ro) + 0.2/H\}}$$

Where, Q : Design discharge, m^3/sec

K : Permiability coefficient, cm/sec

H-ho : Drawdown, m

hs : Depth of water, m

ro : Radius of well, m

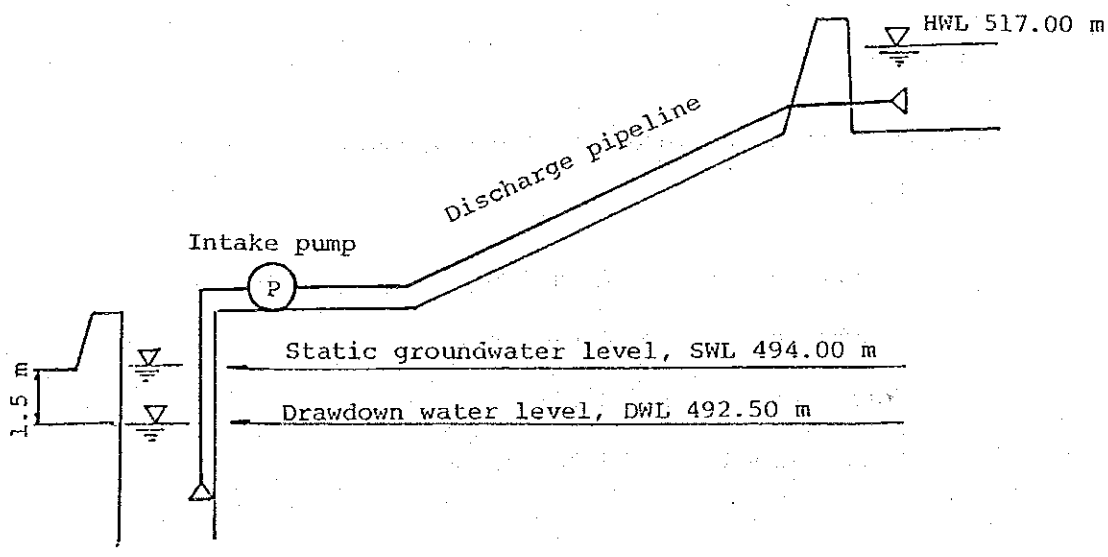
H : Water depth from inpermeable layer, m

$$0.0073 = 4\pi \times 3.5 \times 10^{-4}(H - ho)/\{4.6/5.0 \cdot \log(\pi x5/1.5) + 0.2/50\}$$

$$H - ho = 1.50m$$

(3) Intake pump

To calculate required horse power of intake pump necessary for lifting up a discharge of 0.44 m^3/min. Water head required for operation of the pump is estimated at 36.0 m as follows:



$H = H_1 + H_2$

Where, H : Total water head, m

H_1 : Actual head, m
(HWL - DWL = 517.00 - 492.50 = 24.5m)

H_2 : Head loss by discharge pipe, m

H_2 is calculated at 11.38m by using the said Hazen William's formula.

$H = 24.5 + 11.38 = 35.88 \fallingdotseq 36.0m$

Required horse power of the intake pump is calculated as follows:

$$P = \frac{0.222 \times \gamma \times Q \times H}{\eta} \times (1 + \alpha)$$

Where, P : Required horse power, P.S.

γ : Specific gravity of water, 1.0

Q : Design discharge, $0.44m^3/min$

H : Total head, 36.0m

η : Pump efficiency, 49%

α : Allowance, 0.2

$$P = \frac{0.222 \times 1.0 \times 0.44 \times 36}{0.49} \times (1 + 0.2)$$

$= 8.6 \fallingdotseq 9$ P.S.

Principal features of intake pump are itemized below:

Power	:	9 P.S.
Diameter	:	65 x 50mm
Discharge	:	$0.44m^3/min$
Total head	:	36.0m
Rating speed	:	2,200 r.p.m

(4) Cavitation of suction pipe

Examination of cavitation is carried out by using the following equations:

$$NPSH(av) \geq NPSH(rq)$$

$$NPSH(av) = Pa - hso - Ba - h\ell - \beta$$

$$NPSH(rq) = (N\frac{\sqrt{Q}}{S})^{\frac{4}{3}}$$

Where, NPSH(av) : Available net positive suction head, m

NPSH(rq) : Required net positive suction head, m

Pa : Atmospheric pressure, 10.33m

hso : Suction head, 5m

Ba : Saturated vapor pressure, 0.3m

$h\ell$: Losses on suction side, 1.0m

β : Allowance, 0.5m

N : Rating speed, 2,200 r.p.m

Q : Design discharge, 0.44m^3/min

S : Specific speed, 900

$$NPSH(av) = 10.33 - 5.0 - 0.3 - 1.0 - 0.5$$
$$= 3.53m$$

$$NPSH(rq) = (2,200 \times \sqrt{0.44}/900)^{4/3}$$
$$= 1.90m$$

$$NPSH(av) > NPSH(rq)$$

4.3.3 Farm Pond

Required storage capacity of farm pond is calculated below:

[Required storage capacity, V]

= {[Irrigation hour, T_1] - [Operation hour of pump, T_2]}
x [Design discharge of irrigation pipeline, Q]
+ [Allowance for irregular use]

= (8.0 - 6.0) x 5.51 x 60 x 60 x 10^3

= 39.69 + 10.00

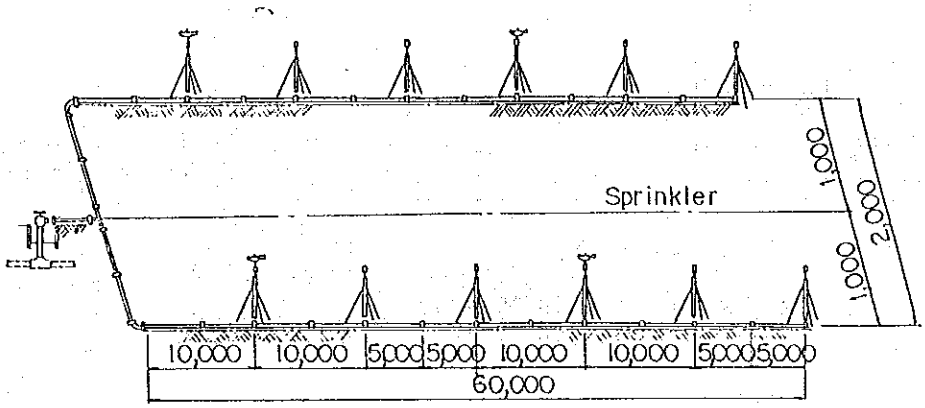
= 49.69 ≒ 50.0m^3

Table 4.1 Hydraulic Calculation of Pipelines of Nepalgunj Sub-center

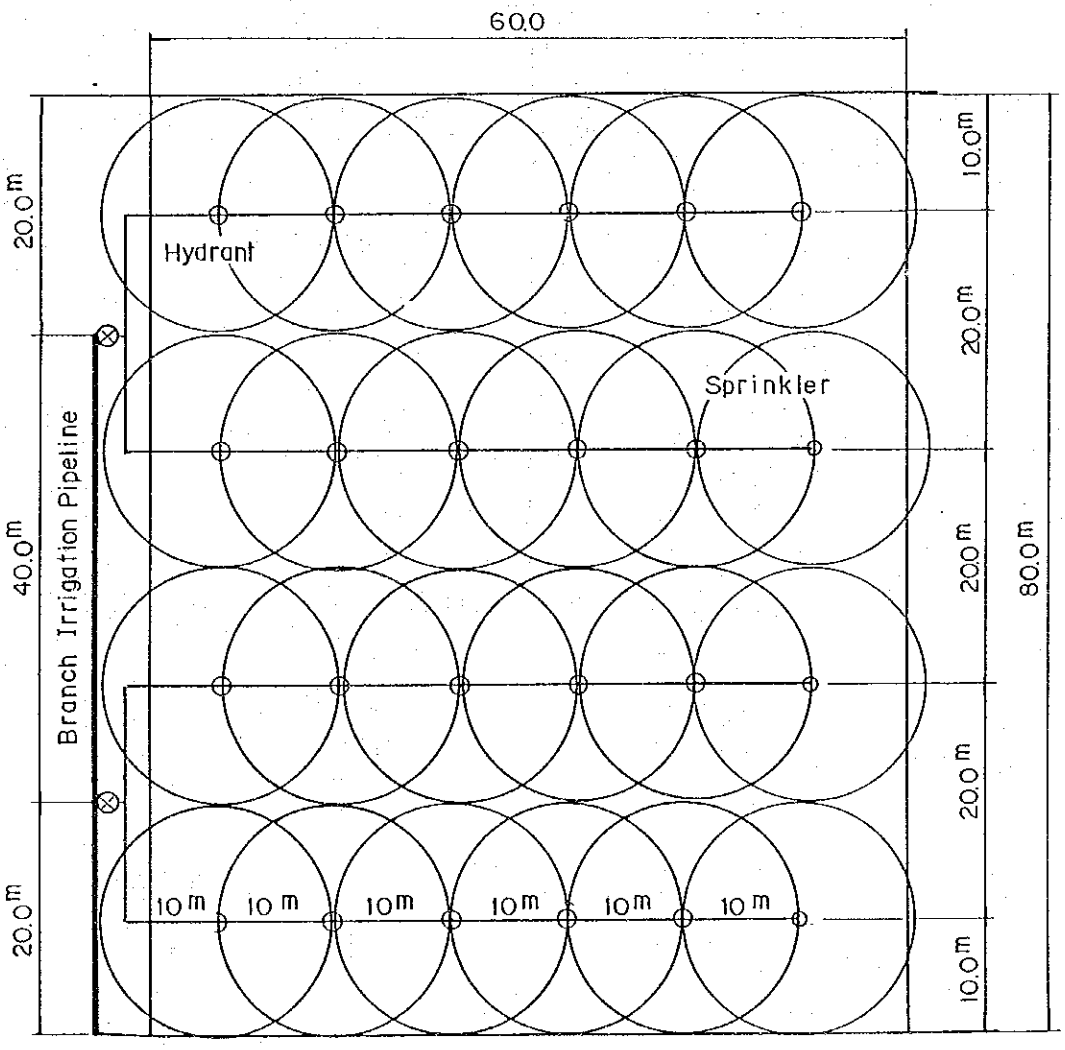
Node		EL	Diameter of pipe	Length	Discharge	Velocity	Head Loss	Dynamic W.Pressure	Static W.Pressure
			(mm)	(m)	(ℓ/sec)	(m/sec)	(m)	(m)	(m)
Case-1									
	P	100.0	-	-	18.84	1.00	-	30.2	30.2
MIP	1	100.0	150	34.5	18.84	1.00	0.22	29.9	30.2
	2	100.0	150	84.5	18.84	1.00	0.54	29.4	30.2
BIP-3	3	100.0	150	64.0	18.84	1.00	0.41	29.0	30.2
	9	99.5	100	112.0	9.42	1.03	1.16	28.3	30.7
	14	99.5	75	45.0	4.71	0.86	0.44	27.9	30.7
MIP	3	100.0	150	-	18.84	1.00	-	29.0	30.2
BIP-5	4	99.5	150	128.5	9.42	0.50	0.23	29.3	30.7
	10	99.5	100	113.5	9.42	1.03	1.17	28.1	30.7
	15	100.0	75	40.0	4.71	0.86	0.39	27.2	30.2
Case-2									
	P	100.0	-	-	18.84	1.00	-	30.2	30.2
MIP	1	100.0	150	34.5	18.84	1.00	0.22	30.0	30.2
BIP-1	2	100.0	150	84.5	18.84	1.00	0.54	29.4	30.2
	5	100.0	150	79.5	9.42	0.50	0.14	28.6	30.2
	6	99.5	100	103.0	9.42	1.03	1.06	28.1	30.7
	11	99.5	75	40.5	4.71	0.86	0.40	27.7	30.7
MIP	2	100.0	150	-	18.84	1.00	-	29.4	30.2
	3	100.0	150	64.0	9.42	0.50	0.11	29.3	30.2
BIP-5	4	99.5	150	128.5	9.42	0.50	0.23	29.6	30.7
	10	99.5	100	113.5	9.42	1.03	1.17	28.4	30.7
	15	100.0	75	40.0	4.71	0.86	0.39	27.5	30.2

Table 4.2 Hydraulic Calculation of Pipelines of Sindhuli Sub-center

Node		EL	Diameter of pipe	Length	Discharge	Velocity	Head Loss	Dynamic W.Pressure	Static W.Pressure
			(mm)	(m)	(ℓ/sec)	(m/sec)	(m)	(m)	(m)
	P	515.0	-	-	5.51	0.61	-	0.0	2.0
MIP	1	509.5	100	25.5	5.51	0.61	0.10	5.4	7.5
	2	508.0	100	30.0	5.51	0.61	0.12	6.8	9.0
	3	503.0	100	27.0	5.51	0.70	0.14	11.6	14.0
BIP-2	4	503.0	100	38.0	5.51	0.68	0.20	11.4	14.0
	9	505.0	50	16.0	2.07	0.83	0.23	9.2	12.0
	10	505.0	50	2.5	2.07	0.82	0.04	9.2	12.0
	11	503.5	50	35.5	1.38	0.55	0.25	10.4	13.5
	12	503.5	50	9.5	0.69	0.27	0.02	10.4	13.5
	13	503.5	50	25.0	0.69	0.27	0.05	10.4	13.5
BIP-4	4	503.0	100	-	5.51	0.68	-	11.4	14.0
	5	502.0	100	16.5	3.45	0.43	0.04	12.4	15.0
	19	501.0	75	27.0	3.45	0.63	0.15	13.3	16.0
	20	501.0	75	13.5	3.45	0.62	0.07	13.2	16.0
	21	500.0	50	17.0	2.76	1.11	0.42	13.8	17.0
	22	500.0	50	13.0	2.76	1.09	0.32	13.4	17.0
	23	500.0	50	17.5	2.07	0.82	0.25	13.2	17.0
	24	500.0	50	21.0	1.38	0.55	0.14	13.0	17.0
	25	499.5	50	19.5	0.69	0.28	0.04	13.5	17.5

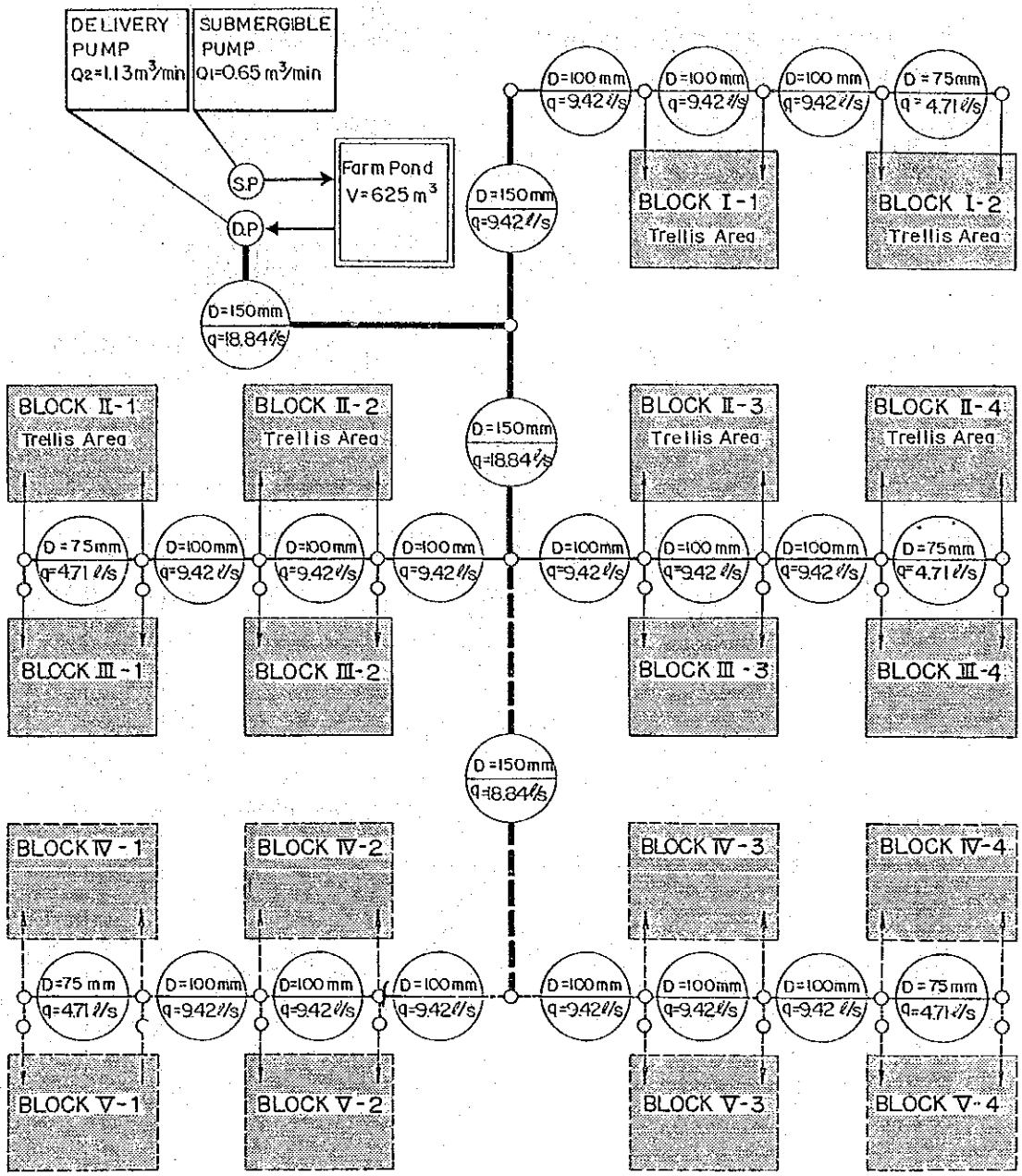


ERSY-REMOVABLE SPRINKLER SETS
(φ50)



Standerd Farm Plot (80x60m = 0.48ha)

Fig.4.1 Layout of Sprinkler System



Note

Irrigation interval is 5-days at peak period.
The farm is divided into five blocks, and
one block is irrigated in a day

LEGEND

(P) ; Pump Station

——— ; Pipeline

—○ ; Hydrant

▭ ; One Plot Area (0.48 ha)

Fig. 4.2 Irrigation Diagram for Grapes of Nepalgunj Sub-center

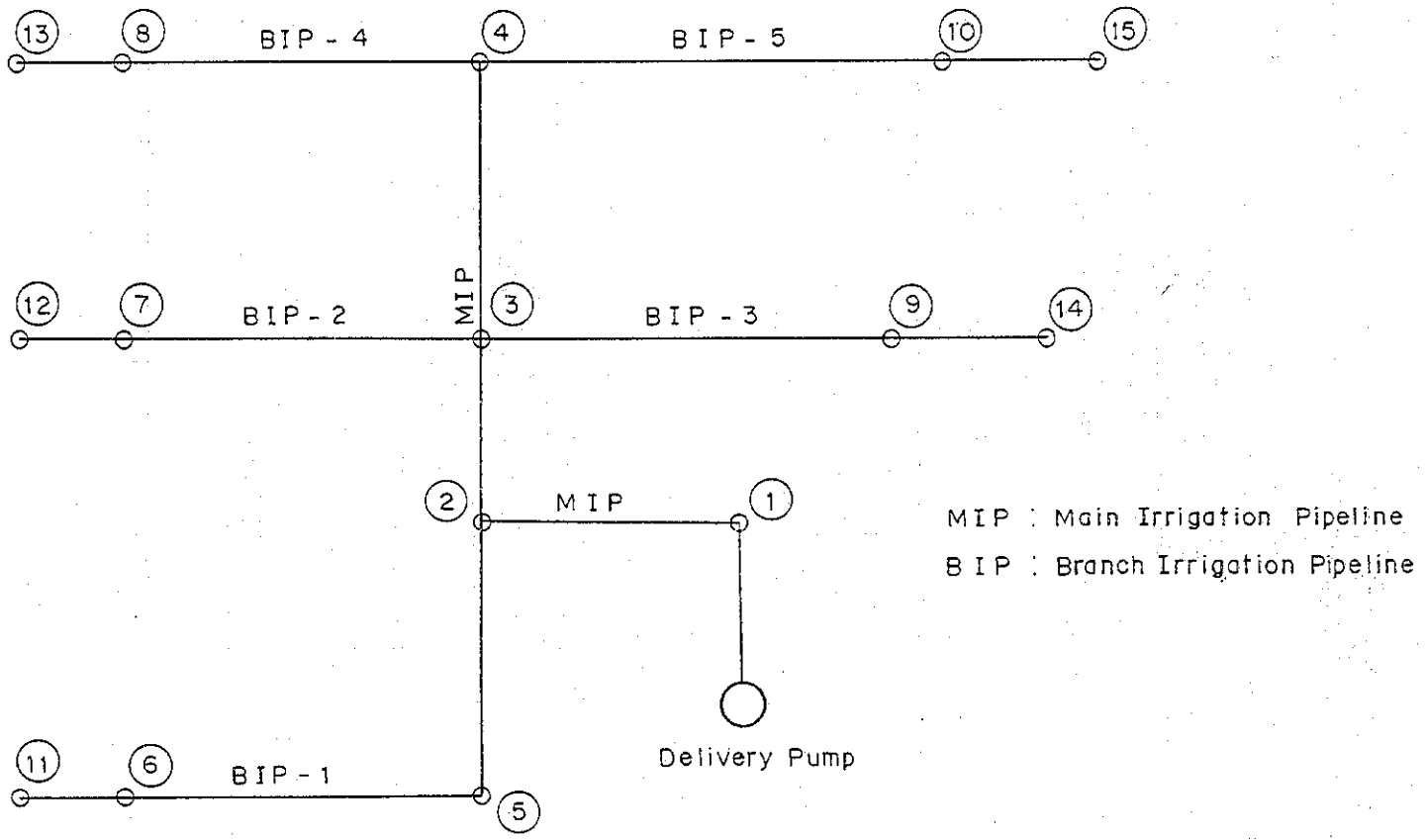
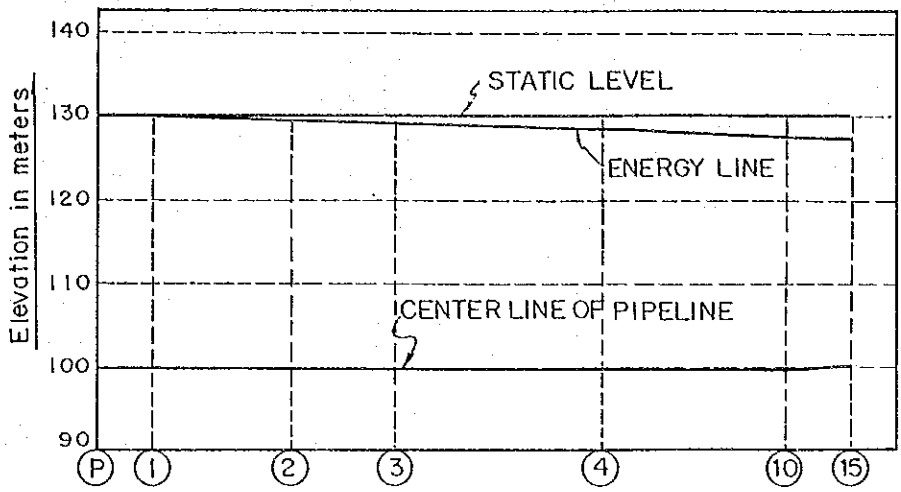


Fig. 4.3 Schematic Pipeline Layout of Nepalgunj Sub - center

Case - 1

SECTION [Ⓟ - ⑮]

MAX STATIC PRESSURE 30.66 M



Case - 2

SECTION [Ⓟ - ⑪]

MAX STATIC PRESSURE 30.70 M

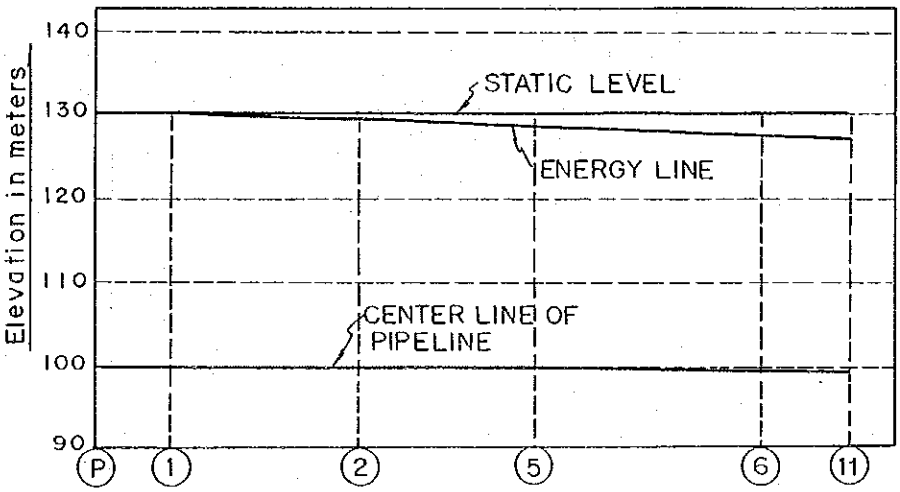


Fig. 4.4 Energy Line of Pipeline for Nepalgunj Sub - center

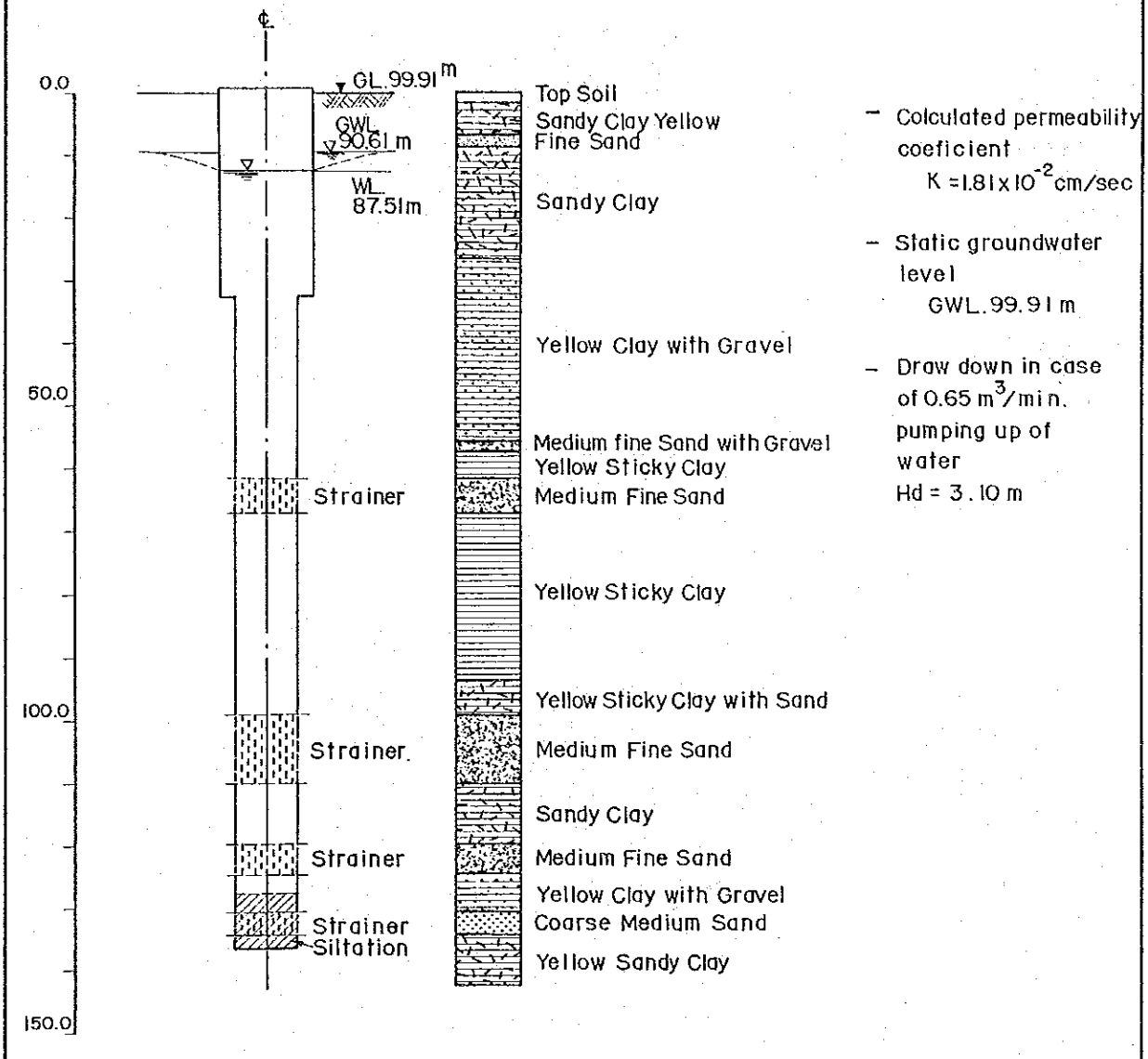


Fig. 4.5 Profile of Existing Deep Tubewell

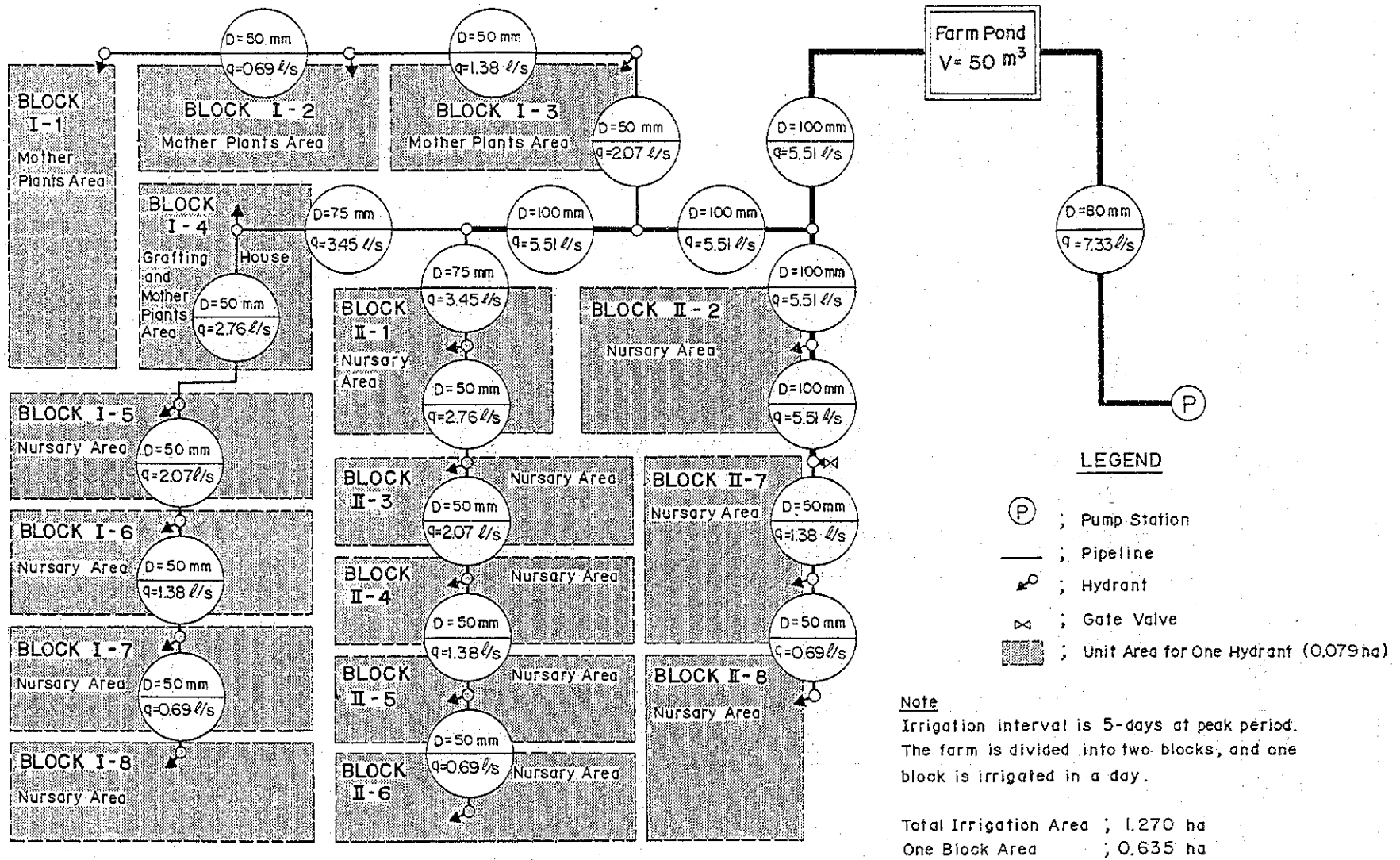


Fig. 4.6 Irrigation Diagram for Junor Nursary of Sindhuli Sub-center.

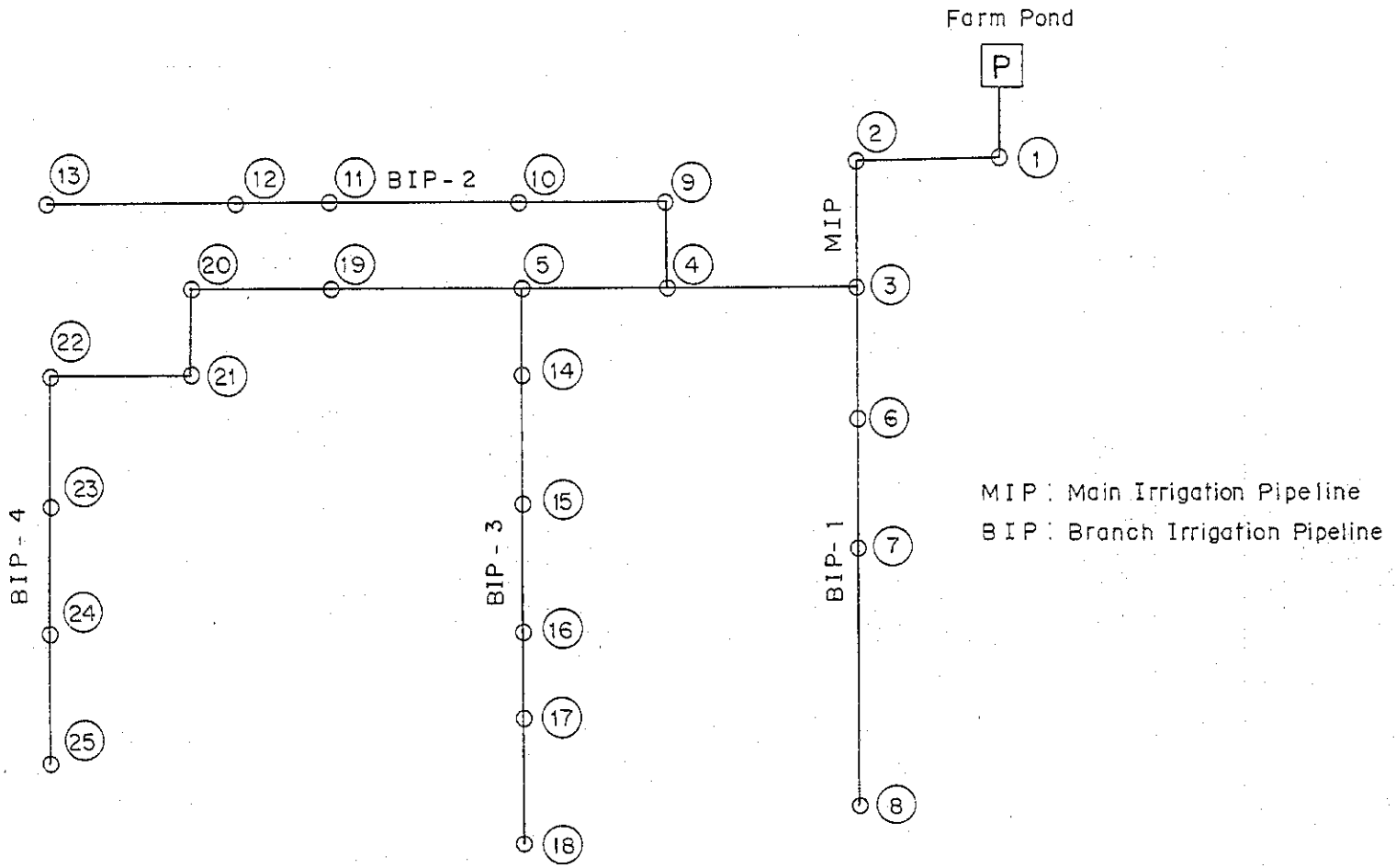
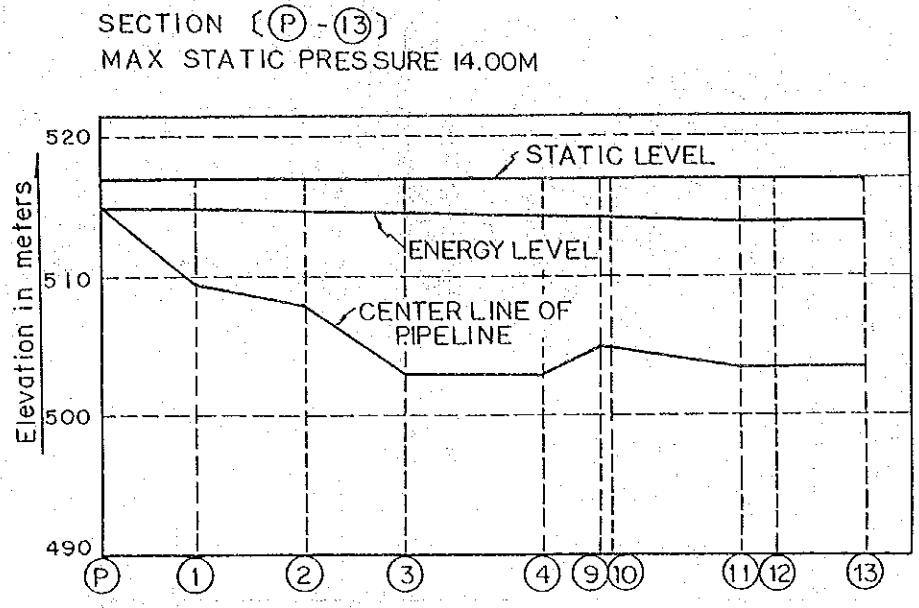


Fig. 4.7 Schematic Pipeline Layout of Sindhuli Sub - center



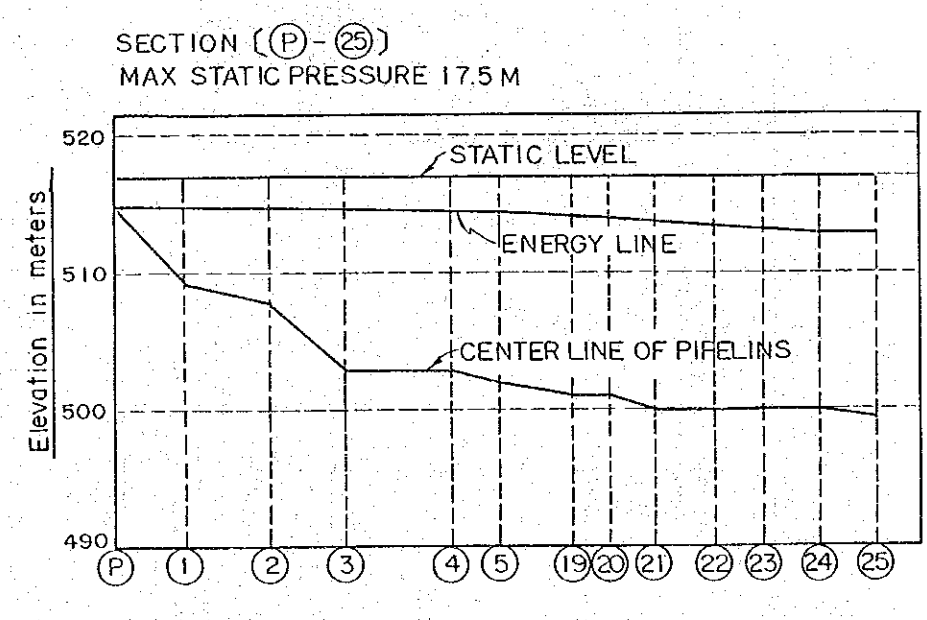


Fig. 4.8 Energy Line of Pipeline for Sindhuli Sub-center

V. HYDRAULIC CALCULATIONS FOR DRAINAGE CANALS

5.1 Hydraulic Formula

For the hydraulic calculations of drainage canals, Manning's formula is employed as shown below:

$$Q = A \times V$$

$$V = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot I^{\frac{1}{2}}$$

where, Q : Discharge, m^3/sec
A : Cross sectional area, m^2
V : Mean velocity, m/sec
R : Hydraulic radius, m
I : Hydraulic gradient
n : Coefficient of roughness

5.2 Coefficient of Roughness

Coefficient of roughness applied to Manning's formula are as follows:

Brick masonry lined canal	:	0.025
Stone masonry lined canal	:	0.025
Earth canal	:	0.030
Precast concrete pipe	:	0.015

5.3 Type of Canal

Drainage canals are classified into three types, i.e. main and collector drains and farm ditch for Nepalgunj Sub-center and main and minor drains and form ditch for Sindhuli Sub-center.

Hydraulic calculations of drainage canals for the Nepalgunj and the Sindhuli Sub-centers are shown in Table 5.1 and Table 5.2, respectively.

Table 5.1 Hydraulic Calculation of Drainage Canals (Nepalgunj Sub-center) (1/5)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
MAIN DRAIN (Canal Length: 520.03 m)													
BP			0.00				96.87	0.56	0.02	96.85	0.68	96.17	
	0.637	69.50		Canal, B=1.00m	1/1,000	0.07							
No.2+20.50			69.50				96.94	0.56	0.02	96.92	0.68	96.24	
	0.637	4.00		No.1 DP, H=0.25m	-	0.25							
No.2+23.50			73.50				97.19	0.56	0.02	97.17	0.68	96.49	
	0.637	88.14		Canal, B=1.00m	1/1,000	0.09							
No.6+11.64			161.64				97.28	0.56	0.02	97.26	0.68	96.58	
	0.385	4.00		No.2 DP, H=0.25m	-	0.25							
No.6+15.64			165.64				97.53	-	-	-	-	-	
	0.385	6.00		No.1 CV, D=1.00m	-	0.03							
No.6+21.64			171.64				97.56	0.50	0.01	97.55	0.60	96.95	
	0.385	4.22		Canal, B=0.70m	1/1,000	0.00							
No.7+0.86			175.86				97.56	0.50	0.01	97.55	0.60	96.95	
	-	0.00		Flow-in	-	0.00							Flow-in CD-1(R)
No.7+0.86			175.86				97.56	0.48	0.01	97.55	0.55	97.00	
	0.331	31.00		Canal, B=0.70m	1/1,000	0.03							
No.8+6.86			206.86				97.59	0.48	0.01	97.58	0.55	97.03	
	-	0.00		Flow-in	-	0.00							Flow-in CD-2(L)
No.8+6.86			206.86				97.59	0.60	0.02	97.57	0.44	97.13	
	0.301	54.00		Canal, B=0.70m	1/500	0.11							
No.10+10.86			260.86				97.70	0.60	0.02	97.68	0.44	97.24	
	-	0.00		Flow-in	-	0.00							Flow-in CD-3(L) CD-4(R)
No.10+10.86			260.86				97.70	0.77	0.03	97.67	0.29	97.38	
	0.218	83.46		Canal, B=0.70m	1/200	0.42							
No.13+19.32			344.32				98.12	0.77	0.03	98.09	0.29	97.80	
	0.218	4.85		Existing CV	-	0.29							
No.13+24.17			349.17				98.41	0.43	0.01	98.40	0.44	97.96	
	0.218	1.69		Canal, B=0.70m	1/1,000	0.00							
No.14+0.86			350.86				98.41	0.43	0.01	98.40	0.44	97.96	
	-	0.00		Flow-in	-	0.00							Flow-in CD-5(R)
No.14+0.86			350.86				98.41	0.42	0.01	98.40	0.46	97.94	
	0.186	82.00		Canal, B=0.50m	1/1,000	0.08							
No.17+7.86			432.86				98.49	0.42	0.01	98.48	0.46	98.02	
	-	0.00		Flow-in	-	0.00							Flow-in CD-6(L)

- to be continued -

Table 5.1 Hydraulic Calculation of Drainage Canals (Nepalgunj Sub-center) (2/5)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
No.17+7.86			432.86				98.49	0.37	0.01	98.48	0.36	98.12	
	0.115	42.17		Canal, B=0.50m	1/1,000	0.04							
No.19+0.03			475.03				98.53	0.37	0.01	98.52	0.36	98.16	
	-	0.00		Flow-in	-	0.00							Flow-in CD-7(R)
No.19+0.03			475.03				98.53	0.34	0.01	98.52	0.37	98.15	
	0.084	24.97		Canal, B=0.30m	1/1,000	0.02							
No.20+0.00			500.00				98.55	0.34	0.01	98.54	0.37	98.17	
	0.084	0.00		-	-	0.00							
No.20+0.00			500.00				98.55	0.87	0.04	98.51	0.19	98.32	
	0.084	20.03		Canal, B=0.30m	1/80	0.25							
EP			520.03				98.80	0.87	0.04	98.76	0.19	98.57	
COLLECTOR DRAIN-1 (Canal Length: 221.00 m)													
BP			0.00				97.30	0.60	0.02	97.28	0.19	97.09	
	0.054	5.50		No.1 CV, D=0.40m	-	0.03							
BP+5.50			5.50				97.33	0.60	0.02	97.31	0.19	97.12	
	0.054	44.50		Canal, B=0.30m	1/160	0.28							
No.2+0.00			50.00				97.61	0.60	0.02	97.59	0.19	97.40	
	0.054	0.00		-	-	0.00							
No.2+0.00			50.00				97.61	0.30	0.00	97.61	0.30	97.31	
	0.054	28.50		Canal, B=0.30m	1/1,000	0.03							
No.3+3.50			78.50				97.64	0.30	0.00	97.64	0.30	97.34	
	0.054	10.00		No.2 CV, D=0.40m	-	0.03							
No.3+13.50			88.50				97.67	0.30	0.00	97.67	0.30	97.37	
	0.054	61.50		Canal, B=0.30m	1/1,000	0.06							
No.6+0.00			150.00				97.73	0.30	0.00	97.73	0.30	97.43	
	0.054	9.00		No.3 CV, D=0.40m	-	0.03							
No.6+9.00			159.00				97.76	0.30	0.00	97.76	0.30	97.46	
	0.054	16.00		Canal, B=0.30m	1/1,000	0.02							
No.7+0.00			175.00				97.78	0.30	0.00	97.78	0.30	97.48	
	0.054	0.00		-	-	0.00							
No.7+0.00			175.00				97.78	0.68	0.02	97.76	0.17	97.59	
	0.054	46.00		Canal, B=0.30m	1/115	0.40							
EP			221.00				98.18	0.68	0.02	98.16	0.17	97.77	

- to be continued -

Table 5.1 Hydraulic Calculation of Drainage Canals (Nepalgunj Sub-center) (3/5)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
COLLECTOR DRAIN-2 (Canal Length: 119.00 m)													
BP			0.00				97.29	0.45	0.01	97.28	0.15	97.13	
	0.030	5.50		No.1 CV, D=0.30m	-	0.03							
BP+5.50			5.50				97.32	0.45	0.01	97.31	0.15	97.16	
	0.030	42.97		Canal, B=0.30m	1/230	0.19							
No.1+23.47			48.47				97.51	0.45	0.01	97.50	0.15	97.35	
	0.030	8.00		No.2 CV, D=0.30m	-	0.03							
No.2+6.47			56.47				97.54	0.45	0.01	97.53	0.15	97.38	
	0.030	62.53		Canal, B=0.30m	1/230	0.27							
EP			119.00				97.81	0.45	0.01	97.80	0.15	97.65	
COLLECTOR DRAIN-3 (Canal Length: 124.00 m)													
BP			0.00				97.54	0.47	0.01	97.53	0.15	97.38	
	0.032	5.50		No.1 CV, D=0.30m	-	0.03							
BP+5.50			5.50				97.57	0.47	0.01	97.56	0.15	97.41	
	0.032	47.49		Canal, B=0.30m	1/220	0.22							
No.2+2.99			52.99				97.79	0.47	0.01	97.78	0.15	97.63	
	0.032	9.00		No.2 CV, D=0.30m		0.03							
No.2+11.99			61.99				97.82	0.47	0.01	97.81	0.15	97.66	
	0.032	62.01		Canal, B=0.30m	1/220	0.28							
EP			124.00				98.10	0.47	0.01	98.09	0.15	97.94	
COLLECTOR DRAIN-4 (Canal Length: 213.00 m)													
BP			0.00				97.68	-	-	97.68	0.44	97.24	
	-	5.50		No.1 CV, D=0.40m	-	0.03							
BP+5.50			5.50				97.71	-	-	97.71	0.44	97.27	
	-	17.93		Canal, B=0.30m	-	-							
BP+23.43			23.43				97.71	-	-	97.71	0.44	97.27	
	-	0.00		-	-	-							
BP+23.43			23.43				97.71	0.85	0.04	97.67	0.14	97.53	
	0.051	45.00		Canal, B=0.30m	1/60	0.75							
No.2+18.43			68.43				98.46	0.85	0.05	98.42	0.14	98.28	
	0.051	0.00		-	-	0.00							

- to be continued -

Table 5.1 Hydraulic Calculation of Drainage Canals (Nepalgunj Sub-center) (4/5)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
No.2+18.43			68.43				98.46	0.30	0.00	98.46	0.29	98.17	
	0.051	1.00		Canal, B=0.30m	1/1,000	0.00							
No.2+19.43			69.43				98.46	0.30	0.00	98.46	0.29	98.17	
	0.051	8.00		No.2 CV, D=0.40m	-	0.03							
No.2+2.43			77.43				98.49	0.30	0.00	98.49	0.29	98.20	
	0.051	60.57		Canal, B=0.30m	1/1,000	0.06							
No.5+13.00			138.00				98.55	0.30	0.00	98.55	0.29	98.26	
	0.051	9.00		No.3 CV, D=0.40m		0.03							
No.5+22.00			147.00				98.58	0.30	0.00	98.58	0.29	98.29	
	0.051	3.00		Canal, B=0.30m	1/1,000	0.00							
No.6+0.00			150.00				98.58	0.30	0.00	98.58	0.29	98.29	
	0.051	0.00		-	-	0.00							
No.6+0.00			150.00				98.58	0.55	0.02	98.56	0.19	98.37	
	0.051	63.00		Canal, B=0.30m	1/200	0.32							
EP			213.00				98.90	0.55	0.02	98.88	0.19	98.69	
COLLECTOR DRAIN-5 (Canal Length: 181.02 m)													
EP			0.00				98.10	0.64	0.02	98.08	0.12	97.96	
	0.032	5.50		No.1 CV, D=0.30m		0.03							
EP+5.50			5.50				98.13	0.64	0.02	98.11	0.12	97.99	
	0.032	51.82		Canal, B=0.30m	1/90	0.58							
No.2+7.32			57.32				98.71	0.64	0.02	98.69	0.12	98.57	
	0.032	8.00		No.2 CV, D=0.30m		0.03							
No.2+15.32			65.32				98.74	0.64	0.02	98.72	0.12	98.60	
	0.032	9.68		Canal, B=0.30m	1/90	0.11							
No.3+0.00			75.00				98.85	0.64	0.02	98.83	0.12	98.71	
	0.032	0.00		-	-	0.00							
No.3+0.00			75.00				98.85	0.27	0.00	98.85	0.23	98.62	
	0.032	52.72		Canal, B=0.30m	1/1,000	0.05							
No.5+2.72			127.72				98.90	0.27	0.00	98.90	0.23	98.67	
	0.032	9.00		No.3 CV, D=0.30m	-	0.03							
No.5+11.72			136.72				98.93	0.27	0.00	98.93	0.23	98.70	
	0.032	44.30		Canal, B=0.30m	1/1,000	0.04							
EP			181.02				98.97	0.27	0.00	98.97	0.23	98.74	

- to be continued -

Table 5.1 Hydraulic Calculation of Drainage Canals (Nepalgunj Sub-center) (5/5)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
COLLECTOR DRAIN-6 (Canal Length: 140.00 m)													
BP			0.00				98.25	0.68	0.02	98.23	0.21	98.02	
	0.071	5.50		No.1 CV, D=0.40m	-	0.03							
BP+5.50			5.50				98.28	0.68	0.02	98.26	0.21	98.05	
	0.071	63.97		Canal, B=0.30m	1/140	0.46							
No.2+19.47			69.47				98.74	0.68	0.02	98.72	0.21	98.51	
	0.071	8.00		No.2 CV, D=0.40m	-	0.03							
No.3+2.47			77.47				98.77	0.68	0.02	98.75	0.21	98.54	
	0.071	62.53		Canal, B=0.30m	1/140	0.45							
EP			140.00				99.22	0.68	0.02	99.20	0.21	98.99	
COLLECTOR DRAIN-7 (Canal Length: 113.00 m)													
BP			0.00				98.31	0.56	0.02	98.29	0.13	98.16	
	0.031	5.50		No.1 CV, D=0.30m	-	0.03							
BP+5.50			5.50				98.34	0.56	0.02	98.32	0.13	98.19	
	0.031	35.81		Canal, B=0.30m	1/130	0.28							
No.1+16.31			41.31				98.62	0.56	0.02	98.60	0.13	98.47	
	0.031	8.00		No.2 CV, D=0.30m	-	0.03							
No.1+24.31			49.31				98.65	0.56	0.02	98.63	0.13	98.50	
	0.031	63.69		Canal, B=0.30m	1/130	0.49							
EP			113.00				99.14	0.56	0.02	99.12	0.13	98.99	

Table 5.2 Hydraulic Calculation of Drainage Canals (Sindhuli Sub-center) (1/4)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
MAIN DRAIN-1 (Canal Length: 121.37 m)													
BP			0.00				496.47	0.76	0.03	496.44	0.31	496.13	
	0.188	6.00		Canal, B=0.50m	1/200	0.03							
BP+6.00			6.00				496.50	0.76	0.03	496.47	0.31	496.16	
	0.188	2.50		No.1 DP, H=1.50m	-	1.50							
BP+8.50			8.50				498.00	0.76	0.03	497.97	0.31	497.66	
	0.188	15.50		Canal, B=0.50m	1/200	0.08							
BP+24.00			24.00				498.08	0.76	0.03	498.05	0.31	497.74	
	0.188	2.00		No.2 DP, H=0.50m	-	0.50							
No.1+1.00			26.00				498.58	0.76	0.03	498.55	0.31	498.24	
	0.188	9.00		Canal, B=0.50m	1/200	0.05							
No.1+10.00			35.00				498.63	0.76	0.03	498.60	0.31	498.29	
	0.188	2.00		No.3 DP, H=0.50m	-	0.50							
No.1+12.00			37.00				499.13	0.76	0.03	499.10	0.31	498.79	
	0.188	62.68		Canal, B=0.50m	1/200	0.31							
IP-1			99.68				499.44	0.76	0.03	499.41	0.31	499.10	
	0.188	0.00		-	-	0.00							
IP-1			0.00				499.44	0.83	0.04	499.40	0.28	499.12	
	0.179	0.32		Canal, B=0.50m	1/150	0.00							
No.4+0.00			100.00				499.44	0.83	0.04	499.40	0.28	499.12	
	0.179	2.00		No.4 DP, H=0.50m	-	0.50							
No.4+2.00			102.00				499.94	0.83	0.04	499.90	0.28	499.62	
	0.179	19.37		Canal, B=0.50m	1/150	0.13							
EP			121.37				500.07	0.83	0.04	500.03	0.28	499.75	BP of MD-1-1 BP of MD-1-2
MAIN DRAIN-2 (Canal Length: 27.12 m)													
BP			0.00				496.91	0.50	0.01	496.90	0.16	496.74	
	0.037	27.12		Canal, B=0.30m	1/200	0.14							
EP			27.12				497.05	0.50	0.01	497.04	0.16	496.88	BP of MD-2-1 BP of MD-2-2
MINOR DRAIN-1-1 (Canal Length: 82.33 m)													
BP			0.00				500.26	0.52	0.01	500.25	0.37	499.88	EP of MD-1
	0.167	9.50		Canal, B=0.50m	1/500	0.02							
IP-1			9.50				500.28	0.52	0.01	500.27	0.37	499.90	

- to be continued -

Table 5.2 Hydraulic Calculation of Drainage Canals (Sindhuli Sub-center) (2/4)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
	-	-		Flow-in	-	-							BP of CD-1
IP-1			9.50				500.28	0.36	0.01	500.27	0.06	500.21	
	0.008	1.00		Canal, B=0.30m	1/150	0.01							
BP+10.50			10.50				500.29	0.36	0.01	500.28	0.06	500.22	
	0.008	6.00		No.1 CV, D=0.30m	-	0.03							
BP+16.50			16.50				500.32	0.36	0.01	500.31	0.06	500.25	
	0.008	24.83		Canal, B=0.30m	1/150	0.17							
IP-4			41.33				500.49	0.36	0.01	500.48	0.06	500.42	
	0.008	0.00		-	-	0.00							
IP-4			41.33				500.49	0.70	0.03	500.46	0.03	500.43	
	0.008	41.00		Canal, B=0.30m	1/20	2.05							
EP			82.33				502.54	0.70	0.03	502.51	0.03	502.48	
MINOR DRAIN-1-2 (Canal Length: 111.97 m)													
BP			0.00				500.10	0.22	0.00	500.10	0.08	500.02	EP of MD-1
	0.007	0.50		Canal, B=0.30m	1/500	0.00							
BP+0.50			0.50				500.10	0.22	0.00	500.10	0.08	500.02	
	0.007	6.00		No.1 CV, D=0.30m	-	0.03							
BP+6.50			6.50				500.13	0.22	0.00	500.13	0.08	500.05	
	0.007	18.50		Canal, B=0.30m	1/500	0.04							
No.1+0.00			25.00				500.17	0.29	0.00	500.17	0.08	500.09	
	0.007	0.00		-	-	0.00							
No.1+0.00			25.00				500.17	0.39	0.01	500.16	0.05	500.11	
	0.007	33.73		Canal, B=0.30m		0.34							
No.2+8.73			58.73				500.51	0.39	0.01	500.50	0.05	500.45	
	0.007	6.00		No.2 CV, D=0.30m	-	0.03							
No.2+14.73			64.73				500.54	0.39	0.01	500.53	0.05	500.48	
	0.007	47.24		Canal, B=0.30m	1/100	0.47							
EP			111.97				501.01	0.39	0.01	501.00	0.05	500.95	
MINOR DRAIN-2-1 (Canal Length: 74.38 m)													
BP			0.00				497.22	0.61	0.02	497.20	0.08	497.12	
	0.020	0.80		Canal, B=0.30m	1/70	0.01							
BP+0.80			0.80				497.23	0.61	0.02	497.21	0.08	497.13	
	0.020	2.20		No.1 DP, H=1.50m	-	1.50							

- to be continued -

Table 5.2 Hydraulic Calculation of Drainage Canals (Sindhuli Sub-center) (3/4)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
BP+3.00			3.00				498.73	-	-	-	-	-	
	0.020	6.00		No.1 CV, D=0.30m	-	0.03							
BP+9.00			9.00				498.76	0.61	0.02	498.74	0.08	498.66	
	0.020	65.38		Canal, B=0.30m	1/70	0.93							
EP			74.38				499.69	0.61	0.02	499.67	0.08	499.59	
MINOR DRAIN-2-2 (Canal Length: 151.85 m)													
BP			0.00				497.16	0.45	0.01	497.15	0.10	497.05	EP of MD-2
	0.017	25.00		Canal, B=0.30m	1/150	0.17							
No.1+0.00			25.00				497.33	0.45	0.01	497.32	0.10	497.22	
	0.017	7.00		No.1 CV, D=0.30m	-	0.03							
No.1+7.00			32.00				497.36	0.45	0.01	497.35	0.10	497.25	
	0.017	49.85		Canal, B=0.30m	1/150	0.33							
No.3+6.85			81.85				497.69	0.45	0.01	497.68	0.10	497.58	
	0.017	5.00		No.2 CV, D=0.30m	-	0.33							
No.3+11.85			86.85				497.72	0.45	0.01	497.71	0.10	497.61	
	0.017	13.15		Canal, B=0.30m	1/150	0.09							
No.4+0.00			100.00				497.81	0.45	0.01	497.80	0.10	497.70	
	0.017	0.00		-	-	0.00							
No.4+0.00			100.00				497.81	0.90	0.04	497.77	0.05	497.72	
	0.017	51.85		Canal, B=0.30m	1/20	2.59							
EP			151.85				500.40	0.90	0.04	500.36	0.05	500.31	
CATCH DRAIN-1 (Canal Length: 32.27 m)													
BP			0.00				500.59	0.81	0.03	500.56	0.32	500.24	IP-1 of MD-1-1
	0.159	8.80		Canal, B=0.30m	1/150	0.06							
BP+8.80			8.80				500.65	0.81	0.03	500.62	0.32	500.30	
	0.159	23.47		No.1 Chute	-	3.25							
EP			32.27				503.90	0.96	0.05	503.85	0.55	503.30	BP of CD-1-1 BP of CD-1-2
CATCH DRAIN-1-1 (Canal Length: 29.72 m)													
BP			0.00				503.94	0.89	0.04	503.90	0.13	503.77	EP of CD-1
	0.049	22.00		Canal, B=0.30m	1/50	0.44							
BP+22.00			22.00				504.38	0.89	0.04	504.34	0.13	504.21	
	0.049	2.00		No.1 DP, H=0.50m	-	0.50							

- to be continued -

Table 5.2 Hydraulic Calculation of Drainage Canals (Sindhuli Sub-center) (4/4)

Station No.	Discharge (m^3/s)	Distance (m)	Reduced Distance (m)	Works	Energy Gradient	Energy Loss (m)	Energy Line EL. (m)	Velocity (m/s)	Velocity Head (m)	Water Level (m)	Water Depth (m)	Canal Base EL. (m)	Remarks
BP+24.00			24.00				504.88	0.89	0.04	504.84	0.13	504.71	
	0.049	5.72		Canal, B=0.30m	1/50	0.11							
EP			29.72				504.99	0.89	0.04	504.95	0.13	504.82	
CATCH DRAIN-1-2 (Canal Length: 64.65 m)													
BP			0.00				503.94	0.86	0.04	503.90	0.24	503.66	EP of CD-1
	0.110	50.00		Canal, B=0.30m	1/100	0.50							
No.2+0.00			50.00				504.44	0.86	0.04	504.40	0.24	504.16	
	0.110	2.00		No.1 DP, H=0.50m	-	0.50							
No.2+2.00			52.00				504.94	0.86	0.04	504.90	0.24	504.66	
	0.110	12.65		Canal, B=0.30m	1/100	0.13							
EP			64.65				505.07	0.86	0.04	505.03	0.24	504.79	

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