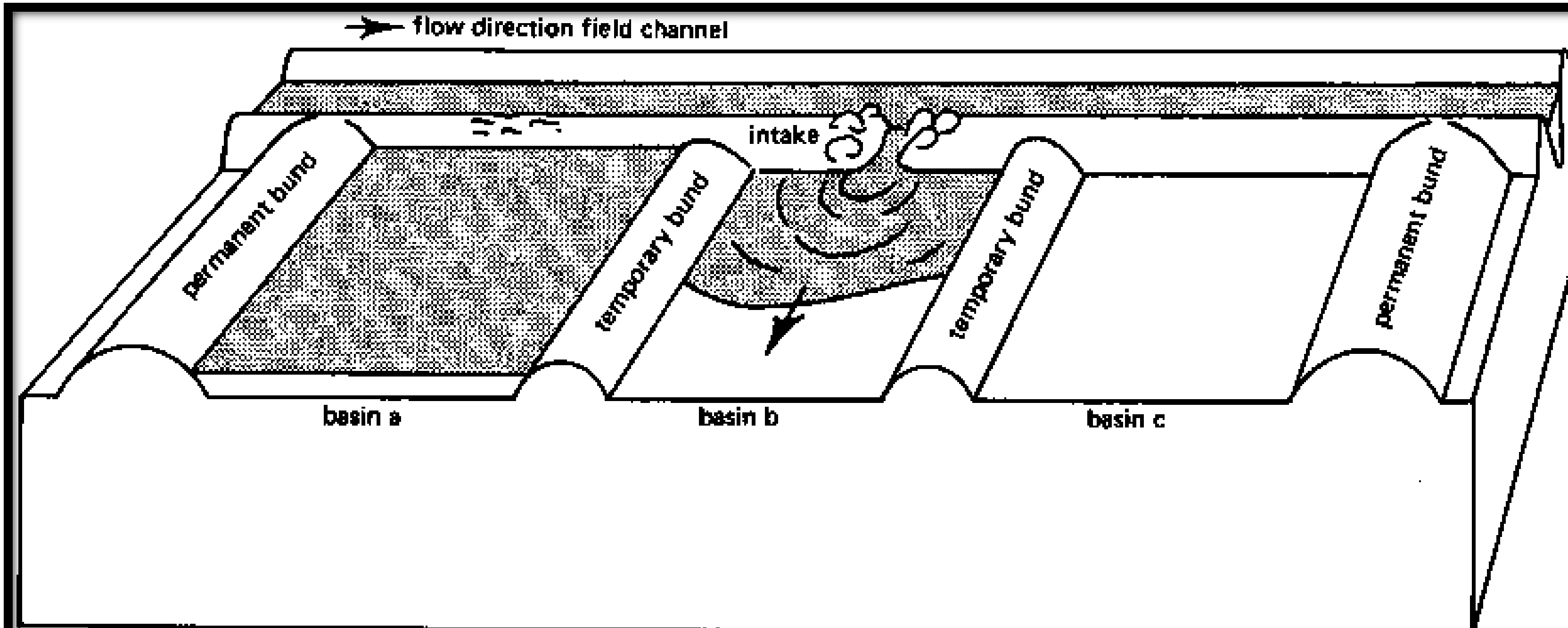
Border irrigation system design


flow direction field channel
intake
permanent bund
temporary bund
temporary bund
permanent bund
basin a
basin b
basin c

Fundamental of design

- 1.W= width of border (m)
- 2.L= length of border (m)
- 3.Qb= discharge per border L/sec.
- 4.Ta= water application in time (min)
- 5. d= depth of flow (7.6-15 cm)
- 6.I.I=irrigation interval time
- 7.Si =irrigation slope [Sy]
- 8.Cs =cross sectional slope (Sx)
- Note =choose smaller slope as Cs

Information required for design

- 1.topogeraphy [Sx , Sy]
- 2.size and shape of the field
- 3.soil investigation (texture , structure) for computing : water holding capacity and infiltration equation (basic infiltration rate)
- 4.climatic data for finding consumptive use
- 5.crop type for finding root zone depth and consumptive use
- 6.water supply (Q available and distribution time)

Two basic criteria for design

- 1.water application time (Ta) should be enough for the soil at the head of border to absorb net depth of irrigation

$$NDI = \frac{PWf.c - PWw.p}{100} \times AS \times De \times Dp\%$$

$$D = ct^m$$

$$Ti = Ta + Tl = Tn$$

Two basic criteria for design

- Where :
- Ti=infiltration opportunity time
- Ta= application time
- Tl=recession time log time
- Tn=time of absorbing the NDI
- Ta=Tn

Two basic criteria for design

- Tl depend on Si (Si≥0.4%)

$$Tl = \frac{d^2}{1200QuSi}$$

- Where :
- TL=min
- Qu=l/s/m

Two basic criteria for design

- 2.volume of water delivered to the border should be enough to cover the border with a depth equal to gross depth of irrigation(GDI).
- Application efficiency=Ea=NDI/GDI
- Time=Ta
- Volume of water=$Qb \times Ta = L \times W \times GDI$
- $Qu = Qb/W$ or $Qb = Qu \times w$
- $Qu \times Ta \times 60 = L \times NDI/Ea$

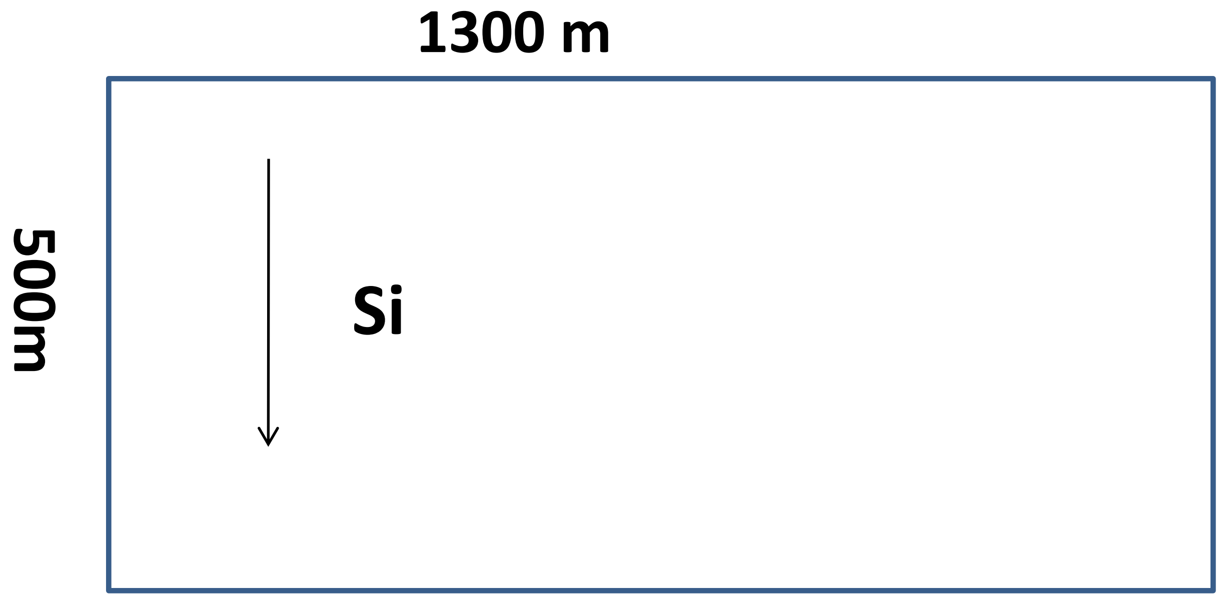
- Where :
- Qu= disharge per unit width of border L/s/m
- Ta=application time   (min)
- L= length of border   (m)
- W=width of border   (m)
- Ea application efficiency of border
- GDI= gross depth of irrigation
- NDI=net depth of irrigation

Design consideration and limitation

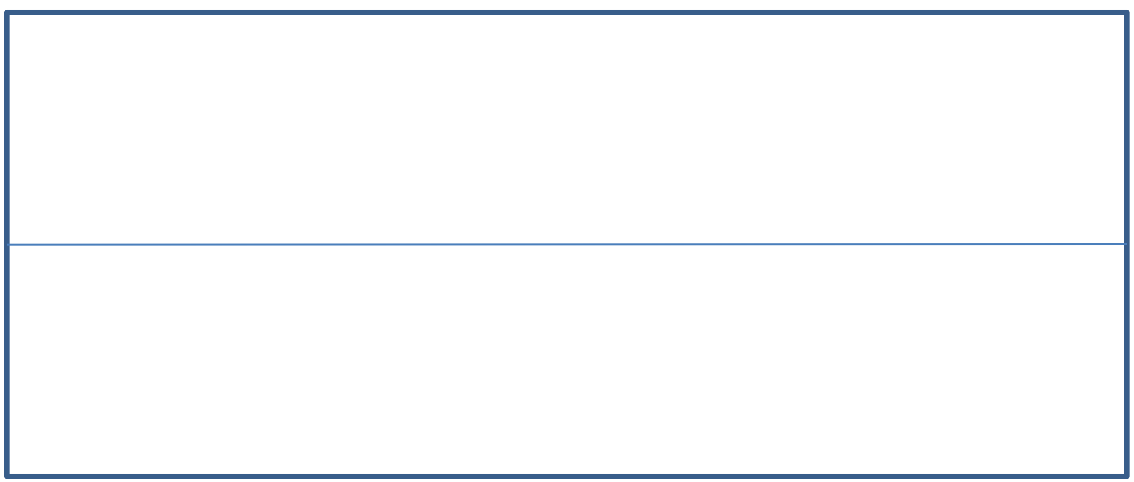
- 1.design flow rate:
- Qu min.≤ Qu design≤ Qu max
- $$Qu\max = 0.175 \times Si^{-0.75}$$ For n≤0.2
- $$Qu\max = 0.35 \times Si^{-0.75}$$ For n>0.2
- Qu=L/sec per meter width
- Qu=discharge per meter width
- Si=irrigation slope (0.5%-0.005%)

- Qu min=$\frac{5.95\times10^{-3}\times L\ design\times si^{0.5}}{n}$

Maximum border length



- L= B, B/2 ,B/3 ,B/4
- According to Qu max and d



B/2=250 m

- $Qu \times Ta \times 60 = L \times GDI$
- $Qu\ max$, $L\ max$
- $L\ max > B$
- $L = B$
- $L\ max < B < B/2$ $\quad$ $L = B$
- $L\ max > B/2 > B/3$ $\quad$ $L = B/2$
- $L\ max > B/3 > B/4$ $\quad$ $L = B/3$

- Check d = (7.0 -15) cm
- d= depth of flow
- For check d go to manning equation

$$Qu = \frac{1}{n} d^{\frac{5}{3}} S^{\frac{1}{2}}$$

- Where: Qu$(m)^3$/sec
- d(m)
- D×100=(7 -15)cm

Width of border

- Qb= Q design× W
- 1.based on cross slope

$$W\max = \frac{d}{400 \times Cs}$$

Width of border

- 2.based on irrigation slope (Si)

Si%	W max(m)
0-0.1	30
0.1-0.5	20
0.5-1.0	15
1.0-2.0	12.5
2 -4	10
4.6	7.5

Width of border

- 3.based on available water

$$W\max = \frac{Qavailable}{Qu}$$

- W max=$\frac{Q\ effective}{Qb}$
- Q effective=Q available $\times Ec$
- Ec = conveyance efficiency

Example

- The field shown in figure compute discharge of the head of the field from given data:
- 1.n=0.15 2.D=$10t^{0.5}$ 3. WHC=1.33 mm/cm
- 4. working water resource (14 hr/day)
- 5.effective RZD=1.2 m
- 6.Sy=0.6% 7.Sx=0.3%
- 8.CU=10.1 mm/day
- 9.Depletion =65%

- II=$\frac{NDI}{Cu}$ NDI=WHC$\times$ $De \times DP$
- NDI=1.3$\times$ 120×0.65=101.4 mm
- II=$\frac{101.4}{10.1}$=10 day$\rightarrow$ $10 = \frac{NDI}{10.1} \rightarrow NDI = 101mm$
- Ta=Tn
- D=10$t^{0.5}$ $\rightarrow$ 101=10$Tn^{0.5}$ $\rightarrow Tn = 102\ min$
- I= i=60$\times$ $c \times m \times t^{m-1}$
- $\rightarrow 60 \times 10 \times 0.5 \times t^{0.5-1}$=300$t^{-0.5}$

- Ib=300$[600\times 0.5]^{-0.5}$ $\rightarrow Ib = \frac{17.3mm}{hr}$
- So from table

	Ib mm/hr				
Si	<5	5-10	10-18	18-64	>64
0.05-0.1	60	70	70	75	65
0.1-0.5	55	65	70	70	70
0.5-1		60	65	70	70
1-2		55	60	70	65
2-4			55	65	60
4-6			50	60	55

- So Ea=65%
- GDI=$\frac{NDI}{Ea}$ so GDI=$\frac{101}{0.65}$=155.38mm
- Qu max=0.175$(Si)^{-0.75}$ for n<0.2 n=0.15
- Qu max=0.175$(0.006)^{-0.75}$ = 8.2L/Sec/width meter
- Qu max×Ta×60=L×GDI So
- 8.2$\times 102 \times 60 =$155.38$\times L$
- L max=322 m

- L=$\frac{B}{2}$ So L design=300
- Qu design ×Ta×60=L design×GDI
- Qu design$\times 102 \times 60 = 155.38 \times 300$=
- Qu design=7.6 L/Sec/width meter

- Cheking d
- Qu=$\frac{1}{n} \times d^{\frac{5}{3}} \times Si^{\frac{1}{2}}$

- Qu=$\frac{1}{n} \times d^{\frac{5}{3}} \times Si^{\frac{1}{2}}$
- $\frac{7.67}{1000}$=$\frac{1}{0.15} \times d^{\frac{5}{3}} \times (0.006)^{\frac{1}{2}}$ so d=0.0795 m
- d= 0.0795$\times$ 100=7.95 cm ok in range
- 7< 7.95 < 15
- NOTE: If above the range we should choose smaller L

- W=$\frac{d}{400\ Cs}$ so $\frac{7.95}{400\times(0.003)}$= 6.6 m =6 m
- From table =15 m
- But we choose smaller one which is 6
- Q border= Qu design×w =7.6× $6 = 45.6\ or\ 46$

- Qu min=$\frac{5.95\times10^{-3}\times L\ design\times si^{0.5}}{n}$
- Qumin=$\frac{5.95\times10^{-3}\times300\times0.006^{0.5}}{0.15}$=0.922 L/Sec/width per meter
- No. of border =$\frac{Total\ area}{Area\ one\ border}$=$\frac{400\times600}{6\times300}$=133 border

- No. of border irrigated in one day by Qb
- $=\frac{working\ time}{application\ time}=\frac{14\times 60}{102}=$8.2=8 border/day
- No.of border irrigated at II$=8\times 10=80\ border$
- Q Total=No.of set$\times Qb$
- No. of set$=\frac{total\ no.of\ border}{No.of\ border\ irrigated\ at\ II}$

- No. of set=$\frac{133}{80}$=1.66=2 set
- So Q total=2$\times$ $46 = 92\ L/Sec$