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Por Harry R. Cedergren

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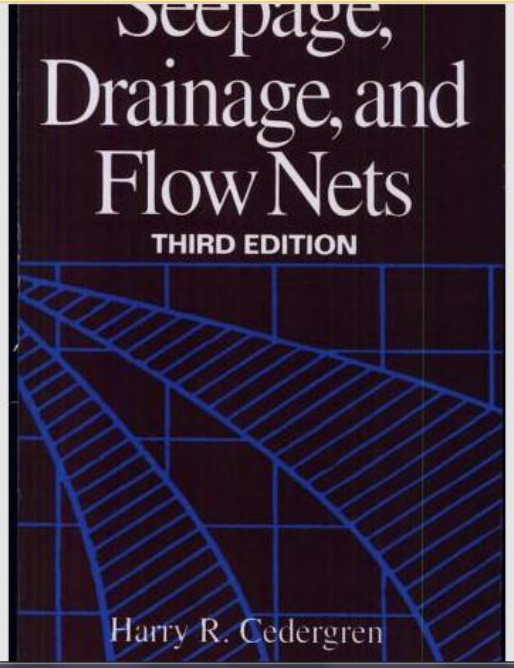

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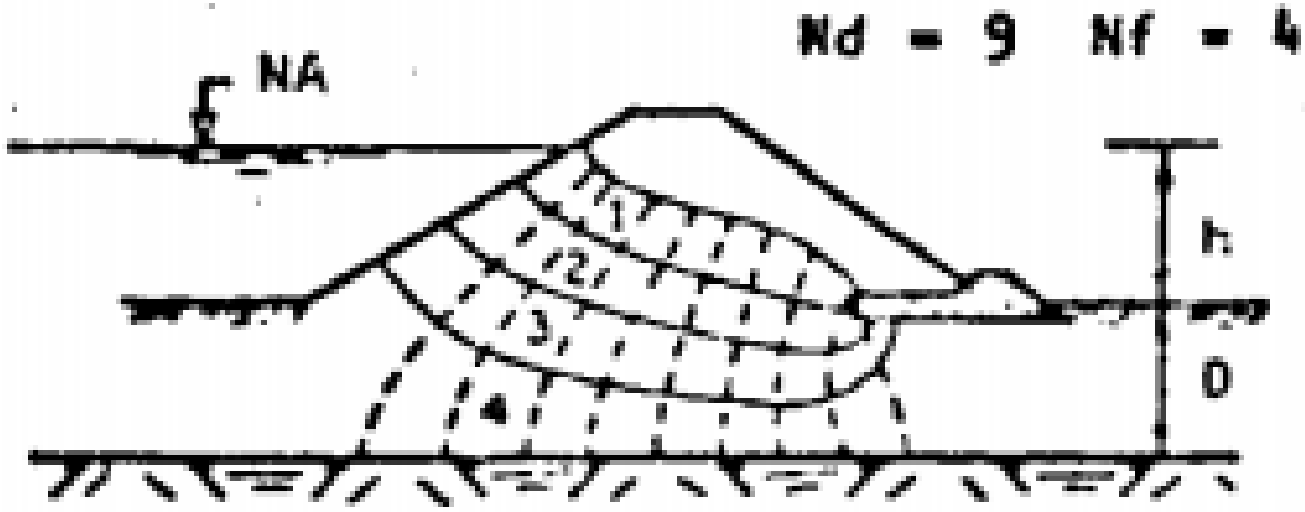
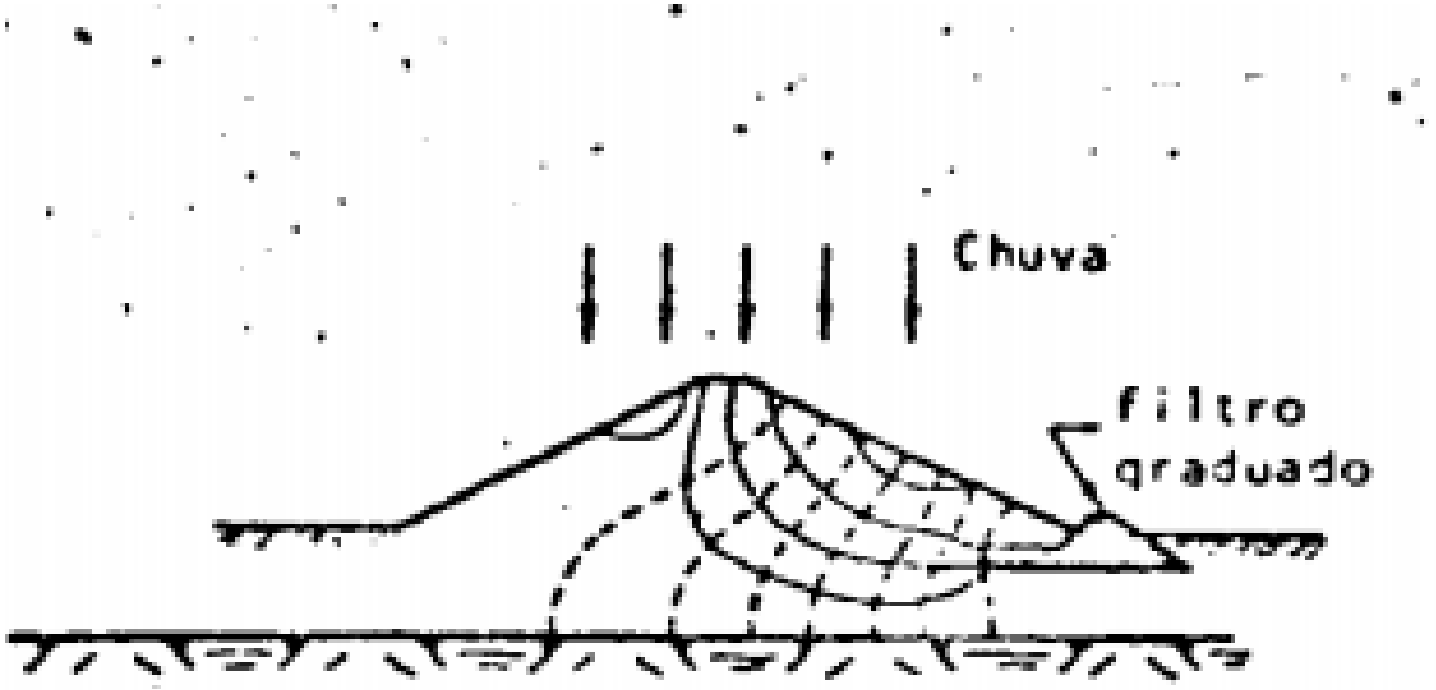


e) Barragem de Terra



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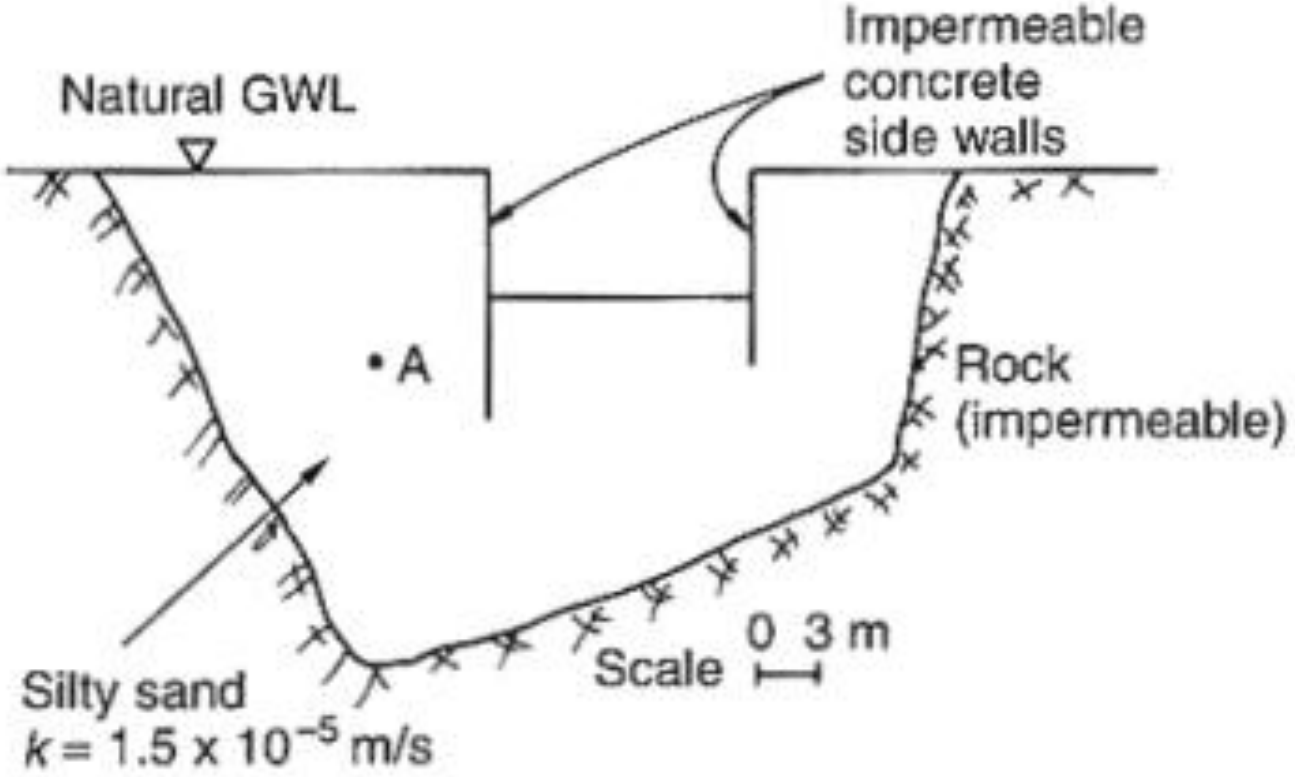
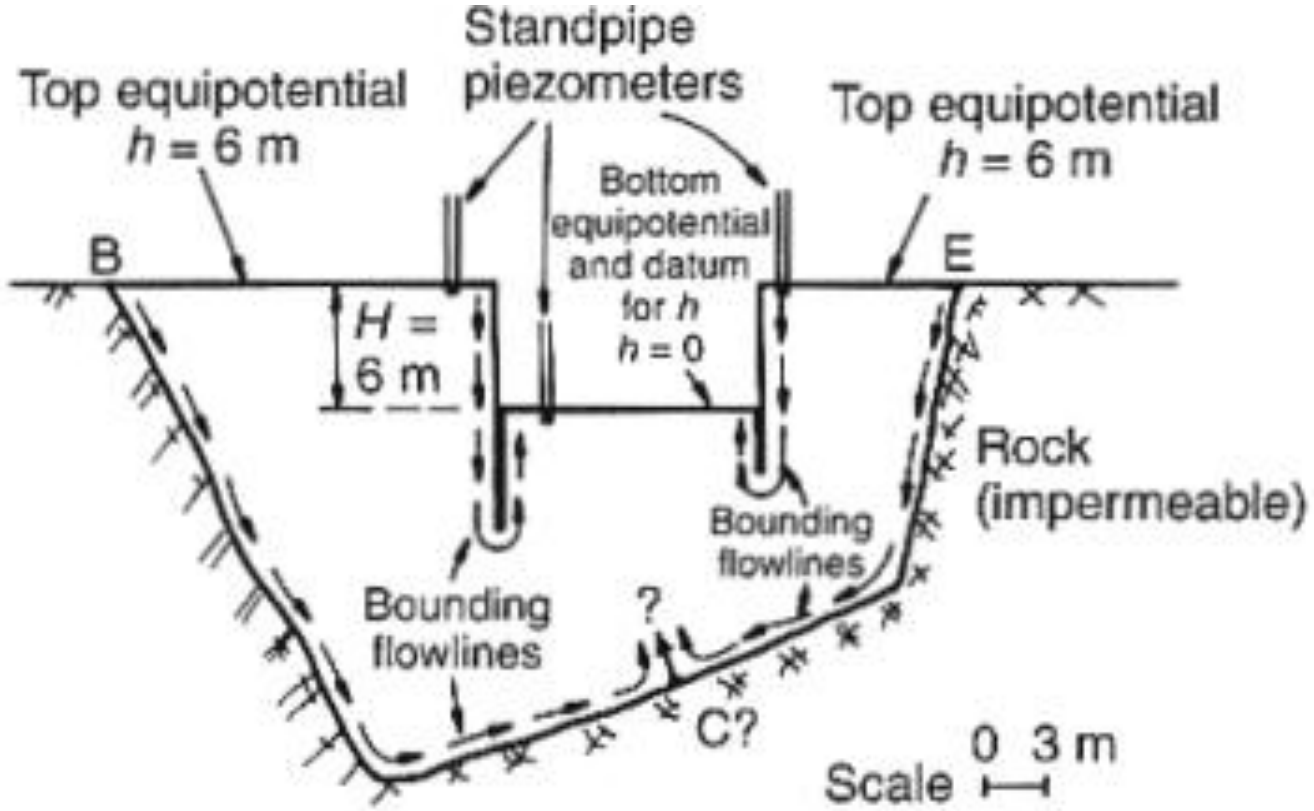
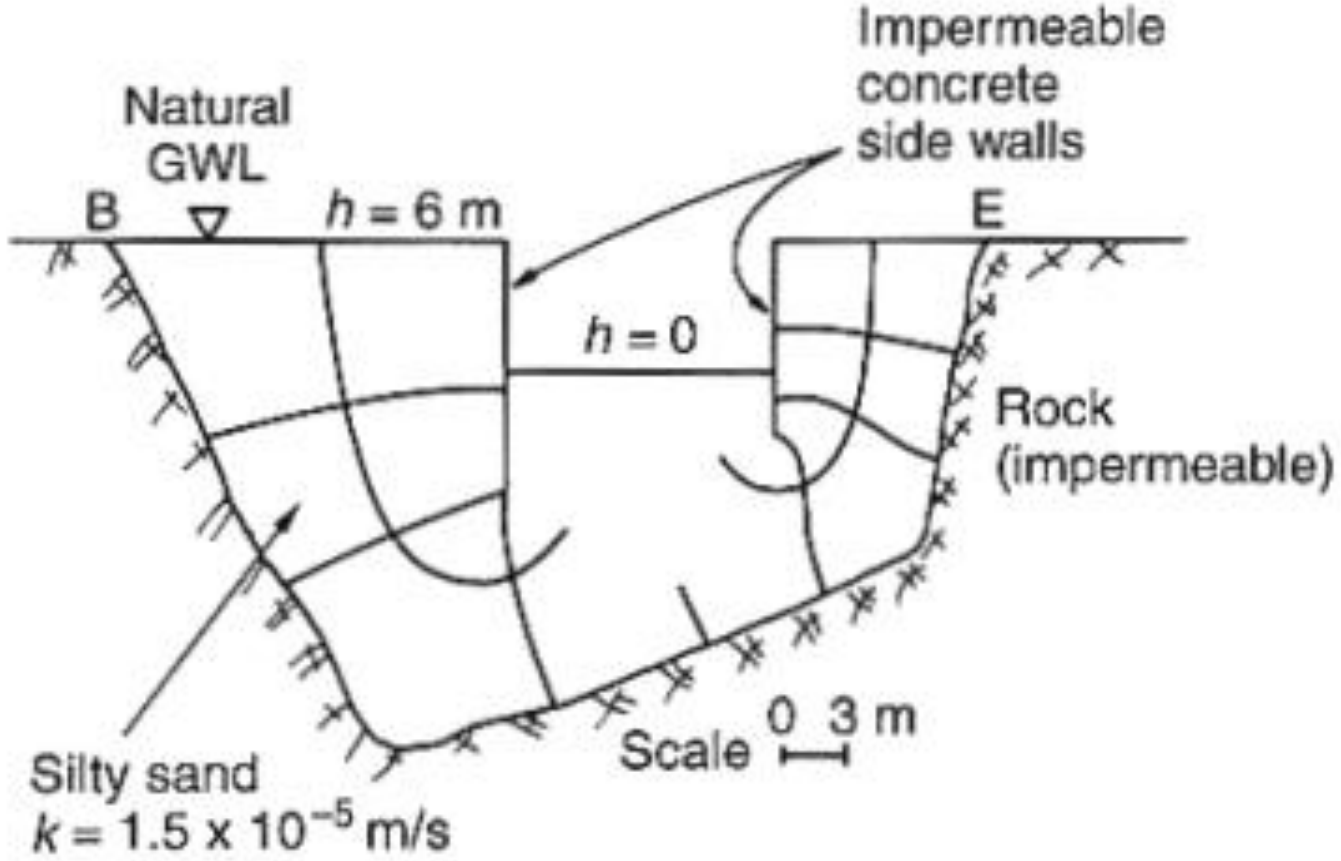
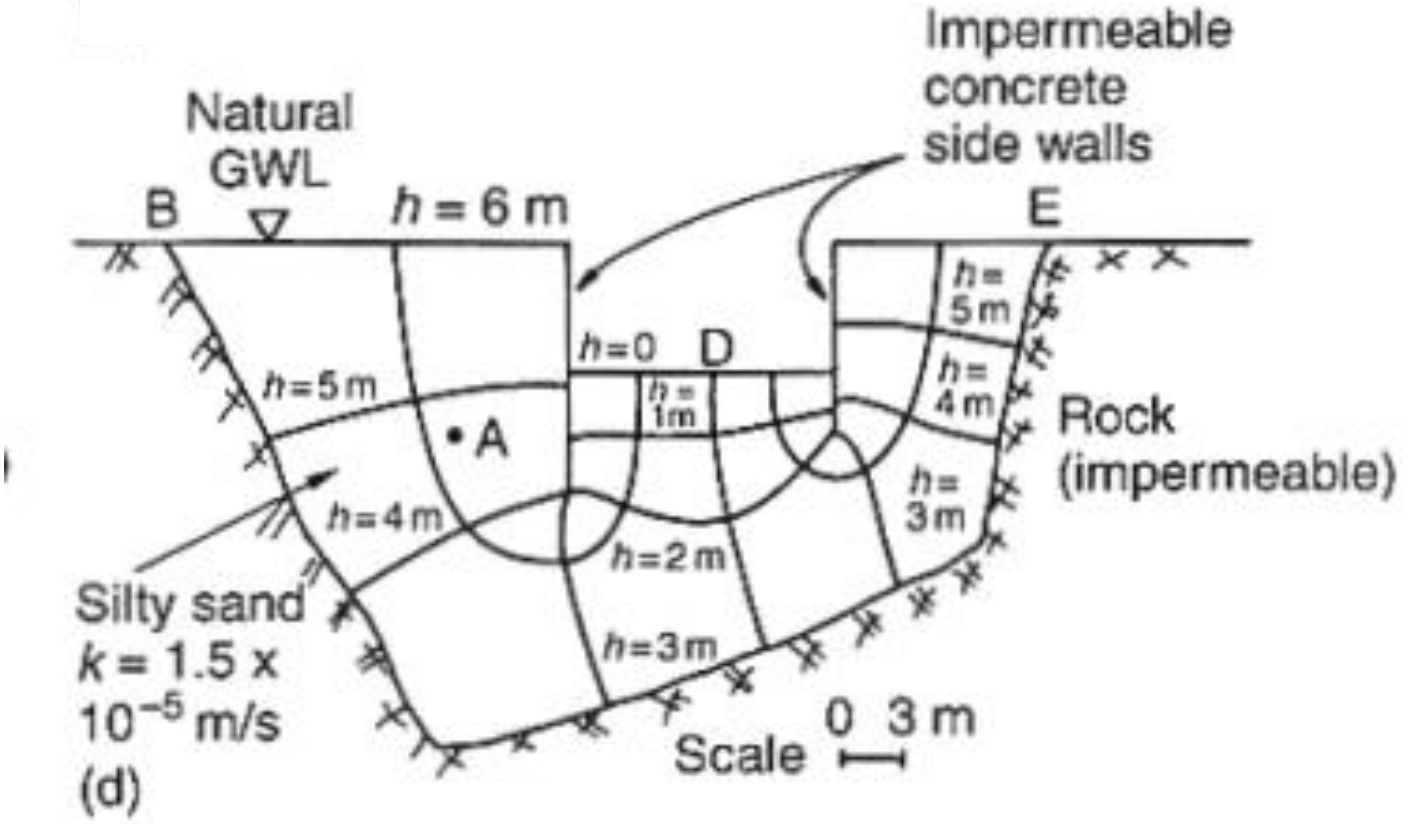

Natural GWL
Impermeable
concrete
side walls
• A
Rock
(impermeable)
Silty sand
$k = 1.5 \times 10^{-5}$ m/s
Scale 0 3 m
(a)

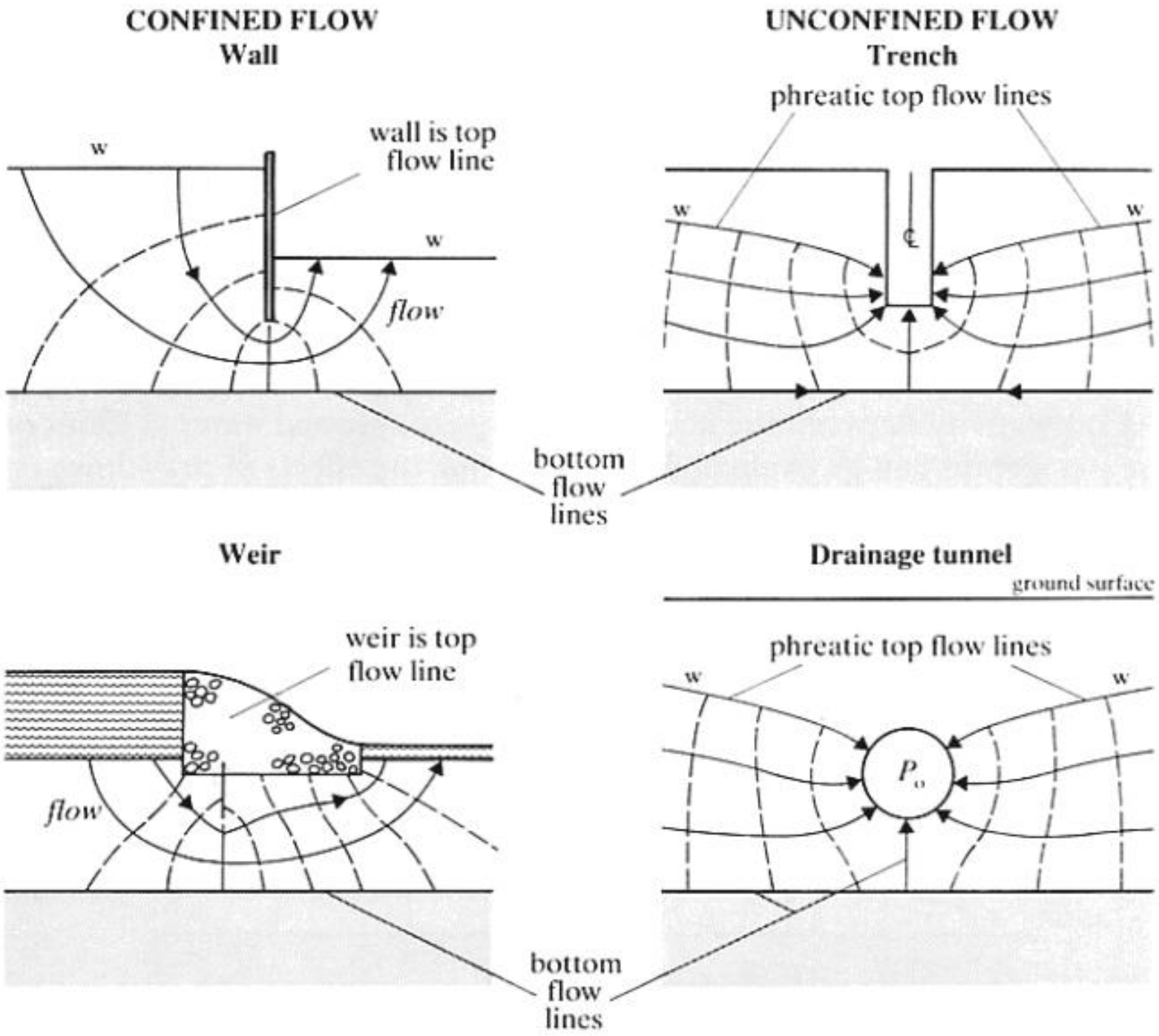

Standpipe
piezometers
Top equipotential
h = 6 m
Top equipotential
h = 6 m
Bottom
equipotential
and datum
for h
h = 0
B
E
H =
6 m
Rock
(impermeable)
Bounding
flowlines
Bounding
flowlines
?
C?
0 3 m
Scale

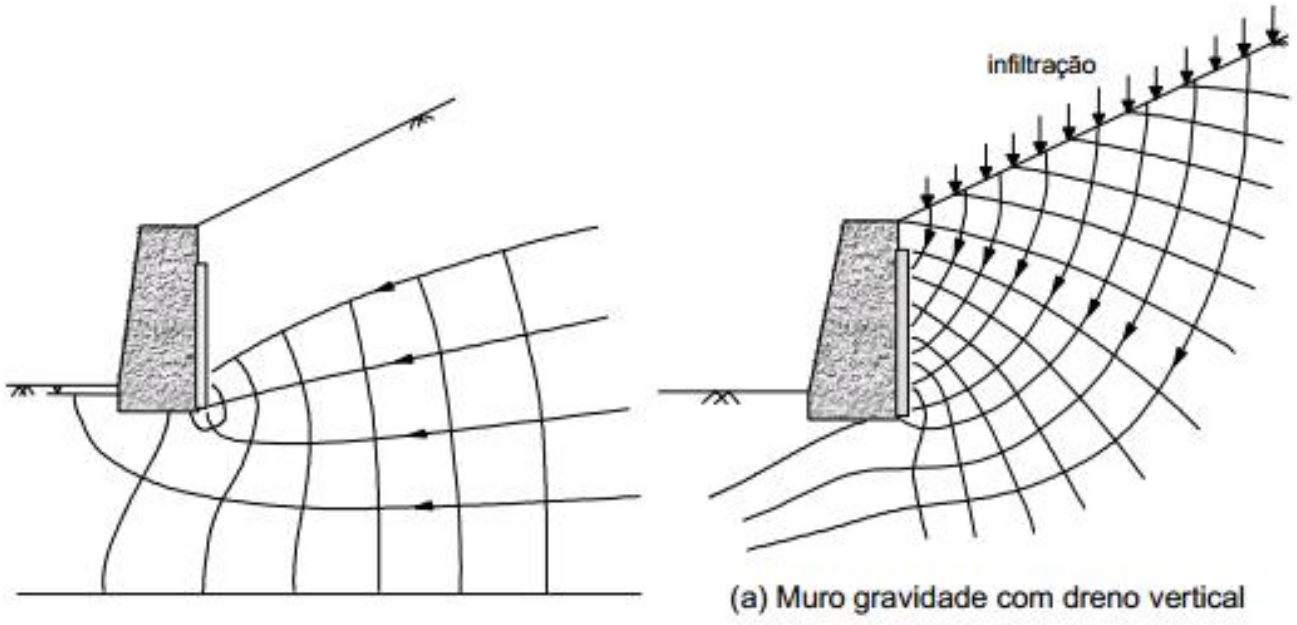
(b)


Impermeable
concrete
side walls
Natural
GWL
B
h = 6 m
E
h = 0
Rock
(impermeable)
Silty sand
k = 1.5 x 10⁻⁵ m/s
Scale 0 3 m

(c)


Impermeable
concrete
side walls
Natural
GWL
B
h = 6 m
E
h=0
D
h=5m
h=
1m
h=
5m
h=
4m
•A
Rock
(impermeable)
h=4m
h=
3m
h=2m
Silty sand
k = 1.5 x
10⁻⁵ m/s
h=3m
0 3 m
Scale
(d)


CONFINED FLOW
Wall
w
wall is top
flow line
w
flow
UNCONFINED FLOW
Trench
phreatic top flow lines
w
w
bottom
flow
lines
Weir
weir is top
flow line
flow
Drainage tunnel
ground surface
phreatic top flow lines
w
w
P_o
bottom
flow
lines



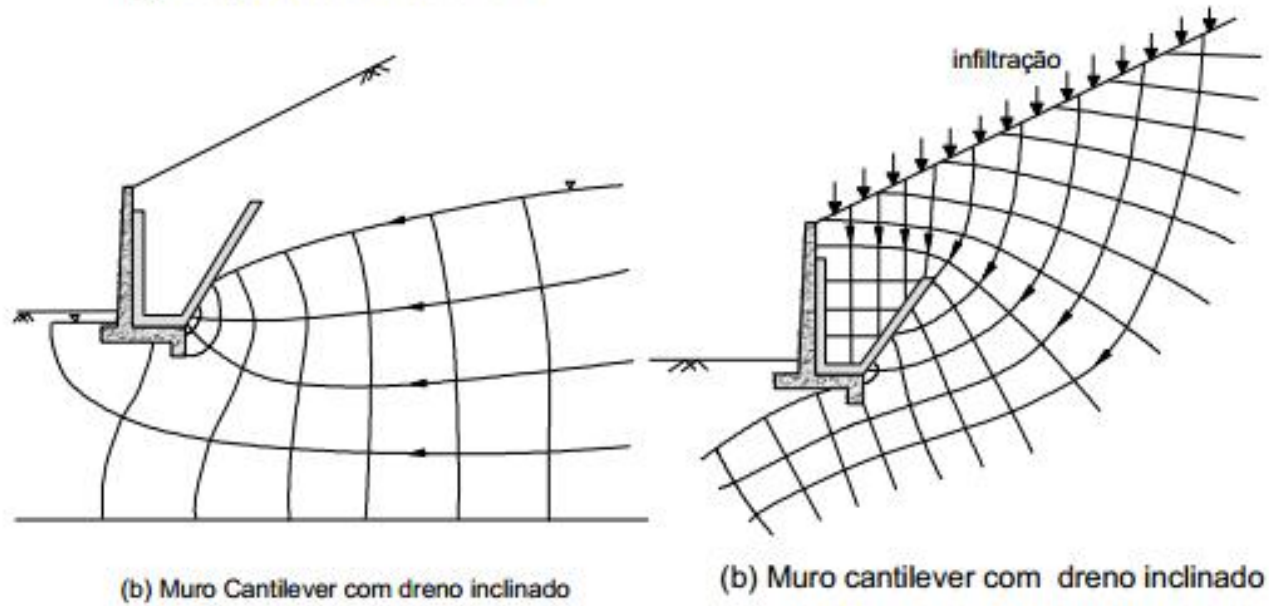


Figura 89. Redes de fluxo em muros

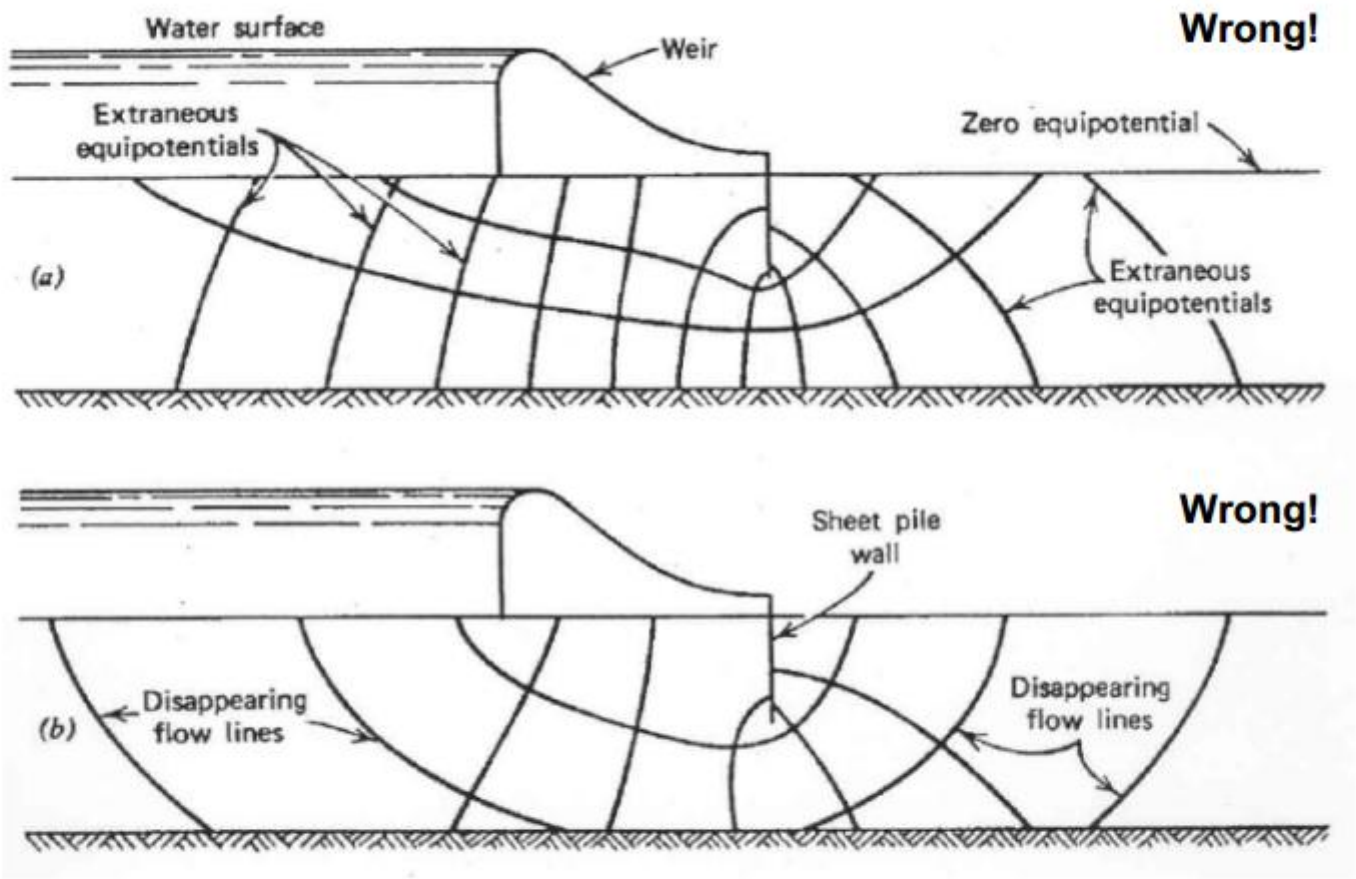


Figure 9. Some common errors include (a) equipotentials entering or exiting a no-flow boundary, and (b) disappearing flow lines.

EXAMPLES:

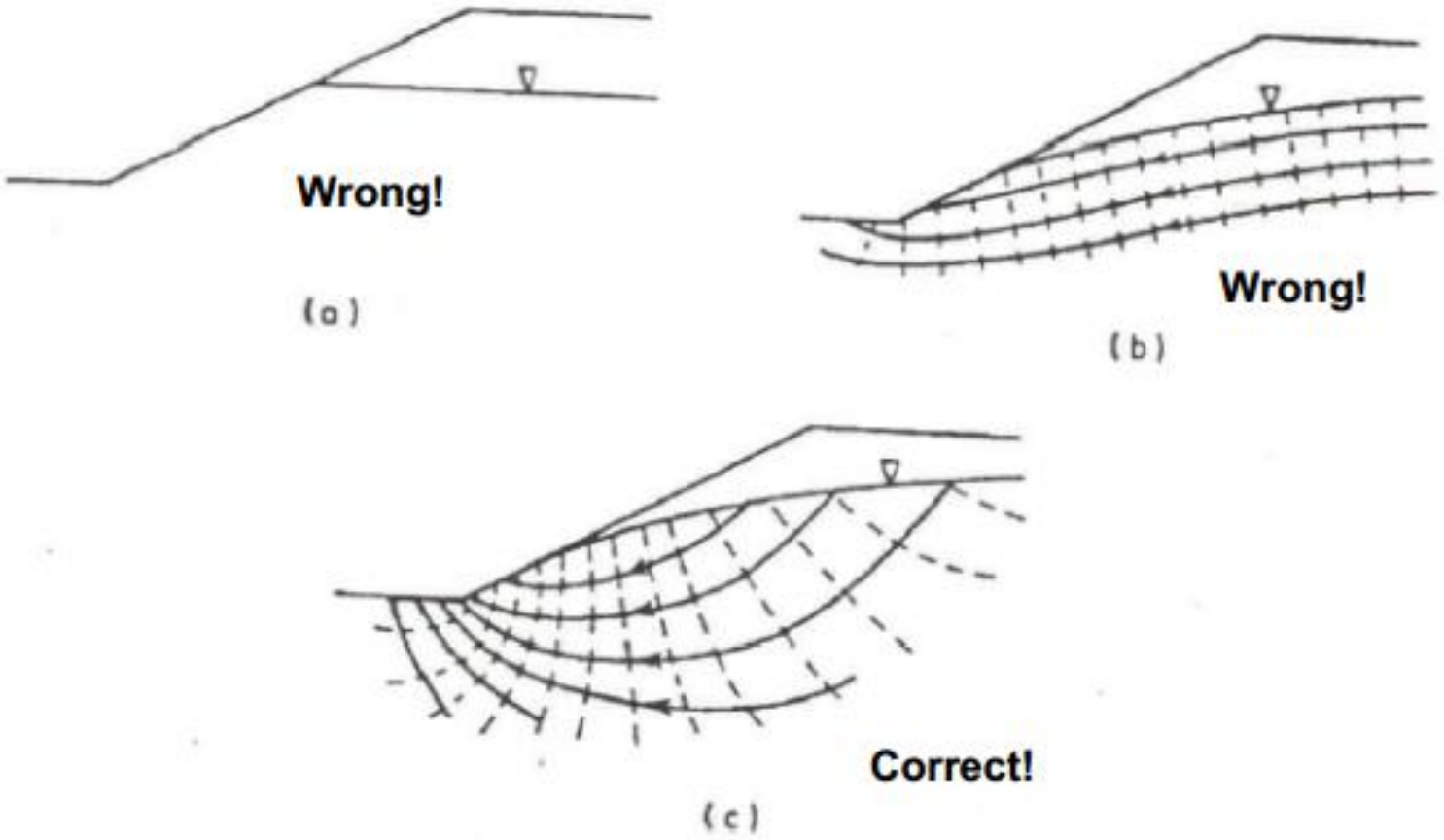
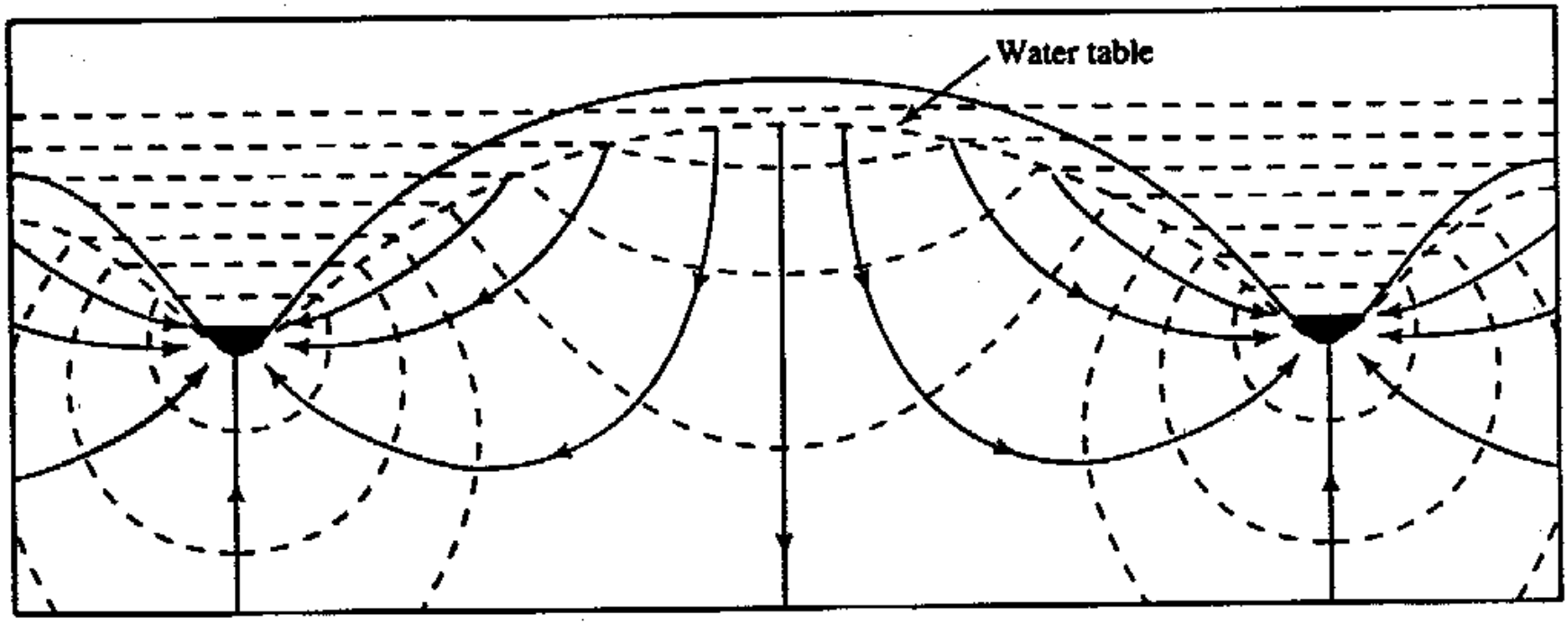
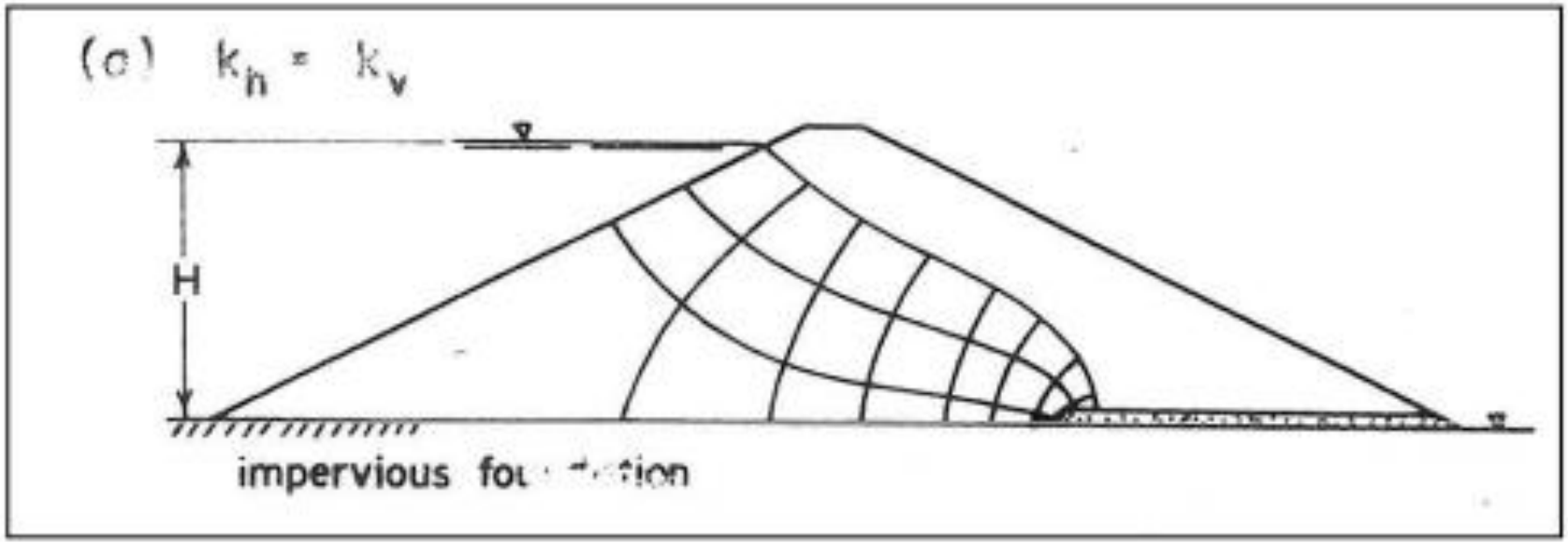


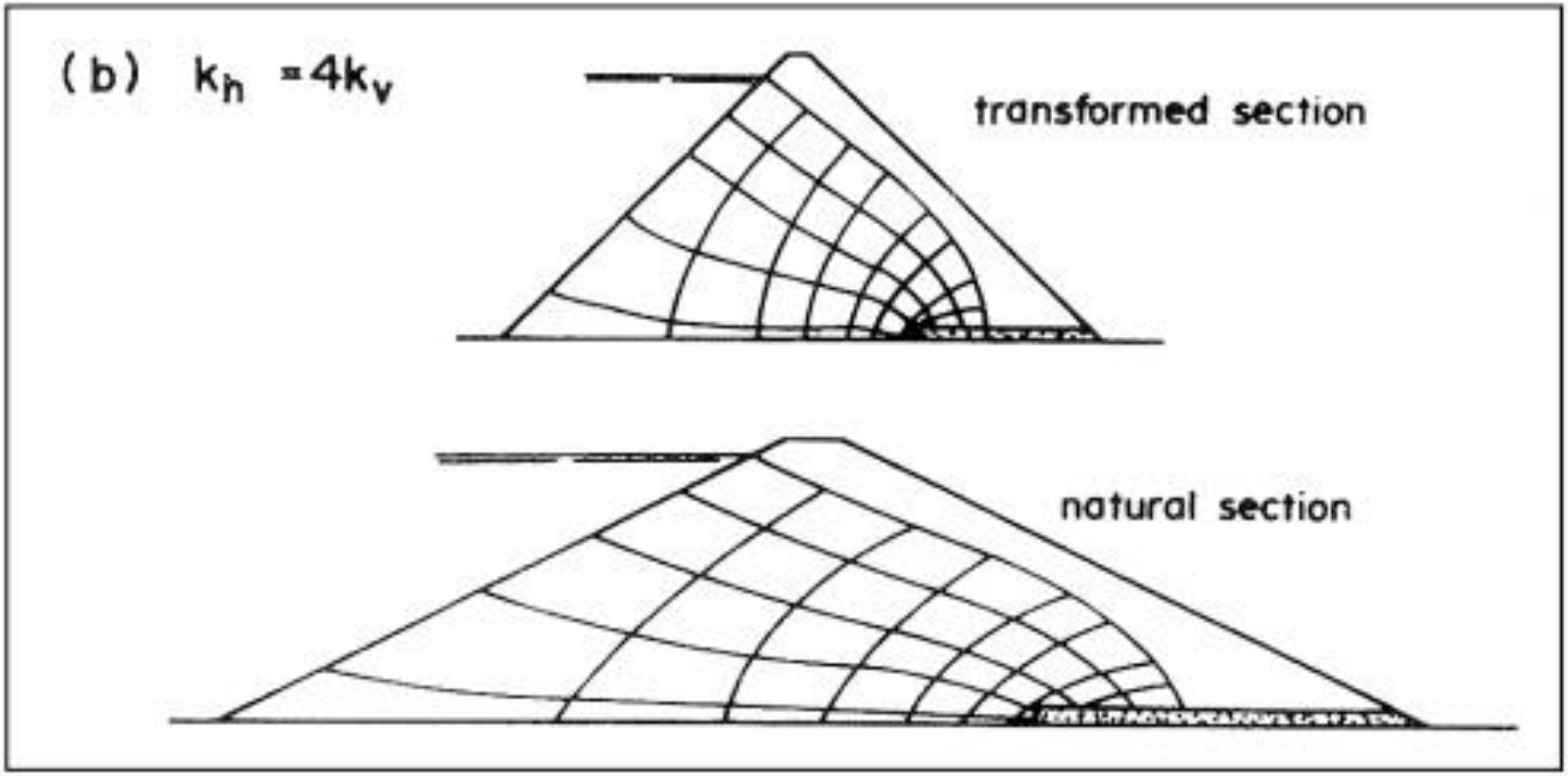
Figure 4. Unconfined groundwater flow nets on a slope.
(a) and (b) are incorrect interpretations, and (c) is correct.


Water table

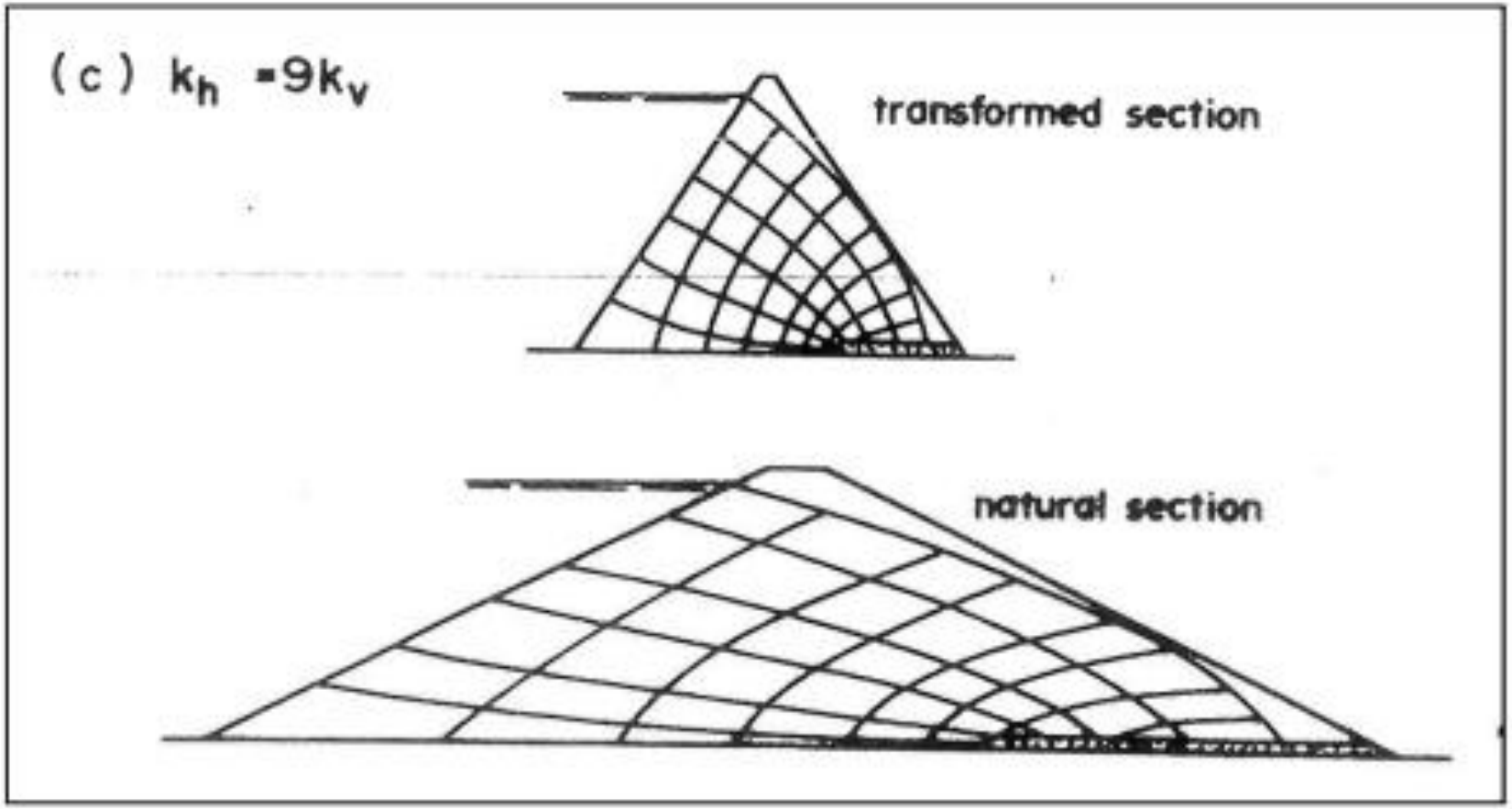
Influência da Anisotropia na Rede de Fluxo Através da Barragem

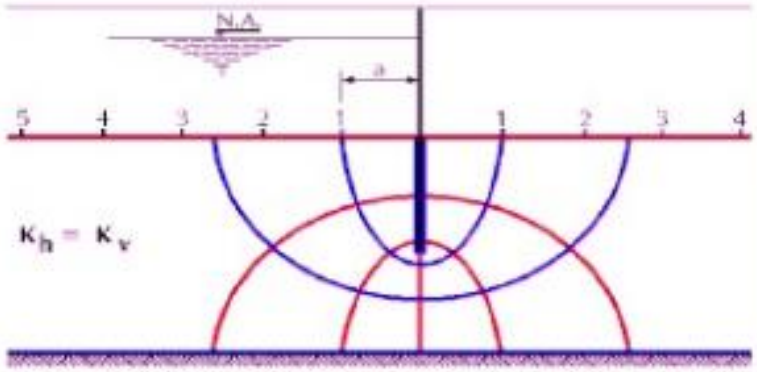


Influência da Anisotropia na Rede de Fluxo Através da Barragem

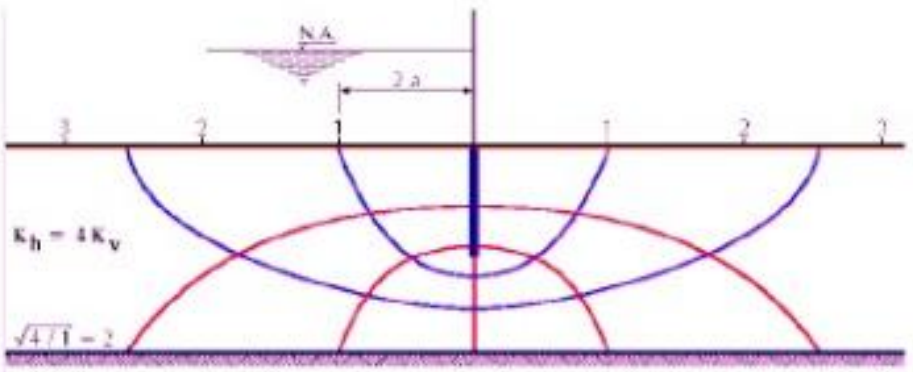


Influência da anisotropia na rede de fluxo através da barragem

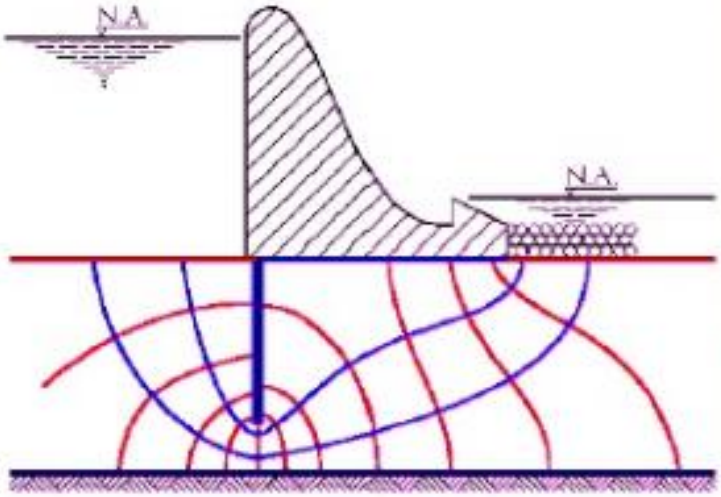




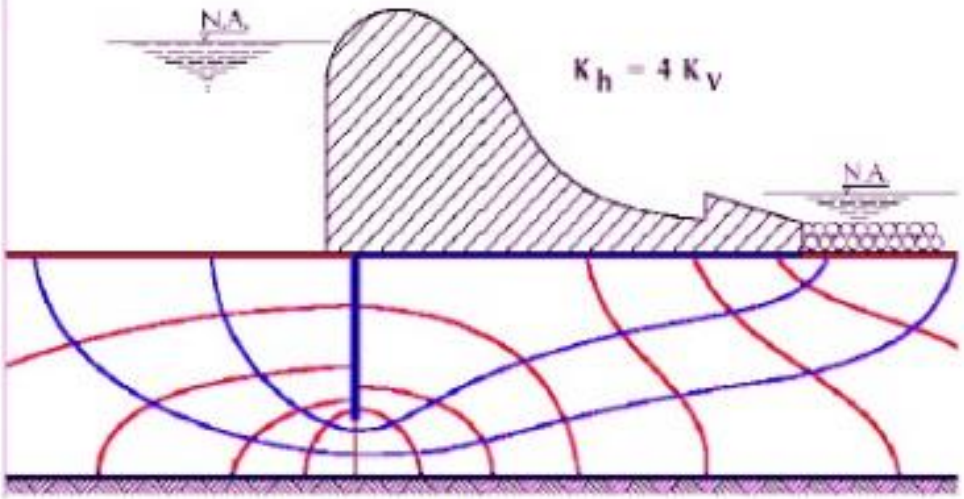
(a) seção transformada



(b) Seção real



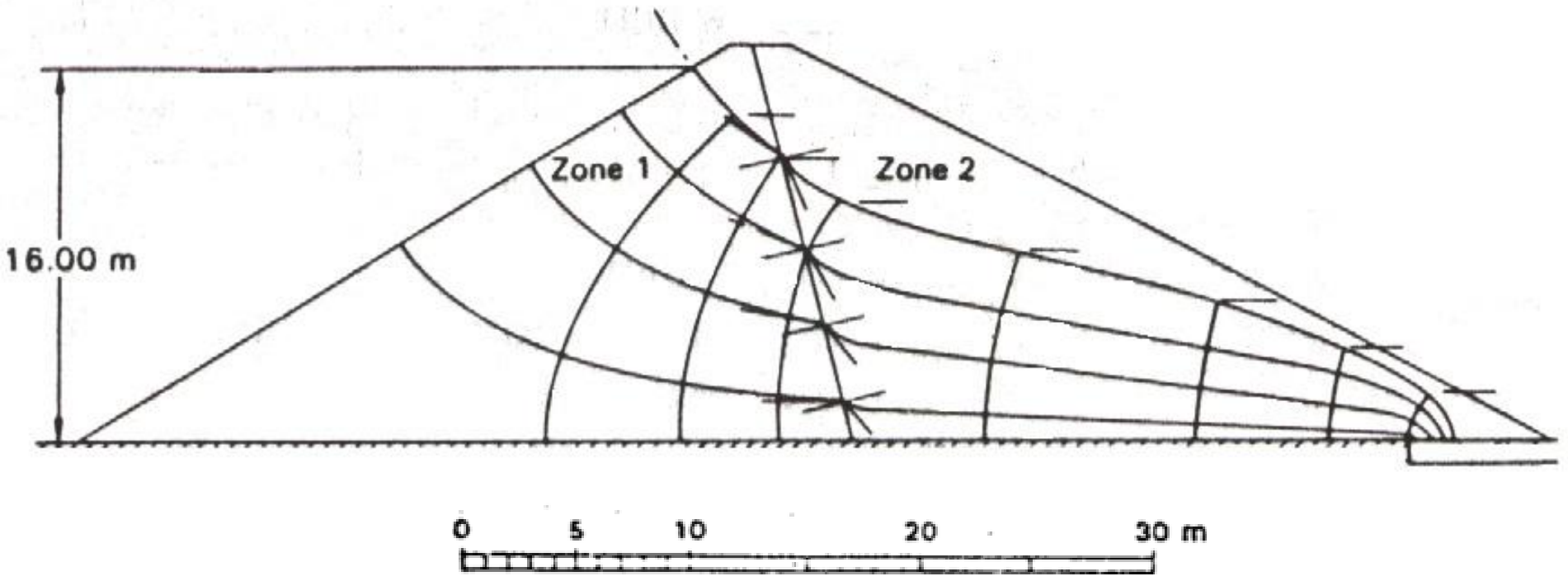
(a) seção transformada



(b) Seção real

Figura 3.20 – Exemplos de rede de fluxo em meios anisotrópicos.Modificado de Stancati (1984).

Influência da heterogeneidade na rede de fluxo através da barragem



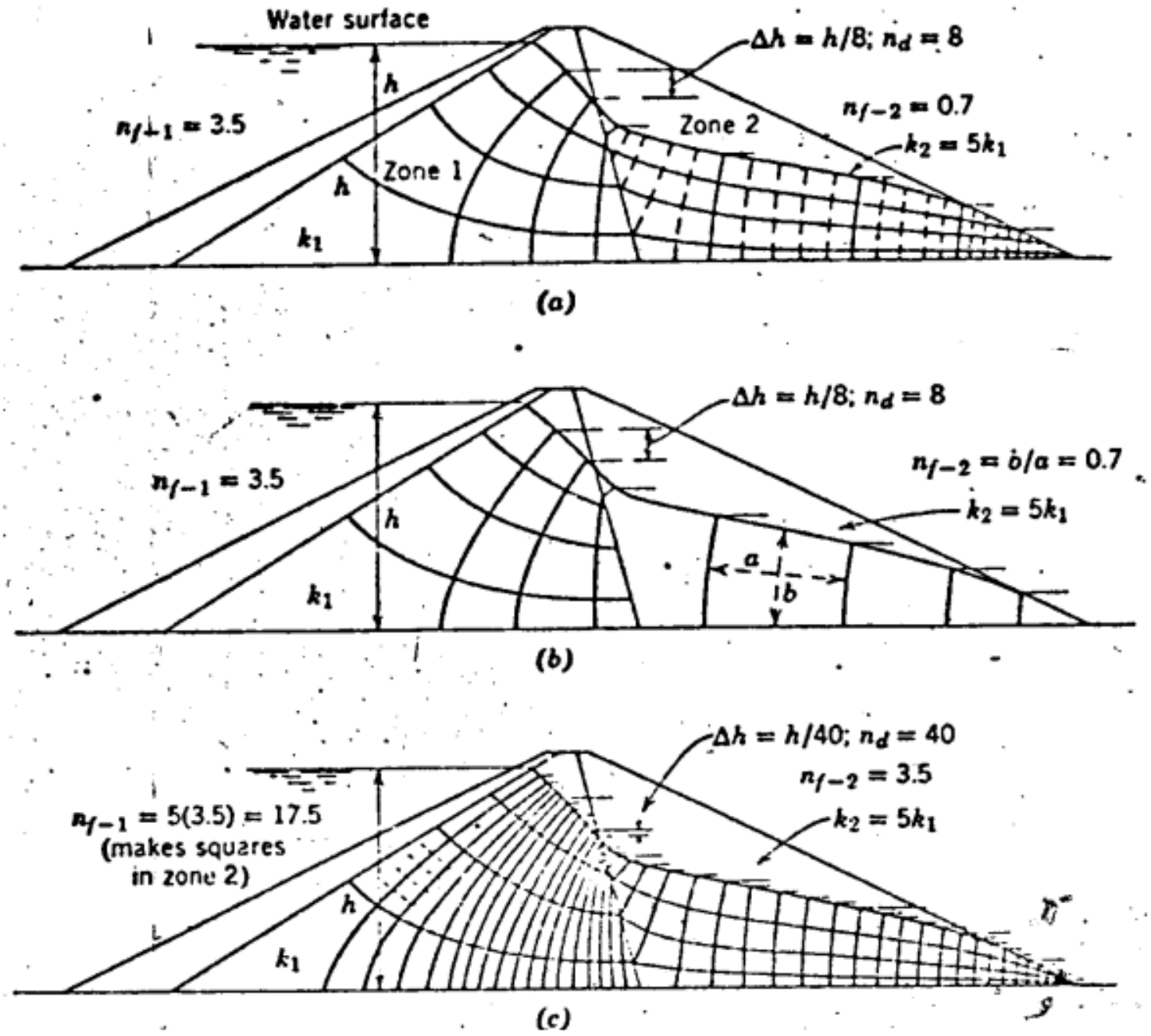


Figura 91 – Three forms of one flow net

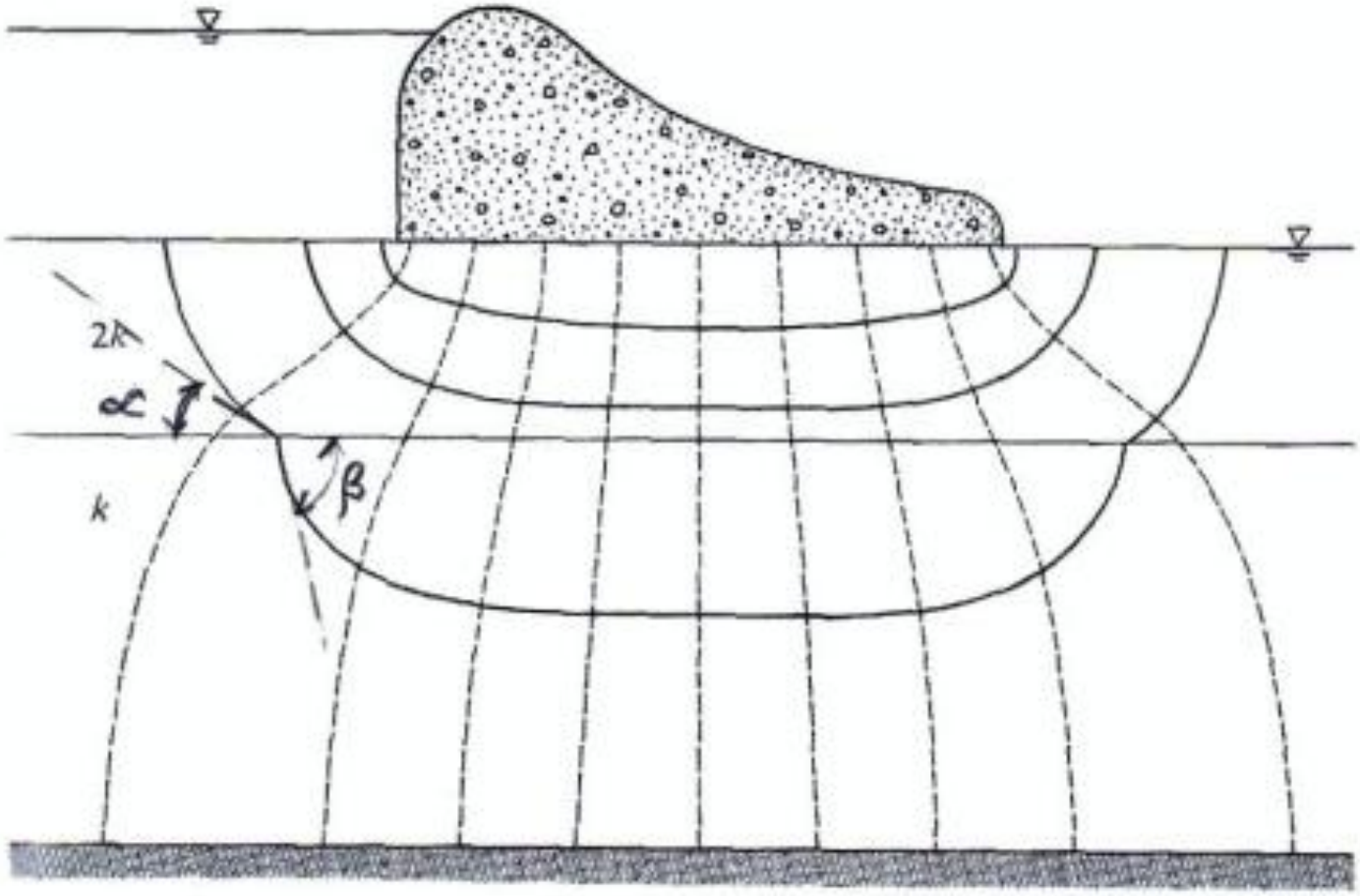


Figura 81. Fundação Hererogenea

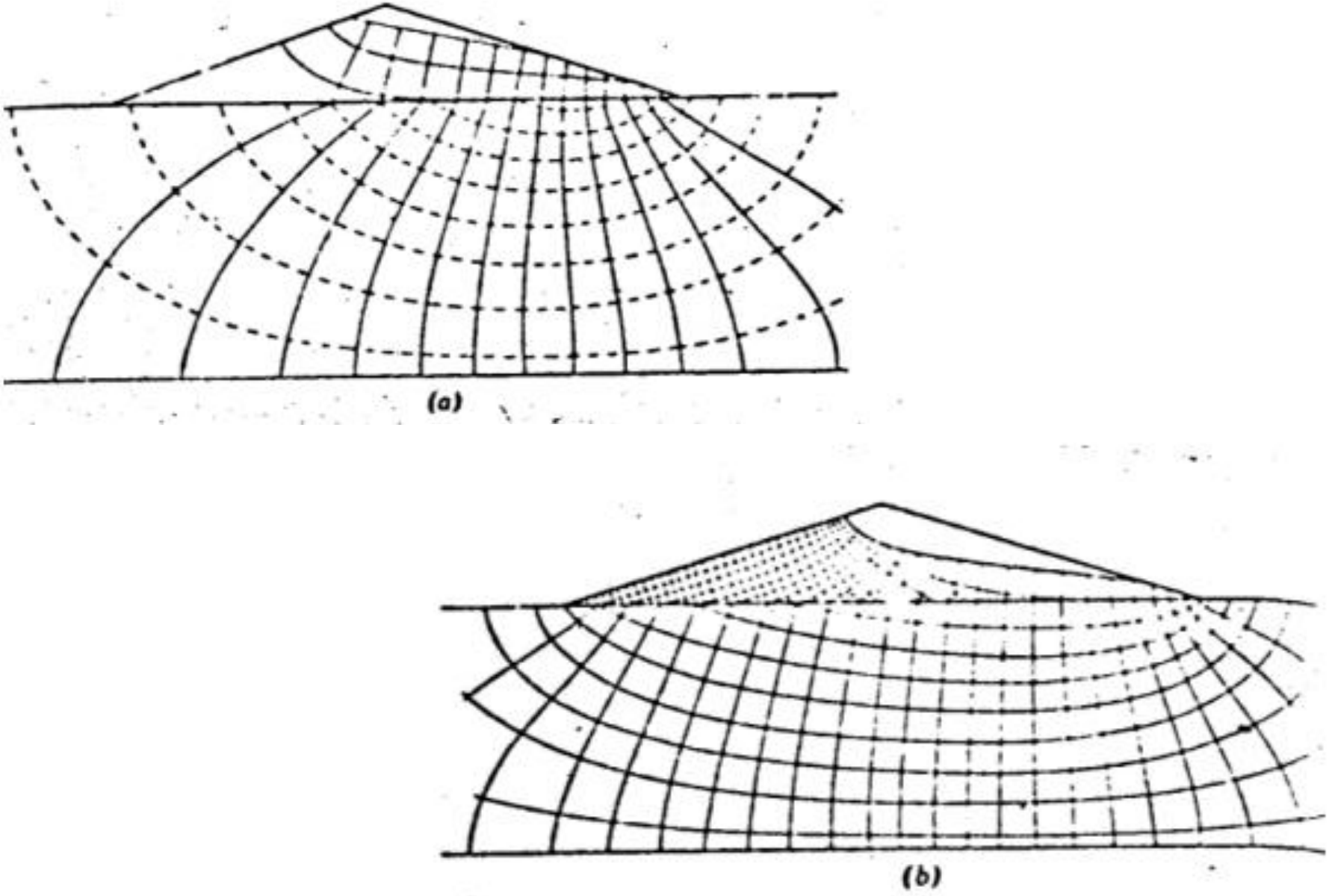
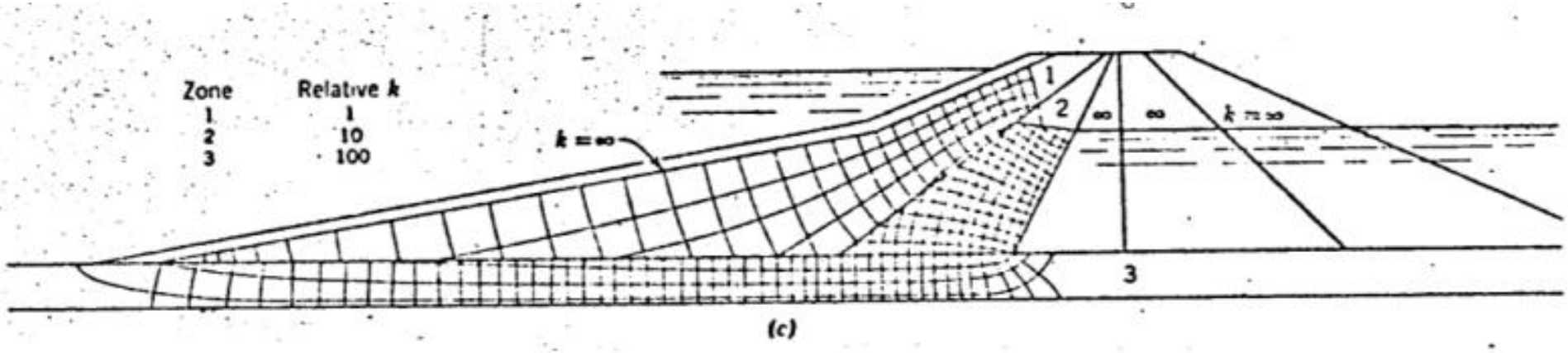


Figura 93 – Typical flow nets through dams of different permeability (after Cedergren, Ref.214). (a) Permeability of embankment 10 times the permeability of foundation. (b) Permeability of embankment 0,1 times the permeability of foundation.



(c)

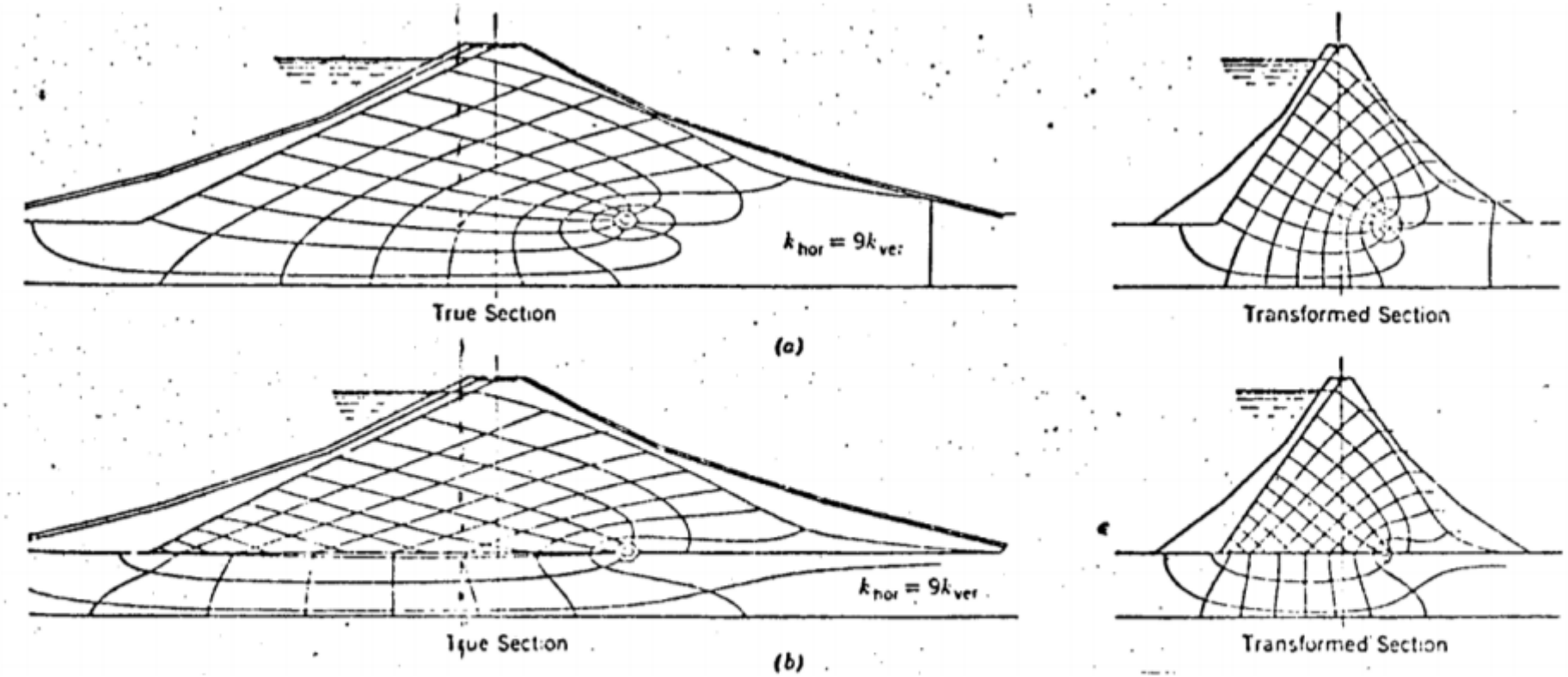
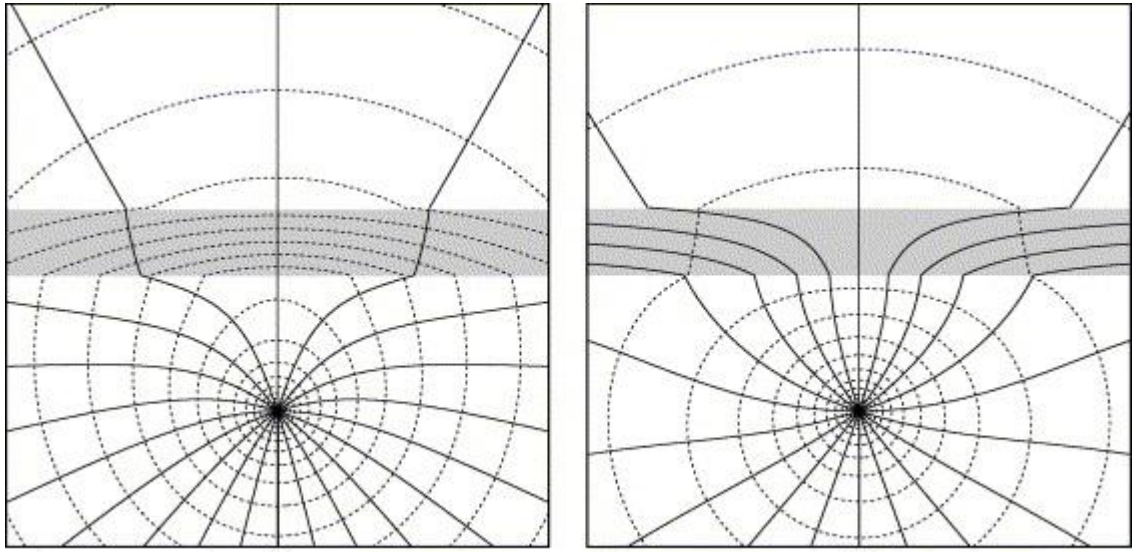


Figura 92 – Typical flow nets through anisotropic embankment and foundations (after Cedergren, Ref.214). (a) Foundation permeability equal to embankment permeability. (b) Foundation permeability 30 times embankment permeability.



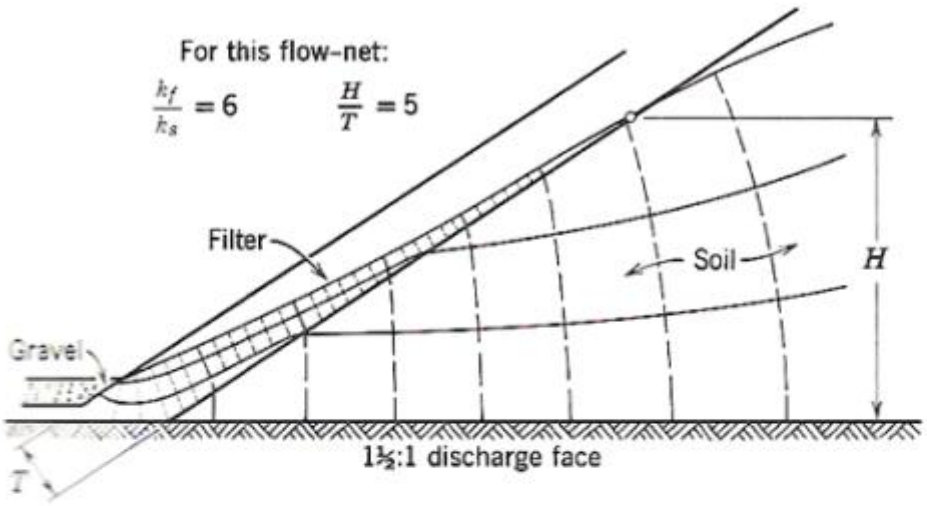
(a) (b)

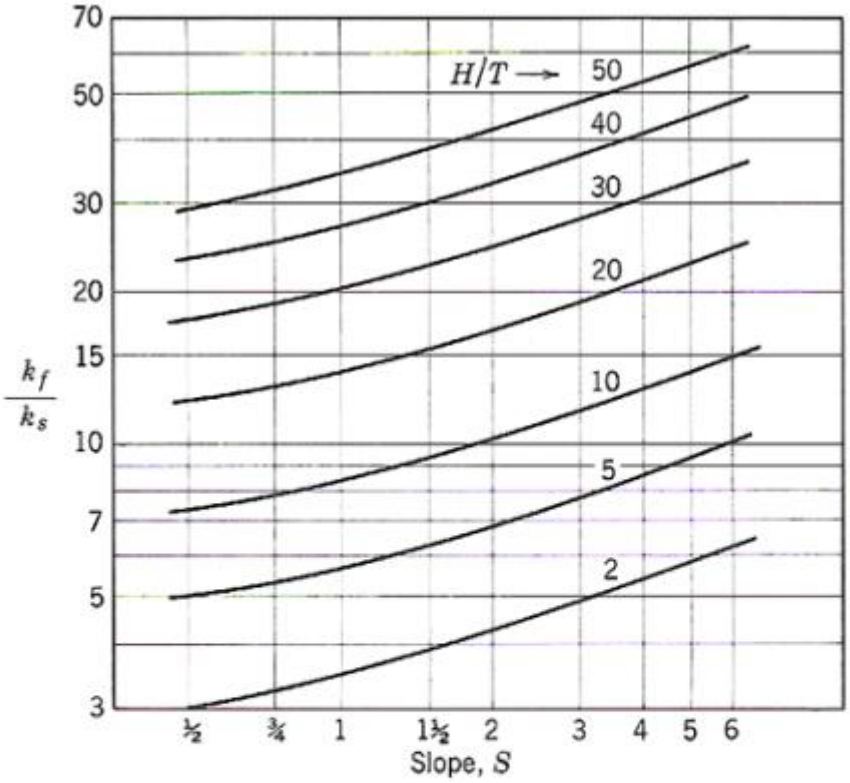
Analytical solutions for flow to a well through a fault

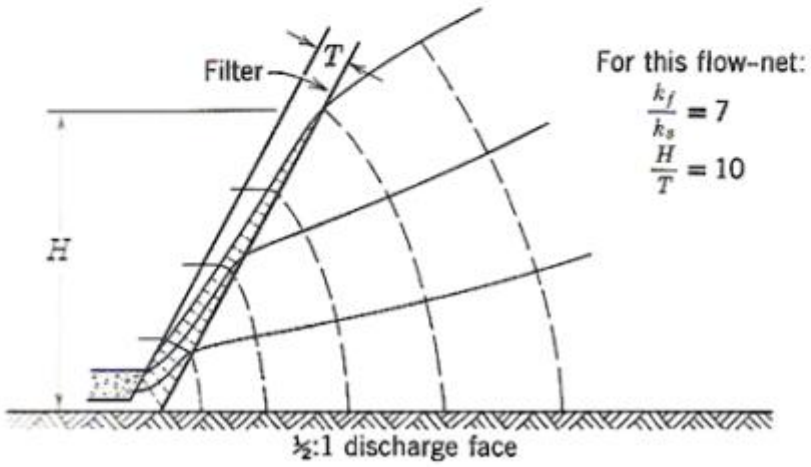
Erik I. Anderson

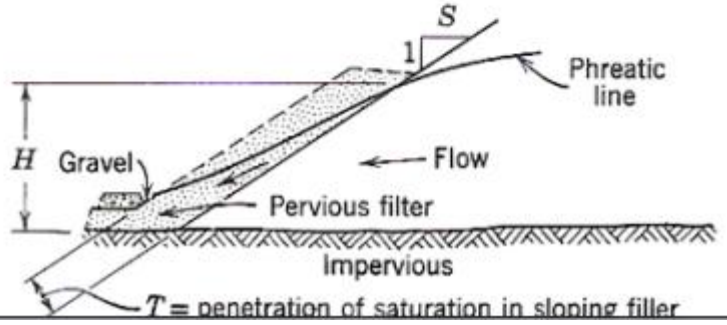
Department of Civil and Environmental Engineering, University of South Carolina, 300 Main Street, Columbia, SC 29208, United States

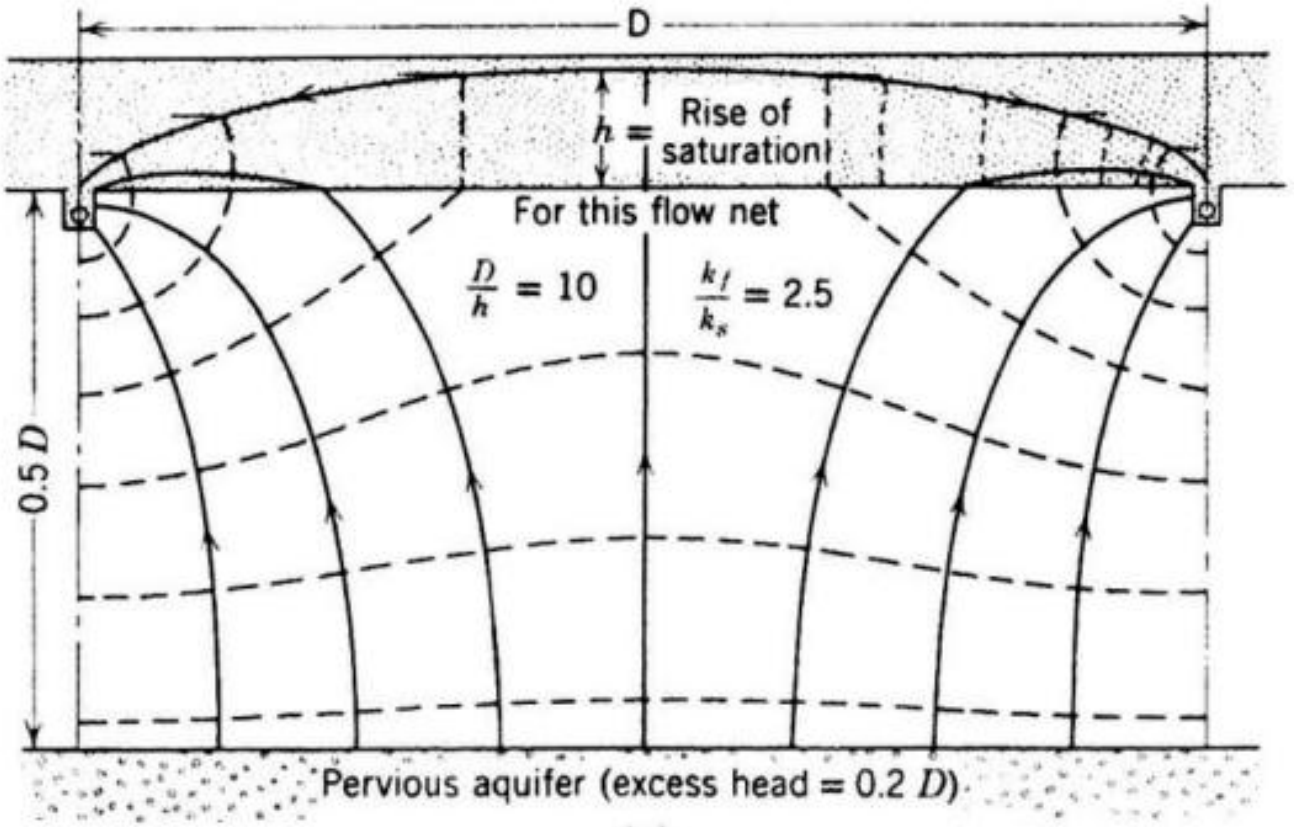
Received 23 August 2005. Revised 20 December 2005. Accepted 20 December 2005. Available online 14 February 2006.


For this flow-net:
$\frac{k_f}{k_s} = 6$
$\frac{H}{T} = 5$
Filter
Soil
H
Gravel
T
1½:1 discharge face

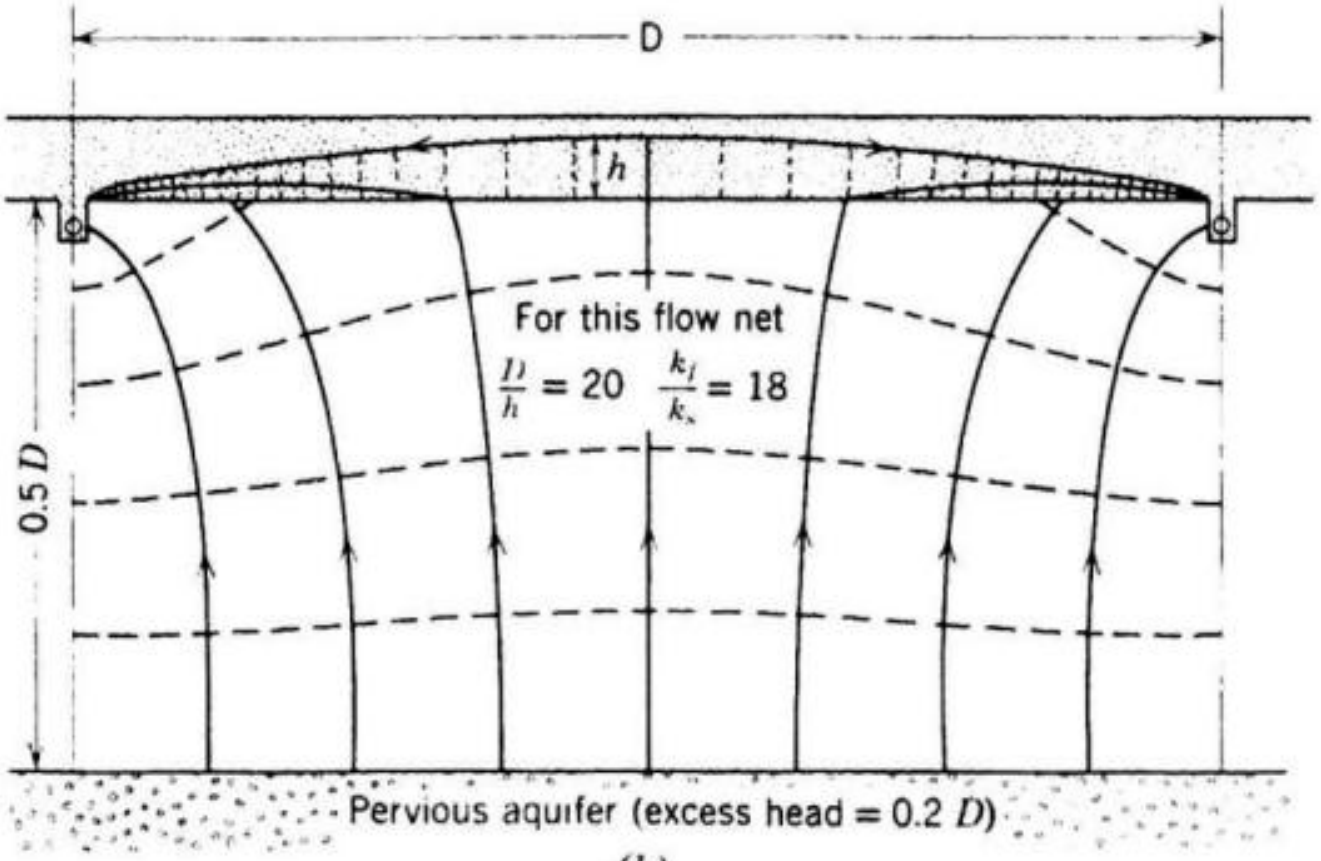

70
50
30
20
15
10
7
5
3
$\frac{k_f}{k_s}$
H/T →
50
40
30
20
10
5
2
½
¾
1
1½
2
3
4
5
6
Slope, S


Filter
T
H
For this flow-net:
$\frac{k_f}{k_s} = 7$
$\frac{H}{T} = 10$
½:1 discharge face


S
1
Phreatic line
H
Gravel
Flow
Pervious filter
Impervious
T = penetration of saturation in sloping filler


D
h = Rise of saturation
For this flow net
$\frac{D}{h}$ = 10
$\frac{k_f}{k_s}$ = 2.5
0.5 D
Pervious aquifer (excess head = 0.2 D)

(a)


D
h
For this flow net
$\frac{D}{h} = 20$ $\frac{k_f}{k_x} = 18$
0.5 D
Pervious aquifer (excess head = 0.2 D)

(b)

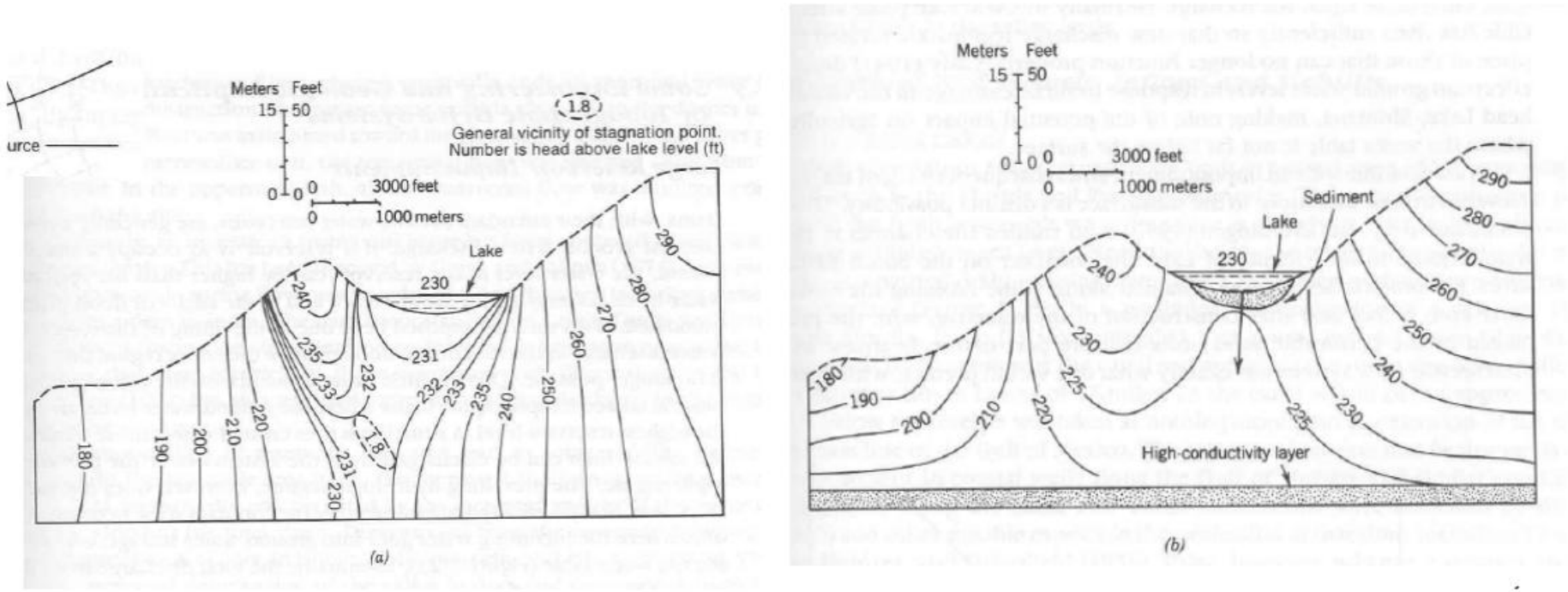


Figure 8. Flow conditions in the vicinity of a lake demonstrating the effect of a high permeability layer at depth (Winter, 1976).

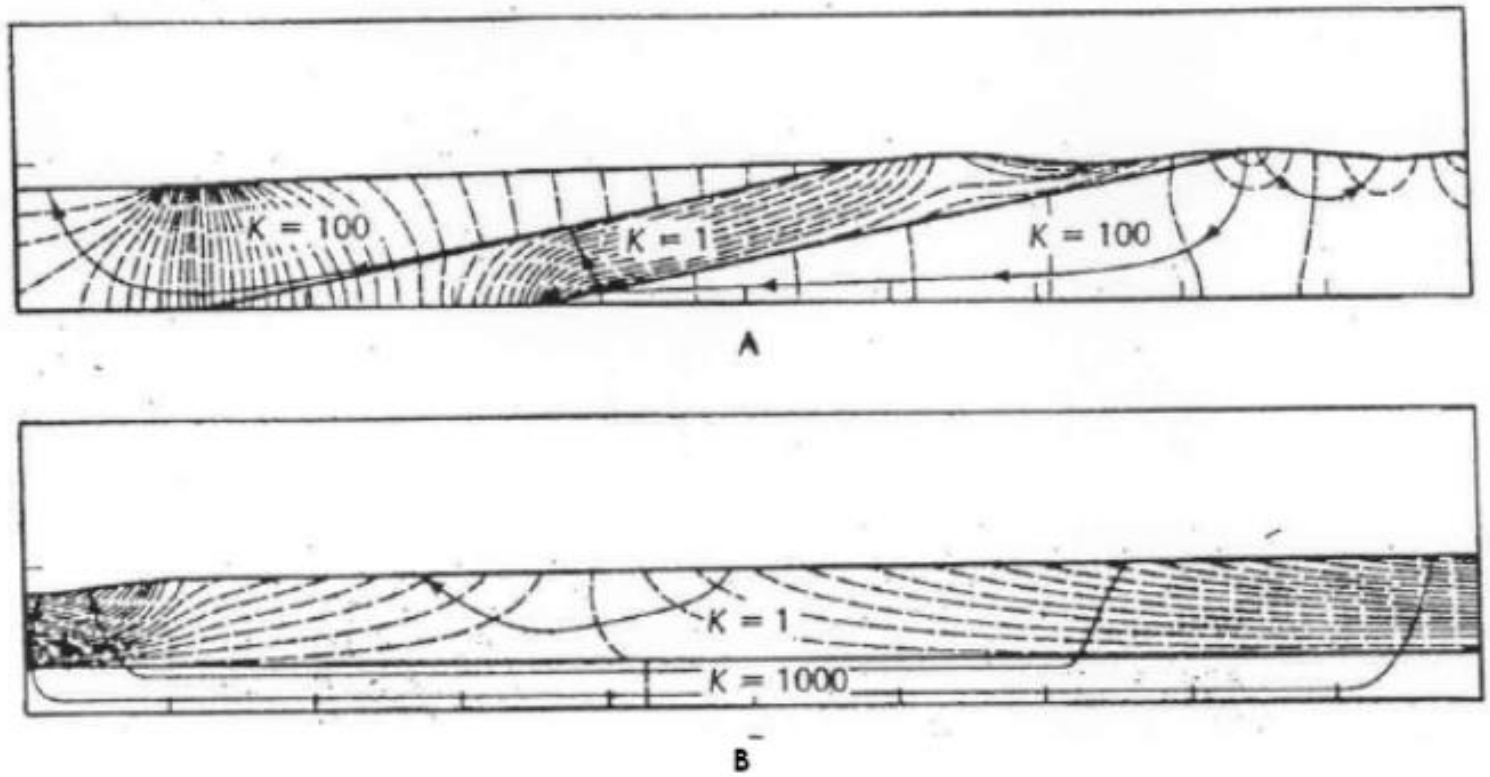


Figure 12. Regional groundwater flow in confined aquifers: (a) Aquifer confined by a sloping confined layer. (b) Aquifer confined by a flat-lying confining layer (Freeze & Witherspoon, 1967).

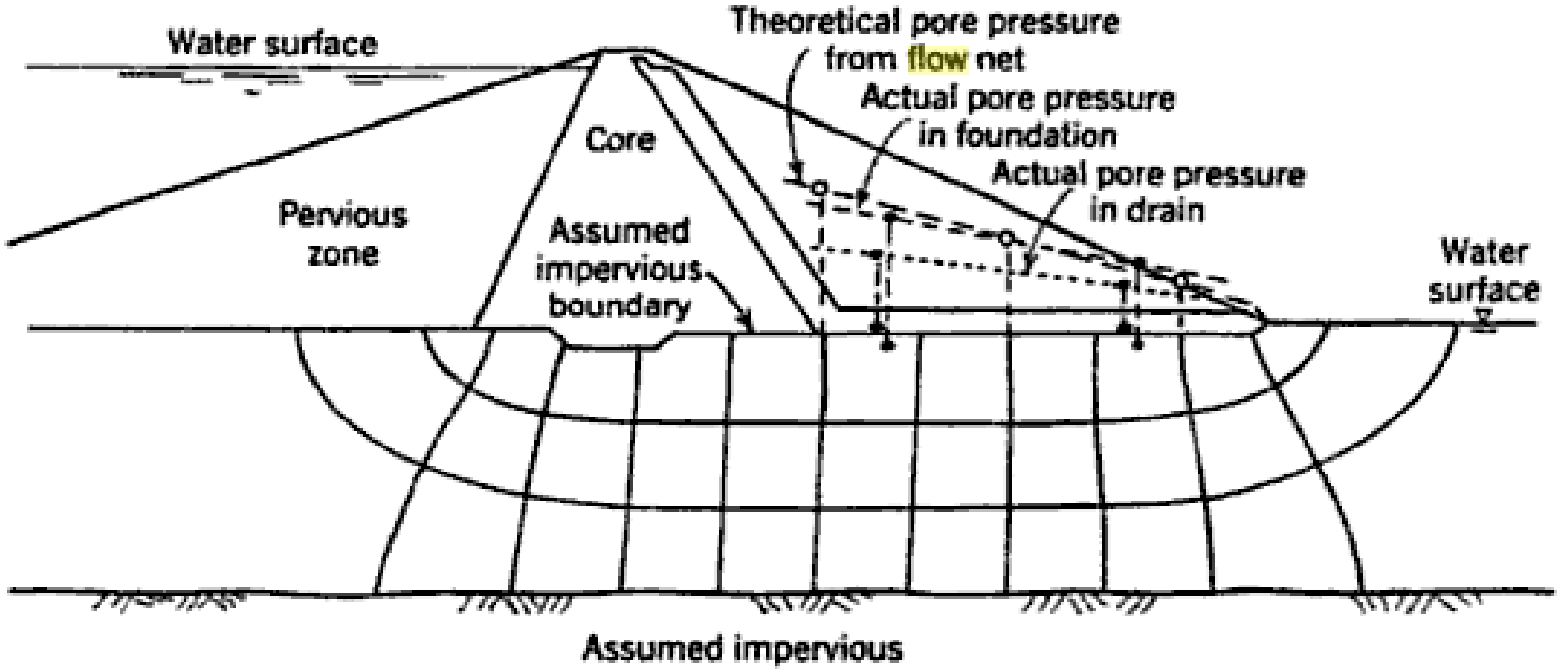
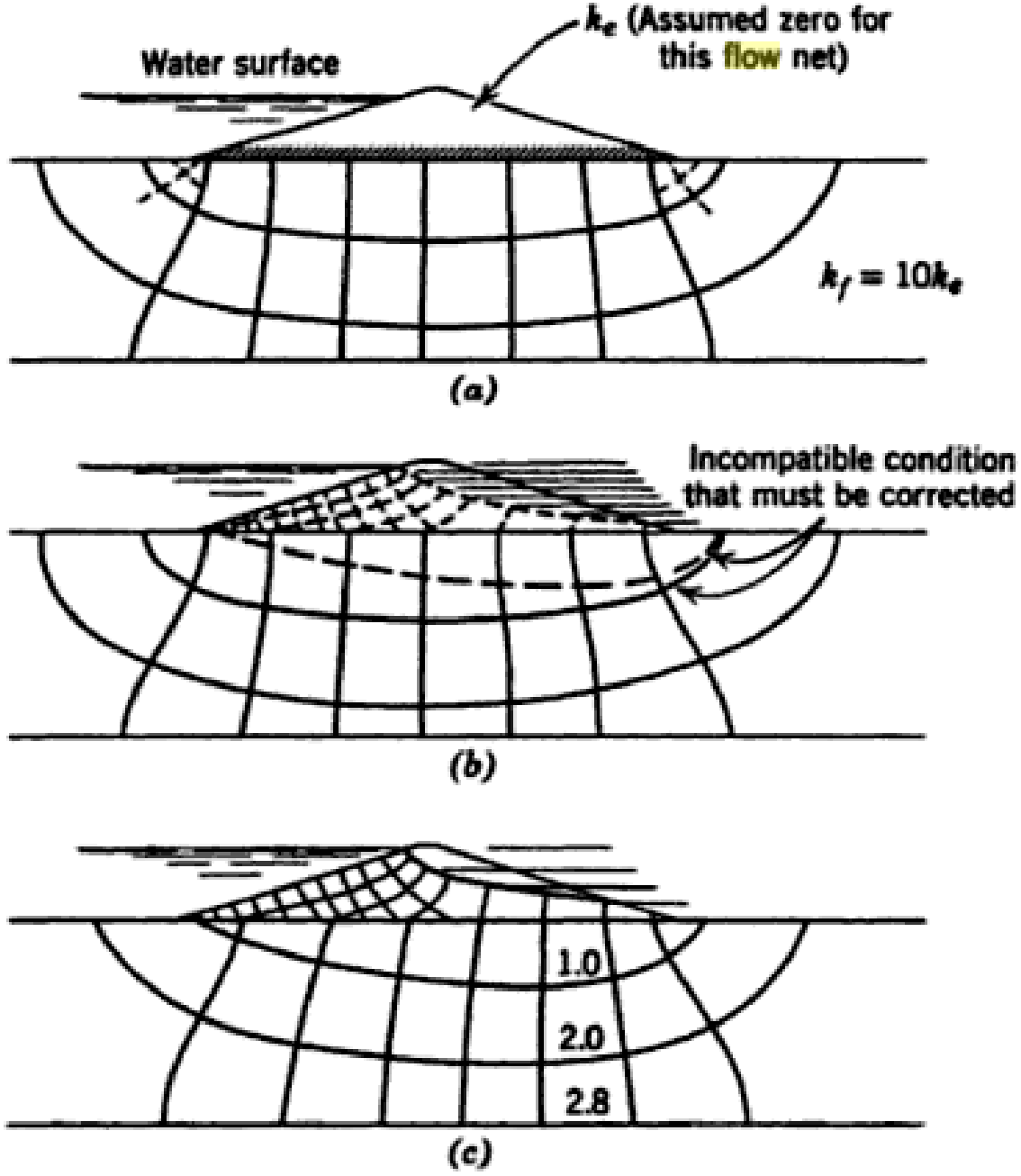


FIG. 5.10 Uplift pressures that built up under an earth dam with an expensive but ineffective drain were not measurably affected by the drain. (From *Embankment-Dam Engineering, Casagrande Volume,* Wiley, New York, 1973, p. 42).


k_e (Assumed zero for this flow net)
Water surface
$k_f = 10k_e$
(a)
Incompatible condition that must be corrected
(b)
1.0
2.0
2.8
(c)

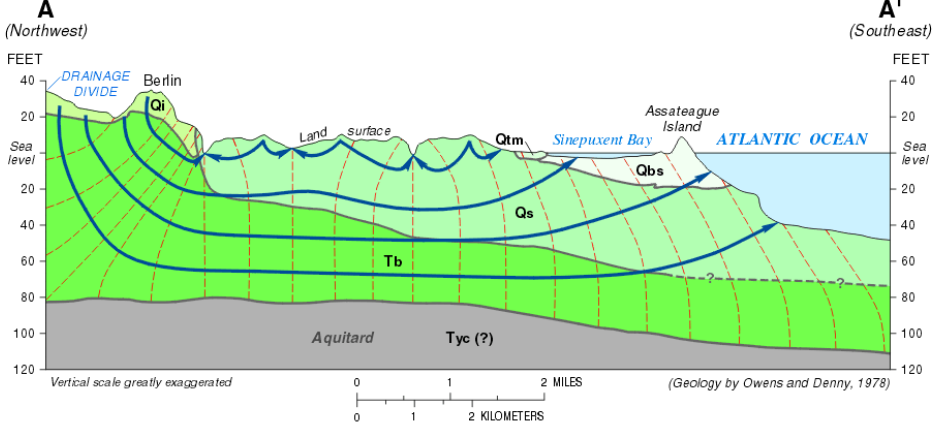


Figure 2a. *Geologic units and flow net for transect A-A' on Figure 1.*

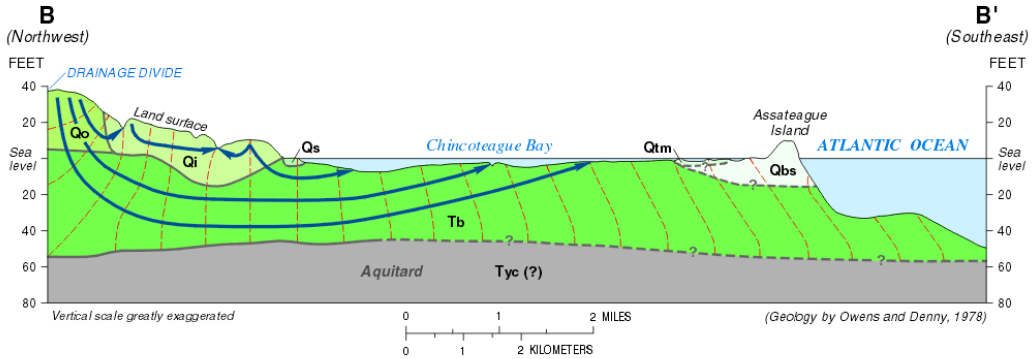


Figure 2b. *Geologic units and flow net for transect B-B' on Figure 1.*

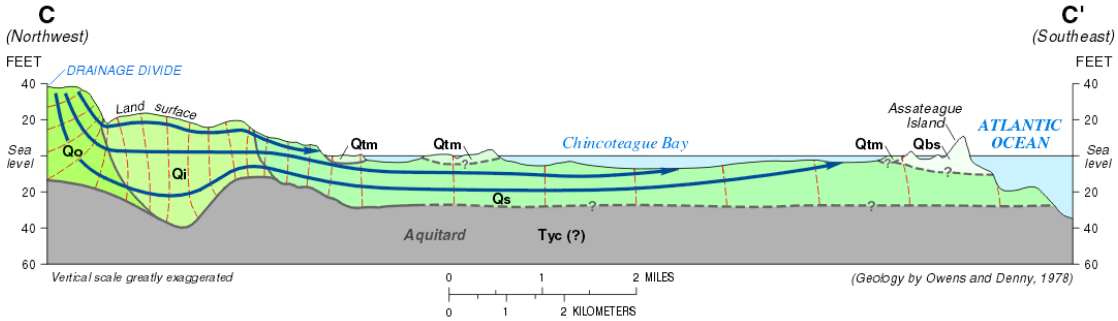


Figure 2c. *Geologic units and flow net for transect C-C' on Figure 1.*

EXPLANATION

GEOLOGIC UNITS

COLUMBIA AQUIFER:

- **Qtm** TIDAL MARSH
- **Qbs** BEACH SAND
- **Qs** SINEPUXENT FORMATION
- **Qi** IRONSHIRE FORMATION
- **Qo** OMAR FORMATION
- **Tb** BEAVERDAM SAND

AQUITARD:

- **Tyc (?)** YORKTOWN-COHANSEY FORMATION

EQUIPOTENTIAL LINE

GROUND-WATER FLOW LINE AND DIRECTION OF FLOW

GEOLOGIC CONTACT (Dashed and queried where inferred)