

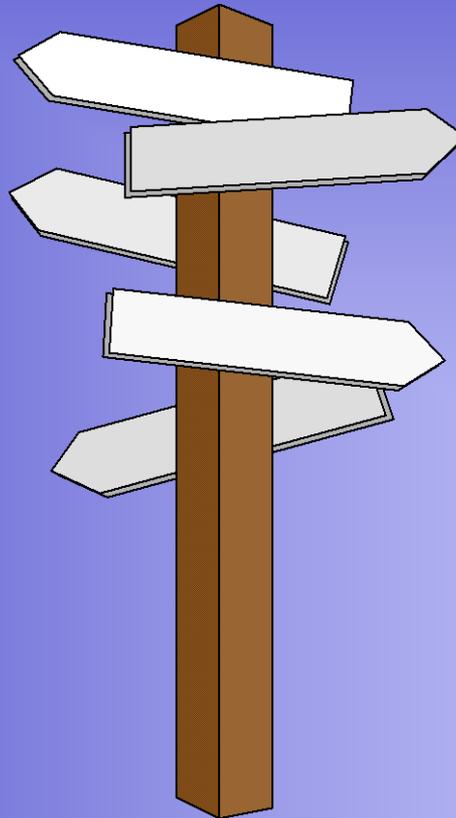
An Introduction to Groundwater Issues at Mine Sites

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Topic 6: Flow Systems

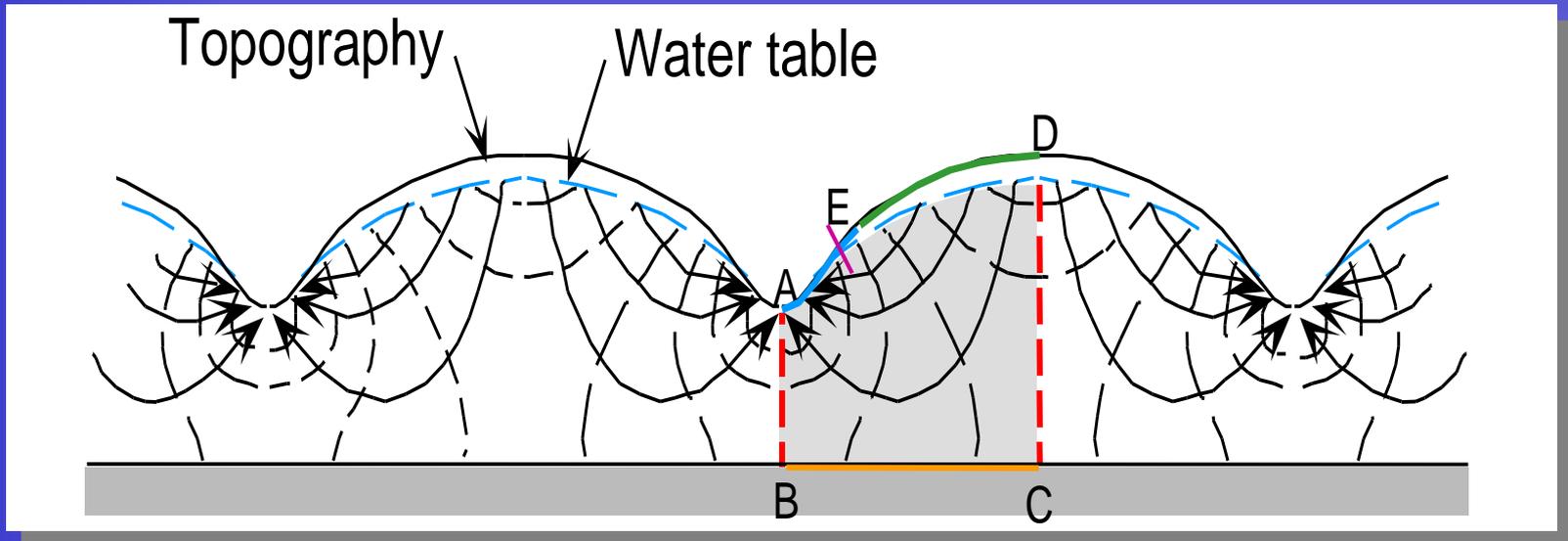


Components of Flow Systems

- Recharge area
- Discharge area
- Groundwater divides
- No flow boundaries
- Constant head boundaries



A Simple Flow System



Recharge - zone of flow directed downward away from the WT (ED)

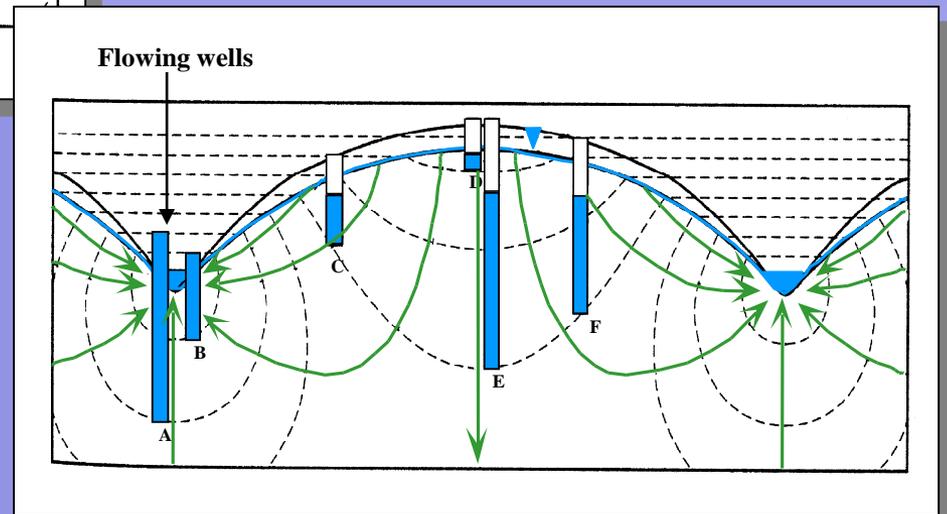
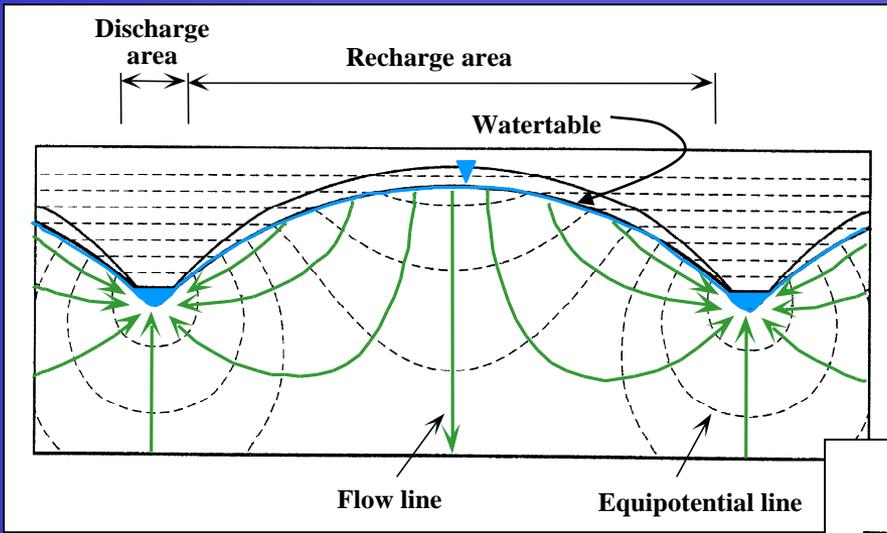
discharge - zone of flow directed upward toward the WT (AE)

hinge line - separates recharge and discharge zones (at E)

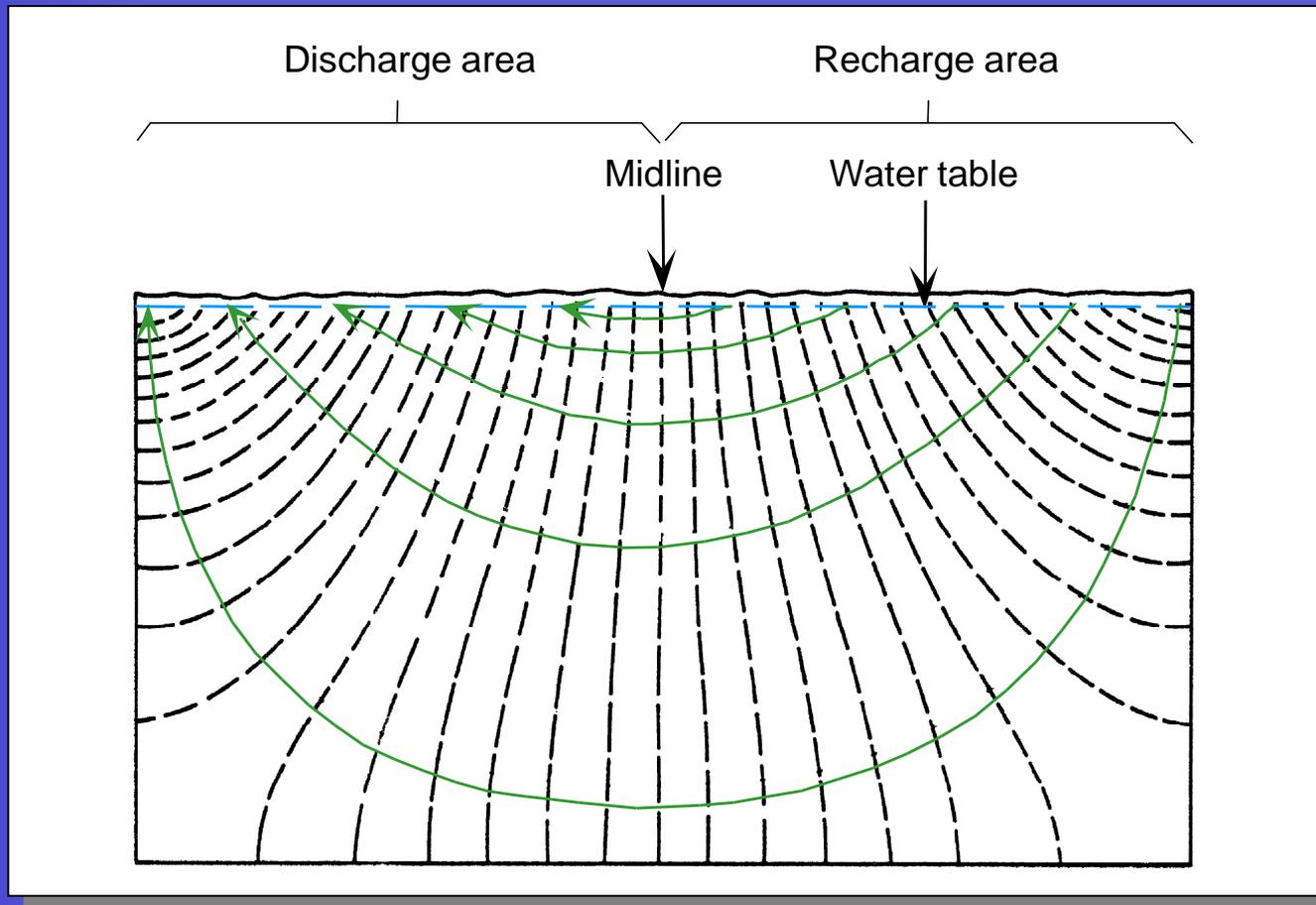
groundwater divide - groundwater flows in opposite directions (AB and DC)

NO-Flow Boundary - acts like a flow line, no flow across (BC)

A Simple Flow System



A Simple Flow System Homogeneous and Isotropic



Constructing Flow Nets

RULES

- Flow lines and equipotentials intersect at right angles (when x and z scales are equal)
- flow lines and equipotentials intersect to form curvi-linear squares
- equipotentials intersect water table at appropriate head values
- no-flow boundaries and divides act as flow lines
- Flow lines never intersect



Constructing Flow Nets

Calculations

$$q' = KH p/f$$

q' = flow rate per unit thickness of section

K = hydraulic conductivity

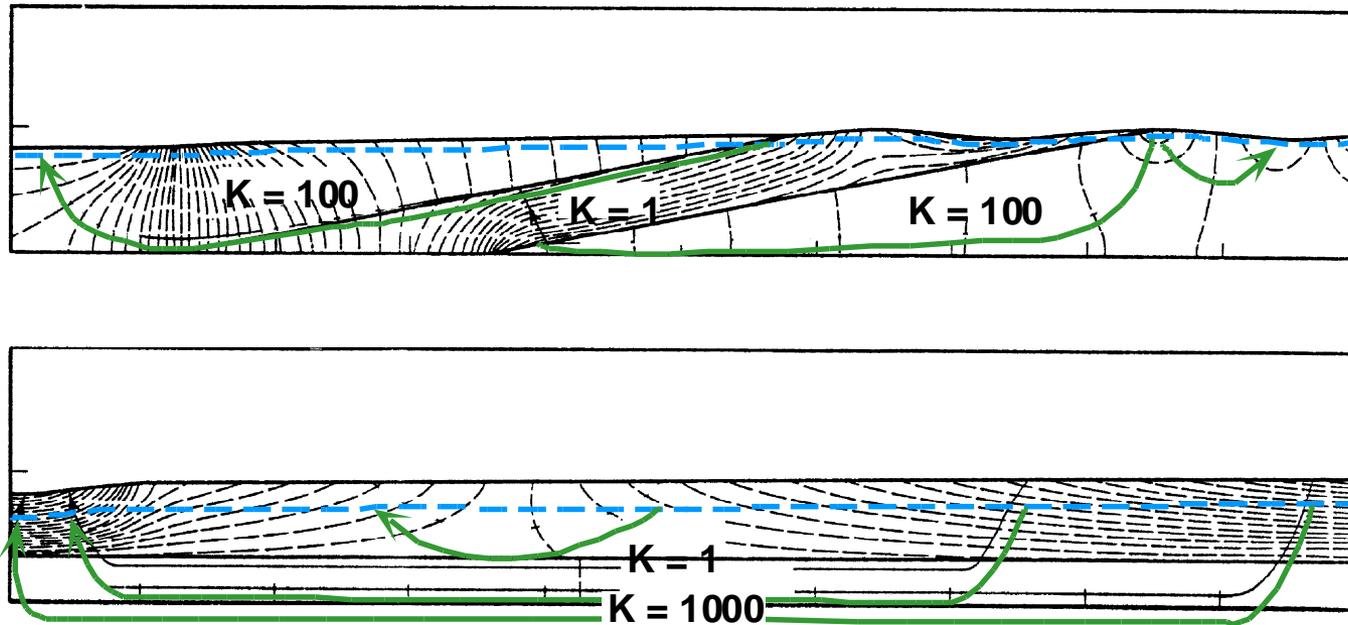
H = total head loss

p = # of flow paths (or tubes)

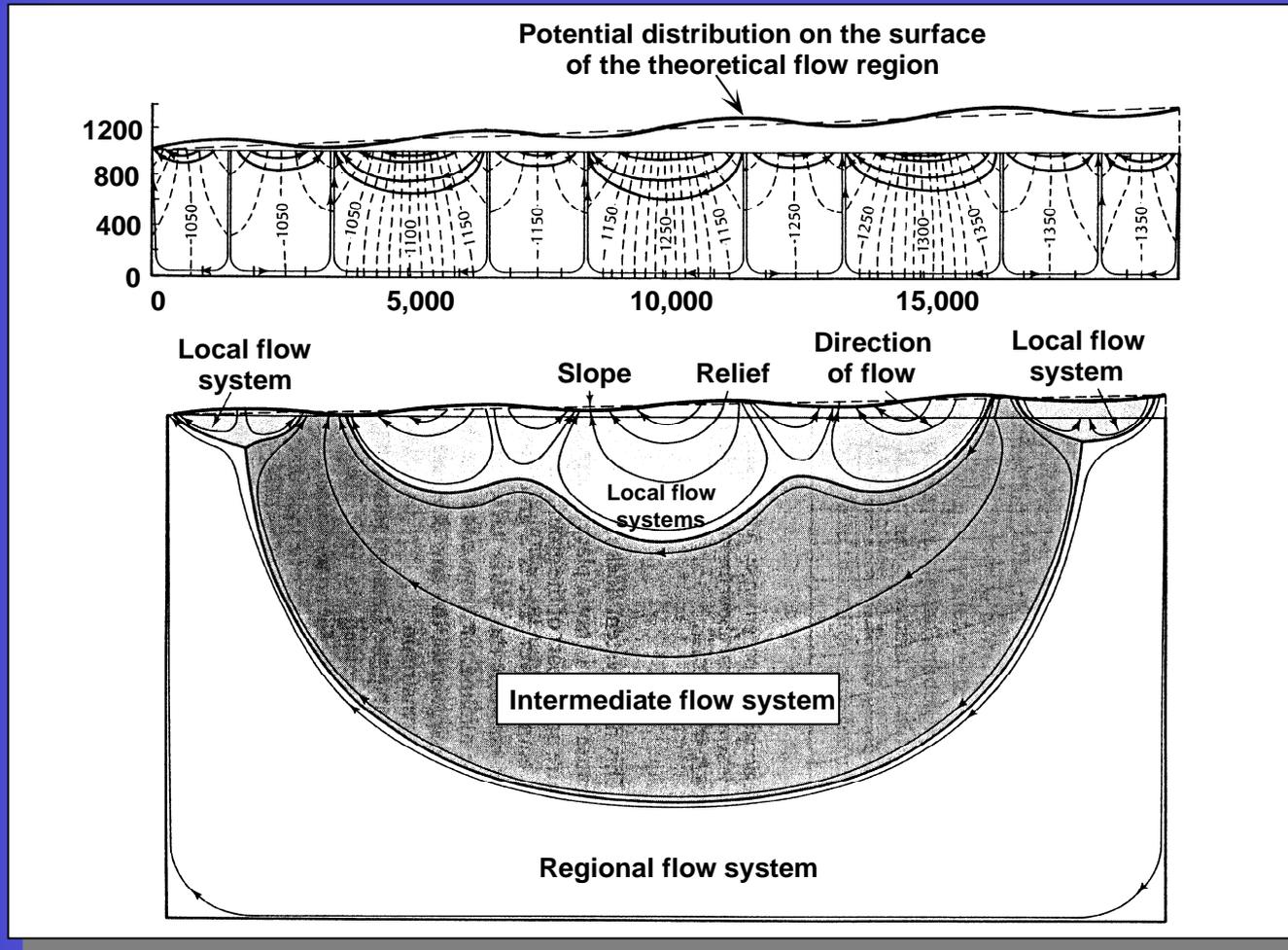
f = # of squares between flow lines over
length of flow



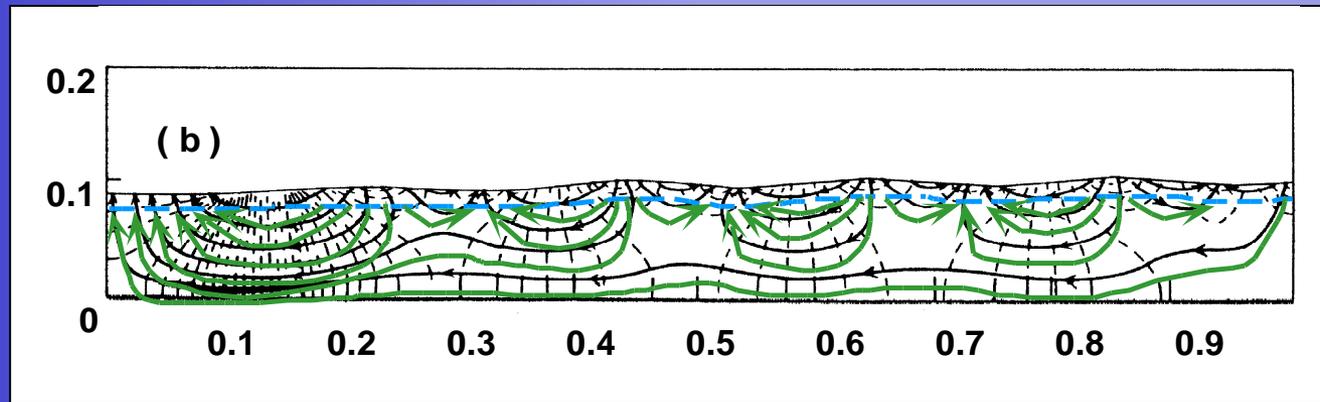
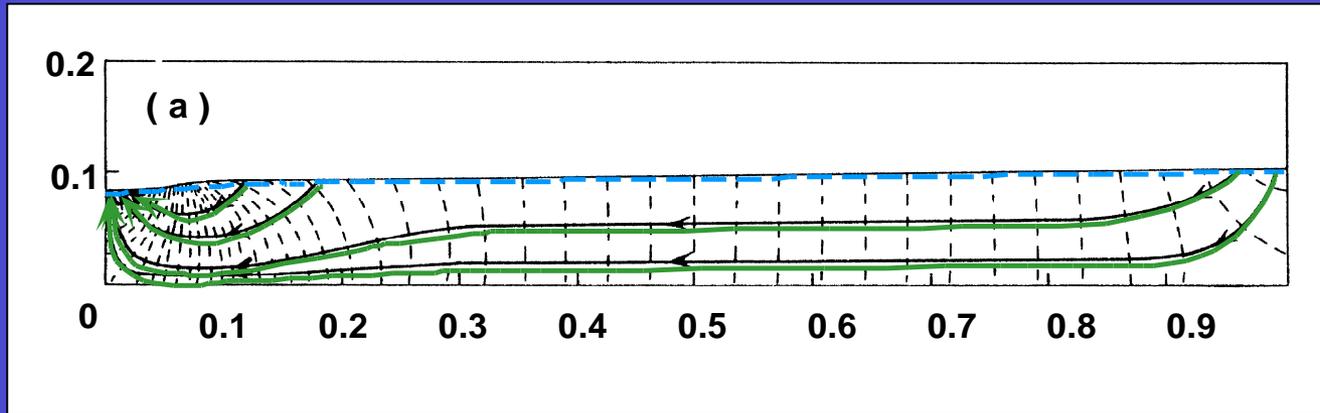
Effects of Boundaries and other Geologic Layering



Effect of Flow System Depth



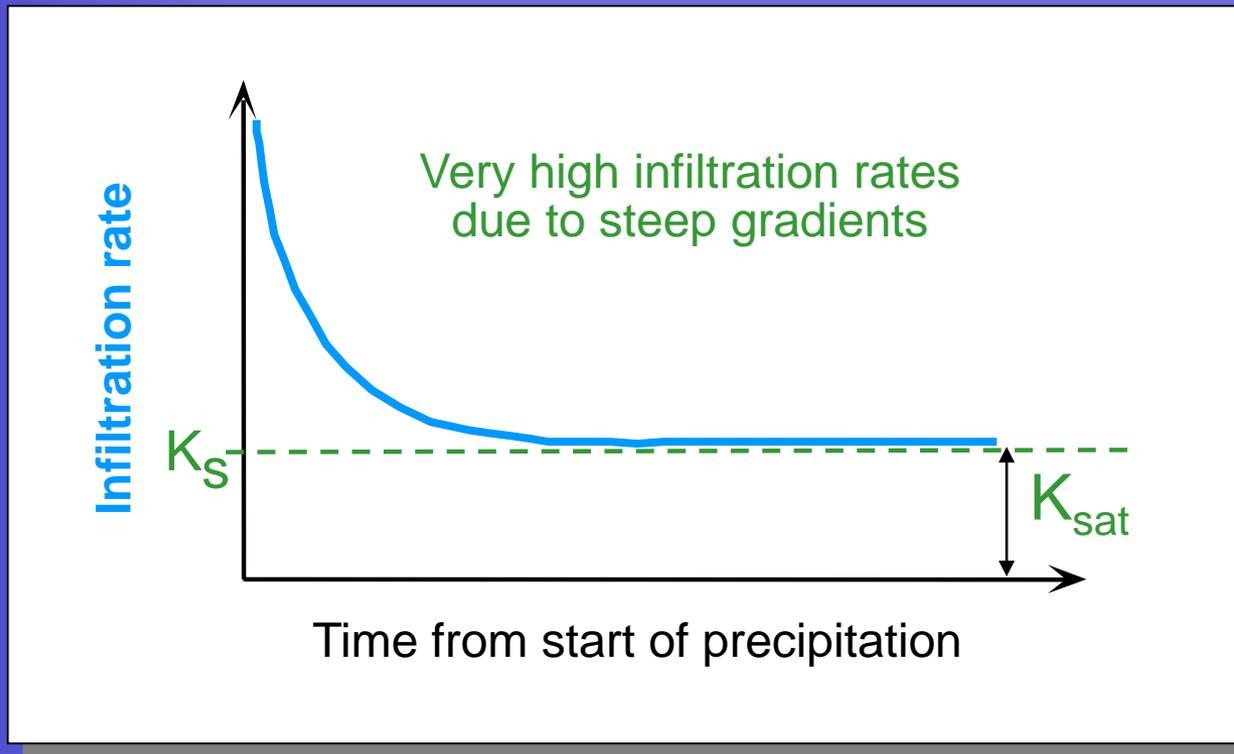
Effect of Surface Topography



- a) flat surface
- b) undulating surface

Infiltration

The source of Groundwater



Infiltration

The source of Groundwater

Infiltration: Maximum rate is $\cong k_{\text{saturated}}$
Average annual infiltration rates relates to precipitation in temperate climates

Surface Material	Infiltration Rate (% of Precipitation)
Vegetated Natural Soils	5% – 15%
Bare Soils (tailings)	10% – 30 %
Waste Rock	20% – 70%