Part 8

WHERE TO APPLY SUBDRAINAGE

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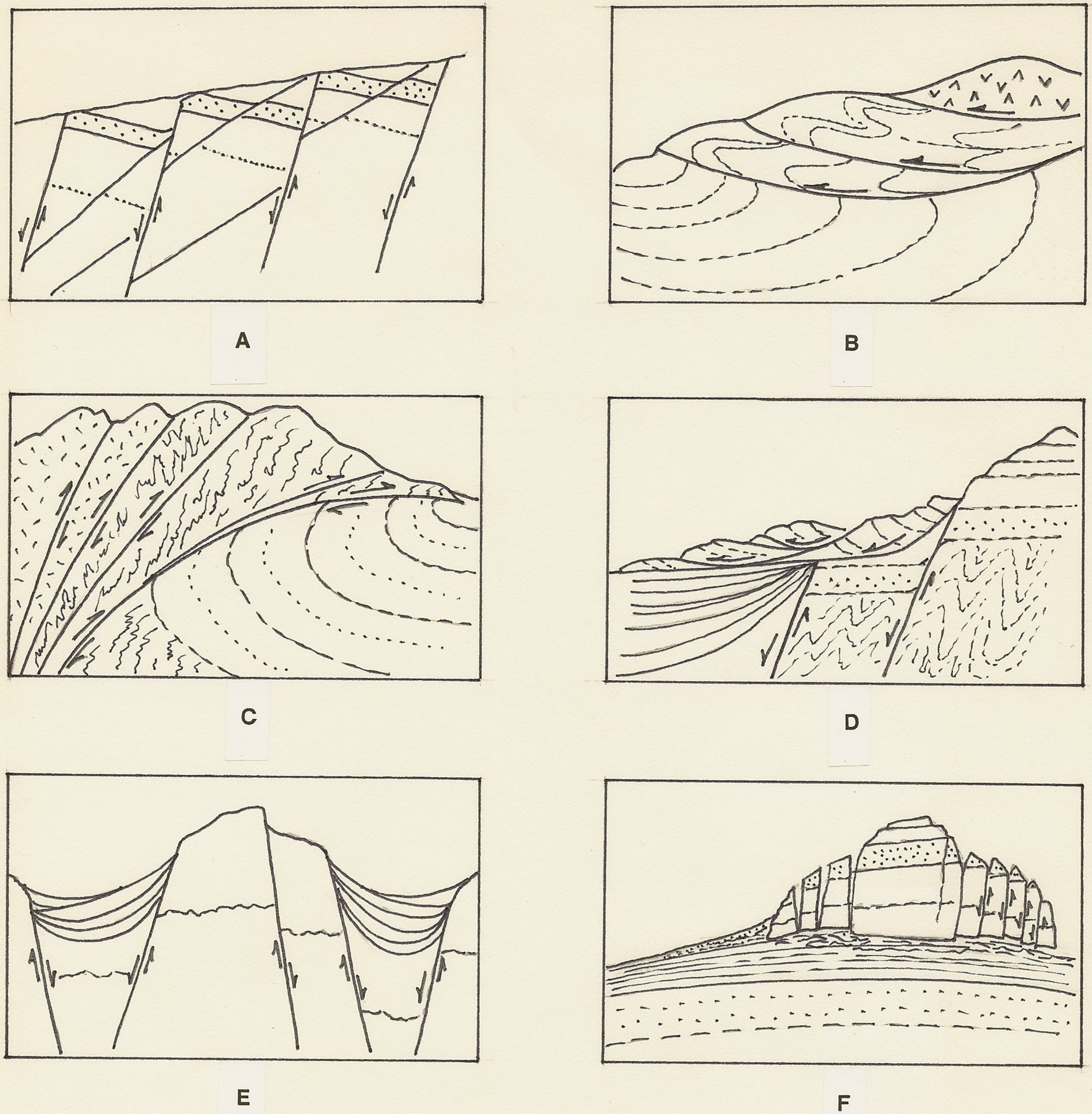
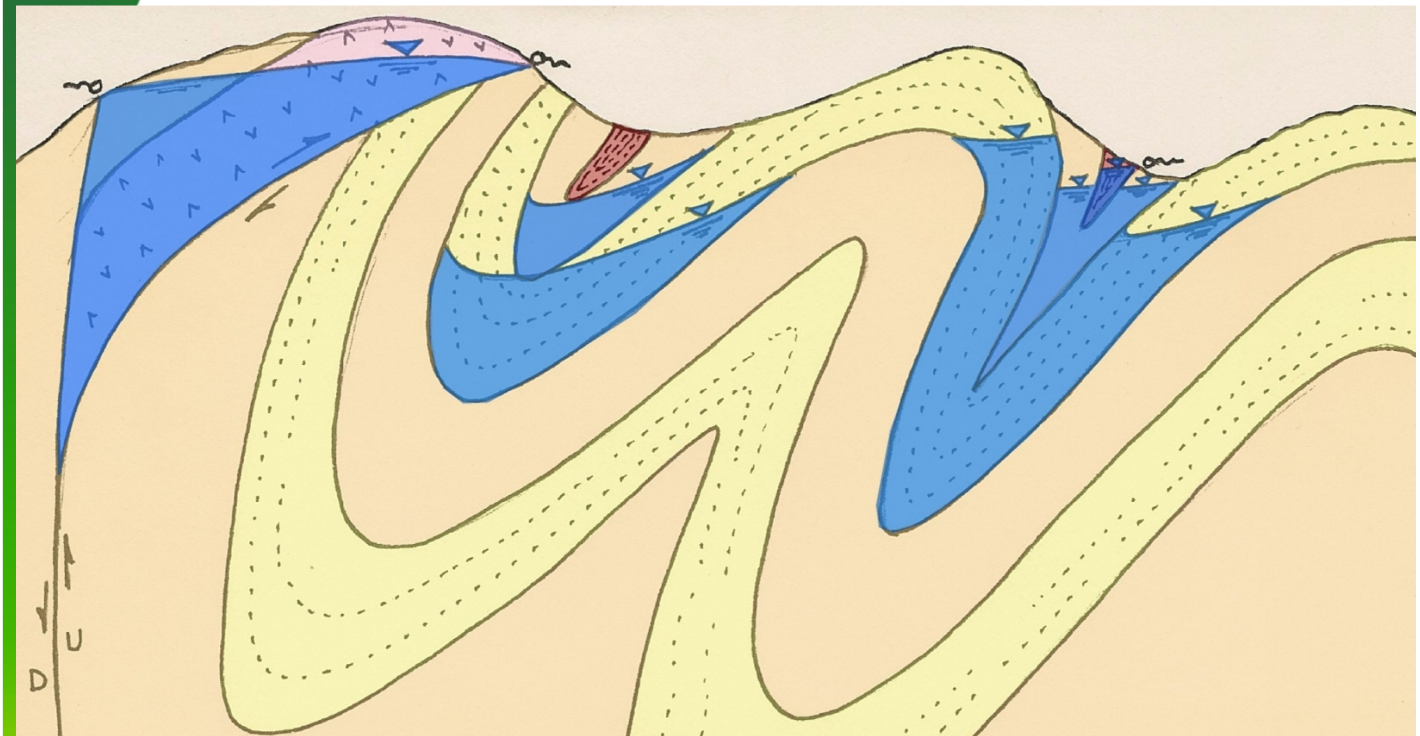


Faults and shale beds

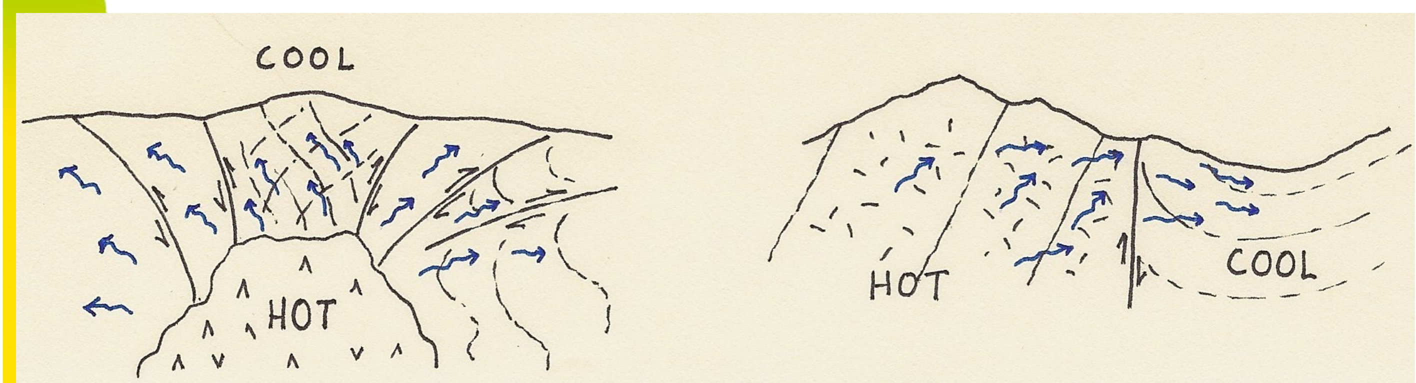
- **Clay gouge within faults and shear zones, as well as shale beds and clay-filled partings, combine to form effective groundwater aquacludes**

Figure taken from Rogers (1993), "An Introduction to Physical Geologic Factors Affecting Groundwater In-flow into Large Bore Tunnels"

Geologic structure influences groundwater



The distribution of groundwater can be exceedingly complicated in complexly deformed strata.



Thermal gradients also provide fluxes that tend to influence groundwater flow

Common Sources of Seepage

<u>**Geological features**</u>, such as:

- Old channels or landslide slip surfaces
- The bottom of infilled swales, ravines or gullies
- Karst features, such as collapse structures
- Rodent burrows, decayed root systems
- Severely fractured materials, such as bedded chert, siltstone, sandstone, conglomerate or overconsolidated shale

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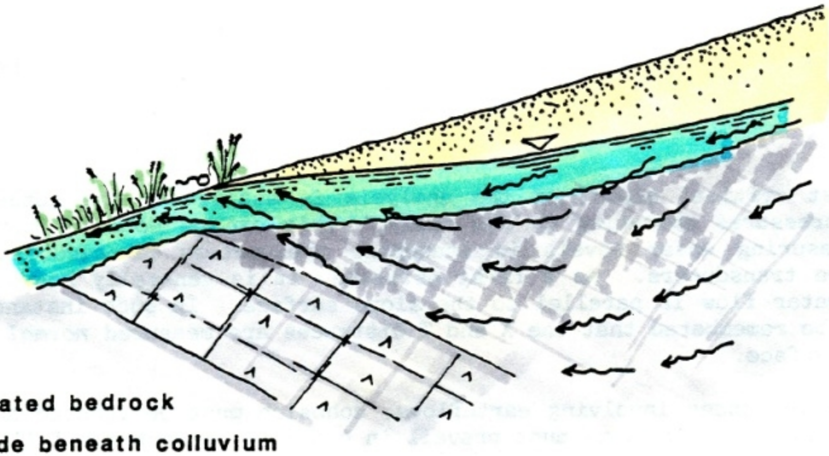
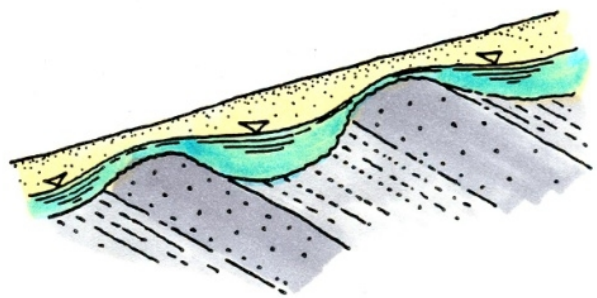
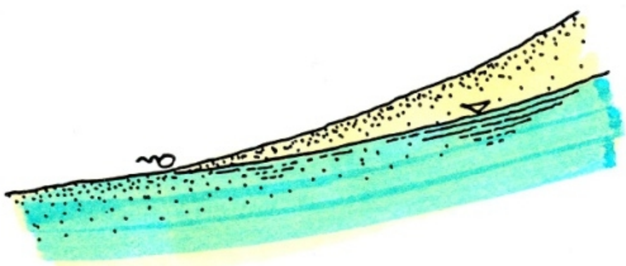
Common sources of ephemeral seepage



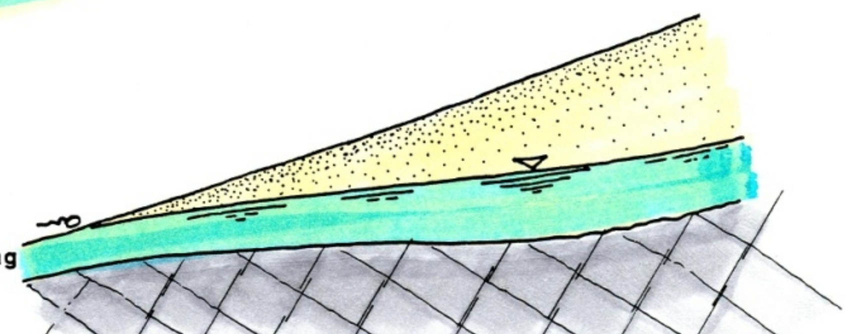
a. deep seated bedrock aquaclude beneath colluvium



b. bedrock irregularities beneath colluvium

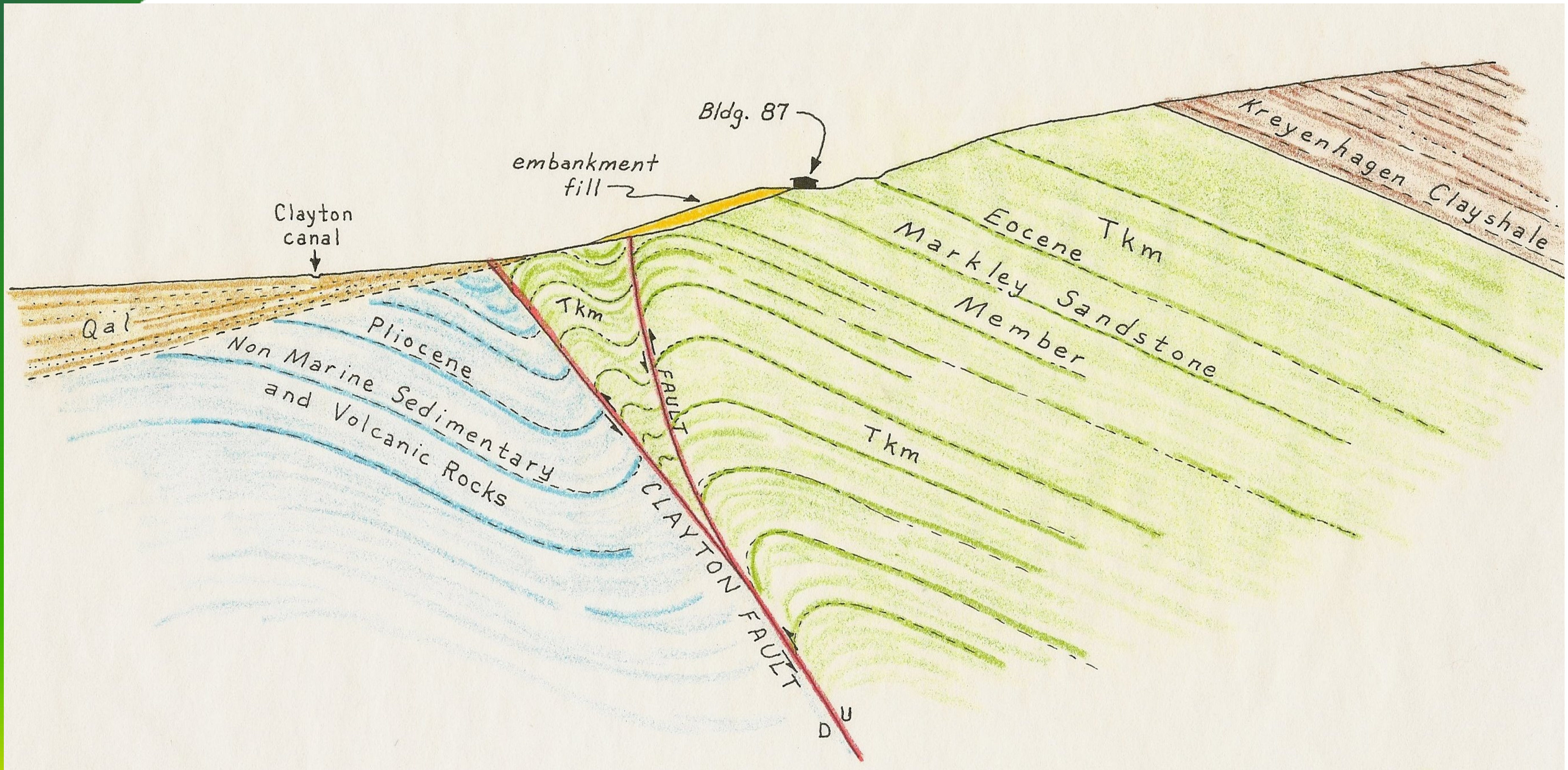


c. seepage due to change in slope



d. seepage due to flow convergence and pinching of colluvial deposit

- **These sketches show some of the most common situations that tend to promote the formation of *ephemeral springs*, which can wreck havoc on embankments**



- **Faults** serve as highly efficient groundwater barriers, but the fractured ground on either side of the fault can often serve as a significant seepage zone. This shows a case where a sidehill embankment was experiencing accelerated downslope creep and settlement, caused by ***elevated groundwater***, on the upthrown side of back-thrust that projected itself into the embankment.

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Common Sources of Seepage

<u>**Man-caused features**</u>, such as:

- Bottom of old fills
- Septic tanks or leach fields
- Old pipelines or backfilled trenches
- Old drainage improvement features, such as storm drain channels
- Old storm drains
- Old canals or swimming pools
- Old dumps

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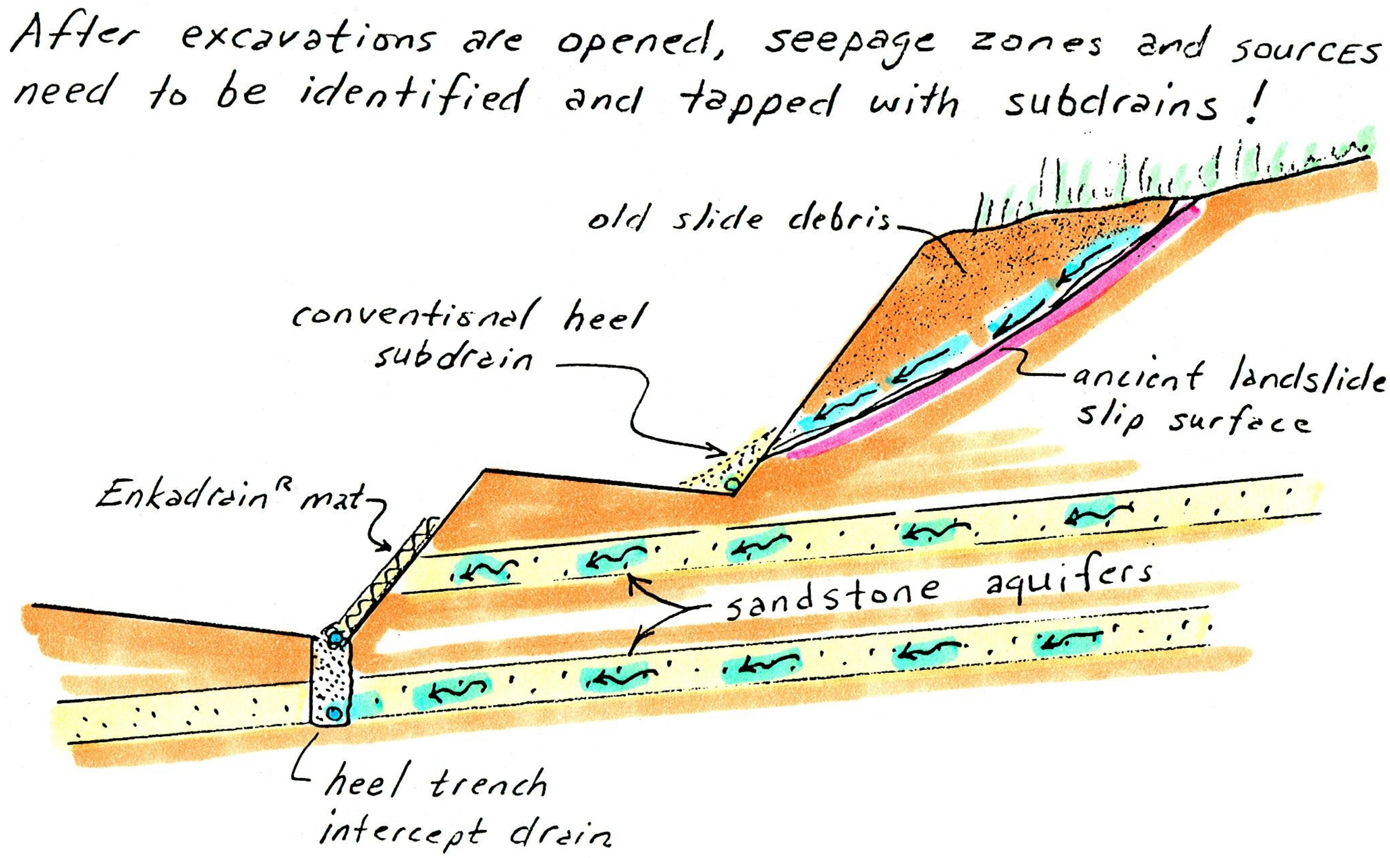

- **After an excavation is opened, try to identify past zones of seepage and make sure these are tapped by the subdrain system being installed**

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- This shows an **active landslide slip surface**, exposed in an emergency buttress keyway. **Seepage** often concentrates along such horizons

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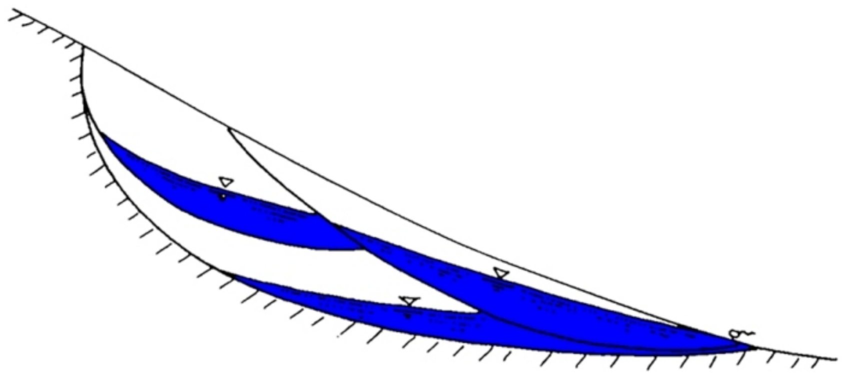
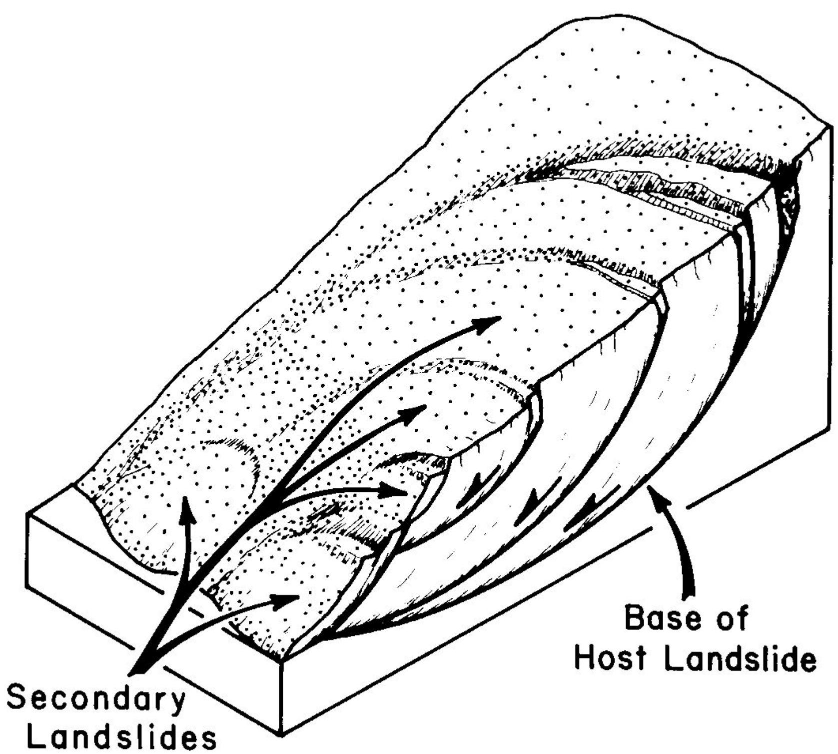
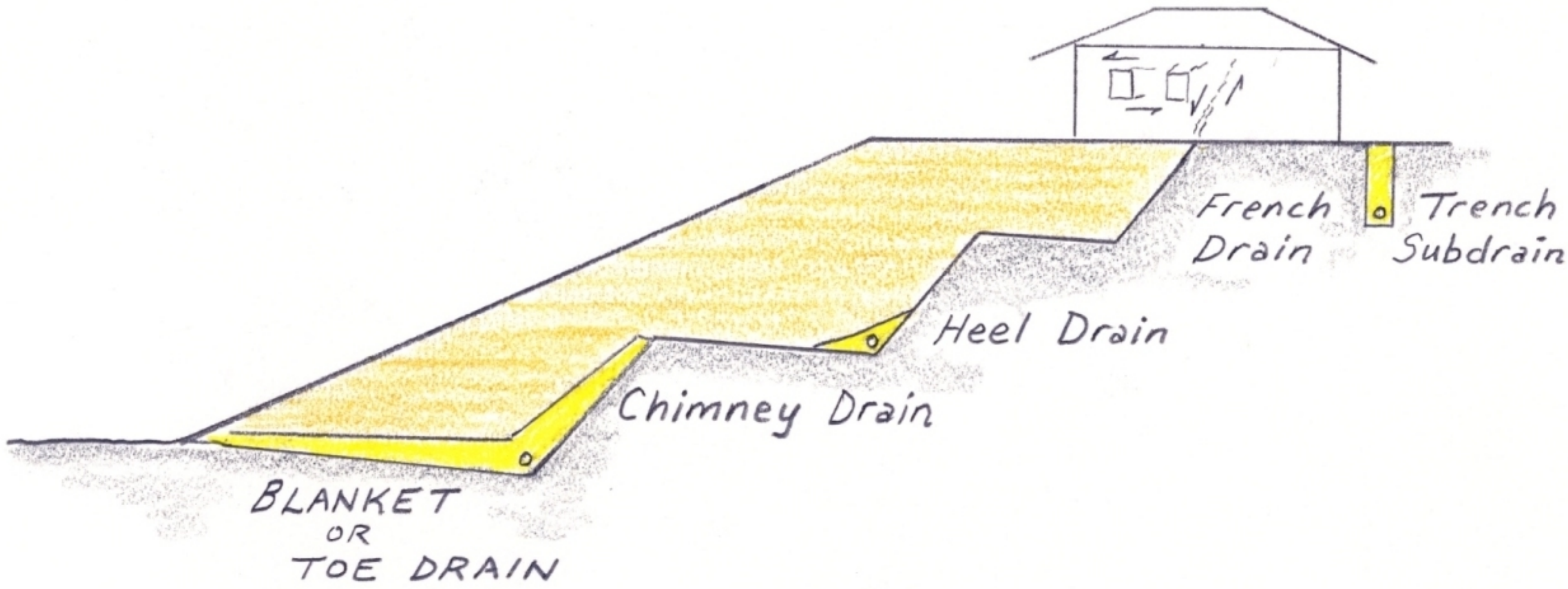


WATER TABLE PERCHED ON ANCIENT LANDSLIDE SLIP PLANES



- **Naturally-occurring landslides tend to form in coalescing masses, with one slide event truncating the next oldest, one over another. The old slip surfaces tend to form multiple permeability barriers, as sketched here**

SUBDRAIN NOMENCLATURE



- **Colloquial names applied to various kinds subdrains that are commonly used in and adjacent to sidehill embankments. The ubiquitous "French Drain" is named after Henry F. French, author of the text "Farm Drainage," published in 1859.**

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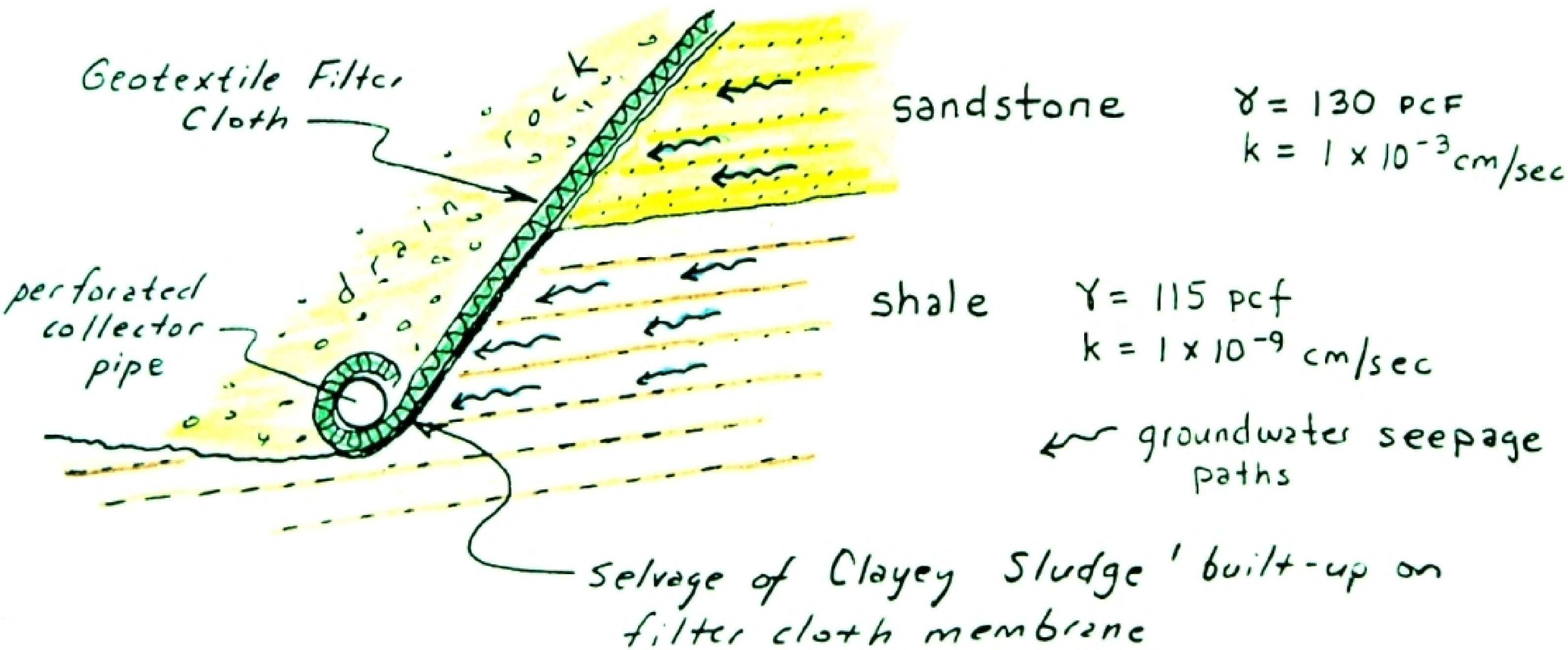
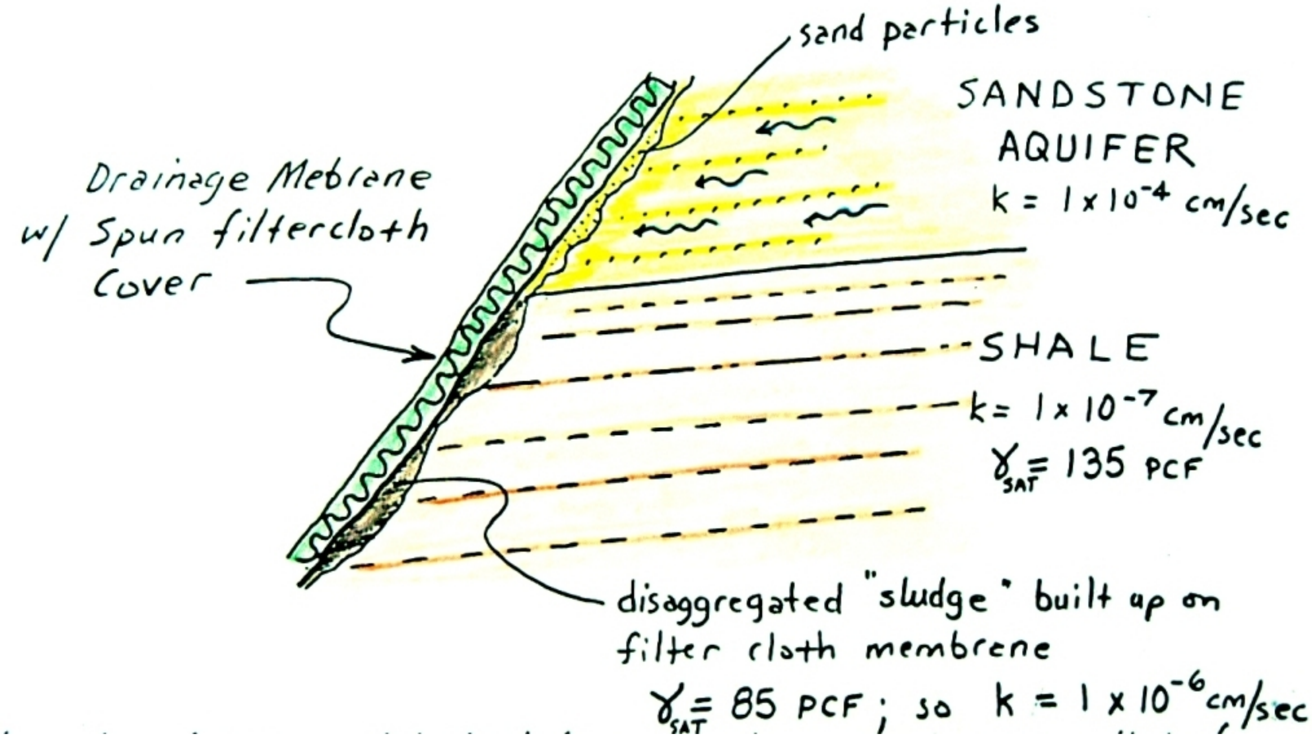
Why Filter Fabrics work



- **Many engineers worry about the build-up of fine soil particles on the upflow side of the filter fabric, as sketched above.**



- **The bulk density of the accumulated "sludge" on the fabric will always be less than that of the parent material; so the permeability of the "sludge" must be greater than that of the parent material.**

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- The temporary backcuts should be inspected carefully, looking for physical evidence of **active seeps**, such as those shown above, along the contact between the weathered band unweathered zones. **Evidence of past seepage (usually caliche) is also valuable**.

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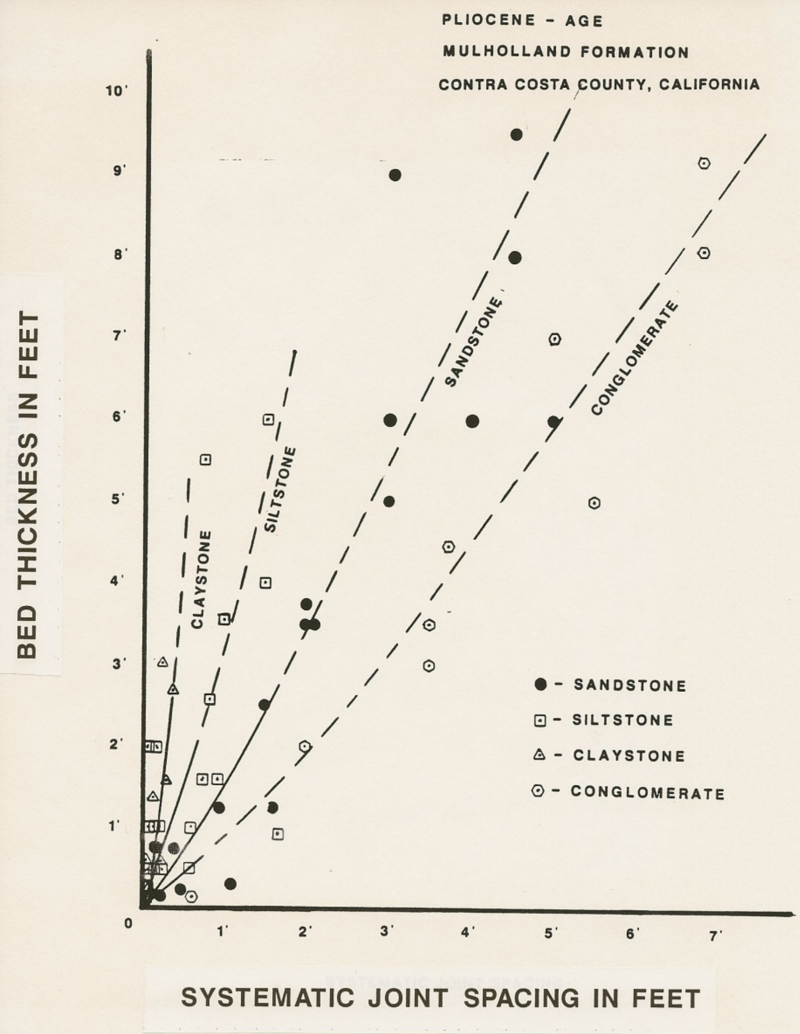
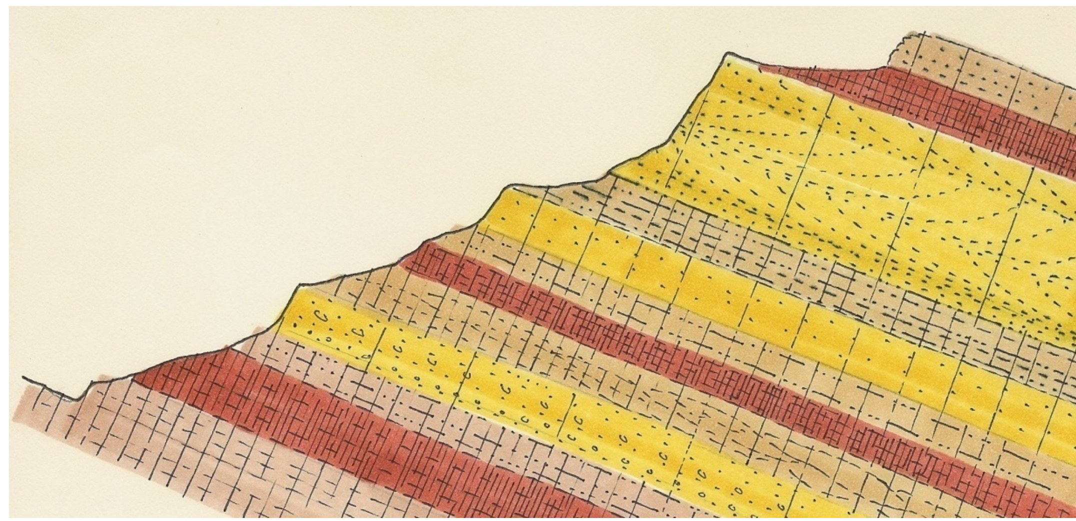
- **Faults, shear zones,** and **shale beds** are the most common aquacludes that bound "groundwater compartments," and tend to promote the formation of natural springs and seeps. This shows Dr. Rogers standing next to a stringer of the Big River fault, 9 miles south of Potosi, Missouri.



Joint spacing is a function of bed *stiffness* and *thickness*



Sedimentary units of increasing stiffness and thickness generally exhibit greater spacings between regional systematic joints; while brittle materials (incl shale) in thin beds tend to exhibit the closest spacings

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Springs are always "spotty"

The most vexing aspect of natural seepage is that it is so "spotty," and discontinuous, influenced by bedding, joints, and preferential weathering. This is easily seen during wintertime in the Midwest, when the seepage freezes, revealing itself.

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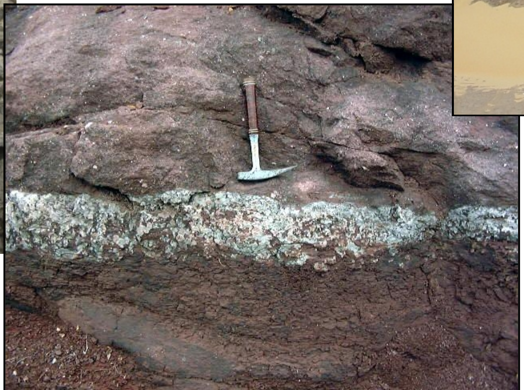
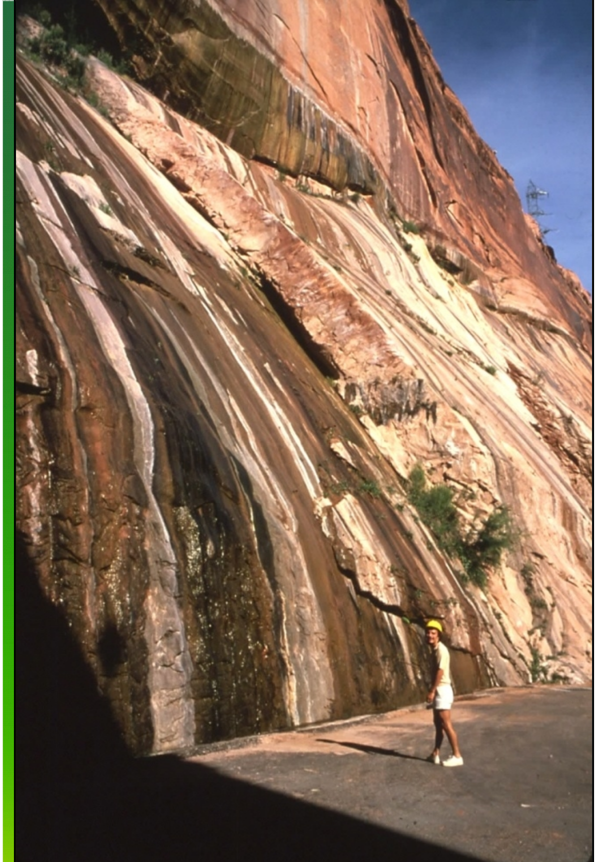
Carbonate Rinds

Carbonate precipitates along joint faces or stratigraphic horizons subject to perennial seepage



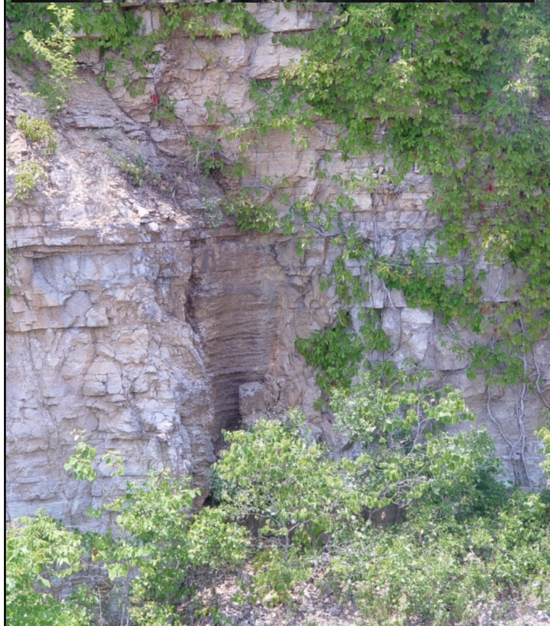
Carbonate can be white to buff color, as shown in these images. Subdrainage needs to be as selective as the seepage…

Iron, Manganese, and Magnesium Oxide Stains

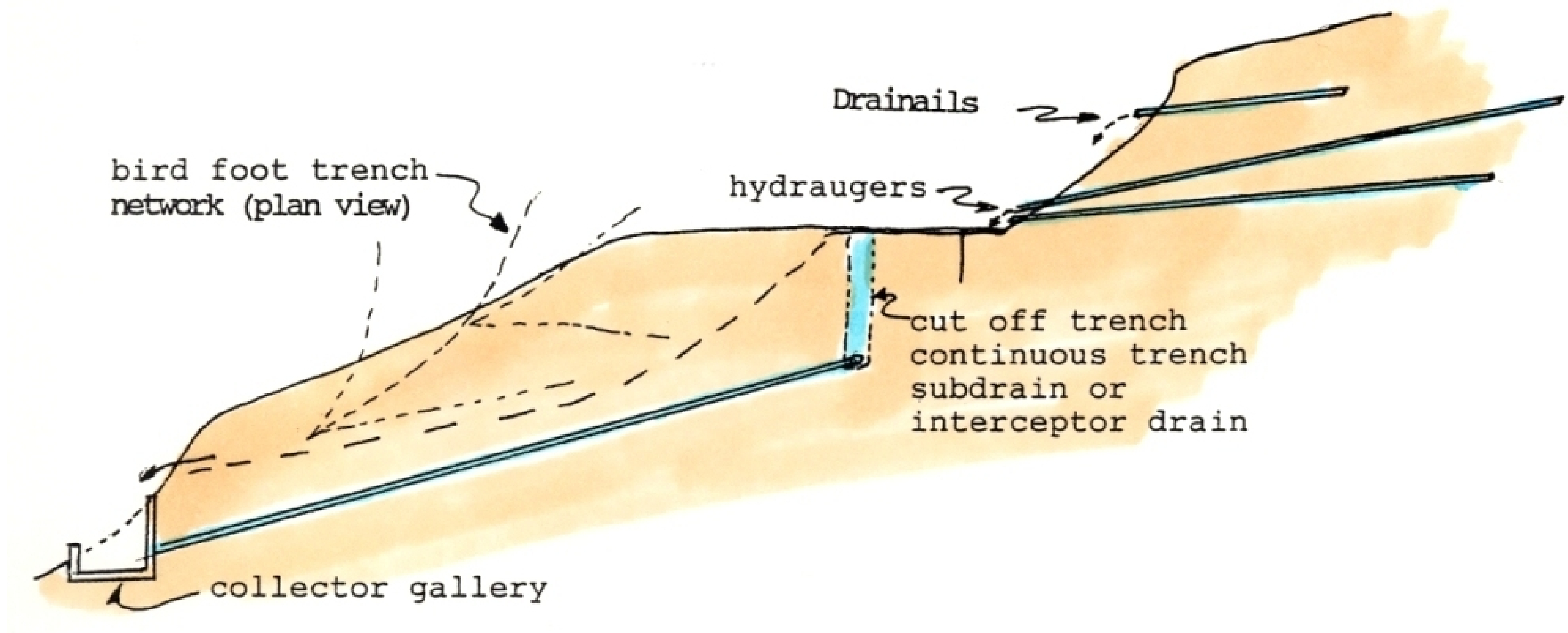


Seepage will tend to leave deposits of Fe, Mg, or Mn oxides along the joint faces through which it percolates through the rock mass

Karst Megaconduits



Areas underlain by karst weathering tend to develop enormous “meagapores” along regional systematic joints which can transmit large volumes of subsurface water



- **Drainage measures** come in a wide variety of types.
- Inclined **horizontal drains** (hydraugers) can be used to intercept seepage back beneath undisturbed ground or used to convey discharge from other drainage measures, which are bereft of gravity outlets

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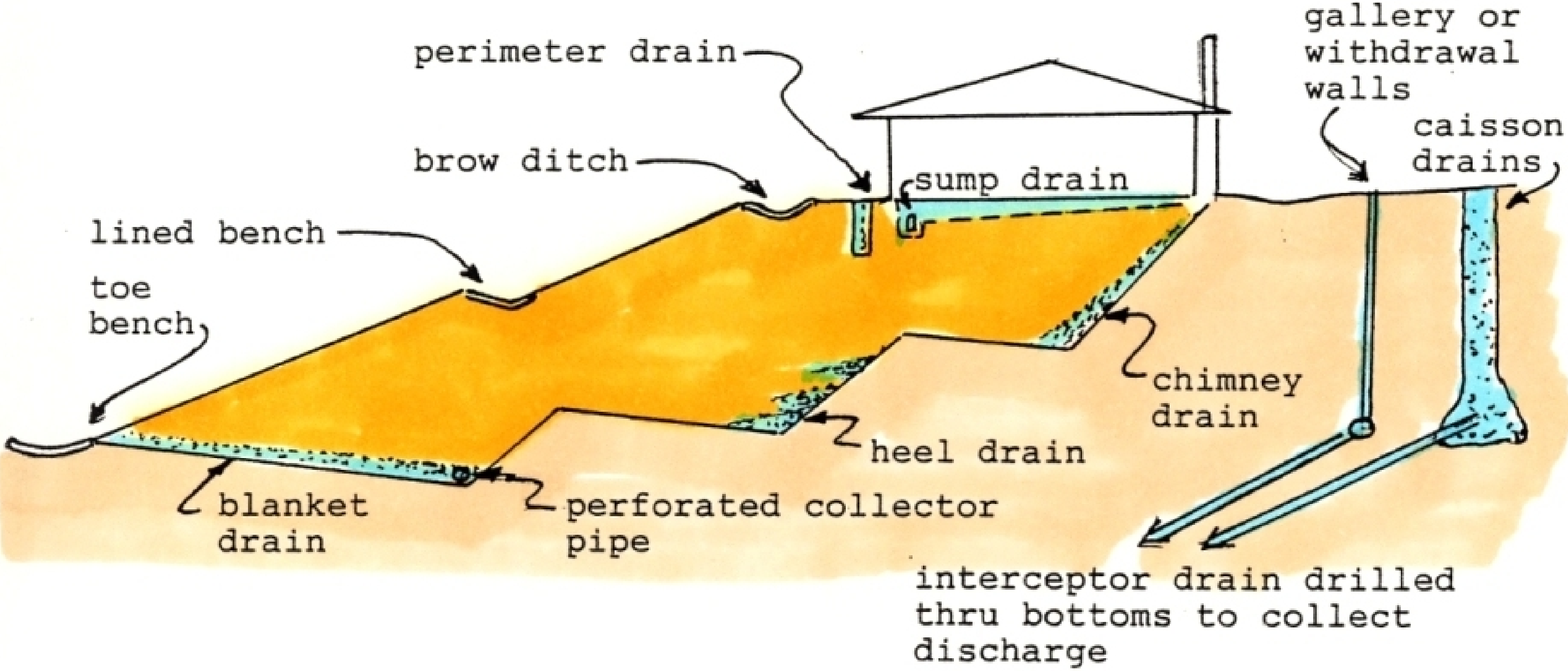

- **Drainage galleries can be installed by excavating a line of wells on close spacings or using underreams to connect caission drains, then decanting collected seepage through horizontal drains.**

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- **Perforated or slotted subdrain collector pipes should be equipped with cleanout risers, so long term operability of the subdrain system can be verified and maintained in perpetuity**

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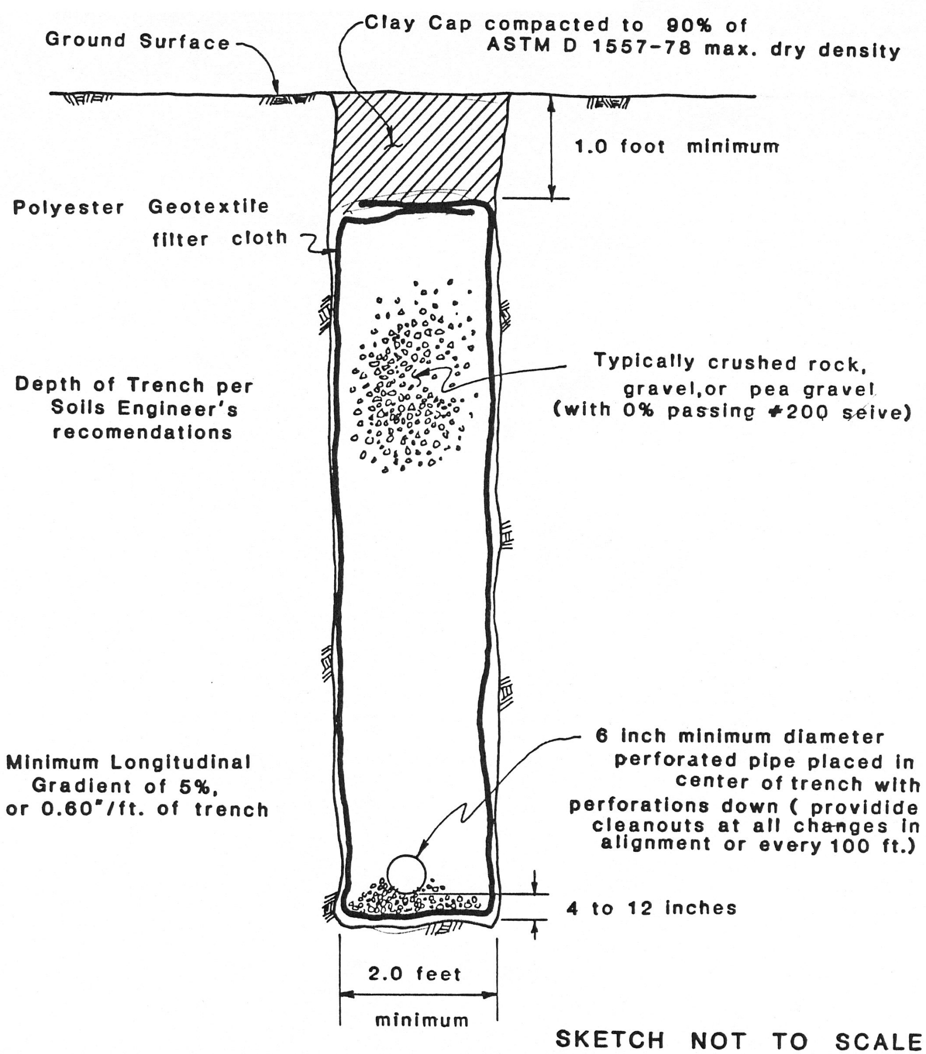

- **Continuous trench subdrains should be constructed with adequate hydraulic grade, a bedding of 4 to 12 inches beneath the collector pipe, a geotextile filter fabric around free-draining gravel and a compacted clay cap at least 1 foot thick**

- Perimeter trench subdrains, or "French Drains" are commonly employed around structures, as shown here.
- An impervious membrane can be used between the floor of the trench and the structure foundation as shown here.
- A geotextile filter cloth protects the gravel from becoming clogged

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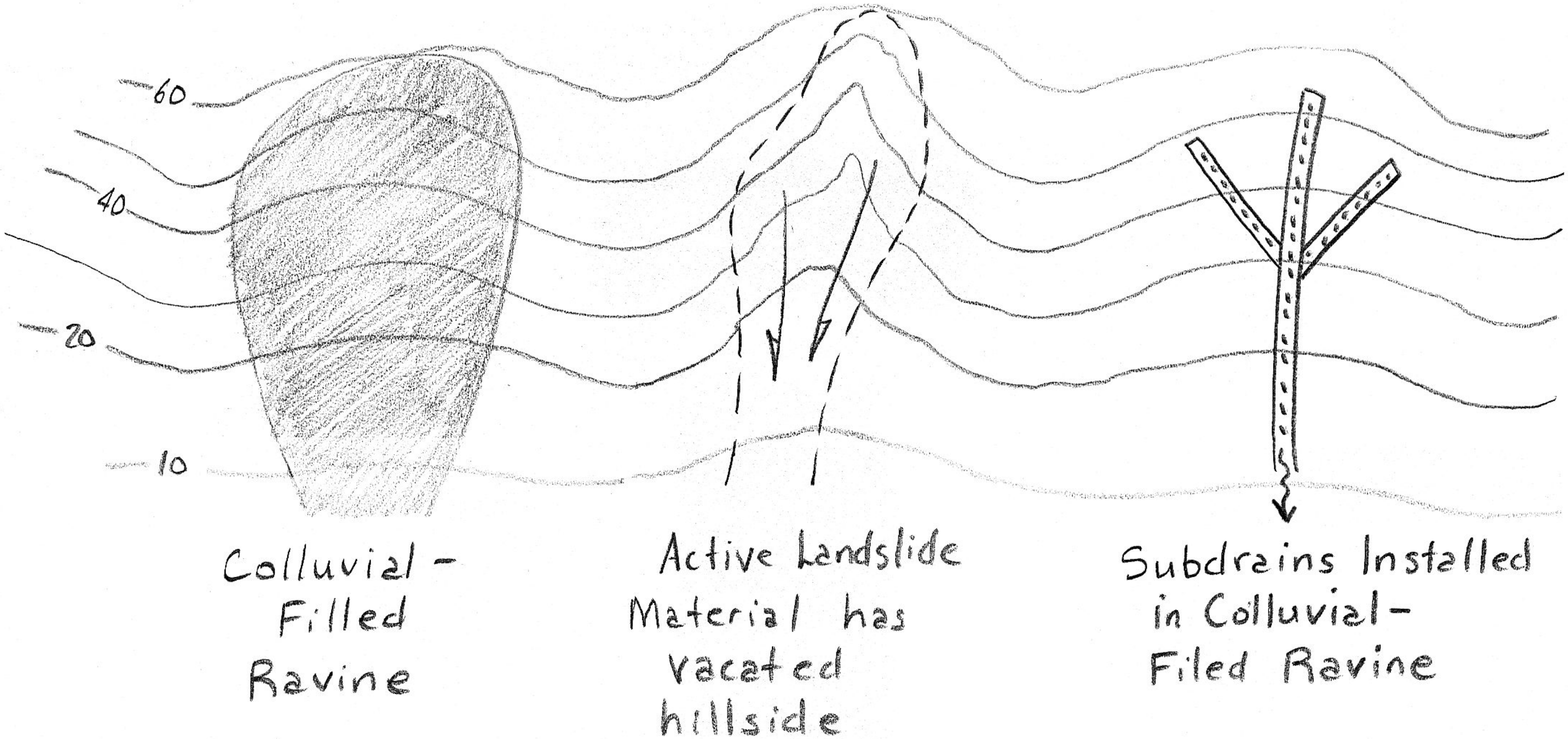
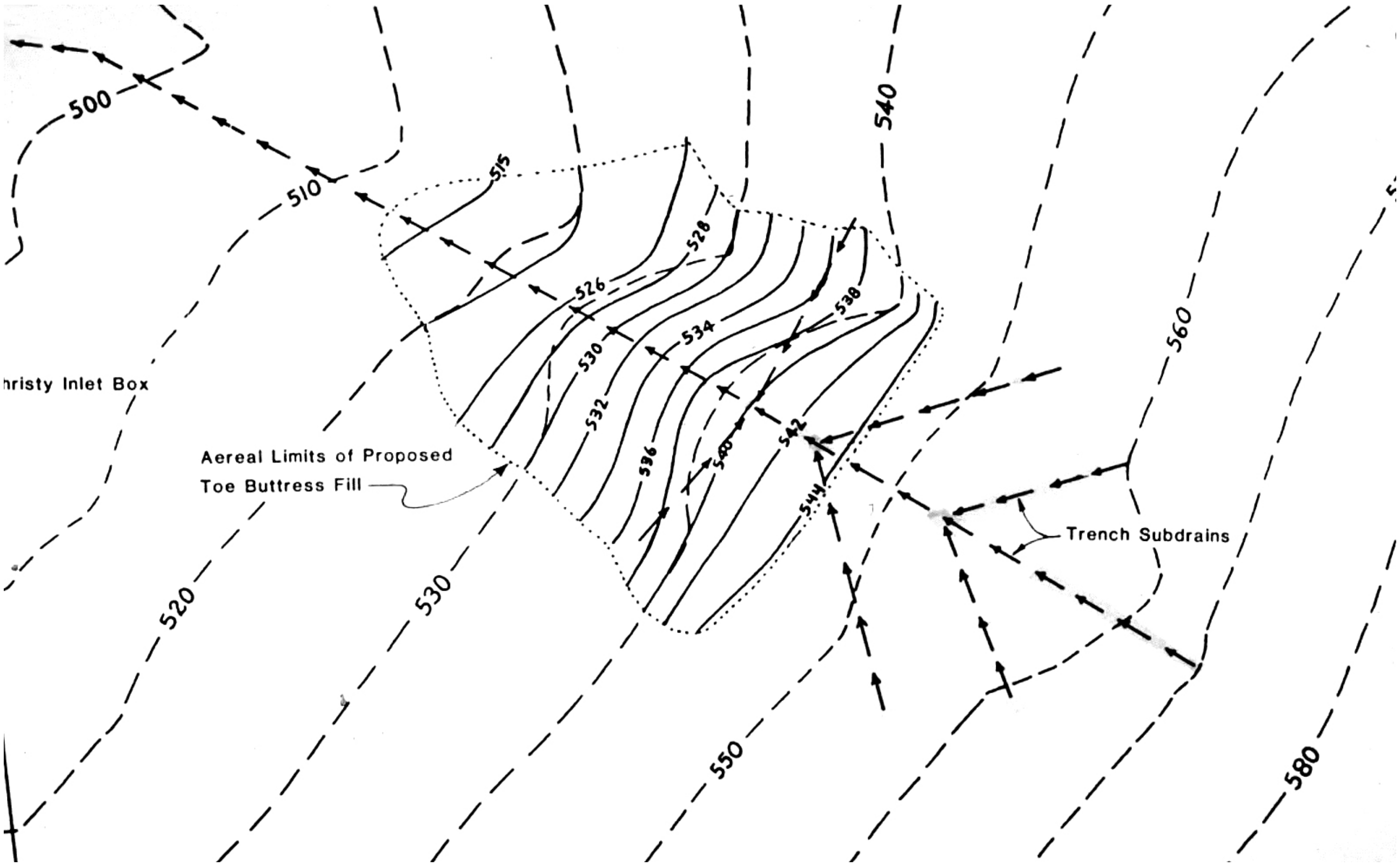
- **Perimeter trench subdrains need to be sloped more than 0.5% to promote gravity flow of collected moisture. This detail often gets overlooked**



- **Interconnected trench subdrains**, **or "birdfoot drains," can be one of the most economical ways of stabilizing active landslides, if sufficient quantities of free-draining materials are available nearby.**



- **Typical work plan for a "birdfoot drain" repair, using a herringbone shaped array of rock-filled trenches, all sloped downhill to promote gravity flow (and without collector pipes)**

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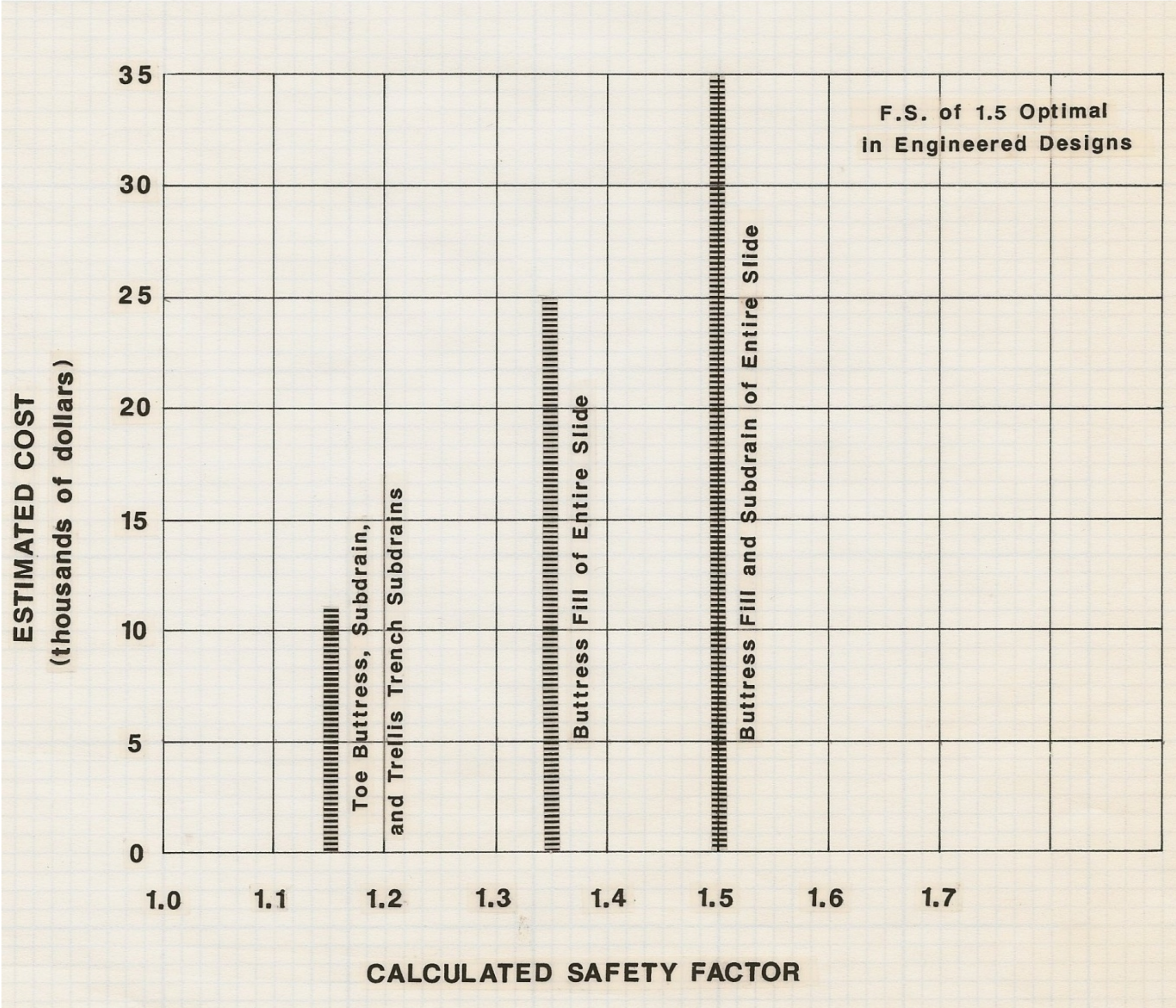

- **Comparative costs for slope repairs of increasing safety factor. Drainage-only repairs are usually the least expensive, but there is no guarantee that the drainage system will continue to operate as intended, without maintenance.**

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