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MODERN DESIGN OF SAND RESERVOIRS FOR WATER STORAGE

AND THEIR APPLICATION IN SAUDI ARABIA AND OTHER ARID COUNTRIES

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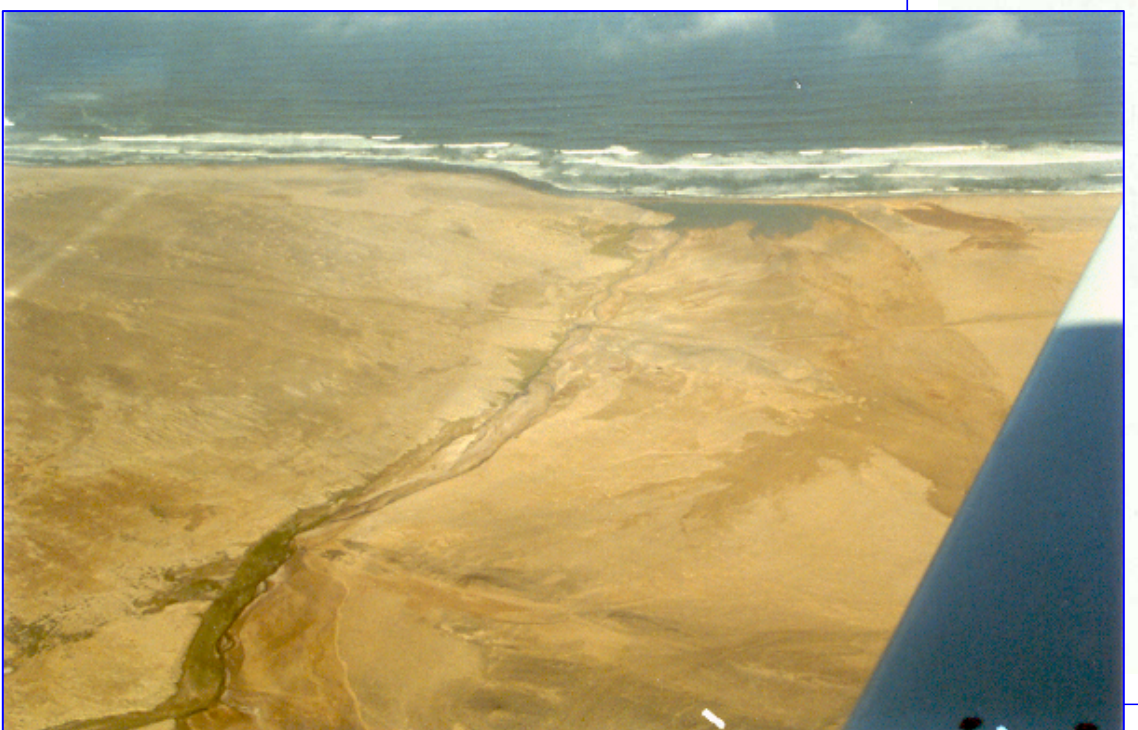
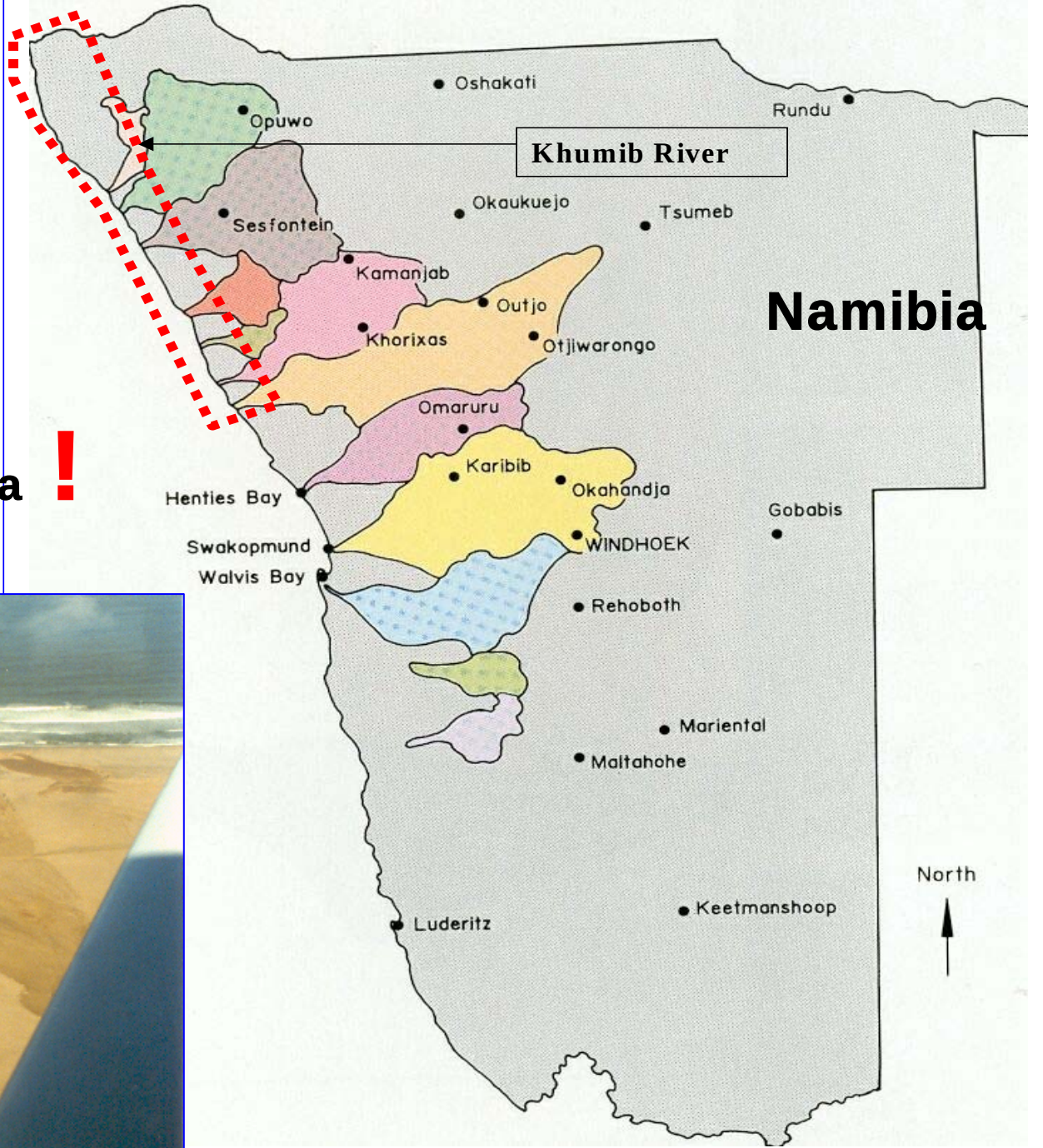
Some of the most common problems in water-resources management:

Operations:	Problems:	Solutions:
1. Groundwater management of coastal aquifers.	1. Leakage, run-off and marine interface	1. Trench-cut diaphragm walls & sheet piles
2. Harvesting of surface water.	2. Evaporation and pollution	2. Artificial groundwater recharge
3. Integrated and sustainable water resources management in semi-/arid regions.	3. Distance to water source	3. Decentralisation of sources and supply

Problem no. 1:
Marine interface

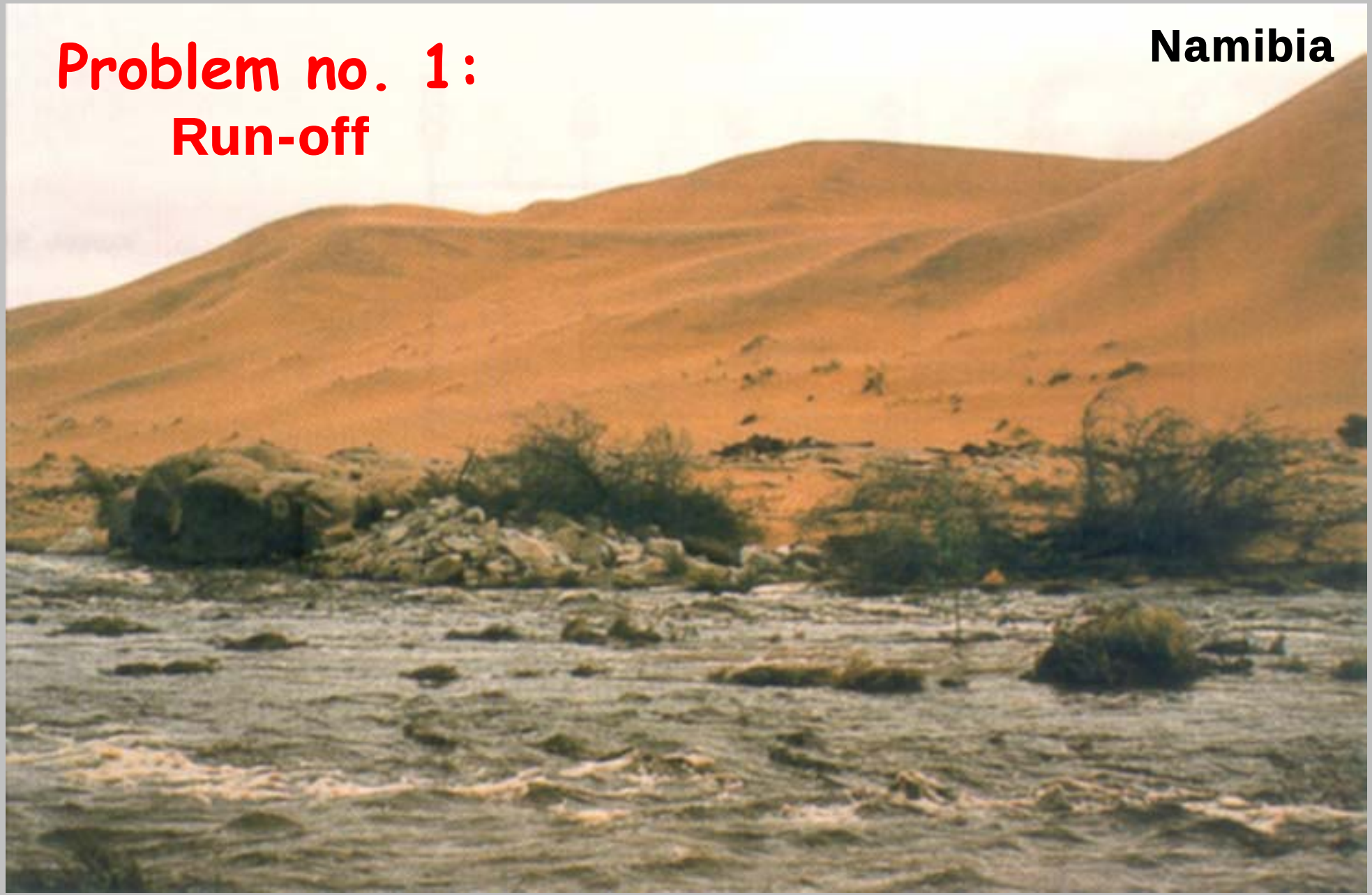
50 m³/s subflow lost to the sea !





Problem no. 1:
Run-off

Namibia



Storm water run-off in the lower Kuiseb River

[Plöthner,D., Z.angew.Geol.45(1999)3]

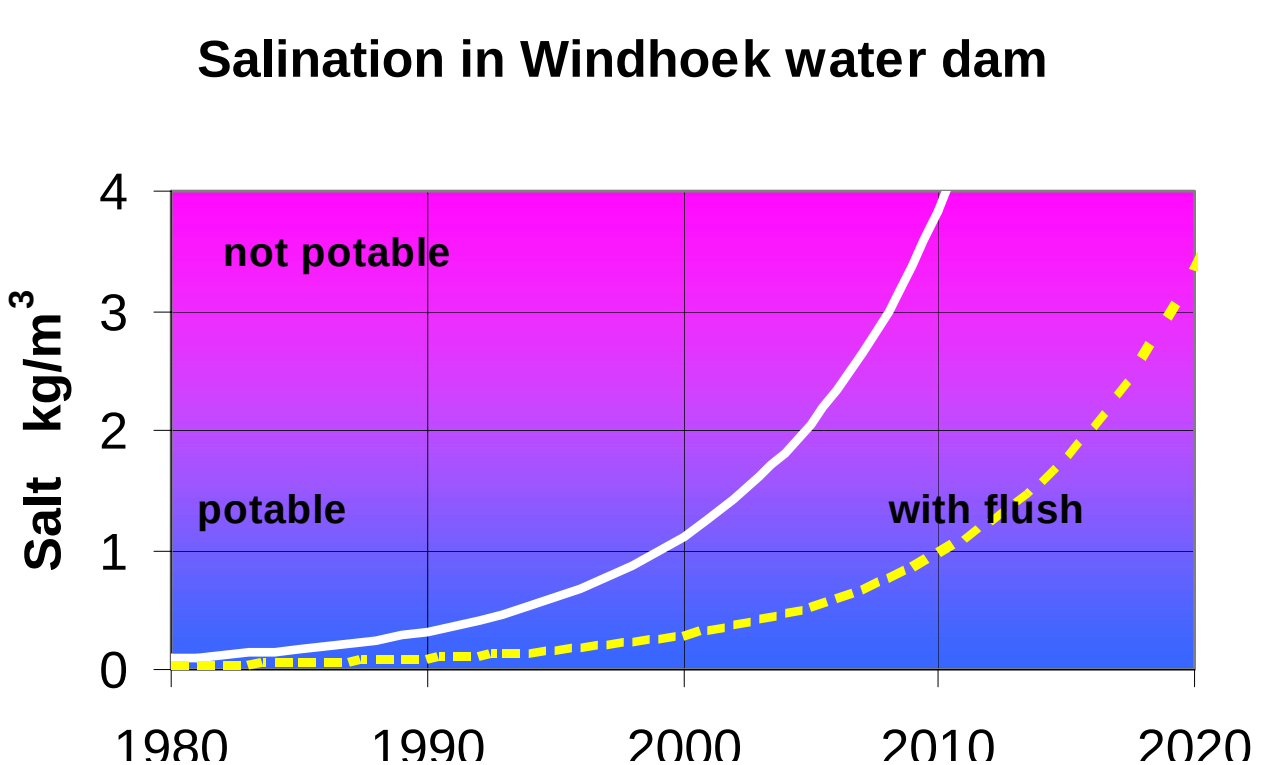
Problem no. 2: Evaporation

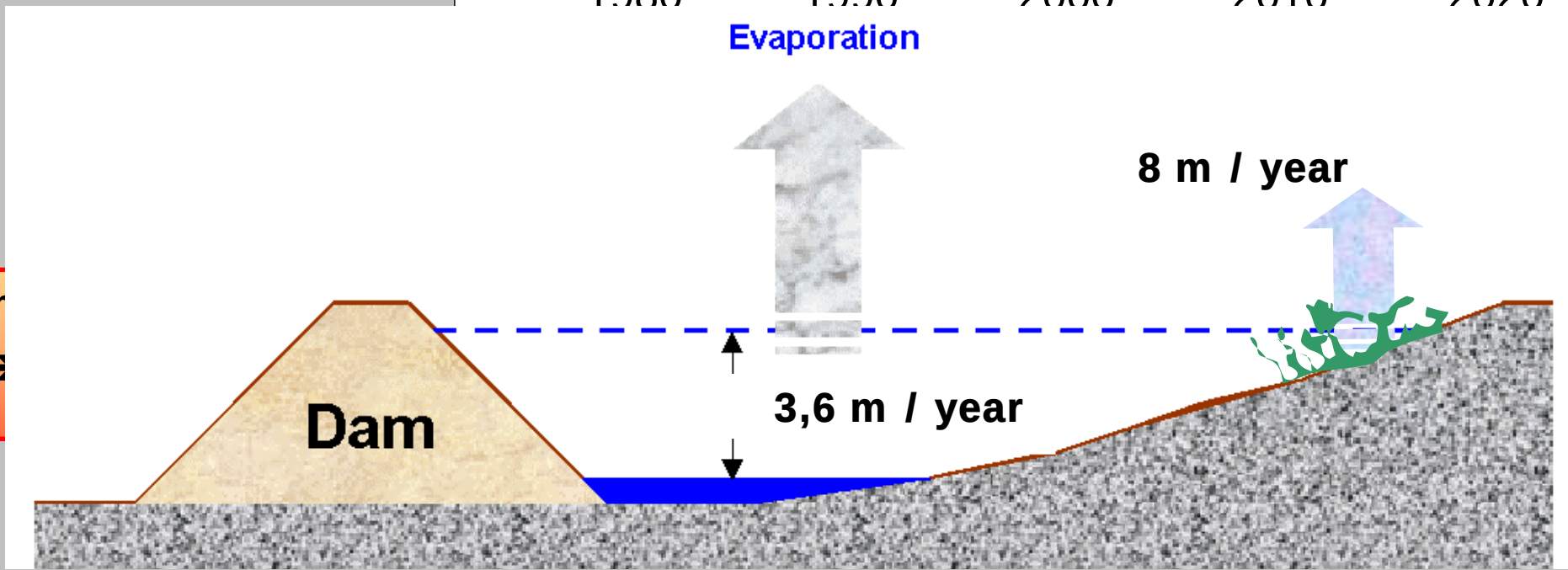
380 m³/s evaporated from small dams !

Namibia

Salinatior

from 300 ➔



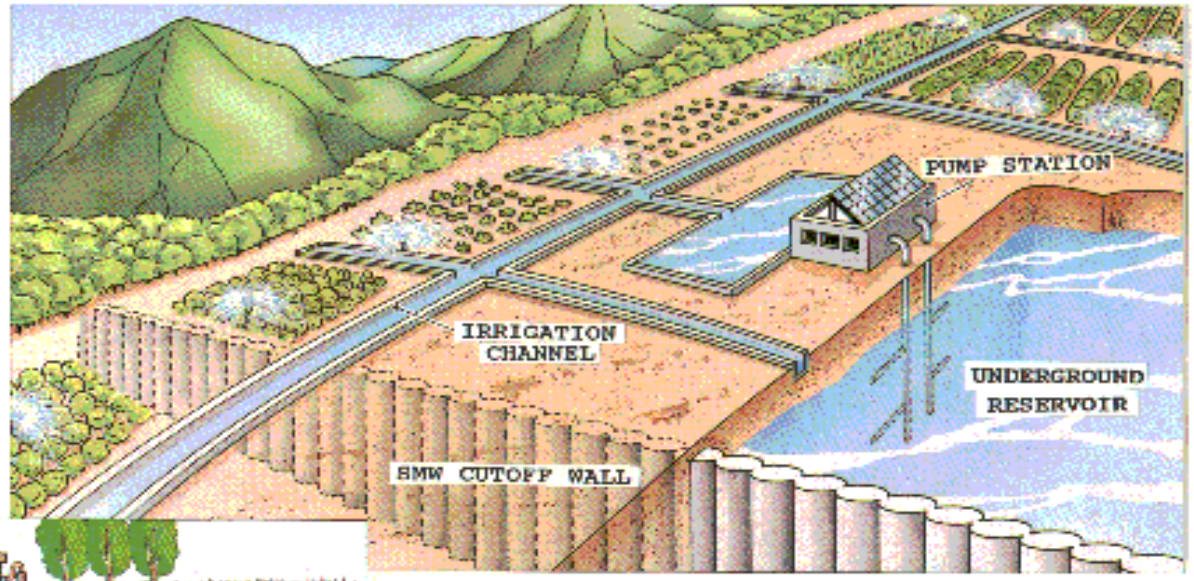


Problem no. 3:
Distance to water source

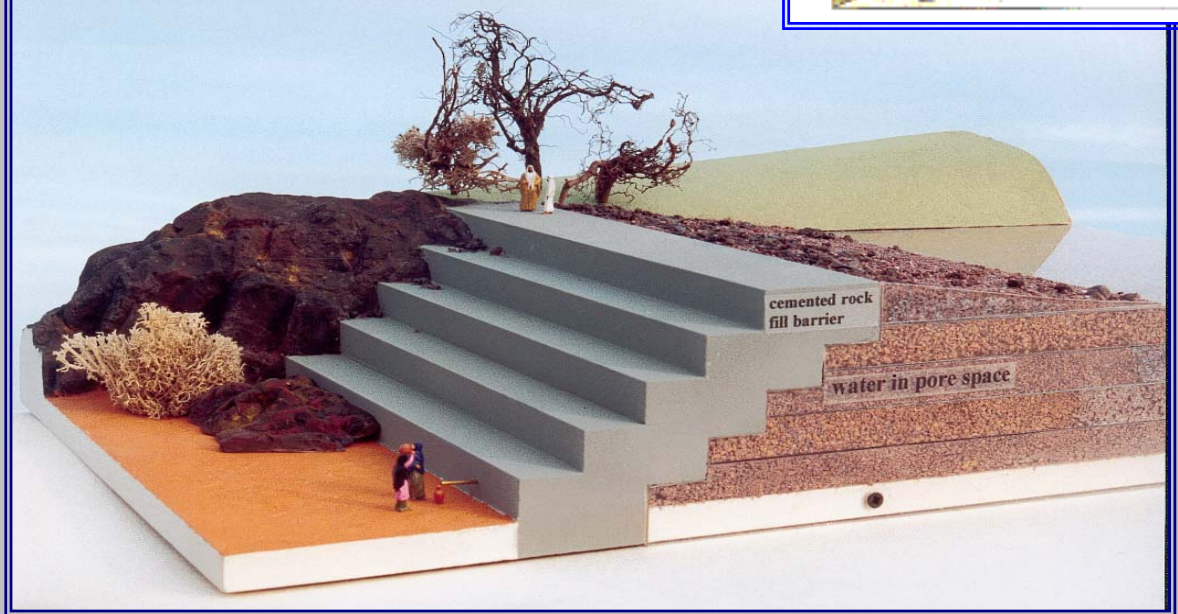
Until 1820, worldwide only 20% of all water costs were associated with transmission.

Today 90% !

A possible solution



Namibian "sand dam"

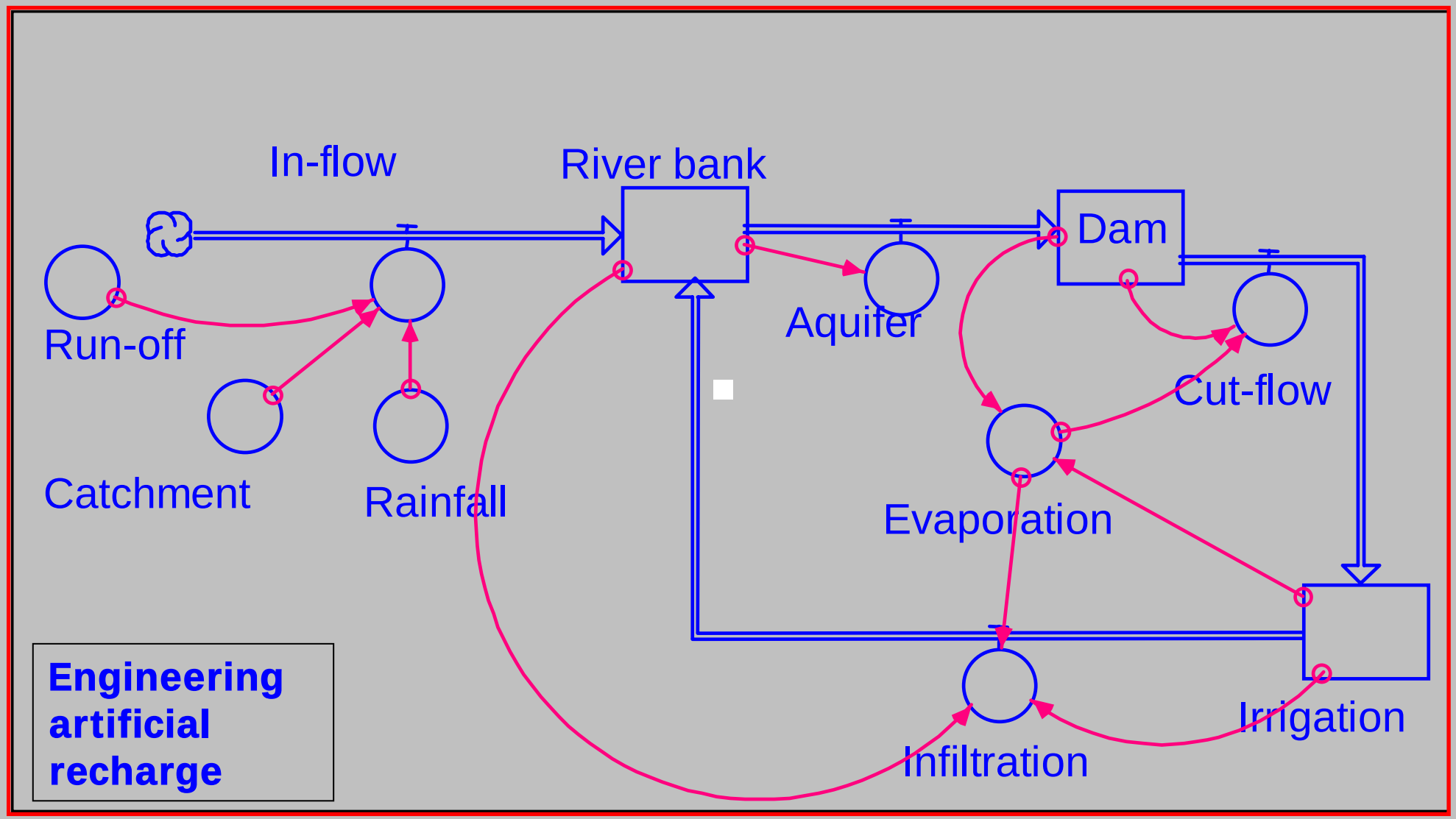


DESIGN OF SAND RESERVOIRS for water storage

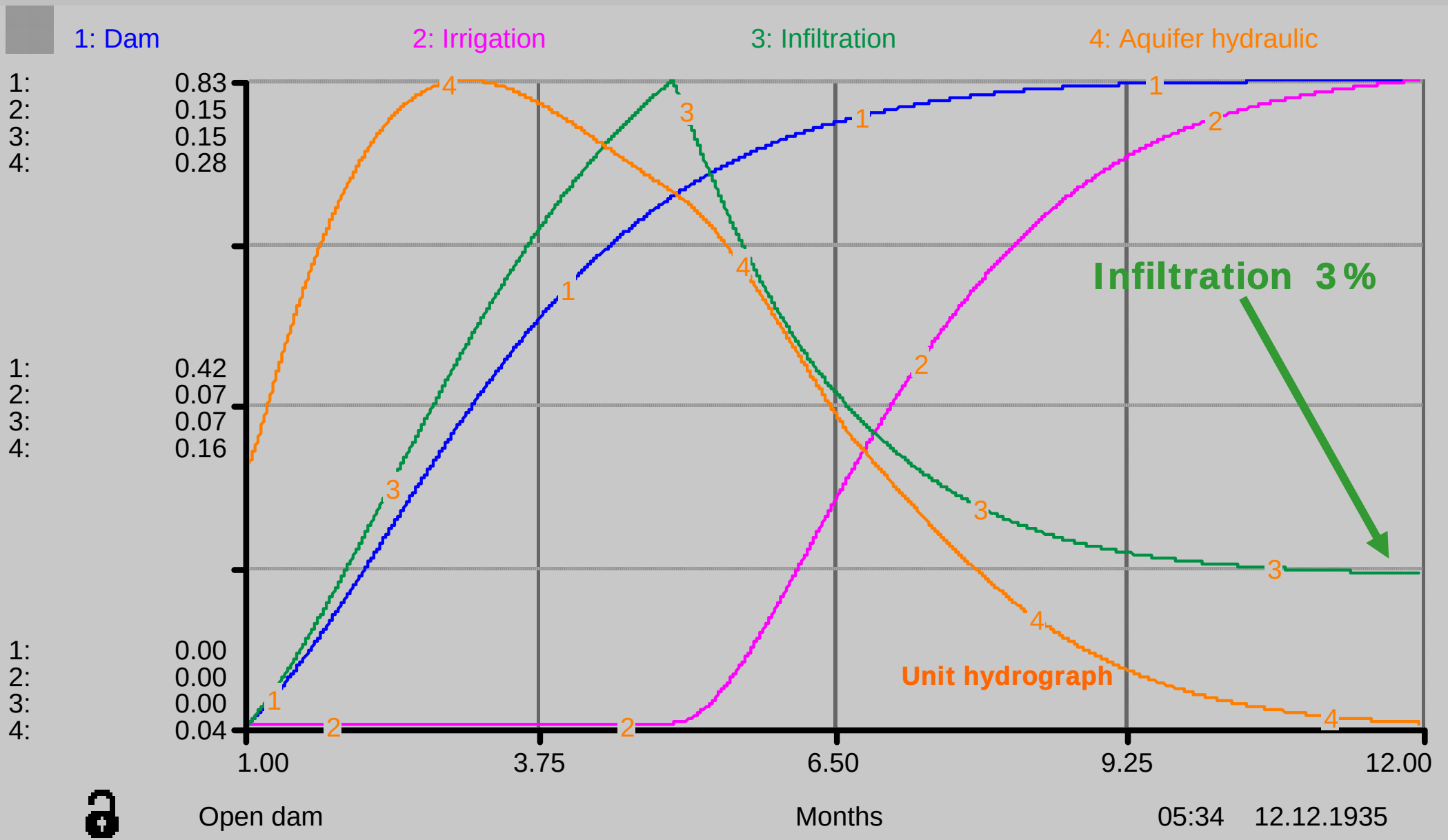
Problems (1950)	Solutions (2002)
1. Unknown unit hydrograph (to design artificial recharge)	2. Differential equation modelling
2. Control of sedimentation	2. Phased elevation of crest
3. Control of storativity	3. Defraction of sediments
4. Stability	4. RCC sloped wall
5. Spill control	5. Step chute

1. Unknown unit hydrograph

2. Differential equation modelling

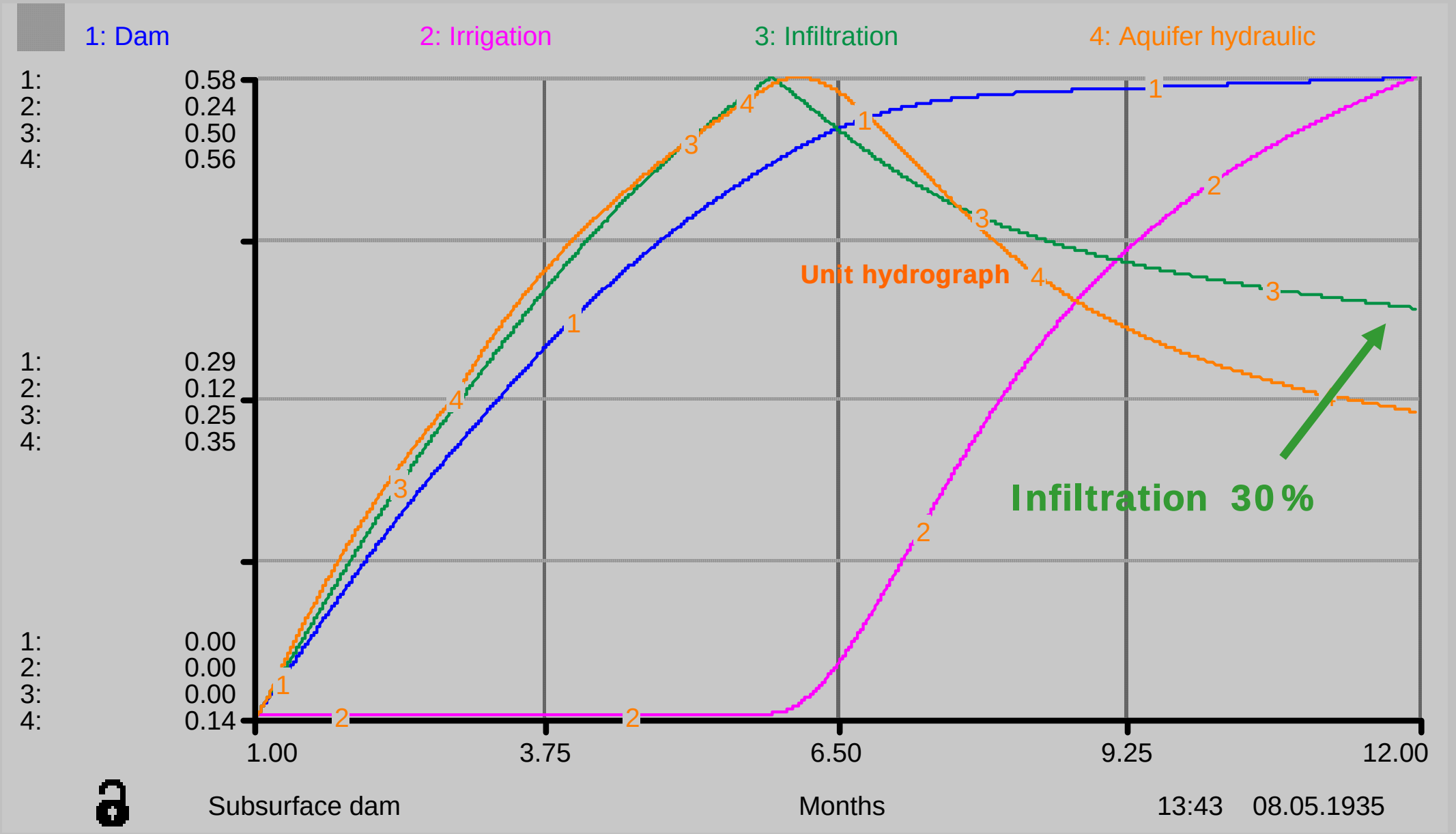


In Cooperation with OMI at TU-München / Germany.
Publication: 2002, DIETTRICH, Th., Irbid, Jordan.



Forrester model output of an water dam reservoir.

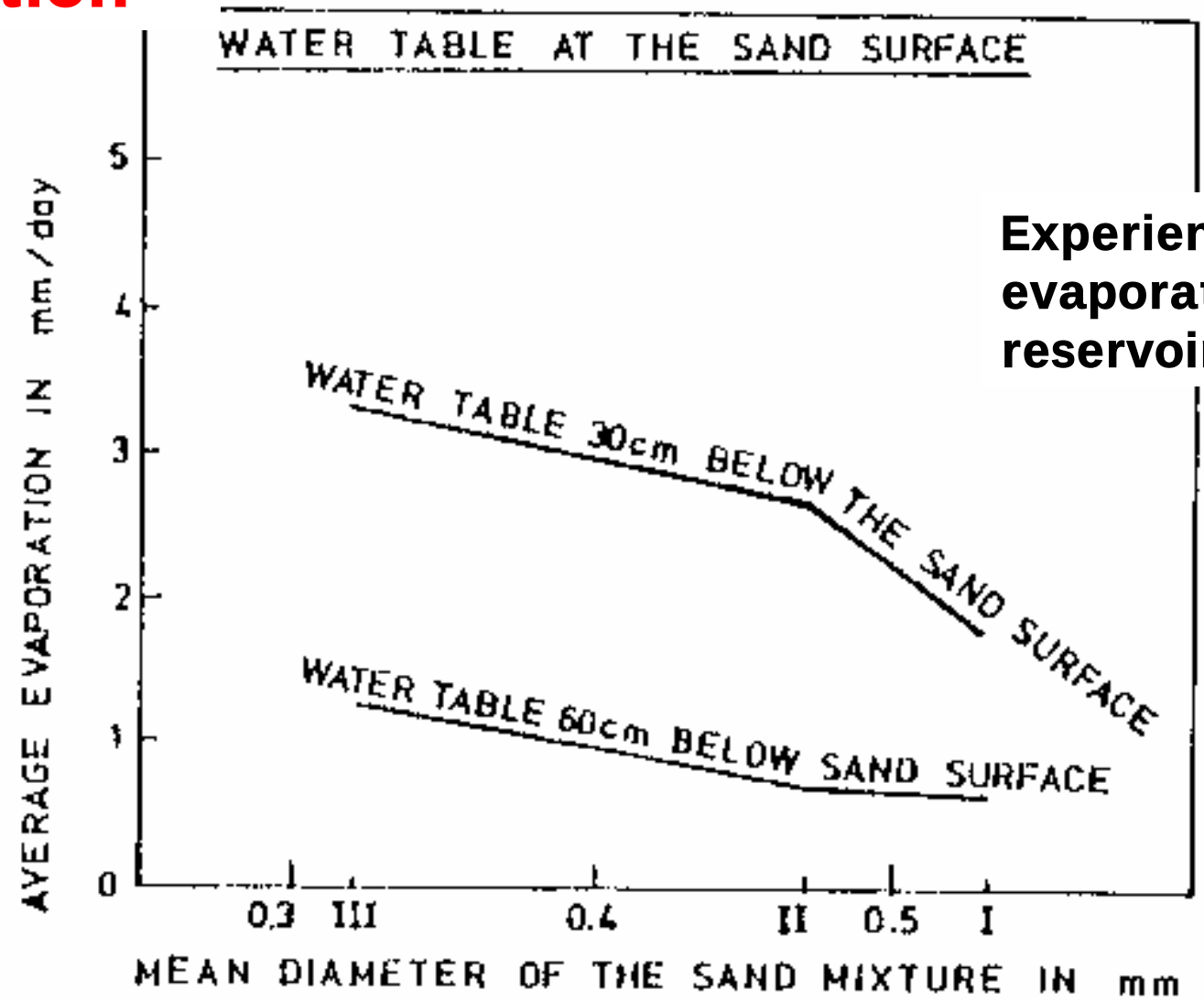
"*Irrigation*" (curve 2) rating 0,15 of total inflow



Forrester model output of a sand dam reservoir.

"*Irrigation*" (curve 2) rating 0.24 of total inflow

Problem no. 2: Evaporation

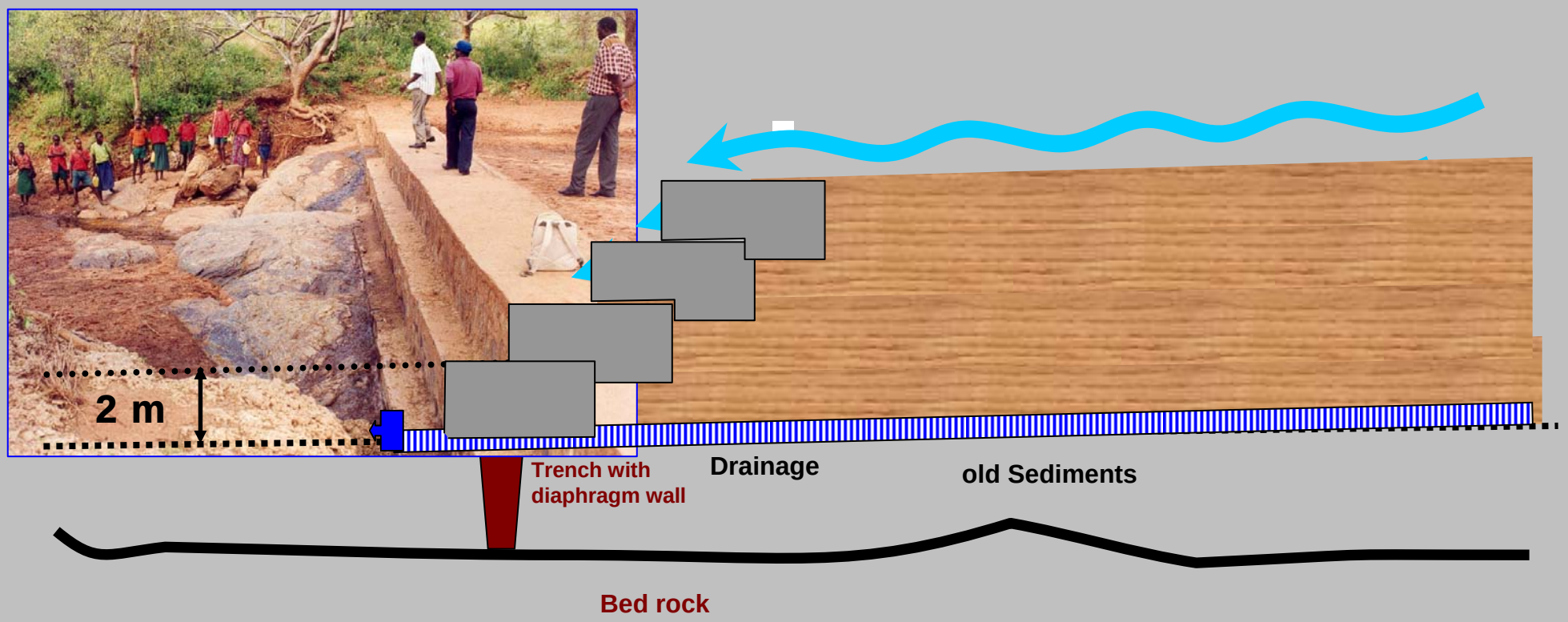


Experience with evaporation in sand reservoirs (Namibia)

FIG.6.3:Evaporation

2. Control of sedimentation	2. Phased elevation of crest

Forth flood



Kenya: S1°54,737' E 36°6,11'

Namibia

1. Sand dam after first flood

2. The same river bank after 3 years

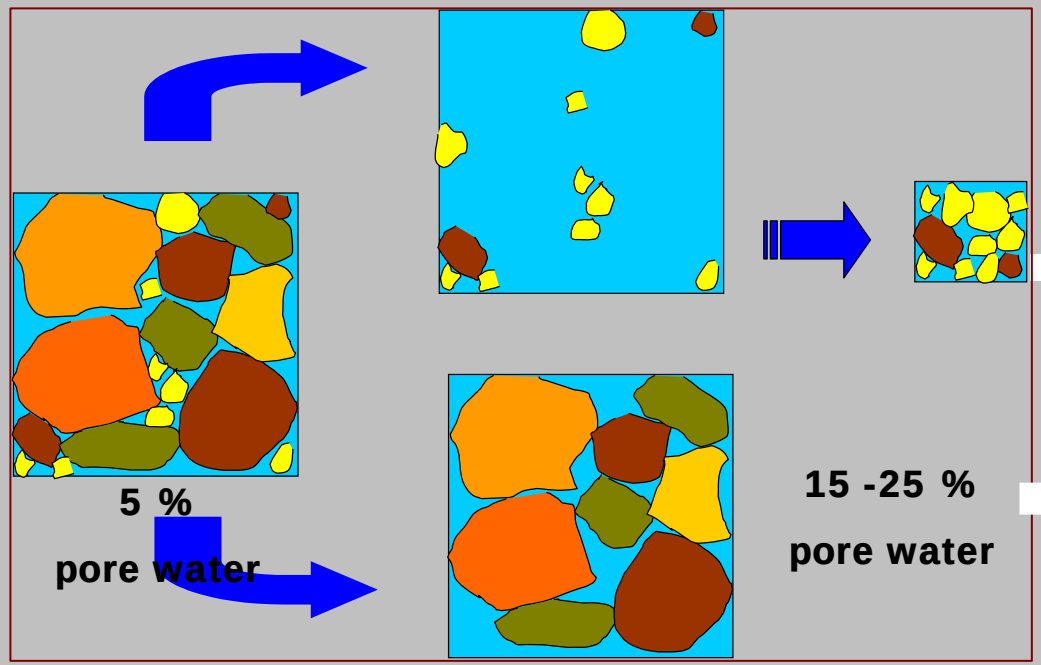
E 016°26.910 / S 23°19.109

300

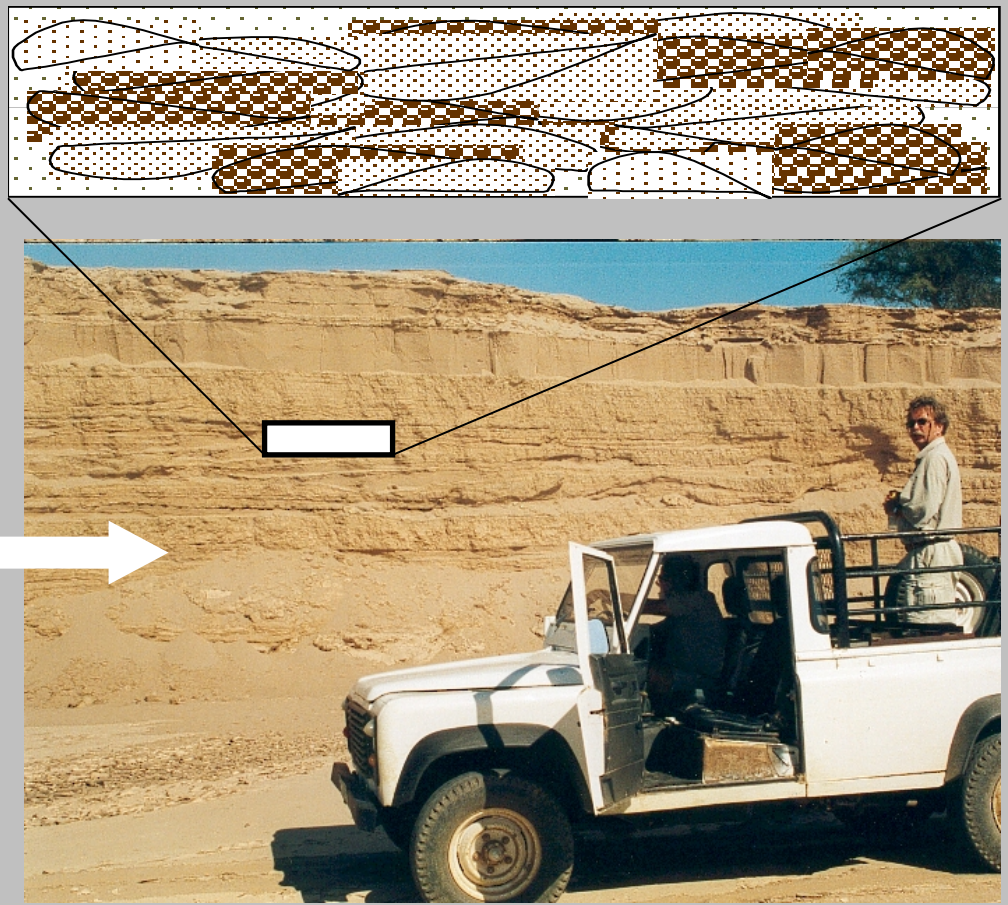
"Sand dams" constructed in Kenya since first introduction in 1996

3. Control of storativity

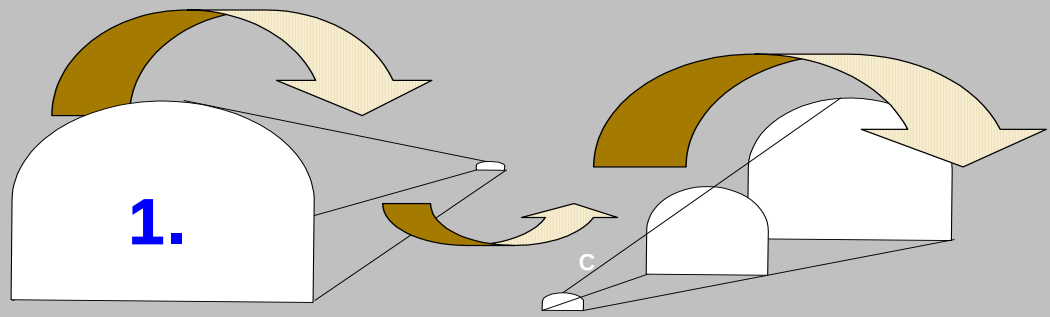
3. Defraction of sediments

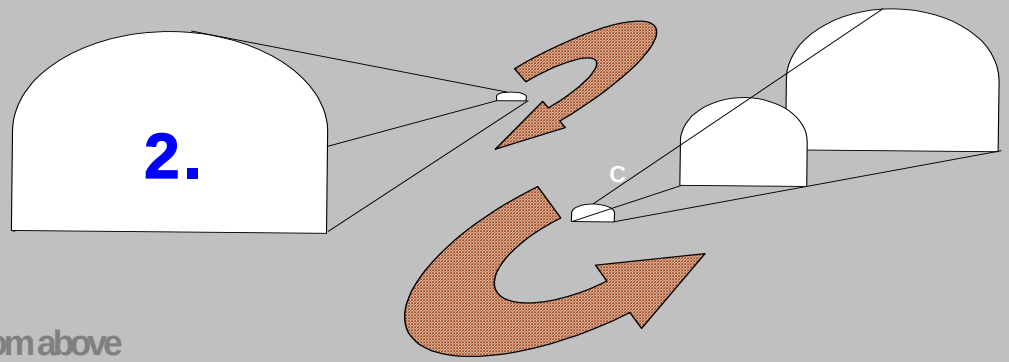


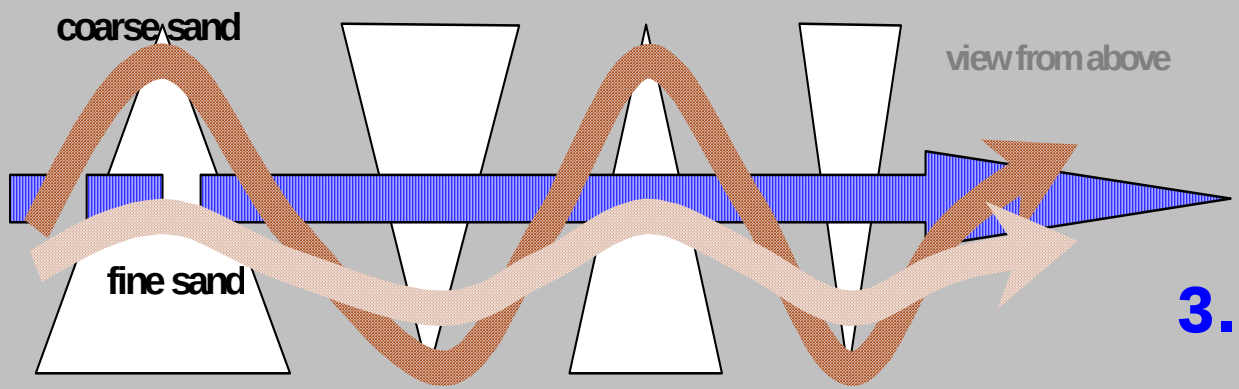
theoretical max. pore space is about 32 %



Sand Defractors







4. Stability	4. RCC sloped wall

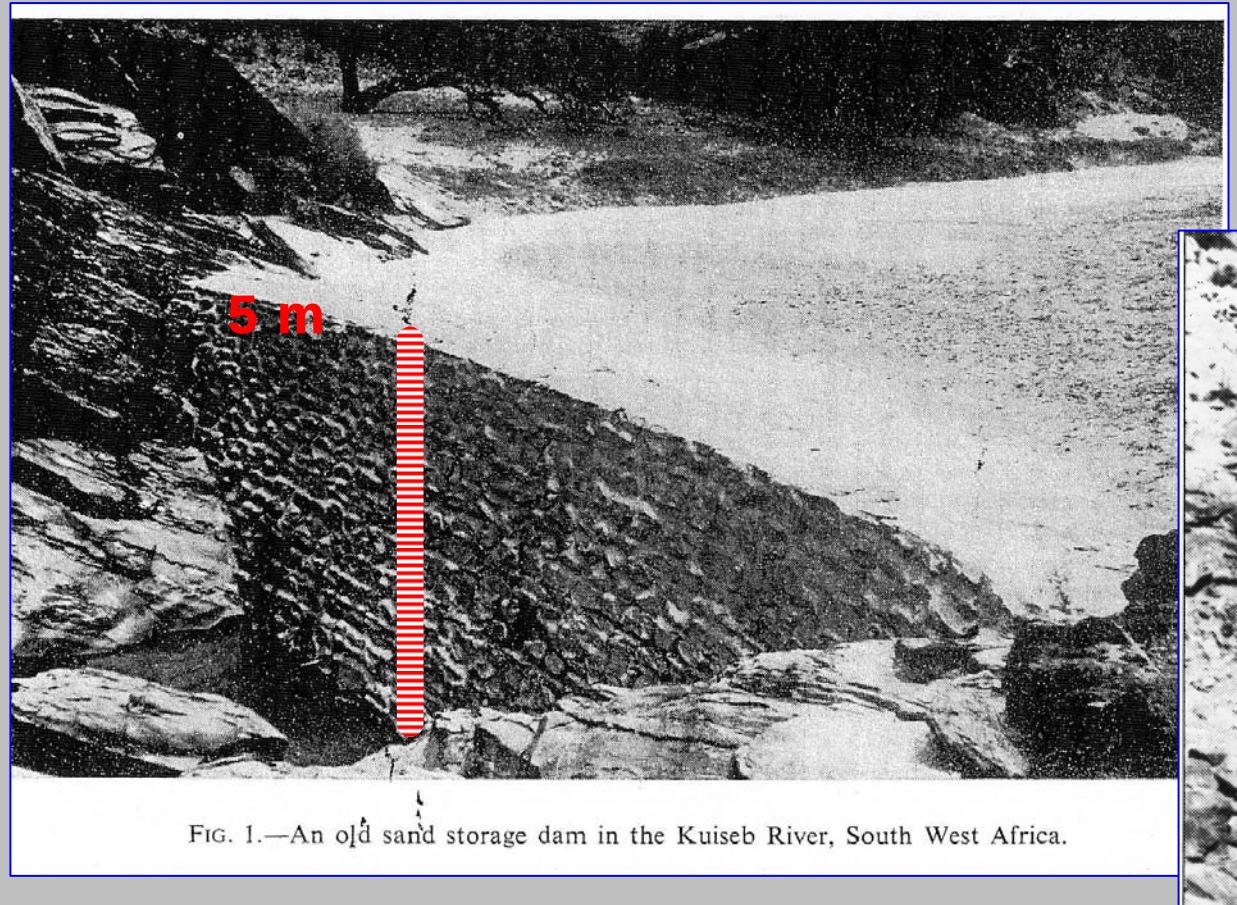
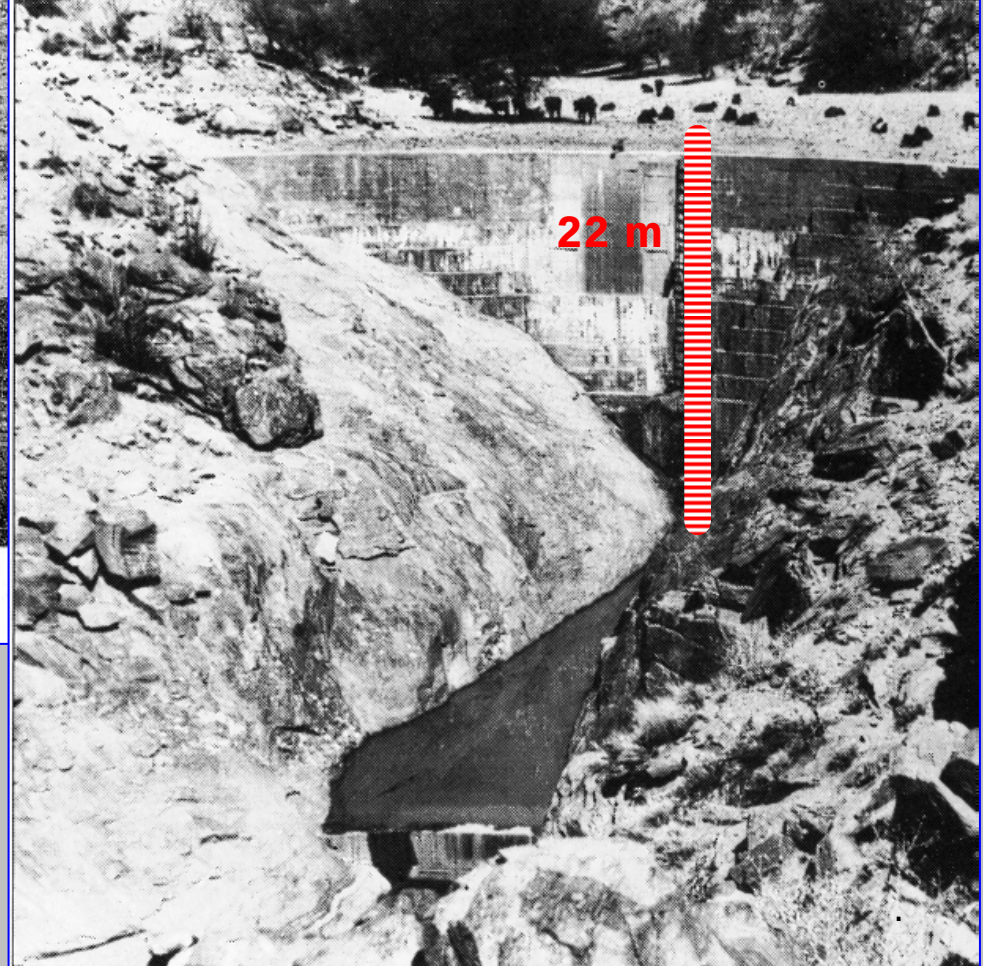


FIG. 1.—An old sand storage dam in the Kuiseb River, South West Africa.

Kuisib River

Hoanib River

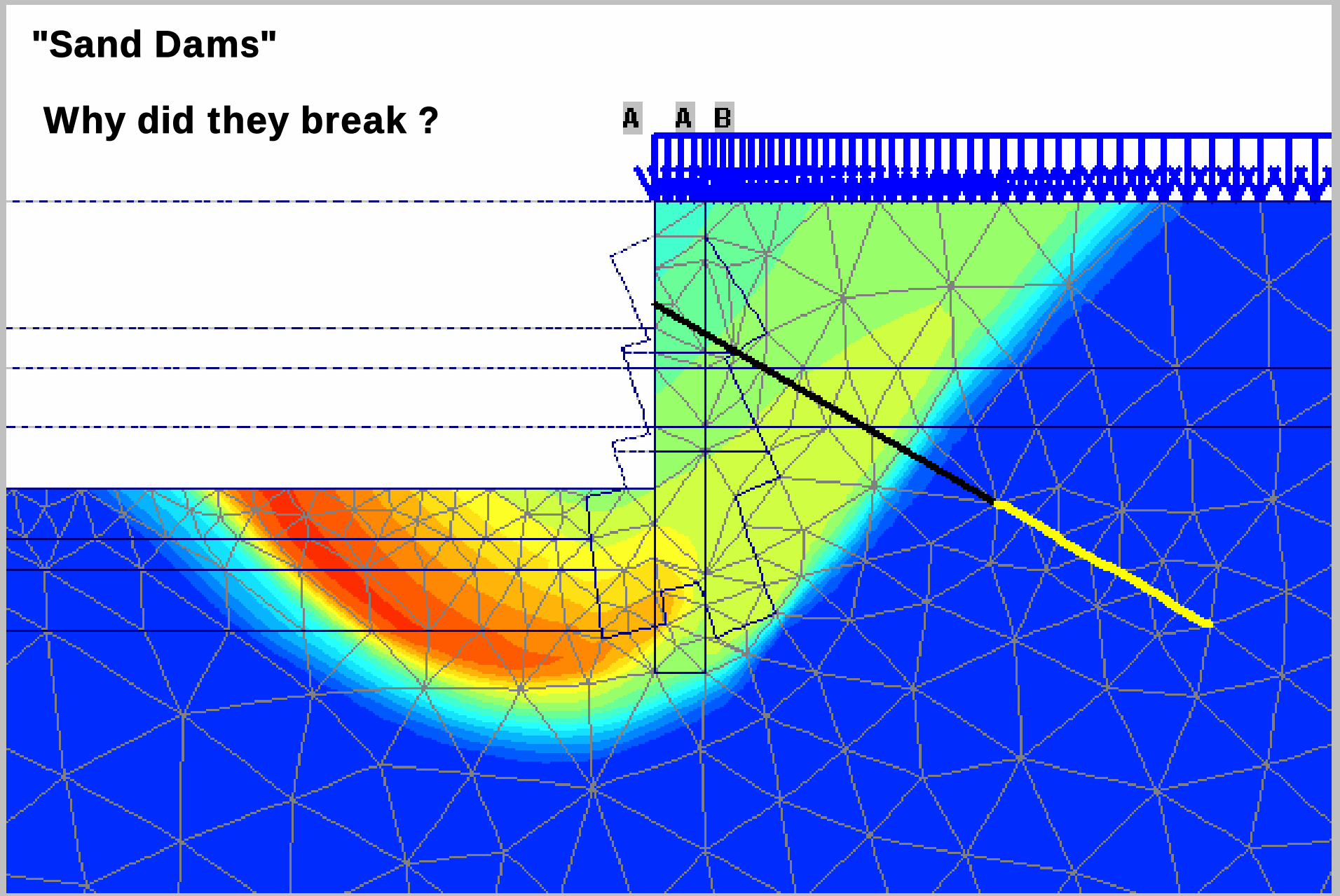


"Sand dams" in Namibian

1950

"Sand Dams"

Why did they break ?

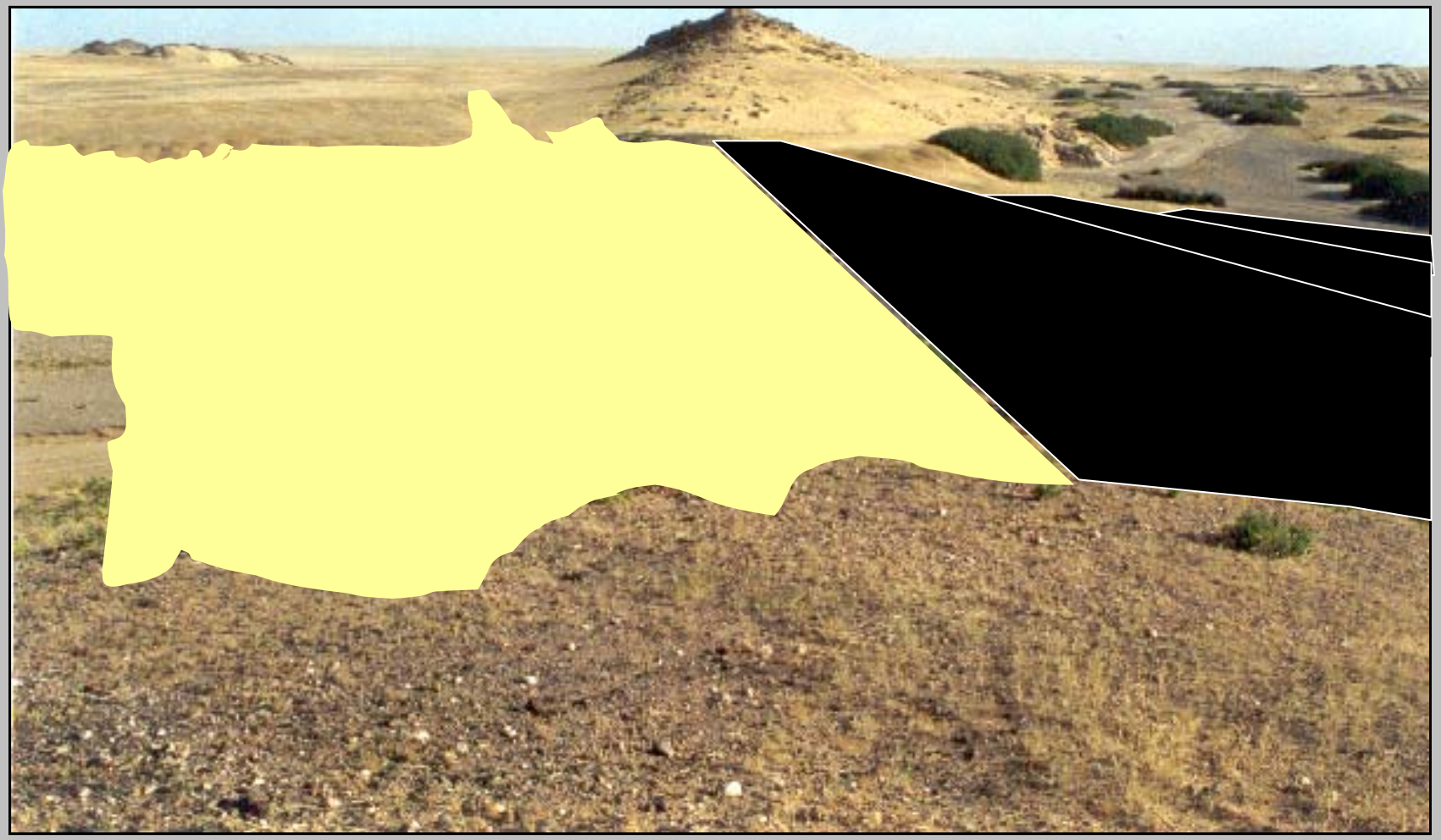


APPLICATION IN SAUDI ARABIA AND OTHER ARID COUNTRIES

Criteria for site selection of dams:

- **river gorges**
- **sandy catchment area**
- **seasonal river flow**
- **torrectial run-off**
- **depth to bed rock < 20m** (-> costs)

Planned applications in Namibia

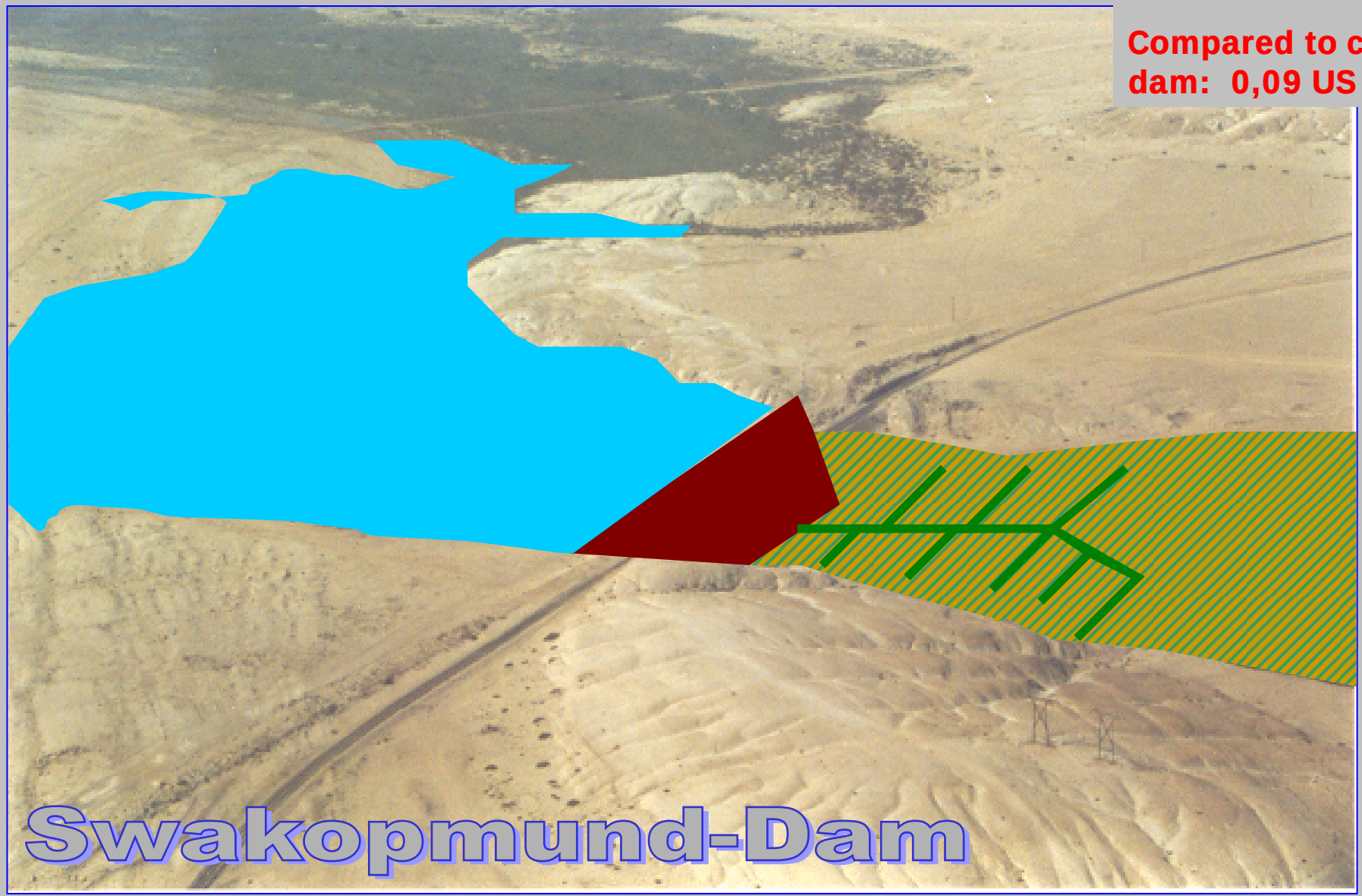


Khumib, potential sand reservoir for
60 Million m³ Water

(12) Khumib S 20°33.906 / E 012°33.491

Development until 2020
Yield 40.000 m^3/day
Costs 4 m US $
Water price 0,015 US $/$m^3$

Compared to conventional dam: 0,09 US $/$m^3$

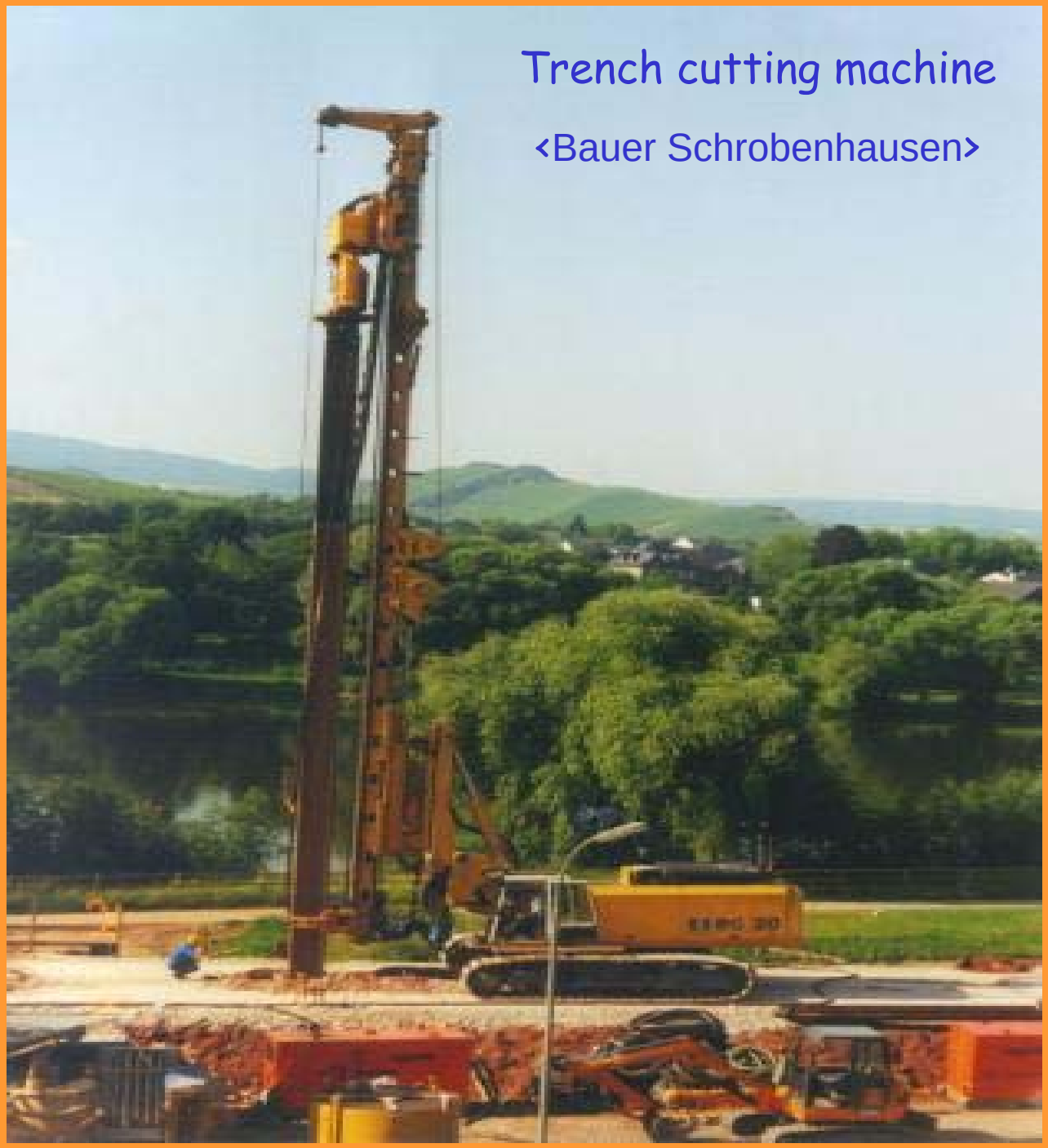


Planned

Applications in Saudi Arabia !

End

Diaphragm wall cut into sediments until it reaches bedrock



Sword of trench cutter: 15 m depth

Core trench: MIP (mixed-in-place) with bentonite.

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