

Artificial Ground-Water Recharge

by means of

Subsurface Dams

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Due to climate changes world wide, ground-water-bearing sediments considerably fall short of sufficient replenishment. To this respect, the [Agenda 21](#) (chapter 12) calls for the development of subsurface dams to challenge the effects like erosion and desertification.

Researchers with [WaterKey®](#) have now found a solution. A new generation of subsurface dams. They can improve the ground-water replenishment at an economical scale. The necessary [Basic technology](#) is known since the 1850s. It is now adapted to the requirements of modern consumers and environmental constraints.

[Subsurface dams](#) are an easy-to-build and economical means to generate, use and process new water cycles in rural areas. Such dams stop erosion, restore river sediments and vegetation, and generate bank storage. In short, they create artificial aquifers. The new type of subsurface dam designed by Seidl & Partner is a sustainable anti-erosion device which retards run-off, diverts it into the sediments, and prevents evaporation. The water abstracted from a subsurface dam is not taken from any existing ground-water regimen, but represents an additional gain in the water cycle of a river basin.

To make it work, researchers with Seidl & Partner-Namibia designed a special river-intake. To a certain extent, it can still the torrential muddy river floods to discharge their sands to sediment with maximum water storativity. This is the key to make subsurface dams compatible to open drinking water reservoirs and small dams.

The Principle of Subsurface Dams

Known from farmer's experience in arid regions, run-off of floods must be retarded to increase ground-water replenishment and to stop erosion. Until 1960 such measures were common use in Southern Africa, and also in other arid rural regions ever since the

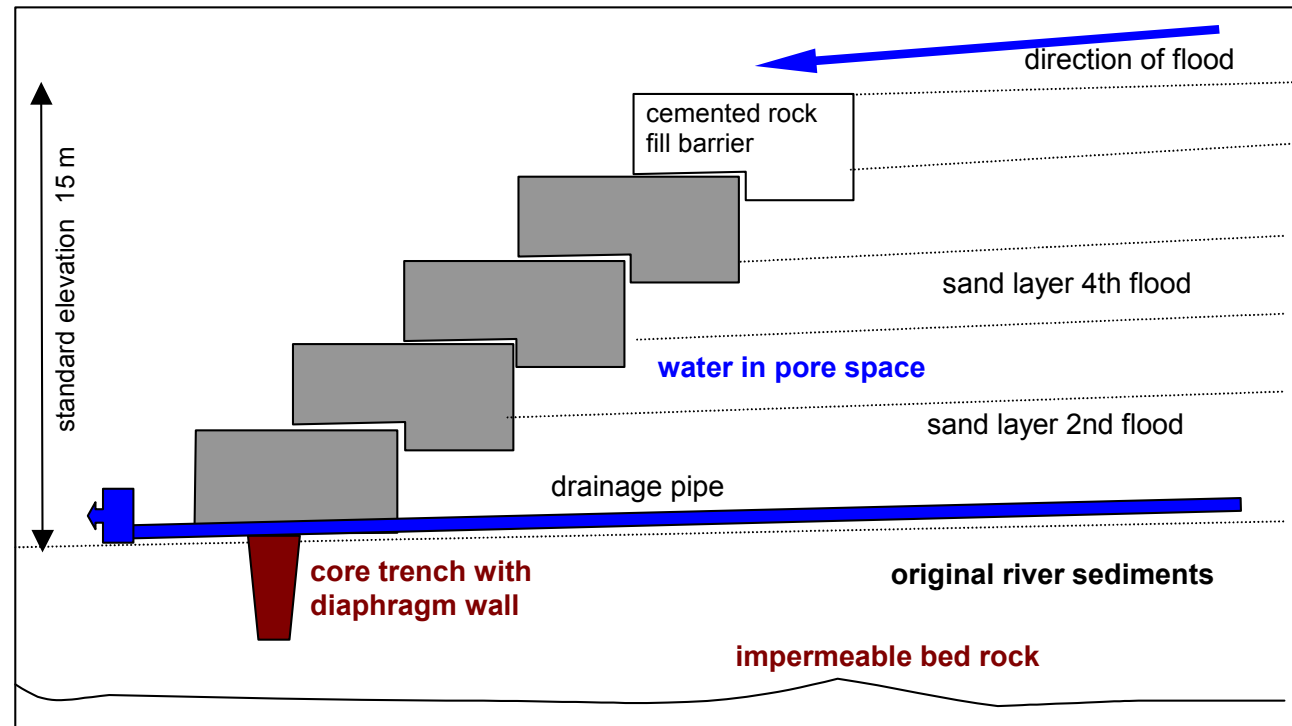
beginning of agriculture in ancient Canaan [6] and China [4][11]. However, along the history of the technical development of modern water transmission lines and deep-hole drilling, subsurface dams became less attractive.

A subsurface dam is a sediment barrier across an ephemeral river. Initially it consists of only one barrier (see figure). The initial stage of a sub surface dam after the first flood. Water leaking out at the foot of the dam is fetched by students of the local primary school at Kwa Ngola Location in the Mwingi District, Kenya, 1997 (Geo Position S1°54,737' E 36°6,11' Map Datum WSG 84).

Whenever the dam-basin has filled up with sand, the crest of the dam wall is topped up by another barrier until the basin builds up a ground-water reservoir (see figure). This process may take 4 to 10 years, depending on the frequency of flood-occurrence. Often the sediment-charged torrential flood lasts only for a few hours once in one to five years.



The rest of the time the river bed remains dry. The advantage of a subsurface dam lies in the fact that the water is protected by the sediments and can not be lost into the atmosphere by evaporation [1]. Whereas in a surface dam, the water is exposed to the atmosphere, and might evaporate up to 8 m per year of its water column depending on the local climate.



Leaks between the joints of the adjacent barriers are of minor concern, as they seal with time by sand suffusion from the reservoir. Environmental concerns would even favour a certain leakage to allow a certain sub-flow to aliment stake holders downstream. The construction shown in the figure is strong enough to hold floods over the central spillway, and resist strong spills due to its steps which absorb its kinetic energy (Kwa Kusa/Mwingi District/Kenya Geo Position S0°50,008' E 38°23,232',Year 1998).

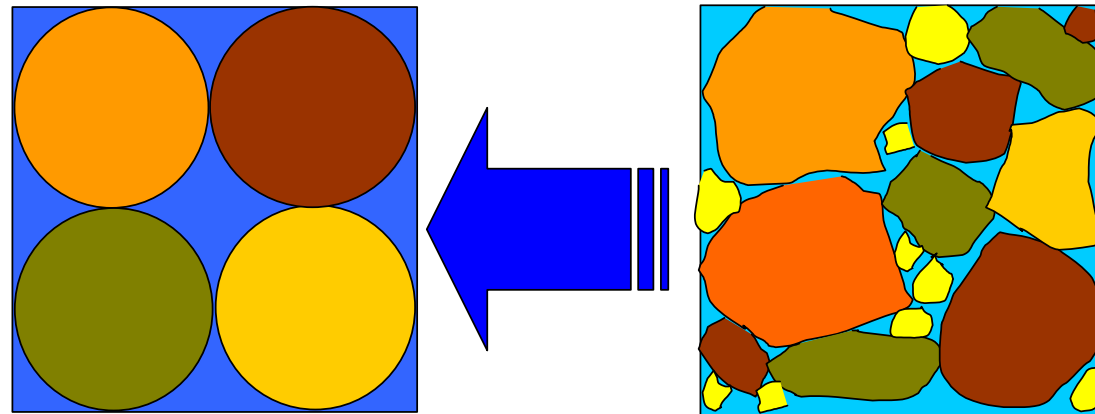
The figure demonstrates how the concept of elevating the barriers is realised. The canyon shown is ideal. It is narrow to permit the construction of a short and economical dam crest, and the flanks left and right consist of an impermeable granite schist. At first, the sealing core is trenched into the already existing river sediments (brown in the figure). Thereafter, a long drainage pipe is laid into the river bed, and packed with filter gravel (blue). The individual barriers (grey dithered) are constructed by caging

chicken-mesh wire, then bricklaying them with rock-fill, and stuffing them with ballast (grey). Finally, wooden moulds are packed against the cages to hold the fresh cement grouted into them.

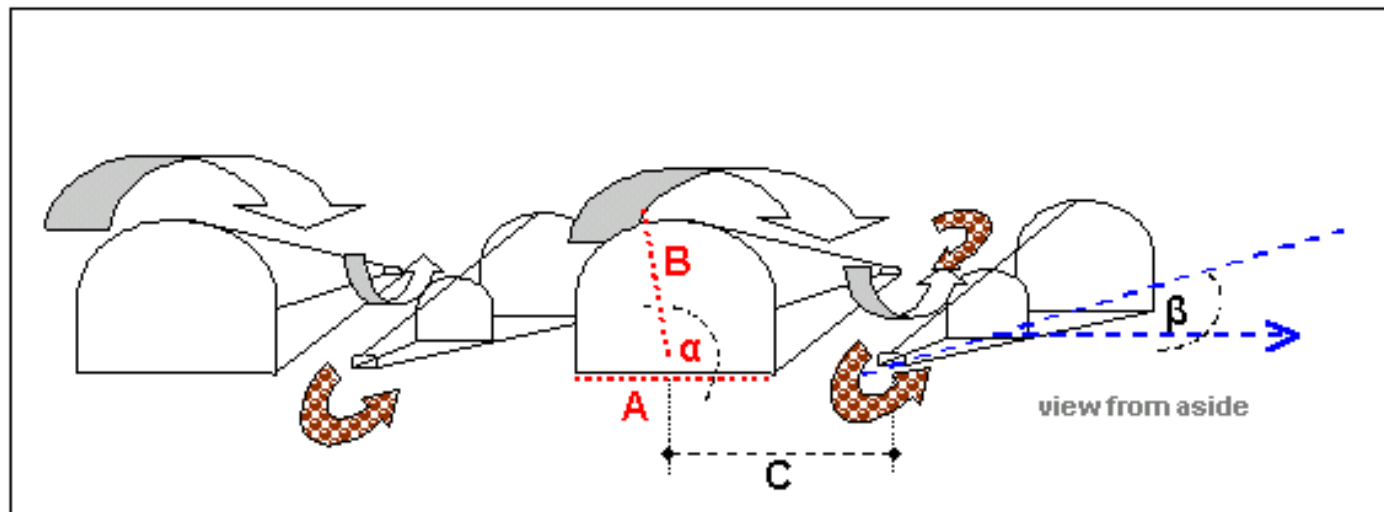


In the reservoir of a subsurface dam the water is stored between the sand grains. Natural sedimentation may produce 7% effective pore space only (figure, right). In theory spheres (brown) produce 47% of pore space (blue). Right: In nature uncontrolled sedimentation produces about 7% effective pore space. In practical sediment engineering, 15% to 32% of storativity can be gen-

erated and most of it be used. In theory, uniform sand fractions, i.e. sand grains of the same size, can produce a maximum water-bearing pore space of 47% (figure left).



In order to improve the storage capacity, in practical sediment engineering the river floods are geared to flush the sands over a set of specially designed hydraulic weirs in the intake channel upstream of the mouth of the reservoir (see figure).

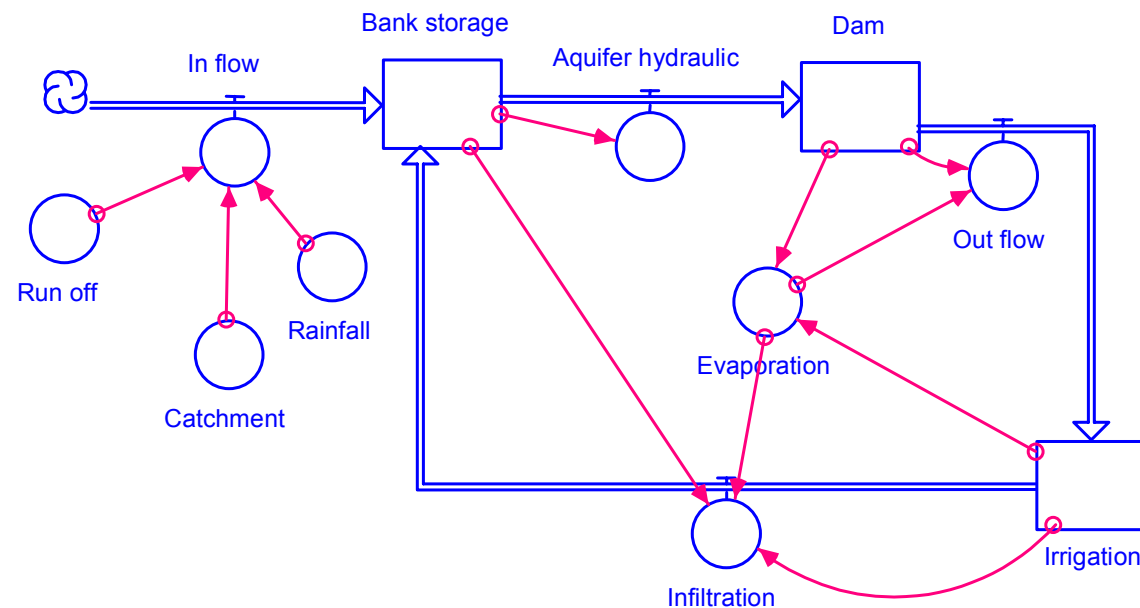


The wedges force the sand to meander. Coarser sand grains tend to remain at the bottom of the channel, while small grains are lighter and are lifted over the wedges. This mechanism forces the sediments to settle in layers and pockets of different grain size. In order to achieve optimum results, parameters such as tilt (A/B), profile (α), width (C), and lining (β) must be adapted to the fractals and hydrology of the river regimen.

The design of the wedges is different for each individual catchment area. The data to be computerized consists of the flood routing, and the satellite data on the fractal distribution of the river regimen, the geology and the hydrology of the catchment basin. The design of the weirs represents the major engineering input. In practical application, the profiles of the weirs are delivered in sets of arc-shaped PVC rulers which vary in arc-radius according to their position. The PVC-rulers are used to fabricate moulds, and those in turn to shape the concrete weirs. The sets of PVC rulers are shipped in boxes of 10 kg.

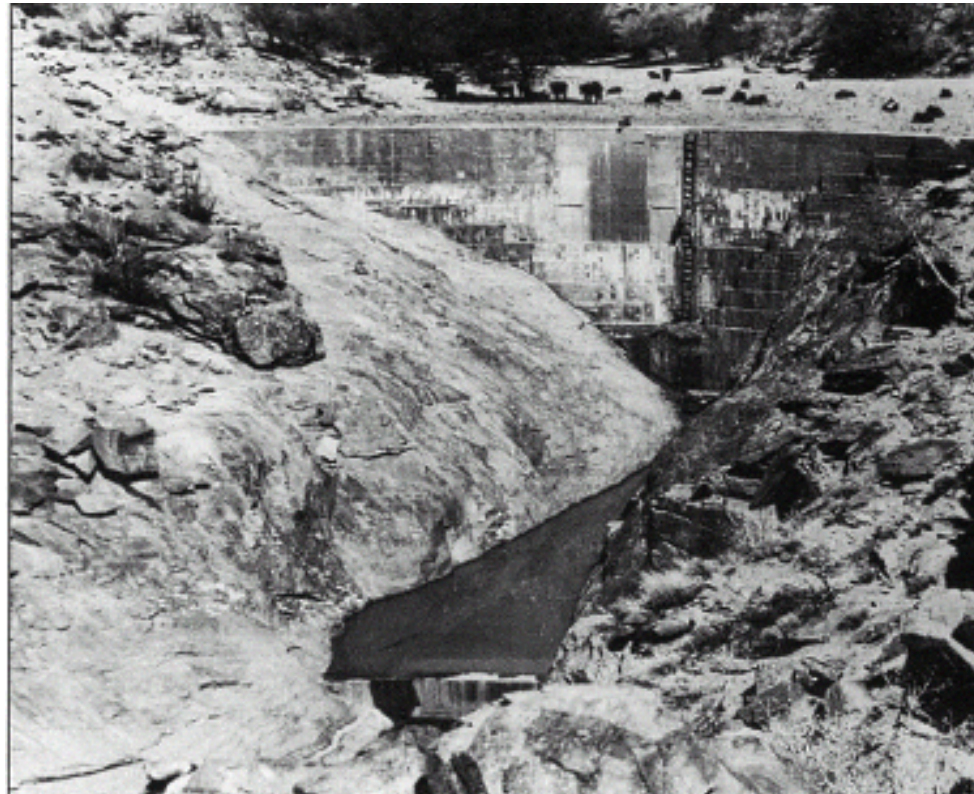
Environmental Impact on the Water Balance

Subsurface dams retard and infiltrate considerable amounts of flood water in ephemeral rivers, and thus reduce the evaporation. The water regained by avoiding such evaporation is an additional surplus. The ecological effect of reducing the evaporation from dams can be measured in practice, but also computed by means of a dynamic model (see figure below). Water losses by evaporation reduce to at least 40% compared to that in open surface dams.



Reference Projects

The largest subsurface dam ever built was constructed by the Department of Water Affairs in the Hoanib River (Khovarib Schlucht) in Namibia in 1956 (figure). Large commercial subsurface dams are built in Japan where they serve as reservoirs in agro-projects. They are mainly constructed in deep sediment river deposits trenched by diaphragm walls or sheet piles to hold the sub-flow of the river.



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Internet links on the subject:

[Construction of Subsurface dams :](#)

http://www.seidl-partner.de/fuer_Internet_Wasserbau/English/Seidl_Partner_New_Design_of_Subsurface_Dams.PDF

[Seidl & Partner-Namibia \(Pty\) Ltd](#) : http://www.who-magazine.com/english/3-01-text_08.html

[Water balance of Subsurface dams](#): <http://www.wb.bv.tum.de/rcc/proceedings.pdf>

[basic technology](#): <http://www.unu.edu/unupress/unupbooks/uu02fe/uu02fe0c.htm>

[Subsurface dams](#): <http://www.oas.org/usde/publications/Unit/oea59e/ch34.htm>

[PIK](#) : <http://www.pik-potsdam.de/>

[Forrester Modelling](#) : <http://www.consecol.org/Journal/vol3/iss2/art4/>

[Subsurface dams in the U.A.E.](#): <http://www.ijjnet.or.jp/mindeco/images/uaesmall.gif>

Additional links to "subsurface dam":

http://www.dorcas.net/main_topic.php?topic=133&menuitem=34

http://www.nww.usace.army.mil/planning/er/studies/WWRBASIN/RECONRPT/appendix/a1_05.htm

<http://waterquality.bio.wku.edu/program.htm>

<http://www.rodaleinstitute.org/education/regenerative/workshop/implement.html>

<http://www.cs.fit.edu/~dclay/art7/TofC.htm>

http://www.dhisoftware.com/uc2001/Abstracts_Proceedigs/Papers01/075/DHI%20Conf2001.htm

<http://www.ce.metu.edu.tr/~ce464/docs/464part5.doc>

<http://www.ceres.dti.ne.jp/~kazukouy/ns108/articles08b.html>

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