2. What is a subsurface dam?

2-1 Concept and principle of a subsurface dam

A subsurface dam is a system to store groundwater by a “cut-off wall” (dam body) set up across a groundwater channel.

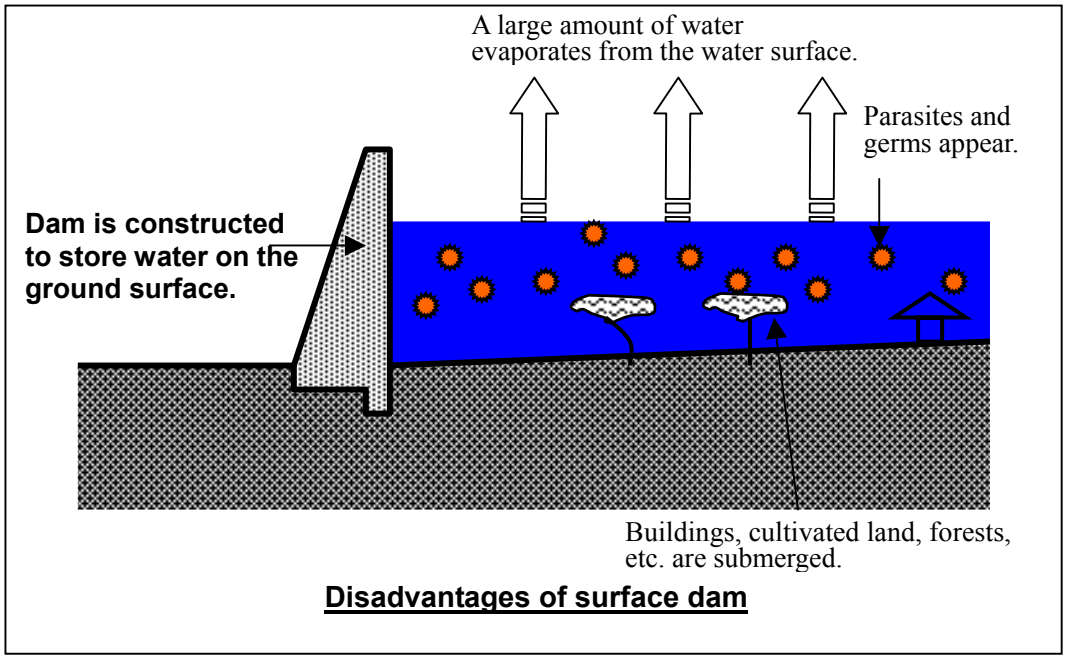
It is similar to a "surface dam" in its function of water storage by a dam body, but is different in the following areas:

(1) A system to store groundwater
In contrast with a surface dam that stores surface water (river water), a subsurface dam stores groundwater. In general, it stores shallow ground water because a subsurface dam to store deep groundwater needs huge-scale construction.

(2) Storage in geological strata
Groundwater is stored in geological strata. In other words, a subsurface dam is a system that artificially recharges natural aquifers.

(3) A dam constructed under ground
To store groundwater, a dam is constructed under ground. However, in the case of a dam to store very shallow groundwater like underflow in the current river sediment, part of the dam is sometimes exposed above the ground surface.

(4) Necessity for water-pumping facilities
The reserved groundwater level is lower than the ground surface because the dam is constructed under ground. Therefore, for using the reserved water, water-pumping facilities are essential.



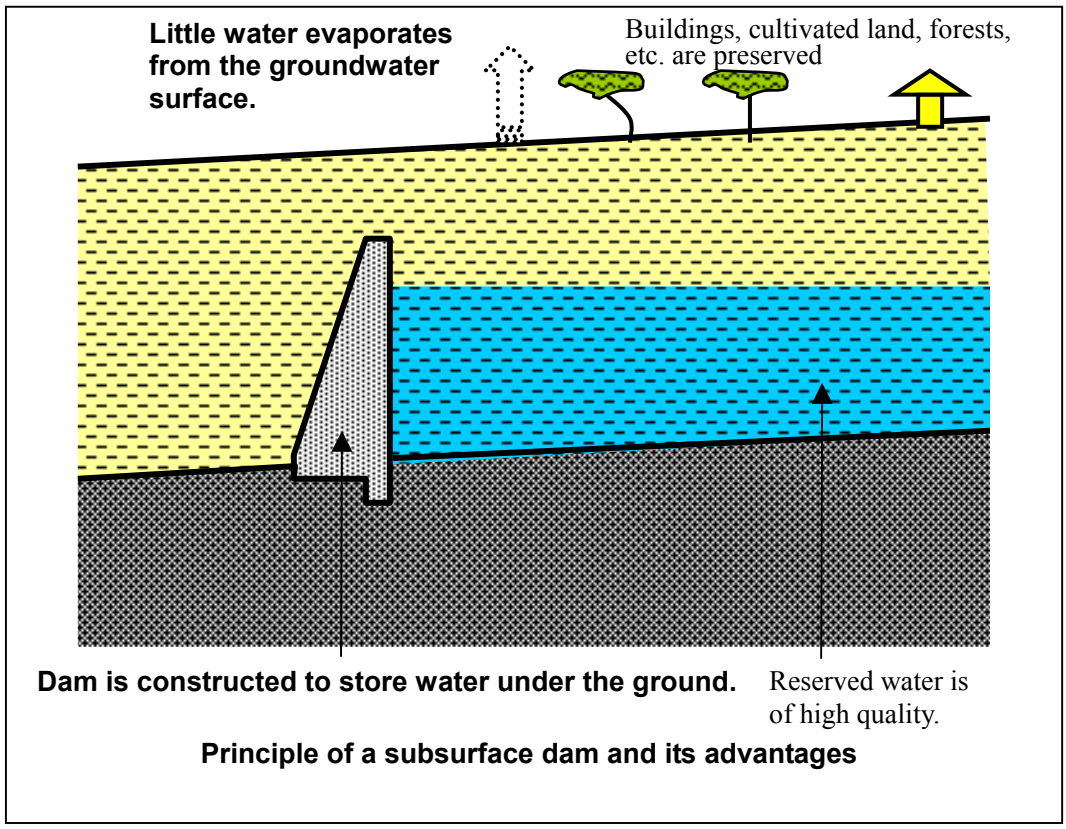


Fig. 2.1: Principle of a subsurface dam

2-2 Advantages of a subsurface dam

Compared with a surface dam, a subsurface dam has the following advantages:

(1) A water storage system without land submergence
A subsurface dam does not submerge land area in contrast with a surface dam because it stores water under ground. Therefore, it does not seriously damage the environment, nor does it cause social problems such as the forced migration of the local people.

(2) Prevention of evaporation of reserved water
A subsurface dam does not lose reserved water by evaporation because water is stored under ground and there is very little evaporation, in contrast with a surface dam that often loses a significant amount of reserved water due to evaporation in the dry season in arid or semi-arid areas.

(3) Clean, safe water
Reserved water using a subsurface dam is of fairly good quality because it is stored under ground, and it can be used like ordinary well water, in contrast with reserved water using a surface dam that tends to proliferate parasites, anopheles that transmit malaria, and germs, and requires purification for domestic use.

(4) A stable, secure dam
In general, a subsurface dam is more stable than a surface dam from the viewpoint of dynamics because it is buried under ground, and thus does not need maintenance. Even if it breaks, there is no damage to the downstream area because the breakage occurs under ground.

(5) Utilization of renewable resources
Shallow groundwater consumed via a subsurface dam system is renewable because it is recharged with rainfall. Therefore, a subsurface dam does not exhaust water resources.

2-3 Disadvantages of a subsurface dam

However, it is necessary to note that a subsurface dam also has the following disadvantages:

(1) Difficulties in site selection
Contrary to a surface dam whose site conditions can be examined by visual inspection, surveys for site selection and calculating the water storage capacity of a subsurface dam rely on estimates of underground geological structures.

(2) Low effectiveness of water storage
In case of a subsurface dam, water is stored in the pores of geological strata. Therefore, the volume of reserved water is determined by the volume of those pores (effective porosity), and reaches only 10 to 30% of the volume of the reservoir layer.

(3) Interception of downstream groundwater flow
A subsurface dam may prevent downstream groundwater flow, and exhausts groundwater in the downstream area. However, groundwater in the downstream area is not always recharged only with groundwater from the dam site area. It is also possible to design a dam with a structure that allows some of the reserved water to drain. Therefore, this problem can be avoided by appropriate site selection that considers the mechanism of groundwater flow, or

by adopting an appropriate dam structure.

In this project, this problem was solved by selecting the dam site at a point near the confluence of the Kolongo River into a larger river.

(4) Salinization in reservoir area

The subsurface dam is likely to cause accumulation of salt on the ground surface in the reservoir area due to the rise of reserved groundwater to the surface by evaporation. However, this phenomenon occurs only when the highest groundwater level is close to the ground surface. It is thus possible to avoid this problem by setting the highest level of reserved groundwater at a sufficient depth below the ground surface.

In this project, the highest level of reserved groundwater (the depth of the crest of the dam) was thus set at 3 m below the ground surface.

2-4 Requirements for a subsurface dam site

The physical conditions (hydrogeological conditions) required for the site are as follows:

(1) Presence of shallow groundwater with high fluidity

There must be groundwater at the dam site. This groundwater must have high fluidity as well, because reserved water using a “cut-off wall” set up across stagnant water cannot increase.

In addition, it is desirable that this groundwater exists at a shallow depth because, if the groundwater aquifer exists at a deeper depth, determining the hydrogeological characteristics of the dam site would be more difficult, and the cost and technical difficulties of the construction of the subsurface dam would be much greater.

(2) Presence of a porous layer (aquifer) for water storage

The higher the volume of pores (effective porosity) of the geological strata that form the reservoir layer, the more effective the water storage. This is because water is stored in the geological strata. High effective porosity is necessary also for high water fluidity.

(3) Presence of the surrounding basement rock with low permeability

The sides and the bed of the reservoir must consist of basement rock with low permeability. If there are big water bypaths, the dam cannot store water effectively.

(4) Presence of a gorge of basement rock with low permeability

To construct a subsurface dam effectively, it is desirable to set up the dam at a bottleneck point, where basement rock with low permeability make a gorge with a vast aquifer upstream, as in the case of a surface dam.

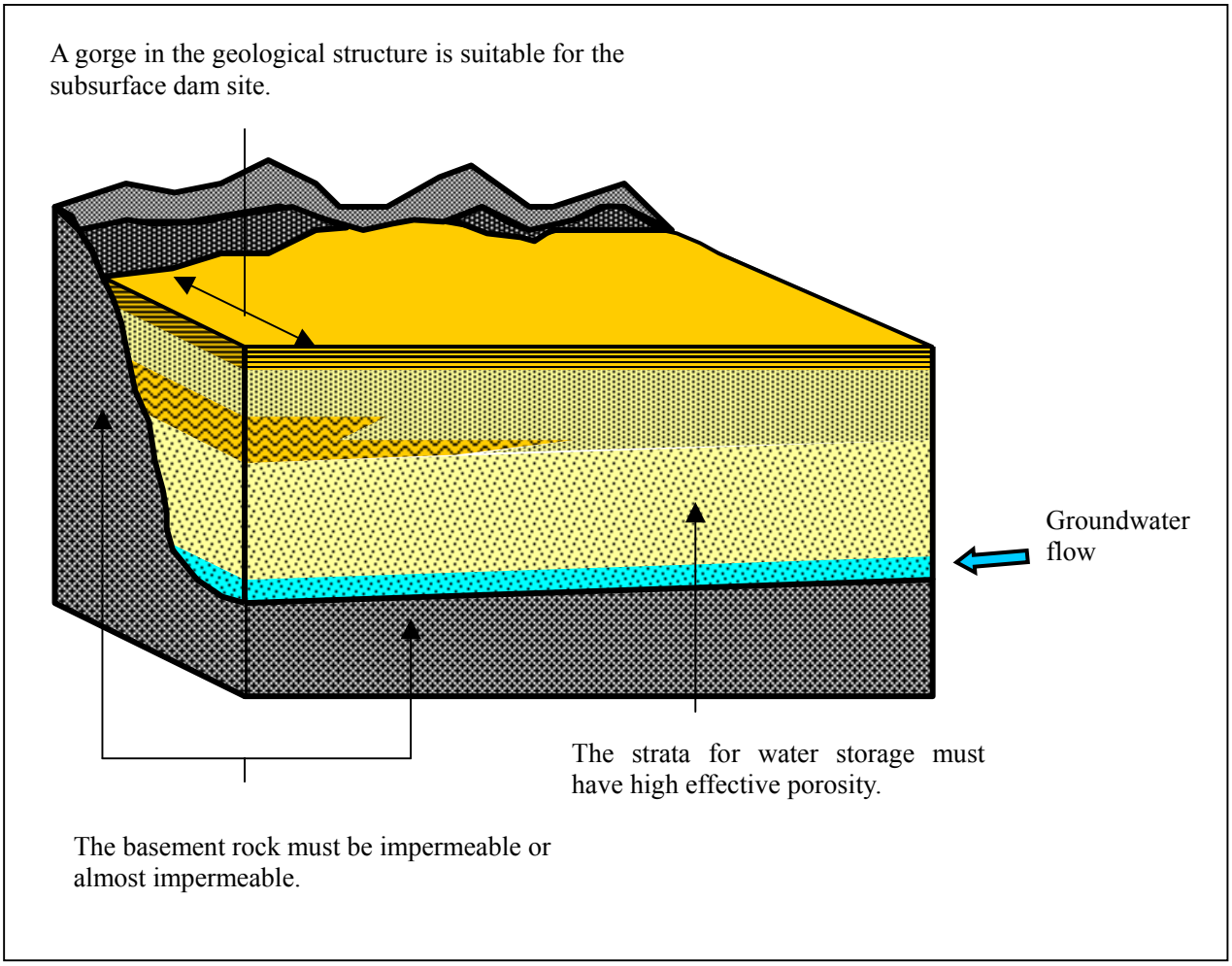


Fig. 2.2: Requirements for a subsurface dam site

2-5 "Fossil valley", a suitable site for a subsurface dam

(1) What is a "fossil valley"?
A "fossil valley" is a geomorphological and geological structure that meets the requirements described above. It is formed by erosion by an old river and subsequently covered by new sediment. It is also known as a "buried valley".

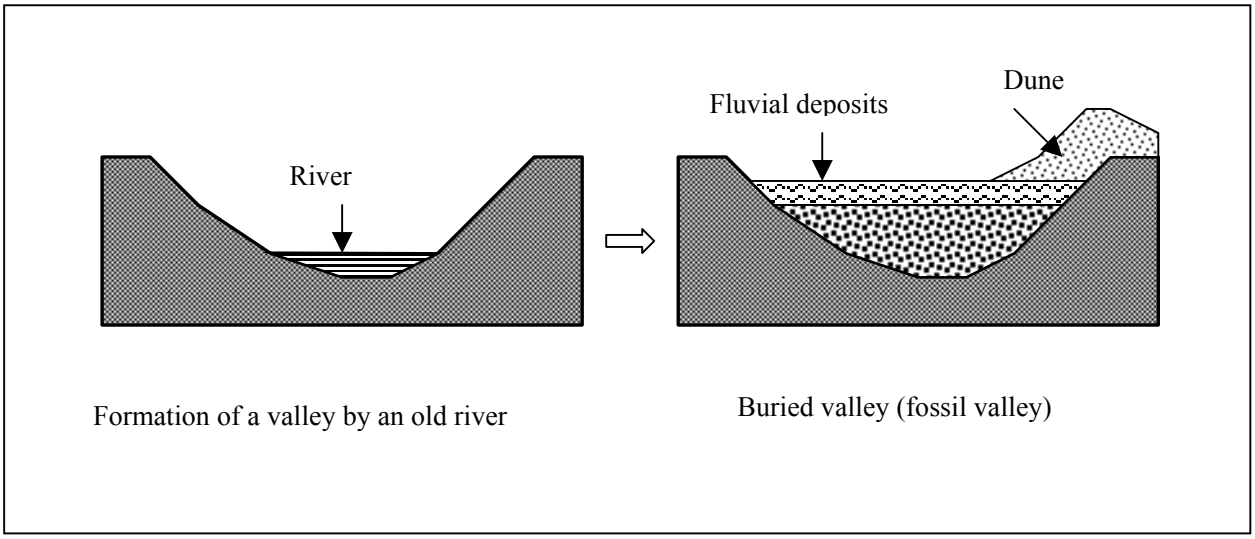


Fig. 2.3: Schematic diagram of a "fossil valley"

(2) Characteristics of a "fossil valley"
A fossil valley is generally regarded as having the following characteristics suitable for a subsurface dam.

1) As a “fossil valley” is an old buried river (valley), it is likely to preserve the drainage system of the old river as shallow groundwater flow in stable regions that have not experienced crustal movement in recent geologic ages. In addition, it probably does not have irregular "water bypaths".

2) In the case of a “fossil valley” formed by the erosion of basement rock, its sides and bed are impermeable, and there is less risk of water leakage from the reservoir layer.

3) The "fossil valley sediment" that buries the “fossil valley” is composed of deposits from recent geologic ages such as fluvial deposits or sand originating from dunes. This porous, unconsolidated sediment is favorable for the reservoir layer of a subsurface dam.