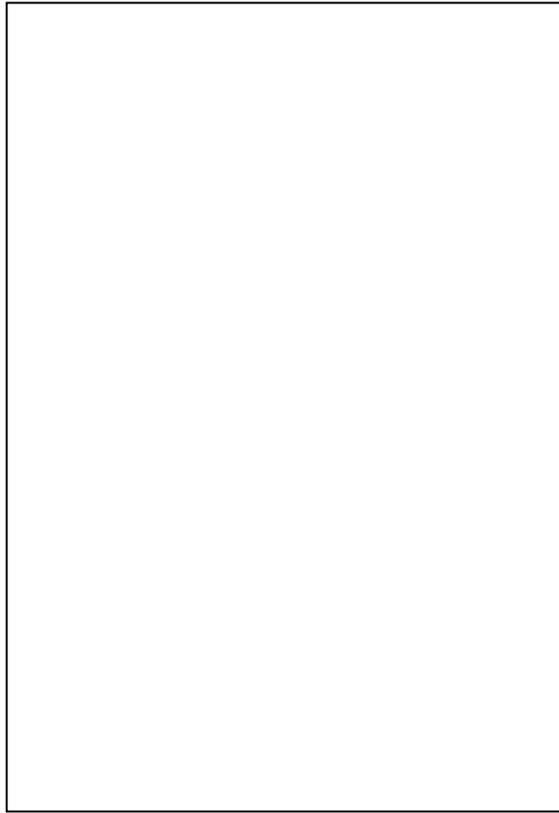
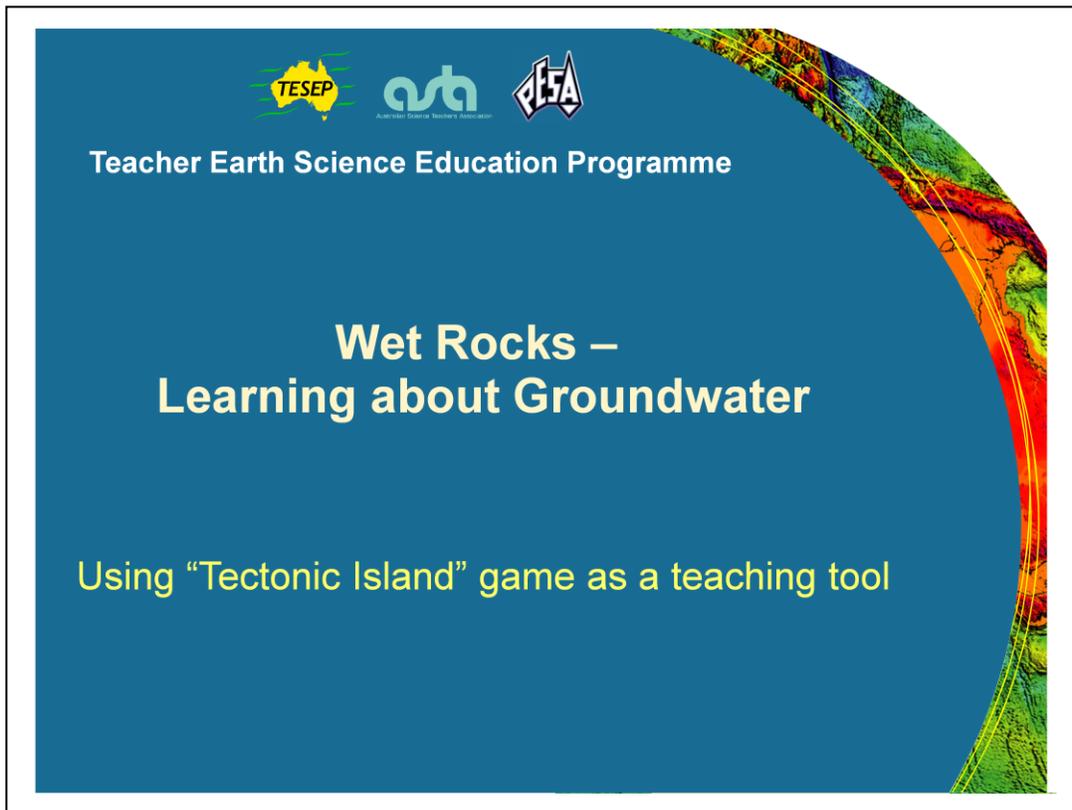


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This talk discusses how to use the “tectonic island” game as an aid to teaching some basic groundwater principles.

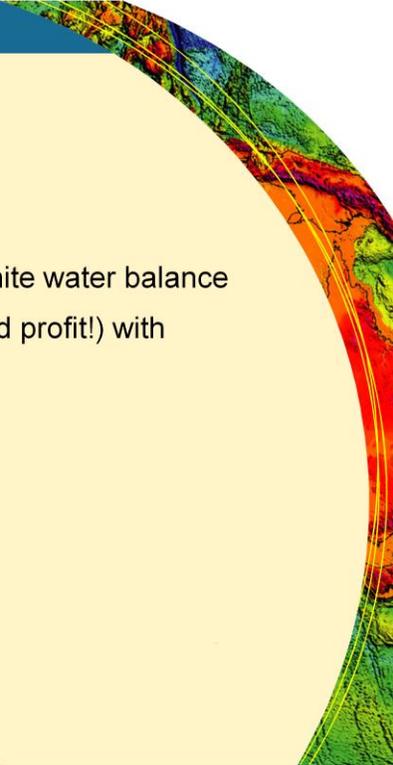
Prepared by Chris McAuley, Principal Hydrogeologist, Department of Sustainability and Environment, Victoria.

Support figures sourced from:

- Lectures given by Chris McAuley
- Referenced sources

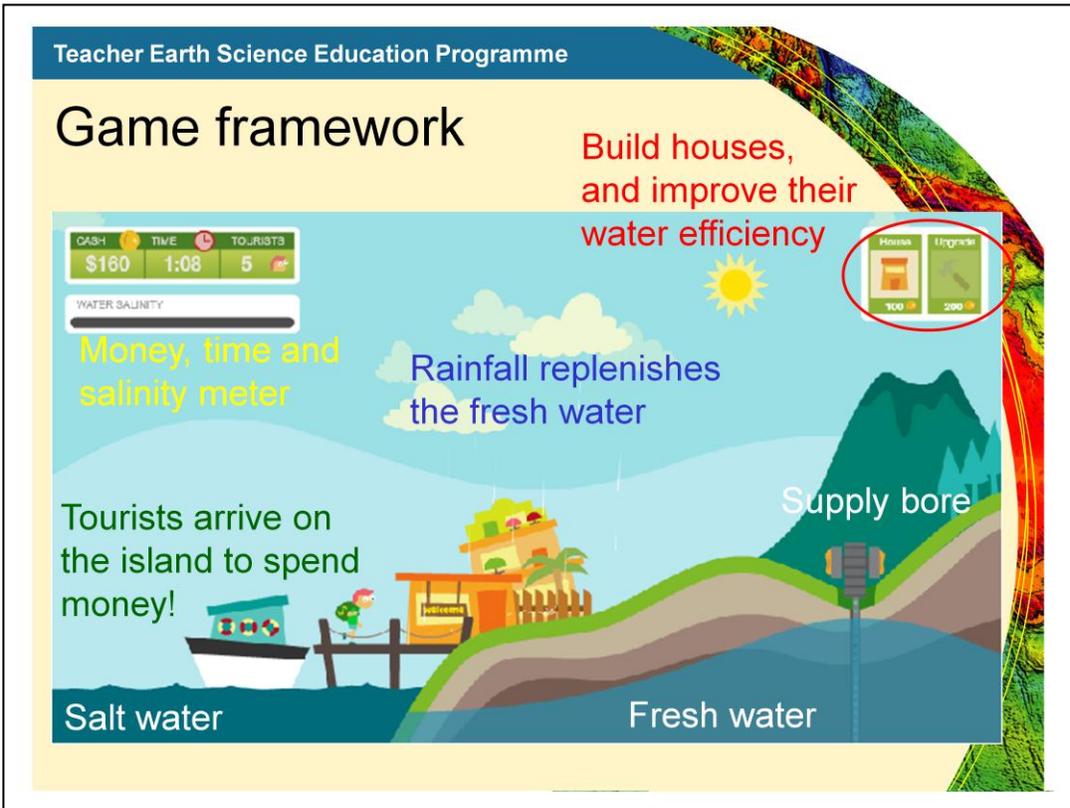
## Tectonic Island – a water balance game

- Key concepts:
  - A tropical coral or sand island has a finite water balance
  - You need to balance development (and profit!) with maintaining your water supply

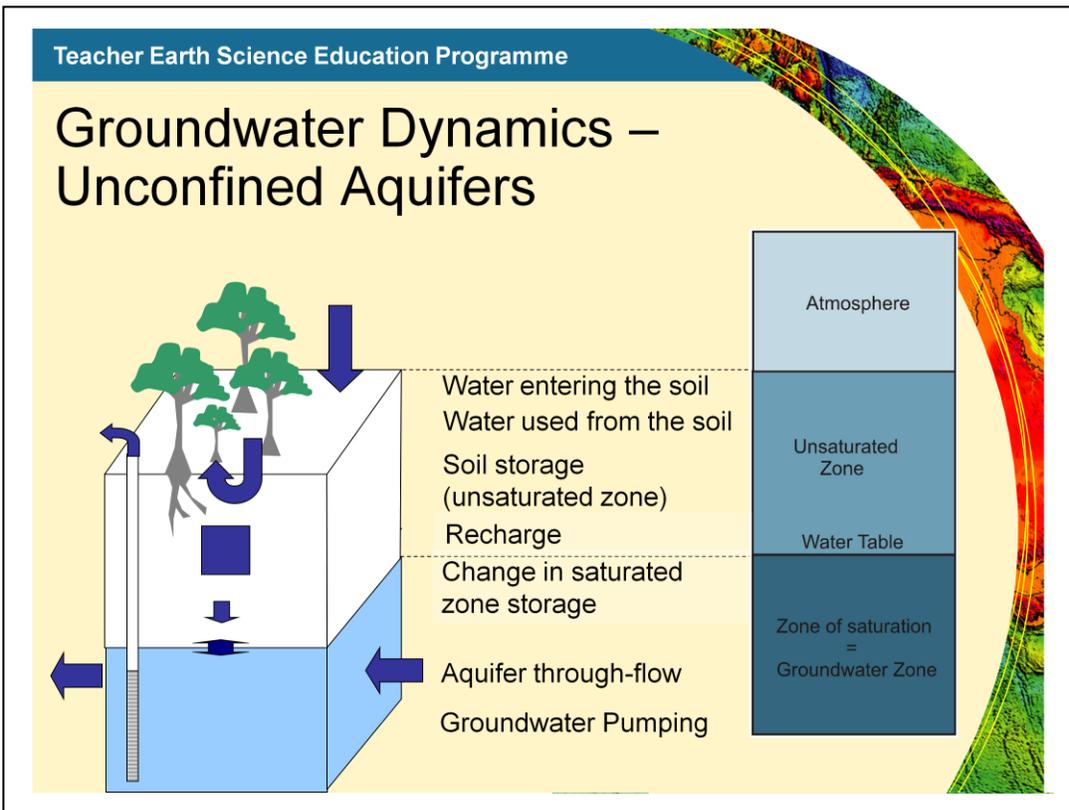


In order to assist in teaching about groundwater, a series of games have been developed that each have a basic groundwater concept.

Tectonic island represents a tropical island. Tropical islands have a relatively simple water balance relationship. Rainfall on the island drains into the sandy soils (recharge), forming a fresh water “lens” surrounded by salty sea water. This lens of fresh water supports the vegetation and populations of the islands. If the fresh water is used up, the salt water comes in and the water can no longer be used.



This is the basic layout of the game. The challenge is to manage development of the island for tourism whilst maintaining suitable water quality!

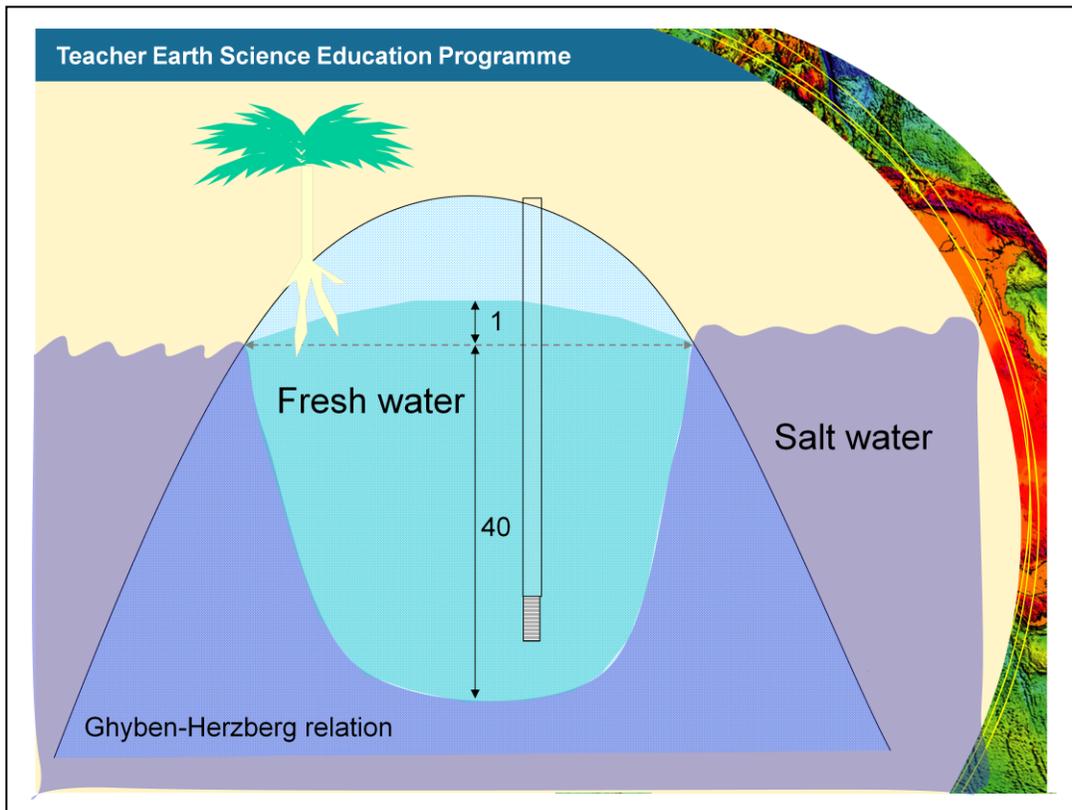


This diagram shows the component parts of the water cycle as they apply to groundwater. Each part of the process will be discussed further.

For a tropical island, effectively the picture is much simpler. There is little storage in the unsaturated zone and, at an island scale, the “through-flow” is of salty water, so affects use. Vegetation is primarily using water directly from the watertable. It is more like a “tank” that fills and empties over the wet / dry cycle.

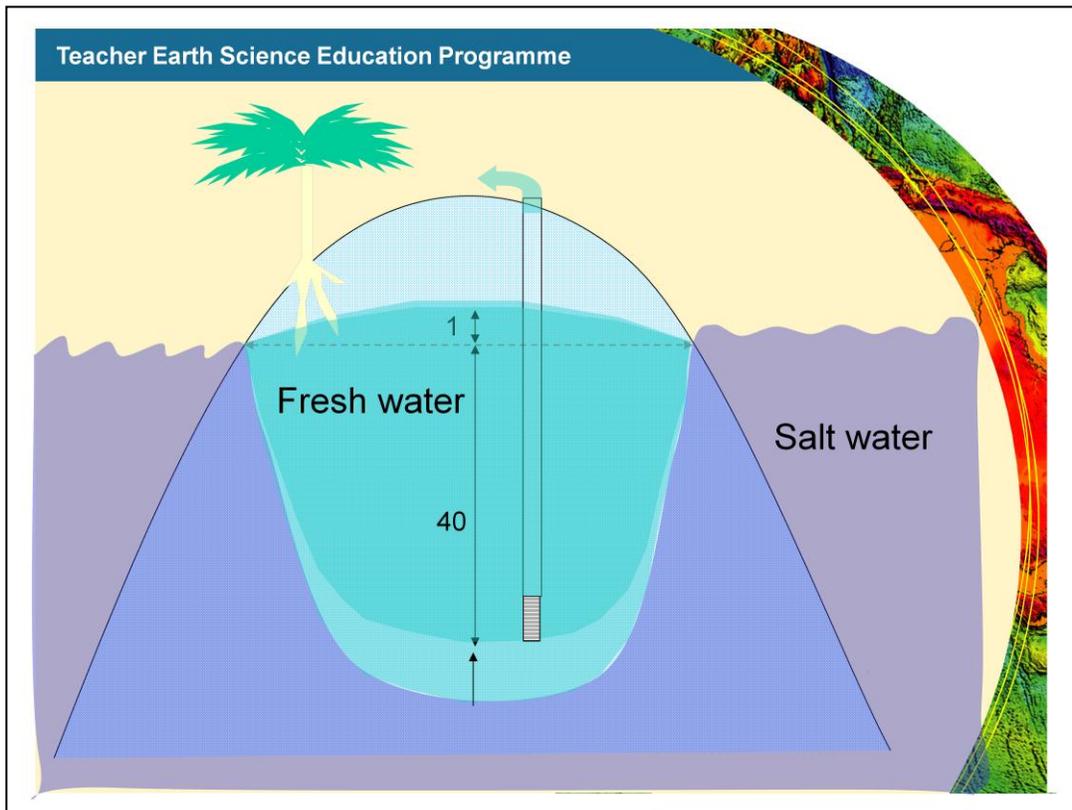
This is a simple representation of a volume cut through the ground. It captures the main processes that pass water into the groundwater and then flow through it. Much of groundwater management is based on trying to “balance” the various components of the water cycle.

From a groundwater perspective, one of the key components of the process is the volume of water that reaches the watertable to form groundwater. This is **recharge**. The amount of water that can pass through the unsaturated zone to the watertable to form recharge is a product of atmospheric processes (primarily rainfall), the amount that evaporates from the soil or is used by plants (collectively called evapo-transpiration) and how much water is stored in the soil profile as it moves through it.

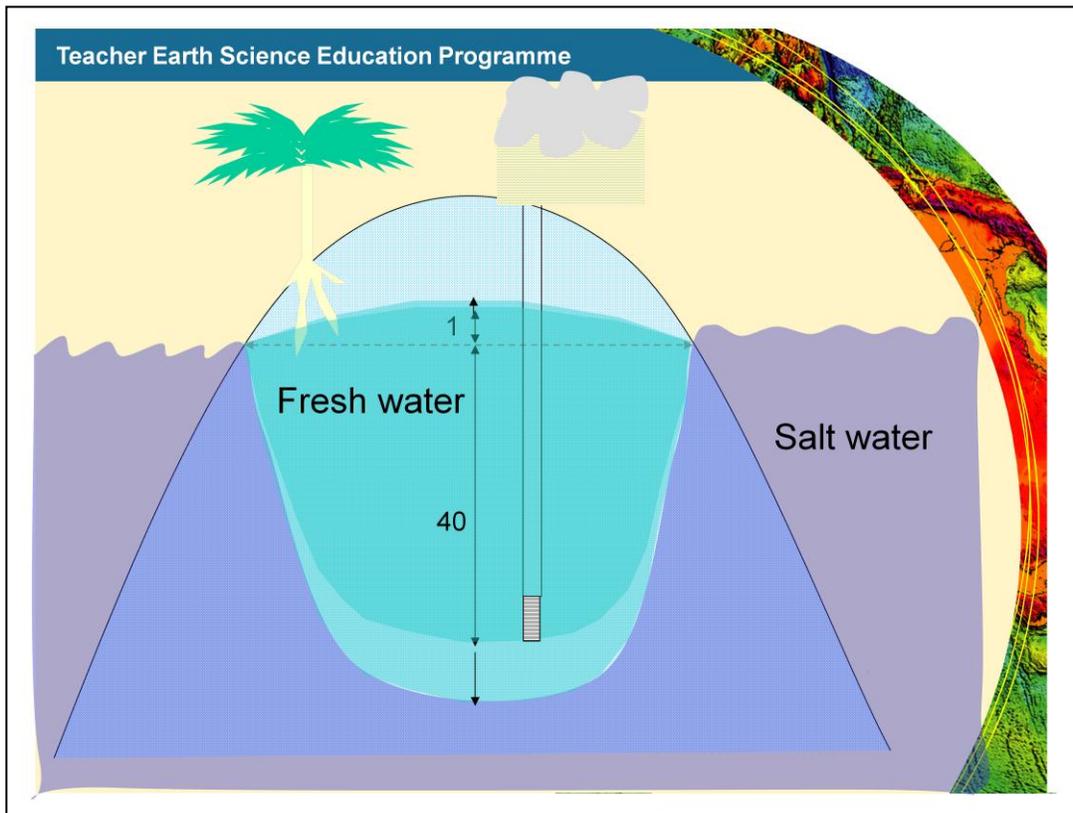


A relationship developed by W. Badon-Ghijben (1888, 1889) and A. Herzberg (1901) (the Ghyben-Herzberg relation) demonstrated that for every unit height of freshwater ABOVE sea level had a corresponding 40 units BELOW the watertable. So even for tropical islands that have a very low relief, it only takes a groundwater level of a metre or more above sea level to have a 40 metre depth of fresh water below the island.

This lens of fresh water supports the vegetation and the population of the island. It is sustained by direct rainfall. As the fresh water is used, it is replaced by salty water. Over an annual wet / dry cycle, water use must be balanced to ensure a sustainable supply is provided.



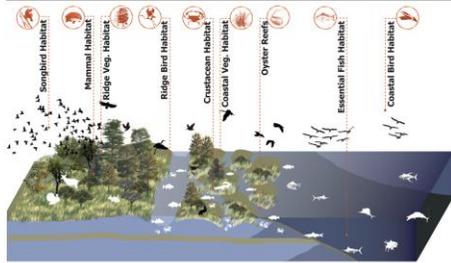
As the fresh water is pumped, the “head” or elevation of fresh water above sea level decreases, the underlying thickness of fresh water also reduces – all the time maintaining this 1:40 approximate relationship.



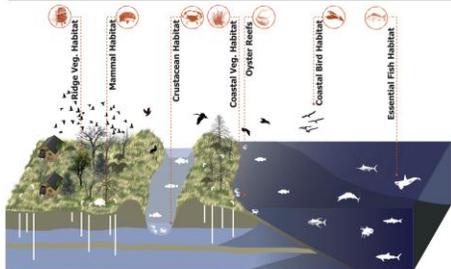
When it rains, the fresh water is replenished and “stored” beneath the island by displacing salty water.

# Teacher Earth Science Education Programme

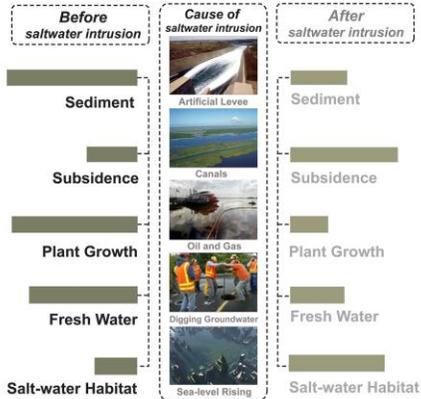
## Diversified Habitat Originally



## Diversified Habitat Loss



## Cause and Impact of Saltwater Intrusion



[http://en.wikipedia.org/wiki/File:Salt\\_water\\_intrusion\\_wikipedia4.png](http://en.wikipedia.org/wiki/File:Salt_water_intrusion_wikipedia4.png)

This is also called saline intrusion - although the contamination of fresh water by salty water can be caused by many different activities, and have many different impacts on the environment and on social values.

## Use in the class room

- Unstructured observation

10 to 15 minutes of "play", recording and or discussing observations at the conclusion.

Some observations may be:

- The faster the development, the faster the water goes salty  
Its really random – it just depends when it rains!  
Improved water efficiency helps keep the island going longer

Groundwater is a significant water resource. Although surface water is commonly thought of as the main supply of water for drinking, agriculture and the environment, in fact there is much more groundwater available. In some parts of the world, groundwater is the only reliable source of water.

Of the available groundwater, a significant proportion is suitable for drinking water. This far outstrips the available surface water.

## Use in the class room

- **Structured “games”**

What is the sustainable limit of development for the island?

Set up a sustainability concept – say use a 10 minute time period as your “sustainable” horizon (another activity is to use longer time periods – but this may be more a project than a class room activity).

Break the class up into groups to “evaluate” different development scenarios – 2, 4, 6, 8, 10 houses, with or without water efficient upgrades.

Run the game – at 10 minutes (or whatever you decide), get the students to report on which scenarios were still “running”, which had failed (and when) and how much money was made.

Collectively analyse the class information and determine what would be sustainable developments.

Note: It is a game – it is built with random functions, so there will be variation even between similar scenarios!

Groundwater is a significant water resource. Although surface water is commonly thought of as the main supply of water for drinking, agriculture and the environment, in fact there is much more groundwater available. In some parts of the world, groundwater is the only reliable source of water.

Of the available groundwater, a significant proportion is suitable for drinking water. This far outstrips the available surface water.

## Use in the class room

### Competitive “games”

Who can make the most money in 5 minutes!

Groundwater is a significant water resource. Although surface water is commonly thought of as the main supply of water for drinking, agriculture and the environment, in fact there is much more groundwater available. In some parts of the world, groundwater is the only reliable source of water.

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## Links to other topics

- Permeability and porosity  
Recharge  
Contamination (a really BIG issue on a tropical island) – things like septic tanks, sewerage run-off, chemicals for food growing (fertilizers, pesticides), petrol / fuel storage,

Groundwater is a significant water resource. Although surface water is commonly thought of as the main supply of water for drinking, agriculture and the environment, in fact there is much more groundwater available. In some parts of the world, groundwater is the only reliable source of water.

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