

The water cycle

The water cycle, or hydrologic cycle, describes the constant movement of water above, on and below the earth's surface. As water moves through the cycle, it can transport products that are in solid form (e.g. silt) or dissolved in the water (e.g. salt). Studying the water cycle enables us to understand issues such as flooding, soil erosion, salinity, environmental flows and water quality.

A water molecule may take days or millions of years to move through the water cycle, and it may change states from a liquid to a solid or gas (vapour) and vice versa, or go straight from a solid to a gas in a process called sublimation. The key water cycle processes are:

- evaporation and transpiration
- precipitation (rain, hail, sleet or snow)
- infiltration
- run-off
- groundwater recharge from deep drainage or streams
- groundwater discharge via springs, wetlands and baseflow.

Evaporation and transpiration

When water molecules absorb heat their energy level increases. If they have enough energy, they will escape the liquid phase and become a vapour. The energy required to do this comes mainly from the sun. Most water vapour in the atmosphere comes from the evaporation of the oceans. Water vapour is also produced by the evaporation of water from streams and the soil.

Plants also absorb water through their roots. This water moves throughout the plant and is returned to the atmosphere via the plants' leaves and branches in a process known as transpiration.

Precipitation

Water vapour rises into the earth's atmosphere where it cools and condenses back into a liquid state, forming droplets. When enough droplets form, they can be seen as clouds. The droplets can increase in size until they fall to the earth as precipitation in the form of rain, hail, sleet or snow.

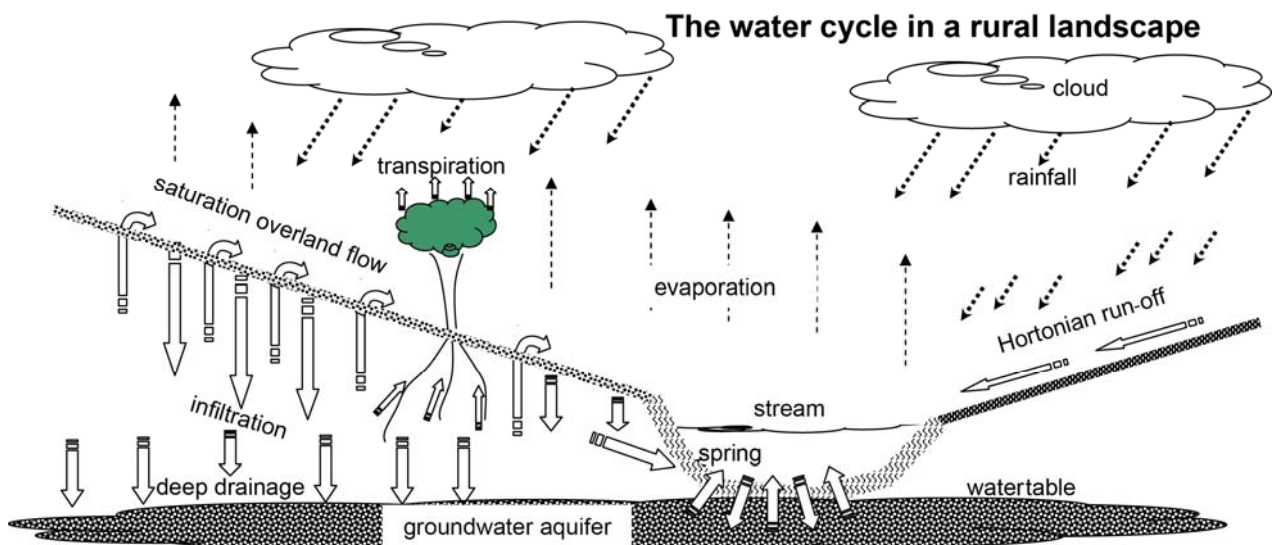
Rainfall has a major impact on the processes occurring in the water cycle. For example, in the arid regions of the state there will be much less run-off, infiltration and groundwater recharge compared to the wet tropics.

Infiltration and deep drainage

During rainfall events, water can infiltrate soil at a rate determined by the soil properties. Surface run-off can be slowed by the presence of mulch or good vegetative cover on the soil surface.

Well-aggregated loams and deep sands have higher infiltration capacity than clay soils or soils with compacted layers. The most restrictive layer will control the movement of water through the soil profile and waterlogging may occur when drainage is restricted. Deep drainage through the soil profile may find its way into aquifers, which store and transmit groundwater.

Water in saturated soils may also move in a lateral direction parallel to the land surface—in a process known as interflow—and eventually discharge to streams.



Run-off

Run-off may occur by one of the following processes:

- Hortonian (or infiltration excess) overland flow
- saturation excess overland flow.

Hortonian overland flow

Hortonian overland flow occurs when the rainfall rate exceeds the infiltration capacity of the soil or any other surface on which it falls. When raindrops fall on bare soils, they can break soils into tiny particles which form an effective seal restricting water entry. Raindrop impact is a major cause of soil erosion and the resulting run-off will be laden with sediment.

Hortonian flow is common in urban areas. Impervious surfaces such as roofs, paving and bitumen roads produce run-off even in a light shower of rain.

Saturation excess overland flow

Steady rain soaking into the soil will move downwards, gradually filling air spaces and leading to saturation. When the soil is saturated, no more water can be absorbed and so any rain that falls on the soil will run off. This form of run-off is known as saturation excess overland flow.

The amount of rain needed to create saturation excess overland flow will depend on the various soil types in a catchment and the wetness of the catchment from previous rainfalls. Following a dry period, rural landscapes may need substantial rainfall before saturation excess run-off occurs—and this may only happen a few times each year. Most floods in large catchments occur as a result of saturation excess overland flow.

Groundwater

The term aquifer is used for geologic materials that can store and transmit water. The sands and gravels of alluvial valleys, fractured rocks, and porous sedimentary rocks (e.g. the sandstones of the Great Artesian Basin) can all store water and act as aquifers.

Unconfined aquifers consist of permeable material underlain by impermeable rock or clay. They extend all the way to the ground surface. The upper boundary of an unconfined aquifer is defined by the extent of saturation, known as the 'watertable'. The watertable rises and falls as water drains into the aquifer (from deep drainage or 'losing' streams) and is removed from the aquifer via pumping or discharge to 'gaining' streams.

A confined aquifer is an aquifer that is both overlain and underlain by a confining layer such as clay.

Stream flows

Water returns to the ocean or an inland drainage system via the stream network of a catchment. This is a tree-like arrangement of drainage lines, creeks and rivers, steadily increasing in size. Water flowing in creeks and rivers can come from overland flow, interflow or baseflow.

Baseflow in a stream is the clear, long duration outflow of groundwater. It may come from spring flows from mountain aquifers or intercepted watertables in alluvial areas. If a stream is above the watertable, it is called a 'losing' stream and its flows may percolate into its bed and banks and recharge alluvial aquifers.

Flash floods in gullies and creeks rise and fall rapidly. Flood waters may take several days to flow downstream and cause major flooding. Rivers in the Channel Country of south-west Queensland may not flood until several weeks after heavy rain in the upper catchments.

Salinity

Salt dissolves in water and moves through the landscape as water moves through its cycle. All rainfall contains some salt, even in inland areas. Soil and weathered rock also contain salt.

The removal of deep-rooted native vegetation or excess irrigation of crops can cause the watertable to rise, mobilising salts in the soil zone. As the watertable rises close to the surface, the salt can be concentrated further as evaporation and transpiration remove water from the soil. Watertable rise caused by the removal of native vegetation is known as dryland salinity, while salinity caused by excess irrigation is known as irrigation salinity.

Dryland and irrigation salinity result in the loss of soil productivity, can cause crop damage and may adversely influence stream water quality.

Further information

The department's website <www.derm.qld.gov.au> contains student resources relating to the water cycle as well as the following fact sheets:

- C2— *Catchments and water quality*
- W155— *Raindrops to tap water—how rainfall contributes our water supply*
- W68— *The Great Artesian Basin*
- L109— *Deep drainage—a problem or an asset?*
- L40— *Soil limitations to water entry.*

March 2012
W49

#30075

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