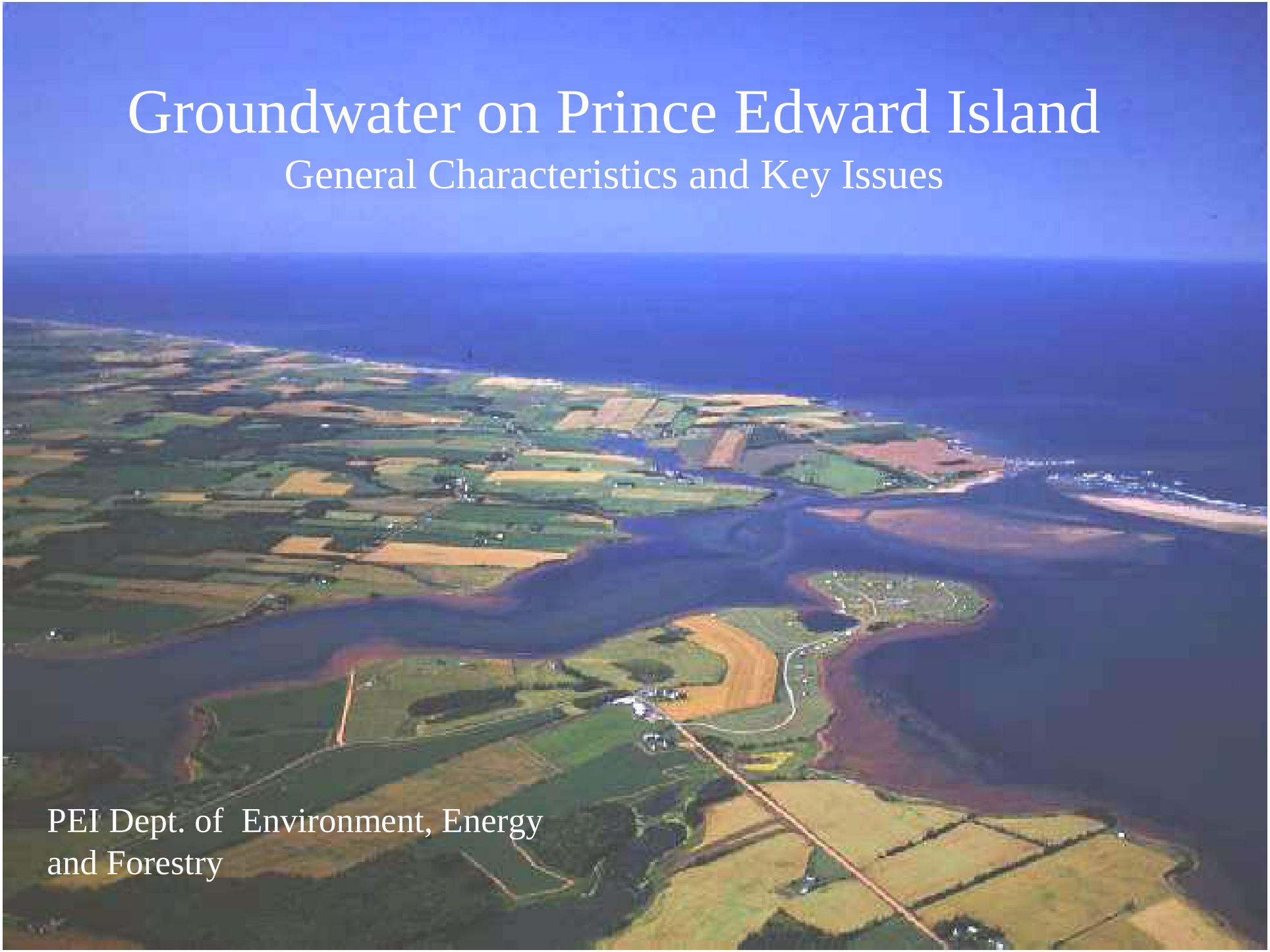
Groundwater on Prince Edward Island

General Characteristics and Key Issues

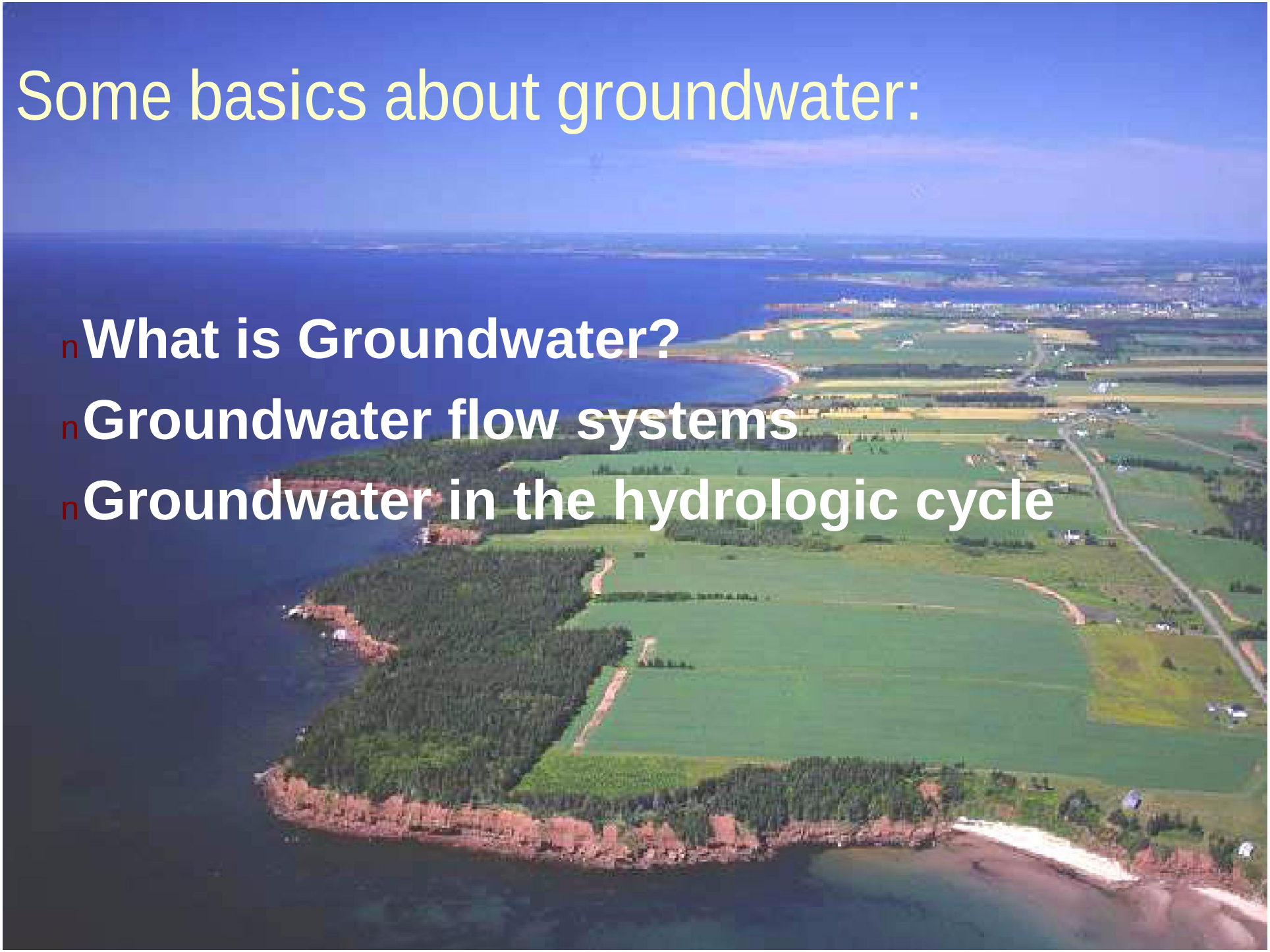


PEI Dept. of Environment, Energy and Forestry

Introduction:

- **Some “basics” about groundwater**
- **Some key groundwater issues**

Some basics about groundwater:

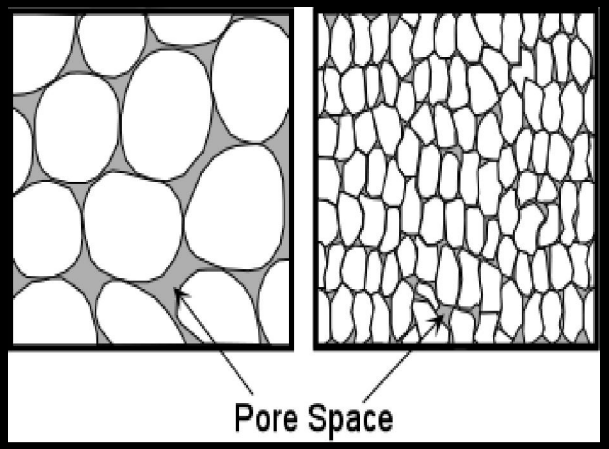


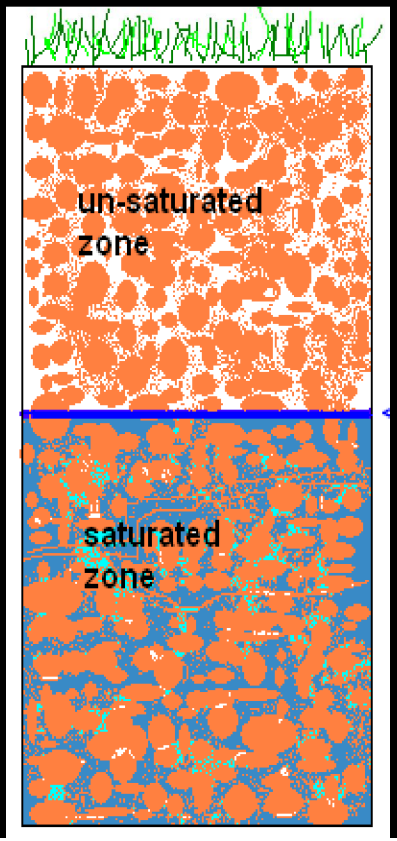
- **What is Groundwater?**
- **Groundwater flow systems**
- **Groundwater in the hydrologic cycle**

Groundwater: What is It?

- Groundwater is water stored in the ground in the tiny pore spaces in the soil and rock below us below the water table. When we pump water from a well, we are pumping groundwater.

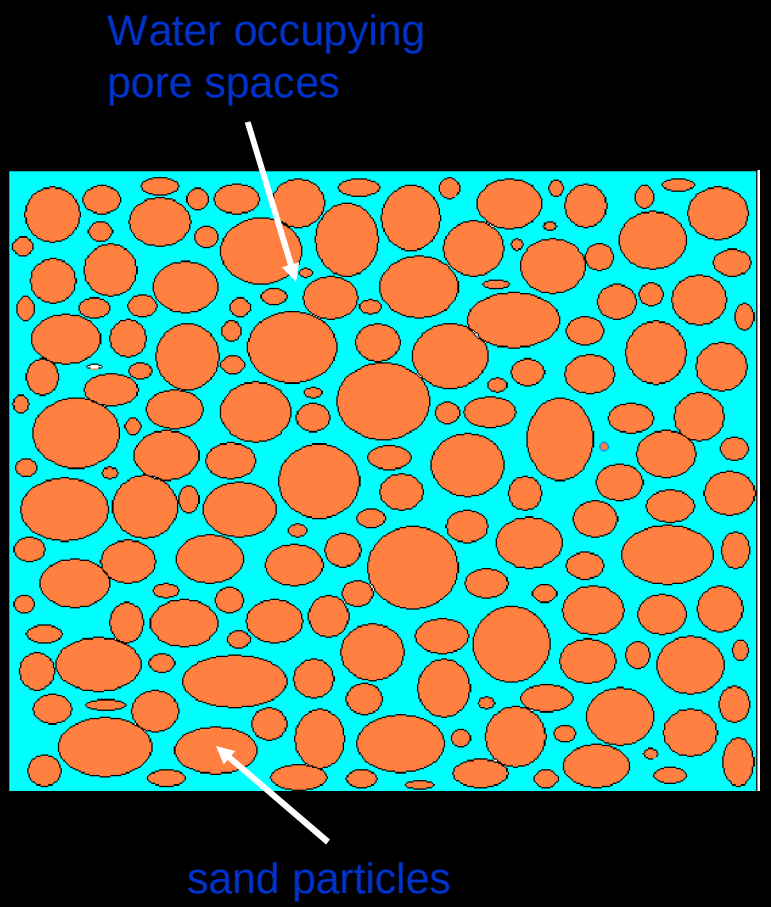
- The area below the ground surface can be divided into two zones:
  - Un-saturated zone where pore spaces and fractures in rocks and soil are partially filled with air, and partially filled with water.
  - Saturated zone where these void spaces are completely filled with water.
  - The "water table" is simply the boundary between the un-saturated zone and the saturated zone.
  - The geological formation containing this groundwater is called an "aquifer".





Aquifers: Reservoirs of Fresh Water

- Aquifers can store vast amounts of water. The aquifer underlying PEI is a good example.
- While the sandstone bedrock below us looks pretty solid, it is actually filled with many tiny *pore spaces* and fractures. The area occupied by these void spaces is referred to as *porosity.*



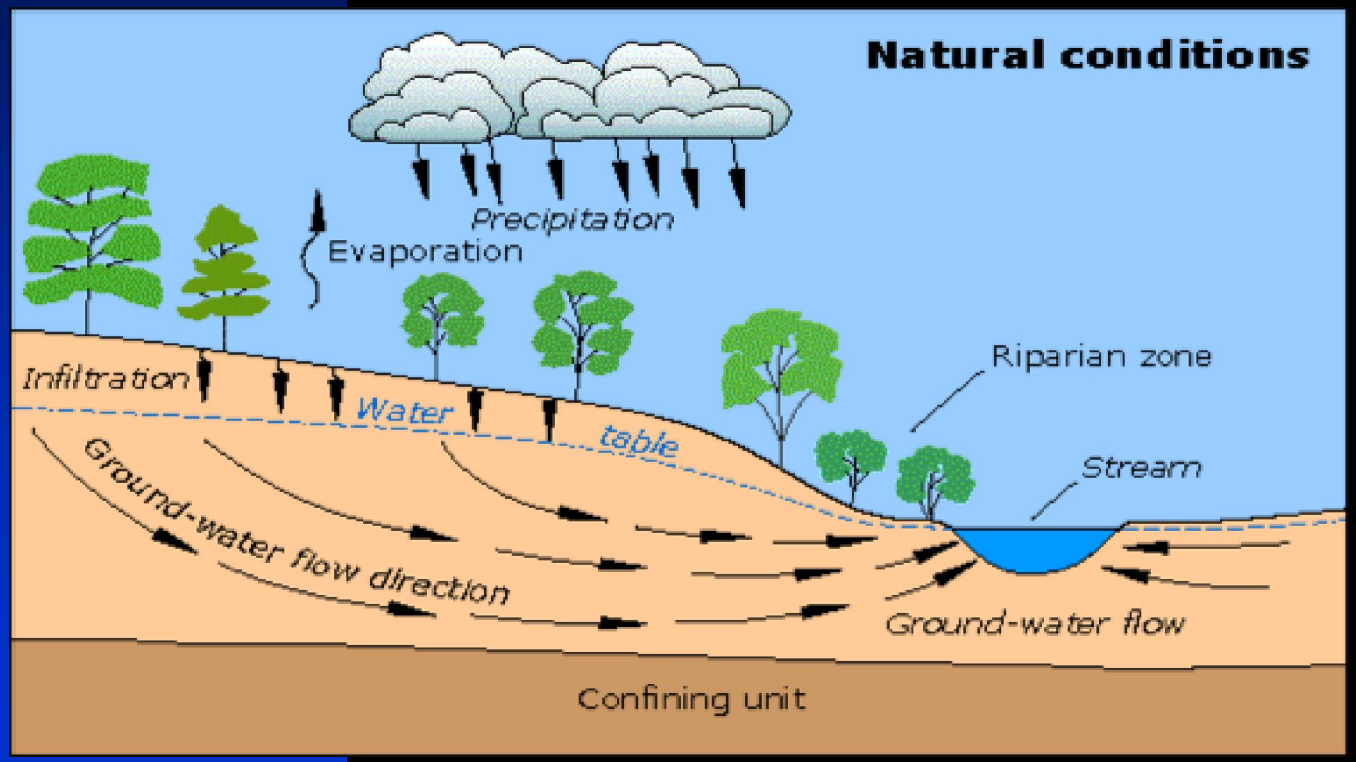
- On Prince Edward Island these spaces make up about 15% of the total volume of the rock, and we would say that the porosity of the rock is 15%.

Types of Aquifers:

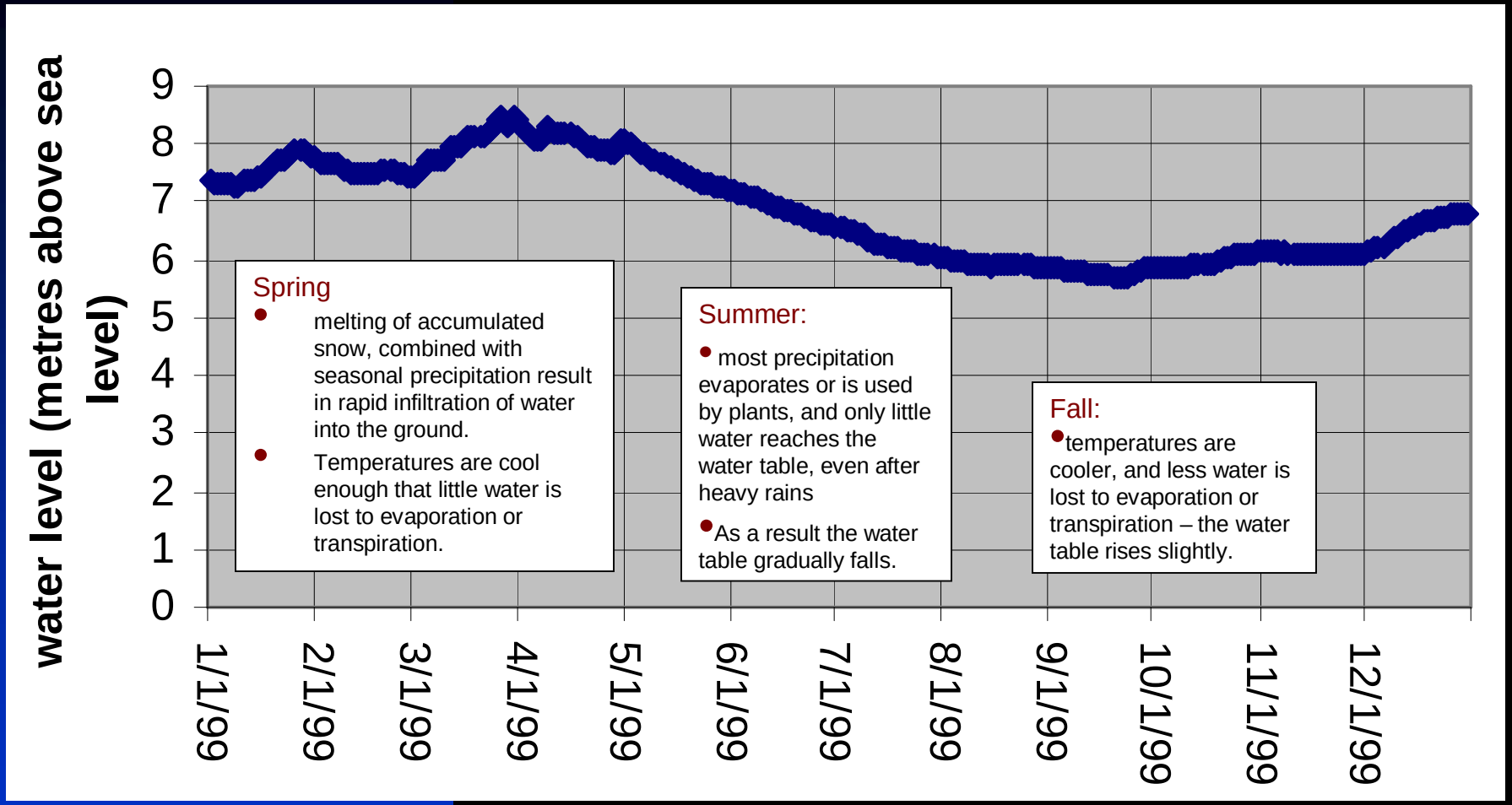
- Aquifers can be classified by their relationship with the surface or atmosphere:
  - Where there is a “free” exchange between the aquifer and the land surface it is referred to as an “unconfined aquifer”
  - Where the aquifer is separated from the surface by a zone of low permeability, it is referred to as a “confined aquifer”
  - The formation that separates a confined aquifer from the surface (or from other overlying or underlying aquifers) is called an aquitard or aquiclude, depending on how permeable it is.

Seasonal Trends in the Water Table

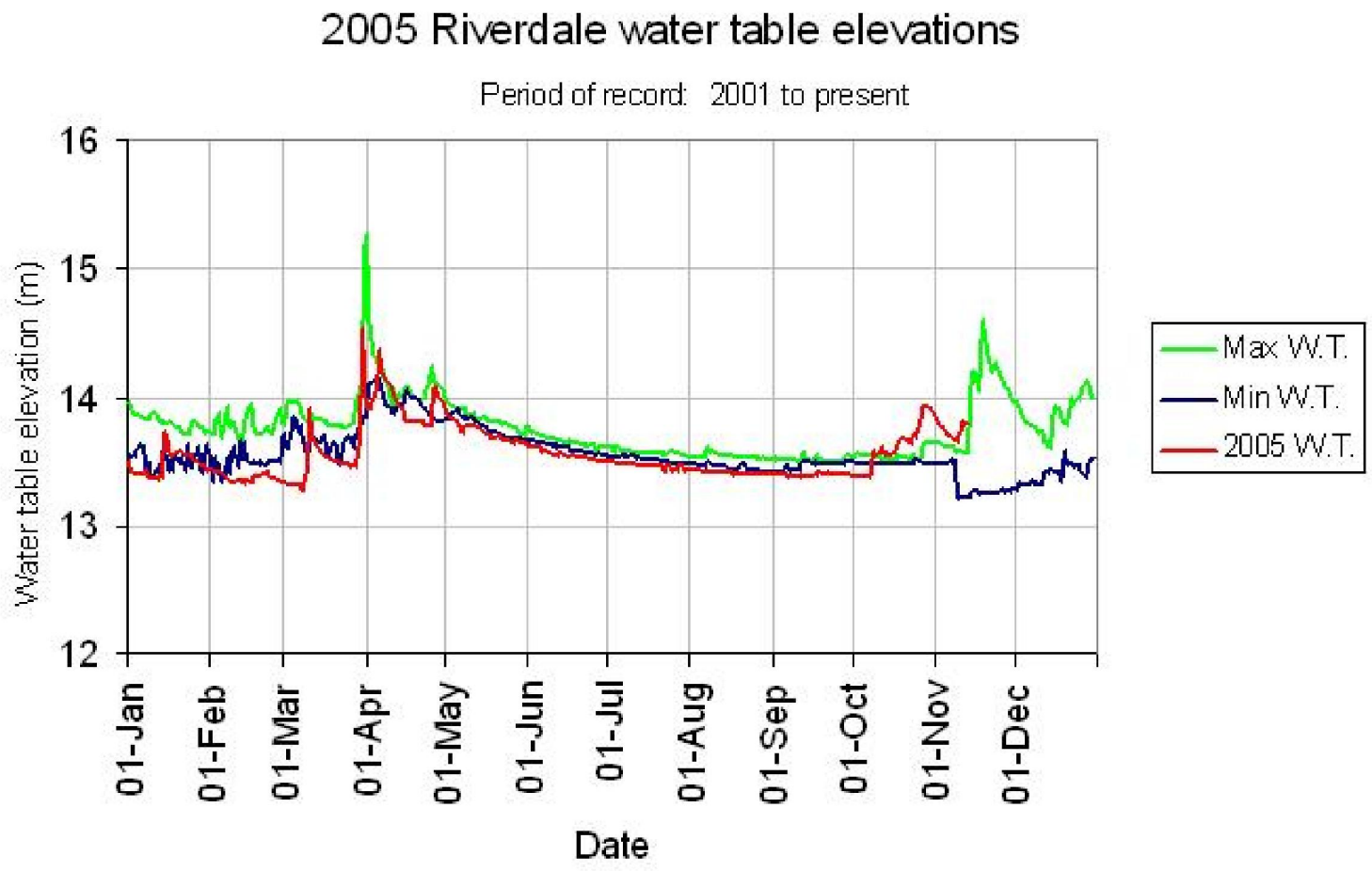
- The elevation of the water table rises and falls throughout the year depending on the *relative* rate at which groundwater is *recharged* and *discharged*.



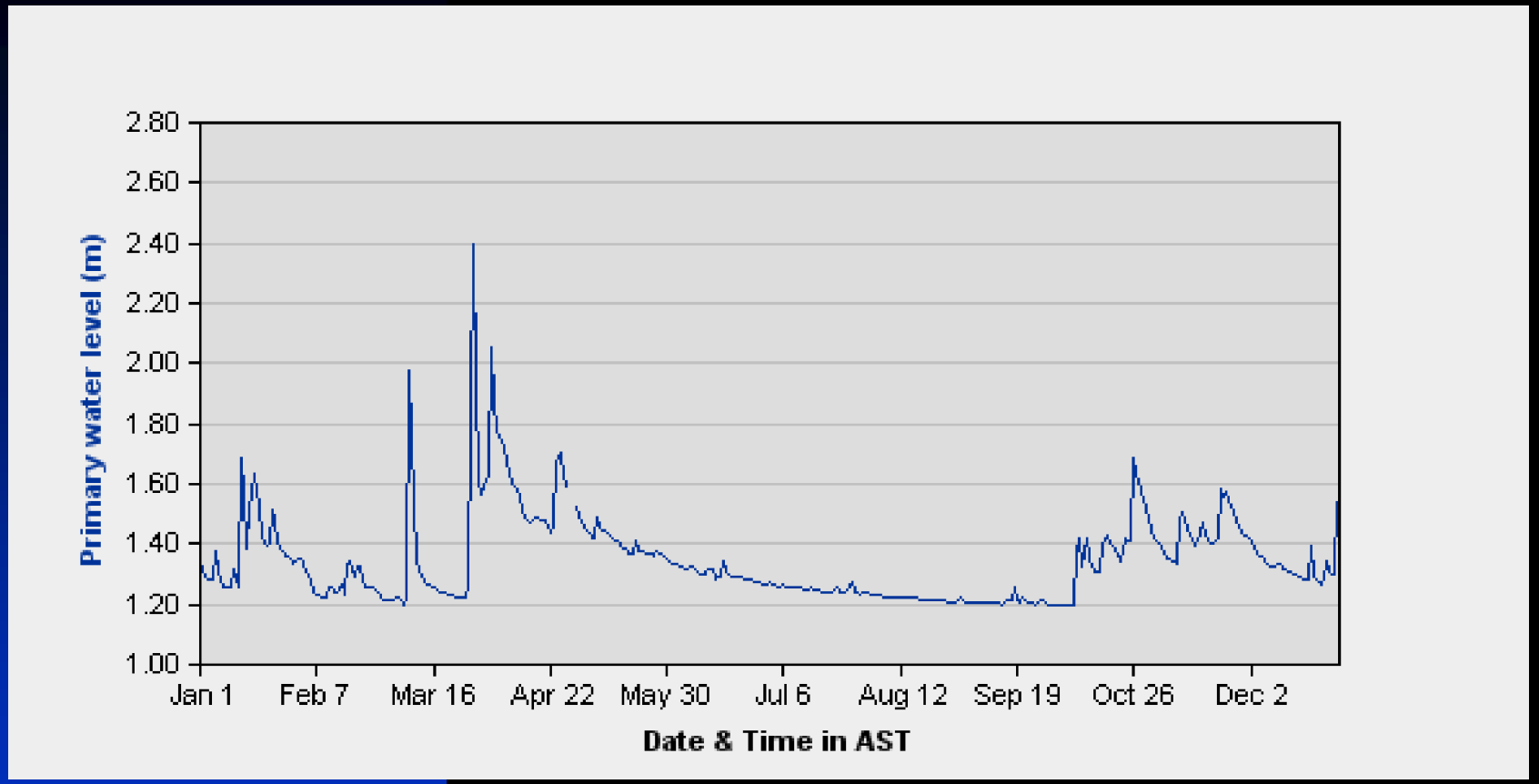
Water Table Elevation, Sleepy Hollow Well 1999



Riverdale Observation well



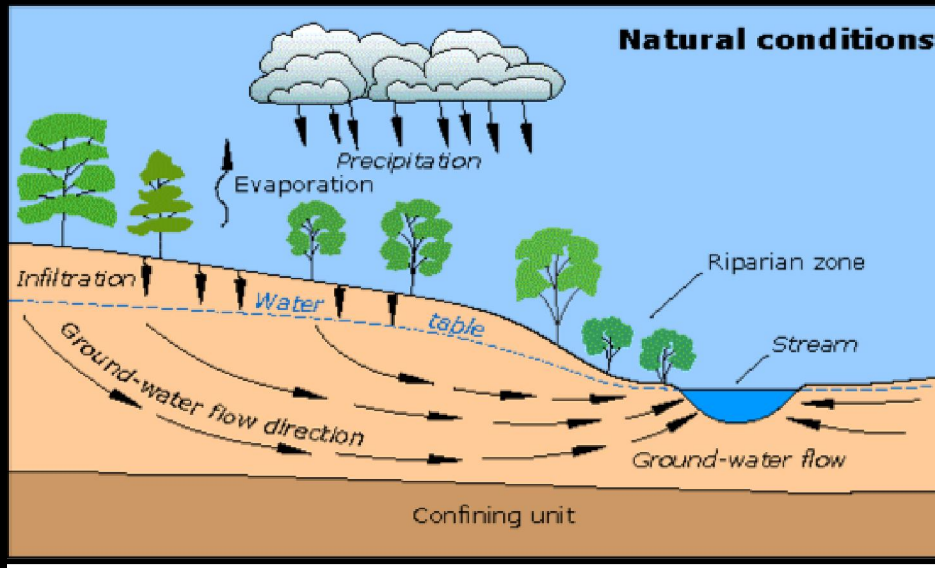
Riverdale station - stream stage for 2005

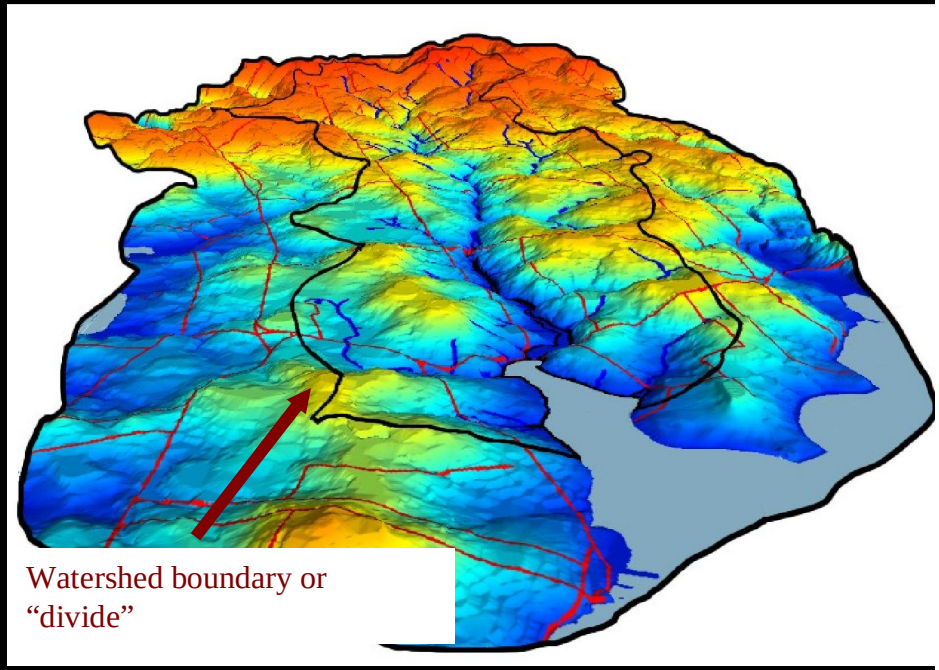


"real time" data available at E.C. website :http://scitech.pyr.ec.gc.ca/waterweb/fullgraph.asp

Groundwater “Flow Systems”

- Groundwater is not static but flows from areas of higher elevation to lower elevation, where it discharges to streams or the ocean.
- On PEI, the boundaries of individual groundwater flow systems are more or less the same as surface watershed boundaries.
- The source of groundwater is the precipitation that infiltrates through the un-saturated zone to the water table – a process called “recharge”.
- On PEI this “groundwater recharge” represents about 30-35% of annual precipitation (~ 360 mm/yr.)



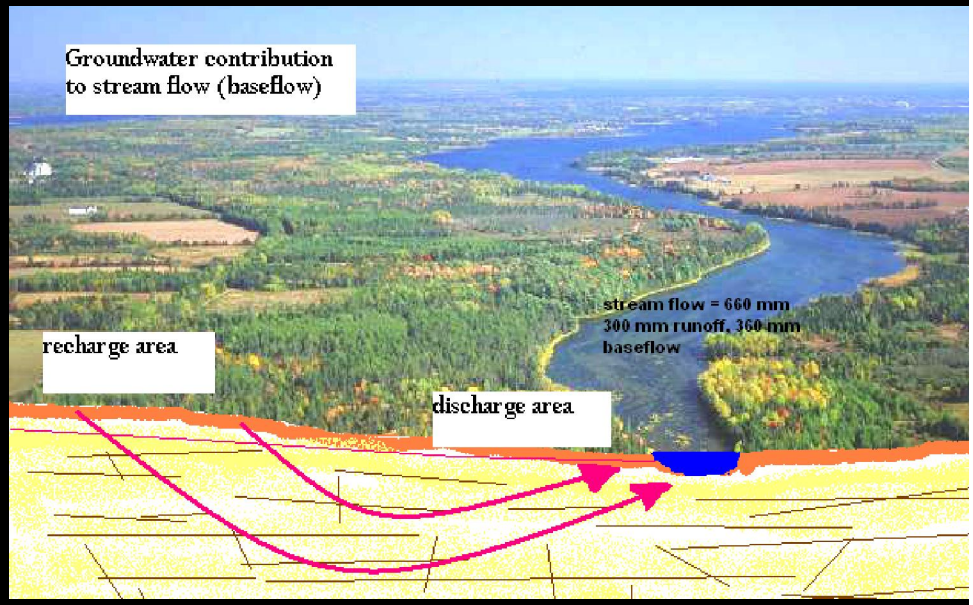


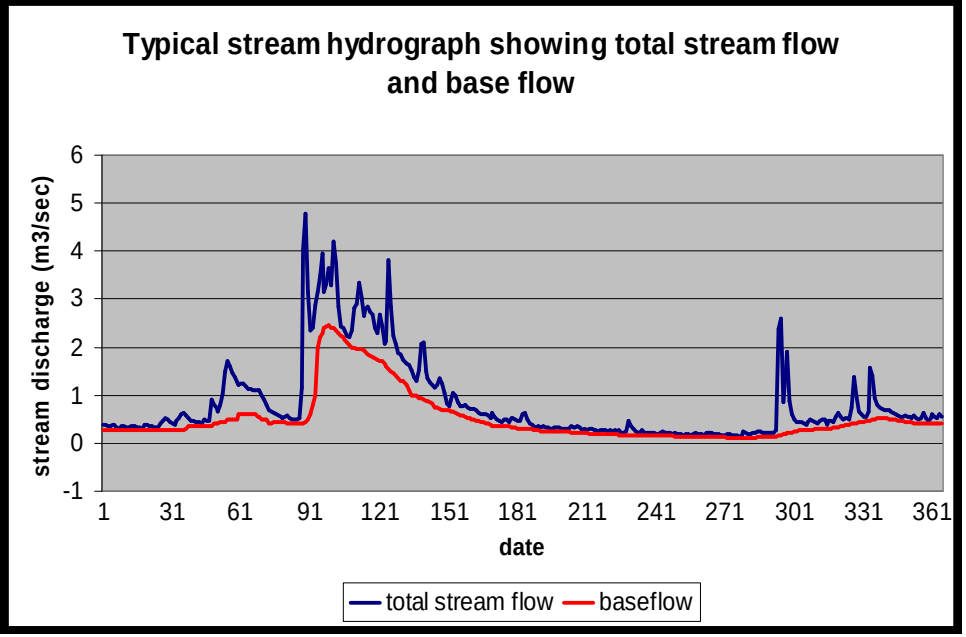
Groundwater “flow” continued:

- The driving force for groundwater flow is the head difference between recharge and discharge areas.
- The velocity of groundwater flow depends on:
  - The hydraulic gradient (ie head difference) and
  - The porosity / permeability of the aquifer
  - Groundwater flow is through:
    - Pore spaces in the aquifer, and/or
    - Fractures in the aquifer
- There are different types of flow “boundaries” but in a really simple world we can consider:
  - Constant head boundaries
  - Groundwater “divides”

Groundwater - Surface water Interaction on PEI

- Groundwater which is *discharged* through springs and *seeps* to rivers or the shore is often called "base-flow"
- Groundwater discharge (base-flow) accounts for 55-65% of average annual stream flow.
- In dry summer months when there is little direct run-off from precipitation, almost all the water we see in Island streams is groundwater discharge.



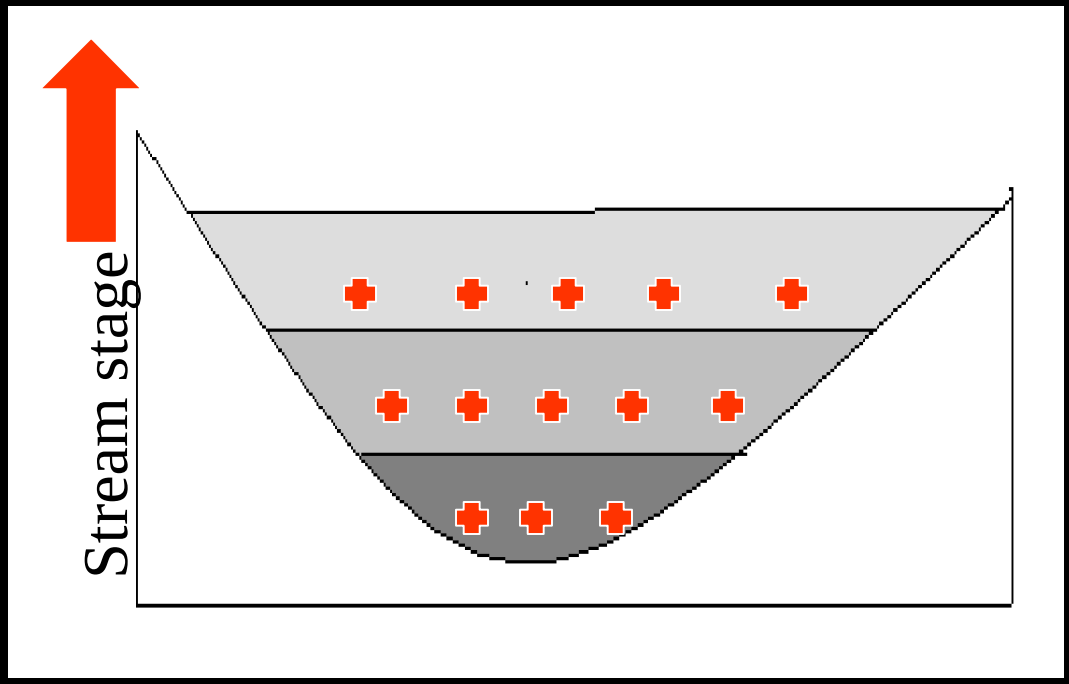


Stream flow:

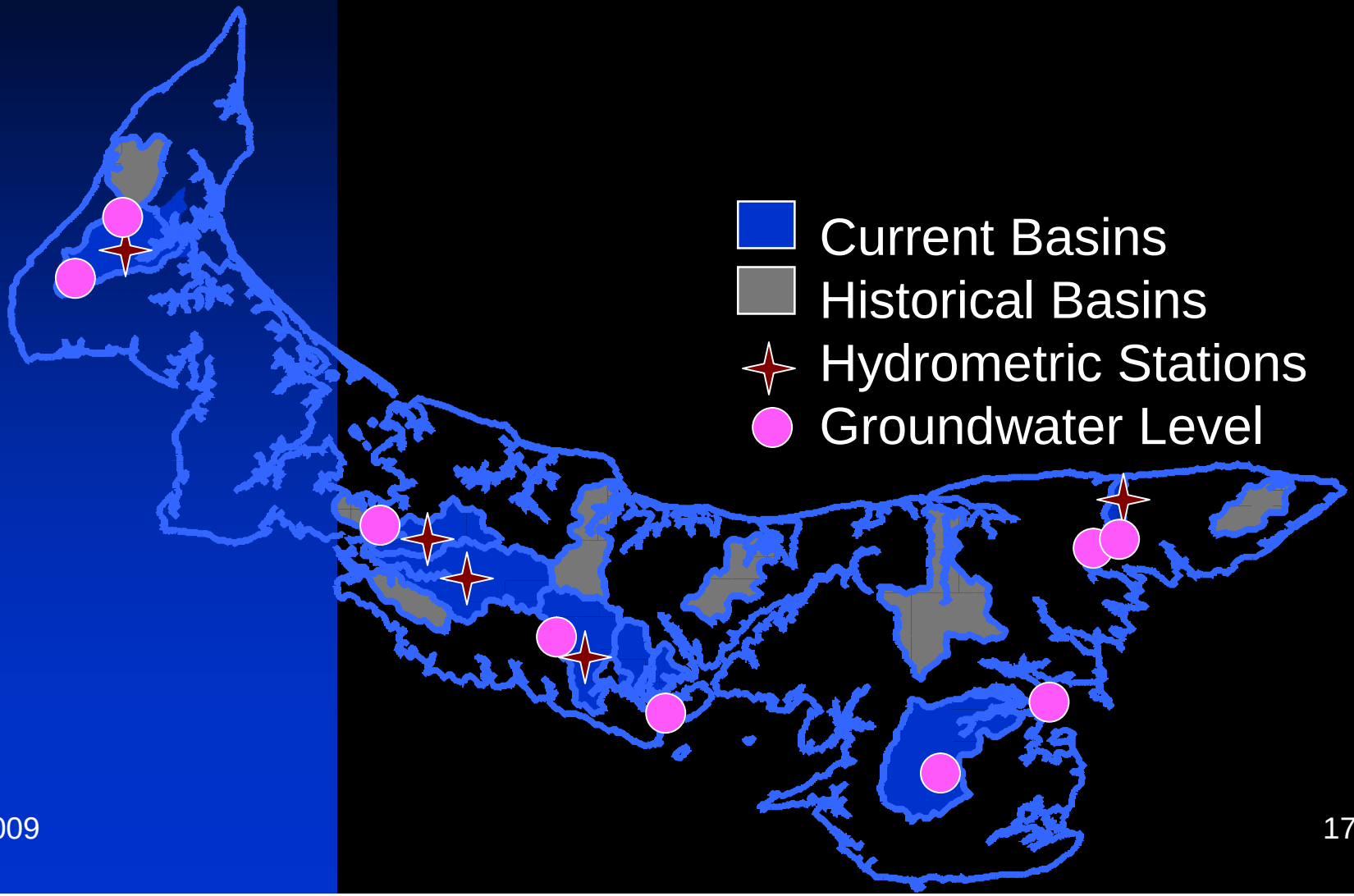
- Stream flow is comprised of baseflow (groundwater discharge) and direct run-off
- "Total" Stream flow can be measured directly:
  - Using profile of stream and velocities at representative points across the stream profile and converted to a flux by the use of a rating curve (instantaneous measurement in m^3/sec) .
- Stream flow can be estimated using regional equations for response of stream flow to precipitation using depth of precipitation (mm) and the area of the catchment (km^2)
  - Approach depends on time frame (ie annual basin yield (simple), or short term responses for maximum or minimum flows with a given return period) more complicated

Direct measurement of stream flow

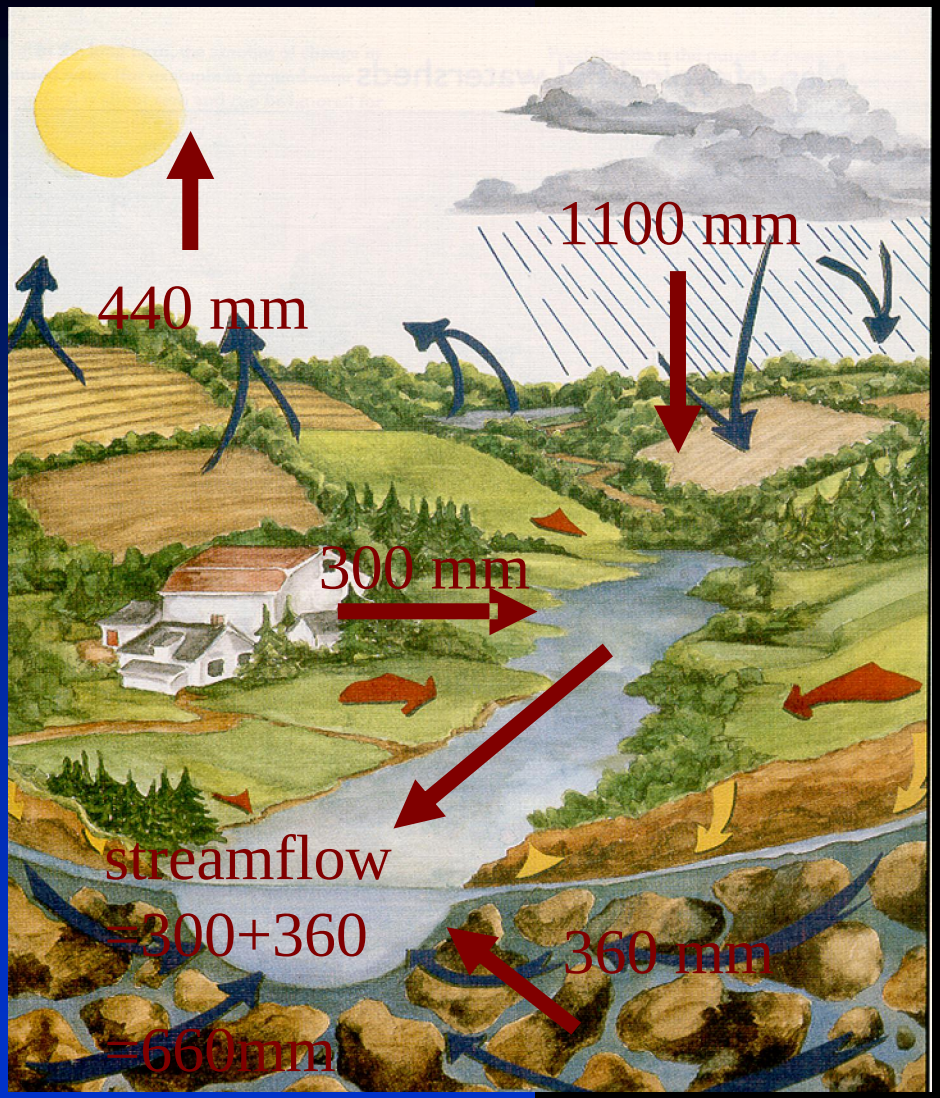
- A rating curve is constructed by measuring the relationship between stream stage (elevation) and stream discharge at different times of the year.
- Using stream stage (usually continuously) and the rating curve, stream flow can be determined



Water Monitoring Network

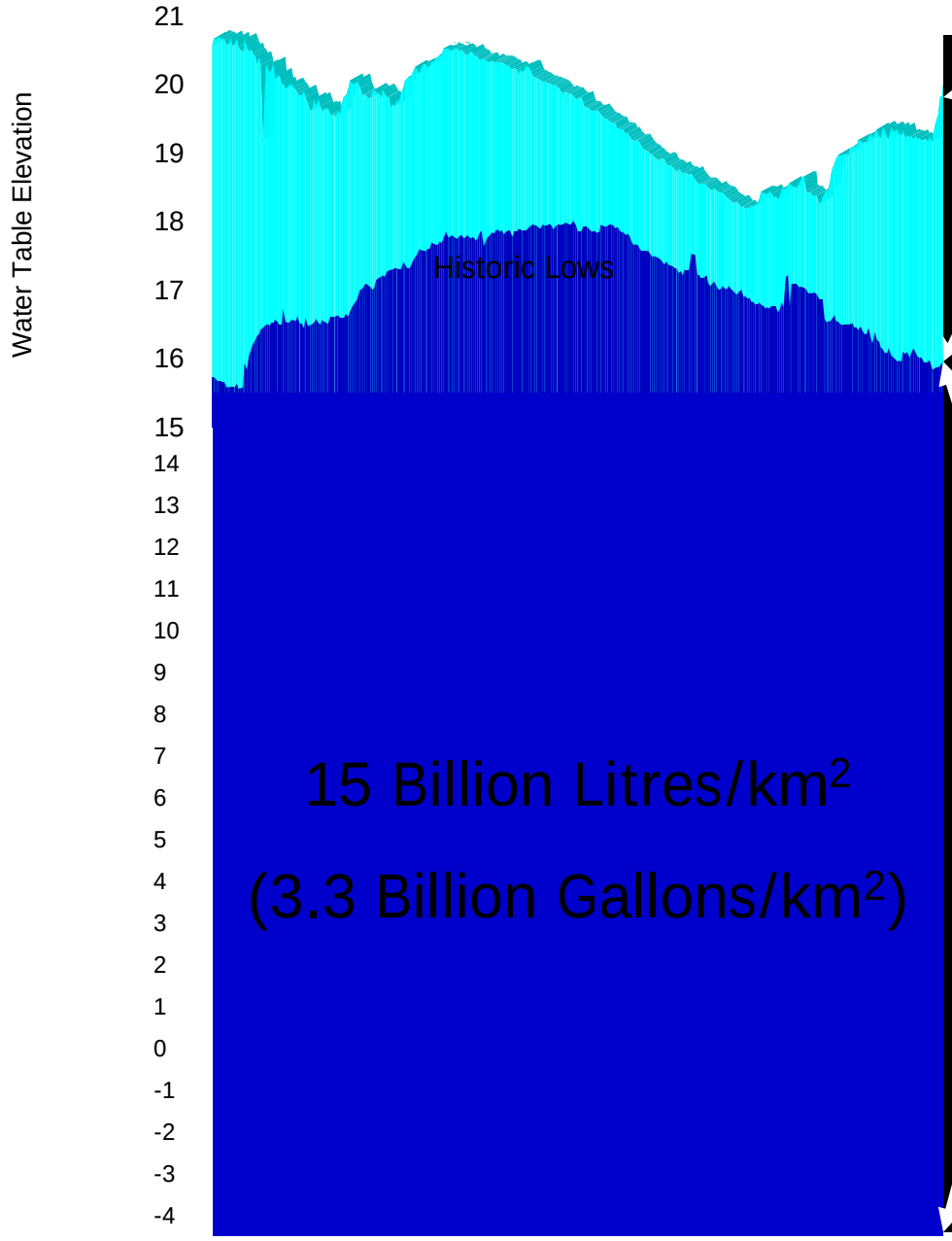


Groundwater in The “Water Cycle”

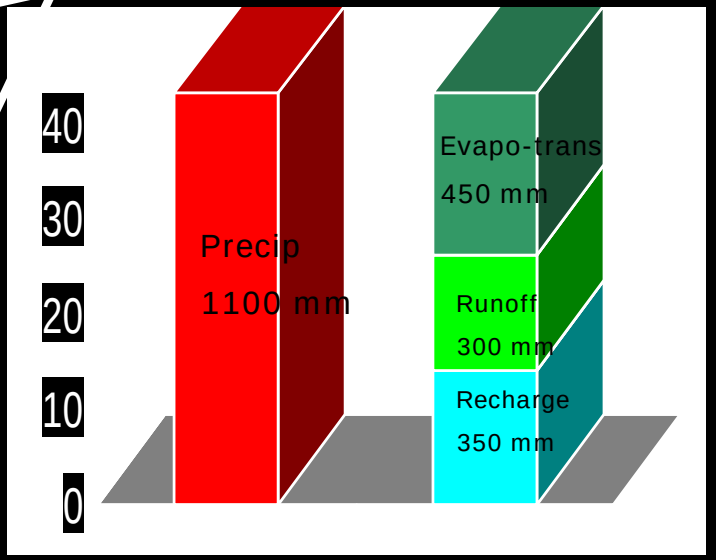


- The water cycle starts with precipitation. On PEI we normally receive about 1100 mm of precipitation annually.
- Water that falls on the ground will follow one of three processes:
  - evaporate and return to the atmosphere (440 mm)
  - run directly over the land surface to streams (300 mm)
  - soak into the ground and become groundwater (360 mm)
- Groundwater flows slowly from areas of higher elevation to lower elevation and eventually discharges to surface water bodies such as streams, ponds etc.
- Surface water evaporates and returns to the atmosphere to complete the cycle.

Groundwater Storage And Annual Fluctuations



Annual Water Budget



Constant Groundwater Storage

Annual recharge = 385,000 m^3 (84,700,000 ig)/km^2/yr

Using Wells to Access Groundwater

- Wells provide a means of tapping groundwater stored in the “saturated zone” or “aquifer”
- When a well is not pumping, the water level in the well is the same as the water table elevation.
- When a well is pumping, the water level in and immediately around the well drop, forming what is called a “cone of depression”.
- As water is pumped, water flows from the aquifer into the well.
- The size and shape of the cone of depression depend on the pumping rate, and the characteristics of the aquifer.
- When a well is located near a stream, heavy pumping may draw water from the stream into the well.