3. Conceptual model

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AQUATEST a.s.

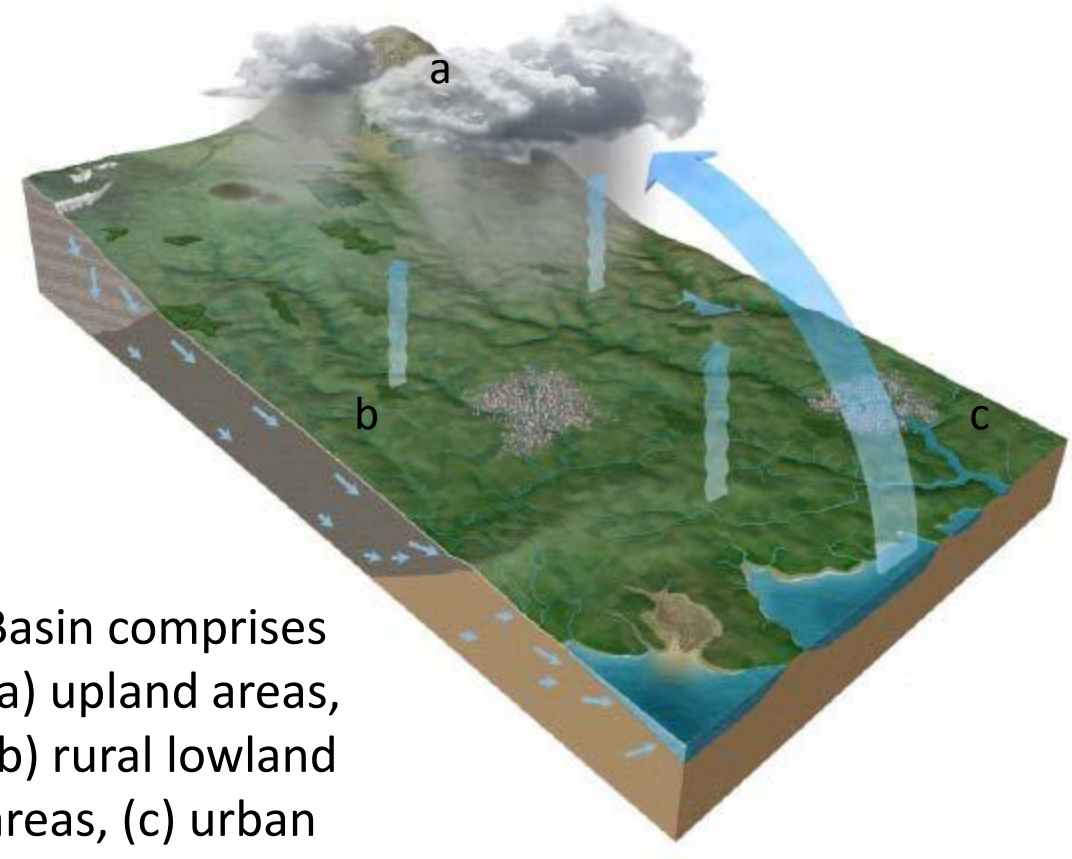
Presentation content

- System approach
- Hydrological system – water cycle
- Study of groundwater system – regional hydrogeological investigation
- CONCEPTUAL MODEL – fundament of modern hydrogeology

System approach

Groundwater resources represent a relatively complicated system which is not easy to understand under complex hydrogeological conditions as it reacts to excitation from the outside environment.

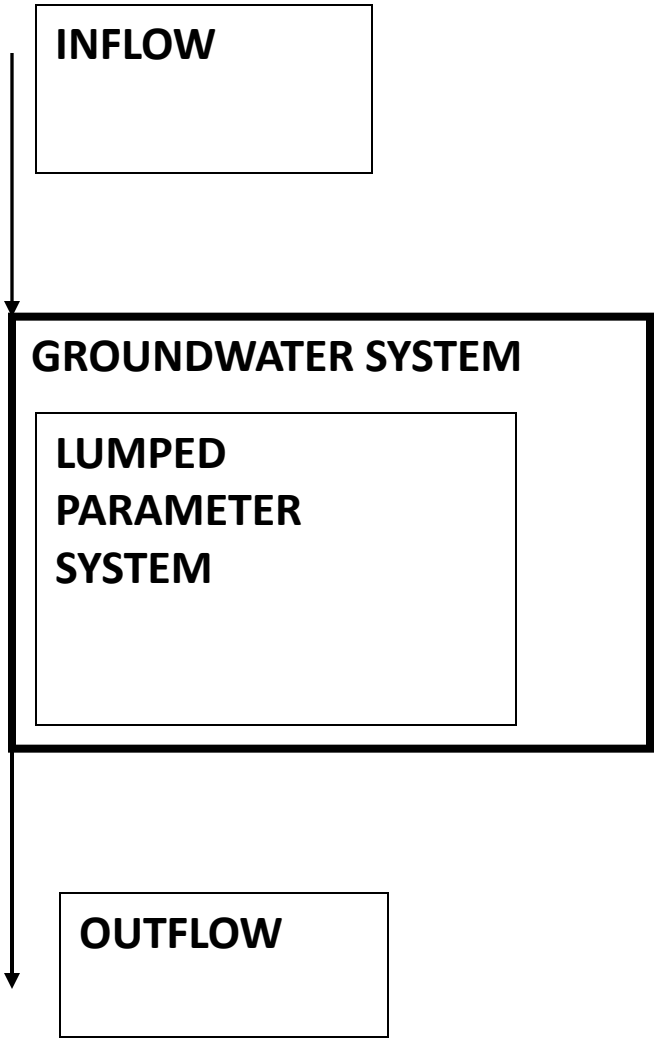
Hydrological system - basic components



Basin comprises (a) upland areas, (b) rural lowland areas, (c) urban lowland areas

Block diagram showing a typical upland to lowland River Basin District (RBD) catchment, and the basic components of the hydrological system where groundwater flows through several aquifer types and it discharges to rivers, lakes, wetlands and the sea

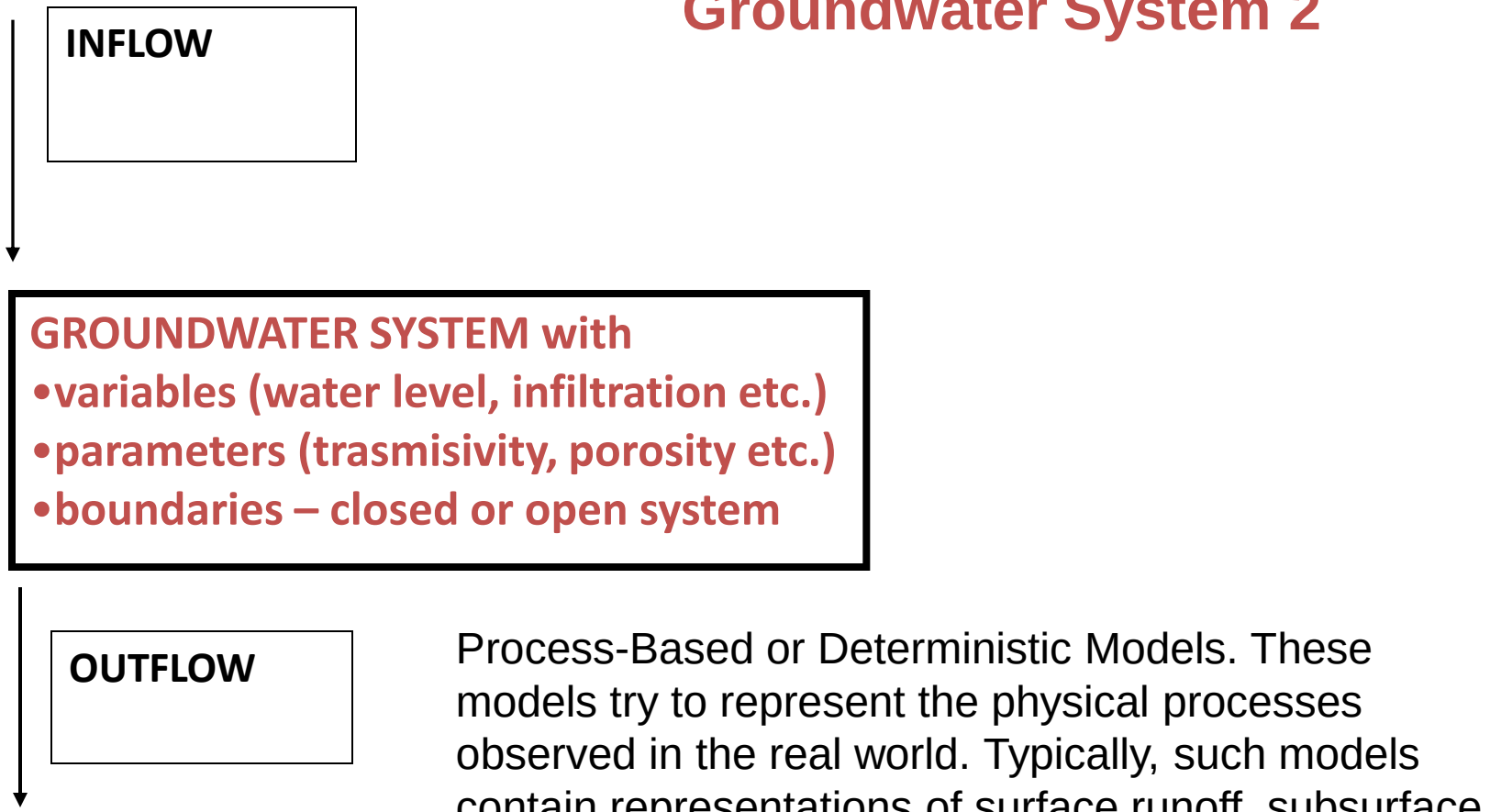
Groundwater System 1



Stochastic Models are black box systems, based on data and using mathematical and statistical concepts to link a certain input (for instance rainfall) to the model output (for instance runoff).
Commonly used techniques are regression, transfer functions, neural networks and system identification

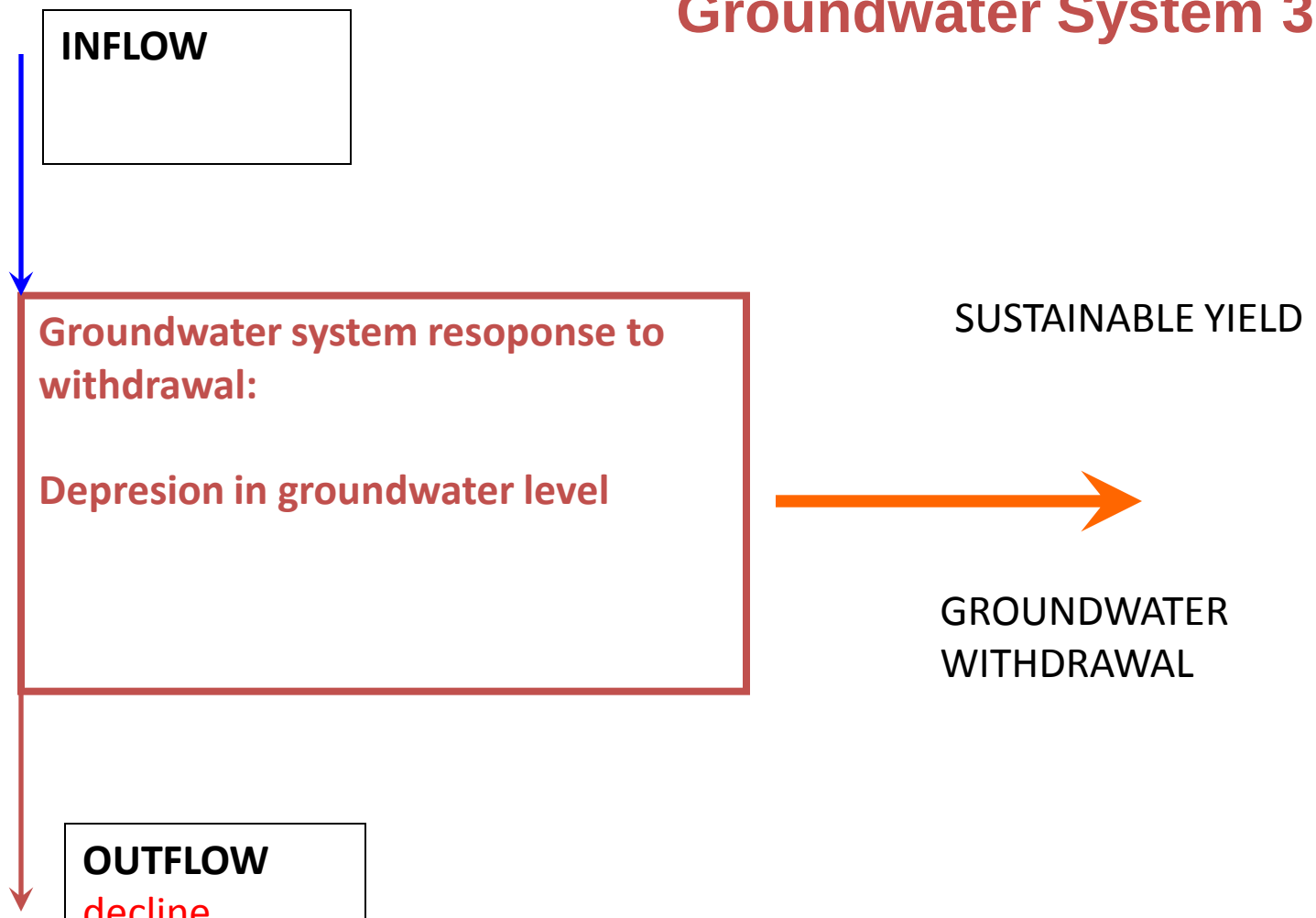
Domenico, P. (1972):Concepts and Models in Groundwater Hydrology. - Mc Graw-Hill. New York.

Groundwater System 2

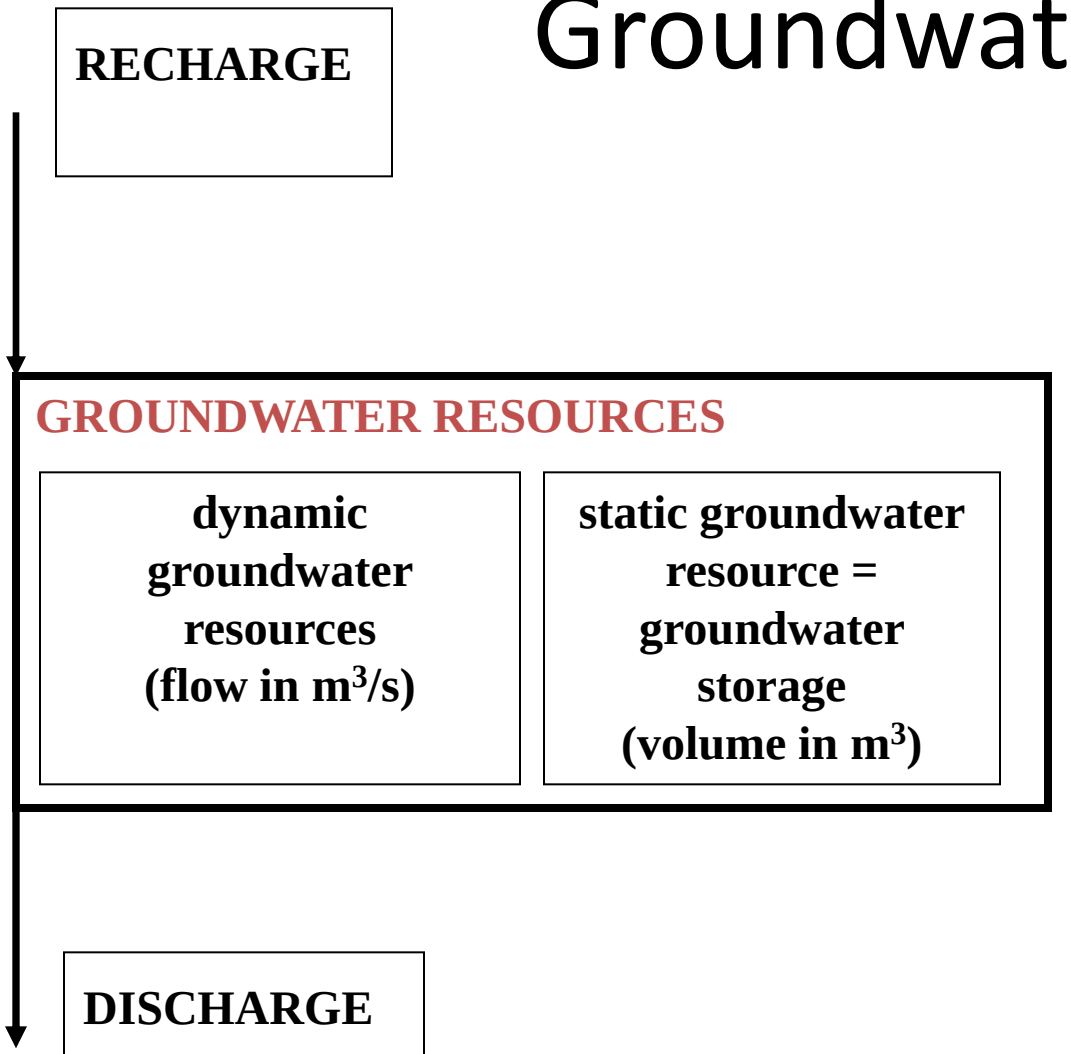


Process-Based or Deterministic Models. These models try to represent the physical processes observed in the real world. Typically, such models contain representations of surface runoff, subsurface flow, evapotranspiration, and channel flow, but they can be far more complicated. Models can be subdivided into single-event models and continuous simulation models.

Groundwater System 3



Groundwater resources



The groundwater potential of an arae

Ggroundwater resources of which origin can be as follows:

- Dynamic (renewable) groundwater resources which depend on annual recharge of rainfall into the system.
- Static groundwater resources which depend on inter-granular fissured or kart porosity of the aquifer.
- Induced groundwater resources which depend on interaction of surface and groundwater

Basic terms

Groundwater resources or groundwater potential of the area, of the basin or of the aquifer

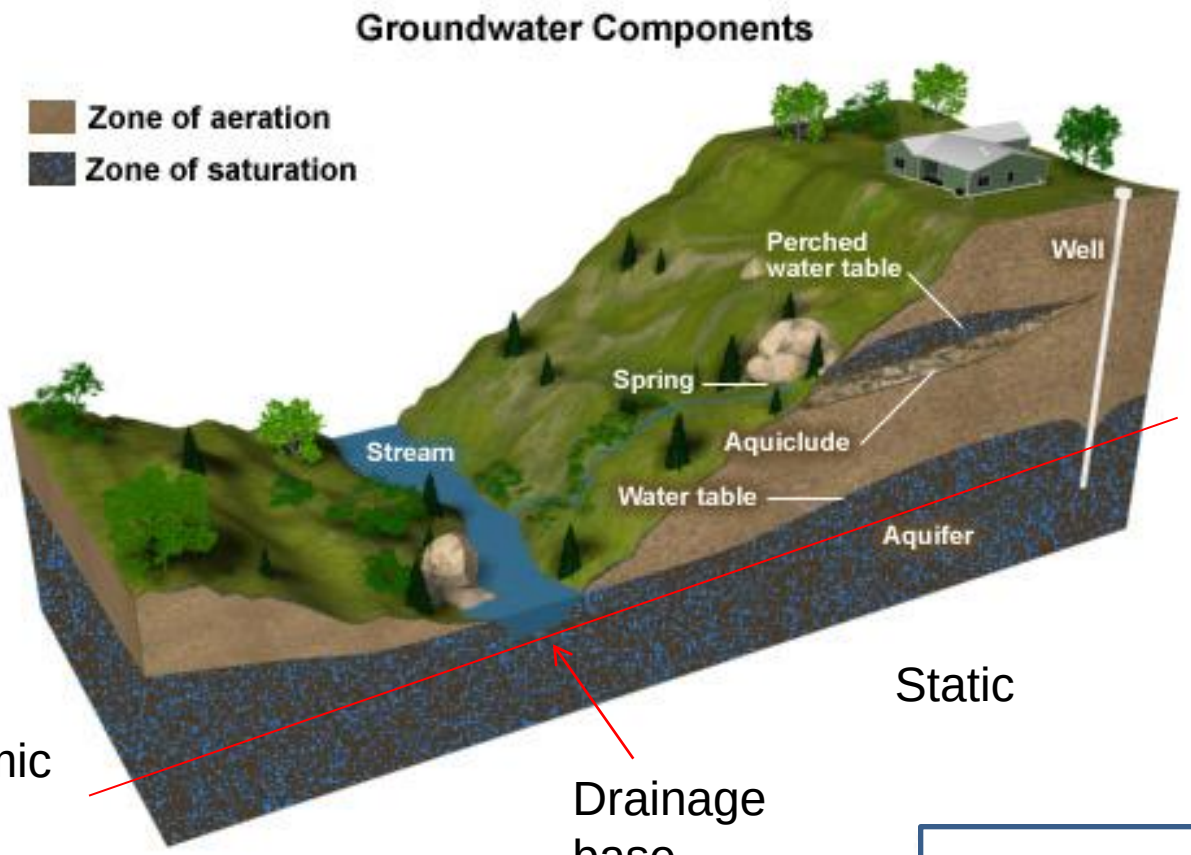
Dynamic (renewable) groundwater resources = Recharge of gw. (m^3/s)

Static groundwater resources = Storage of gw. (m^3)

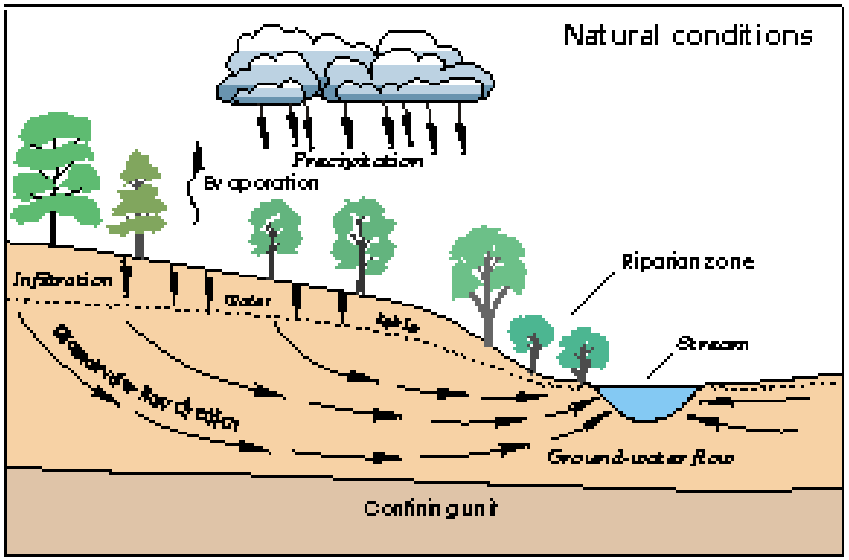
Induced groundwater resources (m^3/s)

Yield of groundwater = Quantity of water which could be withdrawn from the groundwater resources without undesirable response of the environment (maximum, stable, safe, optimal yield)

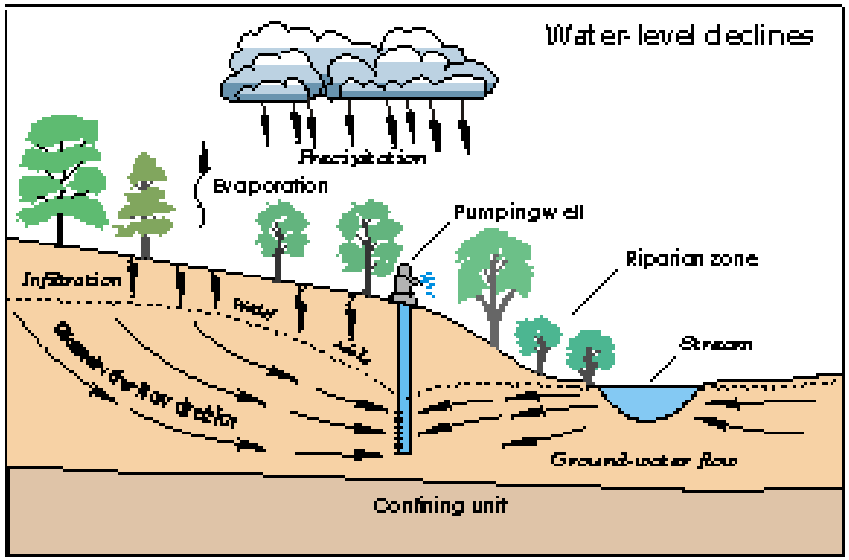
Dynamic - static GWR



Induced groundwater resources



Water is recharged to the ground-water system by percolation of water from precipitation and then flows to the stream through the ground-water system.



Water pumped from the ground-water system causes the water table to lower and alters the direction of ground-water movement. Some water that flowed to the stream no longer does so and some water may be drawn in from the stream into the ground-water system, thereby reducing the amount of streamflow.

Regional hydrogeology – base for GWR assessment

The system at the begining is studied as a lumped parameter - black box - which is fundamental for hydrological modeling, where in particular recharge and discharge characteristic or rainfall and runoff characteristics are analyzed. Later paramenters and proceses are defined.

GROUNDWATER RESOURCES ASSESSMENT

Hydrological data

Hydraulic parameters

Hydrochemical data

Geological and hydrogeological data

GIS supported database treatment, verification and evaluation of data

Recognizance of chemical and treatment types of groundwater, changes of chemistry of water along flowline

Geological structure delineation, aquifer and aquitard definition, groundwater flow systems definition

Hydrogeological conceptual model

Hydrological water balance modeling:
data transfer and input, boundary of balance units, recharge and discharge

Total water balance, groundwater resources – groundwater recharge

Hydraulic modeling (ModFlow, Aquifem N):
data transfer and input, boundary of flow systems, recharge of groundwater

Groundwater flow concept verification, groundwater withdrawal verification, response of flow system to groundwater withdrawal
Optimal groundwater yield of balance unit

Hydrogeological synthesis of results
GIS supported desktop mapping a documentation finalization
Report editing

definition

The conventional definition of a groundwater conceptual model is a mostly qualitative and often pictorial description of the groundwater system, including a delineation of the hydrogeologic units, the system boundaries, inputs/outputs, and a description of the soils and rocks and their properties

Conceptual model 1

Hydrogeological conceptual models are simplified, conceptual representations of a part of the hydrogeological, hydrological and hydrochemical cycle within given geological strata and system of aquifers aquitards. They are primarily used for hydrologic prediction and for understanding hydrologic processes.

The model is used by hyrogeologist for understanding the abundant data from regional investigations describing of groundwater flow system.

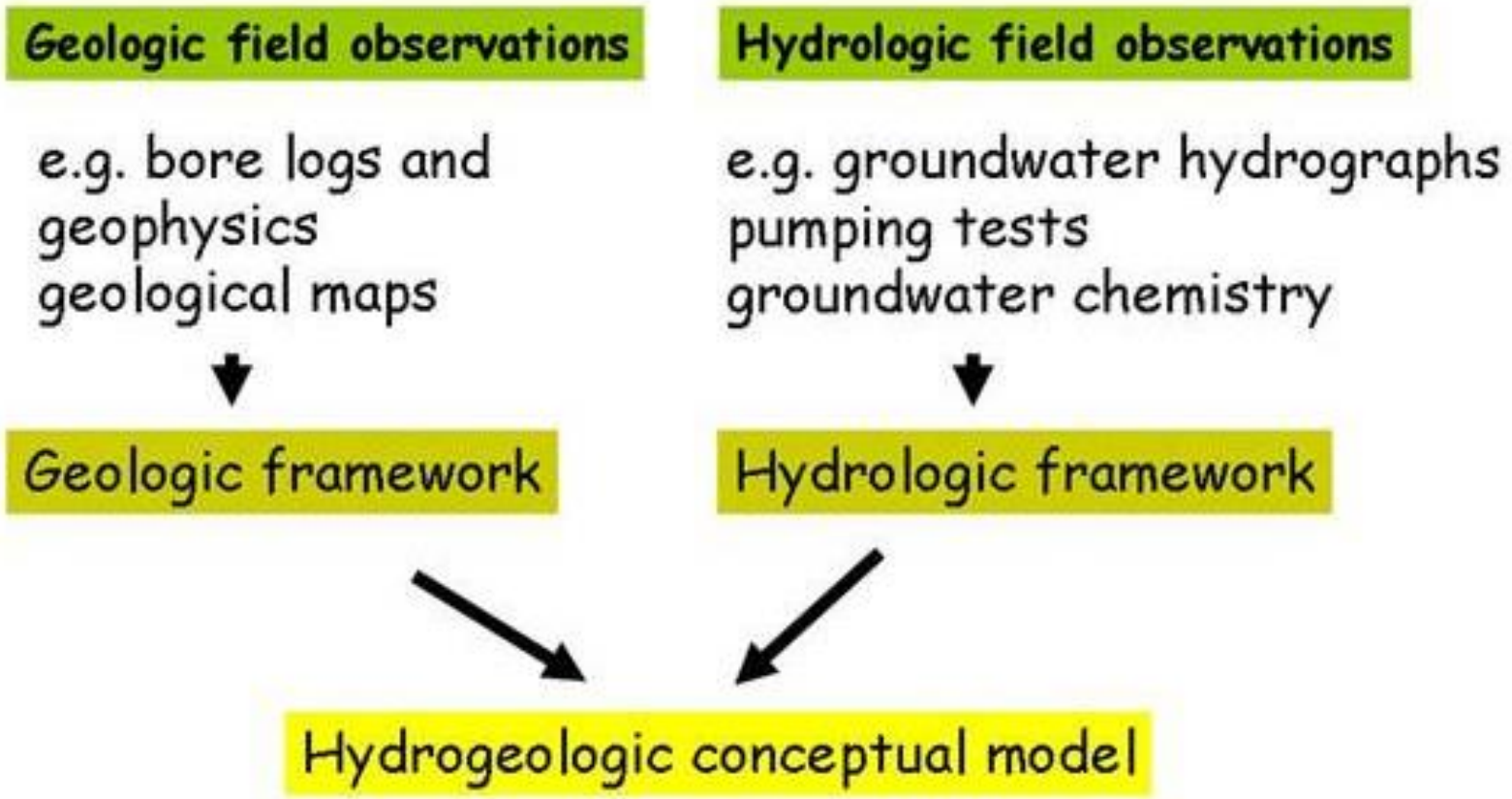
Conceptual model 2

- *catchment framework*, defining the boundaries of the study area, in terms of groundwater and surface water divides;
- *hydrogeological framework*, in terms of the general structure and properties of the aquifers, aquitards and other geological units making up the catchment;
- *surface water framework*, the configuration of streams, lakes, wetlands, reservoirs, estuaries and other surface water features in the catchment landscape;
- *hydrological framework*, the key processes defining the movement of water throughout the landscape such as rainfall, evapotranspiration, run-off, stream flow and groundwater flow;

Conceptual model 3

- *ecosystem framework*, the key environmental assets that have a dependency on the surface water or groundwater features of the catchment such as wetland ecosystems, endangered aquatic species or important vegetation communities; and
- *anthropogenic framework*, the human-induced factors that can influence hydrological processes in terms of water quantity and quality, such as pumping, land clearing, intensive agriculture, drainage, flood mitigation works, mining etc. Also included are the social dependencies of the water resource such as heritage and cultural values.

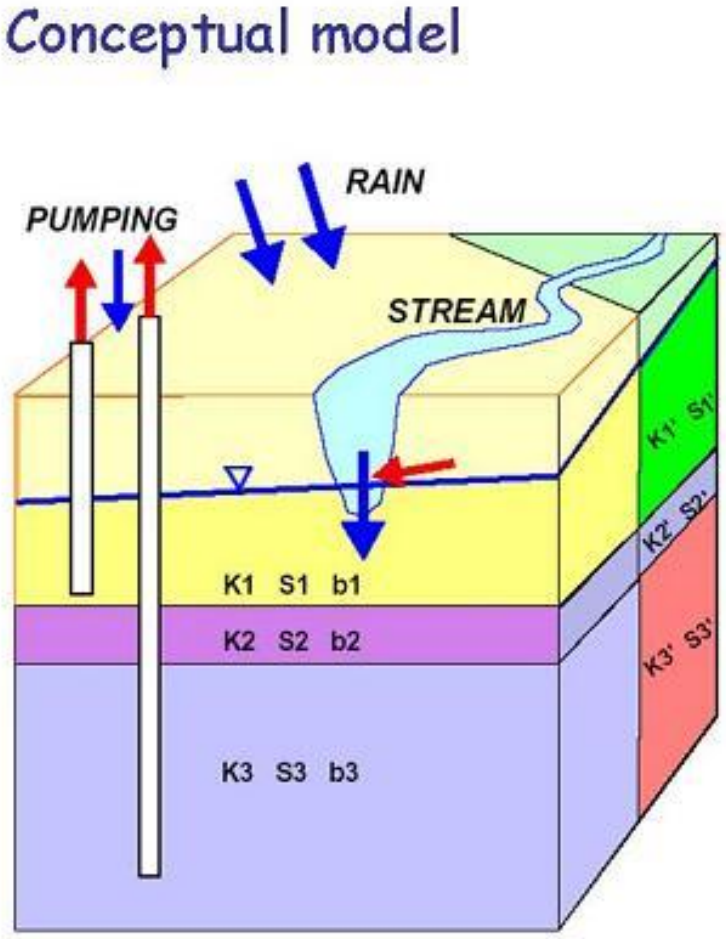
Model development



Example of model components

- Components of the environment: topography, geology, and climate
- Componemts of groundwater regime: amount of water, geometric distribution of water movement, volume or velocity of the flow, chemical composition, temperature, and regime variance

General model



Recharge:
rain infiltration
stream leakage
injection in bores

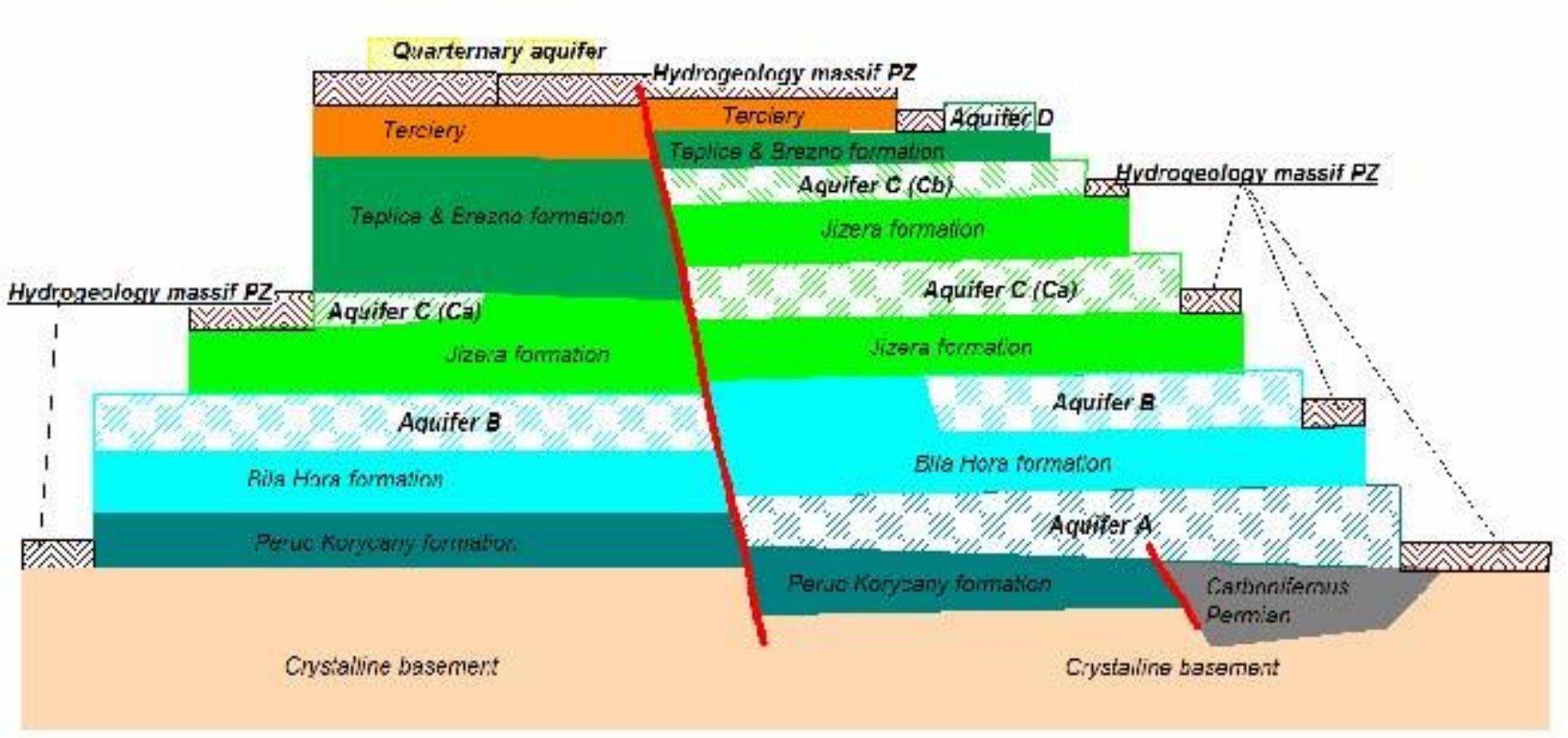
Discharge:
extraction from bores
groundwater baseflow

Parameters:
K = hydraulic conductivity
S = storage coefficient
b = aquifer thickness

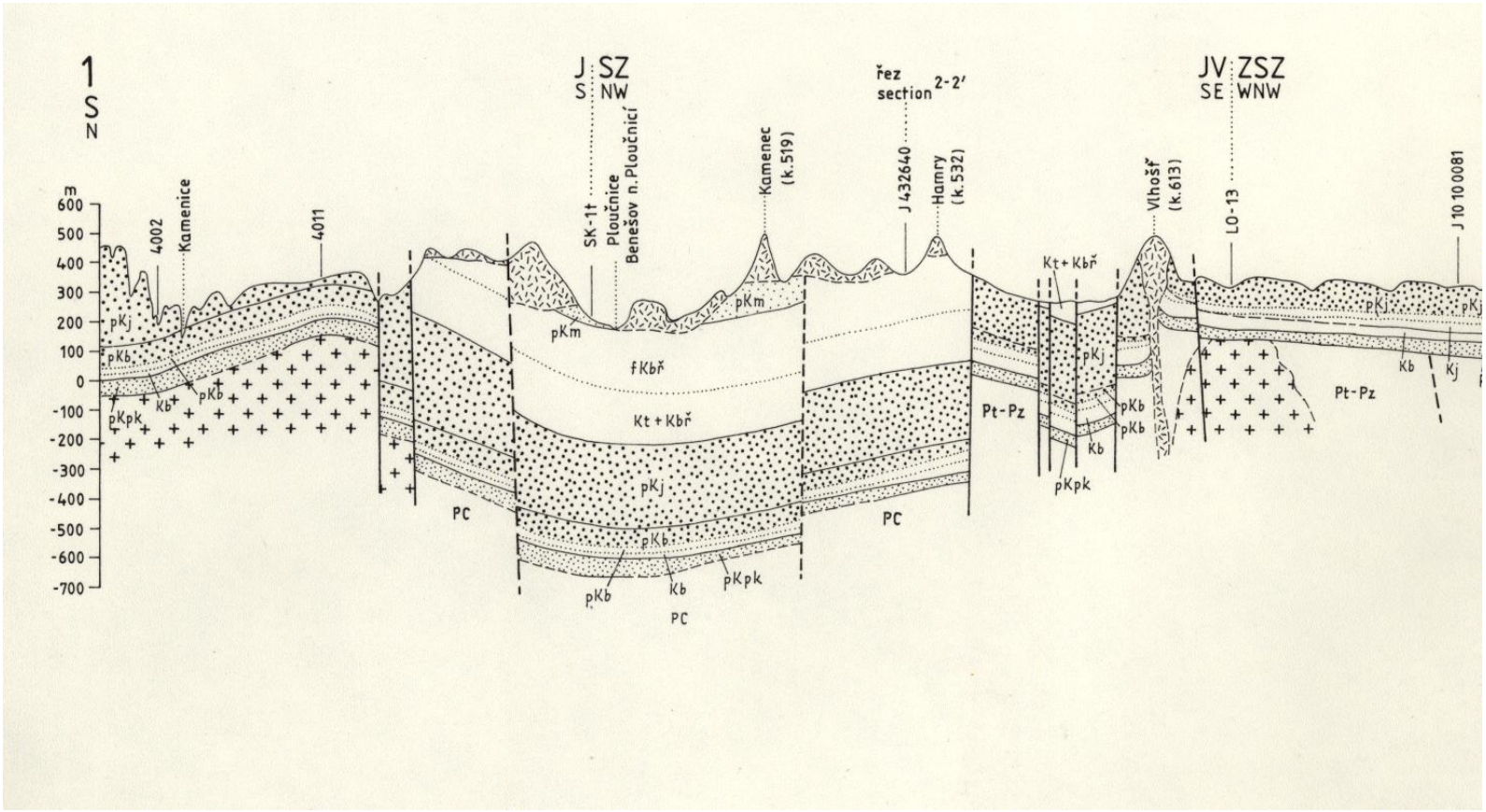
Hydrogeological units

(Merrick, 2004)

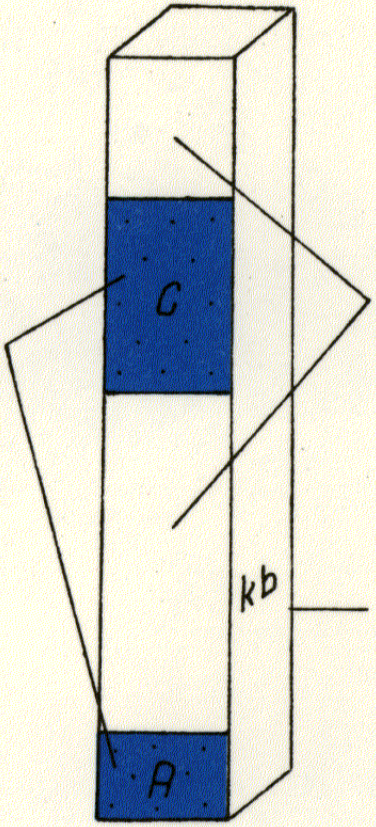
Czech Republic



Cross section (first step)



Column (generalization)



zvodněné kolektory
aquifers

izolátory
aquitards

index litostratigrafické jednotky
index of lithostratigraphic unit

1 cm výšky sloupce cca 150 m
each 1 cm in the column approx. 150 m

Maharlu Basin, Fars

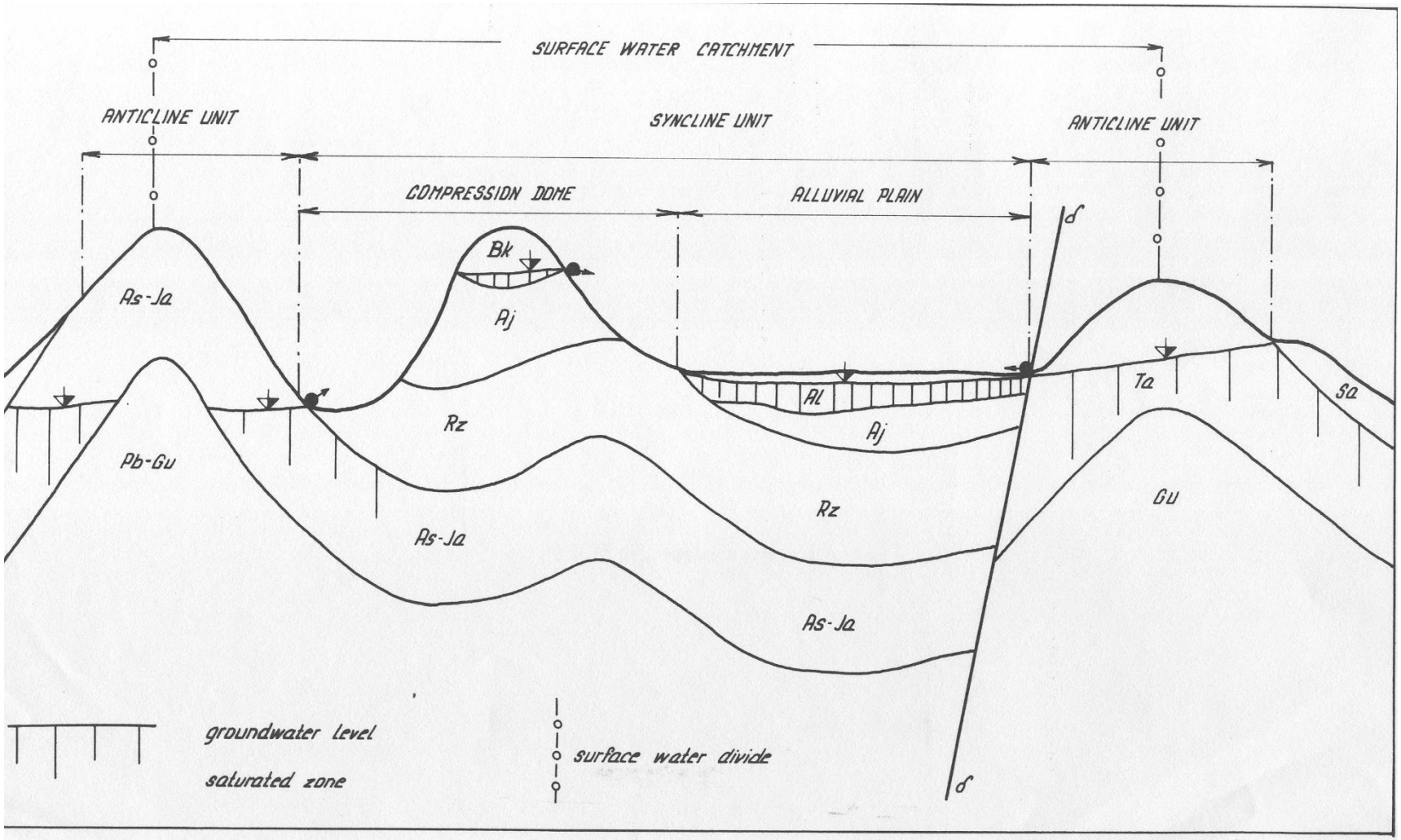
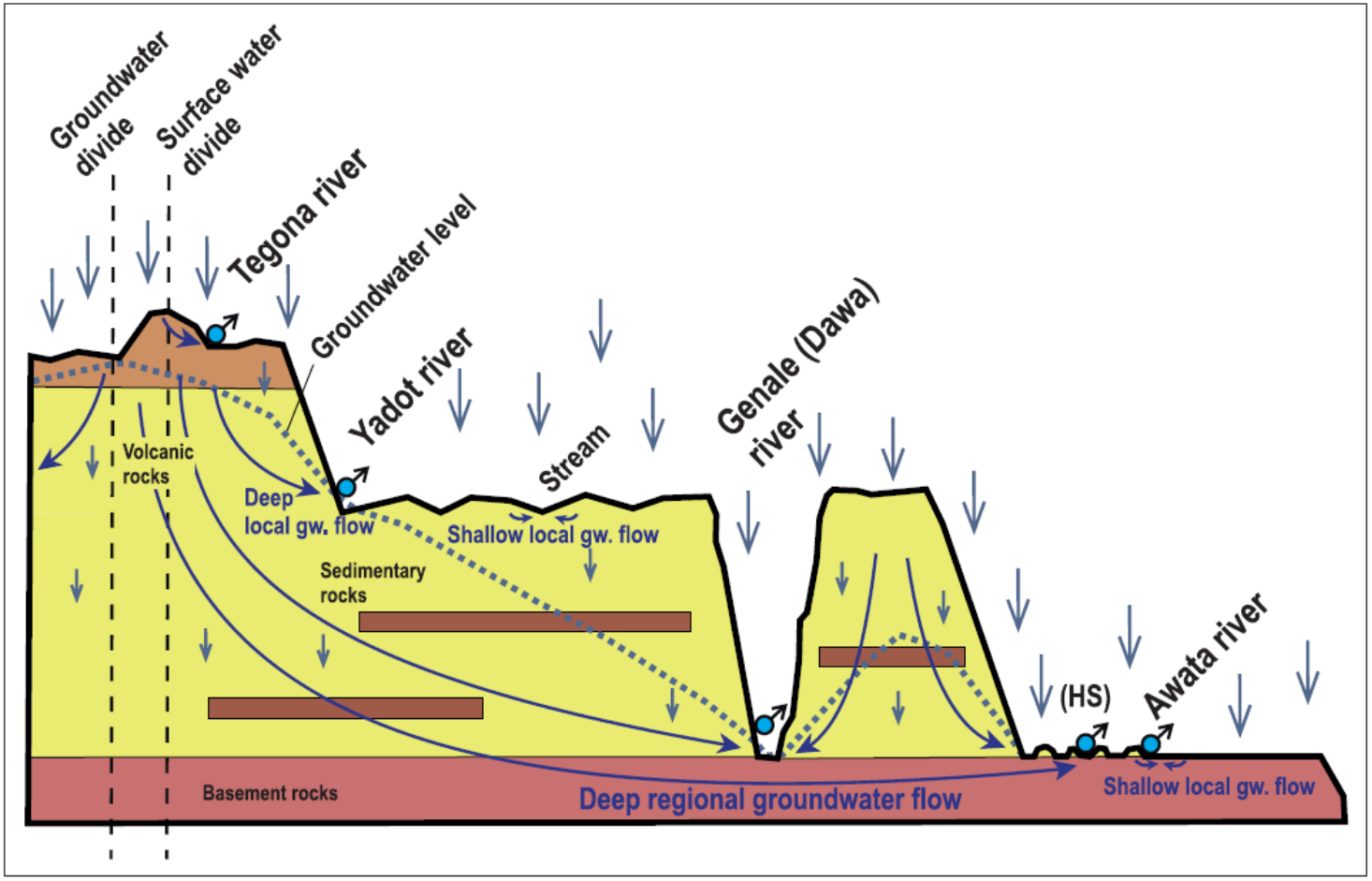
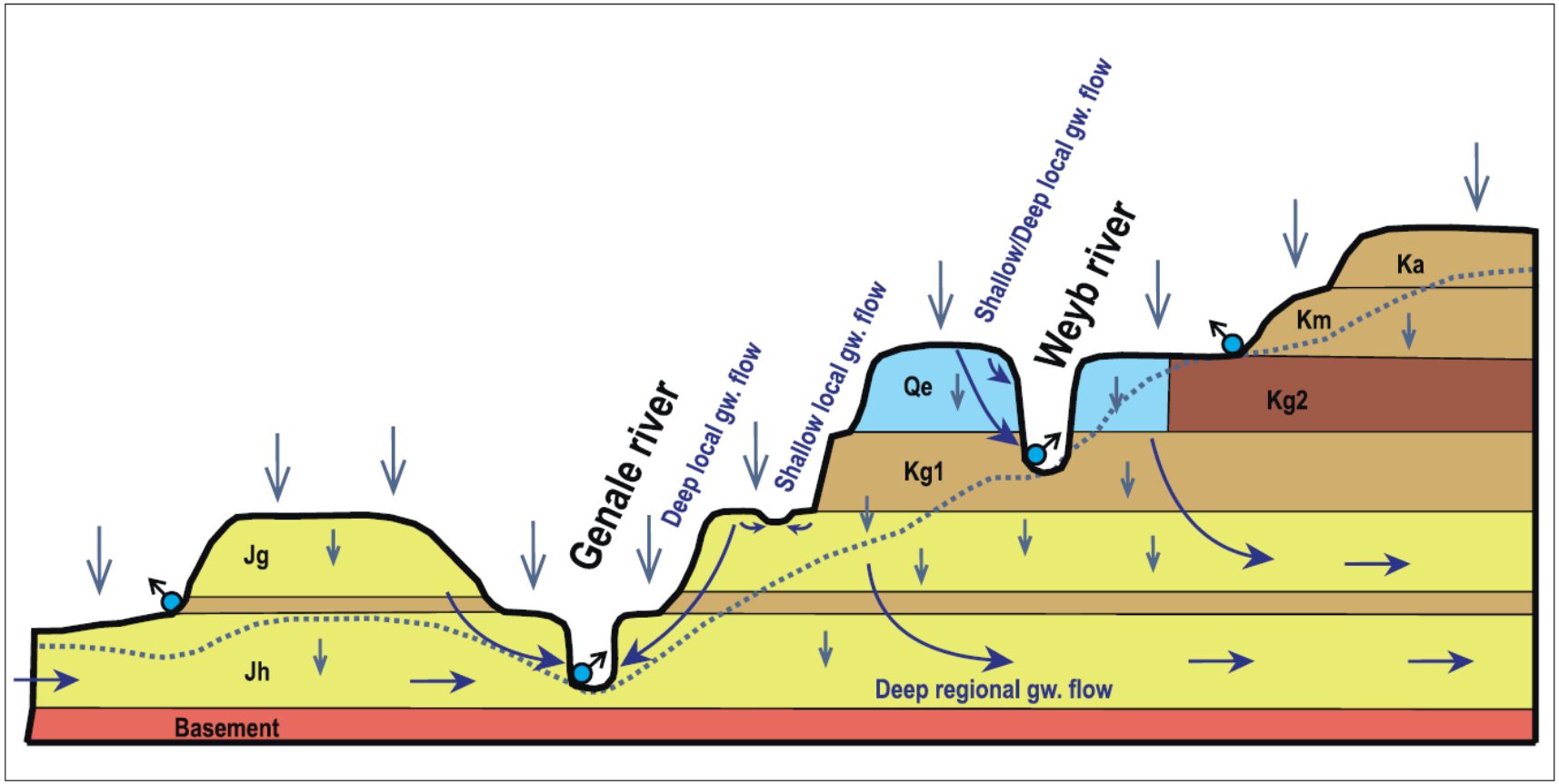


FIG C.4.1 Draft Cross-section of the Main Hydrogeological Units of the Maharlu Basin

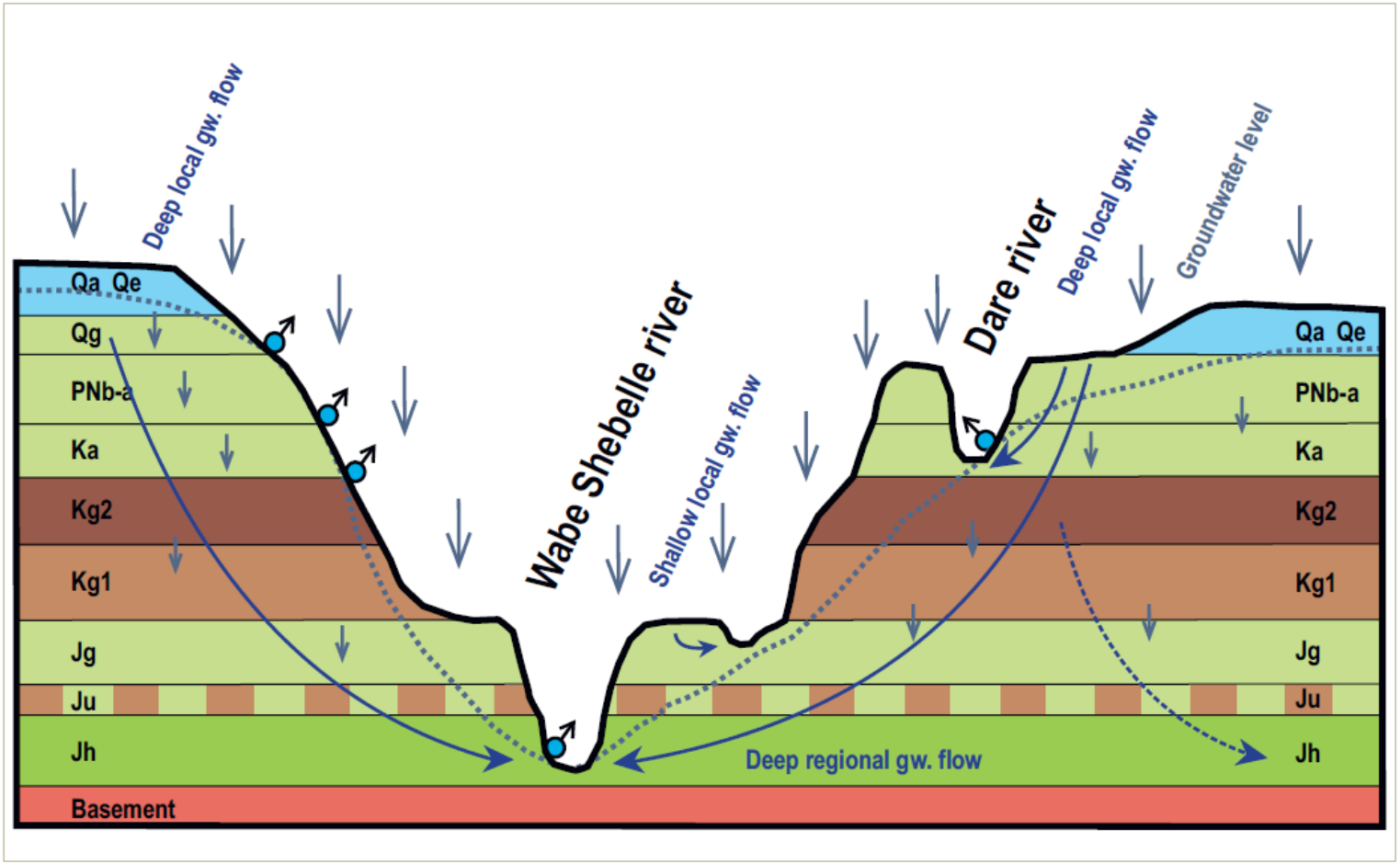
Highlands conceptual model – Dodola, Negele



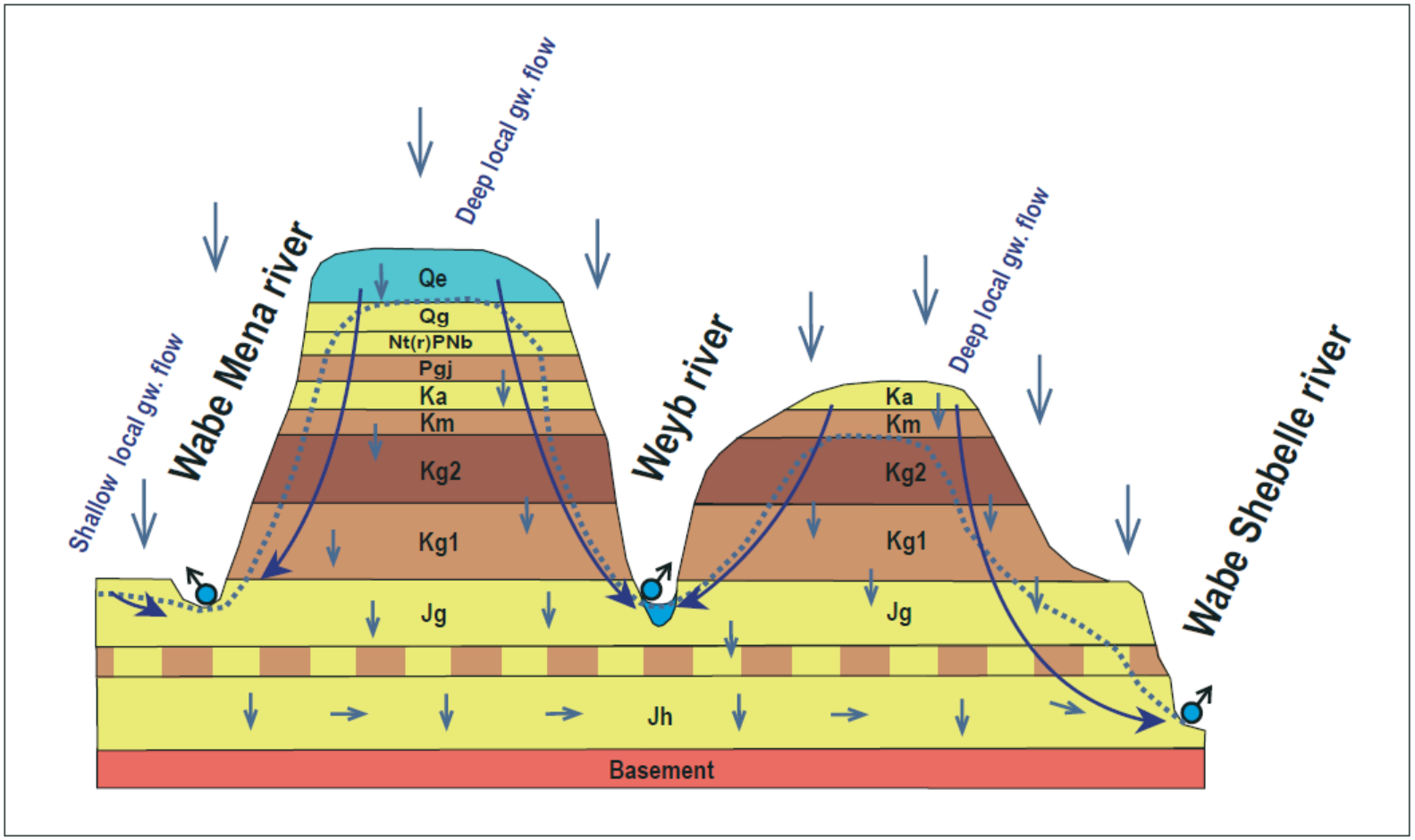
Lowland conceptual model - Filtu



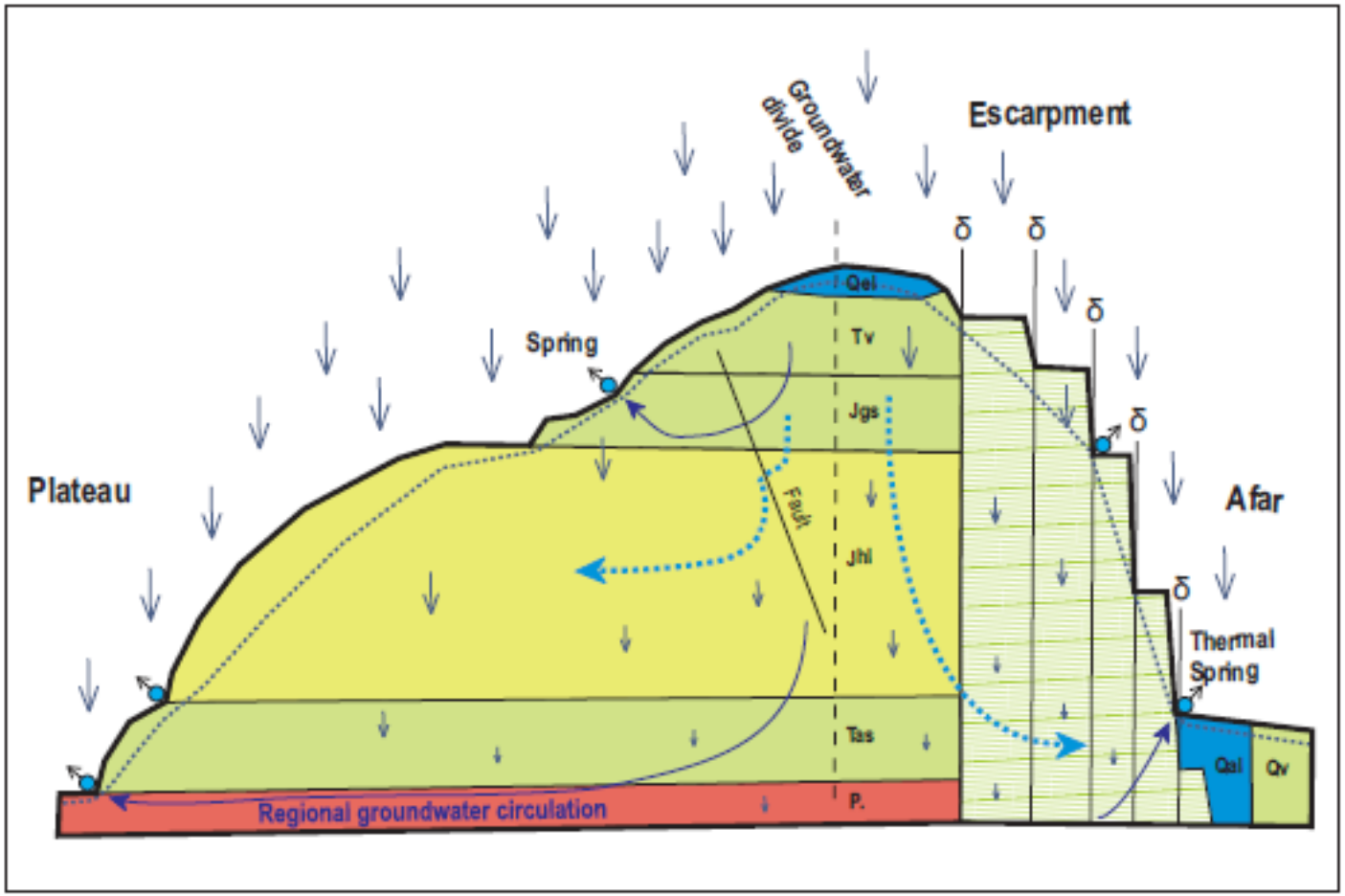
Ginnir conceptual model



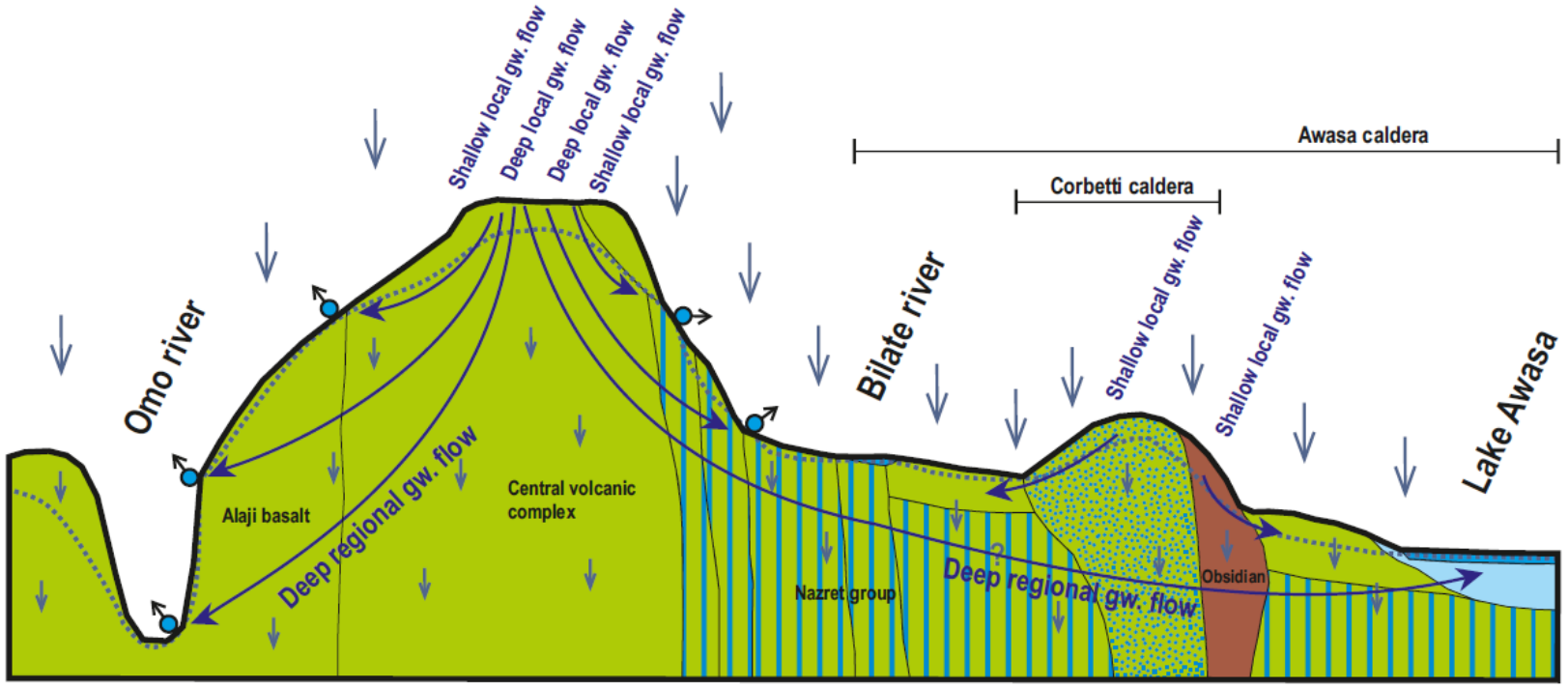
Megalo area


Deep local gw. flow
Shallow local gw. flow
Wabe Mena river
Weyb river
Deep local gw. flow
Wabe Shebelle river
Qe
Qg
Nt(r)PNb
Pgj
Ka
Km
Kg2
Kg1
Jg
Jh
Basement
Ka
Km
Kg2
Kg1
Jg

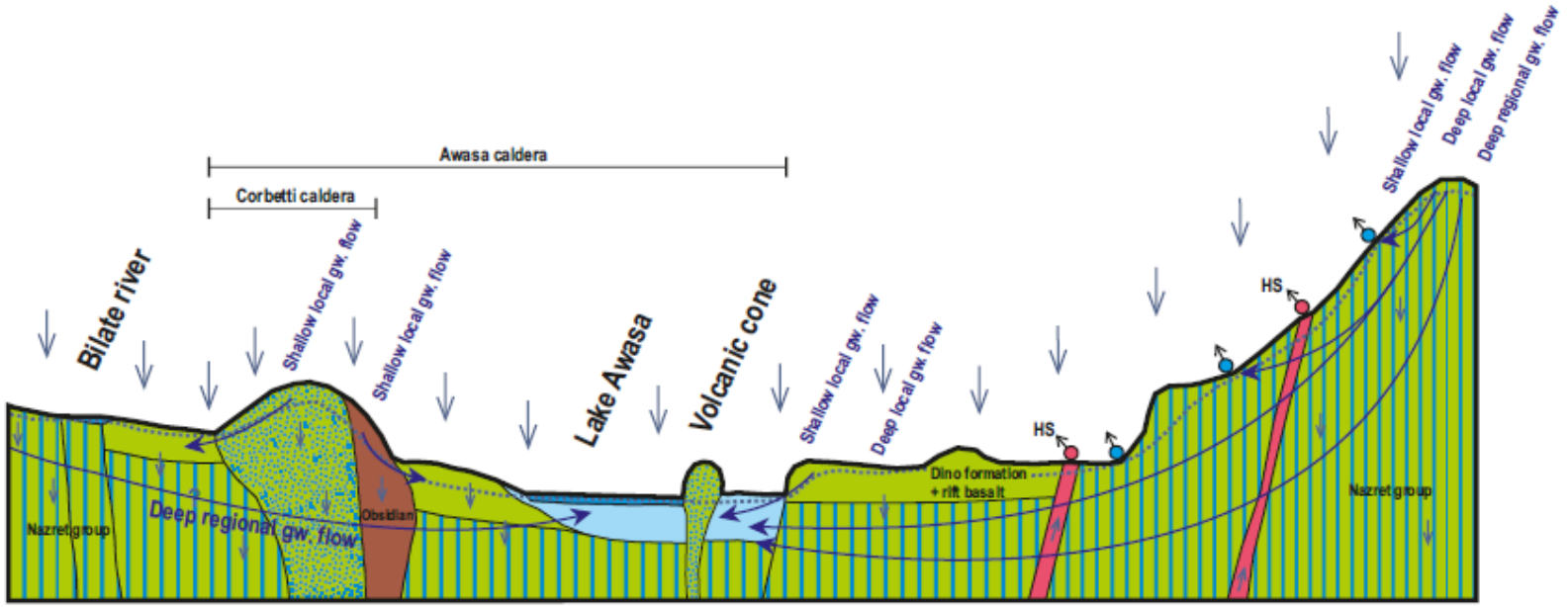
Eastern escarpment – Harar - DD



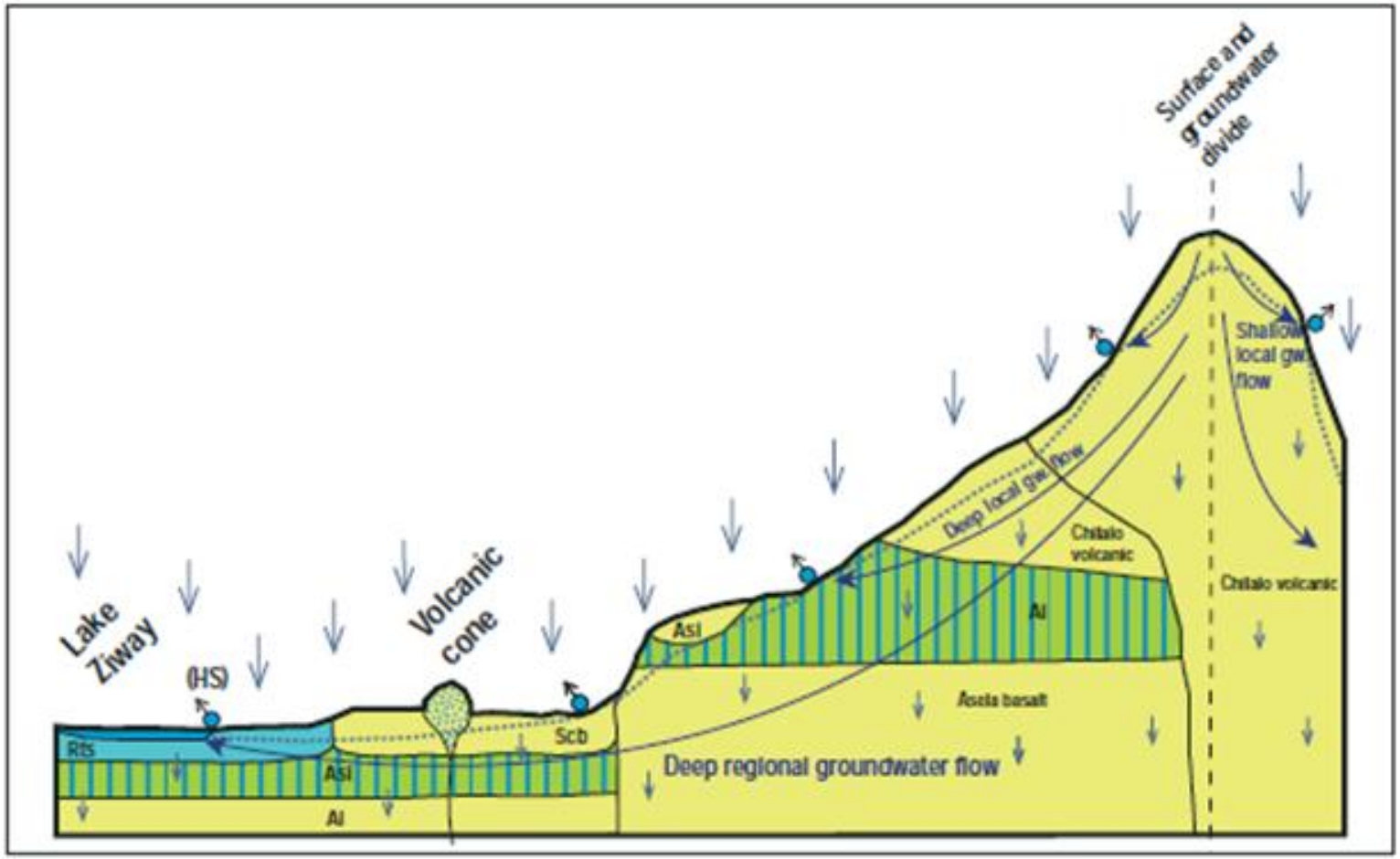
Rift valley - west



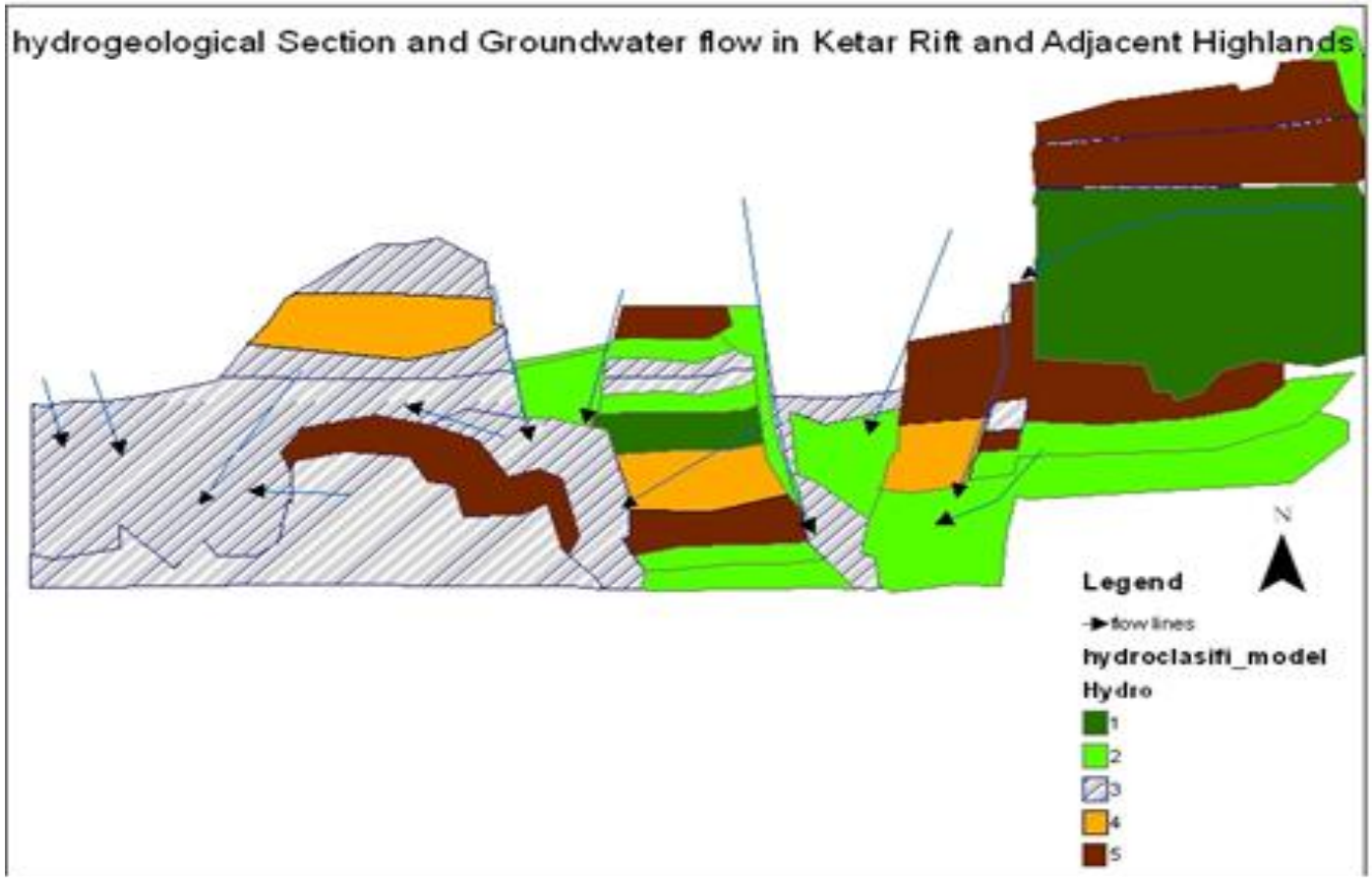
Rift valley – east (Awasa)



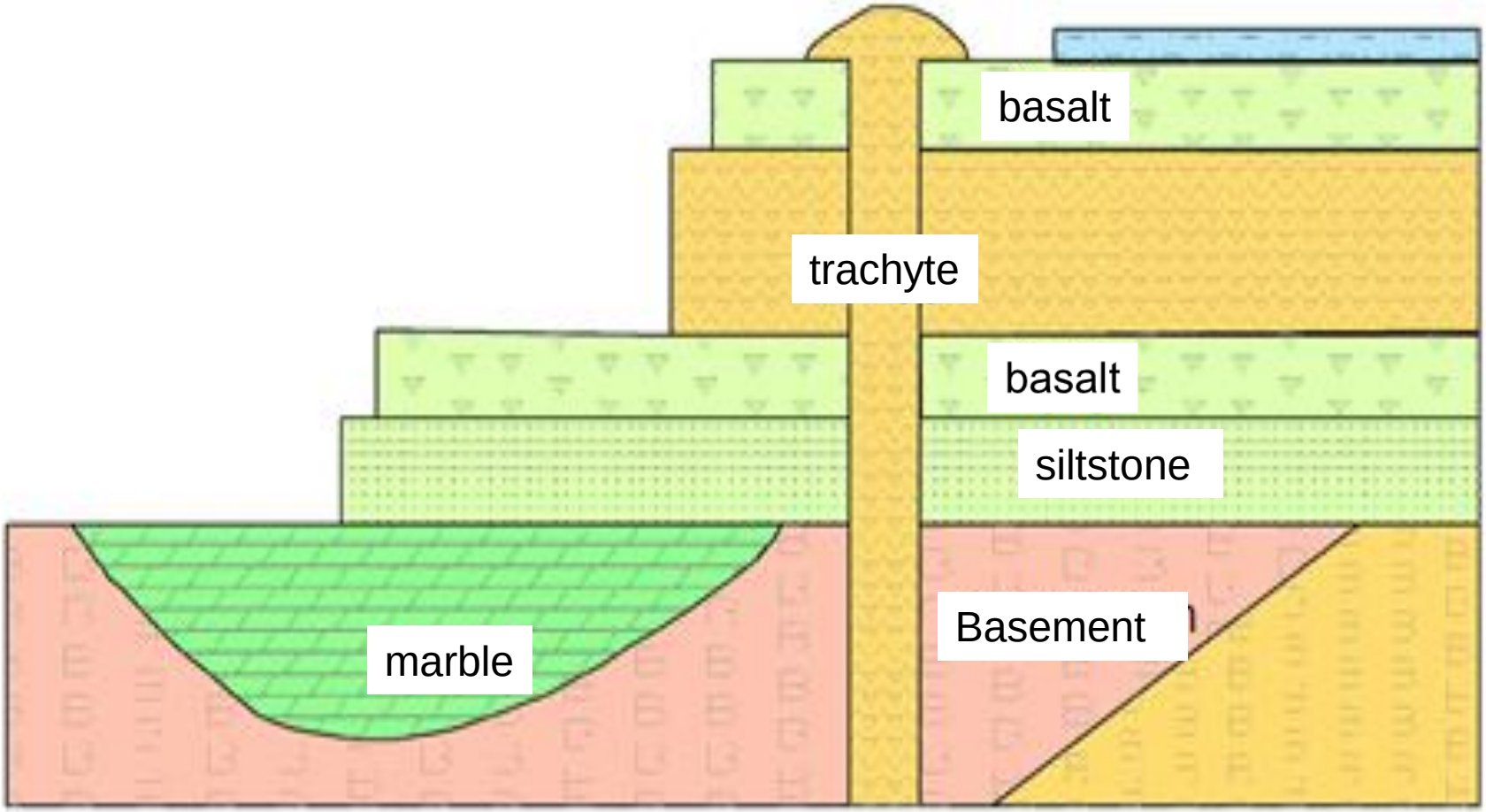
Rift valley – east (Asela)



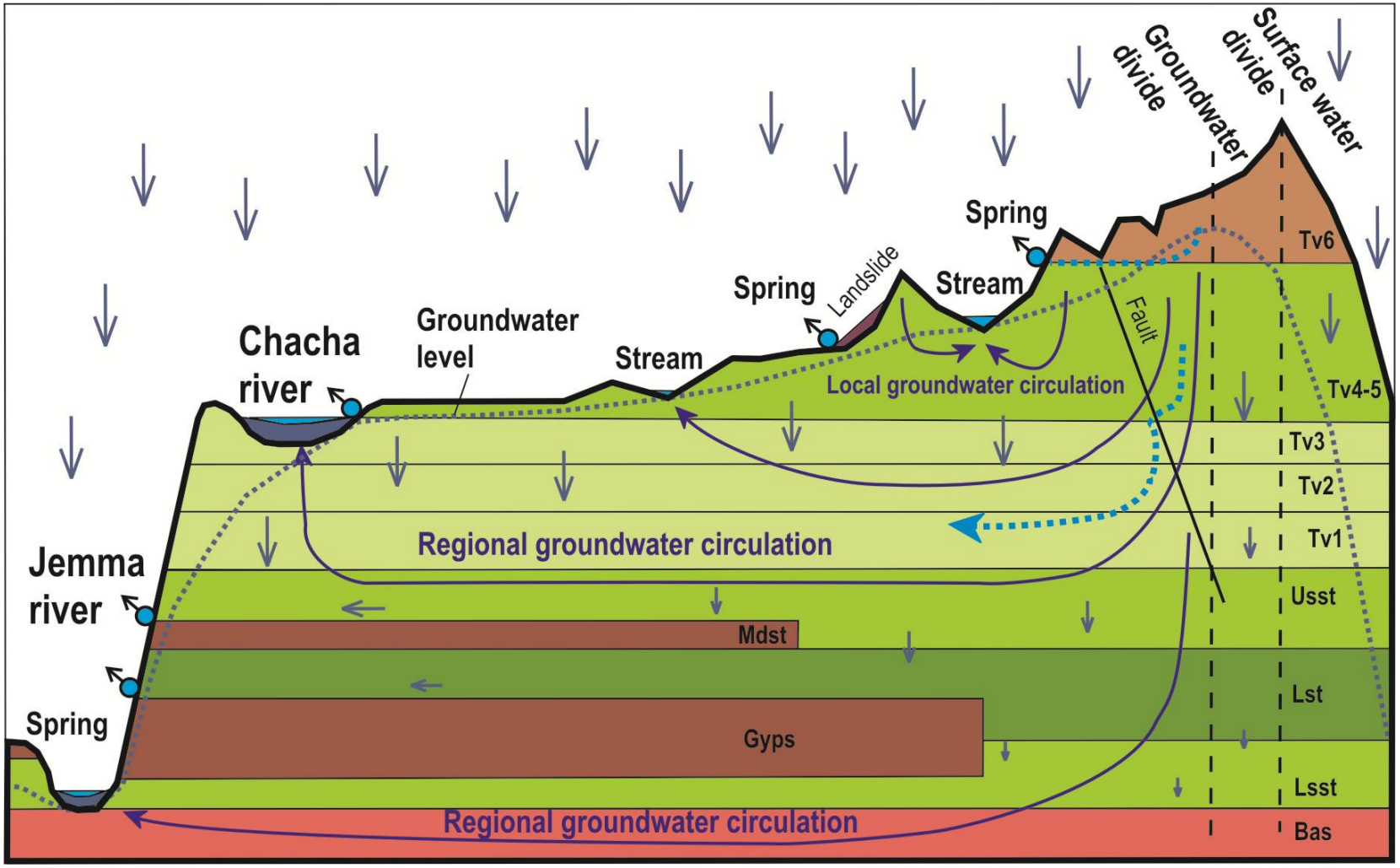
Rift valley – east (Katar – Asela, Demis)



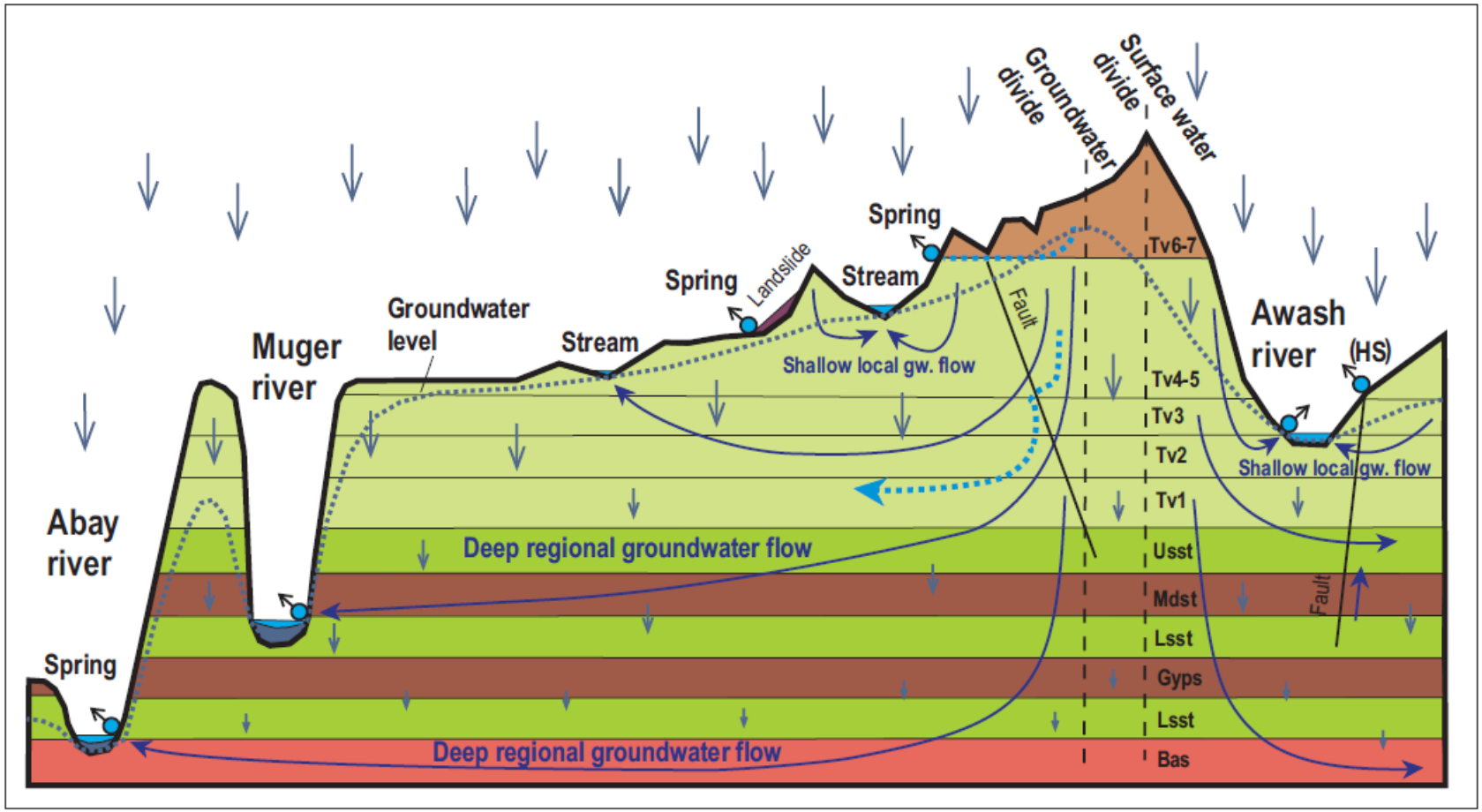
Northen Plateau - Asosa



Hydrogeological – central plateau



Addis Ababa


Groundwater divide
Surface water divide
Spring
Spring
Landslide
Stream
Fault
Groundwater level
Muger river
Stream
Shallow local gw. flow
Awash river
(HS)
Tv6-7
Tv4-5
Tv3
Tv2
Tv1
Usst
Mdst
Lsst
Gyps
Lsst
Bas
Shallow local gw. flow
Abay river
Deep regional groundwater flow
Fault
Spring
Deep regional groundwater flow

Conclusion

Conceptual model lead to definition of strategy for detailed investigation of components required by the this model which will be done by classical methods of geology, hydrogeology, and hydrology and by relevant science-fields like geophysics, hydrochemistry, soil science, geochemistry, isotope physics, etc.