# Hydroecological Processes and Functioning of Groundwater Dependent Ecosystems

**GENESIS 7TH EC FP PROJECT ON GROUNDWATER AND DEPENDENT ECOSYSTEMS**

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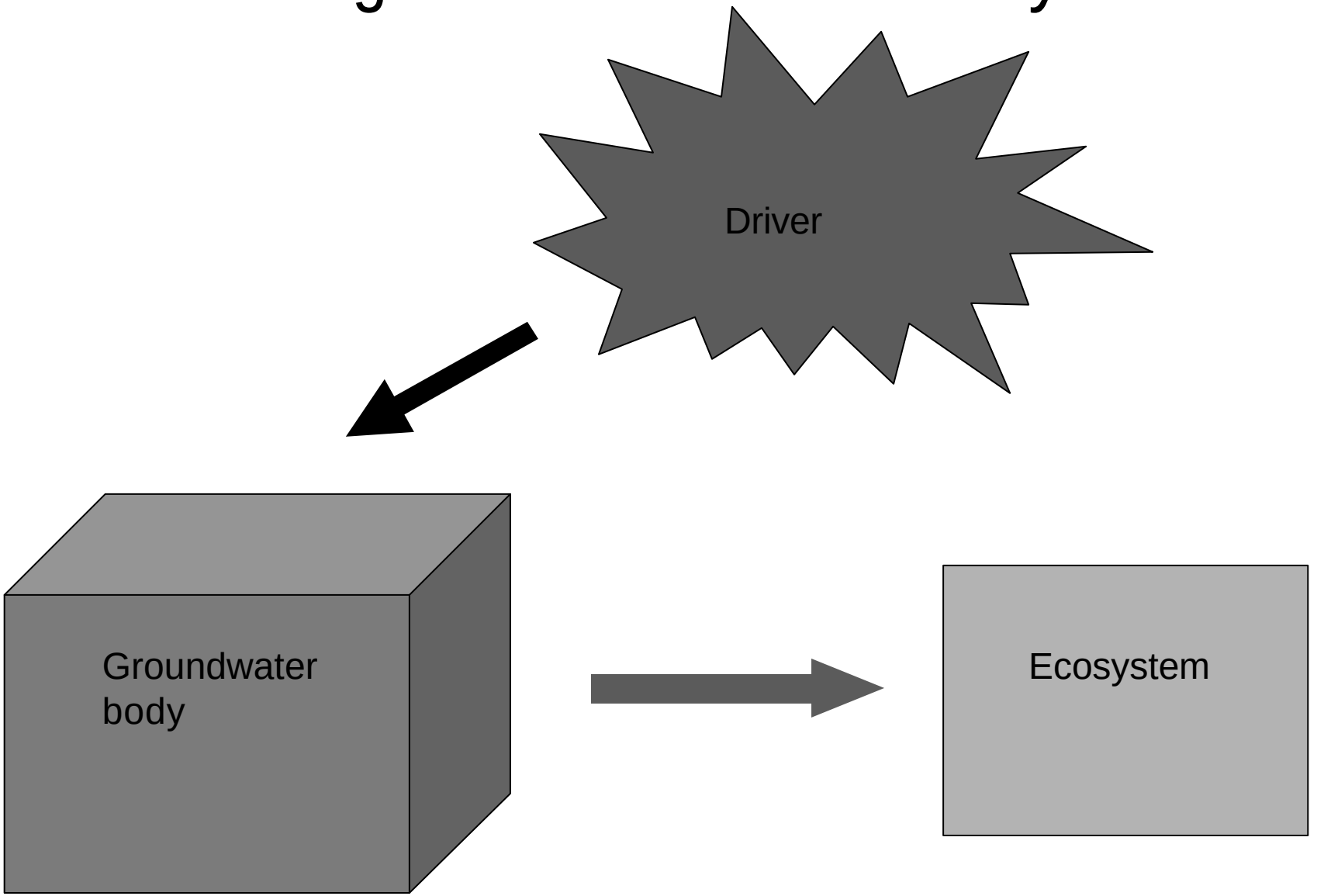
# Background for the presentation

- Provide results of the project that are relevant for determining the interaction between groundwater and ecosystems on groundwater body scale.
- Provide information on how the project results be used by Member States in their risk assessment, status assessment, monitoring activity etcetera for the WFD.
- Interaction between groundwater and ecosystems in light of the WFD.
- Gaps in knowledge and potential GENESIS input based on discussions in the special session.

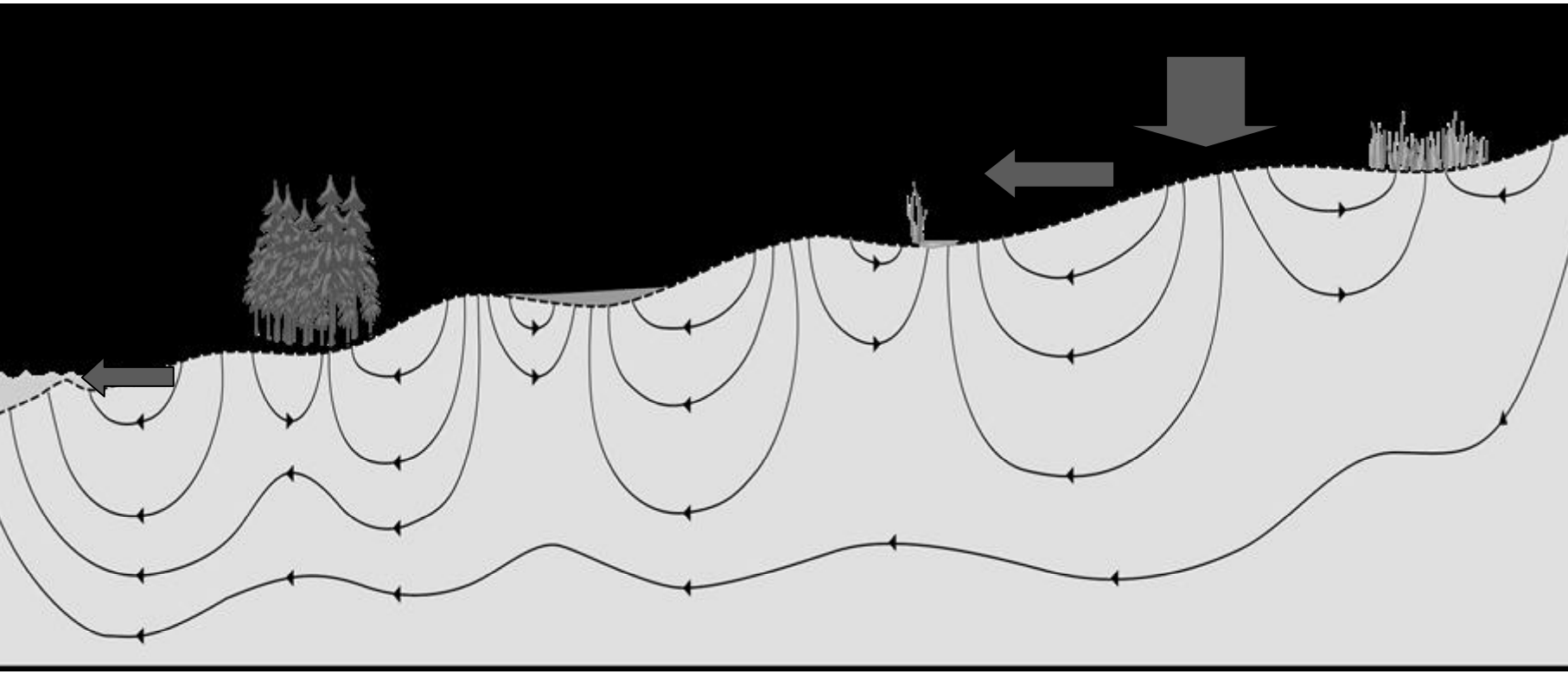
# Content of presentation

- GWD and status assessment
- Risk assessment: drivers, pressures, state, impact, measures
  - Upscaling from individual ecosystems to groundwater body scale
- Groundwater and Ecosystems
  - presentation of some cases

# GWD: groundwater and ecosystems

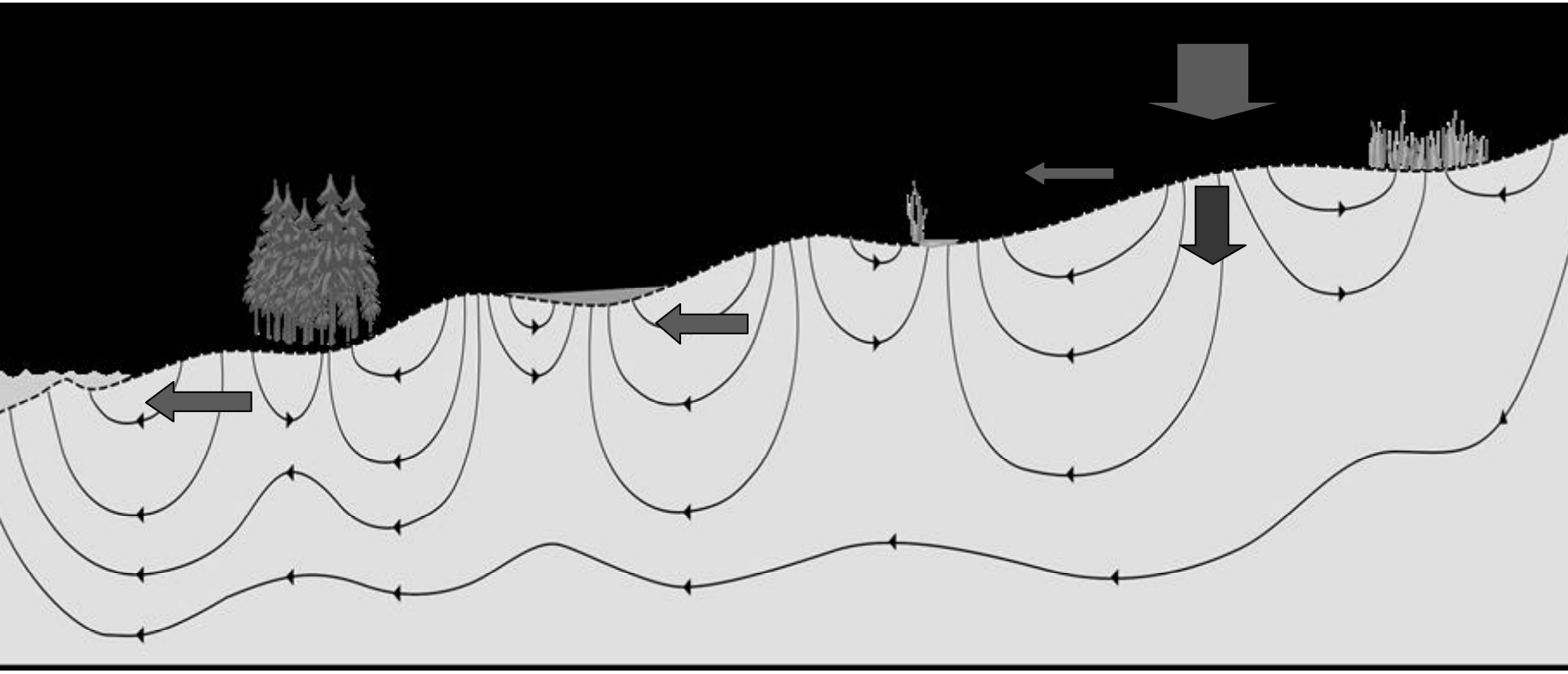


# Ecosystems: drivers, pressures, state, impacts



Groundwater status can be good even if ecosystems status poor if pollution from other sources

# Ecosystems: drivers, pressures, state, impacts



Groundwater status is poor as groundwater status leads to considerable impact in ecosystems

# Considerable impact (CIS No. 12)

- Valuable site is at risk
  - Ecologically important
    - e.g. Natura 2000
  - Socio-Economically important
    - tourism, housing, recreation etc.

- The impact is considerable

# Relevant questions for status assessment

- Quality: Is concentration in groundwater body causing considerable damage to dependent ecosystems
- Quantity: Is the quantity of groundwater changed in such a way that it causes considerable damage to ecosystems

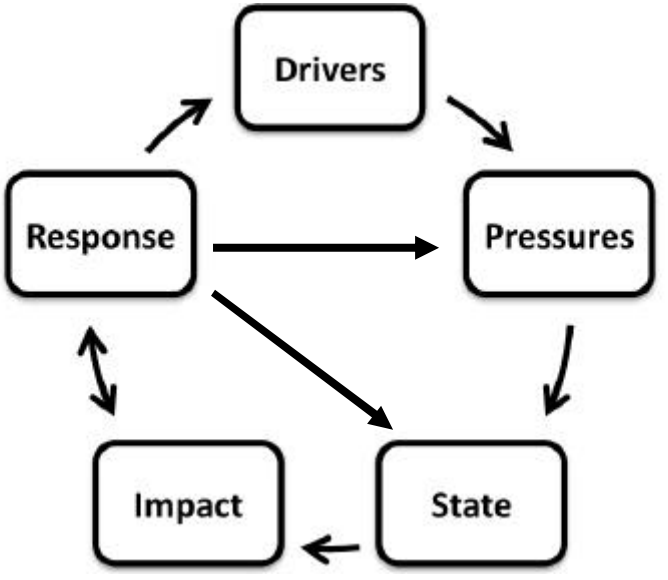
# What information is needed to assess status?

- Status (Qualitative and quantitative)
  - contaminants and pollutants in groundwater
    - For $NO_3$-N the limit is rather high in Annex I if the system is pristine (e.g. Nordic or Alpine situation)
      - evidence exist from pollution and nitrogen removal required from most point sources with environmental permit
    - For pestisides, it seems as the concentration limit set for political reasons. Present limit are old detection limits. No evidence based on ecotoxicology.
    - Other contaminants/pollutants?
      - normally P limiting nutrient in aquatic systems, but the source is not usually groundwater
  - water quantity changes (extraction, drainage etc)
    - there is evidence that quantity changes has considerable impacts on ecosystems

# What information is needed to assess risk?

- Knowledge on the groundwater system and the ecosystems such as a good conceptual model
- Knowledge on drivers, pressures, state and impacts
  - a good conceptual model of risk
- Knowledge on recharge and climate variability

# Impact assessment




| Term | Definition |
|---|---|
| Driver | an anthropogenic activity that may have an environmental effect (e.g. agriculture, industry) |
| Pressure | the direct effect of the driver (for example, an effect that causes a change in flow or a change in the water chemistry. |
| State | the condition of the water body resulting from both natural and anthropogenic factors (i.e. physical, chemical and biological characteristics) |
| Impact | the environmental effect of the pressure (e.g. fish killed, ecosystem modified) |
| Response | the measures taken to improve the state of the water body (e.g. restricting abstraction, limiting point source discharges, developing best practice guidance for agriculture) |

# Drivers at GW body scale (hydrology)

**Hydrology**

- Irrigation and drainage
- water extraction
- soil extratction and mining
- water construction
- impervioUos structures (pavements)
- roads and tunnels
- hydropower and regulation
- forestry and peat extraction
- climate change
- etc

**Water quality (chemistry)**

- agriculture
- forestry
- mining
- urban areas and households
- dumps
- industry
- etc

# Pressures

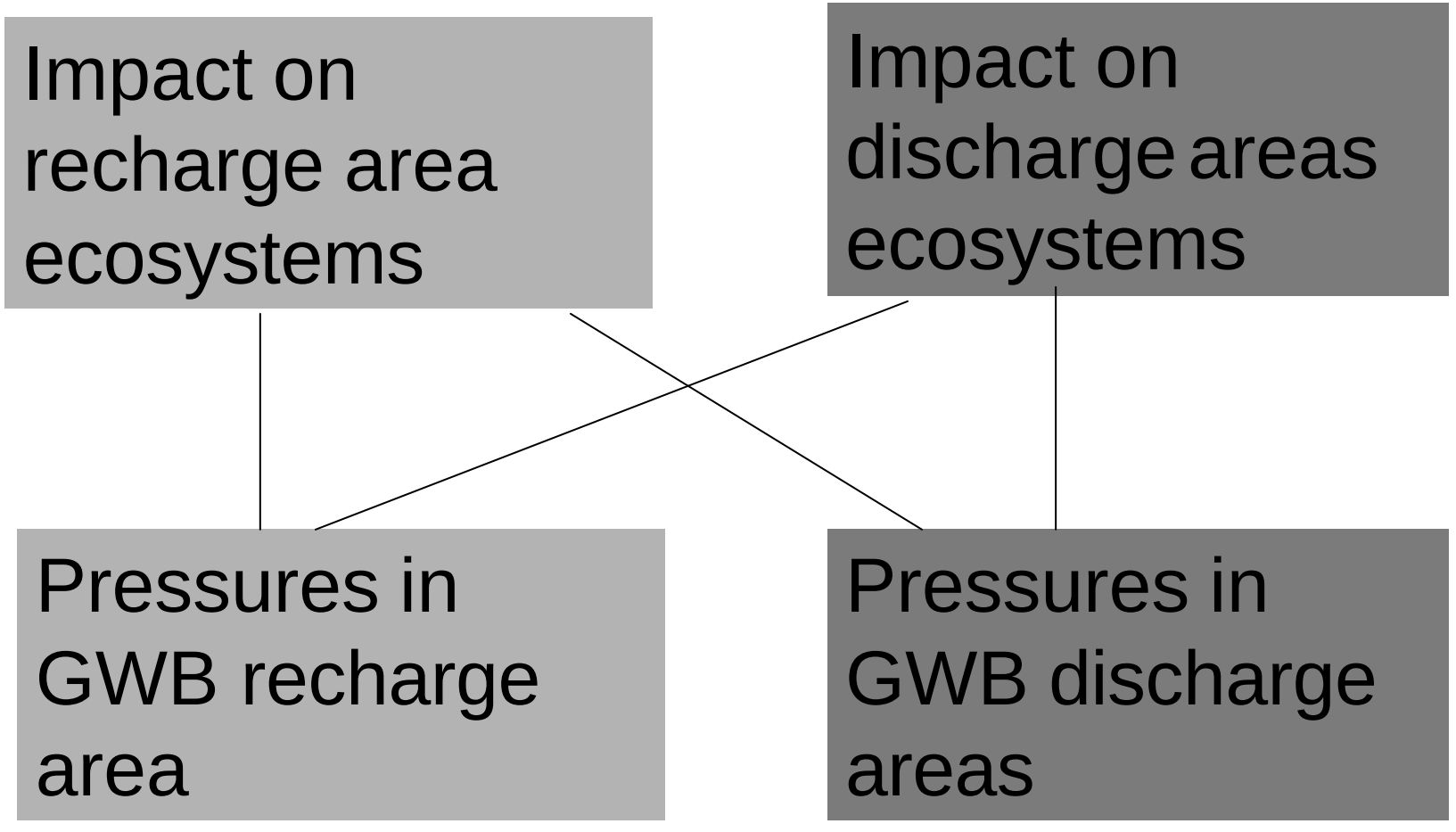
**Quantity**

- amount of recharge
- timing of rain/melt
- spatial distribtution changes
- water balance componenets
- etc

**Quality**

- nutrient loading
- toxic comounds
- erosion
- etc

# Ecosystem impacts?

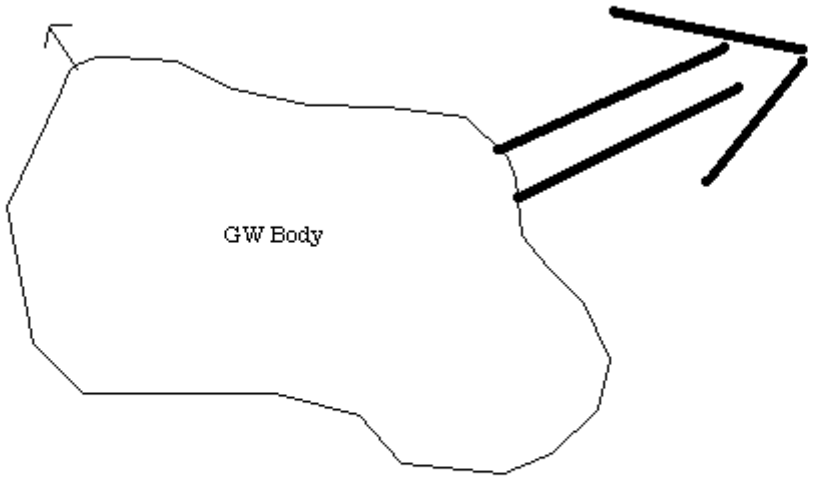



unconfined and confined aquifers?

# Vulnerability

- aquifer and catchment properties
- geology
- ecosystems
- land-use, water use, climate change
- the current state of ecosystem (most systems have been disturbed)
- groundwater/surfacewater/precititation portion

# Spatial aspects

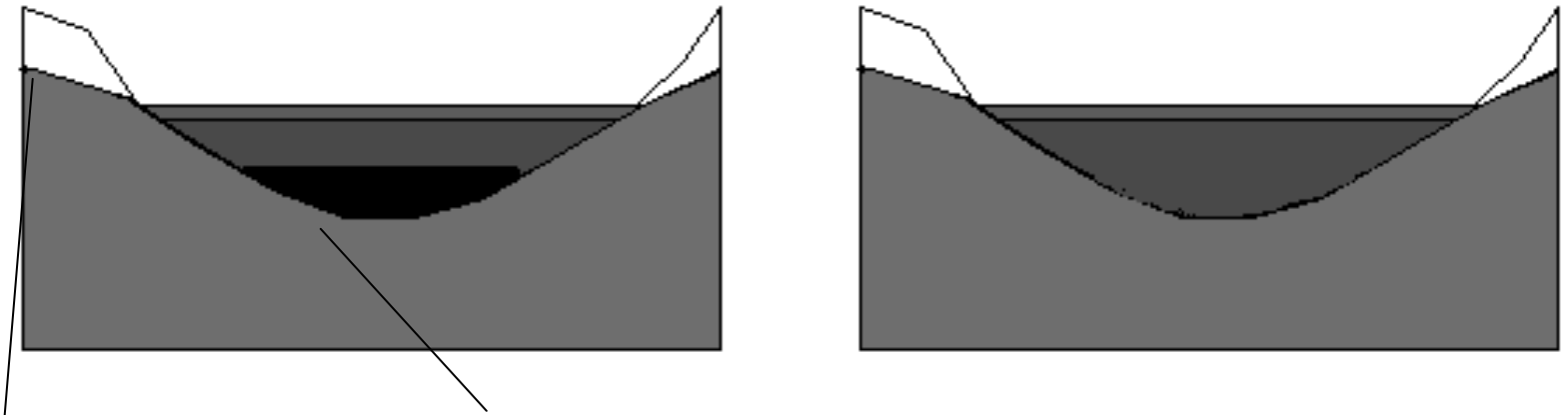



•GW discharge varies. Ecosystems that recieve little discharge can be more vulnerable to small changes if they dry out to extraction in the GW body. Several systems connected to roundwater bodies (surface water, springs, wetlands, terrestrial systems).

•Quality requirements might vary between systems and within a system.

•Operations in the discharge are with high exfiltraton can impact the GW body more than operations in areas with less flow (conductive layers near high exfiltration points).

# Geology and vulnerability



Clay layer can protect from drainage impacts

A large uphill catchment or aquifer can provide much water making the system less vulnerable to pressures

# Temporal aspect

- CIS No 3 “the abstraction of a certain volume of water may have no impact if pumped throughout the year, or be a significant pressure if taken out of a river only during the 2 summer months”
- Vulnerability should not be assessed for mean recharge but a smaller recharge based on assessment of climate variability patterns

# Conceptual models to evaluate risk

- For the aquifer recharge-discharge and ecosystems

- For the driver-pressure-impact or driver-pressure and evaluate impact (ecosystem risk)

# Groundwater contact with ecosystems

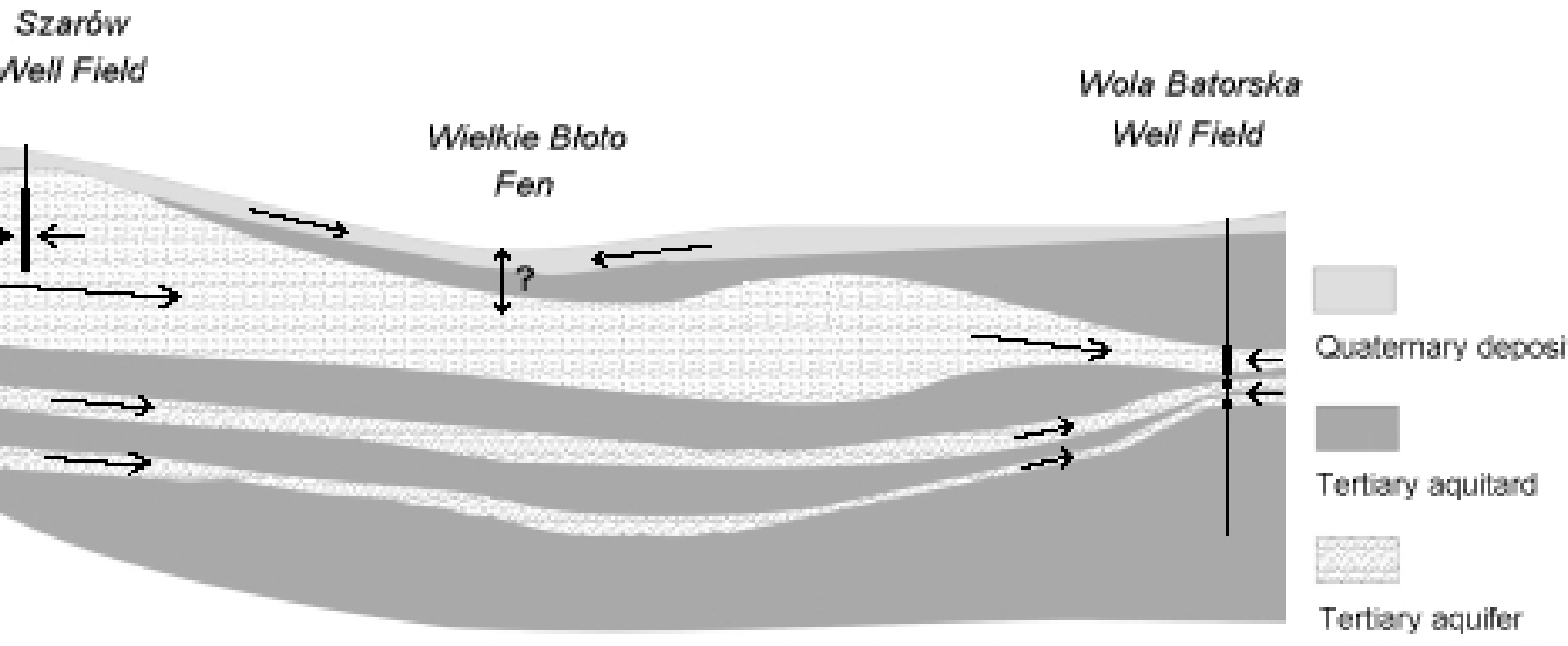
- Aquifer contact (groundwater body contact)
- Groundwater (not aquifer) contact
- Seawater intrusion and groundwater
- Fractured rock
- Karstic systems
- etc

Some ecosystems depend on various water sources

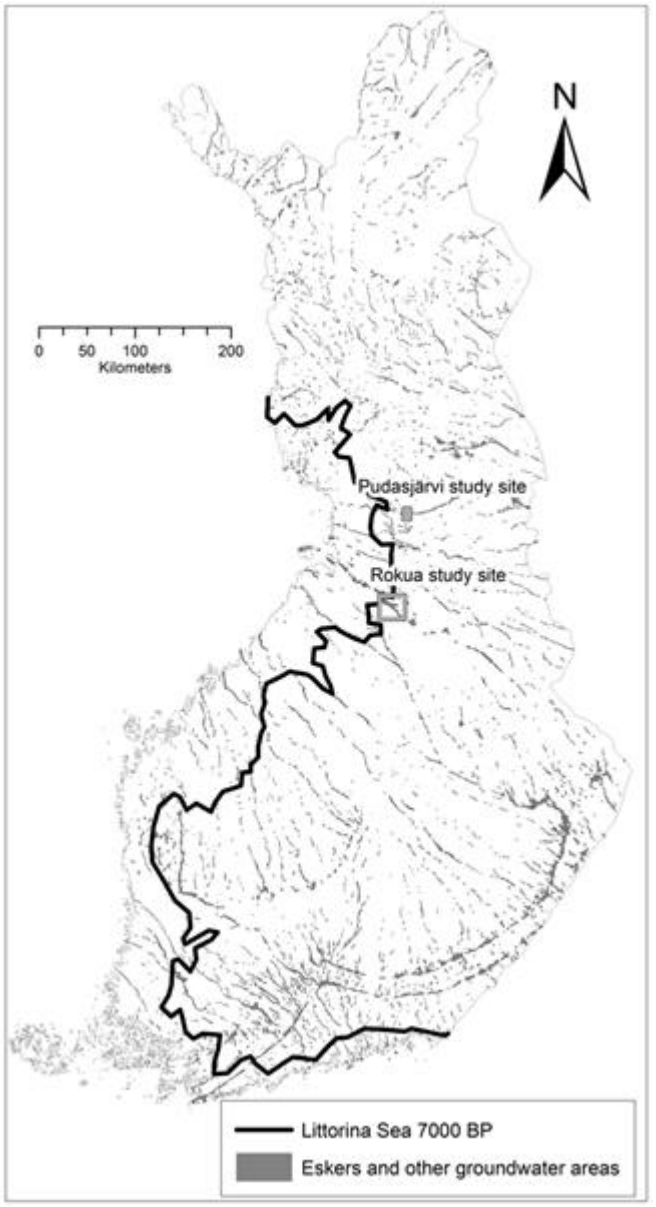
# Examples

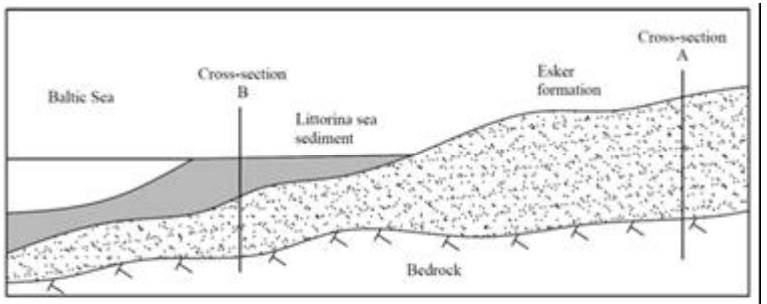
- Switzerland (UNINE), Poland (AGH), Norway (Bioforsk), Finland (UOULU)
- GW-SW interaction
- Driver, pressure, state, impact, measures (Esker in Finland)

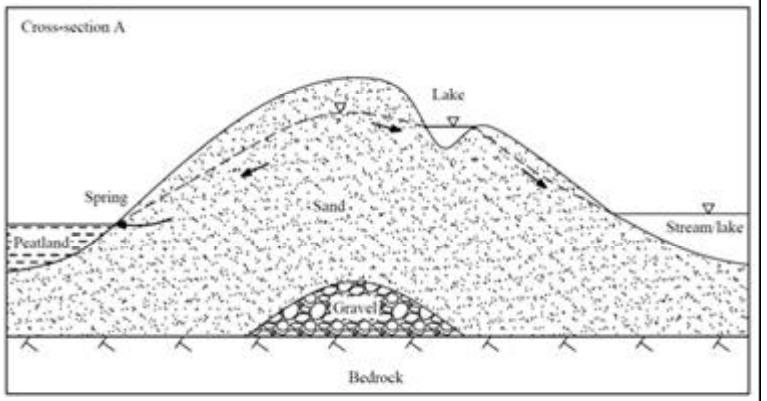
# Wet forests and fen

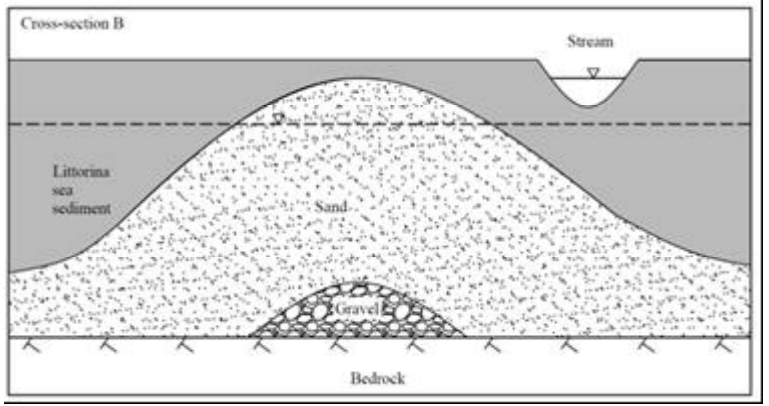


# Aquifers (Eskers) in Finland

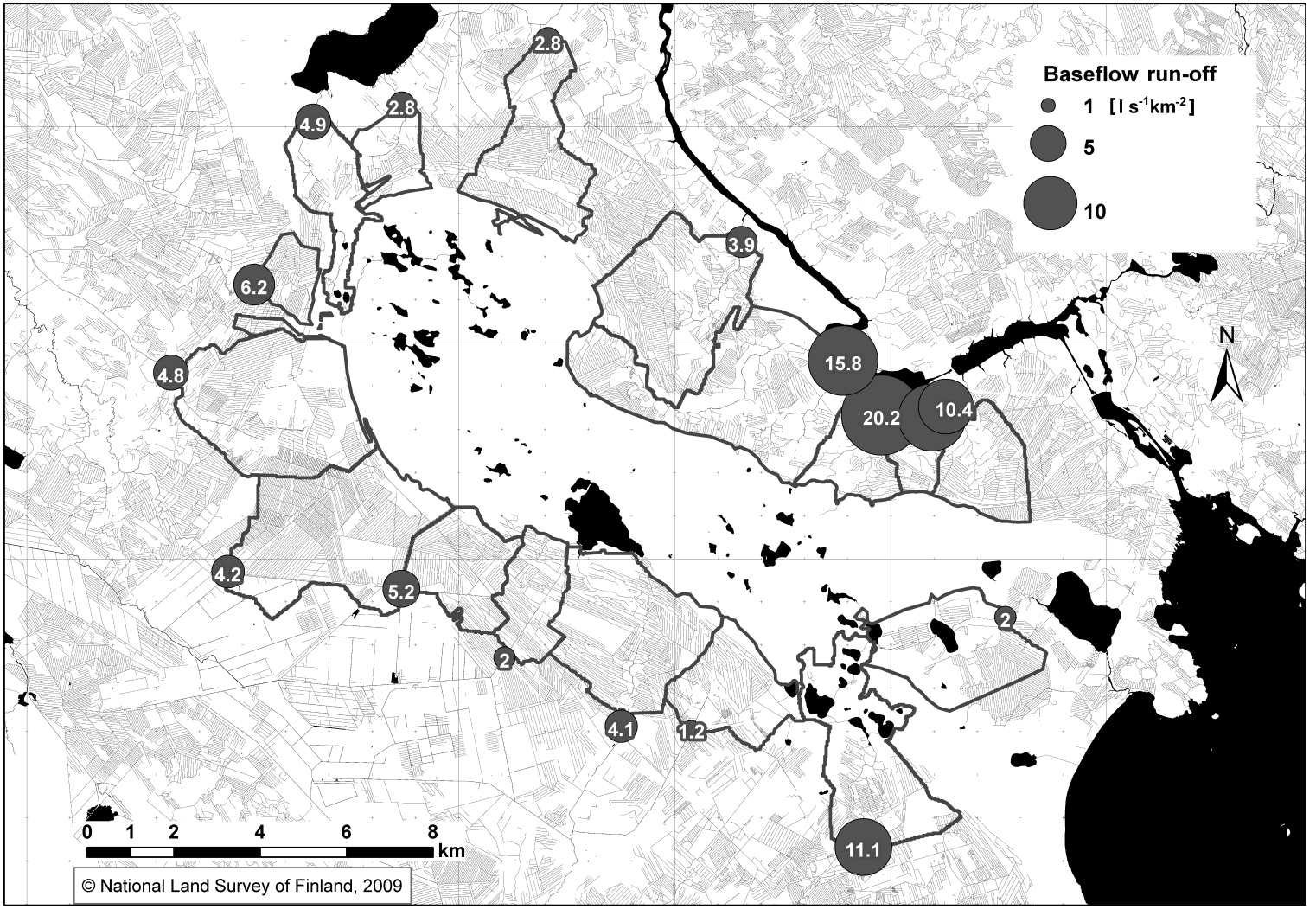


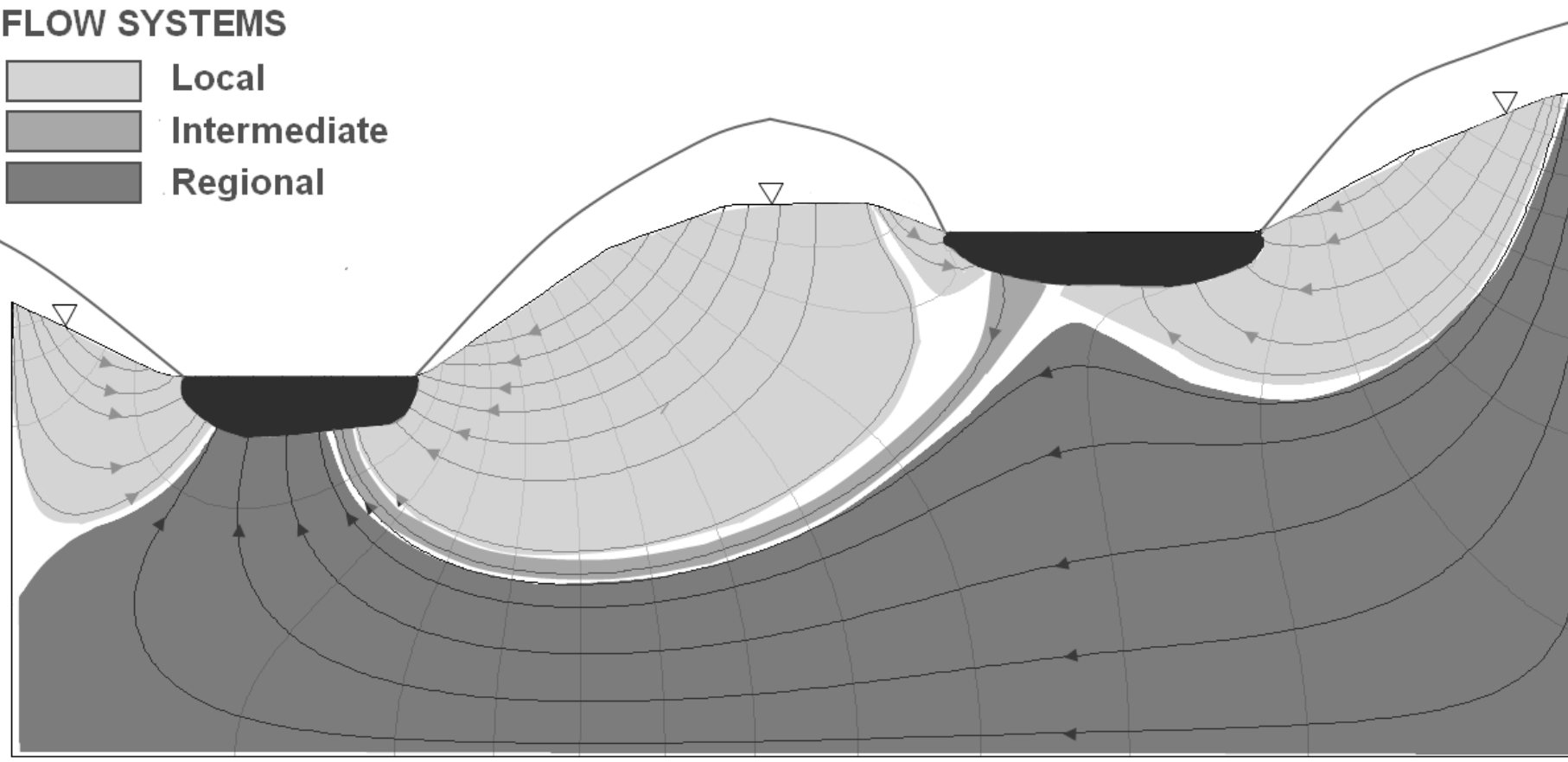



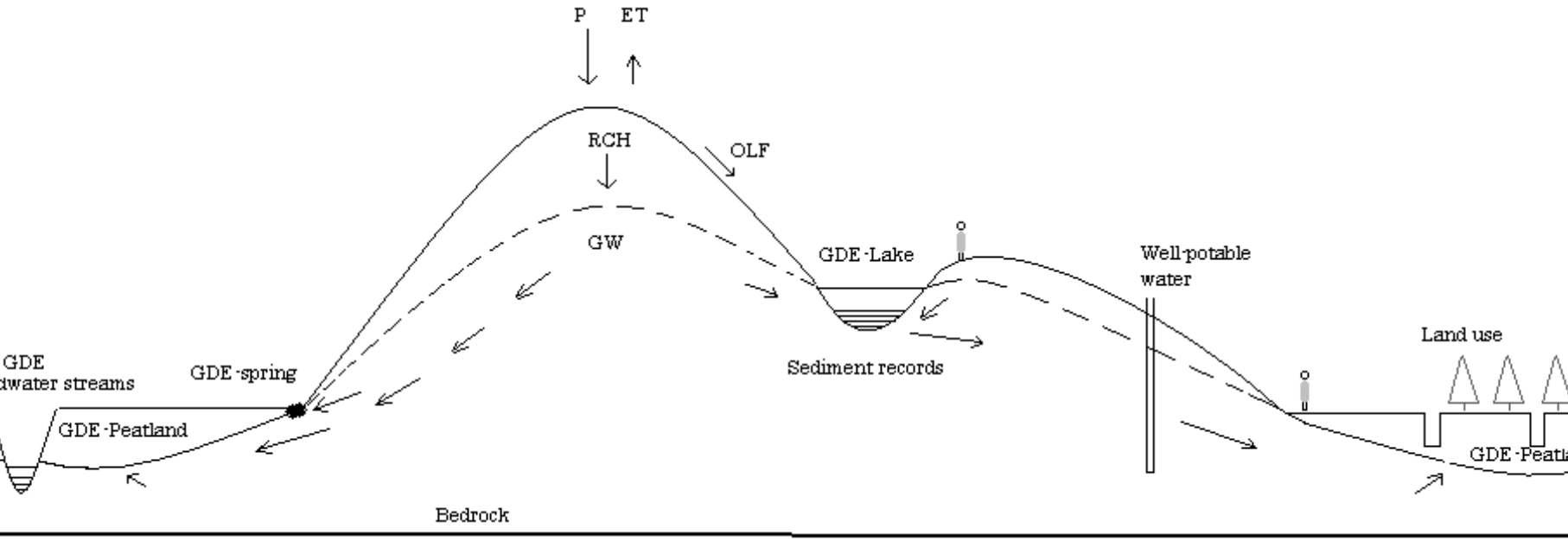
# Rokua aquifer: Recharge and discharge



# Lakes GW-SW interaction



# Conceptual model



# Risk conceptual model

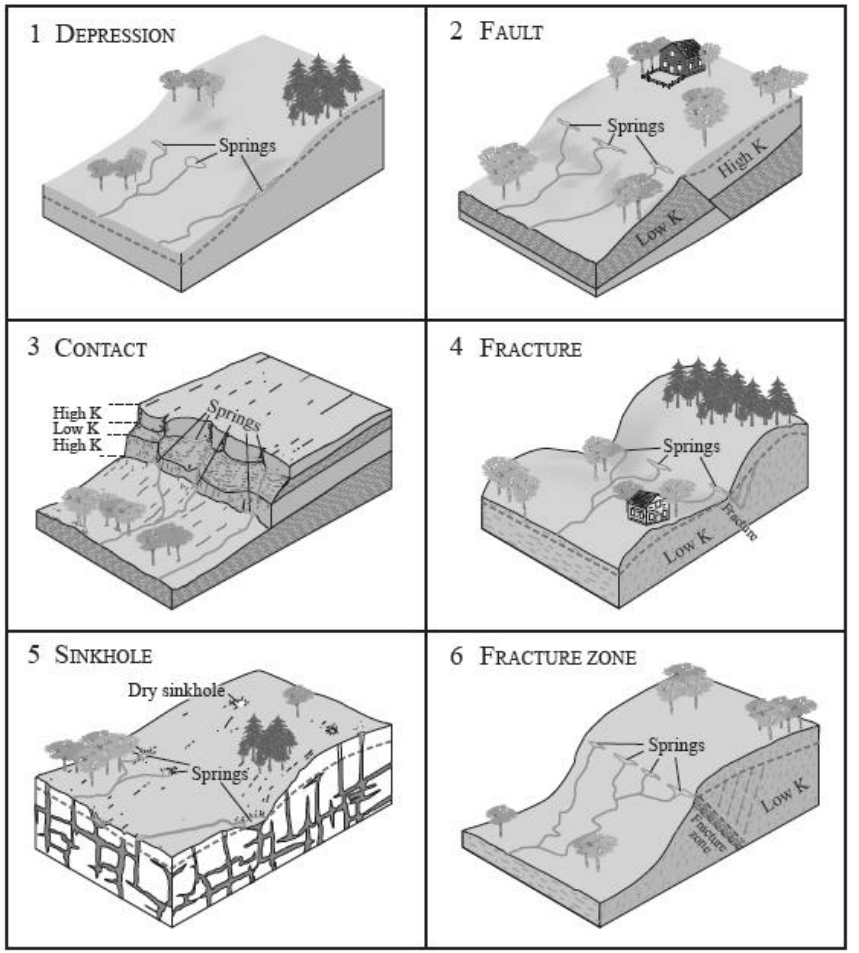
| **Driver** | **Pressure** | **State** | **Impact** |
|---|---|---|---|
| **Forestry**, peat harvesting, agriculture | Drainage | Lower GW level in esker | Lake level decline, loss of property values, and ecosystem services |
| Climate change | Increased droughts (P, ET, snow) and less recharge | Lower GW in esker | Lake level decline, loss of property values, and ecosystem services |

Scientific evidence from monitoring showing the impact of forest ditches:
•P-ET increased the last 20 years, but the groundwater table decreased
•Modelling to study impact of ditches and climate variability (not yet ready)

Measures:
•Continue as before
•Restore dicthes (research must be carried out to demonstrate benefit)
•Prevent drainge at risk sites (research is needed to show how ditching influence GW drainage)
•Expand protection of GW protection areas (research and discussions needed to justify actions)

# GENESIS CONTRIBUTION TO ECOSYSTEMS-GWD

- Review of groundwater dependent ecosystems
- Classification of systems
- GW-SW interaction
- Groundwater flowpaths
- Groundwater and ecosystem conceptual models
- Vulnerability
- Indicators
- Impact of land-use and climate change
- Providing examples and methodology from cases and research
- Concepts of ecosystems impacts and how to protect ecosystems (from a multidisciplinary group)




ENVSCI 905 1–12

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ENVIRONMENTAL SCIENCE & POLICY XXX (2011) XXX–XXX

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# Groundwater dependent ecosystems. Part I: Hydroecological status and trends

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# Summary

ecosystems are complex and depend on various water sources

impacts on GW-body scale can cause changes in dependent ecosystems

- pollution e.g. NO3-N
- less water during droughts to ecosystems, impacts not well known

groundwater interact in many ways with ecosystems

- research still needed

impacts on ecosystems depend on several issues

- vulnerability

conceptual models needed for main systems in each region/MS

- groundwater-ecosystem interaction at the GW body scale including recharge and discharge
- risk driver-pressure-status-impact (inlcuding sosio-economic systems)
- variability and unceratinty in conceptual model, climate, scientific evidence
- research is need on different systems to get correct and accurate models

research and discussion needed on the issue to provide input to policy