LATVIAN ENVIRONMENT, GEOLOGY AND METEOROLOGY CENTRE

Transboundary groundwater bodies assessment in Gauja-Koiva and Salaca-Salatsi river basins

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Interreg Estonia-Latvia
European Regional Development Fund

EUROPEAN UNION

WaterAct
Joint actions for more efficient management of common groundwater resources

WP2 Assessment of common groundwater resources in Gauja-Koiva and Salaca-Salatsi river basins

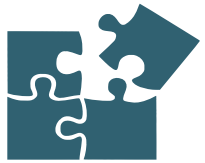
WP2 A.T2.2 Asessment of the status of transboundary GWBs according to harmonized principles

Subtasks included in the activity:

- Transboundary GWB delineation in Gauja-Koiva and Salaca-Salatsi river basins;
- Initial characterization of transboundary GWBs;
- Overall status assessment;
- Recommendations for future.

1. Transboundary GWB delineation in Gauja-Koiva and Salaca-Salatsi river basins

1. Data collection. Information exchange on geological/hydrogeological settings and GWBs – created joint google document;



2. Harmonization. Unified stratigraphy, GWBs grouping (by aquifer systems);

3. Transboundary GWBs identification (developed maps, cross-sections, GW flows, watersheds, discussions).

Stratigraphic unit comparision of geological formations in Latvia and Estonia

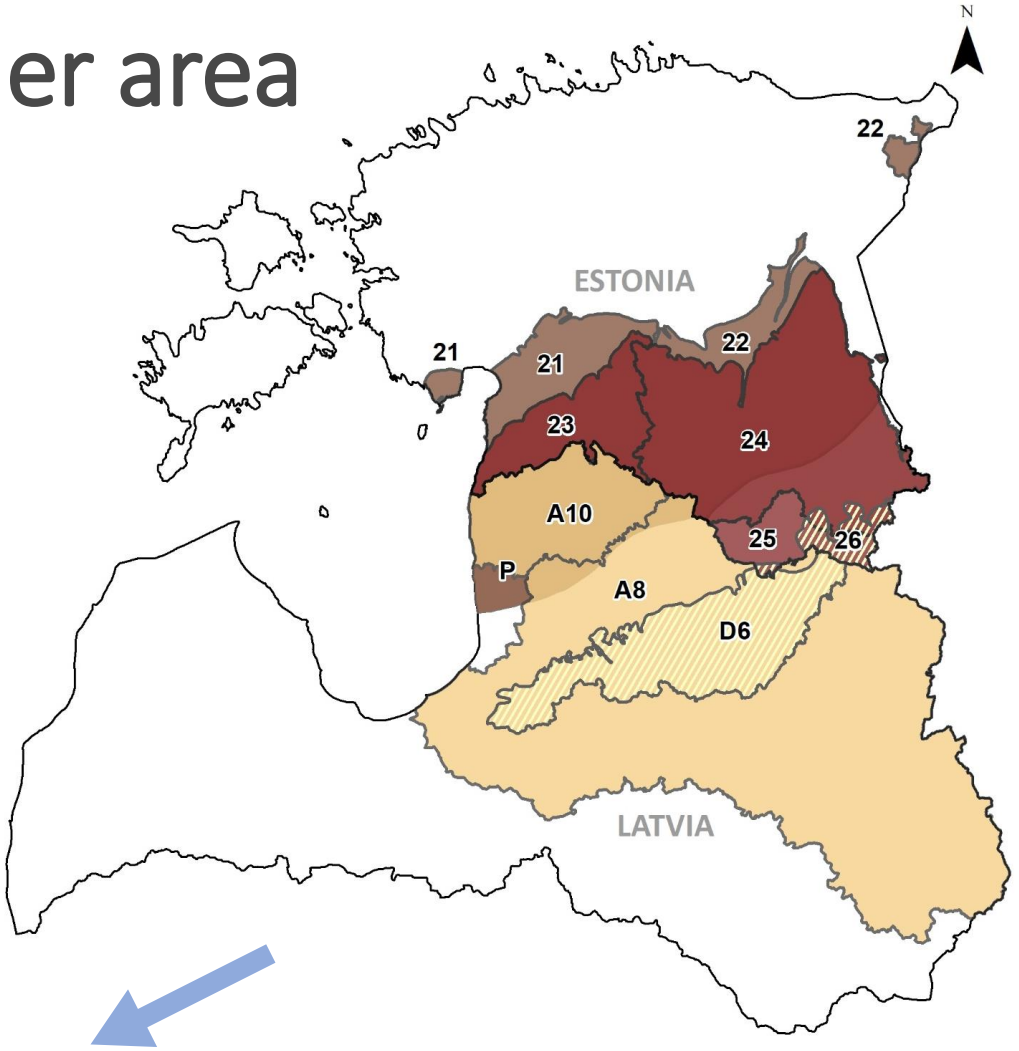
Aquifers	Geological index (LV)	Geological index (EE)	Dominant sediments	Aquifer system (GWBs)
Quaternary	Q	Q	Sand, loam	Quaternary (attached to each GWB)
Stipinai	D_3stp	-	Dolomite, marl	Pļaviņas-Stipinai (LV GWBs D6 and EE GWB 26)
Katleši-Ogre	D_3og	-	Sandstone, marl	
	D_3kt	-	Sandstone, marl	
Daugava	D_3dg	D_3dg	Dolomite, limestone	
Salaspils	D_3slp	D_3db	Marl, gypsum, limestone	
Pļaviņas	D_3pl	D_3pl	Dolomite, limestone	
Amata	D_3am	D_2am	Sandstone, siltstone	Aruküla-Amata (LV GWBs A8 and A10, EE GWBs 23, 24 and 25)
Gauja	D_3gj	D_2gj	Sandstone, siltstone	
Burtnieki	D_2br	D_2br	Sandstone, siltstone	
Aruküla	D_2ar	D_2ar	Sandstone, siltstone	
Narva reģional aquitard D_2nr			Marl, clay	
Pärnu	D_2pr	D_2pr	Sandstone, siltstone	Lower-Middle Devonian (LV GWB P, EE GWBs 21 and 22)
Rēzekne	D_1rz	D_1rz	Marl, sandstone	
Ķemeri	D_1km	D_1km	Sandstone, siltstone	
Gargždai	D_1gr	-	Sandstone, siltstone	
Tilžė	-	D_1tl	Sandstone, siltstone	
Ordovician and Silurian regional aquitard O-S			Marl, solid limestone	
Cambrian	C	Ca	Sandstone, siltstone	Vendian-Cambrian
Vendian	V	V	Sandstone, siltstone, gravelite	
Archean and Proterozoic crystalline basement AP-PR			Gneiss, granite	

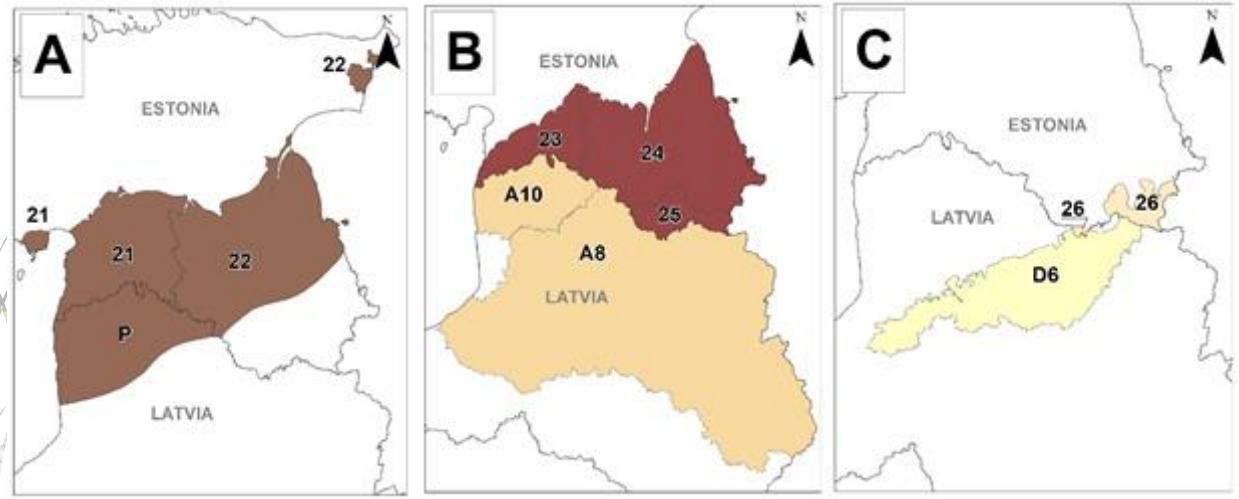
GWBs in Latvian-Estonian border area

Identification

- 10 GWBs in LV-EE border area (6 EE and 4 LV)

- Harmonization – grouped in 3 groups (by hydrogeological settings – aquifer systems)
  1. Lower-Middle devonian (A);
  2. Middle-Upper devonian (B);
  3. Upper devonian (C);

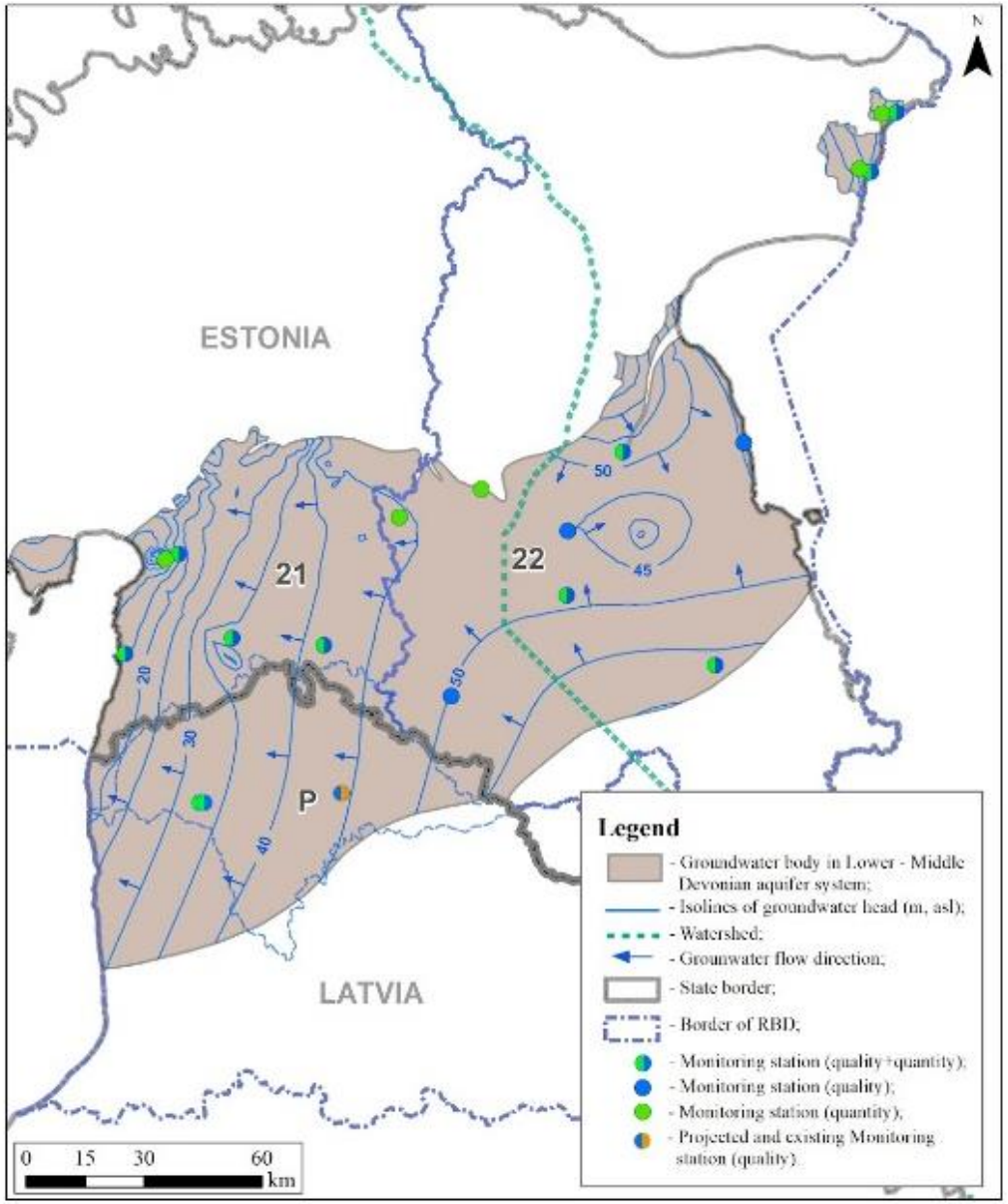




Identification of transboundary GWBs

1.GWBs in **Lower-Middle Devonian** aquifer system

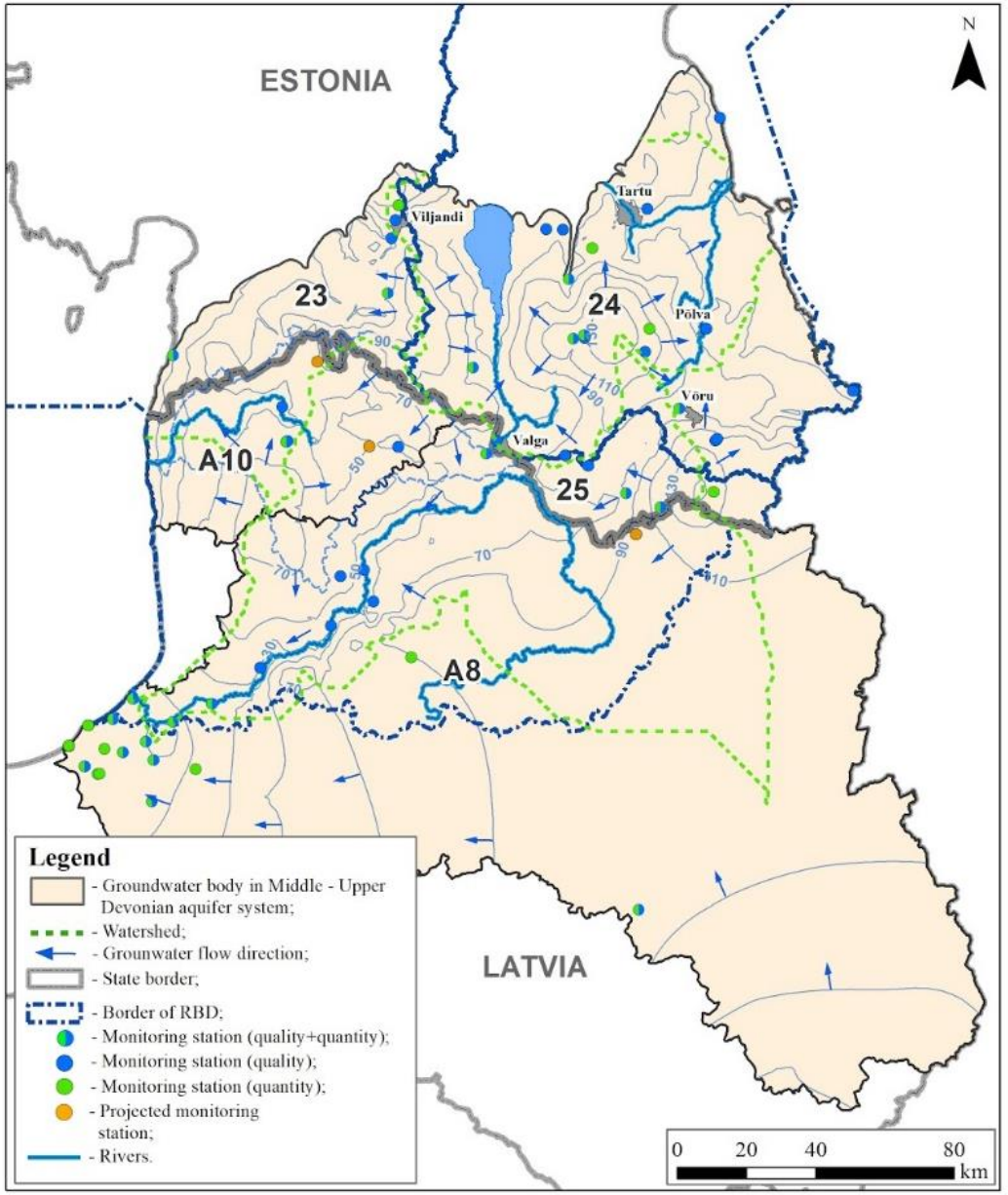
GWBs	21, 22, P
RBDs	3 (East and West-Estonian RBDs, Gauja-Koiva RBD
Situation	
• Deeper GWBs not strictly related to RBDs; • Hydrogeologicaly connected; • GWB 22 – not in Gauja/Koiva or Salaca/Salatsi river basin;	



Identification of transboundary GWBs

2.GWBs in **Middle - Upper Devonian** aquifer system

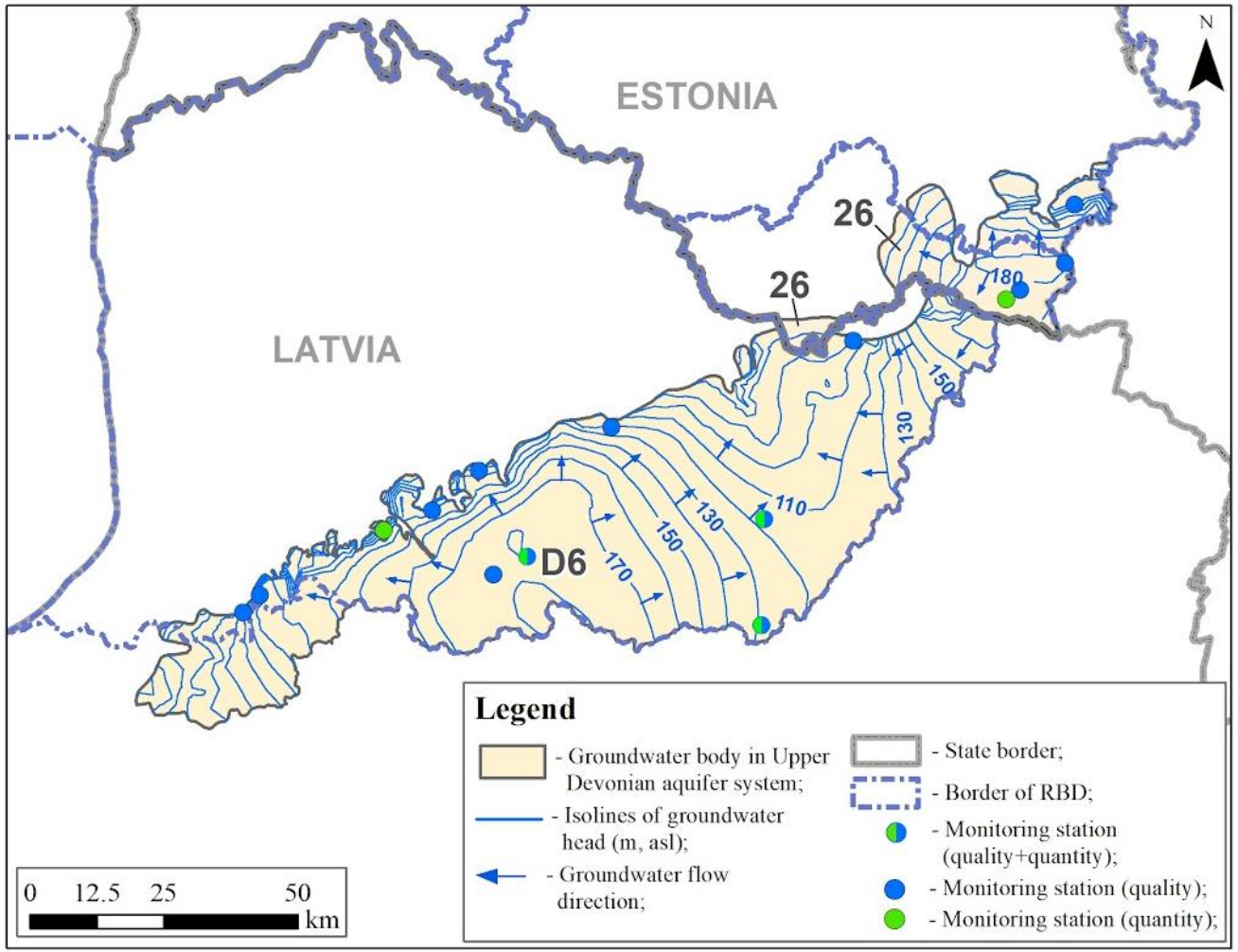
GWBs	23, 24, 25, A10, A8
RBDs	3 (East and West-Estonian RBDs, Gauja-Koiva RBD
Situation	
• Hydrogeologicaly connected: 23 with A10; 25 with A8; • GWB 24– not in Gauja/Koiva or Salaca/Salatsi river basin;	



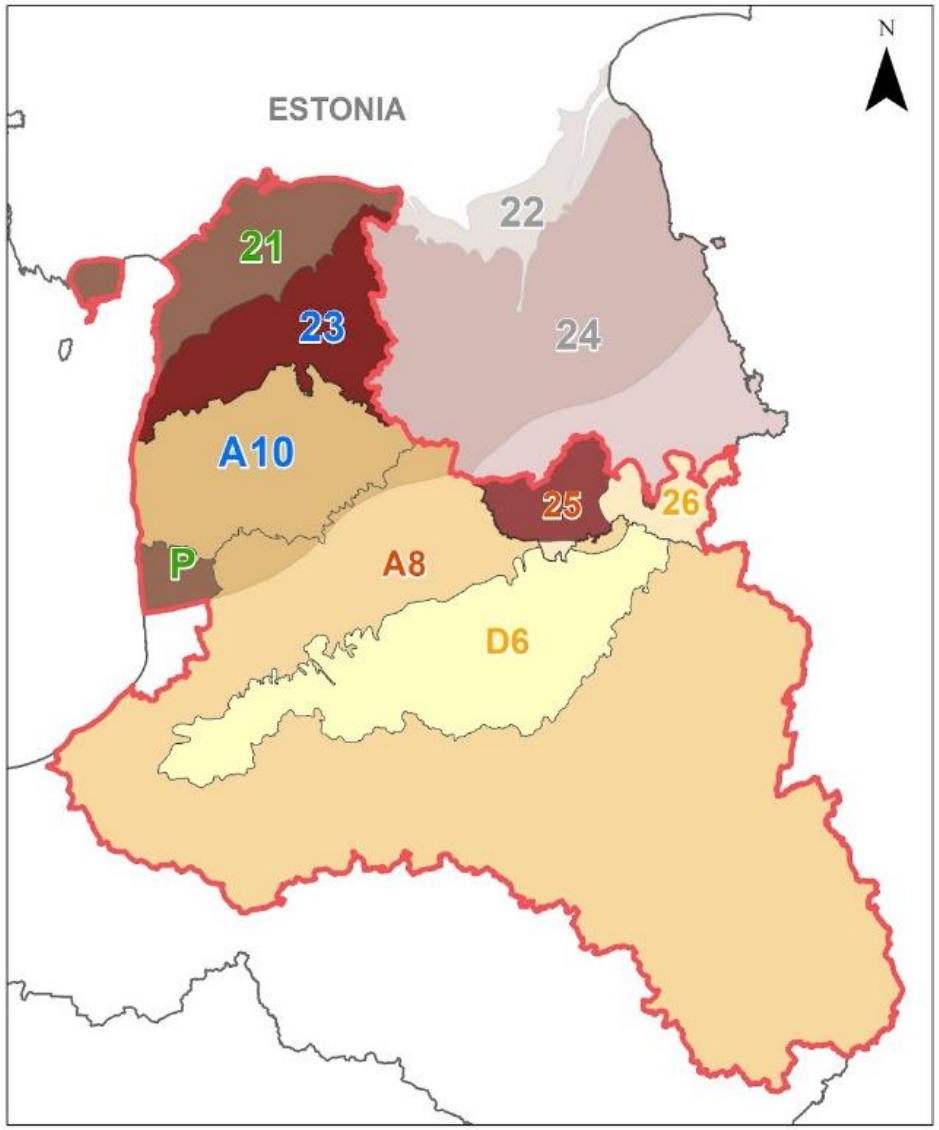
Identification of transboundary GWBs

3.GWBs in **Upper Devonian** aquifer system

GWBs	26, D6
RBDs	Gauja-Koiva RBD
Situation	
• More related to RBD; • Hydrogeologicaly connected;	



Result of Latvian-Estonian transboundary groundwater body delineation



List of transboundary GWBs in Gauja/Koiva & Salaca/Salatsi RBs

Latvian GWBs	Estonian GWBs
Upper Devonian aquifer system	
D6	26
Middle - Upper Devonian aquifer system	
A8 A10	25 23
Lower - Middle Devonian aquifer system	
P	21

2. Initial characterization of transboundary GWBs

Transboundary GWB	National GWB	Area (km^2)	Area (km^2)	Aquifer characterization		Main use	Overlying strata (m)	Criteria for importance
				Aquifer Type	Confined			
GWB-1 Upper Devonian	D6	5617.1	4891	F,P, K	Yes	DRW, IND	0-180	GW resources; GW use
	26		726.1					
GWB-2 Upper-Middle devonian	A8	28 671	27349	P	Yes	DRW, IND	0-200	GW resources; GW use
	25		1322					
GWB-3 Upper-Middle devonian	A10	5662	3321	P	Yes	DRW, IND	0-155	GW resources; GW use
	23		2341					
GWB-4 Middle-Lower Devonain	P	8844	4394	P	Yes	DRW, IND	0-280	GW resources; GW use
	21		4450					

2. Initial characterization of transboundary GWBs

Conceptual model (1)

Situation for GWB-1 (D6 & 26)

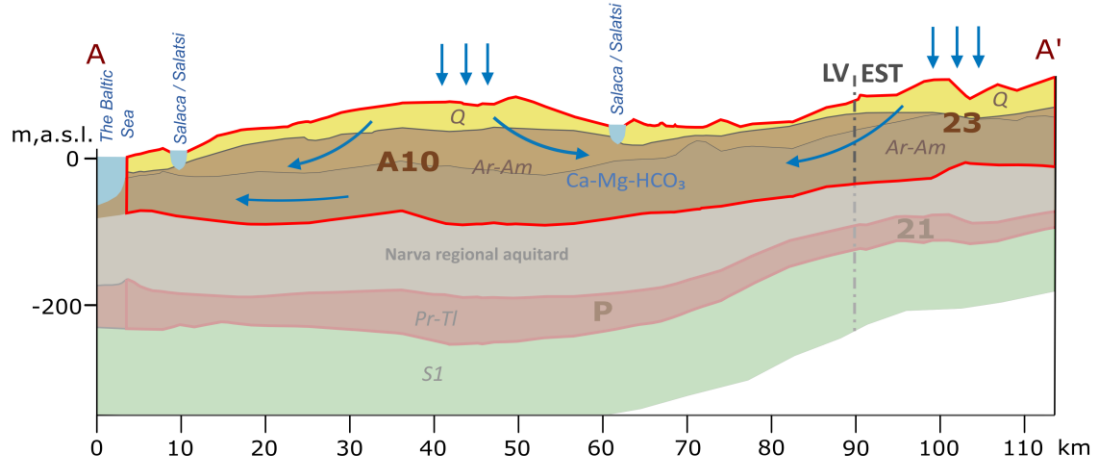
A common table for characterization / conceptual understanding was developed (WP1, AT1.1)

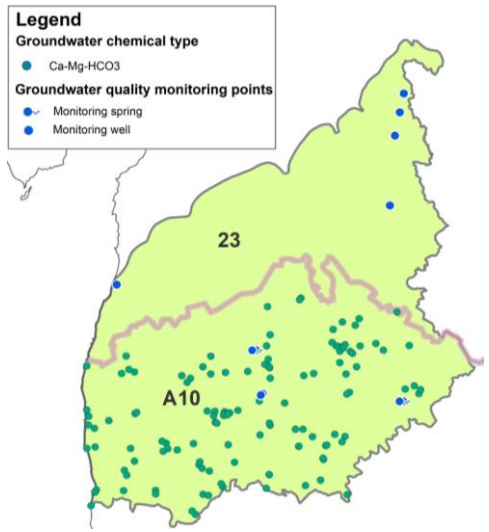
Characteristics		Groundwater bodies in Upper Devonian aquifer system (GWB-1)	
Groundwater body number/code		**26**	**D6**
River basin district		East Estonian/Koiva	Gauja
Aquifer system		Quaternary, Upper Devonian	Quaternary, Upper Devonian
Area (km^2)		726,1	4891
Physiographic characteristics		Most of the trritory is located in Haanja upland, where the absolute height of the terrain varies from about 100 to 230 m a.s.l. Small part of GWB is also located in Hargla Depression, where absolut hight reaches about 60 -70 m. but the relative height is about 160 m a.s.l.	Territory has a changing relief - in the western part there is a plain, the central part and the eastern part are formed by highlands, while the rest of the area formed by wavy plains. The absolute height of the terrain varies from about 90 to 265 m a.s.l., but the relative height is about 176.6 m a.s.l.
Hydrogeological characteristics	***Lithology***	The lithological composition of the aquifer-forming rocks is quite homogenous. The aquifers are hosted by thick-bedded limestone and dolomitized limestone of the Upper Devonian Plavinas Stage and the overlying Quaternary sediments. The lower part of the formation consists of domerite and marl of the Snetnaja Gora Formation, which can be viewed as a local semi-permeable aquitard.	Geological structure that forms the aquifer system are composed of sandstone and dolomite. The local aquitards consist mainly of dolomite marl, siltstone and clay. Dominated by porous rock material. Moraine loam, moraine loam, sand and clay are common in the overlapping Quaternary sediments.
	GWB thickness	The thickness of the bedrock aquifers is in the range of 30–40 m; the thickness of the overlying Quaternary deposits is mostly in the range of 5–10 m, locally up to 20 m.	The thickness of the bedrock reaches up to 105 meters, the average thickness - 30 m; the thickness of the overlaying Quaternary sediments in the plains is in range of 5-25 m up to 75-135 m in the hills. The average thickness of Quaternary sediments is about 50-60 m.
	Overlying aquitard	The Quaternary sediments overlying the bedrock aquifers consist mainly of loamy till, which has a hydraulic conductivity of 0.1–1.0 m/d.	The Quaternary sediments overlying the bedrock aquifers consist mainly of moraine loam, sand and clay.
	Underlying aquitard	The domerite, marl and clay of the Snetnaja Gora Formation	The clay, dolomite marls and clayey siltstones of Amata formation or lower part of Pļaviņas formation
	Groundwater level	The aquifers are mostly phreatic. Groundwater level is usually about 20–30 m below ground surface. The absolute height of the groundwater level is in the range of 165–175 m.	Groundwater level is about 10–20 m below ground surface. The absolute height of the groundwater level in the highlands reach about 170-200 m, in the lowlands - 60 - 80 m, while in the western part (closer to the Baltic coast) the level reaches only 10-20 m
Hydrodynamics	***Flow direction***	The most important groundwater divide in the area is the Haanja Heights, from where the groundwater flows to the south and west towards the edges of the height. Groundwater seeps out in the river valleys and a portion of its volume also infiltrates deeper into the Middle-Devonian aquifers.	The main groundwater flows are from Vidzeme Heights, Alūksne Heights and Haanja Heigths (Estonia) in the direction of lower areas - Gauja river valley and adjacent plains
	Filtration coefficient	The transmissivity of the aquifers forming the groundwater body is in the range of 30–300 m^2/d (Perens et al., 2012). The lateral flow velocity of groundwater is in the range of 1–10 m/d and can reach up to 50 m/d in karst aquifers (Ibid.).	The transmissivity of the aquifers forming the groundwater body is in the range of 26-3580 m^2/d (mostly 700 m^2/d)
	Recharge and regime	The groundwater flows radially away from the Haanja Heights and the local hillocks towards topographically lower regions throughout the year. The amount of infiltrating water depends on the composition of local Quaternary cover. In areas with waterlogged soils or in areas underlain by clayey deposits the infiltration rate can be negligible.	Main recharge areas are located in central part of Vidzeme highland and eastern part of Alūksne highland, discharge in topographically lower regions. The amount of infiltrating water is about 1 792 000 m^3/d
		Groundwater in the groundwater body is mainly of the Ca-HCO3-type, with TDS concentrations ranging from 200 to 600 mg/L. The chloride concentrations are usually <15 mg/L. The concentrations of NO3? are also low and do not exceed 5 mg/L in most cases. In terms of	Ca-Mg-HCO3 type freshwaters with mineralization up to 1 g/l predominate. Elevated concentrations of sulphate ions above 250 mg / l have been observed in local areas in the Z part of the facility.

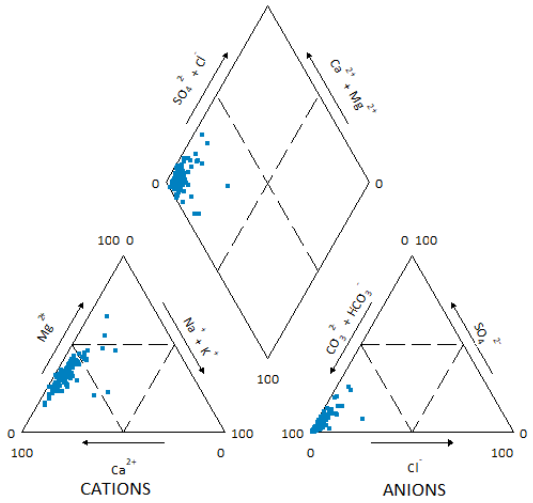
2. Initial characterization of transboundary GWBs

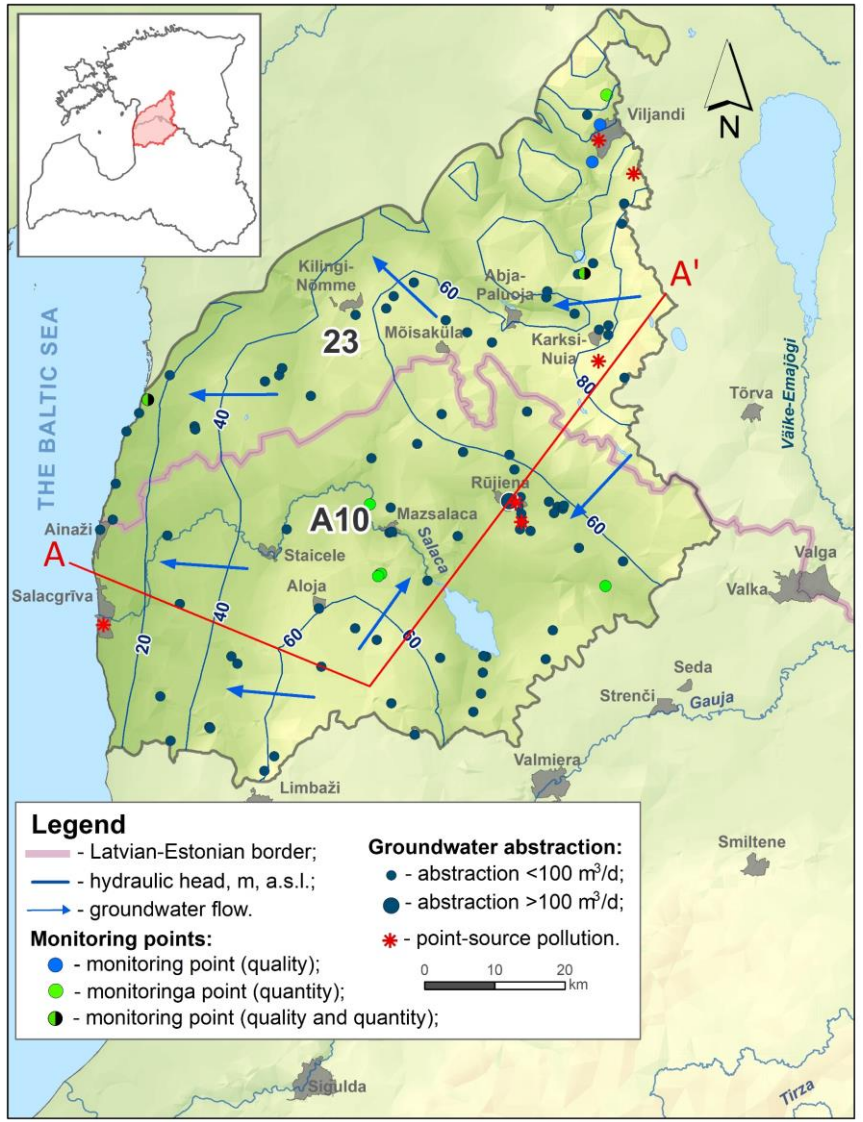
Conceptual model (2)

Situation for GWB-3 (A10 & 23)









2. Initial characterization of transboundary GWBs

GWB-1 **Upper Devonian aquifer system**

- **Total area:** 5617.1 km^2 (D6 – 4891 km^2; 26 – 726.1 km^2)
- **Aquifer type** – fracturated;
- **Geology** – dolomites, limestones, also sandstones;
- **Water use** – drinking water, industrial (in Estonia-locally);

- **Anthropogenic pressure:**

Aquifer system	GWB	Point source pressure	Diffuse source pressure	GW abstraction
1. Upper Devonian	26	Not significant	Not significant	Not significant
	D6	Not significant	Not significant	Not significant

2. Initial characterization of transboundary GWBs

GWB-2 **Upper-Middle Devonian aquifer system**

- **Total area:** 28671 km^2 (A8 – 27349 km^2; 25 – 1322 km^2);
- **Aquifer type** – porous;
- **Geology** – sandstones;
- **Overlying aquifers** – Upper Devonian GWBs;
- **Water use** – drinking water, industrial;
- **Anthropogenic pressure:**

Aquifer system	GWB	Point source pressure	Diffuse source pressure	GW abstraction
2. Upper-Middle Devonian	25	Not significant	Not significant	Not significant
	A8	Significant	Not significant	Not significant

2. Initial characterization of transboundary GWBs

GWB-3 **Upper-Middle Devonian aquifer system**

- **Total area:** 5662 km^2 (A10 – 3321 km^2; 25 – 2341 km^2)
- **Aquifer type** – porous;
- **Geology** – sandstones;
- **Water use** – drinking water, industrial;

- **Anthropogenic pressure:**

Aquifer system	GWB	Point source pressure	Diffuse source pressure	GW abstraction
3. Upper-Middle Devonian	23	Not significant	Not significant	Not significant
	A10	Not significant	Not significant	Not significant

2. Initial characterization of transboundary GWBs

GWB-4 **Lower-Middle Devonian aquifer system**

- **Total area:** 8844 km^2 (P – 4394 km^2; 25 – 4450 km^2)
- **Aquifer type** – porous;
- **Geology** – sandstones;
- **Overlying stata** – Narva regional aquitard, Upper-Middle Devonian GWBs;
- **Water use** – drinking water, industrial;
- **Pressure assessment:**

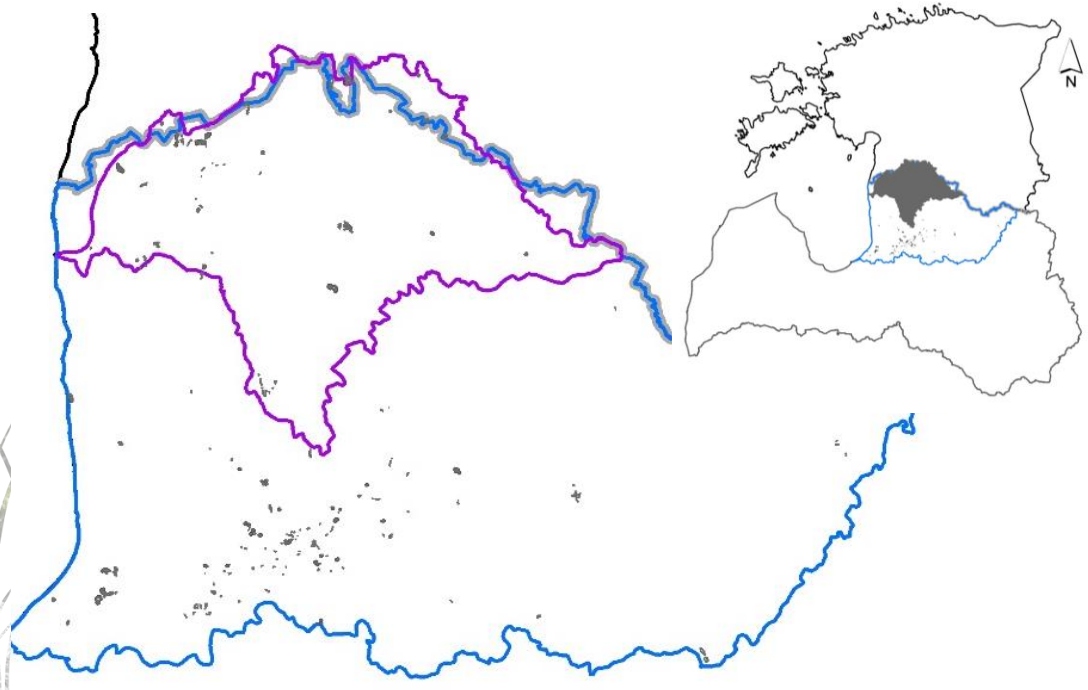
Aquifer system	GWB	Point source pressure	Diffuse source pressure	GW abstraction
4. Lower-Middle Devonian	21	Not significant	Not significant	Not significant
	P	Not significant	Not significant	Not significant

Identification Groundwater dependent terrestrial ecosystems (GDTEs)

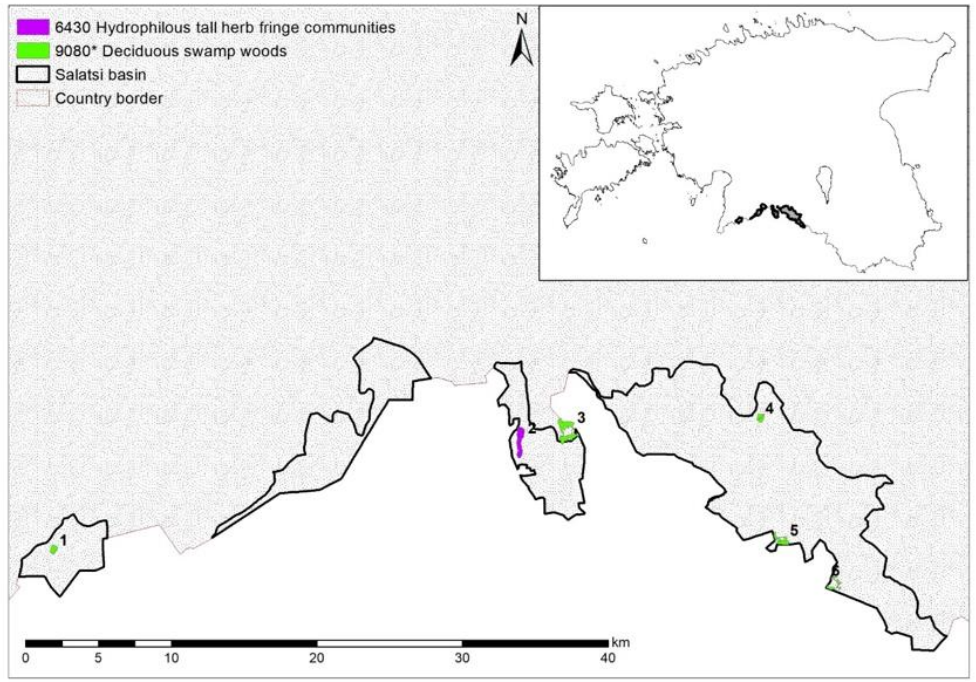
GDTEs identification in Latvia (Salaca/Salatsi river basin) – *189 polygons (individual and multipart)*

Habitat types:

- Deciduous swamp woods (9080);
- Fennoscandian mineral-rich springs and springfens (7160);
- Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp* (3140);



GDTEs identification in Estonia (Salatsi river basin)



Main habitat type	Secondary habitat type	Natura 2000/ National PA	Conserv. status	Area (ha)	GWB
Hydrophilous tall fringe communities (6430)		No/No	A	73.8	23
Deciduous swamp woods (9080*)		No/Yes	NA	37.8	23
Deciduous swamp woods (9080*)	Alkaline fens (7230)	No/No	A, C, NA	20	23
Deciduous swamp woods (9080*)		No/No	NA	91.2	23
Deciduous swamp woods (9080*)		Yes/Yes	B, C	21.9	23
Deciduous swamp woods (9080*)	Hydrophilous tall herb fringe communities of plain and of montane to alpine levels (6430)	Yes/Yes	B	21.1	23

3. Status assessment of transboundary GWBs

Assessment carried out based on harmonized principles (WP1)

1. **Chemical status assessment tests:**
    1. General quality assessment;
    2. Saline or other intrusions;
    3. Groundwater associated aquatic ecosystems;
    4. Groundwater dependent terrestrial ecosystems;
    5. Drinking water protected areas.
2. **Quantitative status assessment tests:**
    1. Water balance assessment test;
    2. Saline or other intrusions;
    3. Groundwater associated aquatic ecosystems;
    4. Groundwater dependent terrestrial ecosystems.

Chemical status assessment

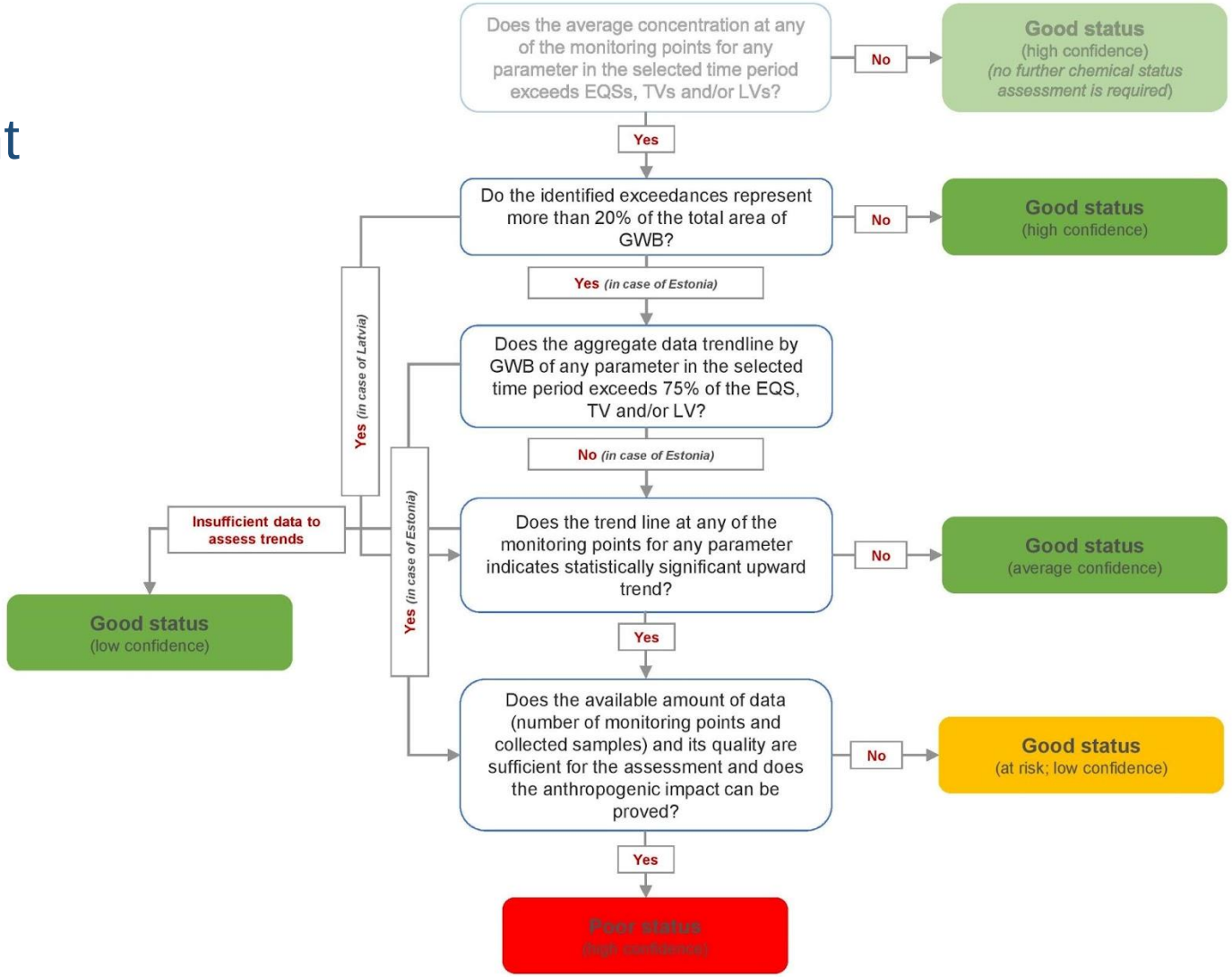
Test 1. General quality assessment

- *General quality (all GWBs) – no exceedance of the 20% criterion was found in any of the Latvian-Estonian transboundary GWB - good status with high confidence;*

- *Diffuse pollution pressure (must be carried out for significant diffuse pressure – not relevant for transboundary GWBs for both EE and LV);*

➢ *Point-source pressure (carried out for GWB A8 (signif. pr.) – affected do not exceed 20% - good, with high confidence)*

  ➢ *Riga territory affected, no threat to LV-EE border area.*



Chemical status assessment

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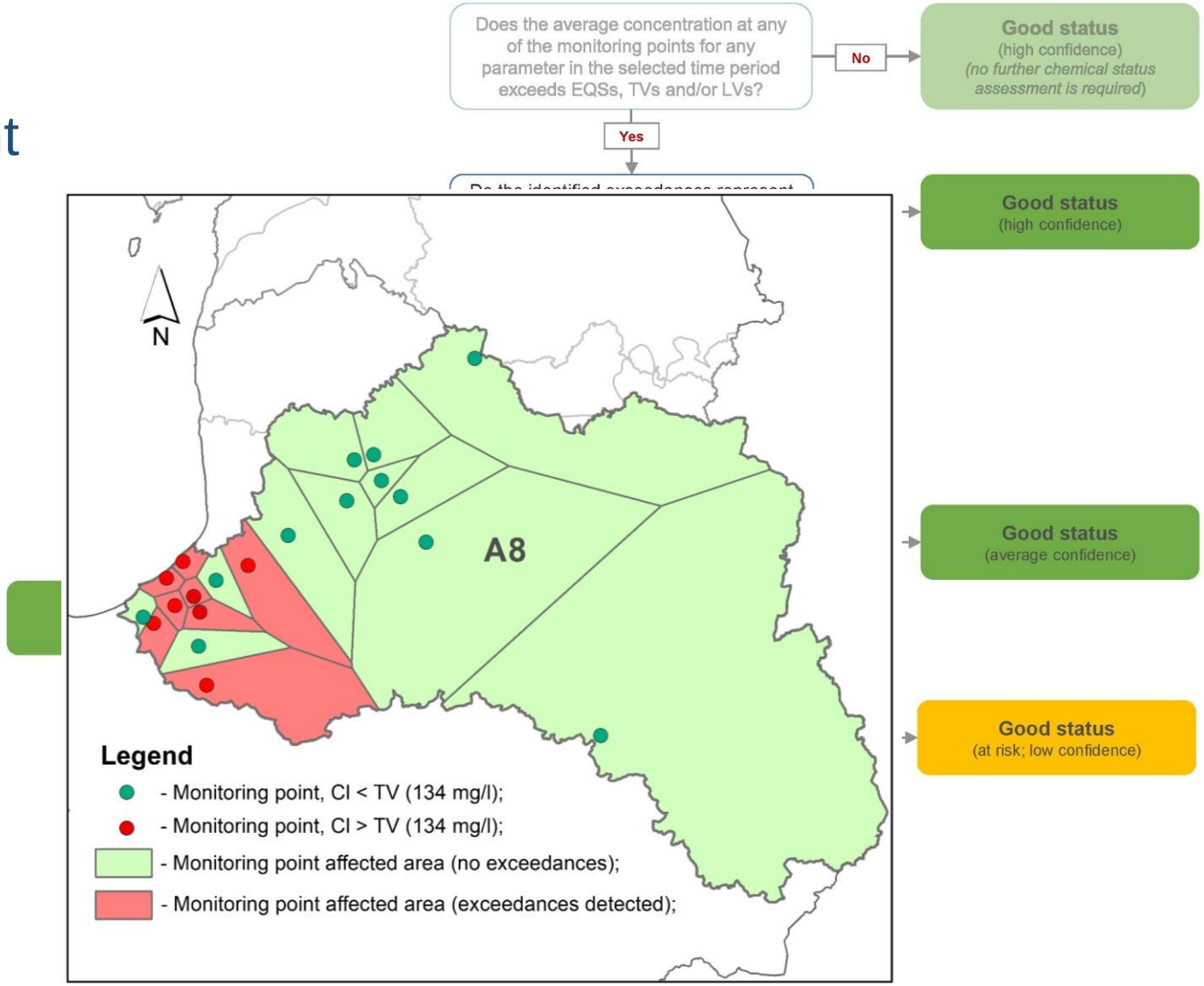
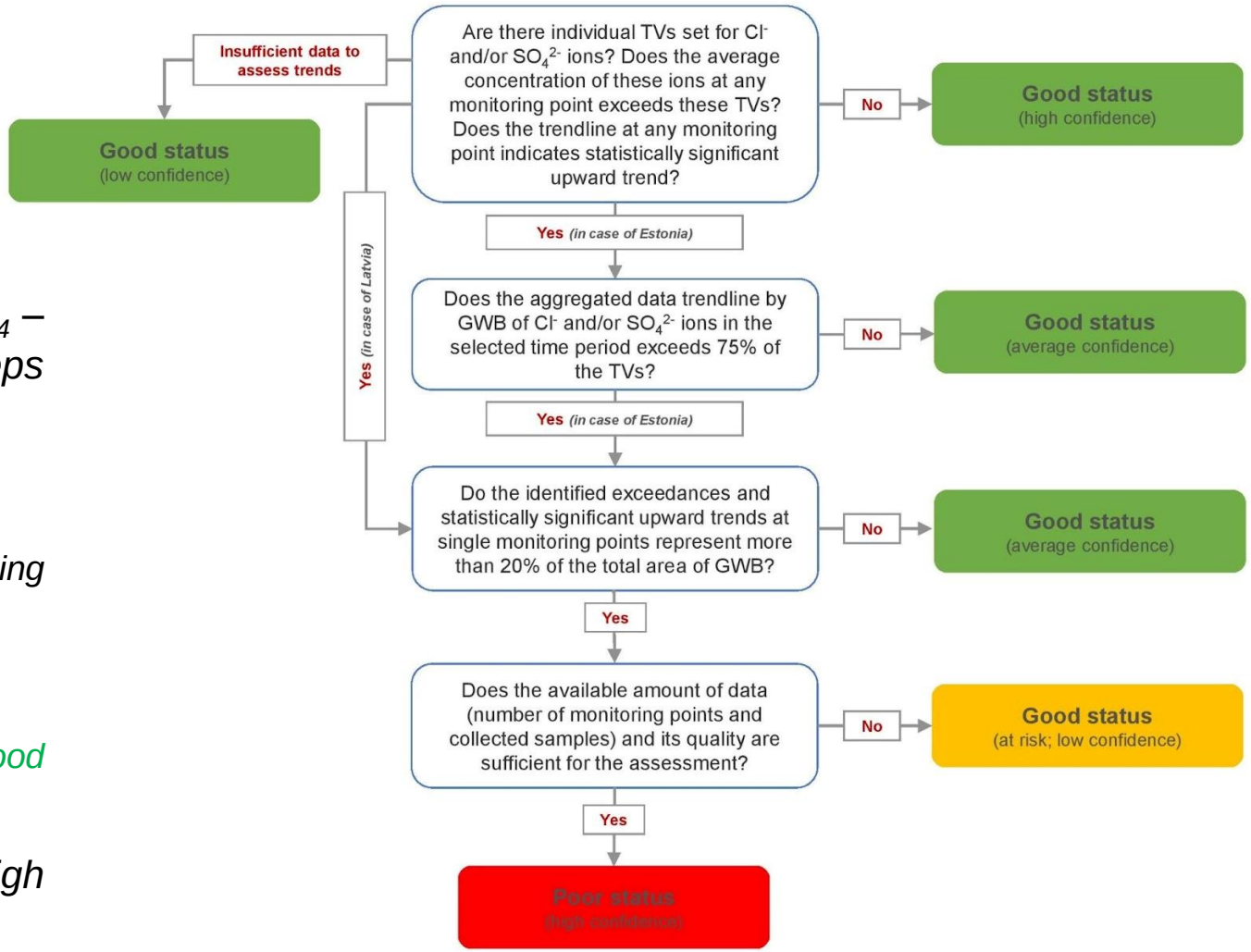


Chemical status assessment

Test 2. Saline or other intrusion

- ***In Estonia*** *- GWBs no TVs set for Cl & SO_4 – no risk of intrusion – no further steps required);*
- ***In Latvia*** *– TVs are set for Cl & SO_4*
  - *Exceedences – GWB A8 in some monitoring points (not in border area);*
  - *affected area <20%;*
  - *insufficient data set to perform trends – good status with low confidence;*
- *all other GWBs – good status with high confidence.*



Chemical status assessment

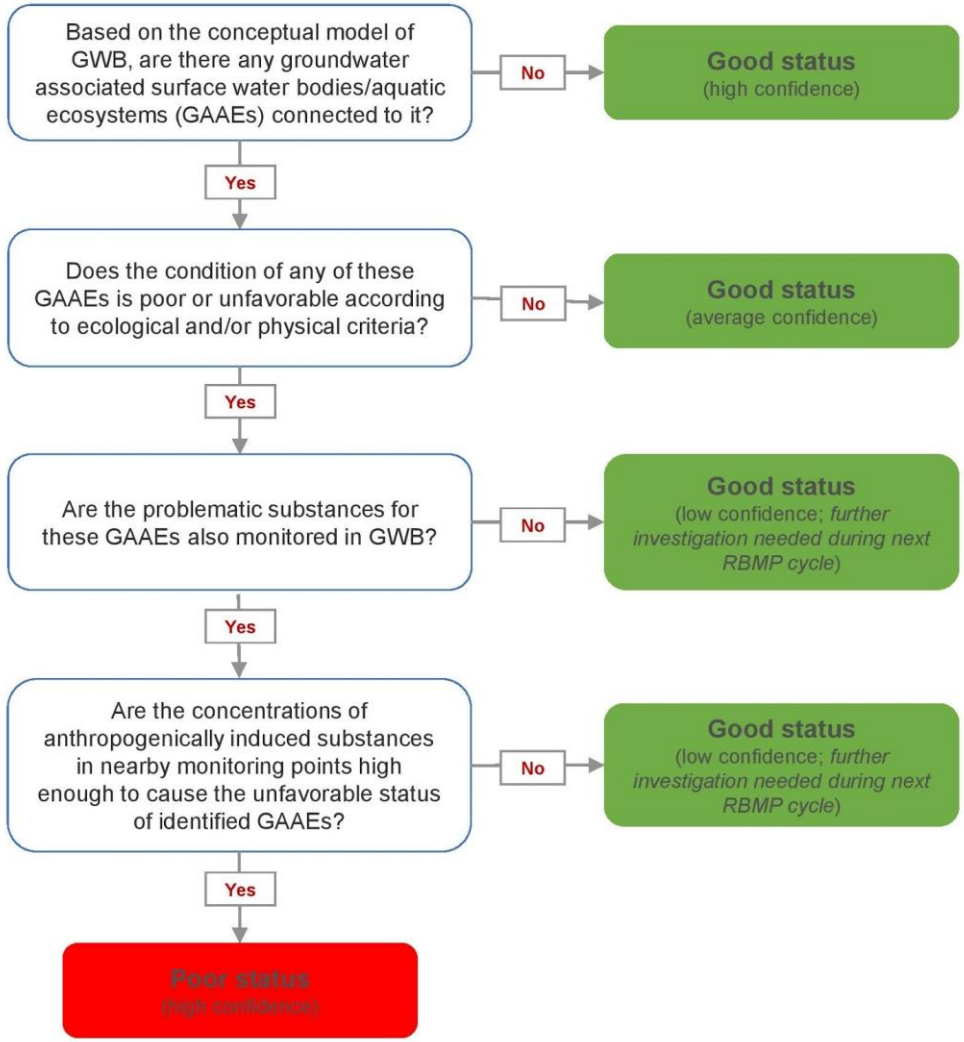
Test 3. Groundwater associated aquatic ecosystems (surface waters)

***In Latvia** – results from UL project (2021)*

- *GAAEs identified in GWB A8 & D6.*
  - *GWB D6 are no poor GAAEs – good status (low confidence);*
  - *GWB A8 – 4 poor quality GAAEs were identified – poor ecological quality not related to groundwater – GWB A8 is in good status (low confidence).*

***In Estonia** – GAAEs test performed for GWBs 21 & 23);*

- *GWB 21- 1 poor-quality GAAE (lack of data) – good status (low confidence);*
- *GWB 23 – good status;*
- *According to test – GWBs are in good chemical status with low confidence and further investigation is required in the next RBMP planning period.*



Chemical status assessment

Test 4. Groundwater dependent terrestrial ecosystems (GDTEs)

In Latvia *(identification by NCA)*

531 polygons *identified (189 in Salaca catch.)*

In transboundary GWBs:

- ***GWB A10*** *– 170 polygons*
- ***GWB D6*** *– 45 polygons*
- ***GWB A8*** *– 275 polygons*

- 11 GDTEs removed from GroundEco list

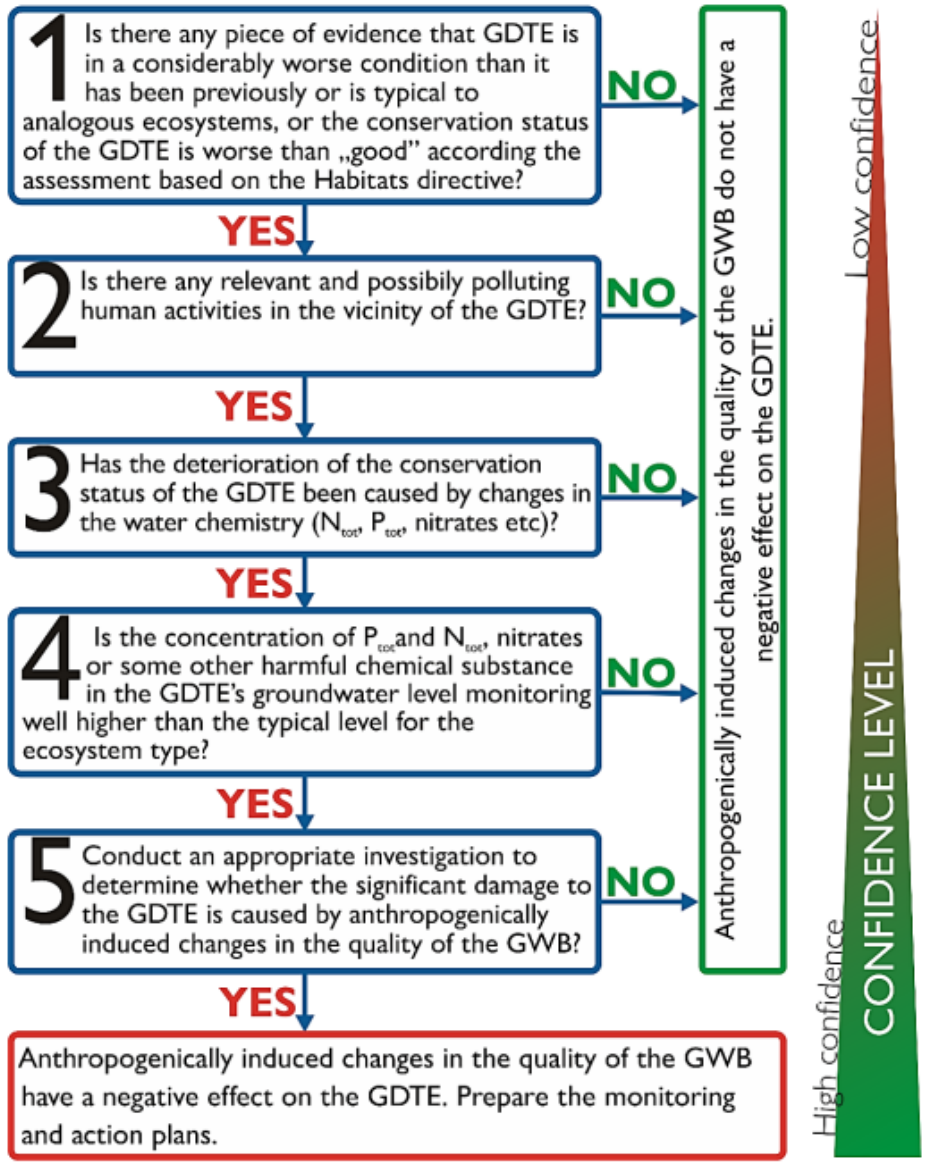
GDTEs for assessment test:

GDTEs with average or poor quality:

- ***GWB A10*** *– 28 GDTEs + 3 multipart GDTEs**
- ***GWB D6*** *– 5 GDTEs + 2 multipart GDTEs**
- ***GWB A8*** *– 28 GDTEs + 10 multipart GDTEs**

* *multipart GDTEs - >20% of GDTEs area covered by polygons with average/poor*

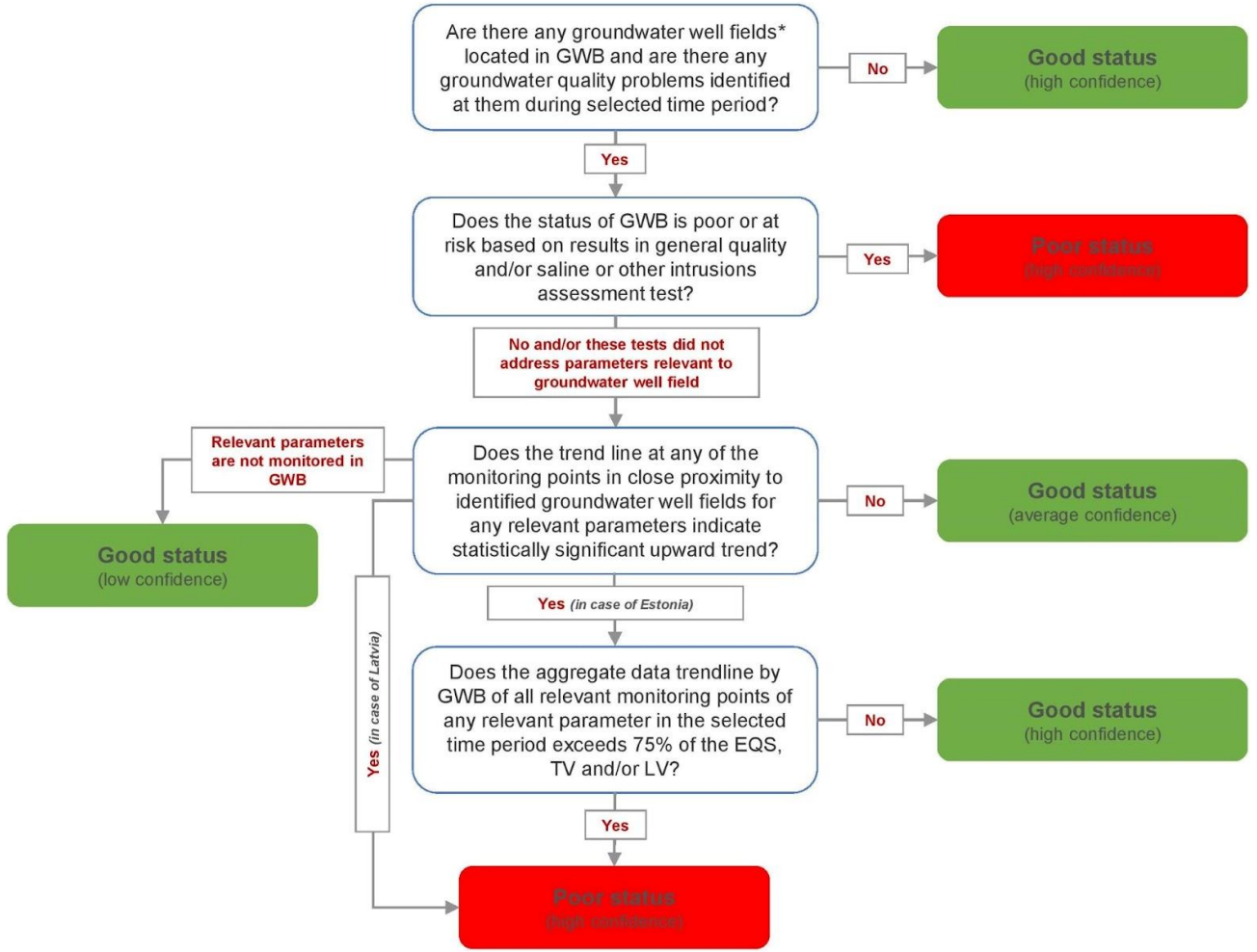
- In progress - anthropogenic activities assessment, possible pollution….



Chemical status assessment

Test 5. Drinking water protected areas

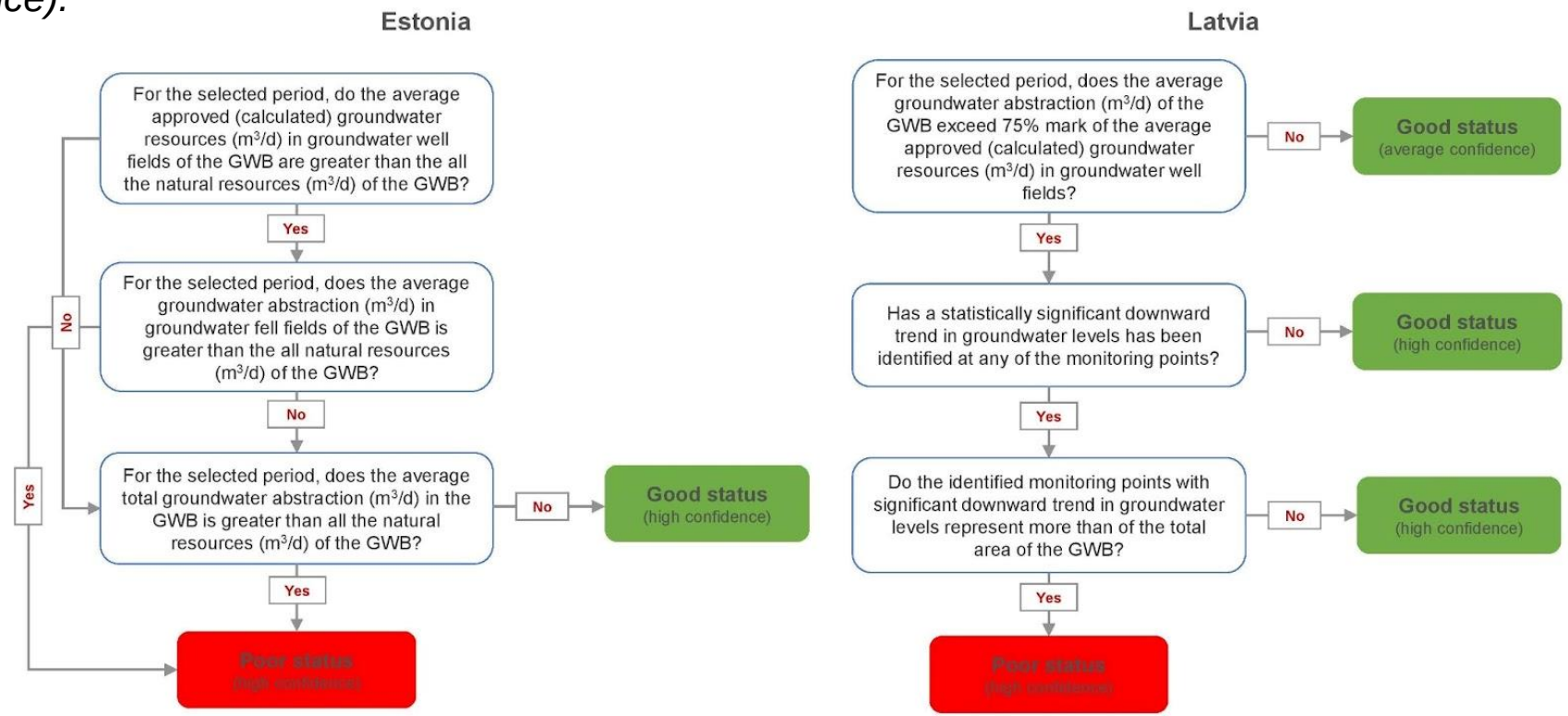
- ***In Latvia*** *(well-field: >100 m³/d)*
  - *well-fields in all GWBs;*
  - *no quality problems for assessment period – GWBs in good chemical status (high confidence);*
- ***In Estonia*** *(well-field: >500 m³/d)*
  - *well-fields located in GWB 21 & 23;*
  - *no quality problems identified for assessment period – GWBs on good chemical status (high confidence);*



Quantitative status assessment

Test 1. Water balance assessment test

- ***Different approaches*** *– not possible to harmonize;*
- *GW abstraction in 2018 compared to natural GW resources (in Estonian case) or approved resources (in Latvian case);*
- *For* ***both sides****, GW abstraction* ***do not exceeds the natural/approved resources*** *– GWBs are in good quantitative status (average/high confidence).*



Quantitative status assessment

Test 2. Saline or other intrusion

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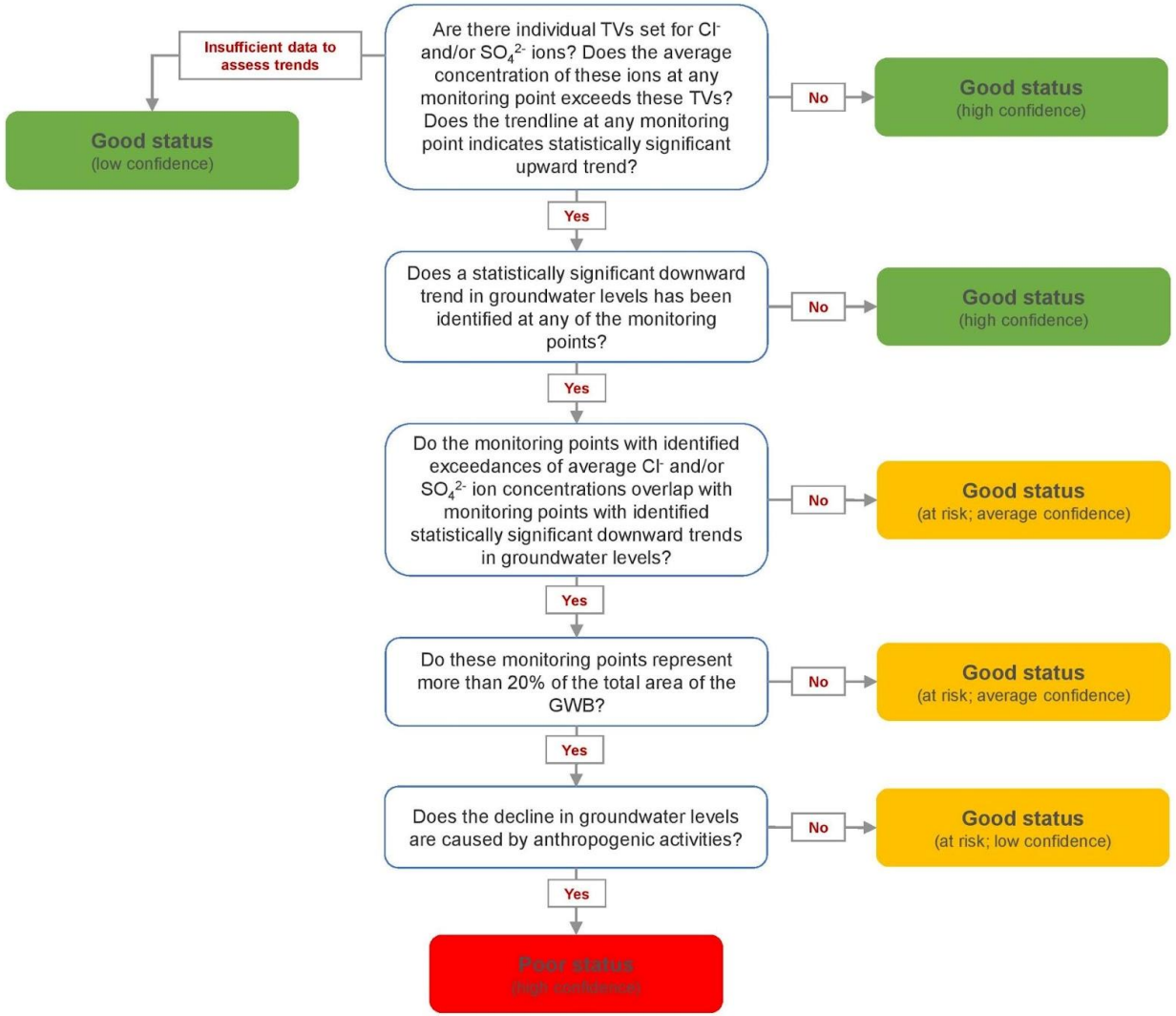
  - *insufficient data set to perform trends – good status with low confidence;*
- *all other GWBs – good status with high confidence.*



Quantitative status assessment

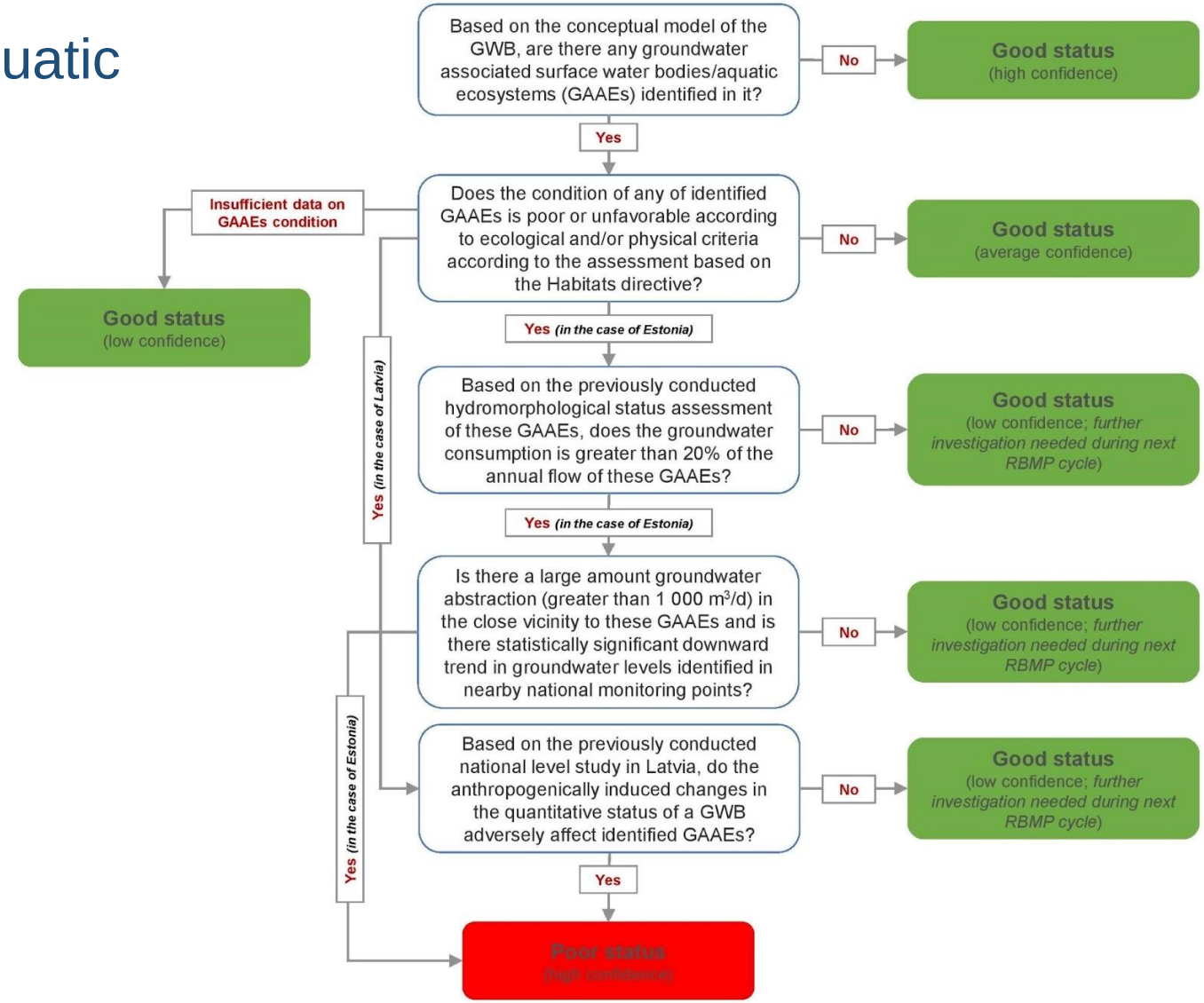
Test 3. Groundwater associated aquatic ecosystems (surface waters)

***In Latvia** – results from UL project (2021)*

- *GAAEs identified in GWB A8 & D6. GWB D6 are no poor GAAEs – good status (low confidence).*
- *GWB A8 – 4 poor quality GAAEs are identified – poor ecological quality not related to groundwater (expert judgement) – GWB A8 is in good status (low confidence).*

***In Estonia** – GAAEs identified in all transboundary GWBs (21, 23, 25, 26).*

- *Water abstraction <20 % of annual flow (rivers), but lakes not assessed. According to test – GWBs are in good quantitative status with low confidence and further investigation is required in the next RBMP planning period*



Quantitative status assessment

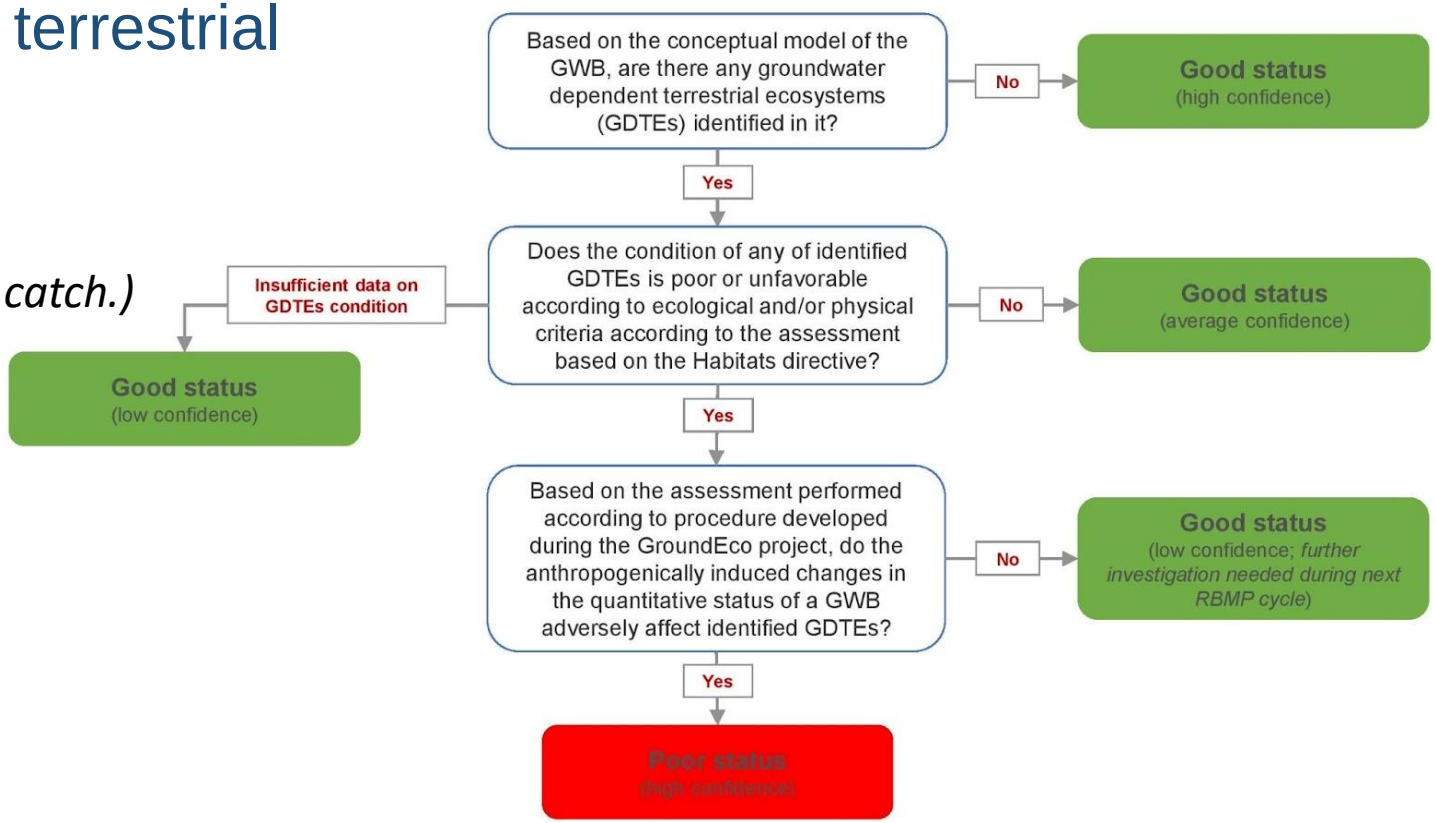
Test 4. Groundwater dependent terrestrial ecosystems (GDTEs)

In Latvia (identification by NCA)

***531 polygons** identified (189 in Salaca catch.)*

In transboundary GWBs:

- ***GWB A10** – 170 polygons*
- ***GWB D6** – 45 polygons*
- ***GWB A8** – 275 polygons*
- *11 GDTEs removed from GroundEco list*



GDTEs for assessment test:

GDTEs with average or poor quality:

- ***GWB A10** – 28 GDTEs + 3 multipart GDTEs**
- ***GWB D6** – 5 GDTEs + 2 multipart GDTEs**
- ***GWB A8** – 28 GDTEs + 10 multipart GDTEs**

* *multipart GDTEs - >20% of GDTEs area covered by polygons with average/poor*

- *In progress – anthropogenic activities assessment, possible pollution….*

Summary of transboundary GWBs assessment

1. **Chemical status assessment tests:**
    1. General quality assessment – *good status*;
    2. Saline or other intrusions – *good status*;
    3. Groundwater associated aquatic ecosystems – *good status*;
    4. Groundwater dependent terrestrial ecosystems – *in progress*;
    5. Drinking water protected areas – *good status*.
2. **Quantitative status assessment tests:**
    1. Water balance assessment test – *good status*;
    2. Saline or other intrusions – *good status*;
    3. Groundwater associated aquatic ecosystems – *good status*;
    4. Groundwater dependent terrestrial ecosystems – *in progress*.

Thank you!

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REPUBLIC OF ESTONIA MINISTRY OF THE ENVIRONMENT

Nature Conservation Agency Republic of Latvia

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Joint actions for more efficient management of common groundwater resources