KALME
VALSTS PĒTĪJUMU PROGRAMMA
KLIMATA MAIŅAS IETEKME UZ LATVIJAS ŪDEŅU VIDI

National Research Program „Climate Change Impact on Water Environment in Latvia”

WP4 results

Geological coastal processes and erosion forecast for Latvia

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WP4 General aim:

The objective of this study is analysis of coastal processes and forecast of climate change impact on the coastal dynamic and ecosystems in Latvian terrestrial waters of the Baltic Sea, to describe the quality and biological diversity of the sea environment, marine resources and service for its sustainable use.

WP4 fourth stage target:

1. Coastal erosion and flooding risk mapping in detail (scale for local planners and developers),

2. Risk evaluation and recommendations for planning, coastal protection and coastal management purposes for the period of next 15 and 50 years,

3. Preparation of recommendations for government level and expert working group "*Adaptation to climate change*".

Main tasks performed

1. Review of historical data, published articles and maps to evaluate changes in coastal dynamics since mid 20th century
2. Collecting and analysis of coastal geology and geomorphology data
3. Analysis of Coastal geological processes monitoring data associated with progressive natural change (*e.g.*, sea-level, storm severity, ice conditions)
    + Estimation of effects associated with direct human interference (*e.g.*, harbors, coastal protection structures)
    + Analysis of coastal response to specific storm impact

1. Review of historical data, published articles and maps

- Investigations of coastal geomorphology in Latvia and first substantial scientific articles or monographs on this topic appeared only in the 50s and 60s of the 20th century.
- Majority of these publications was descriptive with no measured data and calculations.
- Maps are generalized and cartographically distorted (majority of the area belonged to the soviet time secret zone)

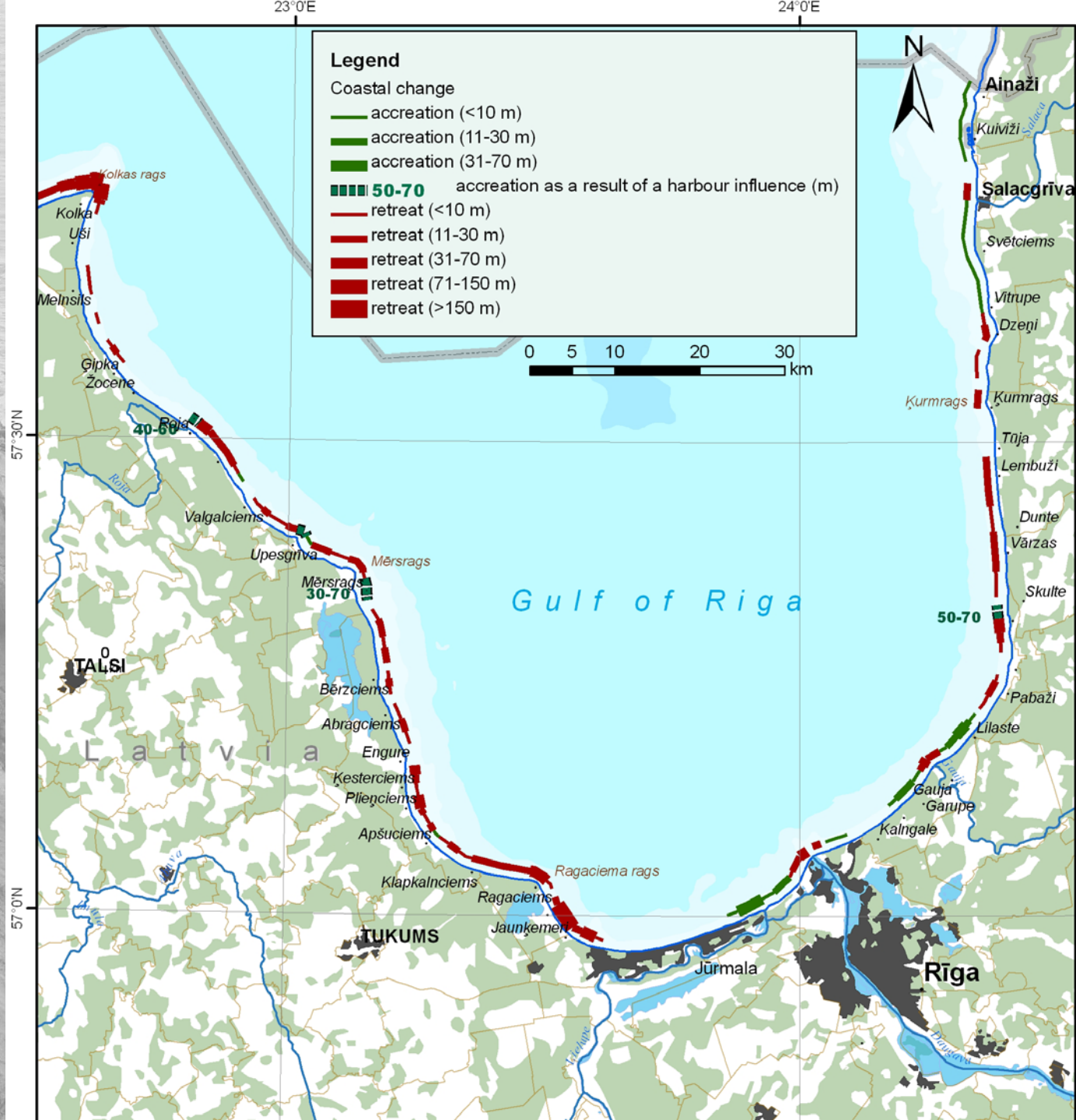
1. Review of historical data, published articles and maps

Digital cartographic data layers prepared:

- Main tendencies in coastal evolution during postlitorina time,
- Coastal processes during 50ties of the 20th century,
- Coastal processes during 80ties of the 20th century,
- Coastal erosion associated with 1969 hurricane,
- Coastline retreat and advance since 1935.

1.

Gulf of Riga coastline retreat and advance (1935-1990)



2. Collecting and analysis of coastal geology and geomorphology data

Digital cartographic data layers prepared:

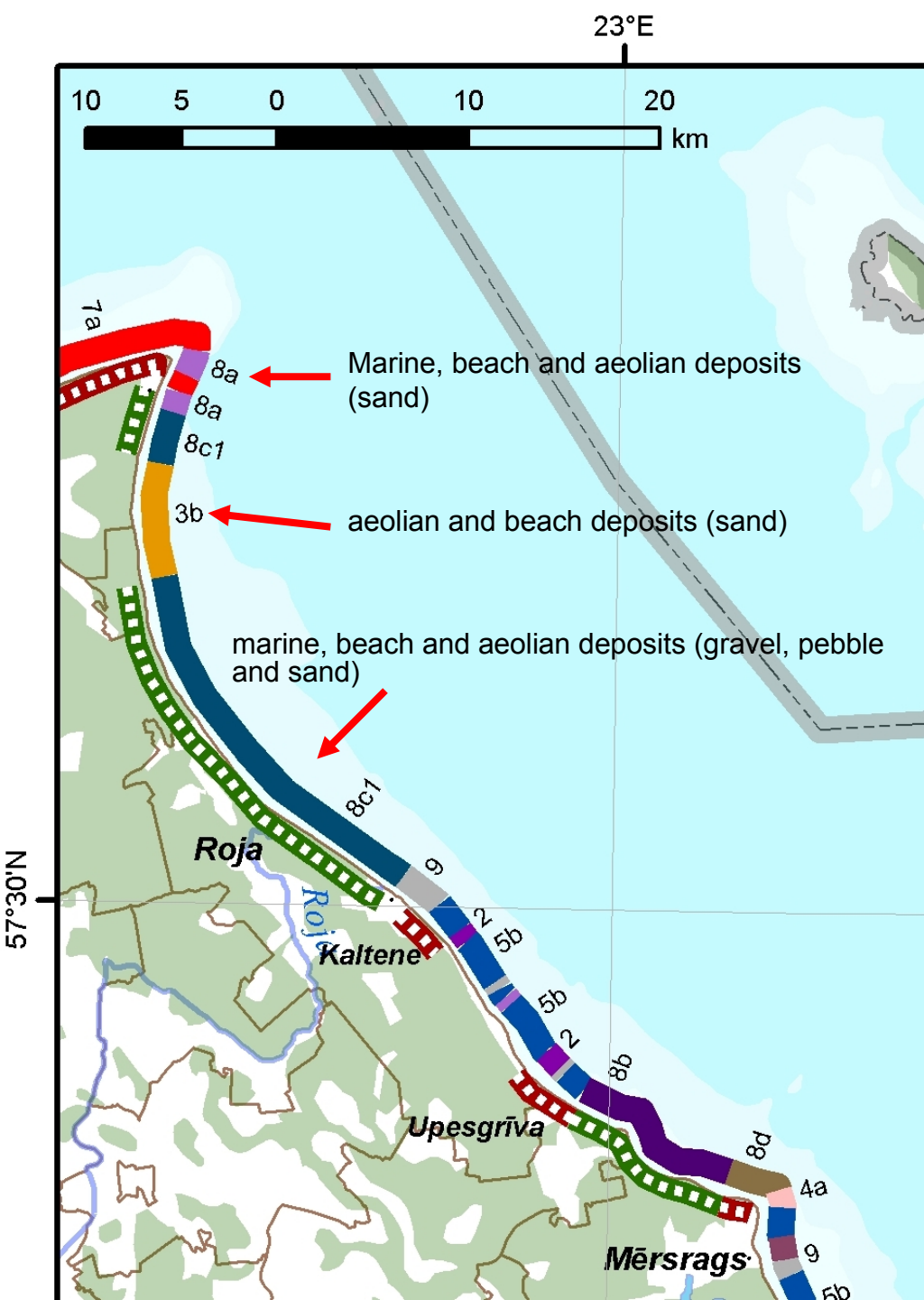
- Geological structure of the coast (coast types),
- Distribution and morphology of foredunes,
- Beach properties,
- Main sediment sources and sinks,
- Erosion risk level distribution.

2.

Geological structure of the Gulf of Riga coast (fragment)

Geological structure of the coast of Latvia is inhomogeneous and variable with deposits of various genesis.

Different resistance to wave erosion and abundance of sediment stores in corresponding coastal sections is affecting coastal evolution both locally and regionally.

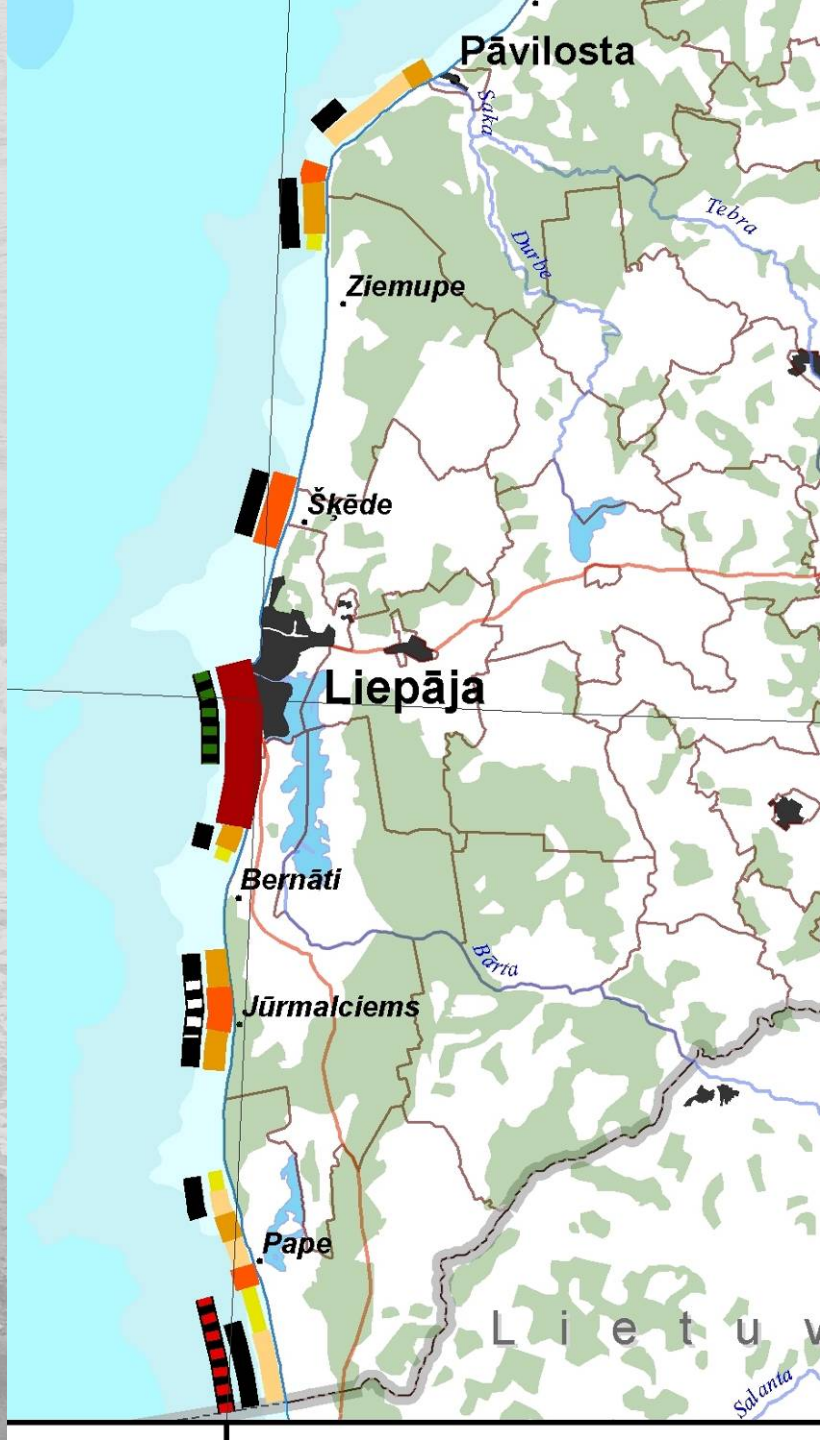


2.

Distribution and morphology of foredunes (fragment)

The distribution, volume and development trends of the foredunes are indicative of coastal process.

A well developed, high and broad foredune belt is an indicator of coastal stability and little erosion risk during future storm events.



2.

Beach properties (fragment)

Like foredune, beach is part of the coastal system and it is in process of constant development, so providing information about coastal processes.

Beach width and it's sediment composition are indicators of sediment budget.

3. Analysis of Coastal geological processes monitoring data associated with progressive natural change (*e.g.*, sea-level, storm severity, ice conditions)

Assessment of the coastal processes that took place during the last decades was based on the long-term coastal geological processes monitoring data and mapping of the coastal erosion cells after storms

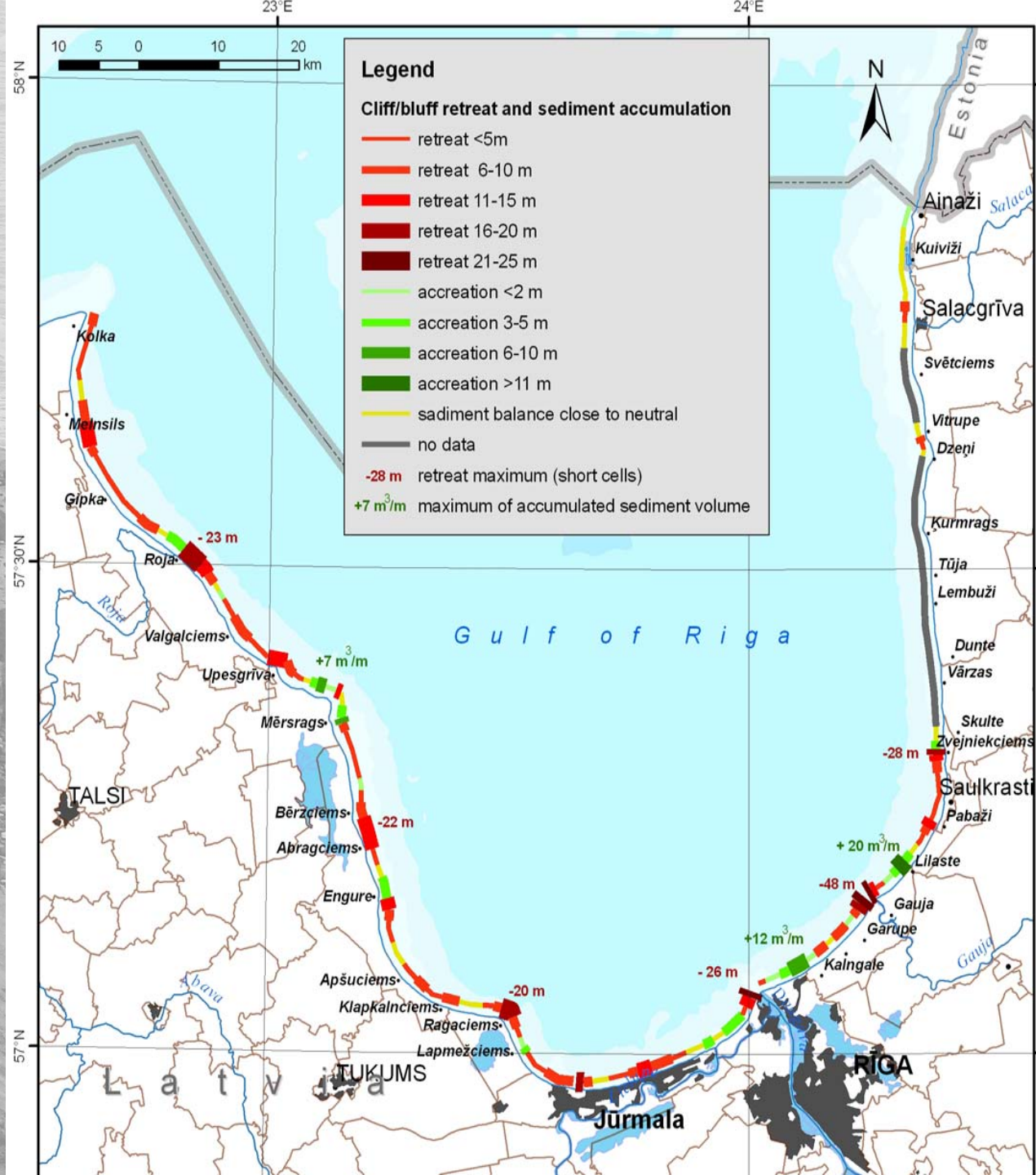
Digital cartographic data layer prepared:

- Changes of coast since 1992 (retreat and advance)

Changes of the coast of the Gulf of Riga (1992-2008)

Mean rate of coastal erosion has increased comparing with 20th century average.

New segments of coastal erosion have appeared in previously stable areas.



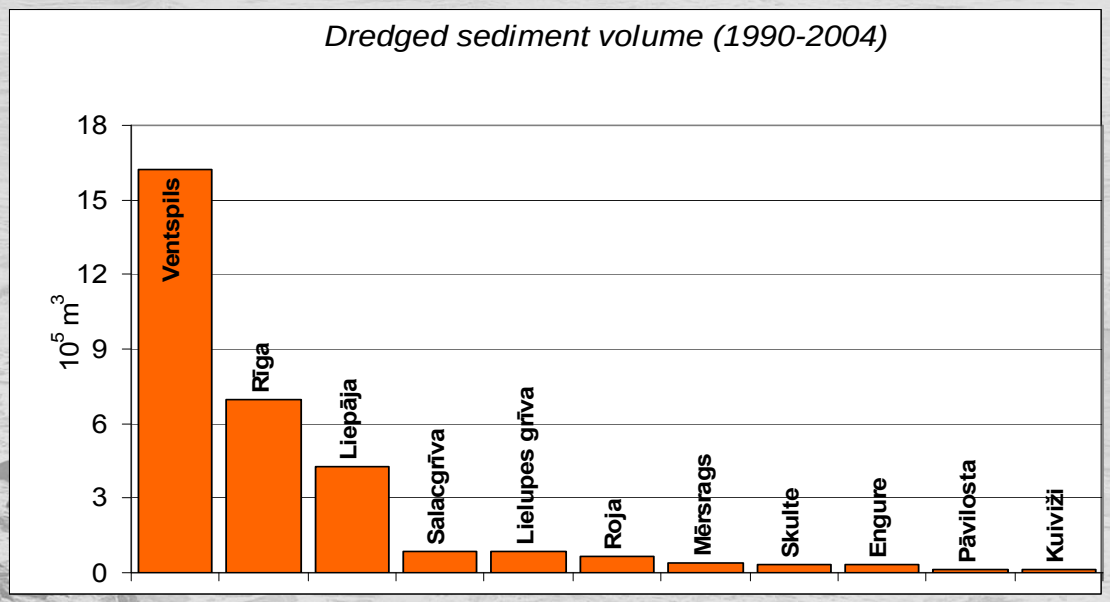
3+ Estimation of effects associated with direct human interference (*e.g.*, harbors, coastal protection structures)

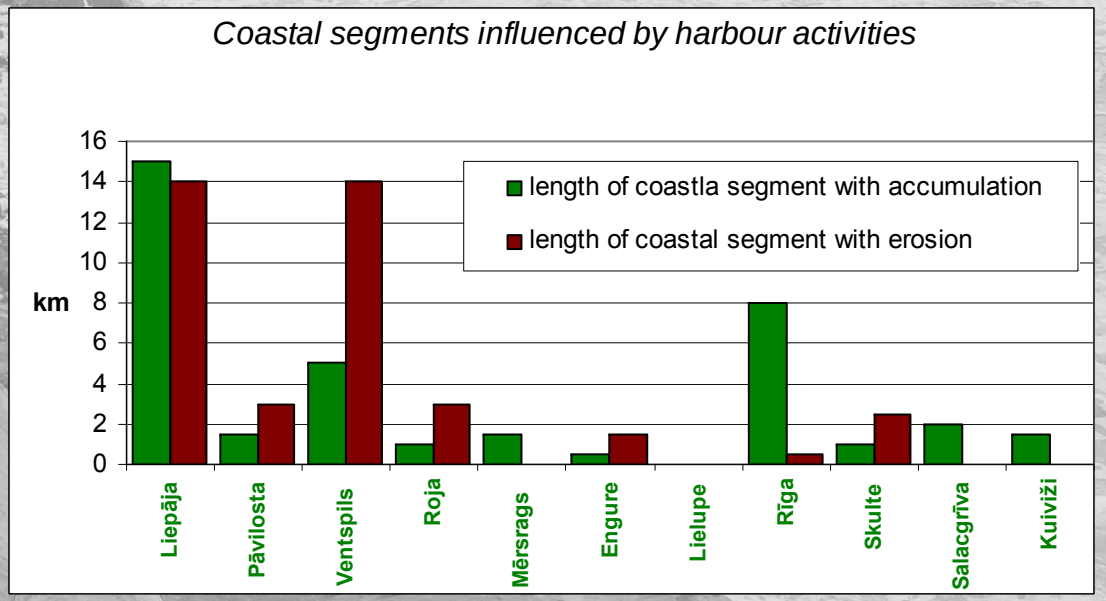
Digital cartographic data layers prepared:

- Changes in coastal sediment circulation due to harbor operation,
- Harbor affected coastal sections,
- Coastal protection structures with affected sections and degree of suitability.

3+

Sediment withdrawal from active, dynamic coastal zone means the artificial creation of an deficit (1-3 10^5 m^3/y^{-1}) in nearshore zone, which results in increased seabed erosion and succeeded coastal retreat.





3+

Coastal protection structures (overview map fragment)

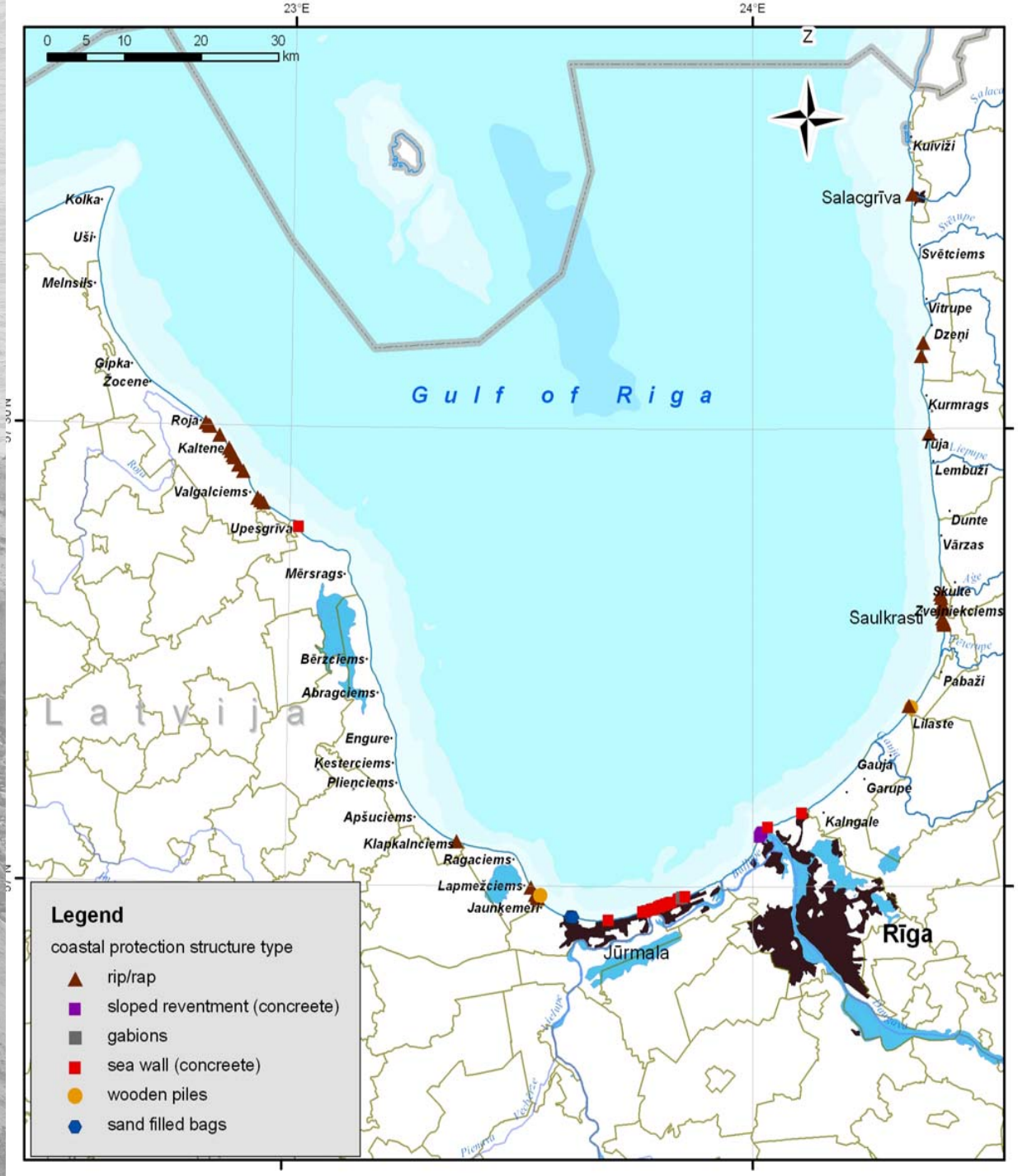
•Total length of protected coastal sections – 3600 m

•Total length of coastal sections directly affected by protection structures (increased rates of erosion in conterminous sections, beach loss, stopped retreat) – 4000 m

•Majority of existing structures can be considered as short term/low quality solutions

3+

Gulf of Riga coastal protection structures (overview map)



3+ Analysis of coastal response to specific storm impact

Digital cartographic data layers prepared:

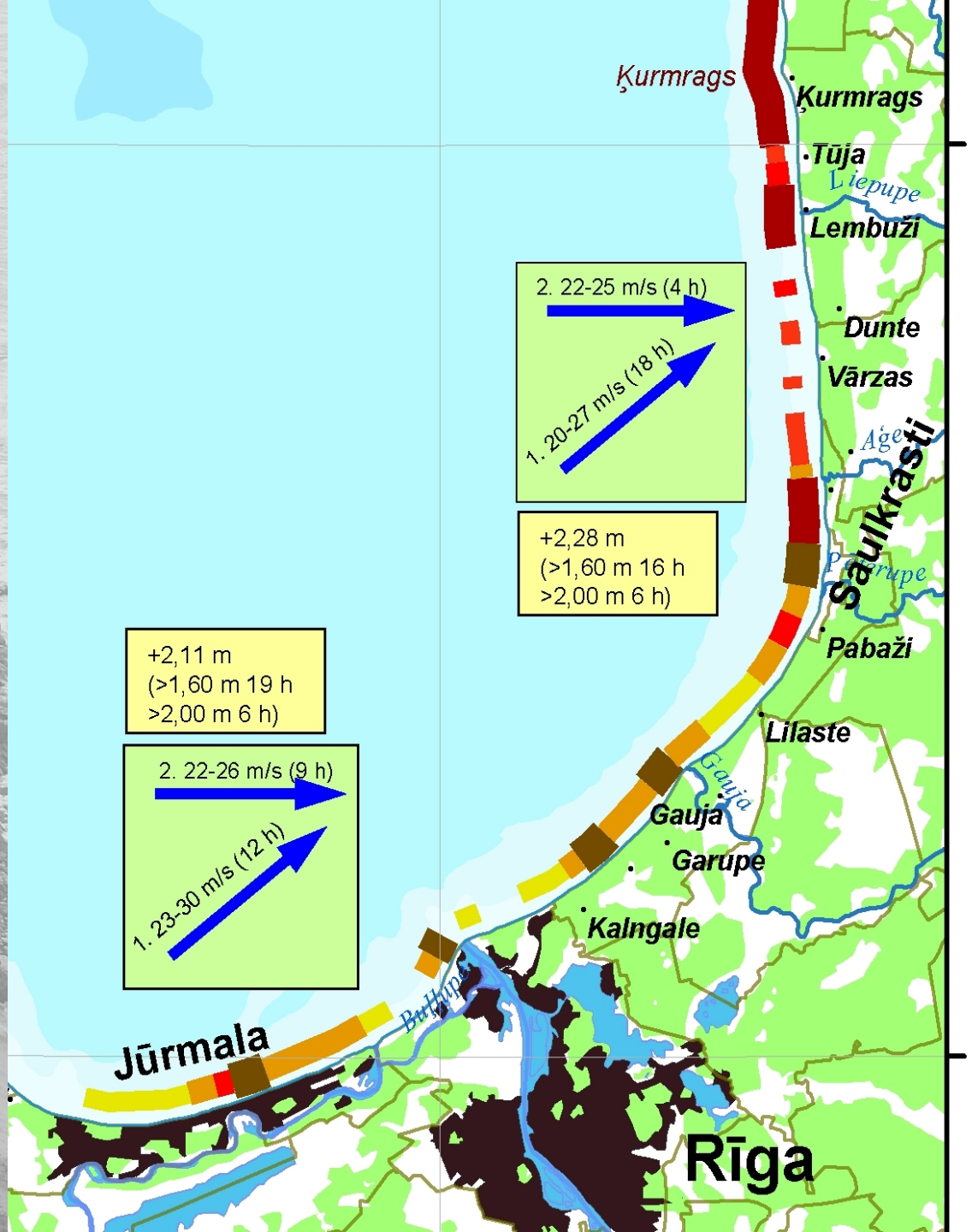
- Coastal erosion during the storm of January 11, 1992,
- Coastal erosion during the storm of January 14, 1993,
- Coastal erosion during the storm of December 4, 1999,
- Coastal erosion during the storms of November 2001,
- Coastal erosion during the hurricane “Gudrun”, January 8/9, 2005,
- Coastal erosion during storm of January 15, 2007,
- “Storm of the decade” impact forecast.

3+

Coastal erosion during the hurricane “Gudrun”, January 8/9, 2005 (overview map fragment)

Data show significant differences in the effect of wave erosion during specific storms because of the coastline configuration, geological structure and pre-storm risk level.

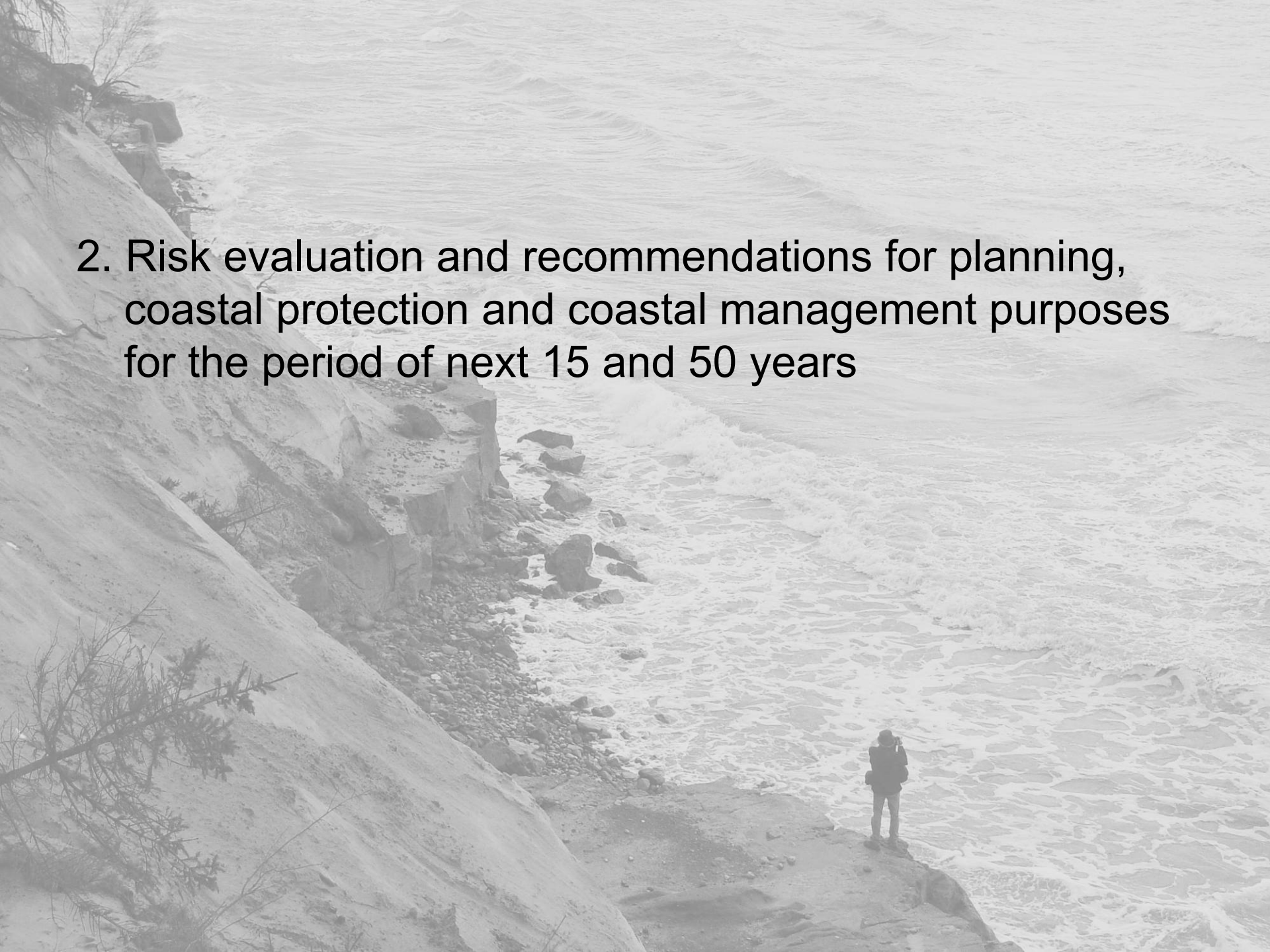
Gulf of Riga western coast can be considered as particularly endangered in case of typical storm direction shift due to climate change.



Main results

1. Coastal erosion and flooding risk mapping in detail (scale for local planners and developers)

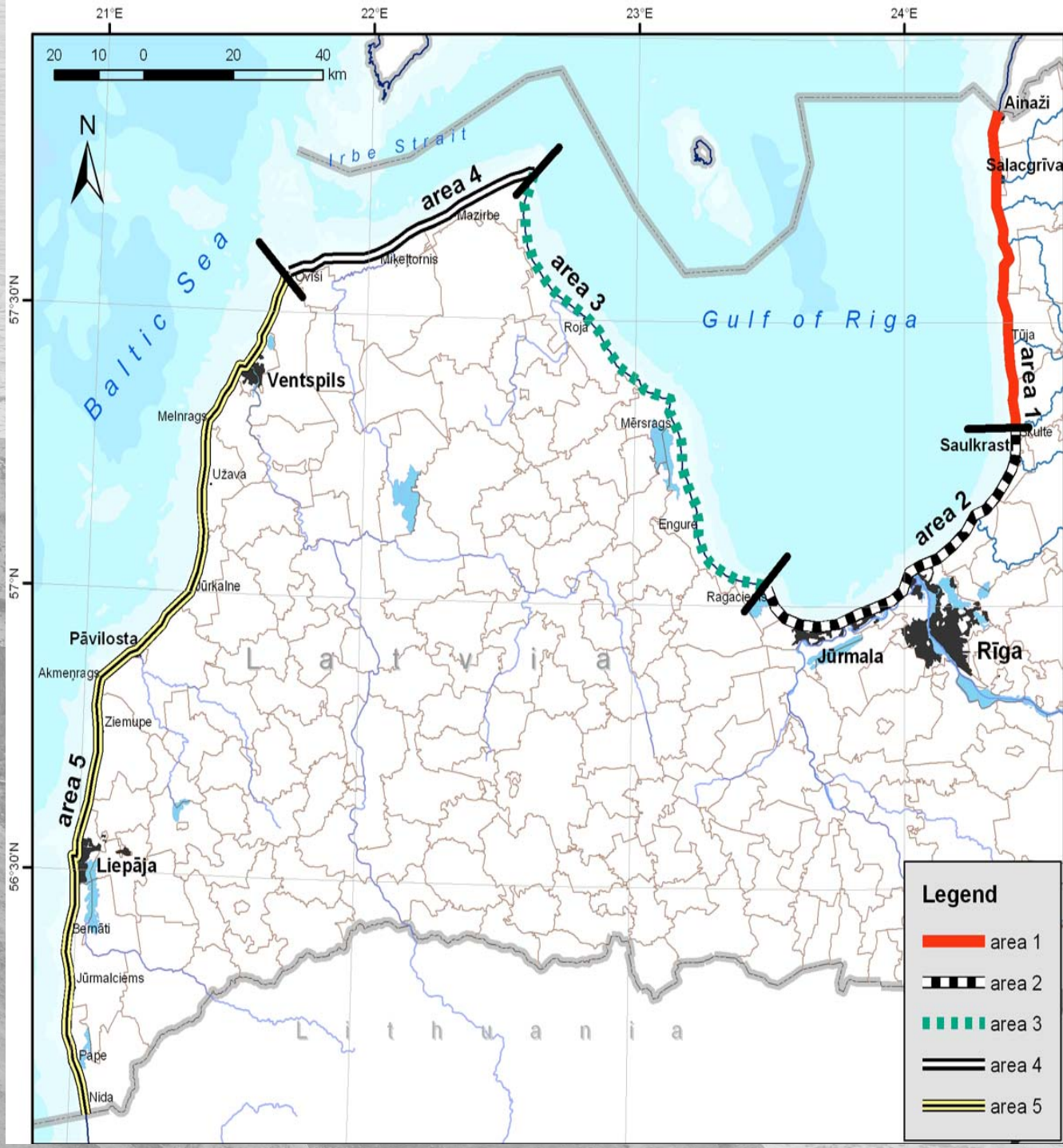
Coastal erosion risk zone for 15 and 50 year period (visualization of digital data layer)



2. Risk evaluation and recommendations for planning, coastal protection and coastal management purposes for the period of next 15 and 50 years

2.

Coastal areas with different erosion and flooding risk degree due to local conditions



2.

Gulf of Riga Vidzeme coast (**area 1**) is considered as high risk area. Severe and average erosion (5-10 m/15%/y^{-1}) with damage to property and infrastructure during W, NW and N storms with surge level over 2.0 m for more then eight hours. Northernmost part of area (10 km) is subject more to flooding then the coastal erosion.

Gulf of Riga south coast (**area 2**) is considered as average risk area. Average erosion (0-10 m/15%/y^{-1}) with damage to property and infrastructure during W, NW and N storms with surge level over 1.7 m for more then eight hours. In local short sections close to Daugava and Gauja embouchures erosion and flooding risk is high.

Gulf of Riga Kurzeme coast (**area 3**) is considered as average risk area. Severe and average erosion (5-10 m/10%/y^{-1}) with damage to property and infrastructure during NW and N storms with surge level over 1.5 m for more then five hours. In local short coastal sections related to Roja, Mērsrags and Engure ports erosion risk is high. Flooding risk is low and very low.

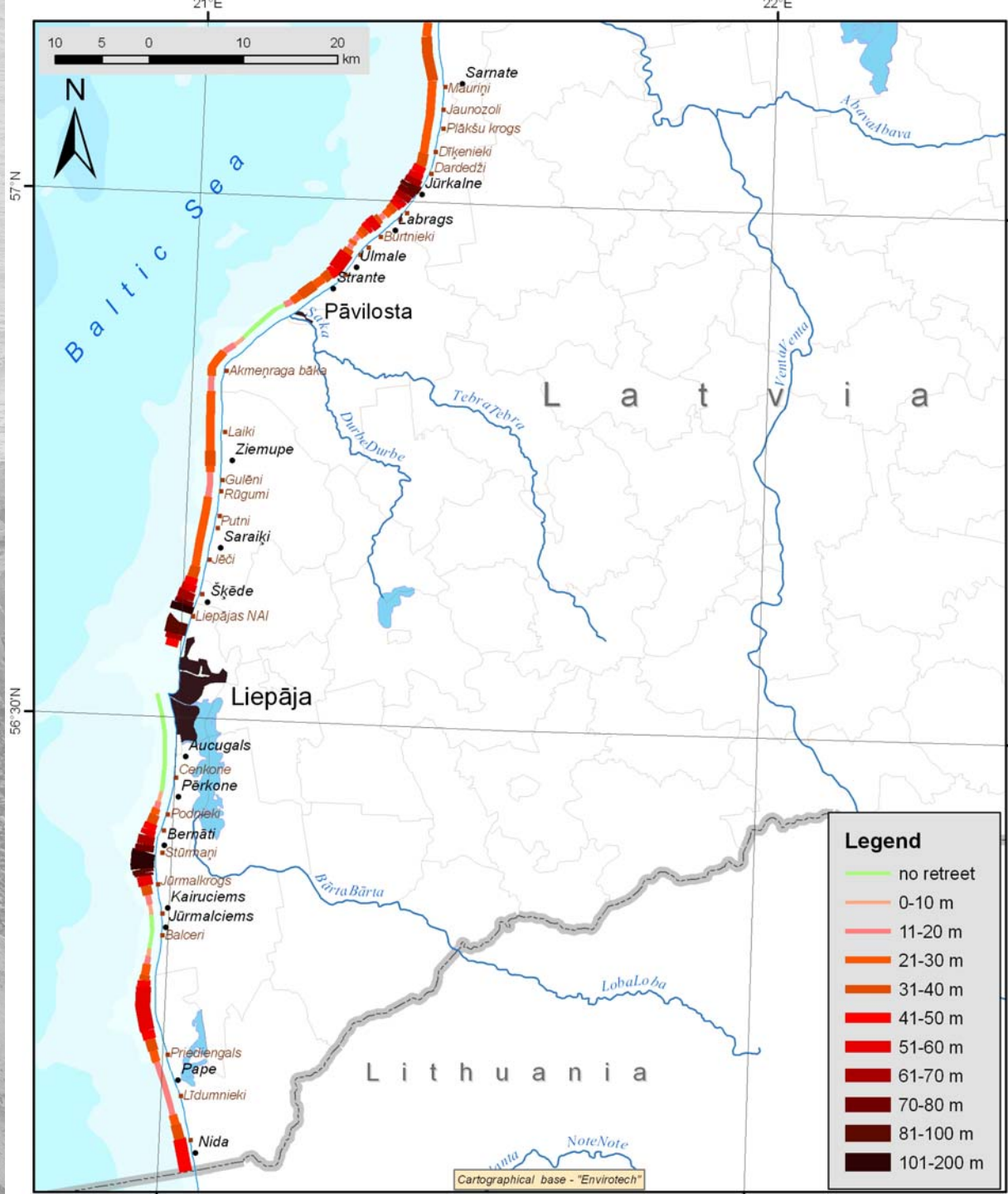
2.

Coast of the Irbe Strait (**area 4**) is considered as low risk area. Week erosion (0-5 m/15%/y^{-1}) with damage to property and infrastructure during W, NW and N storms with surge level over 1.3 m for more then eight hours. In 5 km long coastal section close to Cape Kolka erosion risk is high. Flooding risk is low and very low.

Coast of the Baltic Proper (**area 5**) is considered as high risk area and most threatened by erosion in more frequent storms. Severe and average erosion (5-15 m/20%/y^{-1}) with damage to property and infrastructure during SW, W, NW and N storms with surge level over 1.2 m for more then five hours. In local coastal sections related to Liepāja, Pāvilosta and Ventspils ports erosion risk is extremely high. Southernmost part of area (Lithuanian border - Liepāja) is subject to local flooding risk.

2.

Coastal erosion forecast for 2058 (overview map)



2. Forecast of coastal dynamics associated with coastal erosion risk

(2009-2023):

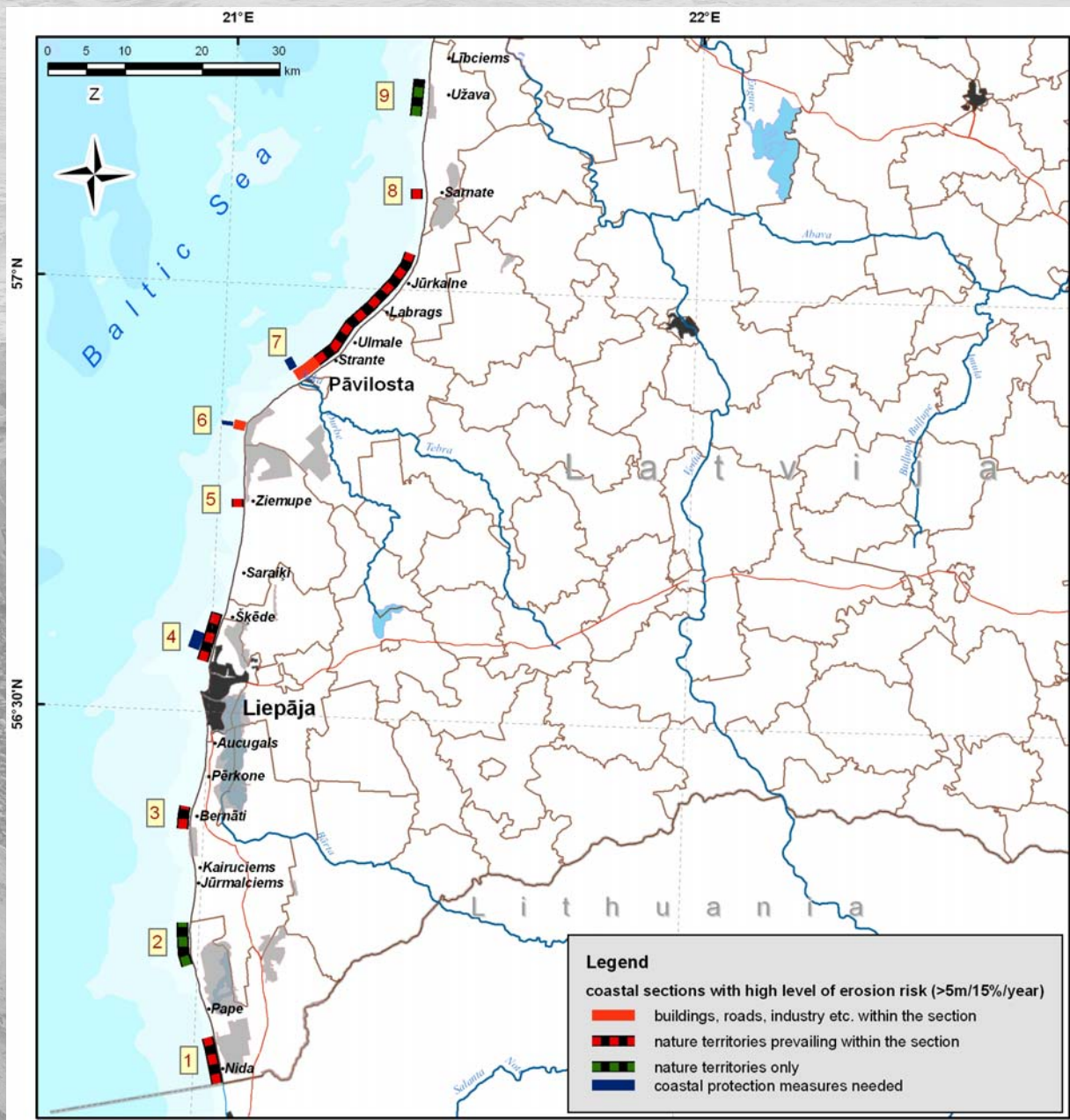
- Long term mean and maximum values of coastal erosion rate will be close to measured during last decade (0.5-3.0 m/y^{-1}),
- Coastal erosion will continue in previously erosional coastal sections, with several new zones potentially at risk.

(2024-2058):

- Long term mean and maximum values of coastal erosion rate will be 30-100 % higher then measured during last decade (1.0-6.0 m/y^{-1}),
- Total length of coastal sections with erosion risk will be 10-20 % higher then measured during last decade,
- Total land area lost due to coastal erosion will reach approximately 1070 ha by the year 2058.

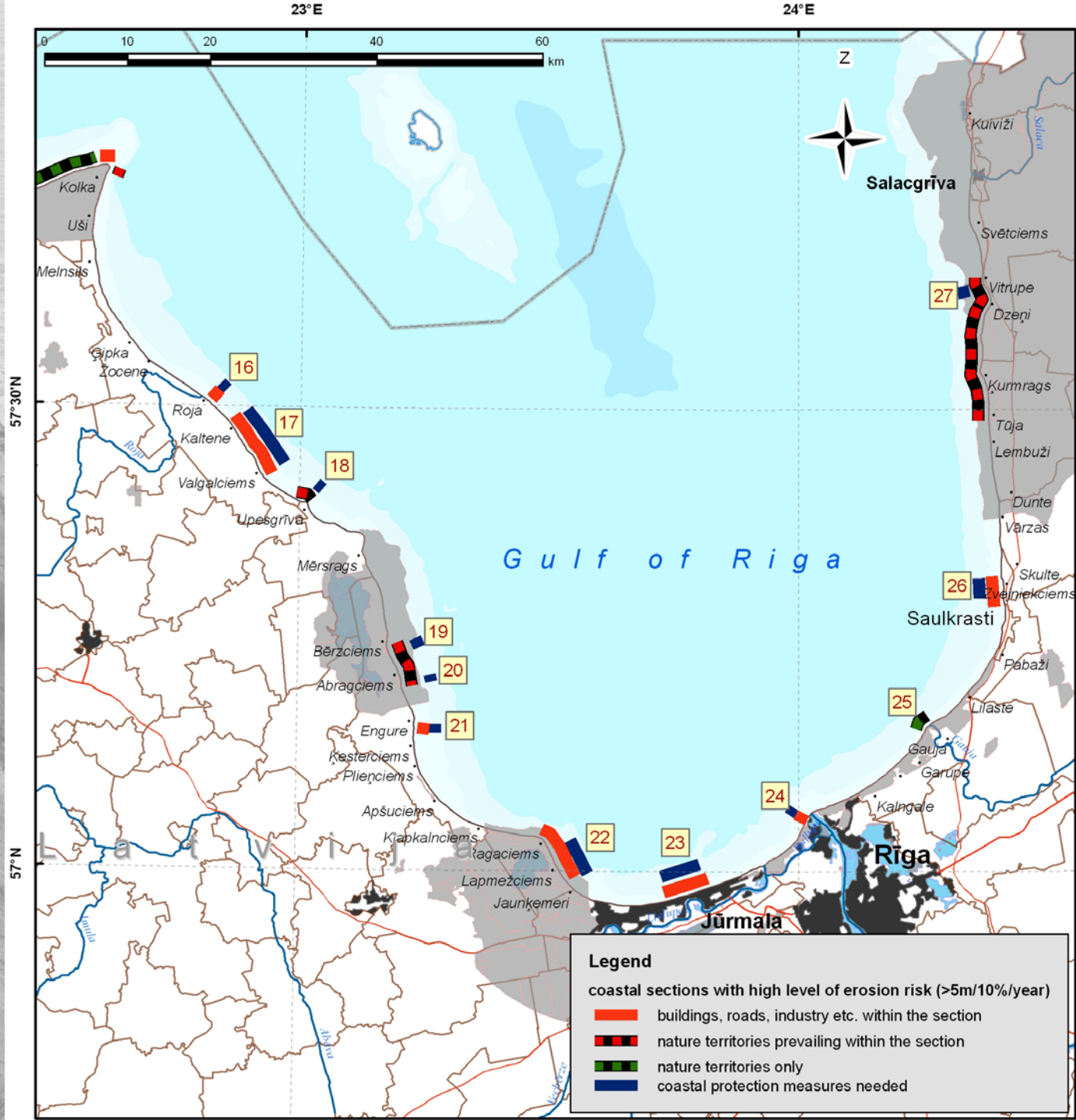
3. Preparation of recommendations for government level and expert working group "*Adaptation to climate change*"

Coastal sections at the Kurzeme coast of Baltic Proper with high erosion and flooding risk (fragment)



3.

Gulf of Riga coastal sections with high erosion risk



3. Coastal sections with high erosion risk

No.	Section	Section length (m)	Erosion risk level (y^{-1})	Main objects within the section	Recommended action (code)
1.	Nida	5500	5m/20%	6 buildings, nature areas	A
2.	Mietrags	5500	5m/25%	Nature areas	A
3.	Bernāti	3000	15m/25%	Nature areas, 3 buildings	A
4.	Liepāja-Šķēde	7000	10m/25% > 5m/15% (decrease in risk level northward)	Liepāja sewage water treatment plant, WW2 memorial, Wind energy farm, infrastructure objects, culture objects.	C (>2000 m)
5.	Ziemupe	800	5m/15%	Ziemupe old cemetery	AB
6.	Akmeņrags	800	5m/15%	Akmeņrags lighthouse buildings, mobile communications infrastructure	C1B (300 m)
7.	Pāvilosta (north)	500	5m/20%	7 buildings	CB (500 m); D
8.	Labrags embayment	19000	10m/30% > 5m/15% (lowest risk level in southern part)	Local roads, culture objects, 7 buildings, infrastructure objects	A
9.	Sārnate	1000	5m/15%	Nature areas, 5 buildings	A
10.	Užava	4000	5m/15%	Nature areas	A

3. Coastal sections with high erosion risk (table continuation)

11.	**Melnrags (Lībciems-Grigaļciems)**	**7000**	**10m/30% > 5m/15% (lowest risk level in center)**	**Nature areas**	**A**
12.	**Ventspils-Liepene**	**11000**	**10m/25% > 5m/15% (differences in risk level within the section)**	**Infrastructure objects, 3 buildings, nature areas (large amount of different buildings and objects are in 50-60 year risk area)**	**D; and/or C (3000 m)**
13.	**Ovīšu cape**	**1000**	**5m/20%**	**Nature areas**	**A**
14.	**Vaide-Kolka**	**5000**	**5m/15%**	**Nature areas**	**AB**
15.	**Cape of Kolka**	**1000**	**5m/25%**	**Infrastructure and culture objects, Nature areas (2-5 farmsteads are in 50-60 year risk area)**	**A**
16.	**Roja (south)**	**1000**	**5m/15%**	**7 buildings, local roads and other infrastructure (large amount of different buildings and objects are in 50-70 year risk area)**	**D; and/or C1 (600 m)**
17.	**Kaltene-Valgalciems**	**7000 (3000)**	**5m/10% (differences in risk level within the section)**	**>26 buildings, local roads and other infrastructure, nature areas**	**C1 (short sections with total length of ~3000 m)**
18.	**Upesgrīva**	**1000**	**5m/10%**	**8 buildings**	**C1**
19.	**Bērzciems**	**1000**	**5m/10%**	**10 buildings, local roads and other infrastructure, nature areas**	**C1 (800 m)**

3. Coastal sections with high erosion risk (table continuation)

20.	**Abragciems**	**1000**	**5m/15%**	**8 buildings, local roads and other infrastructure, nature areas**	**C1 (~300 m) and AB**
21.	**Engure (south)**	**1000**	**5m/10%**	**Engure old cemetery, 10-12 buildings (>20 buildings and infrastructure are in 50-70 year risk area)**	**D; and/or C1 (700 m)**
22.	**Bigauņciems-Lapmežciems**	**7000 (1200)**	**5m/20% > 5m/10% (lowest risk level in northern part)**	**15-20 buildings, local roads and other infrastructure**	**C1 and AB (7000 m)**
23.	**Jūrmala (center)**	**10000 (3000)**	**5m/15% > 5m/10% (differences in risk level within the section)**	**5-10 buildings**	**B (10000 m); C (~1000 m)**
24.	**Daugavgrīva**	**1000**	**5m/15%**	**Industrial area, nature area**	**CB (~1000 m)**
25.	**Gauja embouchure**	**2000**	**10m/15%**	**Nature area**	**A**
26.	**Zvejniekciems-Saulkrasti**	**3000**	**5m/15% > 5m/10% (lowest risk level in southern part)**	**15-20 buildings, local roads and other infrastructure, nature areas**	**C1B**
27.	**Vidzeme coast (Vitrupe)**	**30000 (1200)**	**5m/10% (differences in risk level within the section)**	**10-20 buildings, local roads and other infrastructure, nature areas, ViaBaltica road**	**A and C1 (short sections with total length of ~2000 m)**

3.

Recommendations for coastal protection measures:

- A – No coastal protection actions are needed and in most cases can be considered as unacceptable,
- AB – No coastal protection structures are needed, “green actions” and/or “soft methods” is feasible,
- B – Coastal protection actions combining several “green” and “soft methods” can be considered as suitable,
- C – Necessity for “hard” coastal protection structures,
- C1 – Necessity for “hard” coastal protection structures with advantage for simplified and/or “light” structure types,
- CB – Combining of “hard” coastal protection structures and “green actions” can be considered as suitable,
- D – Necessity for actions providing sediment bypassing to pass obstacles (port jetties) to eliminate erosion in artificial sediment deficit areas.

3.

- 27 specific coastal sections with high and very high erosion and flooding risk has been determined (total length – 110 km)
- Grounded on coastal development level, coastal evolution and erosion risk data, action recommendations for coastal zone planning, management and protection is prepared
- Total length of coastal sections with necessity for coastal protection actions by this day is 5000-7000 m (in case of no bypassing in harbor areas)
- During next 20 years total length of such sections will increase to 10000-15000
- In most of the risk sections “hard type” coastal protection structures can be considered as inappropriate or even unacceptable (losses, costs and deficiencies are higher than the possible benefits)


Thank you!