Norwegian management system for contaminated sediments

- Recommendations for Latvia

Recipient(s):	Everita Zaķe-Kļaviņa, Ance Drevina, Raimonds Slesarevs & Olafs Kalnins	31.10.2024
Prepared by:	Sigurd Øxnevad, Anders Ruus, Merete Grung and Morten Jartun	
Quality assurance by:	Morten Jartun	
Copy:		
Reference number:	0249/24	
Project number:	240181	
Distribution	Open	

Introduction

A delegation of four people from The State Environmental Service of the Republic of Latvia (https://registri.vvd.gov.lv/eng/jaunumi/2014/12/the-state-environmental-service-of-the-republic-of-latvia?id=252) visited NIVA on the 23rd and 24th of September 2024 to learn about practice for classification and risk assessment of contaminated sediments in Norway.

In this document we present the basis of environmental assessments for sediments in Norway. It includes an overview of the main documents in use, in addition to references to specific guidelines and environmental quality standards. Our assessment tools are based on the EU Water Framework Directive but adapted to Norwegian conditions. Most of the key documents are in Norwegian, but we have tested that common AI digital tools (and even Google Translate) will work quite well when translating into English.

Content

Recommendations for a management system specific for contaminated sediments 3
Intro to risk assessment for marine sediments 3
A key document to explore these goals is the Norwegian Guidance 02:2018 (revisions from 2020): 3
Chemical status is defined by EQSs 4
The five-class system for sediments 5
Developing and exploring the EQSs 7
Chemical status – using EQSs 8
Monitoring methodology 10
Sampling methods 10
Environmental status of the Liepāja Karosta Canal 11
Threats – why reaching the ambitious goals might be difficult 13
References 13

Recommendations for a management system specific for contaminated sediments

Intro to risk assessment for marine sediments

Risk assessment for sediments is based on the EU Water Framework Directive (WFD). The baseline is proper management of ecosystems, i.e. to protect the ecosystem and human health from detrimental effects of contamination. Main goal is to achieve a good ecological and chemical quality of water bodies, such as marine areas.

A main part of the holistic management of water bodies are clearly defined environmental goals, see Figure 1. These are highly specific and verifiable goals for each water body, that can be a specific catchment area, a river, a lake or a marine area.

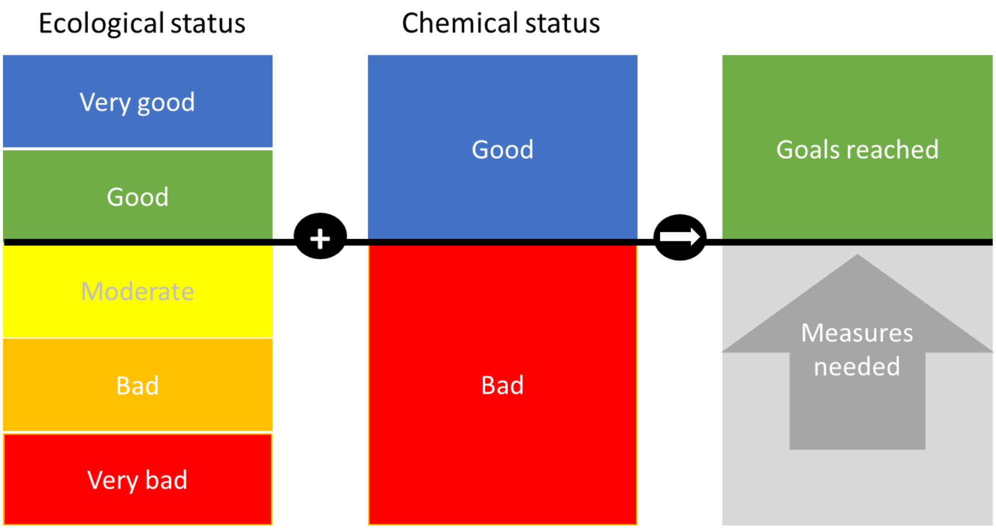
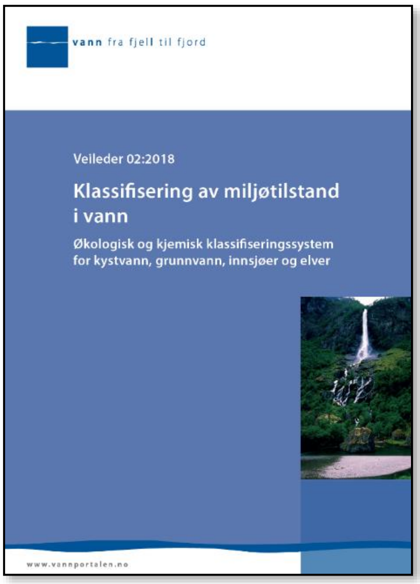


Figure 1 Main goals for water management is to reach good ecological and chemical status for each defined water body.

A key document to explore these goals is the Norwegian Guidance 02:2018 (revisions from 2020): *Classification of environmental quality in water. Ecological and chemical classification system for coastal waters, groundwater, lakes and rivers.* All background information on how to evaluate contamination can be found in this document, initiated by the Norwegian Environment Agency (Norw.: *Miljødirektoratet*). This guidance is based on the EU Water Framework Directive.

Direktoratsgruppen vanndirektivet 2018. Veileder 02:2018 Klassifisering av miljøtilstand i vann. «*Water Directive – Guidance 02:2018, Classification of environmental quality in water. Ecological and chemical classification system for coastal waters, groundwater, lakes and rivers*»

https://www.vannportalen.no/veiledere/klassifiseringsveileder/



Investigations should be conducted so that you are able to detect anomalies (extraordinary pollution) from prevailing trend. This requires proper baseline studies to have an idea of the starting point. A key question might be: “What is contamination and what is natural baseline (reference) concentrations in Latvian marine sediments?” Examining the levels, trends and effects of contaminants, especially for biota (fish, shellfish) is important to document *improvement* or detect *deterioration,* i.e. to be able to determine the source of contamination for the specific area and/or to plan remedial actions.

It is important to collect as much data as possible, because the statistical power increases with amount of data.

This important document provides a comprehensive framework for assessing and classifying the environmental status of water bodies. Main aim of this work is:

1) to establish environmental goals for a specific area to ensure a comprehensive protection of human health and secondary poisoning of organisms in the food chain.
2) Ensure a sustainable use of the water bodies.

Chemical status is defined by EQSs

The WFD defines a list of *priority contaminants*, that is a list of chemical substances with a potential threat to environment and/or human health. These prioritized substances are toxic and often very persistent and bioaccumulating. Examples include heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), per- and polyfluorinated substances (PFAS), siloxanes, dioxins, phenolic compounds and many other. A safe concentration for these substances, *an environmental quality standard (EQS)* is defined locally, and must be calculated for Latvian conditions. In Norway, we have developed EQSs for sediment and biota to be used in management of contaminated sediments.

The five-class system for sediments

The Norwegian guidance document M-608 provides an assessment tool to be used together with guidance 02:2018 (see previous chapter). M-608 provides updated limit values expressed as EQSs in accordance with the EU Framework Directive. EQSs for specific contaminants are given for sediment, water and biota.

Grenseverdier for klassifisering av vann, sediment og biota - revidert 30.10.2020 - «Quality standards for water, sediment and biota - revised 2020.10.30». [Grenseverdier for klassifisering av vann, sediment og biota - miljodirektoratet.no]	

For sediments, the EQSs are used in monitoring projects in Norway for the assessment of chemical status and ecological status according to the Water Framework Directive. This document (no. 608) with EQS values is designed to provide a common tool across Norway for:

- Stakeholders (environmental authorities on a local, regional or national scale)
- Consultants working on specific cases of environmental assessments
- Research

In Norway we generally use a 5-class system for the classification of contaminants in sediments and water, both for freshwater and marine ecosystems. This classification system has been used in Norway for many years to describe the contamination level in sediments, water and biota (organisms), see Figure 2.

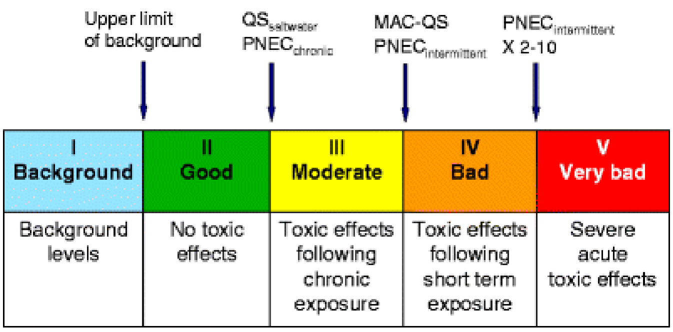


Figure 2 Norwegian environmental quality classification system for contaminants in seawater and sediments (see Bakke et al., 2010).

It is important to develop a classification system meant for **<u>sediment</u>** contamination for marine sediment and freshwater sediments. To use a classification system meant for soil samples is not comparable. We highly recommend developing a classification system in Latvia meant for marine sediments and freshwater sediments, and also for marine water samples and freshwater samples. Norway have developed EQSs for sediment and biota according to the guidance document from the European Water Framework Directive (see next chapter). When a relevant classification system is implemented in Latvia, it will be easy to compare concentrations found in sediment samples with EQSs for sediment developed for Latvia specifically. Latvia could also develop a version of the 5-class system used in Norway.

Examples from the five-class system in Norway is shown in Figure 3.

Navn på stoff	Enhet	Klasse I	Klasse II	Klasse III	Klasse IV	Klasse V
		Bakgrunn	God	Moderat	Dårlig	Svært dårlig
Metaller						
Arsen	mg/kg TS	0 - 15	15 - 18	18 - 71	71 - 580	> 580
Bly[1)]	mg/kg TS	0 - 25	25 - 150	150 - 1480	1480 - 2000	2000-2500
Kadmium[2)]	mg/kg TS	0 - 0,2	0,2 - 2,5	2,5 - 16	16 - 157	> 157
Kobber[3)]	mg/kg TS	0 - 20	20 - 84		84 - 147	> 147
Krom[4)]	mg/kg TS	0 - 60	60 - 620	620 - 6000	6000 - 15500	15500-25000
Kvikksølv	mg/kg TS	0 - 0,05	0,05 - 0,52	0,52 - 0,75	0,75 - 1,45	> 1,45
Nikkel	mg/kg TS	0 - 30	30 - 42	42 - 271	271 - 533	> 533
Sink	mg/kg TS	0 - 90	90 - 139	139 - 750	750 - 6690	> 6690
PAH						
Naftalen	µg/kg TS	0 - 2	2 - 27	27 - 1754	1754 - 8769	> 8769
Acenaftylen	µg/kg TS	0 - 1,6	1,6 - 33	33 - 85	85 - 8500	> 8500

Figure 3 Classification system for selected contaminants in sediment (mg/kg dw) in Norway.

Examples on how to compare site specific sediment concentrations of selected contaminants with the five-class system is shown in Figure 4.

Klasse I Bakgrunn	Klasse II God tilstand	Klasse III Moderat tilstand	Klasse IV Dårlig tilstand	Klasse V Svært dårlig tilstand

Parameter	Enhet	St. RE02	St. RN2	St. RN4	St. RN5	St. RE08	St. RN9
Kvikksølv	mg/kg	<0,015	0,016	<0,014	<0,013	0,020	<0,014
Arsen		6,8	8,7	5,8	4,0	9,7	4,8
Bly		4,4	8,7	4,2	3,3	14	5,4
Kadmium		0,089	0,094	0,079	0,052	0,11	0,081
Kobber		40	75	36	20	59	20
Krom		13	40	12	8,3	30	11
Nikkel		30	48	24	14	36	14
Sink		53	75	51	33	89	39
Acenaften		<10	<10	<10	<10	<10	<10
Acenaftylen		<10	18	<10	<10	12	<10
Antracen		4,8	28	<4,6	<4,6	18	<4,6
Benzo(a)antracen		24	130	12	<10	82	<10
Benzo(a)pyren		26	190	16	<10	140	15
Benzo(b,j)fluoranten		55	300	25	<10	220	22
Benzo(g,h,i)perylen		28	150	19	<10	140	16

Figure 4 Example from a Norwegian marine site, showing concentrations of heavy metals (mg/kg dw.) and selected PAHs (µg/kg dw.) in sediments according to the guidance document M-608 (2020). dw= dry weight.

For a contaminant found in concentrations above EQS, there may be a risk for *significant environmental or health implications*. Certain chronic health effects are explained, and the potential for ecosystem impact is also explained. When substances in water, sediment, or biota are classified in higher classes (Class III, IV, or V), authorities typically take several actions to address the environmental and health risks. This might include increased and more detailed monitoring or detailed short-term assessments which may explore the extent of the contamination, its effects and potential for spreading to other locations.

Authorities may use the assessment to implement regulations for e.g. industries with specific discharge permits. One example may be the implementation of cleaner technologies or lower discharge levels for certain contaminants. Remediation actions and cleanup is also a potential conclusion after a thorough risk assessment in a certain area. Such actions are aimed at mitigating the immediate risks posed by high levels of contaminants and preventing future occurrences. By taking a comprehensive and proactive approach, authorities can protect both the environment and public health.

Developing and exploring the EQSs

Developing national EQSs is an important starting point for investigating environmental status in natural compartments. The baseline is described in a EU technical document called EU TGD (2011, updated in 2018): *Common Implementation Strategy for the Water Framework Directive. Technical Guidance For Deriving Environmental Quality Standards*, see frontpage in Figure 5.

Developing EQSs for sediments in Latvia should be a priority for exploring and monitoring environmental conditions in sediment and biota. Behind EQSs in sediment are extensive and stepwise tasks to explore:

- Toxicity data for organisms living in the area (No Observed Effect Concentrations, NOEC)
- Consider safety factors when limited data is available (literature)
- Statistical interpretation (*p=0.05*) to protect 95 % of organisms, find the HC5 (Hazardous concentration for 5 % of species)
- Find the *acceptable concentration in water*

- Calculate acceptable concentration in *sediment* based on distribution coefficients between sediment particles and water (K_d)

EQSs for biota will consider a) secondary poisoning or b) human health perspective. In WFD, biota is primarily fish, but specific compounds are specified in other organisms, such as PAHs (crustaceans and molluscs) and dioxin (fish, crustaceans or molluscs). Quality standards for secondary poisoning in biota are calculated from a toxicity reference ($NOEC_{oral}$) for birds or mammals. Next step would be to consider duration of tests, and an assessment factor to extrapolate from bird or mammal to QS. When calculating EQS for human health, factors such as a) the Tolerable Daily Intake (TDI), b) body weight, c) fraction of contaminants in fish that is assimilated in the human body, and d) amount (kg) of fish eaten per day, must be considered.

When deriving EQSs for water, you must consider the biomagnification potential and human health, where bioconcentration factors (C_{fish}/C_{water}), biomagnification from lower trophic levels to predators are essential data.

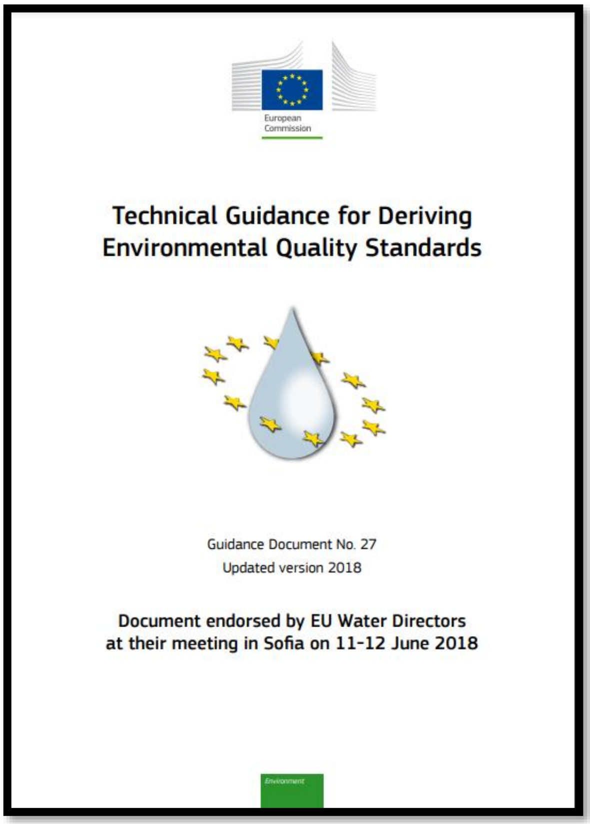


Figure 5 Technical guidance for deriving Environmental Quality Standards (EU commision, 2018)

Chemical status – using EQSs

When assessing chemical status of a given waterbody (marine area, lake, river), the chemical status is either set to:

- **Good** (all concentrations in studied material is below the Environmental Quality Standard (EQS) set for priority contaminants)

- **Poor** (1 or more samples have concentrations of a given priority contaminant above the EQS for the given area).

The classification system is divided into

- **Ecological status**: Five classes based on:
    - Biological quality elements such as biodiversity and indication systems and parameters to ensure the potential impact of different pressures to the area such as eutrophication, acidification and hydromorphological changes.
    - Physical-Chemical Quality Elements including nutrients (total Nitrogen, total Phosphorus), oxygen, pH.
    - Hydromorphological Quality Elements including water fluxes and substrate type.

- **Chemical status**, which provides a set of criteria for assessing the chemical contamination based on concentrations of priority contaminants (such as heavy metals, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), per- and polyfluorinated alkyl substances (PFAS) etc.). Some contaminants are classified as priority substances (on the EU-list), but in Norway we also have a list of additional contaminants in a region-specific list of contaminants adapted to potential sources of contamination for each region.

A schematic overview of exploring ecological and chemical status is shown in Figure 6.

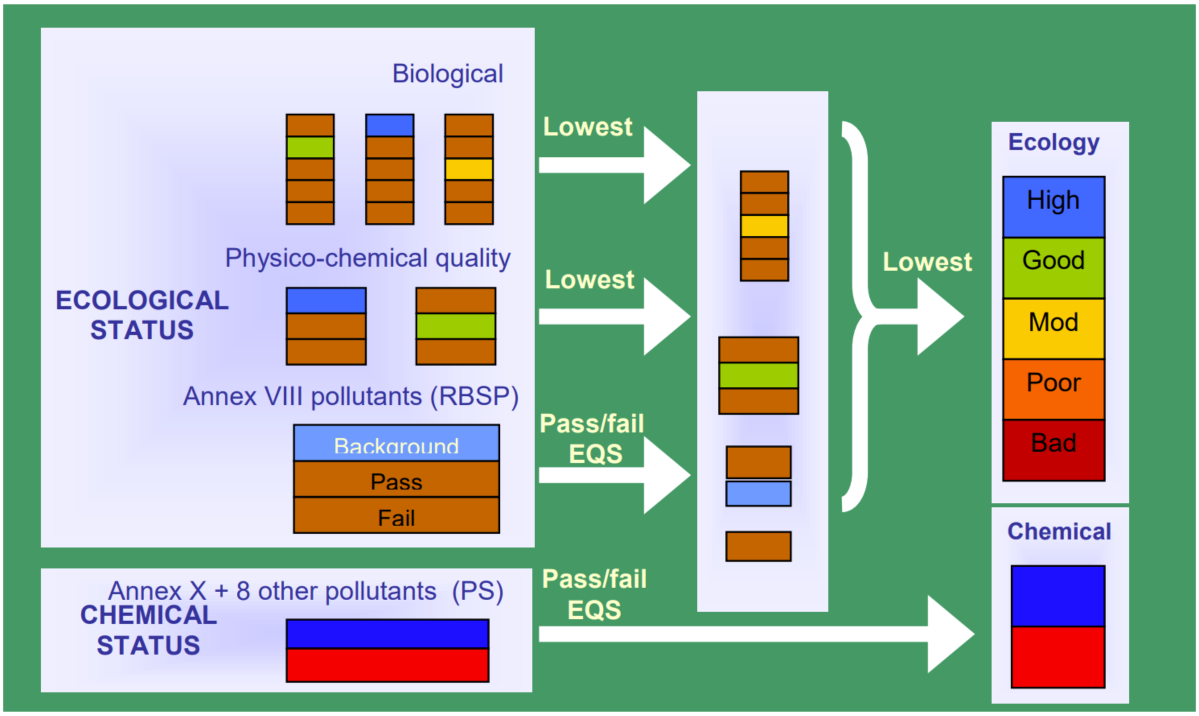


Figure 6 Overview of how to explore environmental status. Ecological status including River Basin Specific Pollutants (RBSP). Chemical status based on EU priority contaminants and their EQS values.

Examples of EQSs used in Norway is shown in Figure 7.

	Navn på substans	CAS-nr.[1]	Ferskvann		Kystvann		Sediment	Biota
			Årlig gjennomsnitt[2] for ferskvann[3] µg/l	*Maksimal verdi[4] for ferskvann[3] µg/l*	*Årlig gjennomsnitt[2] for kystvann µg/l*	*Maksimal verdi[4] for kystvann µg/l*	*EQSsed mg/kg TS*	*EQS_{biota} µg/kg våtvekt*
1	Bisfenol A	80-05-7	1,5	11	0,15	11	0,0011	
2	TBBPA (Tetra-bromobisfenol A)	79-94-7	0,25	0,9	0,25	0,9	0,11	
3	Dekametyl syklopenta-siloksan (D5)	541-02-6	1,7	17	0,17	1,7	0,044	15000
4	Klorparafiner (mellomkjedete)	85535-85-9	0,05		0,05		4,6	170
5	PFOA	3825-26-1. flere	9,1	Ikke oppgitt	9,1	Ikke oppgitt	0,071	91
6	Triklosan	3380-34-5	0,1	0,28	0,1	0,28	0,009	15000
7	TCEP (tris(2-kloretyl)fosfat)	115-96-8	65	510	6,5	510	0,072	7300
8	Dodecylfenol med isomere	121158-58-5, 27193-86-8	0,04	0,17	0,004	0,017	0,0044	
9	Diflubenzuron	35367-38-5	0,004	0,1	0,004	0,1	0,0002	730
10	Teflubenzuron	83121-18-0	0,0025	0,12	0,0025	0,012	0,0000004	610
11	Trifenyltin	892-20-6, 900-95-8, 76-87-9, 639-58-7	0,0019	0,035	0,0019	0,035	3,61E-05	150
12	PCB7	1336-36-3	2,4E-06		2,4E-06		0,0041	0,6
13	Kobber	7440-50-8	7,8	7,8	2,6	2,6	84	
14	Sink	7440-66-6	11	11	3,4	6	139	
15	PAH							
	Acenaftylen	208-96-8	1,28	33	1,28	3,3	0,033	

Figure 7 Examples of EQSs in freshwater, seawater, sediment and biota used in Norway (see document 02:2018).

Monitoring methodology

Once a classification system and EQSs have been established, baseline investigations and future monitoring of the environmental conditions in specific water bodies can be initiated. In Norway, several areas have been studied with various background stories. All industries, WWTPs etc. must have a discharge permit, an upper limit on how much of selected contaminants they are allowed to spread to a known recipient. Strict regulations control this, and all industries with discharges to a water body must monitor the environmental condition by studying concentrations of contaminants in sediment, biota and/or water on a regular basis. In such monitoring projects, chemical status and variations over time (trends) are studied.

Sampling methods

Sediments

Sediments are most often collected using a “van Veen grab”, shown in Figure 8. Usually, sediment from the top layer (0-10 cm) is used for classification, whereas 0-2 or 0-1 cm is used for time trend studies.

Figure 8 Collection of sediment samples using a van Veen grab.

Other equipment such as sediment traps (plastic containers suspended in the water column to collect settling sediments) or corers (collecting sediment cores of 0-50 cm or more to study historical development).

Biota

Monitoring biota may be a useful way to study the impact of contamination in an area. In marine areas, blue mussels are often used as they are filter feeders and absorb contamination from digested particles and from the water phase. Locally found mussels may be used, or it is possible to deploy caged, farmed mussels with an exposure time of more than 2 months.

Fish is also used, as they often represent the predators (high in the food chain), potentially indicating bioaccumulation and biomagnification of contaminants. Some fish species are local and close to the sediment (flat fish), others are more migrating and may represent a larger influence area.

Environmental status of the Liepāja Karosta Canal

Sediment samples were collected after dredging some of the sediment surface area in the canal, shown in Figure 9. Unfortunately, several sampling points were not placed inside the dredged area, making it difficult to study the effect of dredging on the environmental status. This is to document the concentrations of contaminants *after* sediment remediation. Ideally, this should have monitored how successful the remediation action was. The goal of the dredging could have been to remove the most contaminated sediment in the canal. Then you could probably find much lower concentrations in the sediment after dredging.

The samples are currently undergoing physical and chemical testing. Your suggestions on what other parameters should be tested?

Next time the sediment samples should also be analyzed for the content of PCBs. This is because PCBs were found in the Karosta canal in very high concentrations in a report from 2006.

How often to take samples?

To consider the value of remediation (removal of contaminated sediments), it is useful to wait until more sediments have been dredged and from the canal. Only about 50% of the area has now been dredged. Activities such as ship propellers will probably cause a recontamination of the dredged area.

If new *water* samples should be analyzed then they should be analyzed in a laboratory with lower levels of quantification (LOQ) than last time (samples taken in December 2023).

If waterbody status is good for longer period, how long time (years) do you suggest to take monitoring?

After a sediment remediation action (such as dredging), monitoring should be carried out during a 5-10 years' time period. Then it should be decided if more monitoring is needed.

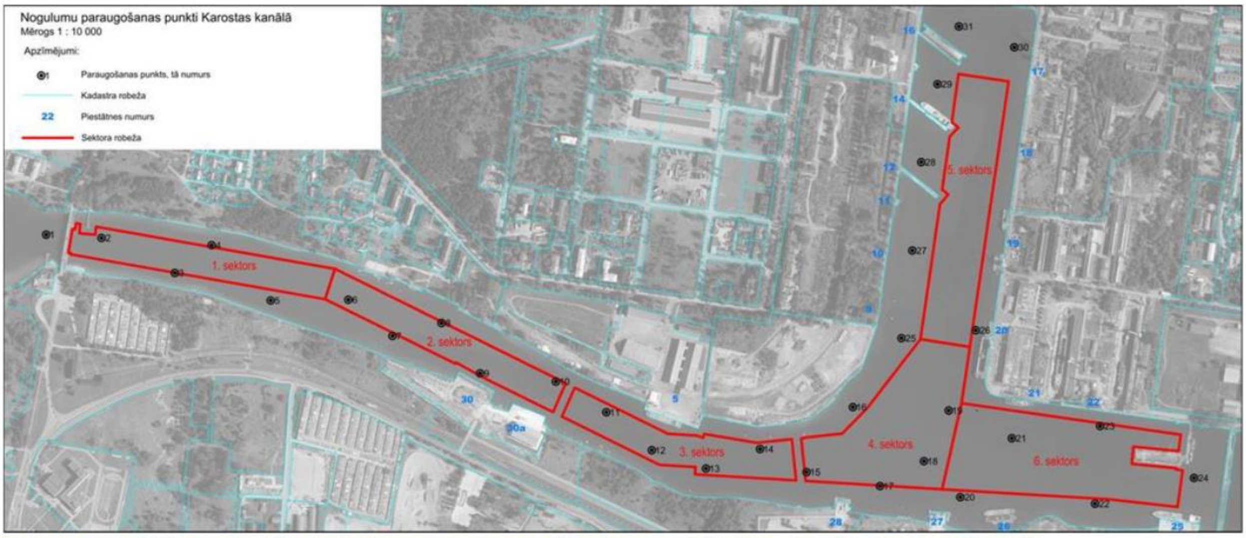


Figure 9 Sediment samples collected from 31 stations after dredging of the Karosta Canal (Map by Liepāja Special Economic Zone Authority).

Threats – why reaching the ambitious goals might be difficult

Proper data collection is essential to have the statistical power to evaluate the environmental condition, and the chemical status of an area. Key elements to be included in environmental management and risk assessment for a specific area is to provide data for:

- The potential discharges of contaminants to the area, e.g. urban runoff or effluents from wastewater treatment plants (WWTPs) to a marine bay area. Controlling the contamination sources is crucial to improving environmental status for an area.
- What is **old** and what is **new** contamination?
- Which activities are important for the area? Large ships? Propelling? Sailing depth?
- Any discharges of leachate from shore-based landfills?

References

Bakke, T., Källqvist, T., Ruus, A., Breedveld, G.D. and Hylland, K., 2010. Development of sediment quality criteria in Norway. J Soils Sediments 10: 172-178. DOI 10.1007/s11368-009-0173-y.

Direktoratsgruppen vanndirektivet 2018. Veileder 02:2018 Klassifisering av miljøtilstand i vann. *«Water Directive – Guidance 02:2018, Classification of environmental quality in water. Ecological and chemical classification system for coastal waters, groundwater, lakes and rivers».*

EU commision, 2018. Technical Guidance for Deriving Environmental Quality Standards, Guidance doc. No.27.

Miljødirektoratet, 2020. Grenseverdier for klassifisering av vann, sediment og biota – revidert 30.10.2020 - Quality standards for water, sediment and biota – revised 2020.10.30. M-608.