Feasibility study for Remediation of Contaminated Sediments from the River Labe (Elbe) at Selected Sites in the Lower Labe

Client: Povodí Labe, s.p., Hradec Králové

Contractor : AQUATEST a.s., Geologická 5, Praha 5

aquatest

AQUATEST PROJECT TEAM

Project manager:	Ing. Michaela Lažanská
Deputy project manager:	Ing. Roman Kříž
Project team :	
Laboratory pilot tests:	Ing. Irena Šupíková, Ph.D. *Director of the R&D Division, D18* *Specialist*: Ing. Kristýna Pešková
Field pilot tests:	Ing. Miloš Hnila *Director of the waste recycling division, D70* *Specialist* : Ing. Josef Horčička
Study completion:	Mgr. Jan Kuklík, Mgr. Aleš Kunovjánek Environmental Studies Division, Geotechnician

aquatest

Elaboration of the Feasibility Study

SUBJECT OF THE STUDY

- Design of remedial methods and definition of remedial conditions
- Pilot verification of the feasibility at selected sites
- Identification of appropriate remedial techniques and technologies
- Design of the optimal remedial method based on the evaluation (efficiency, feasibility, financial costs) and recommendations of the best alternative

aquatest

Elaboration of the Feasibility Study

SCOPE OF THE STUDY

1. More accurate estimate of the amount of sediment at the selected sites
2. Design and assessment of remedial alternative applicable to the given sites
3. Decontamination of extracted sediment and its use

- decontamination of extracted sediment and its return to the original environment
- suitable combination of approaches (decontamination, landfilling)

3. Verification of the effectiveness of the decontamination methods:

- Laboratory scale during the pilot tests
- Field pilot tests

4. Evaluation of proposed remediation methods

aquatest

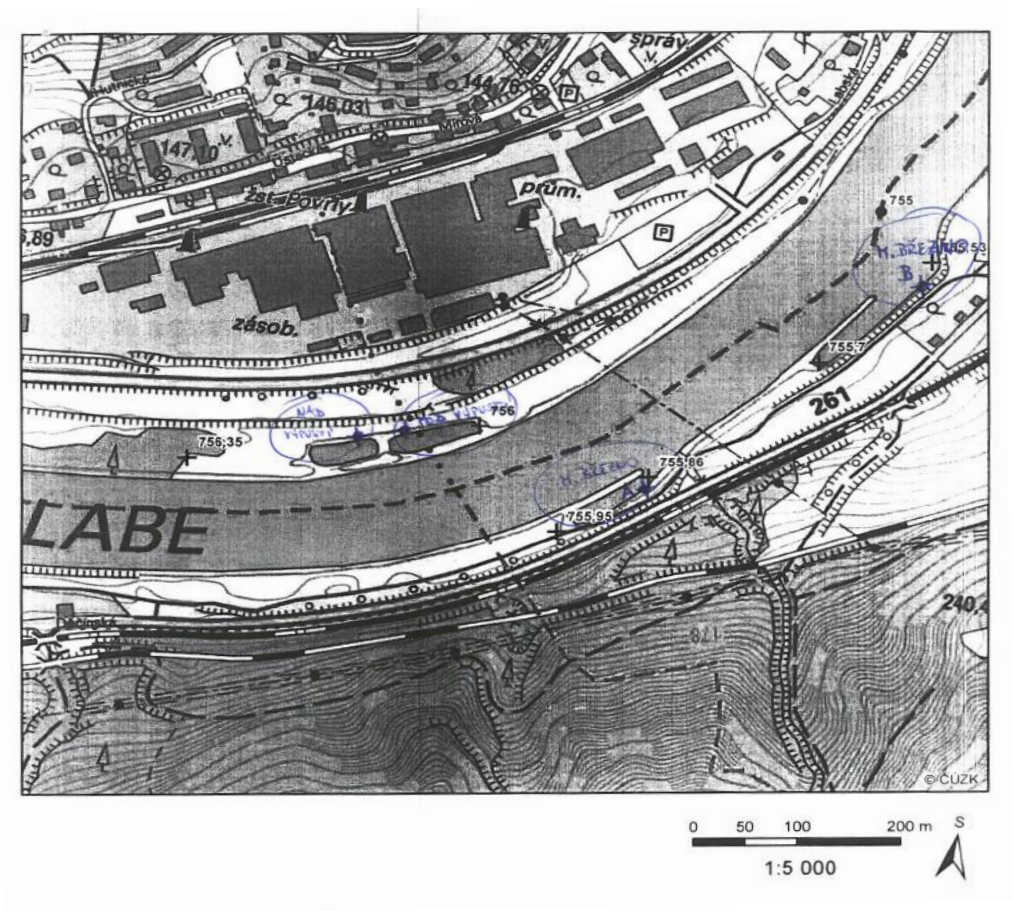
Performance of the study

Based on the results of the study “Importance of Bílina as a historical and current source of pollution for sediment management in the Labe - SedBILa basin” the following 3 most risky sites (quality, quantity, sediment deposition at an elevated state) were selected for testing:

1) Malé Březno A

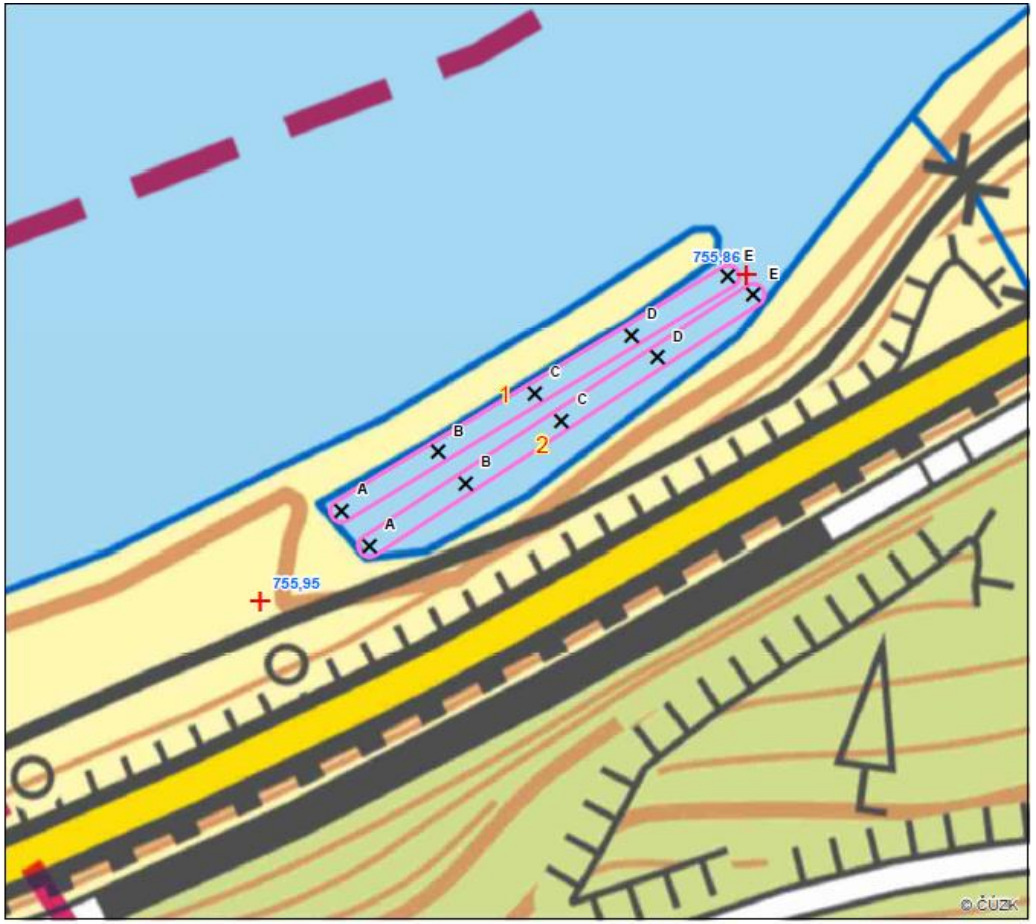
2) Malé Březno B

3) Povrly



aquatest

Malé Březno A



× dílčí vzorek

směsný vzorek

0 10 20 40 m

1:1 000

S

LOKALITA M. BŘEZNO - A

aquatest

Malé Březno B

× dílčí vzorek

směsný vzorek

0 10 20 40 m

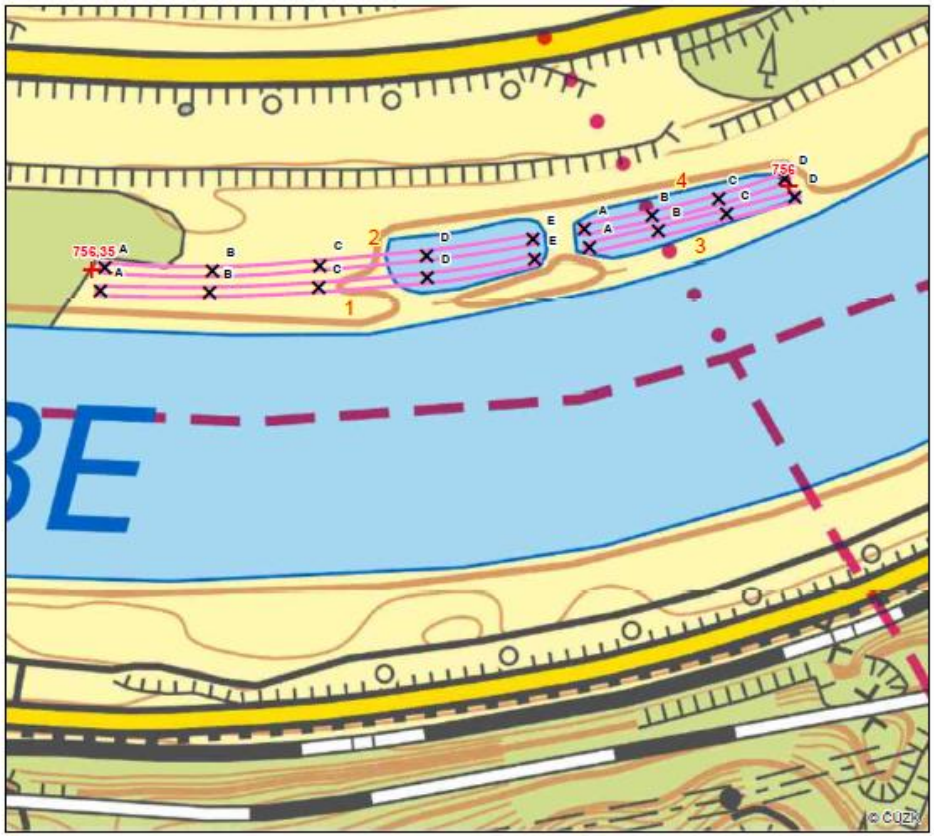
1:1 000

S

LOKALITA M. BŘEZNO - B

aquatest

Povrly



× dílčí vzorek

směsný vzorek

0 20 40 80 m

1:2 000

S

LOKALITA POVRLY

aquatest

Initial Work

Sediment quantity– geodetic survey – total 2,700 m3

Site	Bank	From (km from source)	To (km from source)	Volume of sediment (m^3)	Odhad kubatury SedBILa (m^3)
L8 Malé Březno east	Right	755.7	755.53	61	350
L9 Malé Březno west	Right	755.95	755.86	703	200
L10 Povrly	Left	756.35	756.00	1936	600

Sediment quality – initial sediment sampling,

evaluation of the concentrations of individual pollutants in sediments

- Chlorinated pollutants PCB, HCB, HCH, DDT & PAH
- Heavy metals Hg, Cd, Pb, Cu & Zn

Site	Pollutant	L8 Malé Březno east	L9 Malé Březno west	L10 Povrly above outlet	L10 Povrly below outlet
	Metals	No	No	No	Hg, Cu
	Pesticides	No	p,p´-DDT, p,p´-DDD	p,p´-DDT	p,p´-DDT
	PCB	No	PCB 138, 153, 180; sum of 7 congeners	PCB 153; sum of 7 congeners	PCB 138, 153; sum of 7 congeners
	PAH	benzo(a)pyrene, benzo(b)fluoranthene, indeno(cd)pyrene, benzo(a)anthracene			

Comparison of the situation in 2013 and 2017 - slight decrease in the concentration of contaminants in sediments or no change.

aquatest

Laboratory Verification for the Pilot Tests

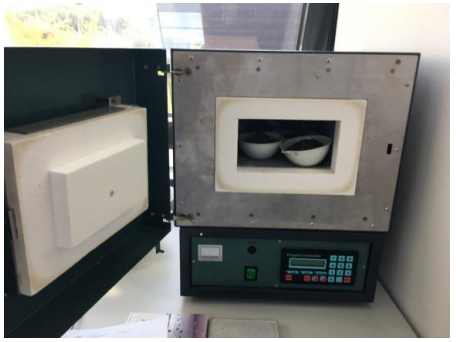
- Tests began with research
- Material for laboratory tests was removed and transferred to TUL for laboratory testing of selected methods

- Three types of remediation methods were proposed based on evaluation of initial analyses:
  - **Thermal desorption**
  - **Oxidation** (sodium persulfate activated at a temperature of 50°C)
  - **Washing with surfactants**

aquatest

Thermal Desorption

Thermal desorption was conducted in a muffle furnace. The residence times were 3h, 6h, 24h and samples were exposed to 350 °C and 500 °C. At 500 °C, residence times of 3h and 6h were tested.



Oxidation with Sodium Persulfate (PSF)

In the first round, the PSF was activated at 50 °C and reaction time was 2 weeks, in the second round PSF was activated at 60 °C for only one week. At the beginning and at the end of the experiment the physical and chemical parameters of the samples were measured.

Washing with Surfactants

A blank and various concentrations of SDS (sodium dodecyl sulphate) were selected as a suitable surfactant. 200 g of soil and 800 g of water were weighed into each sample (1 litre containers) and various SDS 1%, 3% and 5% were added. After weighing, the samples were placed on a horizontal shaker with the blank. At the beginning and end of the experiment, the physical and chemical parameters in the water were measured. After one week the experiment was completed.

Summary of Decontamination Techniques - Results

Summary of the effectiveness of the methods used for the degradation of heavy metals

Site	Test method	Cu	Hg
L10 Povrly below outlet	Thermal desorption	10% effectiveness at a temperature of 500°C	100% effectiveness after 3 hours at a temperature of 350°C
	Persulfate oxidation	20% effectiveness	25% effectiveness
	Soil washing using SDS	10% effectiveness using vyšších koncentrací	15% effectiveness using the highest concentration
L8 Malé Březno west	Thermal desorption	30% effectiveness at a temperature of 500°C	100% effectiveness after 3 hours at a temperature of 350°C
	Persulfate oxidation	20% effectiveness	25% effectiveness
	Soil washing using SDS	10% effectiveness using the highest concentration	30% effectiveness using the highest concentration

Summary of the effectiveness of the methods used for the degradation PAH, PCB & OCP

Site	Test method	PAH	PCB	OCP
L10 Povrly below outlet	Thermal desorption	100% effectiveness after 3 hours at a temperature of 350°C	100% effectiveness after 3 hours at a temperature of 350°C	100% effectiveness after 3 hours at a temperature of 350°C
	Persulfate oxidation	30-80% effectiveness based on specific type of PAH	50% effectiveness	effectiveness of methods completely different based on the specific type of pesticide
	Soil washing using SDS	5-20% effectiveness based on specific type of PAH	5-10% effectiveness	
L9 Malé Březno west	Thermal desorption	100% effectiveness after 3 hours at a temperature of 350°C	100% effectiveness after 3 hours at a temperature of 350°C	100% effectiveness after 3 hours at a temperature of 350°C
	Persulfate oxidation	30-80% effectiveness based on specific type of PAH	20% effectiveness	effectiveness of methods completely different based on the specific type of pesticide
	Soil washing using SDS	5-20% effectiveness based on specific type of PAH	10-15% effectiveness	

aquatest

Summary of the Laboratory Test Results

- The best results were achieved using the thermal desorption
  - almost complete removal of mixed contamination (with the exception of Cu)
- The other methods (PSF oxidation and washing with surfactants) also decreased the concentrations of pollutants, but with a much lower effectiveness, usually depending on the particular type of contaminant
  - The best results were from PSF oxidation

- **→ Thermal desorption removed 100% of the tested contaminants mercury, PAH, PCB and OCP from the Malé Březno and Povrly sites. The effectiveness of the method was much lower in the case of copper (approx. 10 %).**

aquatest

Pilot Laboratory Tests on Real Sediment Samples - Stabilization / Solidification

- Sampling of 3 sediment samples from Povrly and Malé Březno L9 west

- using a digger, 200 kg samples

- Based on long-term experience, the following stabilizers were tested on all samples:
  - 5 % cement
  - 5 % bentonite
  - 10 % quicklime
  - 5 % bentonite + 20 % ash

aquatest

Laboratory Tests for Sediment Stabilization

Leachability tests conducted pursuant to Decree 294/2005 Coll.

Based on the results of laboratory leachability tests, the pilot tests were performed with the addition of:

1. 5 % bentonite
2. 5 % bentonite with 20 % ash as a stabilizer, because

All samples with these stabilizers were in compliance with the leachability class II.a., i.e. possibility to dispose on a waste landfill.

aquatest

Pilot tests for Sediment Stabilization on the Pilot Equipment

- Samples were first sorted using a 25 mm mesh to remove coarse fractions

Samples below 25 mm



Samples above 25 mm



aquatest

Pilot tests for Sediment Stabilization on the Pilot Equipment

- Test line for stabilization of sediment with a fraction of below 25 mm

  - Two-shaft mixer
  - Worm conveyer
  - Vibrating feeder

aquatest

Pilot tests for Sediment Stabilization on the Pilot Equipment

The results of the leachability tests pursuant to Decree 294/2005 Coll. confirmed that all samples stabilized using 5% bentonite and 5% bentonite and 20% ash clearly meet the leachability class II.a, i.e. possibility to dispose on a waste landfill.

aquatest

Evaluation of the Proposed Remedial Methods

- The most effective method is the stabilization of sediment by the addition of 5% bentonite and subsequent landfilling
- Thermal desorption removes organic pollutants and Hg, but the content of Cu hardly changes (Cu decreases by 30% in sediments from Malé Březno and 10% from Povrly at a temperature of 500 °C). In addition, there is currently no fully commercial facility in the Czech Republic for processing 4,500 t of sediment.
- The other methods (persulfate oxidation, soil washing with surfactants) do not completely remove the pollutants from sediments and require further treatment of sediments.

aquatest

Summary of the Results of the Study

Achievement of the objectives of the study

- Samples from sites L9 and L10 confirmed that the use of stabilization techniques will meet the legal limits allowing the treated sediment to be landfilled.
- There is an overall positive effect from a long-term perspective on human health and the environment at the site and potentially affected environment. Pollution will be removed, no residual pollution is expected or any further negative or positive effects of the final remedial at the site and the surrounding area, considering social, aesthetic and other consequences.
- The effectiveness and reliability of the solution were determined based on pilot tests on sediments and their laboratory evaluation. Long-term operation is not foreseen. The remedial equipment is mobile and will be installed for the time necessary for the remediation of the extracted sediments.
- The length of the sediment remediation from the selected sites is expected to be 3 months.

aquatest

Summary of the Results of the Study

- The main technical difficulty will be the sediment extraction and will depend on the hydrometeorological conditions and the navigability of the river. It will also have to take in to consideration the local fauna and flora.
- The technologies for extraction and remediation of sediments are known and available.
- The results obtained in laboratory and pilot sediment remediation tests using bentonite stabilization were analytically verified at AQUATEST a.s. laboratories and the results were accompanied by a test report.
- Pollution at the site is significant, no remediation (i.e. zero action) is unacceptable. Institutional measures are also not possible, post-remedial monitoring is recommended as a complementary alternative.
- The only conceptual measure is the ex-situ treatment of sediments with their subsequent treatment.
- From the tested sediment treatment methods (thermal desorption, washing, chemical oxidation, stabilization), stabilization of sediment with the addition of 5% bentonite was shown to be the most suitable alternative. In the case of this method, the legislative limits will be met allowing the sediment to be landfilled.

aquatest

Conclusion

Thank you for your attention

AQUATEST a.s.
Geologická 4, 152 00 Prague 5
Czech Republic

Ing. Michaela Lažanská
Ing. Roman Kříž

www.aquatest.cz