

10th International Acid Sulfate Soils Conference

15–17 September 2025 Luleå, Sweden

Post-Conference Excursion GUIDEBOOK

18–20 September 2025 Finland & Sweden



GTK

Acid Sulfate Soil Working Group
International Union of Soil Sciences

LULEÅ UNIVERSITY OF TECHNOLOGY

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Site 14: The drained Lake Västervikssjön – An acid sulfate soil hotspot

Jan Åberg & Anton Boman

Location

Google maps: https://maps.app.goo.gl/16w9BHjgJLQMkJhg7?g_st=ac

Coordinates: 64°04'16.0"N 20°42'03.0"E



Figure 1. Location of the drained Lake Västervikssjön (Site 14).

Purpose of the visit

We will visit the formerly drained Lake Västervikssjön, which has become an acid sulfate soil (ASS) hotspot, releasing acid and metals into the environment.

The drained Lake Västervikssjön - an acid sulfate soil hotspot

For almost 5000 years, Lake Västervikssjön was a freshwater lake with an open water area of about 114 hectares (Figure 2). It was formed from a bay of the Littorina sea, due to post-glacial rebound. The total length was 2.7 km and the maximum depth was approximately 2.4 m. The area of the former Lake Västervikssjön mostly contains sulfidic sediments, making it an acid sulfate soil hotspot (Figure 3).

The vast littoral zone of Lake Västervikssjön was biologically rich, nourished by a lake bed of mostly fine grained, sulfide-rich, sediments. The fauna included among others: duck mussels and fish such as pike, roach, perch and trout; mammals such as otters, beavers and water voles; crustaceans, insects and many species of birds.

Lake Västervikssjön was a local source for hay-production already during medieval times (then called Gryssjön). Likely, the lake was harvested also in much earlier times. The practice of harvesting grass in shallow fresh waters is at least 1500 years old in northern Sweden, but the techniques were improved during the 19th century, with intentional regulation of the water levels to maximize sedimentation, minimize frost-damage of root-systems, and stimulate the growth of especially Carex grasses. In the early 20th century, about 40 hay barns were needed to store the hay-harvest from Lake Västervikssjön.

In 1956, Lake Västerviksjön was completely drained to gain tillable farmland. However, the attempts to cultivate the soils failed due to high soil acidity. Today, the former lake bed is instead covered with mostly deciduous forest and swamp-forest vegetation



Figure 2. A map from 1811, covering the Northern part of Lake Västerviksjön.

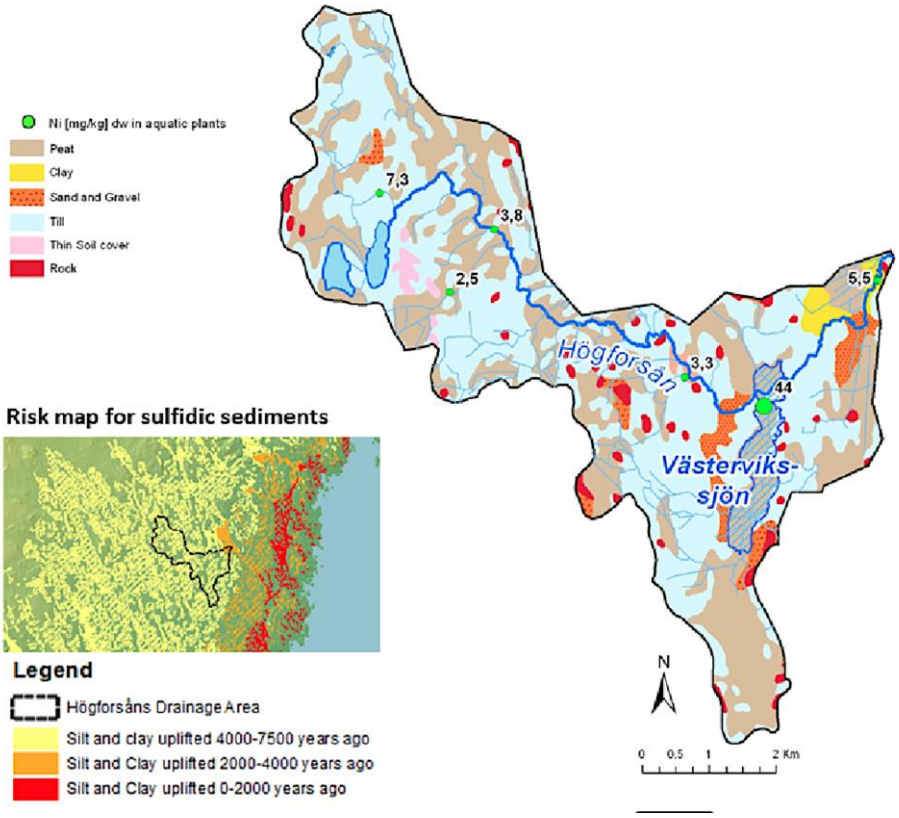

Figure 3. The soils of the Högforsån Creek catchment, with the former Lake Västerviksjön marked in the downstream part. The area of the former lake mostly contains sulfidic sediments.

The failed attempt to convert Lake Västervikssjön to productive farmland

In 1944, a "drainage-company" consisting of local farmers signed a legally binding contract to convert Lake Västervikssjön into 114 hectares of tillable farmland (Figure 4). This project, and many other similar projects in the region, were planned and coordinated by the government to increase the overall agricultural productivity in the region. Co-financing from the government was promised, but not until the project was completed and had been approved by the authorities.

Partly due to geological and hydrological challenges, the drainage company needed several years longer than expected to finish its task. Most of the money required during this phase had to be loaned from the state, and this debt was not fully paid back until several decades later. In 1956, six years later than planned, all water was drained from the lake, and the project was approved for co-financing (about half of the estimated cost).



Figure 4. Construction of the canal that drained Lake Västervikssjön. Photos from around 1956, by Abel Åberg.

The water decree was configured for the purpose of creating and maintaining dry soils and cultivatable fields across the entire area of the lake bed (114 hectares). However, when the lake bed finally dried up, several years later than planned, the soils turned out to be extremely acidic. Only a few hectares were ever cultivated, and when these small fields were planted, most crops failed completely. Liming was considered and attempted in some cases, but the much-needed long-term liming strategy was not economically viable due to the lack of nearby lime sources. In addition, the downstream part of the canal was narrow, leading to flooding of large parts of the former lake bed during periods of heavy precipitation.

Some socioeconomic perspectives on the draining of Lake Västervikssjön

The water decree itself did not include time limits. This means that, even today, about three generations later, the decree remains legally binding and is a shared responsibility among current landowners. The maintenance cost per hectare is high compared to the natural forests surrounding the lake, while the production of high-value wood crops is generally low. Additionally, the soft ground of the former lake bed often leads to extra costs for wood-harvesting operations. Still, some landowners are beginning to receive cash income from the former lake bed. In the lower parts, wetlands and swamp forests, the maintenance cost remains much higher per hectare than the achievable cash income.

There is a legal possibility to change or abolish ("kill") the water decree. These two types of actions are, however, complicated, involving high administrative costs, uncertain outcomes, and potentially challenging negotiations between landowners. Therefore, the incentives to change or abolish the water decree are weak.

Damages not considered in the water decree include, among others: the lost possibilities of living near the lake or waterfront, the missed opportunities for fishing (both in the lake and the acidified river system downstream), and the lost opportunities for various lake-related recreational activities.

Ecological effects after draining Lake Västervikssjön

Around the end of the 1950s, when the old lake bed had dried up, a notable mass fish kill occurred in River Dalkarlsån, about 5 km downstream of Lake Västervikssjön. Thousands of roaches gathered on the water surface of the river to gasp for air before they died and disappeared. Since then, the Högforsån Creek and the downstream River Dalkarlsån have suffered from recurring difficult chemical conditions for many aquatic organisms. Around the 2000s, roaches started to appear again in larger numbers in the main channel of the River Dalkarlsån (after more than 40 years of absence). This was probably mainly due to a combination of reduced acid rain and reduced ditching activities in the potentially acid sulfate soils within the catchment.

The latest major reduction of fish stocks in River Dalkarlsån occurred in late 2018, following a large-scale drought across Scandinavia. The resulting episode of highly acidic and chemically harmful leakage from acid sulfate soils (ASS), not least from Lake Västervikssjön, persisted for several years in River Dalkarlsån. In the summer of 2025, roaches in River Dalkarlsån were back in similar numbers to those before the 2018 event, reflecting a continuous period of wetter summers since 2020.

Chemical effects after draining Lake Västervikssjön

Högforsån Creek is the first recipient of water from Lake Västervikssjön. The lowest recently observed pH in the main channel of Högforsån Creek is 3.9 (just before it meets a tributary of River Dalkarlsån). There is no regular monitoring program for Högforsån Creek, which means that the pH may have been even lower after the drought in 2018. During normal hydrological conditions in ditches within the former lake bed, the pH values of the water can be as low as 3.5, with aluminum concentrations up to 50 mg/l (50,000 µg/l).



Figure 5. Peak flows can lead to the occasional return of the deeper parts Lake Västervikssjön. Photo: Jan Åberg.

Some chemical characteristics summarized

The Högforsån Creek (3,300 ha) receives water from the former Lake Västervikssjön (114 ha) (Figure 3).

Some chemical characteristics of the Högforsån Cree catchment outlet:

- TOCmax >45 mg/l
- Inorganic aluminum (Alimax) >1000 µg/l (about 10x the concentration needed for long term fish survival).
- pH_{min} <3.9
- EC_{max} >130 µS/cm
- Sulfate (SO_{4max}) >0.7 mekv/l (>30 mg/l, and about 15-20x local background level)

Some chemical characteristics of the 114 ha hotspot, in ditches (water-filled) in former Lake Västervikssjön:

- Inorganic aluminum (Ali_{max}) up to at least 34 000 µg/l (very toxic to most water life).
- pH_{min} ~3.5
- EC_{max} >1000 µS/cm
- SO_4 >13 mekv/l (>600 mg/l)

Chemical characteristics of the inlets upstream of Lake Västervikssjön:

- TOC from about 20 to 60 mg/l.
- EC-ranging between 5-60 µS/cm, usually around 20-30.
- Inorganic aluminum below 100 µg/l.
- SO_4 at background levels.
- pH-values in the range of 4-6, with low values due to organic acids.



Figure 6. Field measurements in one of the ditches within the former Lake Västervikssjön. pH 3.59. Electrical conductivity (EC) 595 µS/cm. Photo: Jan Åberg.

Example of seasonal chemical shifts

During snowmelt in spring, soft water containing high concentrations of organic acids flows into Lake Västervikssjön from upstream. A decrease in water colour and the formation of metal-humus precipitates can be observed as a layer of new sediments in the canal (Figure 7). During summertime, under low-flow conditions, deeper groundwater with higher pH flows into the former lake from upstream locations. The natural colour of the water increases dramatically when the high-pH incoming water reacts with the acidic water within the former lake.

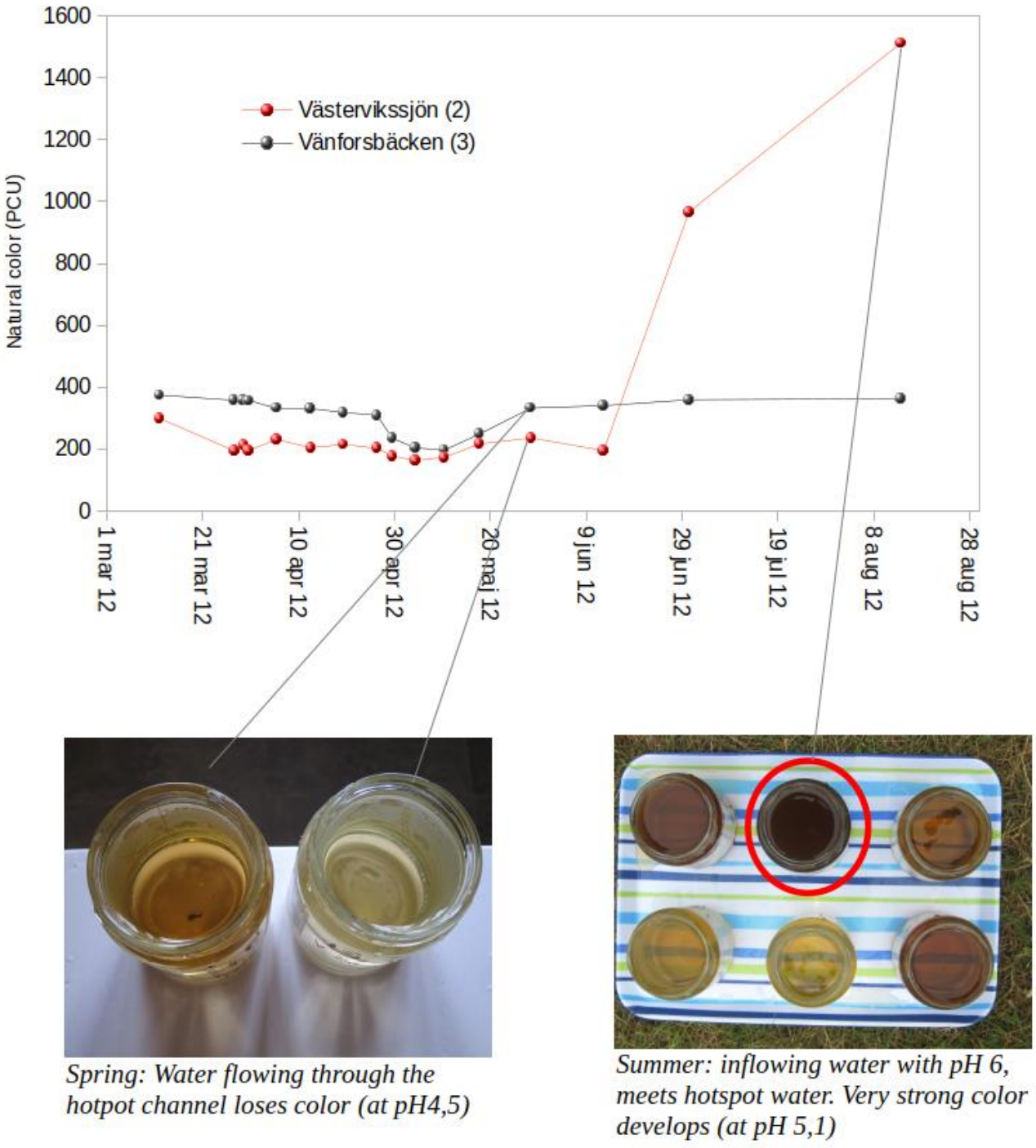

Figure 7. Colour changes in the water flowing through the acid sulfate soil (ASS) hotspot.

Irregular event: the hotspot gets water-filled and starts to produce sulfides

The acid sulfate soil (ASS) hotspot, the former Lake Västervikssjön (114 ha), became water-filled due to a heavy spring flood in 2012 (Figure 8). On that occasion, the outlet of the hotspot had higher pH than the incoming water. This suggests that reducing conditions may have been initiated, possibly leading to sulfide formation.

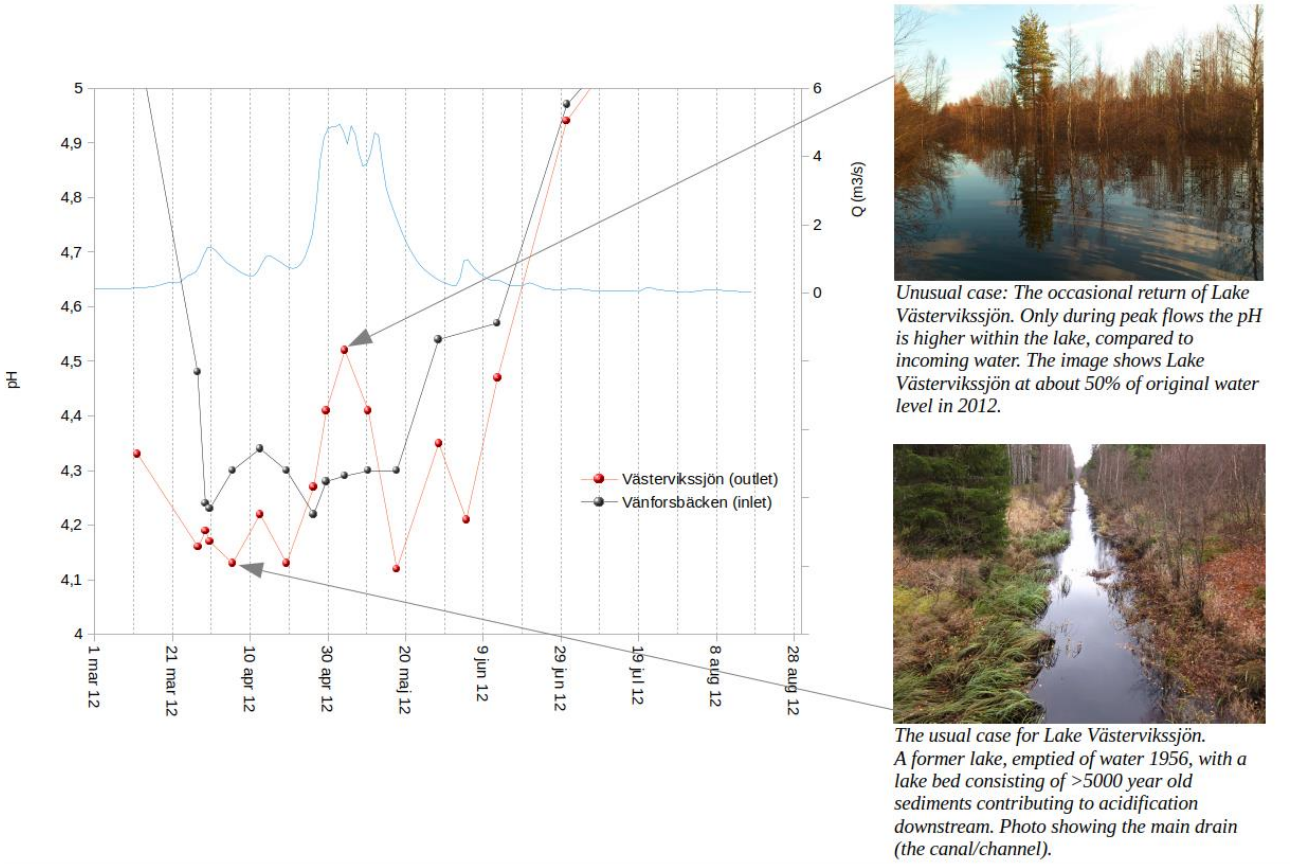

Figure 8. Data and photos from the spring flood in 2012, when Lake Västervikksjön became water-filled.

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