# Amsterdam and the City Swim (ACS)

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**Abstract**
**Water Quality, Public Health and swimming**
All over the world, we collect waste water for the benefit of public health. Sewerage prevents us from polluting our own immediate living environment. Since the European Water Framework Directive (WFD 2000), aquatic life has been the official measure for the quality (functioning and maintenance) of our living environment. An informal measure for water quality is the attractiveness of the surface water. Nowadays, the water in the city is an asset again in contrast to the 19th century when surface water was eliminated from the city. The water can be seen and enjoyed, instead of primarily being a danger. The ultimate activity enjoying water is swimming. On the other hand, swimming is besides fun also vital. Swimming skills in delta areas, to prevent drowning are of the same order of importance as public health. In Amsterdam, the City Swim has the special habit that in addition to pleasure and consumption, it is also about health, namely the fight against the deadly disease ALS (amyotrophic lateral sclerosis). Every participating swimmer organizes his/her own sponsorship.

Over the years, surface water quality in and around Amsterdam has improved enormously. Nowadays, inhabitants of Amsterdam see beautiful water. They have the idea that swimming in this sparkling water is completely safe. They dip on a nice summer day. And more and more, events are being organized in dense cities, like Amsterdam. These events are a great opportunity to show the value of water. However, combined sewer system overflows and false connections in separated systems can and will affect water quality. Monitoring shows that water quality sustains swimming ninety percent of the time. We have developed a monitoring network with the capability of providing people with the basic information on the actual water quality.

**Keywords**
Awareness, combined sewer overflows, monitoring water quality, public health, responsibility, safety, swimming in surface water

## INTRODUCTION

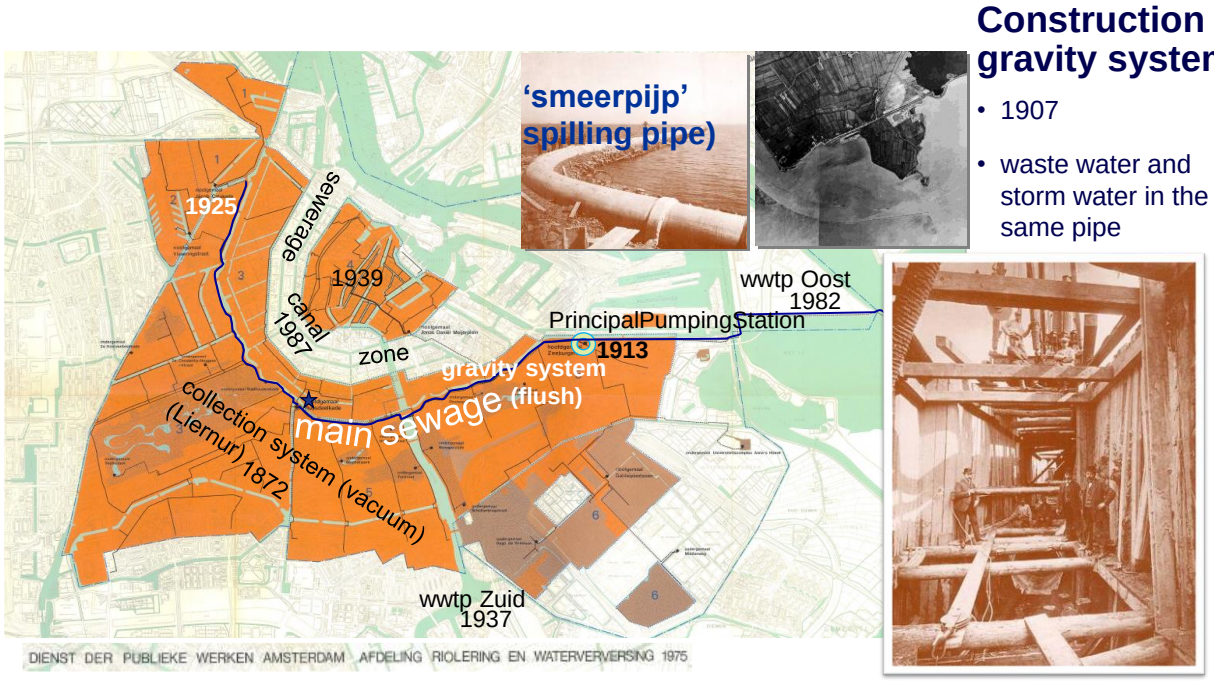
### Amsterdam and its surface water

Amsterdam is a city, located in the river Rhine delta. The city is located in the province of North Holland, on the IJ, the North Sea Canal and the estuary of the river Amstel. The IJ is a body of water, formerly a bay, known for being Amsterdam's waterfront. RWS[1] is responsible for distribution of Rhine water over different distributaries: part goes to Nederrijn/Lek, the Amsterdam – Rhine Channel to the IJ, the North Sea Channel and finally the North Sea. The river Amstel is of local origin. It flows through the city of Amsterdam with discharges ranging from 2 m3/s to maximum -during rainfall- about 50 m3/s. This discharge consists of pumped water from the surrounding polders below sea level.

[1] RWS-Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and Water Management, dedicated to promote safety, mobility and the quality of life in the Netherlands.

Historically, the IJ was connected to the Zuiderzee, a shallow bay of the North Sea. Amsterdam was flushed by tidal action, as is Venice nowadays. In 1872 the IJ was separated from the Zuiderzee, which ended the tidal flushing. This was a part of the construction of the North Sea Channel (including locks), connecting Amsterdam harbor more directly to the North Sea. A water system without tidal action is more vulnerable to discharge of loads: sewerage became necessary.

**How did the water become swimmable: history of waste water collection and purification**
As a consequence, the city of Amsterdam invested in sewerage. New developments had sewerage from the start, the outskirts of the 1870 city were sewed between 1906 and 1925. Until 1913 wastewater was collected on a small scale by a vacuum pumping system and was then being reused. After 1913 wastewater was discharged into the Zuiderzee. Waste water treatment started in the new developments in the nineteen thirties.

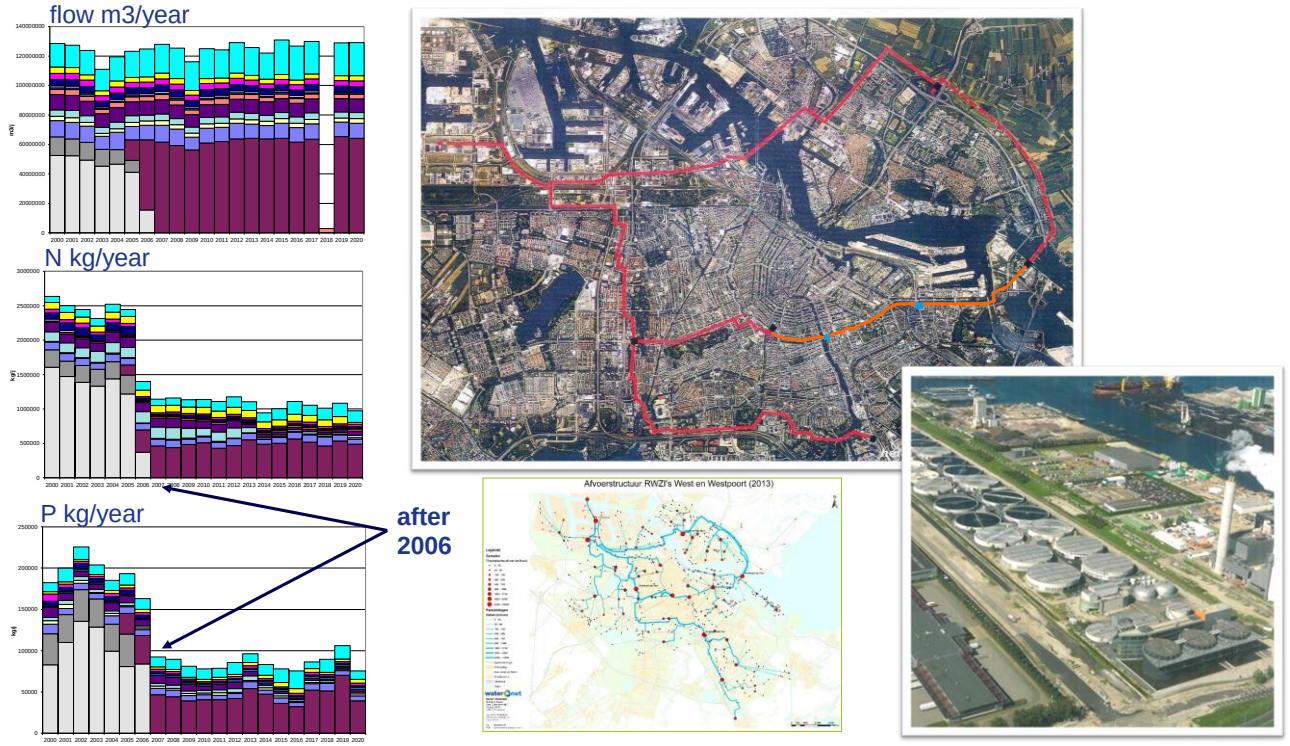



The city center got sewerage just before World War II and the canal zone between 1970 and 1987. Spilling wastewater to the Zuiderzee (nowadays 'Markermeer') stopped in 1982 when wastewater treatment started. Treated water was spilled to the IJ.

Another important step in improving the Amsterdam water quality was the displacement of the wastewater treatment plant (WWTP) outside the city, to the northwest side, near the harbour (WWTP Amsterdam-West, 2006). The discharge now goes downstream, directly to the North Sea Channel and the North Sea, instead of flowing through the city of Amsterdam. As a result, the water in Amsterdam canals is now only polder water from river Amstel. Under normal conditions the water coming from the Amstel contains no pathogens; even the effluent discharge of the located upstream nearest WWTP Amstelveen, South of Amsterdam), has no effect on the water quality in the Amsterdam canals because of the travel time (degradation, dilution, flow).

By moving the WWTP from positions upstream of the city (South and East) to downstream (West) in 2006, not only untreated waste water disappeared from the city, as a result of sewering, but als treated waste water disappeared. The moving of the WWTP to the West would have the risk of decrease in water quality in the North Sea Canal and the coastal zone. However, the quality of the modern WWTP improved, resulting in improving surface water quality.

The graph shows the amount of water, nitrogen and phosphorous coming from the WWTP's in Amsterdam to the surface water. The light grey bar shows the amounts of the WWTP Oost (east) and dark grey bar stands for the amount of WWTP Zuid (south). They were replaced after 2006 by the amount shown by the purple bar of the WWTP Amsterdam-West. As shown, the amount of nitrogen an phosphorous decreased dramatically. The ambitious plan was an important step in improving the water quality in the Amsterdam canals. The discharge was brought downstream of the city.




And still, Amsterdam has the separated and combined sewer system in the city center, 76% and 24% respectively. This means that during heavy rainfall, diluted waste water can still end up in the canals. In the period 1995-2005 Amsterdam constructed basins behind the main combined overflows for storage and settling. The number of sewage overflows diminished further and water quality suffered less.

In 2010 Amsterdam observed the improvement of the water quality in the canals. Vegetation came back in the river Amstel. Until then, we flushed the city canals by pumping in water from the Markermeer (former 'Zuiderzee') overnight, four times a week, during summer, two times a week during winter. Observing the improving water quality, Amsterdam stopped the flushing procedures and replaced them by a monitoring program, always ready to restart flushing when monitoring results indicated to do so. At three fixed points and from a moving inspection boat Waternet started continuous monitoring of oxygen concentration. The new procedure implied flushing at observed oxygen depletion. Since 2010 monitoring results never indicated the necessity of flushing.

In the same period of observed improvements in canal water quality Amsterdam observed more and more people swimming and recreating in the city canals, outside officially monitored swimming sites. Although swimming at non-official swimming sites is forbidden, people dip in summertime. At more and more places new swimming spots develop.

**Covid-19**

2020 was a special year for swimming in Amsterdam, because, due to Covid-19 inhabitants were forced to stay in the city in the summer and were looking for entertainment. There has never been as much swimming and boating in the city as in the summer of 2020, with its relatively high temperatures for Dutch standards.

In the Netherlands, Municipal Health Services (GGDs) protect, monitor and promote the health of the inhabitants of the Netherlands. Relevant is the fact that the GGD has reported that people cannot become infected with Covid-19 as a result of by contact with components of wastewater in surface water.

**What is the Amsterdam City Swim?**

In 2011, 14 friends started a fundraising campaign for ALS (amyotrophic lateral sclerosis), the deadly nerve-muscle disease their friend suffered from. So, an event was born. After the first time, they decided to expand the action. The Amsterdam City Swim nowadays is an annual event in which thousands of people participate. The foundation wants to collect as much money as possible for ALS research by organizing sponsorships.


**How safe can swimming be at non-official swimming sites?**

Analysis lies between measuring and knowing. What is needed to obtain information (in this case for the organization of the ACS)? Stakeholders have to work closely together and need to learn about each other's world! What measuring technology exist? What thoughts are there about the functioning of the water system? What information do stakeholders need? How does it work, what can they ask?

Two main questions arose:
1) How does the water quality in the canals refer to the quality at official swimming sites? Or, in other words can we predict the amount of days during the year that the surface water in Amsterdam is more or less swimmable?
2) Can we predict swimming water quality based on operationally available data, such as meteorological and hydrological data?

## METHODS

**Nowadays, how does the water quality in the canals refer to the quality at official swimming sites?**

Which (un)certainties do we have regarding the water quality? How do the overflows affect the (swimming) water quality? How safe is it for the inhabitants of Amsterdam to play and swim in the water?

The water authority follows up on the growing swimming activity, extending the monitoring network. In order to assess swimming water quality, Waternet uses the legally subscribed methods to measure numbers of Escheridia Coliforma (E-coli) and intestinal enterococs, also applied for official swimming water sites. Nowadays, we take grab samples from Mai, 1 until October 1. We measure the water quality both at official swimming sites and at locations with a lot of swimming. Depending on the location, these samples are taken once a month or every two weeks. It turns out that the swimming water quality is comparable to official swimming

water in most of the samples. After sewage overflow water quality recovers within three to five days, due to degradation of pathogens, dilution and flow. This is valid for the primary channel system and the surface water and canals that are directly connected to it, due to a continuous flow coming from upstream. A sewer overflow in the polder areas has more and longer impact on the water quality, due to a larger hydraulic residence time, with a negative swimming advice.

A crucial point is that the legal obligation of waste water collection and purification is aimed at public health and does not go as far as that the surface water must be swimmable. The swimming water quality relates to the flow conditions in the canals, combined with a sewage system that overflows two to ten times in an average year. A remaining challenge is to notify people after sewage overflow. This is considered a moral obligation and is not legally mandatory, swimming being officially forbidden. Waternet is in close contact with the city of Amsterdam, the public space department. Amsterdam communicates to residents through the website and through a local newspaper about the water quality in relation to swimming. From then on, people need to take their own responsibility.

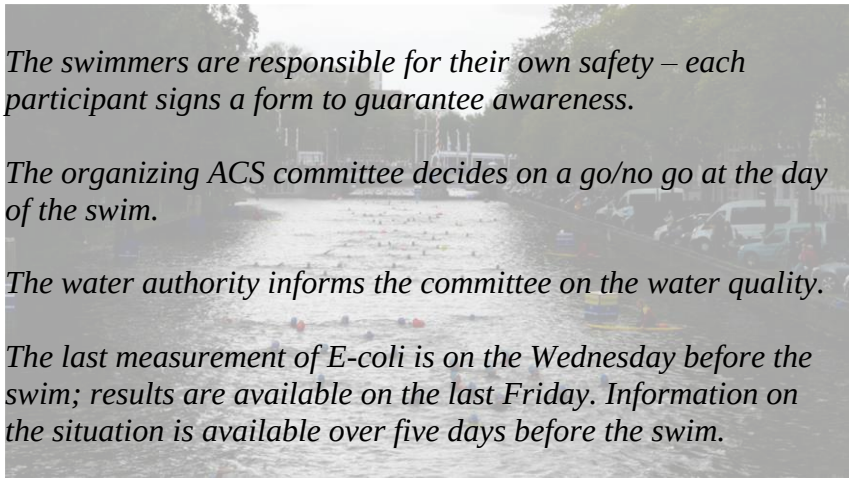
## RESULTS AND DISCUSSION

### Can we predict water quality on an operational level?

The problem in measuring swimming water quality is that the classical method to analyze E-coli and Intestinal Enterococs comprises a 48 hour culture period. As a result, you only know the quality 48 hours ago. The actual quality is hidden. As an alternative, we measure sewer overflow. From historical data we know that there is an immediate deterioration of water quality that lasts for three to five days. We experienced that monitoring the physics is the way to know the actual water quality.

### The event City Swim, its protocol and specific measurements

The City Swim is an event through a couple of canals in the dense urban city. In fact, this concerns non-official swimming locations. A protocol is required for public health and safety reasons.



*The swimmers are responsible for their own safety – each participant signs a form to guarantee awareness.*

*The organizing ACS committee decides on a go/no go at the day of the swim.*

*The water authority informs the committee on the water quality.*

*The last measurement of E-coli is on the Wednesday before the swim; results are available on the last Friday. Information on the situation is available over five days before the swim.*

The basis of the protocol is classical water quality measurements until the last Wednesday before the Sunday swimming event. We then have results on Friday, 48 hours later due to the culture period. If there are water quality problems indicated by these monitoring results we inform the organizing committee. Between Friday and Sunday meteorology is monitored. In case of rain, we look at the sewer overflow data. In case of problems, the organizing committee is informed. Responsibility for the event lies with the organizing committee and finally with the people joining the swim.

**Can we predict swimming water quality based on operationally available data, such as meteorological and hydrological data?**
To understand variability over time we collect relevant available open data on meteorology and information available from our operational water management: water levels, observed discharges, observed water quality continuously monitored using sensor technology and grab samples. In order to interpret monitoring data, we have a hydrodynamical model using historical data. We have available data from 1980. Apart from available data we started to measure water levels at sewer overflows using sensor technology, in 2006.

So, these data with our experience about the flow in the canals, that are in open connection to our primary channel system, make it possible to predict the water quality. The hypothesis after the first year of monitoring: after heavy rainfall, the swimming water quality deteriorates, due to sewage overflow and overland flow from the streets. High values in the graph were all measured within three days of a sewer overflow.
What we learned from monitoring water quality in relation to sewer overflow is that after three to five days water quality recovers due to degradation under the influence of sunlight, dilution and flow.

## CONCLUSIONS

Three to five days after a combined sewer overflow the measured values for E-coli (guide parameter) normalize. This conclusion is derived from many years of monthly/biweekly measurement series. This also includes observations immediately after an overflow and 3, 4 or 5 days after the overflow. It is the result of degradation (under the influence of sunlight (UV)), dilution and displacement. This observation applies to our primary channel system, not to our deeper polder waters. Swimming in the river Amstel and the canals in the dense urban area of Amsterdam is possible, safe and without danger to public health. Monitoring is essential. We have to be aware of the risks and inform swimmers properly. Final responsibility lies with the swimmers.