

Water supply and sewerage in Tallinn since Medieval Times

This paper describes the development of the water supply network and sewage treatment facilities in an overview of the history of water management in Tallinn, Estonia.

INTRODUCTION

The history of water supply and sewerage system development is in principle similar in all European countries. The motives for action have been common: the fear of fire, disease and thirst in earlier centuries and environmental awareness in our times. Yet, in each city the result is particular, due to the unique local natural, technical and political context.

Water deficits are caused not only by increasing industrial and human consumption, but also by the irrational use and pollution of water. Only a few decades ago water was considered to be a free and unlimited natural resource. During the last few years people have started to consider the environmental situation and the human impact on this resource has led to the conclusion that the prevention of environmental pollution is more effective and economical than later elimination of the damage.

In Estonia the problem is the quality, not the quantity of potable water. The quality of potable water is directly related to waste water treatment – improving the waste water treatment also improves the quality of raw water. Therefore, more attention has been paid to sewerage development.

WATER SUPPLY

Network

In the 14th century Tallinn was one of the largest towns on the Baltic coast. In those days the fortress of Tallinn was the centre of life. In its midst there was a well where the people got their drinking water. When Tallinn expanded outside the town wall, the rivers and springs also became sources of water. The wells could not meet Tallinn's needs, which also reduced the defence potential and this caused lengthening and widening of the moats.

The first water supply pipes were built as early as in 1417 [1] (Figure 1). Made of wood, they were used during the next four hundred years. In the 19th century the length of the wooden pipeline was 2.8 kilometres. In 1844 cast iron pipes were introduced, and in 1867 there were 9.6 kilometres of cast iron pipeline [2]. The main pipeline ran from Lake Ülemiste to Town Hall Square and from there to all the streets in the Old Town.

The first project for a water supply network was made in 1881. The network was divided into first and second pressure zones. The length of the first pressure zone network was 12.7

and of the second pressure zone network 18.7 kilometres. There was also a plan to build a water tower to Tõnismäe and a sedimentation basin next to Lake Ülemiste, which was the source of raw water. The construction work was finished in 1883 [1]. During 1883 – 1915 the length of the network increased from 32 to 83 kilometres and the number of buildings connected to the network increased fivefold from 656 to 3,166 [1].

In the 1910s Tallinn had a population of 150,000 people and Lake Ülemiste could no longer supply enough water for the city of Tallinn. About 80% of population was dependent on the water network. The water quality was bad, and a new water supply system was designed in 1915 for a town with 300,000 inhabitants (30,000 m³/d) [5]. Because of World War I the construction work did not start. In 1922 the Pirita River was connected to Lake Ülemiste, thus solving the quantity problem. However, the water quality problem remained unsolved. In 1934 the length of the pipeline was about 105 kilometres serving 4,020 houses [5].

A new plan for a water supply network was made in 1947, but due to a lack of money it was never implemented. In 1958 a new project was prepared. This project was drafted according to the projected water demand in 1970 (142,000 m³/d) [5].

Today the main water source of the city of Tallinn is still Lake Ülemiste, located on the edge of the city. The system of surface waters, including the drainage area of the Jägala, Pirita and Soodla rivers starts from the upper course of the Pärnu River. The total surface of the catchment area is about 2,000 km². The system consists of six water reservoirs: Vaskjala (1970), Paunküla (1960/79), Soodla (1980), Raudoja (1981), Aavoja (1984), Kaunissaare (1984) and Lake Ülemiste (Figure 2). Without the supporting system Lake Ülemiste can guarantee water for Tallinn City only for a hundred days. About 85% of Tallinn's water demand is supplied by surface water [3]. The daily water consumption in Tallinn has been decreasing during the 1990s and it is expected to decrease further. This is caused by the shutdown of big industries and by the introduction of new, more up-to-date water treatment and sanitary equipment. Today more than 90% of the customers have water meters [4]. In 1997 the total length of the water supply network was 790 kilometres (Figure 3) [4].

Water purification plant

The first design of a water purification plant began in the 1920s. The water treatment scheme, which was never completed, consisted of clarification (Al₂SO₄), sand filters and chlorination. In 1924 a new design was prepared and in 1927 the first plant was ready. The pipelines were also rebuilt

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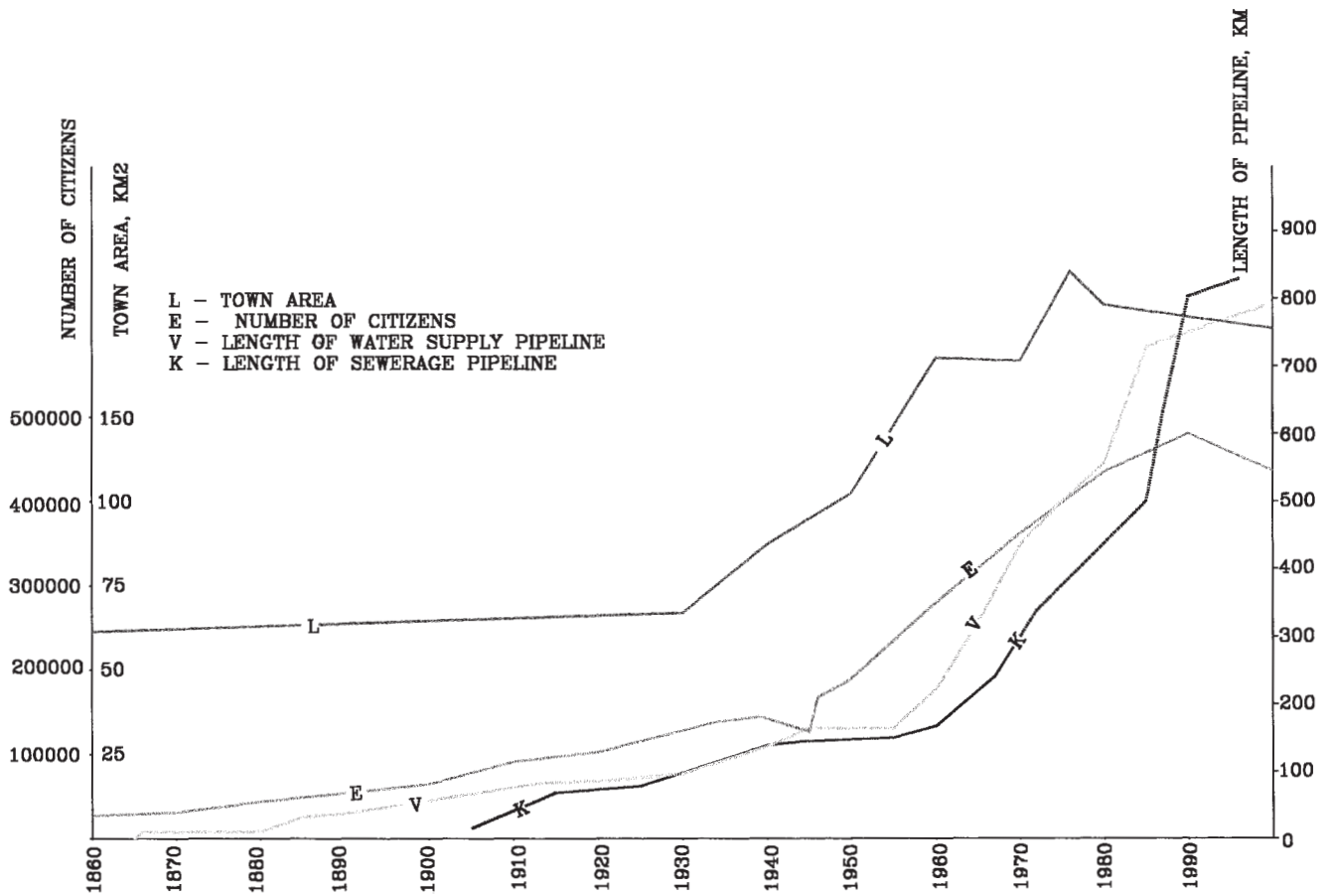


Figure 1. Development of Tallinn, water supply and sewerage

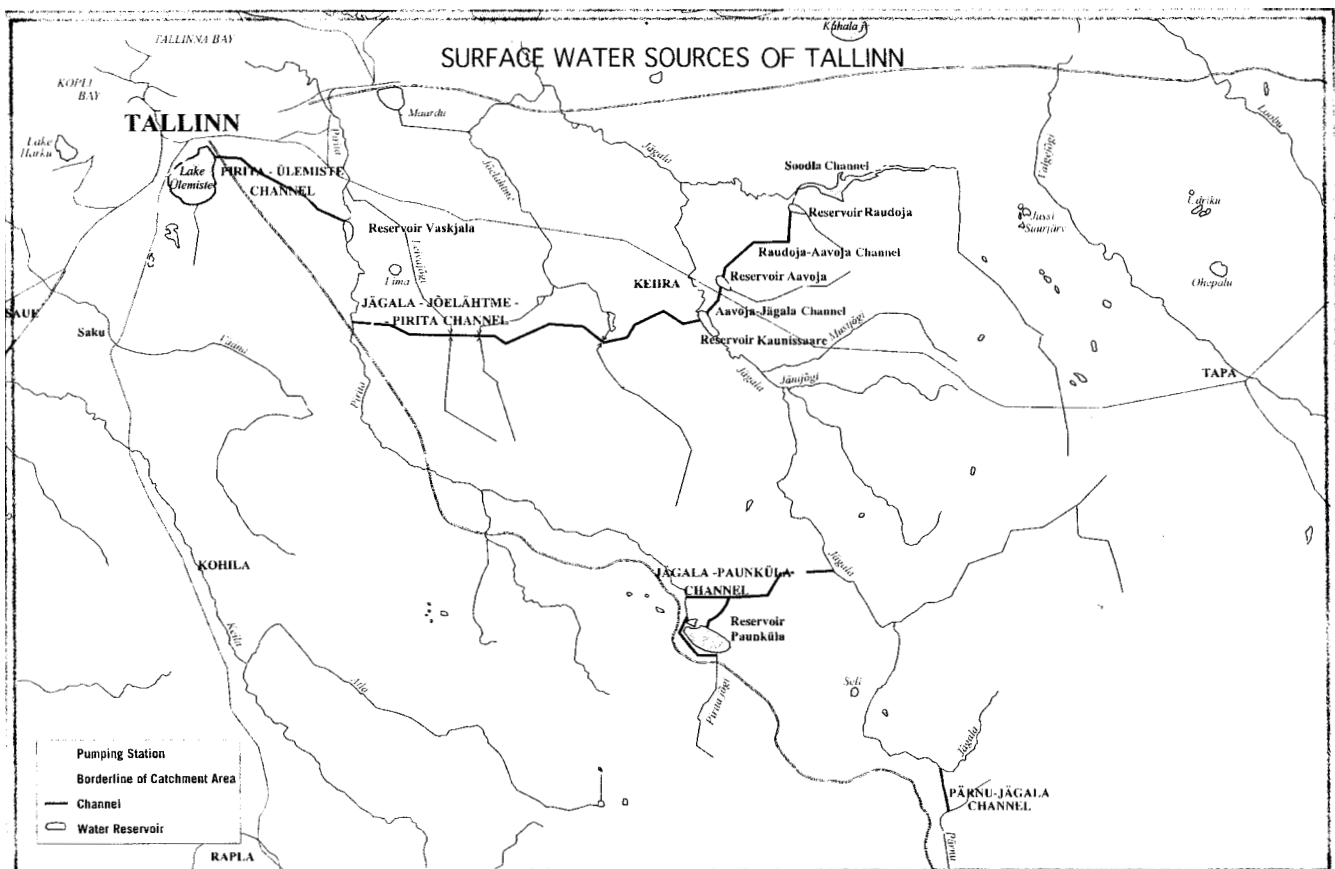


Figure 2. Surface water sources of Tallinn

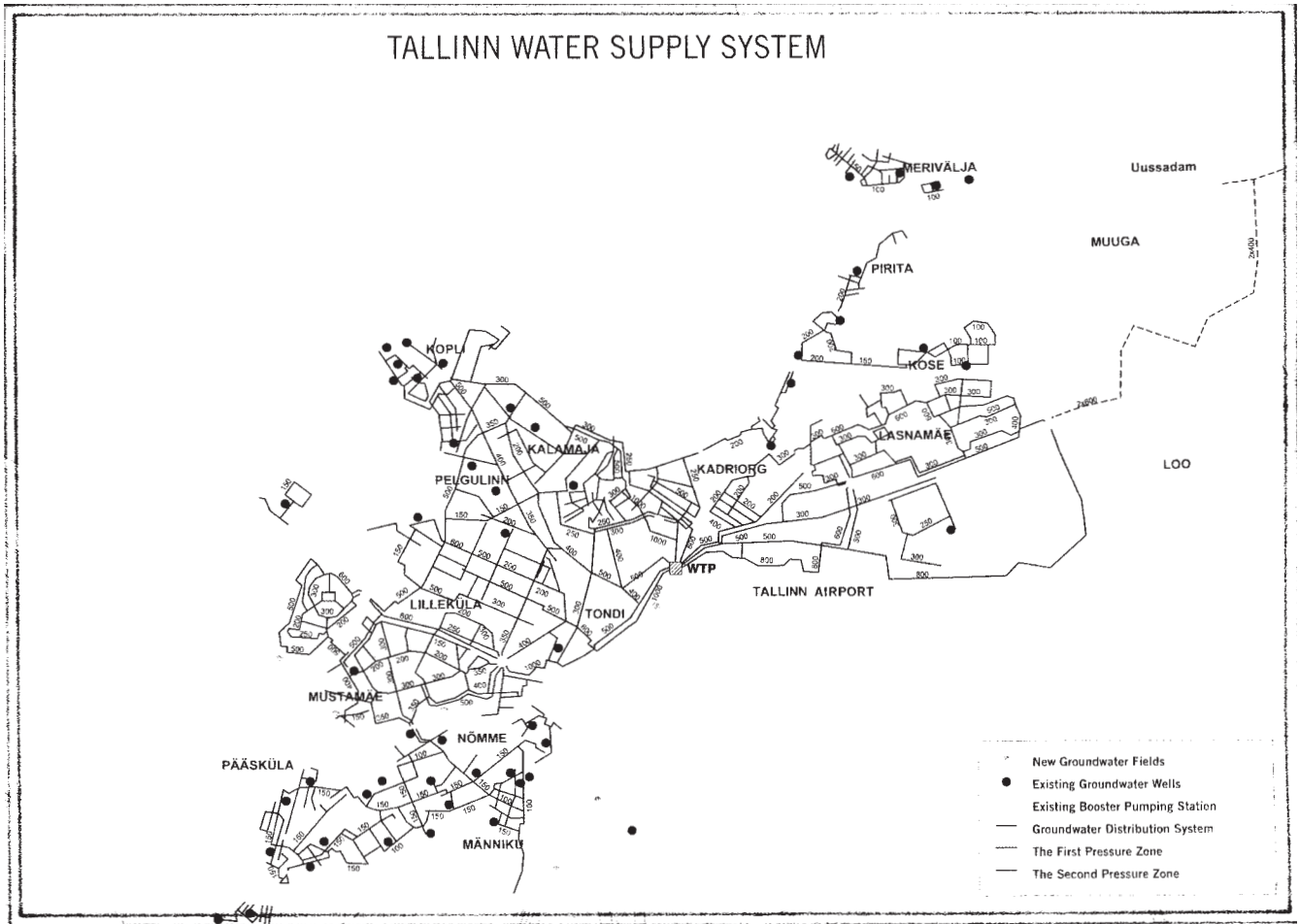


Figure 3. Tallinn water supply system

TALLINN WATER TREATMENT PLANT TECHNOLOGICAL CYCLE

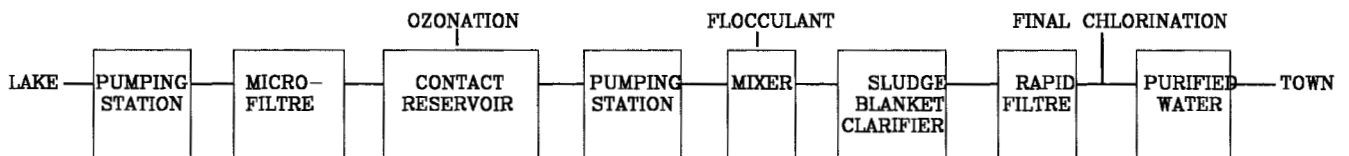


Figure 4. Tallinn water treatment plant

and cleaned. There were both mechanical and biological treatment facilities: screens, sedimentation basins (Al_2SO_4), sand filters and chlorination. The total capacity of the plant (24,000 m^3/d) did not satisfy Tallinn's needs (125,000 inhabitants). Therefore, in 1928 the price of the water was raised and water meters were made obligatory. This improved the situation a little, but in 1941 with 200,000 people living in Tallinn, the situation was bad again [2].

After World War II the main task was to repair the water treatment plant and network. Only after that was the extension of treatment facilities tackled. Reaction chambers were installed ahead of sedimentation basins, and vertical sedimentation basins were replaced with horizontal ones. In 1950 the total capacity of the plant was raised to 36,000 m^3/d . As this was still not sufficient, in 1959 the enlargement of the treatment plant was started: Sedimentation basins were replaced with clarifiers and sand filters with rapid filters. By 1964 the capacity had increased by 25-30%. The enlargement of the plant continued and in 1965 the capacity was already

102,000 m^3/d . In 1968 some changes were made to the treatment facilities and the capacity increased to 105,500 m^3/d . This work continued until 1979 when new treatment facilities with a capacity of 120,000 m^3/d were ready. The total capacity of the plant was 270,000 m^3/d with a treatment scheme consisting of microfilters, reaction chambers, mixer, clarifiers and rapid filters (Figure 4). In 1995 the construction work on an ozonator started, and in 1996 it was substantially ready [1].

The major sources of pollution are nutrients from fertilisers and organic matter and bacteria from small rural centres in the catchment area. To improve the water quality, leakage in the network should also be eliminated.

Artesian wells

The first artesian well, drilled in 1842-45, was 97.5 m deep. At the beginning of this century, artesian wells were sunk only for military and industrial purposes. During the

Estonian Independent Republic (1920-40) artesian wells became common. In 1927 there were in Tallinn 24, in 1943 64 and in 1945 already about 150 deep (80 - 175 m) artesian wells. After World War II the restoration of Tallinn's water supply system was begun and by 1967 the total length of artesian wells was 42 km. Today there are about four hundred artesian wells that are more than thirty metres deep, and about half of them are in use [4]. They satisfy about 15% of Tallinn's water demand and their use is common mainly in private residential areas. The groundwater for the artesian wells in Tallinn mainly originates from the Cm-0 water layer, and as it is situated about 4-10 km from the coast, it is impossible to use it more actively because the sea water could intrude.

SEWERAGE

Network

The sewerage of the city of Tallinn started during the 12th century. Already then, waste water was directed to the sea. During the 14th century, when paving of streets started, gutters were built for sewerage. The oldest written information about underground sewers dates from the year 1422. This system consisted of wooden pipes. In spite of clogging and gradual decay wooden pipes were in use for the next four hundred years. During the 16th and 17th century there were sewers almost in all the streets of the Old Town, and limestone canals have been found in a few streets. In 1843 cast iron pipes were brought into use and in 1892 ceramic pipes were laid. In 1881 sewerage work began in the suburbs. The cost of sewers was shared on an equal basis by property owners and the city. Natural water bodies were used for sewerage. In 1882-85 the Toompea sewerage plan was built. Before then waste water was just conducted down the slope by ditches.

Around the turn of the century the area of the Härjapea River was the most densely populated area of the city, but it still lacked sewerage. At that time, construction began on

facilities to drain waste water off into the Härjapea River. Since pollution was increasing, the inhabitants had insisted in 1879 that instead of using the river, a closed sewer should be built. The city council decided that this solution was too expensive, and an inspector for the Härjapea River was employed. His job was to eliminate clogging, take care of bridges, and guarantee that people would not pollute the river too much.

In 1905 the total length of the sewer system was forty-six kilometres and in 1915 it was sixty-eight kilometres [2]. The network was divided into eight independent systems, two of them flowing into Kopli Bay and six into Tallinn Bay. Since the network was created without a unified design, floods became more frequent and sanitation worsened. Waste water amounts increased because the water supply system kept on expanding. In 1915 K. Keskküla made a comprehensive design for city sewerage. It provided for all waste water to be directed to a waste water treatment plant near Kopli Bay, from where it was supposed to be directed to the sea, 750 m from the coast. The war prevented this design from being carried out [2].

In 1925 the total length of the sewer system was 78 km. New sewers were built by using gravity flow because pumping was too expensive. In 1927 the first waste water treatment plant was built in the form of a wooden septic tank at the end of the Pelgulinna sewer (4x25x1.6 m) [2].

In 1930 the total length of the sewer system was 90 km. In 1931-33 the Paldiski-Seevaldi sewer (1.3 km) was enclosed. Here for the first time concrete pipes one meter in diameter were used. In places where it was impossible to conduct waste water into the city sewers, biological treatment facilities were built. After treatment the water was fed into water bodies [5].

The Härjapea River had turned into an open smelly sewer. In 1923 the river was covered with planks. In 1927 the city council requested A. Velner to make a project for this sewer. The construction work was delayed until 1932. Seventy-five per cent of the construction costs were paid by the city and the rest by the state. The work was completed in



Integrating old and new sustainable technology. The sewers built in the 18th century in the Old Town of Tallinn are still actively used. These sewers are now renovated with the help of videos taken by a robot camera operated with a remote control system. Photo: Tallinn Water Ltd/Instituform Finland Ltd.

1938. Every day there were about five hundred men working without the help of machines. This sewer, which measures 3.3 km in length, was used for sewerage of the eastern part of the town [5].

In 1937 mechanical treatment facilities were designed for the end of the Seevaldi sewer, and there were also plans to build a separate sewer system. When World War II interrupted this project in 1939, the total length of the sewer system was 130 km.

In 1945 the sanitary situation of Tallinn's sewerage was unsatisfactory. There were forty-six sewer outlets to the Tallinn and Kopli bays, plus outlets from recently-built "closed" (i.e. military) factories [6]. The Kopli Bay was even closed to swimming. Since all the sewers were working under the influence of the sea, extensive sedimentation and flooding became common in town. A great effort was made to rid the sewers of sediments. The economic situation after the war was bad and the construction of new housing areas and industries worsened the situation even more. The pipes were too narrow for the growing amounts of waste water. Separate sewer systems were built in the new residential areas. Storm water was led into Kopli Bay.

As the old design was not applicable any more, new local solutions for different parts of the city were found. Because differing and insufficient data were used, these projects did not take into the consideration the needs of the city. In 1947 in Leningrad the first plan was made for reconstructing the sewerage of Tallinn. In 1952 a new attempt was made. According to this project the combined sewer in the old town was to be preserved. The sewerage system was supposed to consist of two main sewers and a main pumping station in

Paljassaare. All the waste water was to be treated in mechanical treatment facilities and then led to the sea. The total flow of waste water was designed for 86,000 m³/d [1].

Construction work started, and in 1962 main sewer no. 2 was completed to serve the western part of town. At that time, it became evident that the real speed of development was faster than planned. An increase in the output of the main pumping station to 220,000 m³/d was not sufficient. In 1962 the city council ordered the Governmental Design Institute "Eesti Projekt" in collaboration with Tallinn Technical University to design a new sewerage system that would not pollute the sea. Even the Tallinn Bay model was built in an effort to find the best solution. In this design phase construction funds until the year 1966 were allocated, however because the city development strategy was not ready, the design work was delayed.

In 1963 the construction of the sewerage for the Mustamäe area started. Bad soil conditions (quicksand) caused construction delays, and a temporary solution for waste water had to be found. Until 1968 waste water from the Mustamäe area was led to the sea by open ditches. Today Mustamäe has a separate sewer system.

In 1966 the city development strategy included construction plans that were completed in 1972. The waste water flow was calculated according to the growth estimates of the city for 1970, 1980 and 1990. The sewerage system was designed according to the estimated flow in 1980, and the main facilities (main pumping station, etc.) were based on the estimated flow in 1990 plus 50% growth. In this project it was planned that all the sewers in town would be connected with

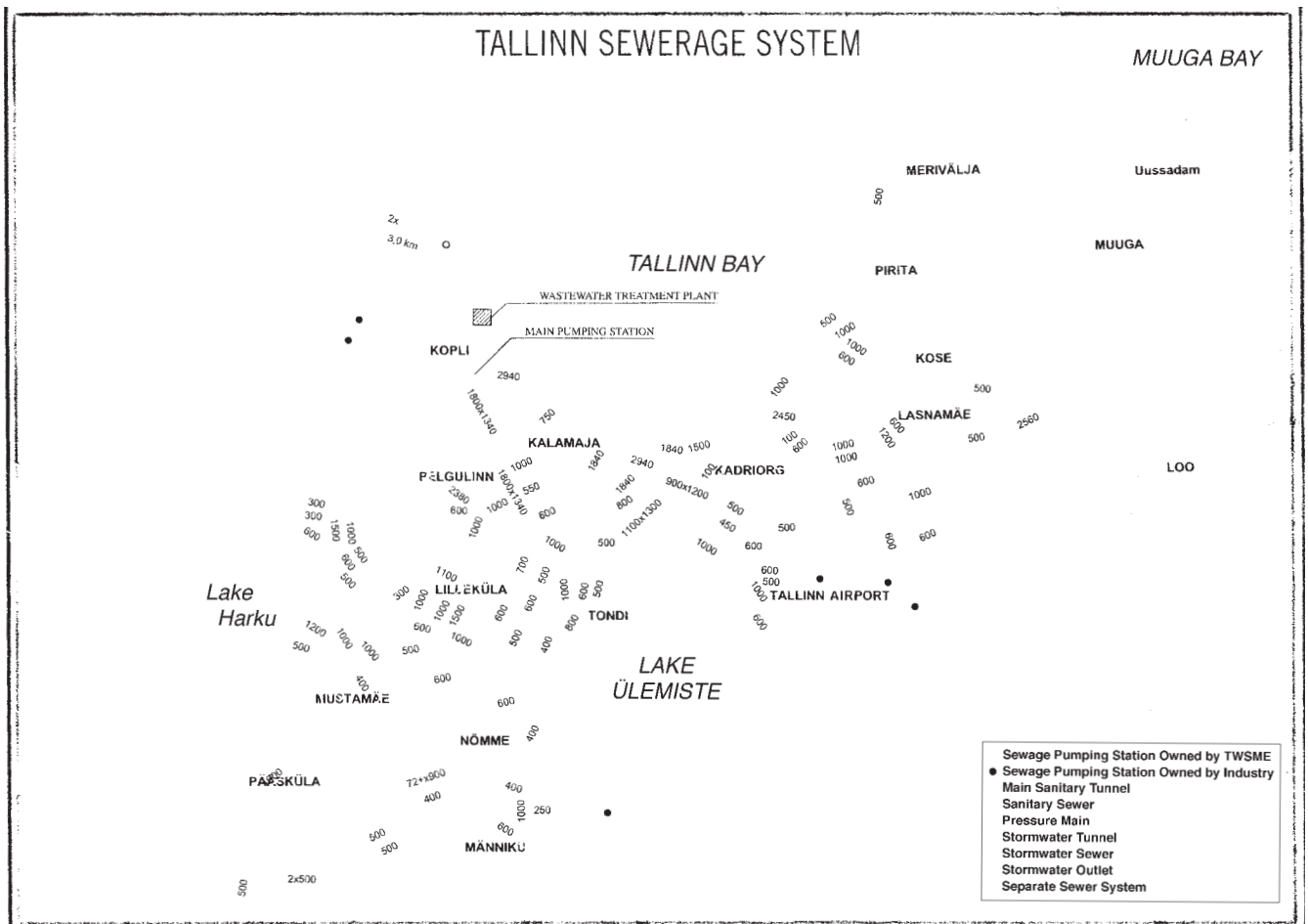


Figure 5. Tallinn sewerage system

a common sewerage system and all waste water would be treated in a treatment plant and then conducted to the sea. The sewers had to be built first, followed by the waste water treatment plant. Since the existing sewers were combined, it was decided that only new sewers would be separate sewers. In an old plan made before 1940, pumping had been avoided, but this project provided for more than thirty pumping stations in order to avoid clogging.

In 1967 the total length of the sewer system was 241 km and there were six pumping stations in use [1]. In 1968 construction work on the main sewer no. 1 (length 5.1 km) started. Completed in 1978, it served the central and eastern parts of town.

The construction work on a main pumping station started in 1968 and was finished in 1978. Plant capacity is 9.6 m³/s. During the planning phase this pumping station was the largest in the Soviet Union with a diameter of 28 m, wall thickness 1.4-1.8 m and a depth of 20 m [2].

In 1969 construction work in the Õismäe residential area started. The idea was to finish sewers simultaneously with houses, but bad soil conditions spoiled the plans again. When the first houses were ready, the sewers were also ready. Since the Harku pumping station was not yet finished, temporary pumps were installed in 1973. In 1975 the pumping station was ready with a diameter of twenty-four metres, a depth of ten metres, and walls one meter thick. According to the plan waste water was to be led to main sewer 3, but since it was not ready yet, they were temporarily led to Kopli Bay. Today this sewer system is the best in Tallinn.

The works on main sewer no. 3 (length 2.8 km) began in 1971 and were completed in 1979. This ended the polluting of Kopli Bay. In 1972 the total length of the sewer system was 338 km. In the 1980s the construction of sewerage in the Lasnamäe area started and today it has its own separate sewerage system. In 1987 the total length of the sewer system was 632 km [6].

Today there are three main sewers, a main pumping station, a shore well and a sea outfall. The installation of mechanical treatment facilities in the waste water treatment plant is completed, and a part of biological treatment facilities too. No major changes had been made in the 1962 project. In 1991 the total length of the sewer system was 804 km and at the end of 1996 it was 841 km (Figure 5) [4, 6]. There are twenty-six waste water and four storm water pumping stations in the city. The most widely used pipe materials are

concrete, clay and asbestos cement. The diameter of the tunnels is 1,840-2,940 mm and that of storm water tunnels 2,540 mm. Typical problems are sedimentation and insufficient gradients. About 150 - 200 km of sewers are very old and need renovation [6]. In the 1980s Tallinn water consumption peaked at ca 340,000 m³/d. Since 1990 water consumption and the amount of waste water have decreased. Almost 99% of the waste water is led to the sea. The biggest achievement is that in 1992 Tallinn's pulp and paper mills were closed. In 1994 the HELCOM recommendations in effect at that time were met in the treatment plant [6].

Many attempts have been made to bring the Tallinn sewerage system up to international standards. Some major tasks are still to be completed: the biological treatment unit has to be built, a new storm water sewer system has to be created and sewers in private housing areas have to be constructed. The replacement of old sewers (12% of the sewers are more than seventy years old) must be given a high priority.

Storm water

Ninety per cent of the precipitation in the Tallinn area comes as rain. Ten per cent of waste water drained away to the sea is storm water. The two problems connected with storm water are how to drain it quickly away from the town (low cost and maximum effectiveness) and how to minimise the pollution transported to the sea.

Storm water was led away by separate sewers to all water bodies in the town. Since dilution was 1:1 there was a big possibility that polluted water would be drained off straight into the Tallinn, Kopli and Paljassaare bays. The Tallinn coastline is an intensively used zone, so there should not be any outlets to the sea.

The reconstruction plan of the storm water sewer system was finished in 1982. Storm water was to be led by sewers to Paljassaare and then, depending on the situation, treated or simply drained off to the sea. However, because of a lack of money nothing was done. Today this solution is not good enough. This problem should be solved on the basis of the latest environmental principles: polluter fines, preventive measures, etc. Consideration should also be given to dry methods of street cleaning, local treatment facilities for storm water coming from industrial areas, and the elimination of

TALLINN WASTE WATER TREATMENT PLANT TECHNOLOGICAL CYCLE

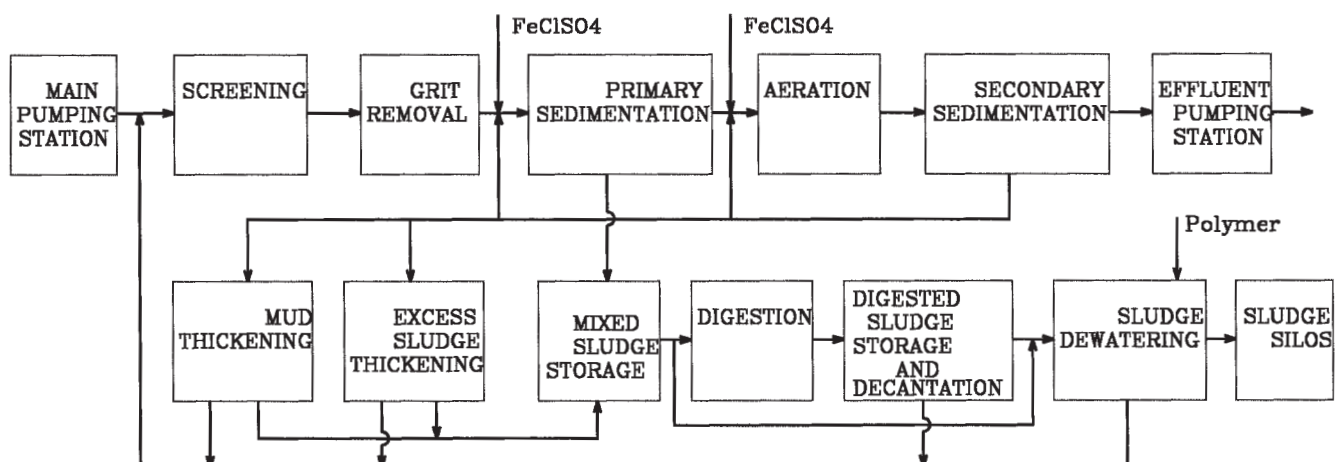


Figure 6. Tallinn waste water treatment plant

illegal connections.

Studies show that since the 1980s big changes in pollution have taken place. The main threats are no longer nitrogen and phosphorous (although they should not be underestimated), but heavy metals, oil and microbiological pollution. Since pollution caused by storm water is intermittent and depends directly on precipitation, more attention should be given to polluters, which have an extended impact.

Wastewater treatment plant

Before the planning of the WWTP started, a study of the quality of waste water was undertaken. Because of the difficulties caused by combined sewers, it was decided that mechanical and chemical treatment would be sufficient to guarantee the self-purification capacity of Tallinn Bay. It was the first treatment plant in the Soviet Union where chemical treatment was used to guarantee as high a purification capacity as possible at a low cost. Mechanical screens are used and residues were passed through a worm press into a container. Annually about 18–20 tons of waste is removed. This is followed by aerated grit removal. Sediments from this process are sent to grit dewatering and then to primary sedimentation tanks. Here coagulation (FeClSO_4) is employed and the sludge is removed with pumps. The mechanical/ chemical treatment facilities and deep-sea outlet were not finished until 1984.

In the second phase the plan was to construct biological treatment facilities and increase plant capacity up to 440,000 m^3/d . There was a plan to construct aerotanks and secondary sedimentation tanks. Sludge from secondary sedimentation tanks was to be pumped back to aerotanks. Initially, centrifuges and thermal treatment were planned for sludge dewatering, but now digestion will be used. In the beginning dry sludge was sent to waste disposal, but now it is composted with peat and used as a fertiliser. Second-phase construction work started in 1986 and was to be ready in 1989 (Figure 6). However, the first biological treatment facilities (no nitrogen removal) were not finished until 1994 and the HELCOM recommendations for BOD and Pt have been met. Today the construction of biological treatment facilities continues. In 1988 it was decided that complete biological treatment is obligatory for waste water fed to the Baltic Sea, and now some additions to the biological treatment unit have been made.

Sea outfall

The purified waste water is pumped into the sea and there is a shore well to remove air and to minimise damage caused by a hydraulic pressure blow. At the beginning the sea outfall was to be constructed of steel, but later a decision was made to use plastic pipes. There are two $\text{Ø}1,200$ mm pipelines three kilometres long, and their depth at the end is 23 m. Pipes were welded to 308 m lengths on the ground, and after sinking they were joined with bolts. Sinking started in 1974 and in 1978 the sea outfall was taken into use.

CHARGING

Until 1925 the city paid all sewerage construction and maintenance costs. Since then project confirmation, supervision and connection fees have had to be paid. In the 1930s the economic situation improved and construction activities intensified. New sewers were also needed. To finance this, a new sewerage tax was introduced in 1935, based on the area of the plot of land. In 1941 the Soviet government introduced a new tax corresponding to floor space in m^2 . This tax was different from earlier ones because it had to be paid annually. In 1945 it was decided that the sewerage fee should depend on the potable water amount used. Clients connected to the water supply system paid a water-consumption tax; others were taxed on the basis of floor space in m^2 . In 1978, after sewerage system improvements had been completed, new taxes were adopted and they are increasing continuously. Since 1994 customers have been charged according to a tariff based on the pollution category and the amount of pollution created. In 1995 it was decided that all pollution led to a water body is subject to taxation.

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