Watering the City of Tampere from the mid-1800s to the 21st Century

By Tapio S. Katko and Petri S. Juuti

TAMPERE WATER

International Water History Association

Contribution of Tampere Water to the 5th IWHA Conference, 13 to 17 June, 2007 at Tampere

Watering the City of Tampere from the mid-1800s to the 21st Century
By Tapio S. Katko and Petri S. Juuti

Publisher: Tampere Water and IWHA, Cheney, WA, USA
Graphical design: Aino Myllyluoma

Printer: Hermes Oy
ISBN 978-951-609-331-7

Photos on covers:

- Front: Upper: Drawing water from Tammerkoski Rapids before the piped system (Photo: Photo Archives of Tampere Museums); Viinikanlahti wastewater treatment plant downstream of the rapids close to the city centre around 2000 (Photo: Tampere Water)
- Back: Sewer construction in Messukylä, eastern Tampere in April 1963 (Photo: Photo Archives of Tampere Museums, Kauppila).

Table of Contents

Foreword

"Those who cannot remember the past are condemned to repeat it"
George Santayana (1863–1952)

The history and development of Tampere, the biggest inland city in the Nordic countries, have been shaped extensively by issues related to water and water management over the years. The city was established along rapids that cut their way through the glacio-fluvial esker between two large lakes some 7 500 years ago (Tikkanen 2006). Tampere is the city with the longest history of modern industrial enterprises in Finland, and it is currently known for its high-tech industries, including the research centres of Nokia, the world's largest manufacturer of mobile devices. The company has its origins in the industries established downstream from Tampere in the neighbouring municipality – Nokia.

Tammerkoski Rapids and its banks were a favourable location for a town due to the available water power and the lakes suitable for waterborne transport. In the beginning of the 19th century, peasants built a channel in the upstream part of the rapids; a cotton mill and an engineering works were founded in the early 1820s followed later by other industrial activities. As early as in the 1830s, water was pumped from the lake above the City of Tampere and led via a wooden pipe to the centre. The first, bigger water works and sewerage system was started in the early 1880s while the high-pressure system followed in 1898. The first phase of a piped sewerage system was completed in 1894. By the 1950s and '60s the waters upstream and downstream from the City of Tampere had become deteriorated but the introduction of efficient water pollution control allowed them to recover surprisingly fast. Groundwater utilization was suggested in the 1910s and has been implemented to some extent since the 1950s – to be possibly followed by artificial recharge in the early 2010s.

Presently interest towards long-term experiences and water history seem to be increasing worldwide. We hope that this case of one city up North could, for its part, remind of the necessity and need to explore the history of water and sanitation in all cities and communities of the "global village" and promote comparative studies for a better understanding of the applicable key principles and practices.

The financial and professional support of Tampere Water, and managing director Reijo Kuivamäki, is gratefully acknowledged. We are also thankful for the approaches made available for this work developed in the following projects: Academy of Finland (210816) and the Ministry for Agriculture and Forestry (4998/421/2005).

The authors wish to thank Esko Haume, Timo Heinonen, Jarmo Hukka, Petri Jokela, Saila Kallioinen, Markku Leinonen, Antero Luonsi, Harri Mäki, Pekka Pietilä, Riikka Rajala, Katja Rasi, Heidi Rauhamäki, Johann Tempelhoff, Robert Varady, Eija Vinnari and Dorothy Zeisler-Vralsted for their constructive comments. Language checking by Jorma Tiainen, and assistance from Kaisu Anttonen, Tellervo Kiviniemi, Reija Kolehmainen, Esko Kuusisto, Sari Merontausta, Olli Niemi, Reijo Oravainen, Petri Pulli, Pertti Vuoriranta, and Sverker Westman are also acknowledged. Special thanks are due to the International Water History Association for accepting this publication to their series.

Tampere, 6th of December, 2006
89th Anniversary of the Independence of the Republic of Finland

Authors

1. Introduction and sources

Water supply and sewerage (WSS) are arguably the most vital infrastructure service of any society. Lack of adequate WSS services is a prime contributor to poverty, ill health and civil discontent in many developing economies of today, like in many industrialised countries earlier. Provision of water services, which also include sewerage in this book, is a highly capital-intensive business. By its very nature, the provision of water services is a natural monopoly. Yet, in addition to being an economic issue, these services are a basic necessity justified by wider social, environmental and health requirements.

This study aims to explore how water supply and sanitation services with such distinctive features have developed in Tampere, the first industrial city and currently the third biggest city in Finland, located some 140 km northwest of Helsinki, the capital, as shown on the inside front cover. Tampere is also the largest inland city in the Nordic countries. In many respects, it is representative of the development of water supply and sanitation in the whole country, although local conditions and solutions may vary considerably (Katko, 1997).

Besides describing and analysing the historical development of water and sanitation services in Tampere, this book tries to establish the key strategic decisions and principles applied over time that mostly affected overall development. Decisions had to be made between public and private ownership, ground and surface water sources, water metering, water closets, nearby and distant water sources, wastewater treatment, integration of water and sewerage services, and ways of cooperation at various levels. Practically the same issues have been discussed at many international water forums in the early 2000s, which too often – purposely or not – have tended to forget such lessons, as if our present and future options could be determined in a historical vacuum.

Geographically, Tampere lies on an isthmus between two large lakes, Näsijärvi and Pyhäjärvi (Fig. 1.1). The surface area of Tampere is 24 percent water, and there are some 180 lakes within the city boundaries. The quality of lake water is usually good. The centre of the city is traversed by the nearly one kilometre long Tammerkoski Rapids (Fig. 1.2) – with the fall of 18 meters and the mean discharge of 71 m^3/s (Perälä 2006).

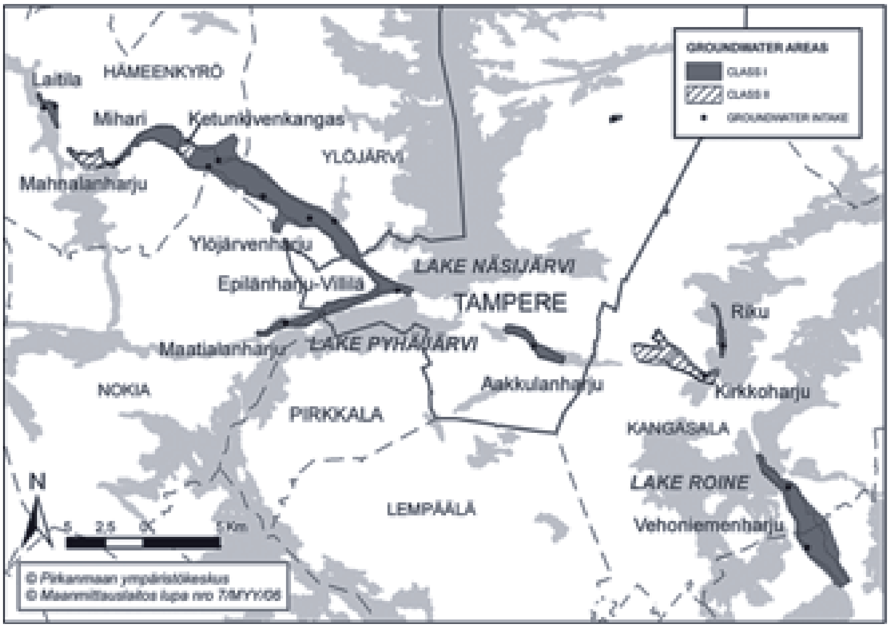


Fig. 1.1 Location of Tampere in relation to major surface waters, the eskar formation running mainly northwest to southeast, major groundwater intakes, and boundaries with neighbouring municipalities (Drawn by Kiviniemi 2006).

The Rapids, which run north to south, break an eskar formation separating the lakes, the highest traverse ridge in the world formed during the ice age. This Pyynikki ridge is also an important recreational area in close proximity to the centre. The eskar formation forks out at the western and eastern sides of the city. The major ground water intakes operating in Tampere are located on the western side of the city (Fig 1.1 and Fig 1.2). In Finnish and Fenno-Scandian conditions all major groundwater supplies exist in such esker formations; elsewhere average soil thickness above the bedrock is just a few metres.

The population development figures from 1900-2020 are given in Table 1. At the end of 2002 the population density of the City of Tampere was 382 persons/km^2, and there were 1.9 persons per dwelling. The population density around 1900 was estimated to be as high as 2250 persons per km^2 due to the quite small area of the city at that time. Later on, population density continued to drop through gradual mergers of neighbouring, mostly sparsely populated, areas with the city.

Fig. 1.2 Tampere city centre penetrated by the Tammerkoski Rapids flowing north to south (Photo: Tampere City Tourist Bureau).

Table 1. Population growth and estimates in Tampere, 1900–2020 (City of Tampere 2003; 2006b).

Year	Population	Year	Population	Year	Population
1900	36 300	1970	155 400	2000	195 468
1950	101 100	1980	166 200	2005	204 337
1960	127 300	1990	172 600	2020	229 000 (est.)

The social change of the 1960s brought many people from the countryside to Tampere. In the 1960s Tampere started planning a satellite city: the Hervanta plan was closely tied to the building of the Tampere University of Technology which started in 1972. The rural areas of Aitolahti and Teisko in the northeastern part of Tampere (Fig. 1.1) were the next ones to be annexed to Tampere; Aitolahti in 1966 and Teisko in 1972 (Koivisto and Tuulasvaara-Kaleva 2000). The more recent structural change in Finland has caused big industry to move away from the city centre except for the

Tako board mill (M-Real Ltd., Fig. 6.2). The old factory buildings have been partly demolished or refurbished for new uses such as boutiques, workshops, studios, restaurants, museums, and cinemas.

In the early 21st century Tampere Region (Pirkanmaa in Finnish), the second largest region in Finland, is a modern concentration of industry, commerce, services and education. The region divides into six sub-regions, which in 2007 consist of 28 municipalities. The main branches of industry are wood processing, metalworking, mechanical engineering and automation, while other growth sectors of importance for employment include information technology and health technology. The traditional, staple industries of the region are textiles, leather goods, rubber products and chemicals. The Tampere Region is the principal centre for research and development in Finland after the Helsinki conurbation, accounting for 13-15 percent of national spending on both private and public-sector R&D (The Council of Tampere Region 2004).

This study is based on several studies mainly by the authors, such as the book on the history of Tampere Water (Juuti & Katko 1998), Juuti's doctoral dissertation in history (2001), and a more recent study on the evolution of water services in 29 European cities – Tampere being one of the case cities (Hukka & Seppälä 2005, Juuti & Katko 2005). Some comparisons to other water utility case histories will also be made, especially those of Hämeenlinna (Juuti, Rajala & Katko 2000), Porvoo (Juuti, Rajala & Katko 2003), Vaasa (Juuti & Katko 2006), Espoo (Juuti & Rajala 2007) and a comparative study on the key strategic selections at the national level (Katko, Juuti & Pietilä 2006). The analysis of the study, and especially the key strategic changes, were finalised in several review discussions between the authors and the managing director of Tampere Water. The historical study by the key authors is followed by future implications by the managing director in the last chapter.

2. Water and industrial heritage

The banks of the Tammerkoski Rapids between the two lakes (Fig. 1.1) were a favourable location for a town because of the available water power and the lakes suitable for waterborne transport. The right to fish salmon in the rapids was a bone of contention already in the Middle Ages, and milling rights in the rapids were granted to people who were able to build a mill (Tuulasvaara-Kaleva 2006a).

In 1779 the borough of Tammerkoski was granted its charter by King Gustav III (1746-92), as Finland had been a part of Sweden for centuries. This new town enjoyed a number of concessions not readily awarded to other towns. After Finland became an autonomous Grand Dutchy of Russia in 1809, Tampere became the first Finnish free city in 1821 by order of Czar Alexander I (1777-1825).

The first artisan workshops on the bank belonged to dyers, who harnessed the water power of the lower and upper parts of the rapids. Although a paper mill operated in the middle section of the rapids as early as the 1780s, the use of water power was small in scale; a spa by the central calm section of the rapids and the town pharmacist's herb gardens used it and there were places along the bank where the townspeople fetched their water (upper part of the front cover). In the beginning of the nineteenth century, the current was made stronger. The peasants on the shores of Lake Näsijärvi built a channel called the Teisko flume at their own expense in the upstream part of the rapids on the city's side and the Crown had Tammerkoski cleaned out (Tuulasvaara-Kaleva 2006b).

The Scotsman James Finlayson (1771-1852) moved to the city from St. Petersburg in the early 1820s and founded a cotton mill and an engineering works (Timonen 2003, 199-200). However, it took a long time before industrialisation actually got under way on the banks of the rapids (Fig 2.1). In 1837 a modern six-floor industrial building was completed, and the same year the factories were the first in Scandinavia to introduce sprinklers six years after their invention (Juuti & Katko 1998; 242, 244).

Fig. 2.1 Tammerkoski Rapids in 1847, a lithography by Lennart Forsten. In the back the six-storey Finlayson building (Photo: Photo Archives of Tampere Museums).

Box 1. In 1992, altogether 27 national landscapes were designated around Finland that distinctly represent the special natural and cultural features of their region. Tammerkoski Rapids and their surroundings in Tampere are one of them. http://www.ymparisto.fi/default.asp?node=686&lan=fi

The triumphal march of electricity in Tampere began from Finlayson's cotton mill in the 1880s. On 15th of March, 1882 an electric light was turned on in the weaving room at Finlayson's for the first time in Northern Europe – thanks to the initiative of Carl von Nottbeck (1814 - 84). Five decades later, the power of the rapids had been harnessed for four power stations: Tampella and Finlayson's had theirs in the upper part of the rapids, the city's electricity plant generated power in the middle, and Alavoima Ltd operated in the lower part of the rapids – it was owned jointly by the factories located there (Tuulasvaara-Kaleva 2006c).

For long, Tampere was the centre of Finnish industry which is also reflected in its nickname "Manse" which derives from Manchester, the English city of industry. Many industries established in Tampere from the 1830s to the 1950s were among the first of their type launched in Finland (Table 2, left). As for later history of high-technology (Table 2, right), the first NMT mobile phone call in the world was made in Tampere in 1974 and the first GSM call in 1991 followed by many other global innovation "firsts" before the 21st century. Thus, from the British point of view it might nowadays rather be called "Leedse" – a current high-tech centre as well.

Table 2. Tampere, an industrial forerunner in Finnish and Nordic circles in the late 1800s, and a century later in global high-technology (Niemi 2005).

Year	Early innovations: 1st in Finland	Year	High-tech innovations: 1st in the world
1779	City of Tampere founded with free trade rights	1974	NMT call
1821	1821 Finlayson factory starts operations	1978	Cash dispenser (Minisyp)
1837	1st multi-storey factory building + steel pillars - Finlayson	1985	Electromechanical film (EMFi)
1843	1st paper machine - Frenckell	1991	GSM call
1875	1st shoe factory - Aaltonen	1993	Analog Cellular Data Card - Nokia
1878	2nd phone connection (1st in Helsinki 1877)	1994	GSM Data Card - Nokia
1882	1st electric light - Edison generator number 3	1995	Walking forest machine - Timber-jack
1888	1st street lights - 30 arc lamps	1995	Internet call - Sonera
1908	1st automatic weaving machines - Tampereen puuvillatehdas	1996	Personal Digital Assistant - Nokia Communicator
1909	Largest tapestry factory in Nordic Countries - Winter	1997	Data Suite - Nokia
1911	1st attempt to fly	1997	GSM card phone - Nokia
	1st industrial clothing factory - Pukutehdas	1998	digital x-ray photograph - Imix
1916	Electric melting furnace- Lokomo	1999	WAP Server - Nokia
1921	1st plastics industry enterprise - Sarvis	1999	Wireless LAN - Nokia
1923	1st radio broadcast	2000	Wireless Mine – Tamrock
1929	Gold medal for Lokomo's chrome steel anvils at world exhibition in Barcelona	2001	Road snoop – Nokian Tyres
1959	1st machine producing on-machine coated paper	2003	N-Gage - Nokia
		2003	FogScreen – Fogscreen Ltd

3. From prototype to modern water supply and sewerage systems

The evolution of water supply started in Tampere in the 1830s when the first plans to build a water pipe were made. The population of the city was some 1,520 in 1835, some 33,800 in 1900 and some 200 000 in 2002 (Table 1). The first municipal "water pumping installation" was founded in 1835. At that time, the first attempt was made to pump water by a German-made iron pump from Mältinranta (Fig. 3.1), upstream from Tammerkoski Rapids, through a wooden pipe to a well in the market square. The contemporaries deemed the effort a failure, since only a small amount of water reached the well and even that was dirty and smelt bad. Regulations, effected expansions and maps do, however, prove that water was pumped for several years (Juuti 2001).

In 1853, the Senate of the autonomous Grand Duchy ordered the city to lay the groundwork for the establishment of a professional fire brigade and also some kind of a water pipe. The building of a water pipe had been on the agendas of meetings of tradesmen and town elders already before the mid-1800s. The latter applied for a loan from the Senate on the suggestion of certain merchants in 1858 for constructing a water pipe. Pipes were actually purchased, but the project was then delayed (Juuti & Katko 1998, 10).

Debate on public or private

The early houses of Finnish towns were of timber and thus easily caught fire. In 1865 there was a great fire in Tampere which destroyed completely 287 houses leaving over 500 people homeless –about 10 percent of the town´s population at the time. A new fire fighting system and ordinance were adopted later the same year (Juuti & Katko 1998, 20).

After the Fire of 1865, the industrialist William von Nottbeck (1816–1890, Fig. 3.2), who originally moved to Tampere from St. Petersburg, made an offer to build a water pipe at the request of the municipal authorities. He proposed that a wooden pipe be constructed from Mältinranta at the head of Tammerkoski Rapids to the Central Square at a cost of 7,500 silver rubles (equals 105 000 euros in 2004). In his second proposal, a network cover-

Fig. 3.1 “City pumping station” situated upstream of the rapids (shown on the top left with text “Stadens pumpverk”), and water canals with water wheels of several factories on the western bank of the rapids. Map drawn in 1842 and 1843.

ing the whole town would have cost 28 000 rubles (400 000 euros). He was then asked to submit his conditions for running the water supply. These conditions (Box 2), consisting of ten paragraphs, actually meant that the industrialist would make a tidy amount of money while the town would assume all the risks (Juuti & Katko 1998, 11; Juuti & Katko 2005; Katko, Juuti & Hukka 2002). The city declined his offer. Thereafter the development of water and sewerage was deemed the city´s responsibility.

Fig. 3.2 William von Nottbeck (1816-1890), one of the early industrialists of Tampere.

The first recorded rural water supply system using wooden pipes was completed in 1872 in Ilmajoki Ostrobothnia, in the western part of Finland (Turunen 1985, 181) while the first urban water and sewerage system with cast iron water pipes and oval-shaped brick sewers was established in Helsinki four years later in 1876. In 1874, Malakias Pasi, a rural builder of water pipes, also from the western part of the country, offered to construct a wooden pipeline for the City of Tampere as a contractor but not to operate it. This proposal also came to nothing. The Tampere city council also rejected the proposal for building a water pipe put forth in 1880 by civil engineer August Ahlberg, the "sanitary policeman" of the city (Juuti & Katko 1998, 14-16).

The first water supply and sewerage system

In 1881, the governor of the province ordered a water works to be built in the city due to recurring fires and the poor quality of well water. In Finland, fire insurance companies have contributed significantly towards the development of water services especially since the Great Fire of Turku in 1827 which made fire insurance a highly topical issue (Juuti & Katko 2005, 61). As a result, the people in Tampere also considered the establishment of a water works for fire fighting purposes a top priority.

The same year, 1881, construction began on a gravity cast iron water pipe from Mältinranta, upstream of the rapids, to a market square in the

Box 2. Von Nottbeck´s terms for establishing a private water works for the city of Tampere in 1866 (Katko et al. 2002; Juuti & Katko 1998, 11).

1. Arrangements must be made to allow piping water initially from Mältinranta (upstream) or Mustalahti through the City to Kauppatori (marketplace) so that pipes of practical size can be used.
2. Permission to lay water mains in the middle of streets must be granted so that the owners of the houses along the streets can be supplied the necessary water at a reasonable price.
3. The conveying of water is to be considered an entitlement for myself or my heirs, and I shall therefore be allowed to use the water freely for my own needs. The City Board agrees not to allow the building of any other water supply system within the City without my permission as long as I maintain the water supply system in proper condition and gradually expand it to other parts of the City.
4. Should I decide to sell the facility, I agree to offer it first to the City Board at the offered price.
5. Should an act of God render the water supply inoperable for a period of time, I agree to repair it, but will not pay compensation for any resulting damages.
6. The City Board agrees to impose a large enough fine to prevent acts of vandalism against the water pipe or any part of it.
7. The City Treasury shall pay me annually 200 Finnish marks for the use of the water system by the City Hall, the upper elementary school and the hospital, even if said institutions do not use it.
8. As the water system contributes to public safety and, among other things, benefits the City dwellers in the form of lower insurance premiums on their properties, I consider cheap a charge of 40 pennies for each one sixteenth (market fee) charged by the City Board which entitles people to use water free during fairs and regular market days.
9. I agree to set as reasonable a price as possible on the water consumed in the marketplace and from fire plugs installed in certain locations.
10. In the future, should the income from the one sixteenths fall below 2,500 marks, the City Board agrees to make up the difference.

southern part of the city – the pipe had several connections. The contractor was Robert Huber, a Swiss-born engineer, who supervised the construction of the Helsinki Water Works the previous decade, and also operated the system for a few years. The pressure of the system was low while technically and administratively it operated much like a modern water works.

Several tall apartment blocks were erected in the city centre towards the end of the 19th century. Then it was noticed that water pressure was too low to carry water to the top floors. The pressure was also inadequate for fire fighting purposes as shown in Fig. 3.3.

Fig. 3.3 Destruction after one of the last great fires at the corner of Näsilinnankatu and Puutarhakatu streets in 1893 (Photo: Photo Archives of Tampere Museums; Jansson-Lehtinen, Koivisto & Tuulasvaara-Kaleva 1999, 93).

Particularly due to the demands of fire fighting, the city council requested that C. Hausen, the engineer of the Helsinki Water Works, design a new high-pressure facility. The facility which was operated according to modern principles was completed in 1898. It had an underground tank (Fig. 4.6a) high up in the Pyynikki Ridge which is still in use a hundred years later providing sufficient pressure for the core city. A public fountain (Fig. 3.4) in front of the City Hall, donated by the afore-mentioned industrialist William von Nottbeck, was taken into public water supply use, and later became an ornament. A large part of the original network built in 1898 consisted of cast iron pipes with leaded joints. However, lead pipes have never been used in house connections in Tampere or anywhere else in the country – a very wise decision from today's perspective as concerns public health. The system also incorporates several valves more than 100 years old installed around 1900 (Leinonen 2006).

Fig. 3.4 Public fountain, made in Potsdam, Germany, has operated since 1898 in front of the City Hall of Tampere (Photo: T. Katko).

Early metering

In Finland, the City of Helsinki introduced water meters first to industrial users in the 1870s and to flats in 1891-92 following the German tradition (Herranen 2002, 48-51; Lillja 1937, 269-278). This is obviously why some water meters were also installed in Tampere already during the low-pressure system in the 1880s – they became commonplace with the high pressure system introduced in 1898. Since then all bigger buildings and one-family houses have been metered while some individual meters have also been installed by real estate companies in flats and row-houses starting in the 1990s. These companies are the customers that sign a contract with Tampere Water.

From the individual consumer´s point of view metering often means savings while being a dilemma for the water utility. Since the utility's income used to be based exclusively on the amount of water sold, basic charges were introduced in 1974 partly to balance the income (Juuti & Katko 1998, 213). At the end of 2005 Tampere Water had a total of about 17 000 meters in use.

Water closet?

In Helsinki, the capital, a debate went on for 25 years about whether the water closet should be allowed or not. Based on the request of the City of Helsinki, the Senate had in 1884 decided that water closets are not allowed. In practise water closets were allowed in 1895, although formally only in 1904, when the new police ordinance of the city allowed their construction (Herranen 2002, 60-63, Laakkonen 2006).

In Tampere the debate on water closets was probably not that heated, and they were accepted along with the high-pressure water supply system. Although the water closet became gradually more and more common, dry toilets were still typical in the areas of wooden and single-family houses in the 1950s (Juuti & Katko 1998, 185). At the turn of the 20th century, faeces from city houses were transported on horse carts to the fields of the Hatanpää manor. In 1913 the manor became the property of the City of Tampere while faeces still continued to arrive from the dry toilets of the city – four times a day in summertime and three in wintertime (Juuti & Wallenius 2005, 123).

Early sewerage

The evolution of sewerage in Tampere began with subsoil drainage like in many other cities (Melosi, 1998). Actual wastewaters have been conveyed through sewers since the late 1800s. As the city expanded in the mid-1800s, ditches were straightened, opened and covered. These measures were, however, insufficient and the city's population was "greatly disturbed" by the filthy ponds, water-logged soil and such. A report by the health committee from 1866 describes the "drainage of the city" and notes how hardly any improvements had occurred in two hundred years (Juuti 2001, 67-71).

After the founding of the city in 1779, it was ordered that the previously free-flowing ditches had to follow the boundary lines of lots and be carried through culverts and under buildings. The health committee suggested the construction of a sewer system in the city. The next year the burghers decided to launch the design of such a system. In 1873, a surveyor prepared a plan involving two main sewers. The 1879 public health decree obliged the city to prepare a plan for a sewer system commensurate with the population within 10 years. The city administrators took seriously the deficiencies in sewerage and the demands of the government: starting in the early 1880s, the municipal health board repeatedly exhorted the city to expand and upgrade the sewerage system. The initial sewer line took from 1887 to 1894 to build: it consisted of a total of 15 kilometres of pipes of oval cross-section and hand-made bricks, and nearly 200 manholes (Juuti 2001, Leinonen 2006). The initial phases of the water and sewage works were both built in the 1880s which makes the utility around 120 years old.

Savings in water treatment and misplaced pipes may cost lives

Due to the inadequate service standard of the low-pressure system, the city council decided in 1885 to have a high-pressure water system, yet without the proposed slow sand filters. The water committee had made its proposal, seconded also by the Tampere Technical Society, to save costs. Opponents argued e.g. that ”Lake Näsijärvi has lakewater of the highest quality in the world”. The planner, Carl Hausen, is also supposed to have said: “You will live to regret this” (Juuti 2001, 126).

This savings proved costly in that together with the misplaced sewage discharge point upstream near the intake, it resulted in typhus epidemics in 1908-09 that killed 53 people, followed by the even more fatal one in 1915-16 with almost 300 fatalities (Fig. 3.5). It has been estimated that the immediate direct hospital and health care costs due to these savings were four times the savings, not to speak of the impact of the lives lost on the citizens and local economy (Juuti 2001, 245-246). In 1917 chlorination was started and the intake pipe was made longer. It brought an end to typhus epidemics.

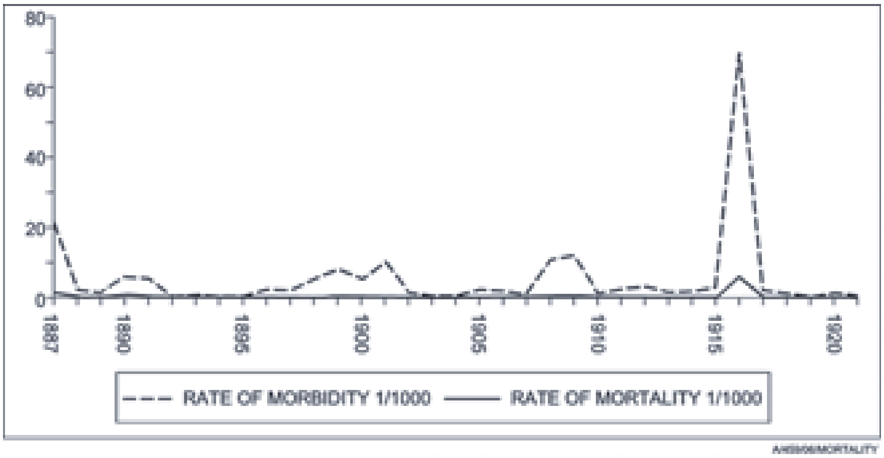


Fig. 3.5 Typhoid epidemics and related morbidity and mortality rates in Tampere, 1887-1920 (Koskinen 1998, 90).

In spite of gradually improving living standards, including piped water to the house or courtyard, the housing conditions among working-class people remained quite poor as described by Lauri Viita (1916-1965), a nationally well-known and Tampere-based poet (Box 3).

Box 3. The common housing form including a shared kitchen for working-class families in Tampere in the early 1900s described by Lauri Viita (Juuti & Wallenius 2005, 19; Juuti & Pál 2006, 384).

"From the open porch a door led directly into the shared kitchen […] and the familiar sight in the kitchen, starting by the door and moving clockwise was: a slop bucket, a shelf and window, a slop bucket, the pantry, a slop bucket, a door to the kitchen, a potato basket, a door to the kitchen, a chair and a water bucket, the stove, a door to the kitchen, a potato basket, a door to the kitchen, a big glass jar, a door to the kitchen, a slop bucket, a box, a table, a door to the kitchen and in the last corner a box, a slop bucket and the stairs to the attic […] five rooms and a shared kitchen, eighty square metres in total; this was home to thirty-two occupants and one almost blind granny […] next to the stairs (or rather ladders) leading to the attic, the leaking slop bucket that regularly tipped over[…]"

Fig. 3.6 Tannin cisterns in Tampere around 1900 (Photo: K. Mäkinen, Photo Archives of Tampere Museums).

Besides polluted waters and water sources, soil contamination also occurs in city sectors with high population density. A major problem in Tampere were tannin cisterns (Fig. 3.6), seven of them existing right in the centre of the city. A certain type of dry toilet was common, but only part of the faeces were taken to agricultural fields (Harjula 2003, 35-37).

4. Expansion of systems

Ground or surface water?

In the 1910s, especially after the typhus epidemics, there were discussions about whether Tampere should begin to use ground water, which in terms of salubrity and taste was better than the water from Lake Näsijärvi. Extensive ground water inventories (Fig. 4.1) were made, but in 1920 the city council finally abandoned the plans for establishing a ground water intake. This decision probably also influenced the "city fathers" of other Finnish urban centres of that time. After World War II (WW II) ground water was finally adopted widely and constitutes currently about 30 per cent of total consumption in Tampere (Juuti and Katko 1998, 101-107; Juuti 2001, 190-194). Interestingly enough, some 70 years later, when ground water protection plans were being prepared for the city, it was estimated that the yield estimated in the 1910s for the Vuohenoja intake was probably of the right magnitude – something that was questioned by many at the time (Molarius 1997).

Fig. 4.1 Ground water investigations in Vuohenoja, Tampere in 1916 led by B. Gagneur (Photo: Photo Archives of Tampere Museums).

Expansion after World War II

After World War II the water works grew rapidly. Reconstruction in Tampere meant that the city started to expand and new suburbs were constructed. This is also reflected by the growth of the water network (Fig. 4.2). The reconstruction and expansion was described, for instance, by the afore-mentioned poet Lauri Viita in his poem "Concrete mixer" from 1947 (Viita 1947; Box 4).

Water supply in Tampere. Finland, 1900-2002

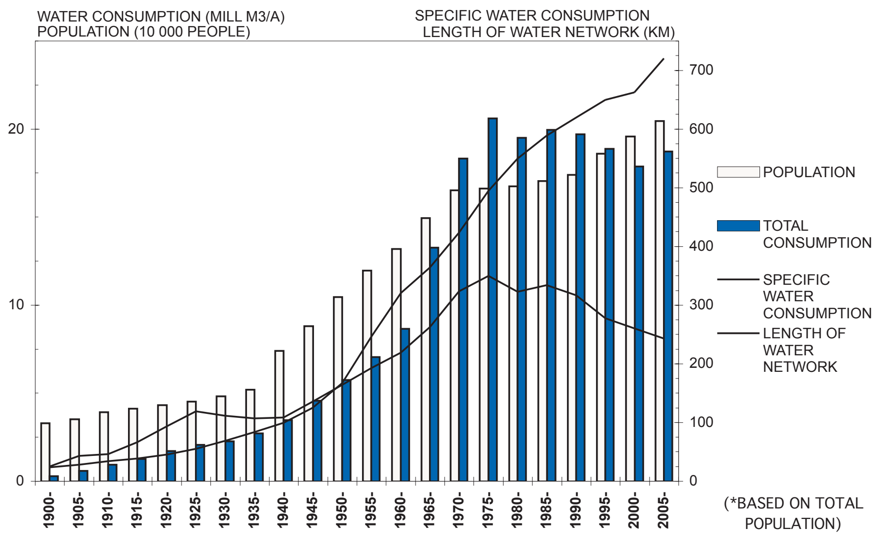


Fig. 4.2 Expansion of networks (Juuti & Katko 2005, p. 68).

The repair and maintenance workshop has been an important part of the water works´ operations while it has been housed in various places over the years. The workshop also used to serve other departments and works of the city, but this service was gradually ended (Juuti & Katko 1998, 170). Fig. 4.3 shows the workshop in 1951. Still those days hardly any excavators were available and the trenches had to be dug for construction and repairs manually by spade. In winter, the soil froze to a depth of more than two metres and temperature could fall to -25 °C which made the work even harder.

Box 4. Extracts from "Concrete mixer" (1947), a poem by Lauri Viita (1916-1965).

"A building site: cranes, lumber, junks,
towers, scaffolding, concrete chunks,
and round it a dead-pan city-block frown:
a large industrial town.
….
A skilled man, me,
with a trinity
of materials: these three:
with gravel, water, and cement
I conjured concrete, as I was meant –
and some sweat I lent."

In the past water works used to have more true characters than nowadays. In the late 1990s several staff members still remembered stories of the legendary master pipe fitter Erkki Raittinen (Fig. 4.4 on the right) who fixed his Zeta motorcycle nearly every lunch break in the 1960s. Once while riding with mechanic Niilo Aura on back, he crashed into the stone wall of the works. Afterwards, the smith Santavuori straightened the front fork and Raittinen had another go. After the second unsuccessful attempt and subsequent repair measures Raittinen asked Aura whether he dared to ride with him once more. This time he chose to walk (Juuti & Katko 1998, 131).

Motor vehicles were gradually introduced to the water works and its operation and maintenance duties. Yet, in the 1960s it was common for workers to use bicycles to get to their work sites. In those days the above-mentioned master pipe fitter bought a new Skoda, carried a 150 mm valve into the car and slammed the boot lid shut whereby the valve stem pierced the lid. Raittinen coolly remarked: "Nothing to worry about – your cow can only die if you have one". Soon thereafter the master pipe fitter was the first person to get the water works' permission to use his own car for work-related driving (Juuti & Katko 1998, 131).

Fig. 4.3 Workshop of the water works in 1951 (Photo: Tampere Water).

Fig. 4.4 Measuring water head through fire hydrant in the city centre in the late 1940s (Photo: Photo Archives of Tampere Museums).

Water reservoirs and towers

The first elevated water reservoir built underground in the Pyynikki esker in 1898 was expanded in 1938 (Fig. 4.6a); it still remains in operation in 2006. As the system expanded to new suburbs, more water towers were constructed (Fig. 4.5). Since 1969 water towers have been made of concrete with a mushroom-shaped cross-section (Fig. 4.5, 4.7) based on continuous casting. In 2006 the total capacity of water towers and elevated reservoirs is some 23 000 m3, i.e. about 45 percent of the average daily use. Fig. 4.5 also illustrates how the system expanded and how the three last towers were constructed at higher elevations in the suburbs.

The architecture and design of Finnish water towers and elevated water reservoirs varies, and they are a prominent feature in the local landscape as described by Nagler (1966) in his article in the Journal of AWWA. Accordingly, Prof. John P. Klus, University of Wisconsin, points out that "water towers play an important role not only in our need for sufficient water pressure, but as a local symbol" (Asola 2003, 5). The various aspects of the country's water towers have been analysed and presented by Asola (2003).

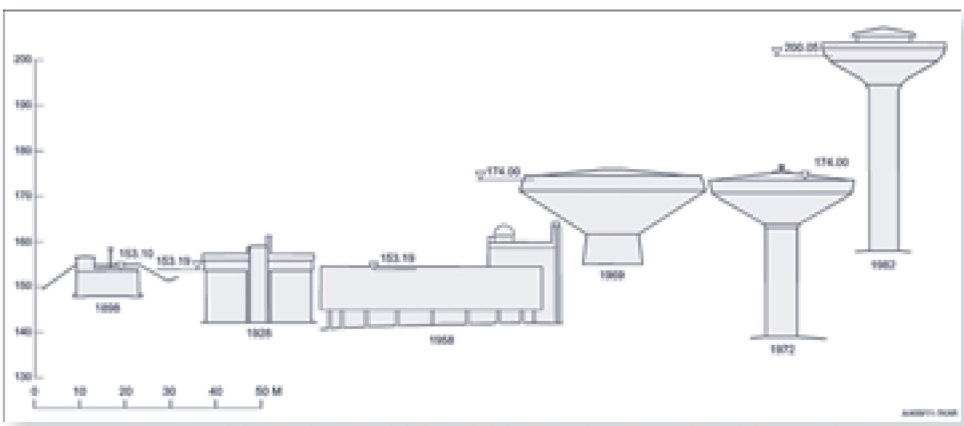


Fig. 4.5 Silhouettes of elevated water reservoirs and towers in Tampere with their year of completion: from left: the "cellar" of Pyynikki ridge from 1898, old "crown" of Kauppi from 1928, new "ice-hockey puck" of Kauppi from 1958, "Gomphidius glutinosus" mushroom of Tesoma from 1969, "Rozites caperata" mushroom of Peltolammi from 1972, and "Tricholoma virgatum" mushroom of Hervanta from 1982 (Juuti & Katko 1998, 164).

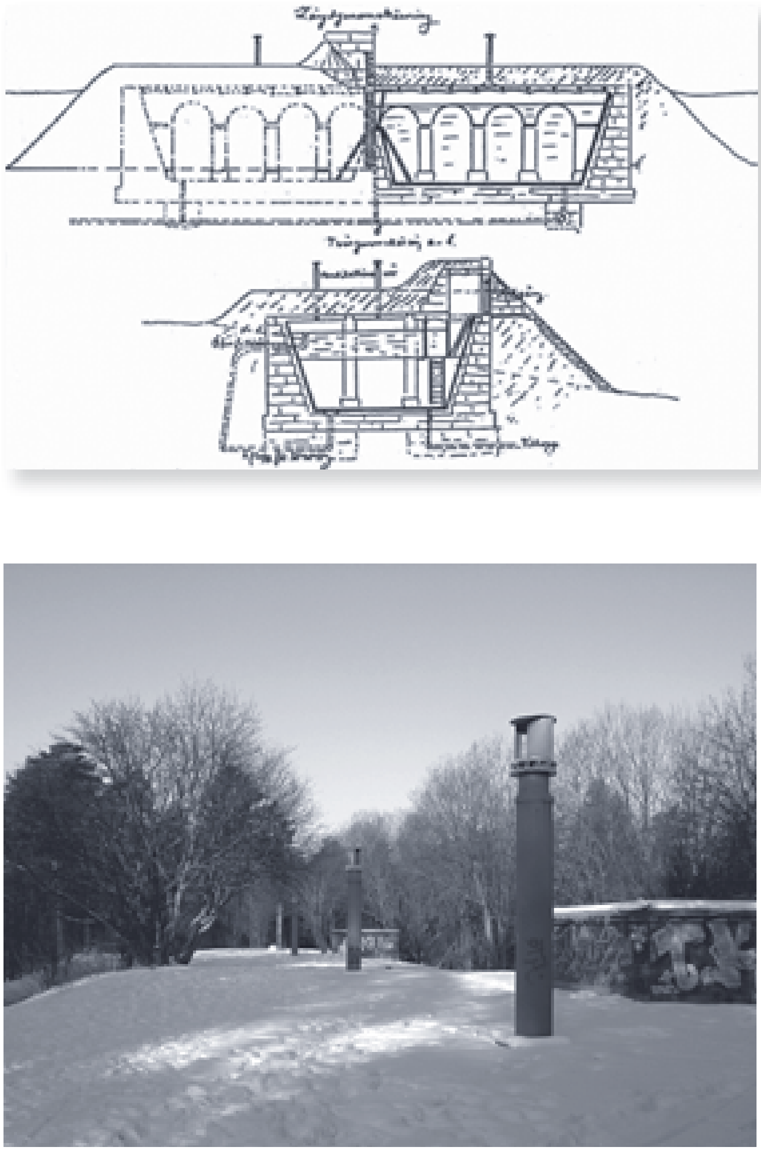


Fig. 4.6 Cross-section of the underground water reservoir in the Pyynikinharju esker taken into use in 1898 (upper: Brandt 1899), and the same facility over 100 years later (Photo: T. Katko).

Fig. 4.7 The first mushroom-shaped water tower of Tesoma in the western part of the city, completed in 1969 (Photo: T. Katko).

Nearby or more distant water sources?

At the turn of the 1960s, the quality problems with raw water caused by forest industry pollution along Lake Näsijärvi, upstream of the rapids, became issues of top priority (Fig. 1.1). Lake Roine, situated in a neighbouring municipality to the east, became the new source of raw water in 1972. It constituted at the time one of the best raw water basins in the country. The estimated radical increase in the amount of water needed (Fig. 4.8) particularly influenced this selection of a more distant source. Ground water had been taken into use gradually since the 1950s (Fig. 4.9), but even in 2005 its share was not more than one third of the total.

Evolution of water treatment

Since the suggested slow sand filters were never built, water treatment started in Tampere in 1928 at the surface treatment plant of Kaupinoja on Lake Näsijärvi where chlorine gas was used for purification. A new plant was built in 1931 next to the first pumping station dating to 1835 and the intake of the low-pressure system dating to 1882. Chemical treatment was introduced there in 1934 and at the Kaupinoja plant one year later in the form of flocculation, sedimentation and rapid sand filtration. As stated above, in the mid-1960s it was decided to take raw water from Lake Roine west of Tampere and pump it to Rusko, just within the city limits, and further towards the city centre through a Swedish-made concrete and steel pipeline 800 mm in diameter.

The early water treatment process in Rusko was quite conventional chemical treatment with gravity sedimentation and a flow rate of about one metre per hour (m^3/m^2) (Juuti & Katko 1998; 223, 225). After development and pilot test runs in 2000, a new full-scale dissolved air flotation dissolved air flotation (DAF) application with turbulent flow regime was constructed (Fig. 4.10). In 2005 the average hydraulic loading was 17–18 m^3/m^2 x h, i.e. some 20-fold compared to the old gravity based system. Flow rates as high as 29 metres per hour have been reached, the capacity of subsequent rapid sand filters being the limiting factor (Haume 2006, Jokela 2006). The flotation basins are flushed every fifth hour for three minutes. The DAF technology has proved to be applicable especially to cold climates, Finland being one of the pioneers of this technology. An international conference on flotation

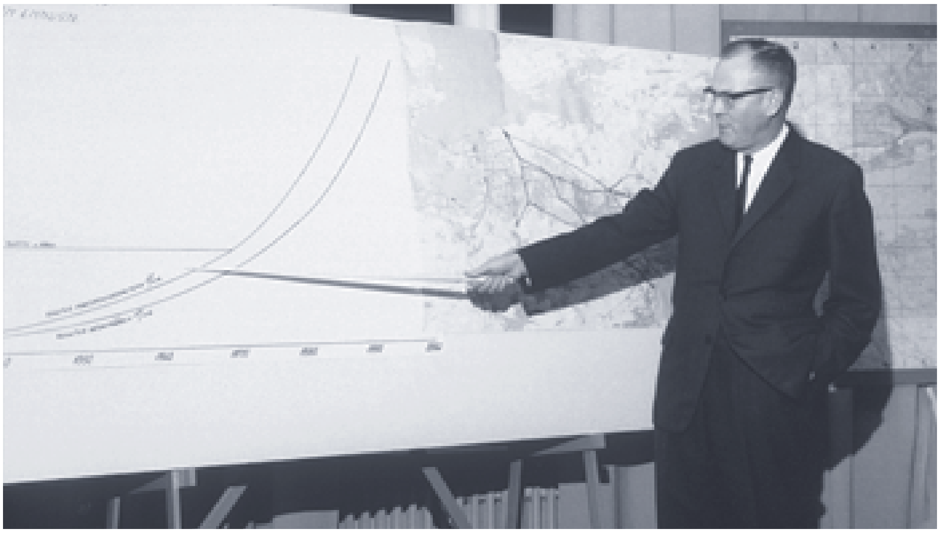


Fig. 4.8 Mr. Matti Murto, managing director of Tampere Water in 1952-77, presenting the sky-rocketing water demand estimate made in the mid-1960s (Photo: Photo Archives of Tampere Museums).

.

Fig. 4.9 Series of tube wells under construction in Julkujärvi, west of Tampere, in the late 1970s (Photo: J. Koskinen).

Fig. 4.10 Ms. Terttu Mäkinen, the operational manager at the Rusko surface water treatment plant in 2007 (Photo: T. Katko).

in water and wastewater treatment was organized in Helsinki in September 2000 (FIWA & EWA 2000), including 60 visitors from some 25 countries to see the plant in Tampere.

Although Lake Roine and the treatment plant in Rusko are the major surface water plants, Tampere Water also runs two smaller treatment plants in the northern region of Teisko. The old treatment plant in Kaupinoja is also kept in running condition in case it might be needed.

Since it started operating in 1972, the Rusko water treatment plant has had a water quality laboratory equipped with modern analysis methods like the TOC analysis introduced in 1995 (Juuti & Katko 1998, 179-1809). In 2005 the laboratory analysed some 3 900 samples (Tampere Water 2005). Along with the treatment of raw water, it has played an important role monitoring water quality in the network. In the 1970s and ´80s the water works had problems in certain areas with excess manganese. It tended to accumulate in the pipeline and cause quality problems. One means of avoiding such deposits was to flush the networks regularly by night (Leinonen 2006, Fig. 4.11).

Fig. 4.11 Flushing of water network during a summer night 1986 (Photo: Tampere Water).

5. From polluted to clean bathing waters

Should wastewaters be treated or not?

The typhoid epidemics of the early 1900s and the "dirty water" produced by households and industry led local decision makers to examine the possibility of treating wastewaters or conveying them further away. At that time it was considered economically too expensive to treat wastewaters: it was assumed that the Tammerkoski Rapids could purify them sufficiently. It was even believed that wastewaters from industries could be useful in eliminating typhus and would thus improve the health situation (Juuti 2001). The matter was taken up again only in the 1950s and the first wastewater treatment plant was completed in 1962 in Rahola, a western suburb of the city. From the very beginning this treatment plant had biological treatment with activated sludge and had also a digestor for sludge treatment. In the Finnish context such a plant was one of the earliest taken into use. Later the plant was expanded, and since 1977 chemical treatment introduced. (Juuti & Katko 1998, 195-199)

Wastewater treatment was considered in the 1920s but found infeasible due to the high costs and relatively small benefits. In 1954 a general plan on sewerage systems and tentative locations of wastewater treatment plants was completed. It also introduced separate sewers which, in practice, paved the way for sewage treatment. At that stage certain core areas of the city still retained their combined systems, but their share gradually decreased (Juuti & Katko 1998, 193-195).

Since 1972 the wastewaters of the central and eastern parts of Tampere have been led to the Viinikanlahti treatment plant (Fig. 5.3) on Lake Pyhäjärvi downstream from the city. The plant is the largest environmental investment the city has ever made. It lies on top of what used to be waste masses and due to changes in land use is being encroached upon by the expanding core of the city. The Pyynikki traverse ridge divides the city into two natural sewerage systems which originally depended merely on gravity, but later introduced also pumping.

Fig. 5.1 Construction of water pipe and sewer mains under the Tammerkoski rapids in summer 1973 (Photo: Tampere Water).

The construction of the Viinikanlahti wastewater treatment plant required connecting sewers - that had earlier discharged wastewaters directly into the Tammerkoski Rapids - to the treatment plant as well as building other trunk sewers (Fig. 5.1). Since those days, the first year students at Tampere University of Technology have been dipped ceremoniously in the almost ice-cold water of the rapids on Mayday with a sizable group watching the happening (Fig. 5.2). In 1973 the first author of the book experienced his cold dip without any major risk to his health, since the sewers discharging straight into the river had already been connected to the sewage treatment plant.

As the city has grown and land use has changed, the site of Viinikanlahti treatment plant has become surrounded by high-rise offices and related premises (Fig. 5.3). This is also one argument behind a proposal that this and the other wastewater treatment plant in Rahola should be replaced by a bigger central plant underground. Interestingly enough, when the general plan for the water supply and sewerage of the city in 1954 was being prepared, only Messrs. Makkonen and Virtanen from the YIT company raised the argument that the Viinikanlahti site is too close to the expanding city and that the plant should therefore be located downstream. In 1997 the same issue was raised in newspaper headlines which put it back on the agenda (Juuti & Katko 1998, 195).

When Tampere Water held its 100th anniversary in 1998, an old Archimedes screw pump that had been used at the Viinikanlahti wastewater treatment plant was turned into a statue in recognition of this indeed ancient, but still modern, technology that is still in use at many wastewater treatment plants (Fig. 5.4). At Viinikanlahti these pumps convey incoming raw sewage to a higher level from where it flows by gravity through the treatment process.

The Viinikanlahti wastewater treatment plant started with mechanical treatment in 1972 and was upgraded with chemical precipitation in 1976. Biological-chemical treatment based on simultaneous precipitation was taken into use in 1982 (Juuti & Katko 1998, 205) while the biological part and the pre-treatment were renovated and expanded in 2003. The current treatment requirements set by the Environmental Permit Authority for this plant are as follows: less than 15 mg/l of BOD (biological oxygen demand) in the

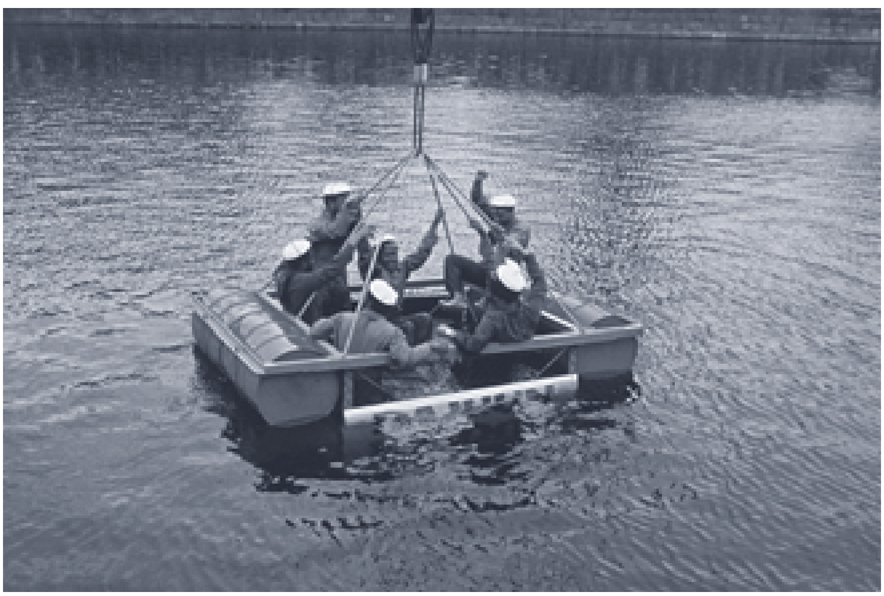


Fig. 5.2 “Mayday dip” into the Tammerkoski Rapids in 1980 involving water engineering MSc students from East Africa (Photo: T. Katko).

Fig. 5.3 Viinikanlahti wastewater treatment plant with the city in the background in 2004 (Photo: T. Katko).

Fig. 5.4 Archimedes screw pump –- one of the most ancient water technologies still in use at Viinikanlahti wastewater treatment plant. The pictured one is no longer in use but has commemorated the 100th anniversary of the works since 1998 (Photo: T. Katko).

outlet, under 0,6 mg/l for phosphorus and under 4,0 mg/l for ammonia-nitrogen (Table 3). Tampere Water has set its own and tighter objectives while the average treatment results are remarkably better – reaching 98 percent for BOD and 96 for phosphorus (Tampere Water 2005).

Table 3. Average treatment results and related requirements at the Viinikanlahti wastewater treatment plant in 2005 including the overflows (Tampere Water 2005).

Viinikanlahti wastewater treatment plant	Treatment results		Treatment requirements	
	mg/l (outlet)	Reduction %	mg/l (outlet)	Reduction %
BOD_7	4.1	98	<15	>92
P	0.31	96	<0.6	>92
NH_4-N	0.39		<4.0	
Rate of nitrification		99		>90

As for sludge treatment, the methane gas from two anaerobic digesters is utilised for electricity and heating purposes. In 2005 the rate of self-sufficiency was 44 percent regarding electricity and 75 percent regarding heating energy. (Jokela 2006) Some 23 thousand tons of digestion- treated and dried sludge is produced annually and composted before taking to fields or other purposes. (Tampere Water 2006)

In 2006 Tampere had 37 beaches where water quality is monitored during the swimming season. The microbiological water quality at the beaches has usually been good (City of Tampere 2006b). Another sign of clearly improved water quality in the lakes is the fact that since 1998 it has been possible to catch crayfish from Lake Pyhäjärvi, downstream of the city (Juuti & Katko 1998, 207). With a special permit one can also fish for salmon along the Tammerkoski rapids in the city centre.

6. Industrial connection

The factories on the banks of Tammerkoski Rapids, representing the textile, leather and wood processing industries, had their own water intake plants and sewers by the rapids from early on. The Finlayson textile mill (Fig. 2.1 and 6.1 upper) had a water reservoir for sprinklers on top of the 6-storey building. Below the reservoir there was a dry toilet on each floor from where the faeces dropped down a shaft for transportation to agricultural fields. In 1959 the factory started to treat water taken from Lake Näsijärvi, and in 1967 one of the earliest applications of flotation was introduced (Juuti & Katko 1998, 245).

Tampella Ltd. (Fig. 6.1 lower) was engaged in three major fields: it had a large linen factory – the only one in Finland – a machinery works and a wood processing plant. It imported linen from the former Soviet Union and Belgium. The factory curtailed its production and finally ended its operations when artificial fibres came and conquered the markets (Silander 2006). The company took its raw water from Lake Näsijärvi and also had a sprinkler system already in 1899. In 1903 Tampella connected its fire fighting network to the city's network. During World War II Tampella was the major heavy industry enterprise in Finland and was later heavily involved in the production for war reparations. In 1961, as the waters of Lake Näsijärvi had become deteriorated, the factory started to treat its water, and in the 1980s its system was connected to the city's (Juuti & Katko 1998, 247-249).

When water pollution control became topical, enterprises started to clean their effluents and gradually also to lead them to the city's wastewater treatment plant. But only after heated debate. The city, for its part, was able to postpone treatment of its wastewaters by pleading the fact that industries were much bigger polluters and should thus start treatment first (Katko, Luonsi & Juuti 2005). Industry also underwent a major structural change in the 1980s which further reduced the wastewater load.

Since 1972 the Tako board mill (Fig. 6.2) at the southern end of Tammerkoski Rapids has led its sanitary wastewaters to Viinikanlahti treatment plant, and since the 1990s a remarkable share of its process wastewaters (Juuti & Katko 1998, 250-251). Due to their higher temperature, the latter facilitate treatment especially in wintertime.

Fig. 6.1 The best known traditional industries in Tampere also in relation to water history: The six-storey industrial building of Finlayson with its originally combined water reservoir and dry toilets (upper), and the Tampella factories with a water reservoir hidden behind the sign (Photos: T. Katko).

Fig. 6.2 The Tako board mill the only large industrial plant still in operation in the city center of Tampere (Photo: T. Katko)

7. From a supply- to demand-driven approach

Water consumption and customers

The average per capita water consumption of the 14 Finnish urban water works was about 45 litres per day in 1915. Except for the war period (1939-44), per capita consumption increased in the Finnish cities of Helsinki, Tampere and Turku continuously until 1974 (Fig. 7.1). The highest value of 355 litres was reached in Tampere in 1977. In Stockholm, Sweden, the respective value was about 500 litres at its highest in the mid-1970s. Since then, per capita consumption has decreased more or less continuously in each city (Katko 1997, 45). These figures show the total amount of water consumed divided by the number of people in a city. In Helsinki, Stockholm and Tampere the water companies sell remarkable amounts of water to their neighbours – thus the real figures are lower. The data for Turku is based on the billed amount of water which explains the lower figures there. In any

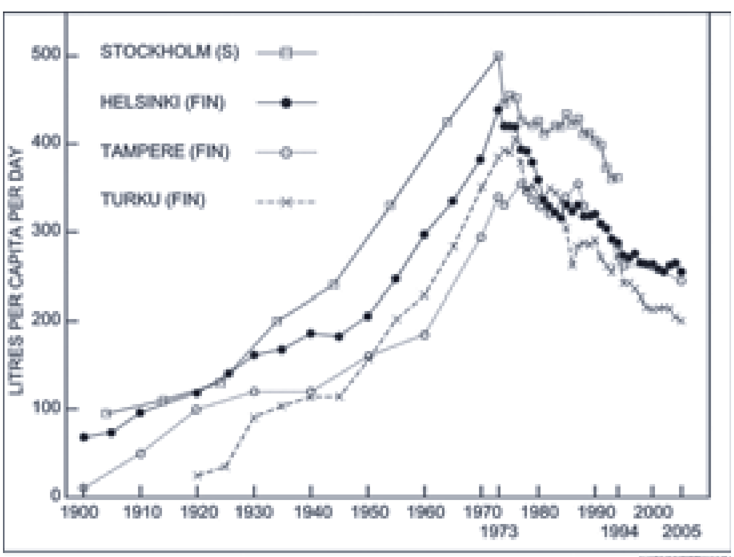


Fig. 7.1 Specific water consumption in Helsinki, Tampere, Turku and Stockholm (Sweden) in 1900-2005 (Katko 1997, Kuivamäki 2006, Nordman 2006, Pirinen 2006, Westman 2006).

case, the development has clearly been towards a demand- rather than a supply-driven approach.

There are several reasons for this decrease. In addition to the energy crisis in the early 1970s, the Wastewater Surcharge Act came into force in 1974 and at once more than doubled the average water bill. Water companies started to conduct systematic leakage surveys and improve the oldest networks. More accurate water meters were also introduced. Particularly in flats, the typical bath-tubs were replaced by showers while better water fixtures such as single-handle mixers were also introduced. Property maintenance companies also reacted promptly when water consumption was exceptionally high. It is obvious that consumers react the more strongly, the better they understand their billing (Katko 1997, 45; Rajala & Katko 2004). Thus, it really pays to charge properly for water while making sure that it is affordable. More recently meters have been installed by real estate companies in individual dwellings of apartment blocks and row-houses that earlier used one master meter.

The development of pipe materials and leakage control systems has also affected overall consumption rates. The older networks consisted of cast iron pipes, while in the 1930s and ´40s water works installed also German-made Mannesmann steel pipes. The latter proved problematic, caused leakages and were rehabilitated between the 1970s and the 1990s. (Leinonen 2006; Juuti & Katko 1998, 136)

In the 1970s SG cast iron pipes, manufactured in Finland at that time, were taken into use (Fig. 7.2). More recently the larger size main pipes laid under streets have been of SG cast iron, imported from Europe. However, plastic pipes, of PVC and especially the smaller PEH pipes for house connections, are made in Finland. (Leinonen 2006) A biggest share of water pipe breakdowns and leakages – annually some 50 to 80 in the actual network excluding house connections - occur normally during the winter months of December to February, while the lowest in the summer months of June to August (Pulli 2006).

As for sewers, the first combined sewage systems were of hand-made brick, but concrete pipes have been used since. In Tampere the latter have been used relatively more than in other Finnish cities due, for instance, to the local manufacture of concrete pipes by a city-owned company. Plastic sewer pipes have been used increasingly in more recent times. Yet, since 2005 a modern version of the old oval concrete sewer pipe was introduced (Fig. 7.3). It has been known for long that the oval shape is better for self-

Fig. 7.2 Mr. Pauli Sirén fetching T-pipes of SG cast iron around 1970.

Fig. 7.3 Installation of prefabricated concrete gravity sewer of oval shape in the suburb of Hervanta, Tampere in December 2006 (Photo: T. Katko).

cleansing sewers (Heilä 2006) – a feature that was made use of in the first sewers of the city in the 1890s.

Over the last decades systematic leakage control programmes on sewers and network rehabilitation programmes have been carried out. These activities have clearly reduced the peak flows in stormwater sewers during rainfall and snow-melting periods. They have also reduced leakages in actual wastewater sewers, leading to more concentrated wastewaters. Concrete sewers have been rehabilitated by sliplining them with PEH pipes or flexible liner material (Leinonen 2006). The principle is to use no-dig methods wherever and whenever possible.

The system in 2005

In 2005 the water supply system of Tampere had over 720 km of pipeline and about 17,440 connections. The water supply system had six high-level storage tanks with a combined capacity of about 23 000 cubic metres or less than half the average daily consumption. In addition, there were ten booster pump stations. About 20 percent of the water supply network was plastic while in the case of new piping the figure is over 50 percent. In 2005 Tampere Water was responsible for the water supply of over 200 000 and the sewage treatment of some 250 000 inhabitants in the Pirkanmaa Region (Tampere Water 2005).

The total length of the city's sewerage system was about 1,200 km, of which 650 km consisted of wastewater sewers, 50 km of combined sewers, and 500 km of storm sewers. There were still some tens of kilometres of combined sewers in the city centre, while their relative share has declined continuously. The rest of the system consisted of separate sewers. Sewers as well as water pipes have been increasingly rehabilitated and modernized. In 2005 the sewerage system had a total of 72 wastewater pumping stations that are monitored from a central control room. (Rasi 2006) The operations of Tampere Water comply with the ISO 14001 Environmental Management Standard (Tampere Water 2006).

Tampere Water operates as a municipal public utility under a managing director who is assisted by a management group. It has a total of about 155 employees, increasingly female, even in traditionally male-dominated tasks (Fig. 7.4).

Fig. 7.4 Ms Sirpa Lindholm, an electrician at Tampere Water.

8. Institutional arrangements and reforms

As for institutional and management issues, the utility has developed as part of society: it has had, and continues to have, an impact on technology as well as health and industrial and commercial activity. The development of the utility has required versatile institutional development: education, research and cooperation with business, political decision makers and the actual owners, the inhabitants. In many respects urban water supply, sewerage and solid waste treatment were treated as a single issue in the 1800s, in the early phases of their development. Over time they became separated while more recently convergence has occured. (Katko & Nygård 2000)

Integration of water and sewerage services

In Finland, as in other Nordic countries, most urban water supply and sewerage systems became formally integrated under one utility in the 1970s – something that was placed on the international water policy agenda in the late 1990s, while still not adopted by many countries. In Tampere it happened in 1981 after some organisational rearrangements in 1978-81 (Tampere City Water and Wastewater Works, 1977-81). It is obvious that water supply and sewerage systems form a natural integrated cycle. Yet, integration can also be guaranteed by various forms of cooperation rather than formal structures. Besides, especially in the case of inter-municipal systems, such as those planned for Tampere region, the demand and conditions for water supply and sewerage by the parties often differ. However, some within the sector have also voiced their concern that the prevention of any hygienic problems would require that these services are not cross-managed by the same persons. In any case, a joint public utility forces people on both sides to think about the impacts of certain actions on the other party.

During the writing of this, there is a national debate in Finland about how stormwater management should be arranged. Some argue that it should be part of street maintenance activities and funded accordingly, while others think that water and sewage utilities, like Tampere Water, would be the natural entity to take care of it, assuming it has the funds for it.

Another clear trend in terms of operations has been the relative increase of utility autonomy. Earlier quite small issues were taken to the committees or boards of the water and sewerage works while in the early 21st century the utility has had much autonomy in operational matters. This trend would seem to allow decision makers and elected local government representatives to concentrate on bigger policy issues and principles.

Overall institutional framework for water services in Finland

Fig. 8.1 illustrates the current administrative water services framework in Finland at three levels: central, regional and local. Water resources management at the central (state) level is the responsibility of the Ministry of Agriculture and Forestry (MAF) and the Ministry of the Environment (MOE). These ministries are in charge of water and environmental policy and strategy development, and legislation. Under these ministries operates the Finnish Environment Institute (FEI) as a national advisory body (Hukka & Seppälä 2004).

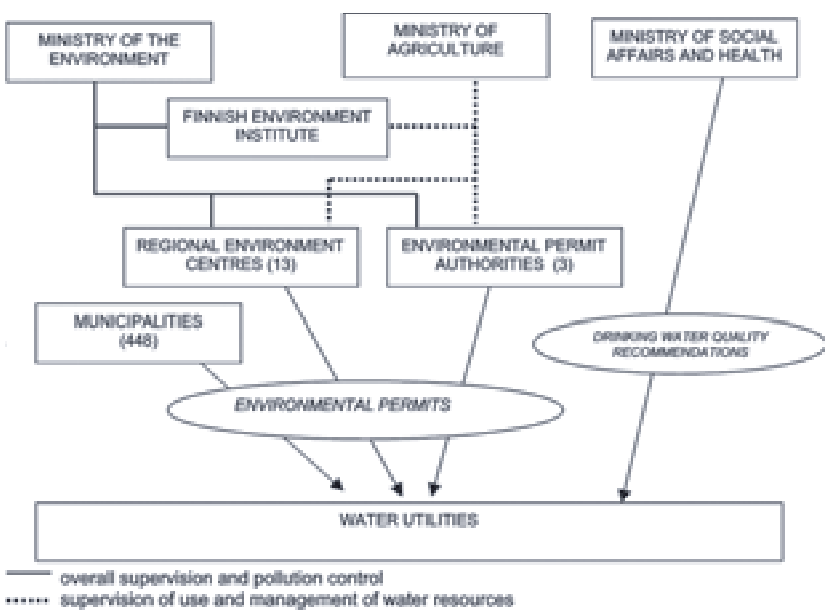


Figure 8.1 Central-, regional- and local level water administration in Finland (Pietilä & Spokas 2004).

Other national level key authorities with regard to water services are the Ministry of Social Affairs and Health (MOSAH) and the Ministry of Trade and Industry (MTI). At the regional level, water and sewerage undertakings are regulated and monitored by the 13 regional environment centres which also are responsible for regional planning, monitoring and guidance in water issues within their area.

At the local level, municipalities (431 as of 1 January 2006) are responsible for the provision, i.e. overall development and organising, of water and sewerage services in their jurisdiction in accordance with the Water Services Act, enacted in 2001. The water and sewerage undertakings (approx. 2000, including both water undertakings and sewerage undertakings) are responsible for the production of water services, i.e. construction of the water infrastructure and its operation and maintenance (operational management). The water and sewerage undertakings are also responsible for the collection and conveyance of storm water and drainage water from the building foundations. The undertakings are monitored and controlled by the municipal health protection and environment protection authorities, and by the regional environment centre.

Buying works, goods and services from the private sector

In Finland, and certainly also in Tampere, there is a long tradition of water and sewage utilities buying private sector services. Figure 8.2 shows a rough estimate of the share of annual money flows that have finally benefitted either the public or the private sector as payment for works, goods and services. For most of the period since the late 1700s till 2000, the city boards or utilities in charge of water and sanitation services have bought a large share of their goods and services from the private sector or other city departments. Only from around 1918 to 1949, due to the two world wars, the share of bought services remained low which is explained by the relatively low investment rate at that time. Yet, some of the figures may contain services bought from other city departments (Juuti 2004; Juuti & Katko 2005, 71). These services most often include design and planning by consulting companies, construction activities by private contractors, equipment from suppliers, and research by research institutions and universities.

From the strategic point of view of the utility, and obviously the owner, the city and the local government, it is important that outsourcing of services is managed in a way that guarantees real competition. In the case of bigger contracts, tenders are to be invited according to the legislation. It is important that the utility keeps the core competence in its own hands while outsourcing is more applicable to non-core operations.

Fig.8.2 Estimated moneyflows to public and private sector (Juuti & Katko 2005, 71).

9. From local to inter-municipal and international cooperation

Cooperatives

The peripheries of cities relied for long on wells and latrines. Sections of surrounding municipalities have often been incorporated into the cities over the years. Finland's first official consumer-managed water cooperative was founded in Pispala in 1907. The community was part of a neighbouring western municipality at that time, and was incorporated into Tampere in 1937. The city water works assumed control of that particular system in the 1960s. Two built-up areas of the Teisko-Aitolahti rural district (Fig. 1), which nowadays is part of Tampere, have water supply and sewerage systems run by the city. In other sparsely populated areas water supply and sewerage will continue to be provided through cooperatives or by individual property owners themselves (Juuti & Katko 1998, 74-87).

Fig. 9.1 Construction of water pipeline by Pispala water cooperative (Photo: P. Wilén).

In his last poem called "Happiness", published the day he passed away, Lauri Viita describes the summers of his childhood in Pispala in the 1920s, referring also to the water service of the day as follows (Laitinen 2006):

> *"Narrow path from well to door / overgrown with grass. /*
> *In front of window / withered apple tree. /*
> *Rucksack hanging by the door / with a bird's nest inside. /*
> *When I'm dead and gone. / Summer goes on. Sweet summer."*
> *(Translated by J. Tiainen)*

In Messukylä rural municipality, east of Tampere, a small partnership, informal water cooperative was founded in 1928. A more formal water cooperative for the central village was established in 1937. Ten years later, after WW II, Messukylä became merged with Tampere. The city expanded its water and sewage network to Messukylä, and in 1954 the water cooperative started to distribute the water that it bought from the city network until 1960 when the city waterworks took over its operations (Juuti & Katko 1998, 86-87). More recently, in the 1990s, Tampere Water was involved in the establishment of two water cooperatives of Sisaruspohja and Nurmi, in the Northern part of the city in Teisko area (Juuti & Katko 1998, 264; Heinonen 2006). The projects were supported also by the EU Life programme.

Inter-municipal cooperation

Bilateral cooperation with the neighbouring municipalities started in 1965 when Tampere started to sell water to Pirkkala municipality (Juuti & Katko 1998, 254) while cooperation with neighbours was further developed in the 1970s. In 2005 water was sold or wastewater received and treated, based on contracts (Fig. 9.2) between Tampere and Pirkkala, Nokia[1], Lempäälä, Kangasala, and Ylöjärvi.

Since 1980 wastewaters have been led from Kangasala municipality to the Viinikanlahti wastewater treatment plant in Tampere (Fig. 5.3) based on bilateral agreement. The main raw water source of Lake Roine, and the water intake are within the boundaries of Kangasala, though constructed by

1 birthplace and original domicile of Nokia Ltd.

Tampere alone. In the mid-1990s a submerged trunk sewer, of polyethylene plastic pipe welded on the lake ice (Fig. 9.3), was constructed from Pirkkala municipality south of Tampere to Rahola wastewater treatment plant in western Tampere. The availability of submerged plastic PE pipes has promoted inter-municipal cooperation in a country with numerous lakes.

After many intermediate phases, the general plan of water acquisition for the municipalities in the Tampere and Valkeakoski Region was finalized in 1993. A bulk water supply joint-stock company, Tavase Ltd, was established by the municipalities (Tampere, Valkeakoski, Kangasala, Sahalahti, Lempäälä, Toijala, Vesilahti, Viiala, and Kylmäkoski) during May-December 2002, and the constitutive meeting was held on December 5, 2002. The environmental impact assessment (EIA) process for the artificial groundwater recharge project was carried out in 2001-2003, and the required corresponding water and environmental permits for the artificial groundwater recharge plant were submitted to Western Finland Environmental Permit Authority

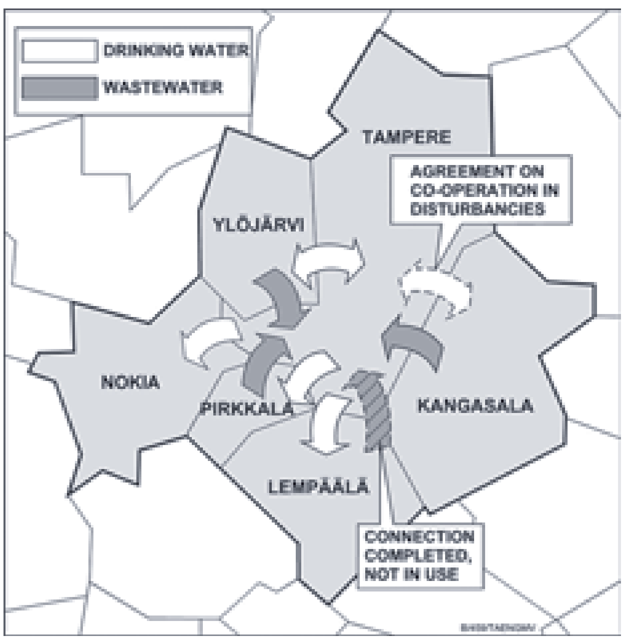


Fig.9.2. Bilateral cooperation in selling water and receiving wastewaters with neighbouring municipalities of Tampere in 2005.

Fig.9.3. Construction of a submerged pressure sewer of PEH on the ice of Lake Pyhäjärvi for bringing wastewaters from Pirkkala municipality to Rahola wastewater treatment plant in Tampere in late winter of 1995 (Photo: Tampere Water).

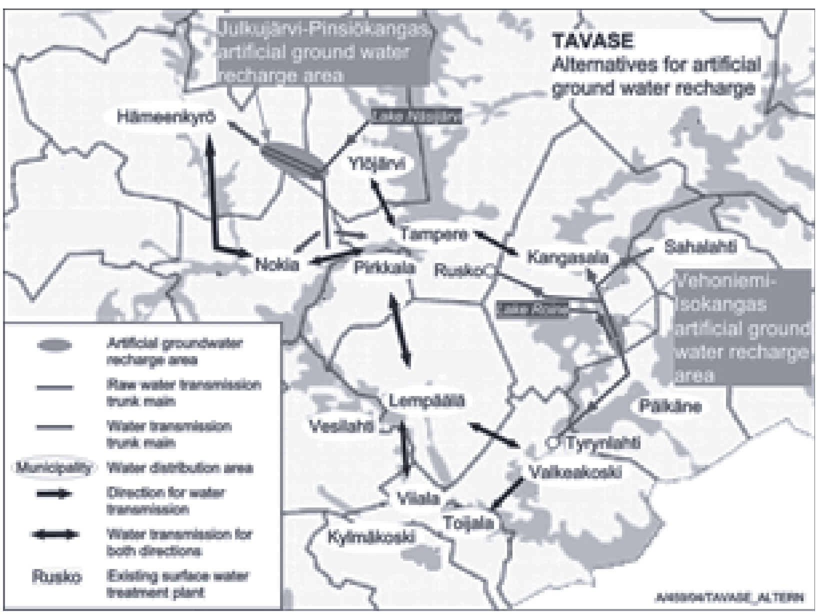


Fig. 9.4 Tavase Ltd, regional wholesale company is planning to use artificial recharge in Vehoniemi-Isokangas area in the south-eastern part of the area. Julkujärvi-Pinsiönkangas area in the north-western part is planned to be taken to use later as an option.

in 2003. (Hukka & Seppälä 2005) The planned regional bulk water system based on artificial recharge is shown in Figure 9.4. The plan is that by the early 2010s the water supply is based entirely on groundwater.

Regional wastewater treatment plant of the future?

The Pirkanmaa regional development plan for water and sewerage services was published in 2005 (PREC 2006). It is based on the Water Services Act (2001) and was produced in cooperation between regional authorities and municipalities. The plan proposed that wastewater treatment should be improved and concentrated in bigger units and that a central wastewater treatment plant be constructed underground in bedrock. A joint consultancy report (Kaleva, Meriluoto, Salmelainen & Taskinen 2006) proposed four major options for the location of this central wastewater treatment plant: (i). Saukonvuori on the border between Pirkkala and Tampere, (ii) an area north of Pirkkala airport, (iii) Koukkujärvi in Nokia, and (iv) the Melo area in Nokia. In the case of each optional location, alternative discharge points for treated effluent were also presented. (Kaleva et al. 2006, 7) By spring 2006 the Saukonvuori option near the airport was found unfeasible, leaving three options for further exploration (Jokela 2006). At the time of writing, discussion on the most feasible location continues.

Research and education cooperation

Over the years Tampere Water has cooperated especially with Tampere University of Technology. The university was established in 1967 and has had a chair in water engineering since 1975. Over the years Tampere Water has also funded various types of research and development projects – often in collaboration with other cities, institutions and bodies. These have included, among others Finnish Forest Research Institute, Geological Survey of Finland, Helsinki University of Technology, National Public Health Institute, Technical Research Centre of Finland, University of Tampere, and various consulting companies. The projects have helped in finding solutions to local conditions, planning and design of treatment systems, or provided new knowledge in required areas including the history of the water undertaker.

Figs. 9.5 depict small scale and pilot scale studies on microbiological aspects of organic matter removal in artificial groundwater recharge. The util-

Fig. 9.5 Small and pilot scale experiments at Rusko water treatment plant in 2006, Reija Kolehmainen on the right (Photo: T. Katko).

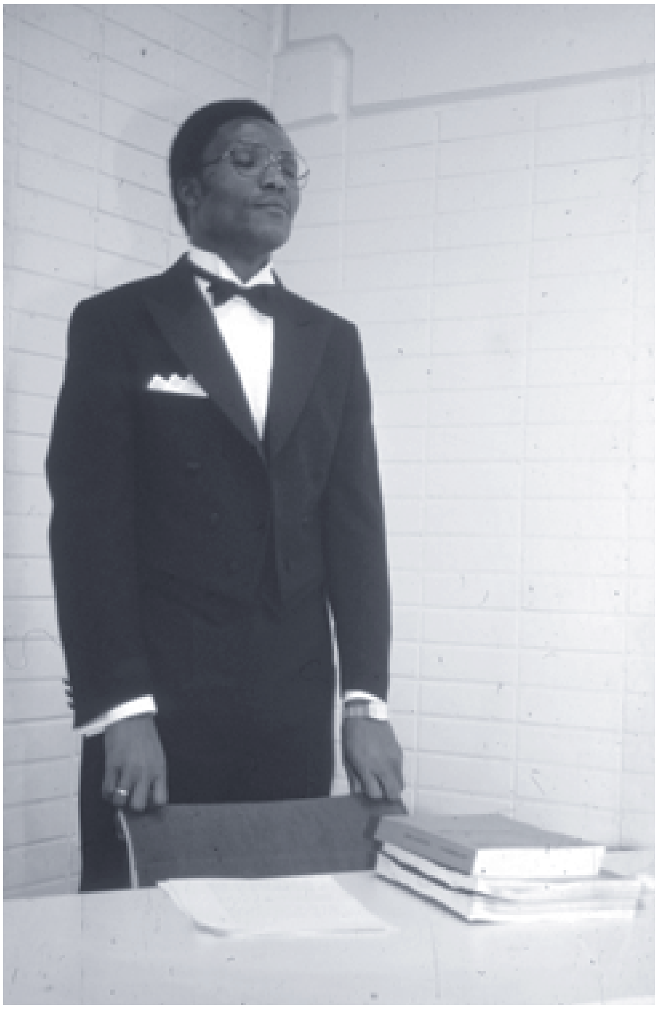


Fig. 9.6 Public defense of doctoral dissertation by P. Odira from Kenya in 1985 at TUT, based on research cooperation with Tampere Water (Photo: T. Katko).

ity has also taken part in several joint research projects with water companies of other cities and research institutions. For instance, the attachment and growth of bacterial cells on the solid-liquid interfaces of a distribution network, resulting in the formation of biofilms and biological deposits, has been explored by full scale monitoring (Vuoriranta et al. 2006). Accumulation of biofilm-derived biomass and organic material may have consequences for water quality and the service life of the distribution network.

In addition to research, Tampere Water has also been involved in water and environmental engineering education at Tampere University of Technology. The cooperation has involved especially guest and even more permanent lecturing by water utility staff and site visits by students to the facilities of Tampere Water.

Since the early 1980s TUT has conducted a Doctoral Programme for Developing Countries on an individual basis, a Postgraduate Course in Water and Environmental Management in 1992-98 especially for the needs of the Baltic region, a Postgraduate Programme in Water Supply and Sanitation in 1979-1992 for the East African countries, and a B.Sc. Programme in Civil Engineering for Namibian students in 1989-1992. Tampere Water was involved in all of them in one form or another (Fig. 9.6). Furthermore, Tampere Water has also engaged in educational cooperation with Tampere Polytechnic over the years.

Fig. 9.7 Signing of twinning agreement in Daugavpils, Latvia in 1996: Esko Haume (on left) former managing director of Tampere Water (1979-2003) and managing director Ivan Fedorov, Daugavpils (Tampere Water 1996).

Twinning cooperation

From 1996 to 2000 Tampere Water was involved in a twinning arrangement with the Daugavpils city water and sewage works in Latvia (Fig. 9.7), supported by the Ministry of the Environment in Finland, as part of the Baltic Sea protection programme. The works´ contribution during the four years of cooperation was equal to two person-years. This cooperation included several activities for capacity building: organisational development, improvement of accounting systems, developing operation and maintenance systems and practices, and exchange of staff members for on-site training in Daugavpils and Tampere. The experiences of the involved staff members of Tampere Water who were interviewed by the authors were quite positive. (Juuti & Katko 1998, 268)

10. Discussion and concluding remarks

Impacts of improved water and sewerage services

The utility has decisively improved the city's fire safety, hygiene and health conditions, and the quality of the city environment. It has also played a central role in enhancing the operating conditions of industry and commerce.

Due to an improper sewerage system and the lack of water treatment facilities, the typhus epidemics of 1908-09 and 1915-16, the latter being the more fatal one, killed altogether some 350 citizens – something that could have been prevented by better understanding and policy and a fairly small additional investment. Although cold winters have for their part reduced the risk of fatal diseases, and although the experiences are not necessarily applicable or transferable as such, this in any case reminds us of the wider current global challenges stated in the Human Development Report 2006: "Water and sanitation are among the most powerful preventative measures available to governments to reduce infectious disease. Investment in this area is to killer diseases, like diarrhoea, what immunisation is to measles – a lifesaver" (UNDP 2006, 6).

Since the early 1970 Tampere, and later also industries, expanded efforts on water pollution control although not necessarily always as national pioneers. Fig. 10.1 shows the continuous decline of phosphorus loading and content – the major nutrient in Finnish water bodies and lakes – since the late 1960s. The development has been so positive that the water of Lake Näsijärvi is now better than that of Lake Roine, which was assumed to be one of the purest sources in the 1960s. After point sources were brought under control, dispersed loadings, e.g. in Lake Roine, became the major problem - Lake Näsijärvi receives much fewer dispersed loadings.

Fig. 10.2a presents the total BOD loading in the Tampere region over a 30-year period showing the very high share of forest industries till the mid-1980s and subsequent rapid decline. The phosphorus loading (Fig. 10.2b) has declined continuously along with the development and expansion of municipal wastewater treatment.

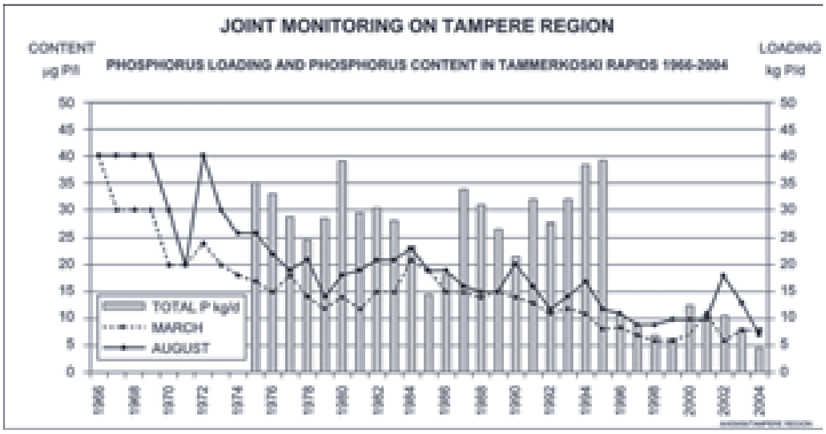
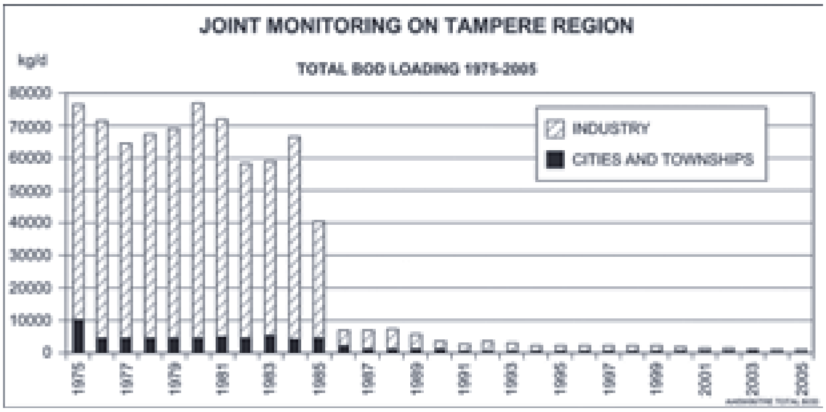


Fig. 10.1 Improved water quality indicated by phosphorus loading and content in Tammerkoski Rapids downstream of Lake Näsinjärvi (Water Pollution Control Association of Kokemäenjoki River 2006).

The impacts of improved water pollution control and declined loadings to water bodies can be seen in the improvement of surface water quality in the region from 1970 to 2000 (Fig. 10.3). The classification was focused on physical-chemical properties while the more current European parameters tend to focus on biological indicators. In any case, the development has been overwhelmingly positive and shows that proper policies, legislation, enforcement and actions by utilities and industries make positive changes possible. The rapid development has most probably been a surprise even to experts.

The City of Tampere has participated internationally in environmental activities. It is a member of ICLEI (Local Governments Implementing Sustainable Development) and Eurocities Environmental Forum. Tampere won the European Sustainable City Award in 1999. The city also participated in the Presud Project in 2002–2004 (Peer Review for European Sustainable Urban Development) where nine European cities jointly explored the possible ways of making progress towards sustainable development. The City of Tampere has actively developed its Environmental Management System and also actively benchmarks its environmental policy. (Anttonen 2006)



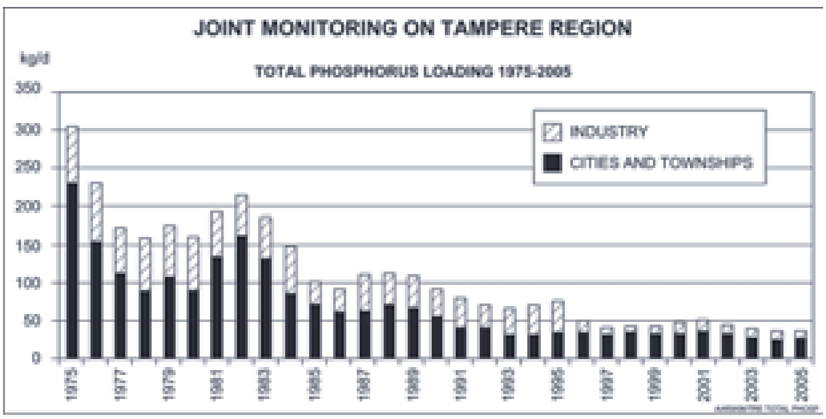


Fig. 10.2 Declining BOD (a) and phosphorus (b) loadings in Tampere region and its water bodies, 1975-2005 (Water Pollution Control Association of Kokemäenjoki River 2006).

Key strategic decisions

During the 170 years of attempting to provide better water supply, and somewhat shorter period of trying to control water pollution, Tampere City Water and Sewage Works – today Tampere Water for short – and the decisions makers in local government have made certain key strategic decisions that have affected especially the overall development of the systems and services. At the same time, some of them have, at least temporarily, closed out other development paths for decades to come.

Such key decisions identified in this study include the following:
(i) Public ownership and operational management of the city water and sewerage systems since 1866
(ii) Metering based billing for some consumers from the 1880s and for all since 1898, when the high pressure system especially for fire fighting needs was introduced
(iii) The introduction of water closets in connection with the high pressure system
(iv) The unfortunate attempt to save costs by abandoning the suggested slow sand filtration. That questionable savings combined with the wrong point of discharge of wastewaters in the end led to the loss of nearly 300 lives in the 1916 typhoid epidemic.
(v) The decision to introduce separate sewers in the early 1950s, followed by a gradual decrease in combined sewage systems, paved the way for sewage treatment.
(vi) The start of city wastewater treatment in 1962 that was gradually expanded and improved to a very high level, followed later by industrial wastewater treatment.

There has also been a continuous debate on whether to use ground or surface water. Ground water was abandoned in 1920, gradually re-introduced since the 1950s, and currently there are plans to serve the whole region through artificial recharge in the early 2010s. At the same time cooperation with neighbouring municipalities has expanded from bilateral and backup agreements to regional wholesale water supply and waste water treatment. It remains to be seen how far such systems can and will be expanded.

Key principles

In addition to the key strategic decisions, we can also identify some key operational principles that may be based on the above presented decisions or that have emerged otherwise. Firstly, since 1981 water and wastewater works have been merged and their services integrated – one of the practical solutions of the commonly emphasized Integrated Water Resources Management (IWRM) principle.

Secondly, from the very beginning public/private cooperation has been practiced: the core competence is kept within the municipality-owned util-

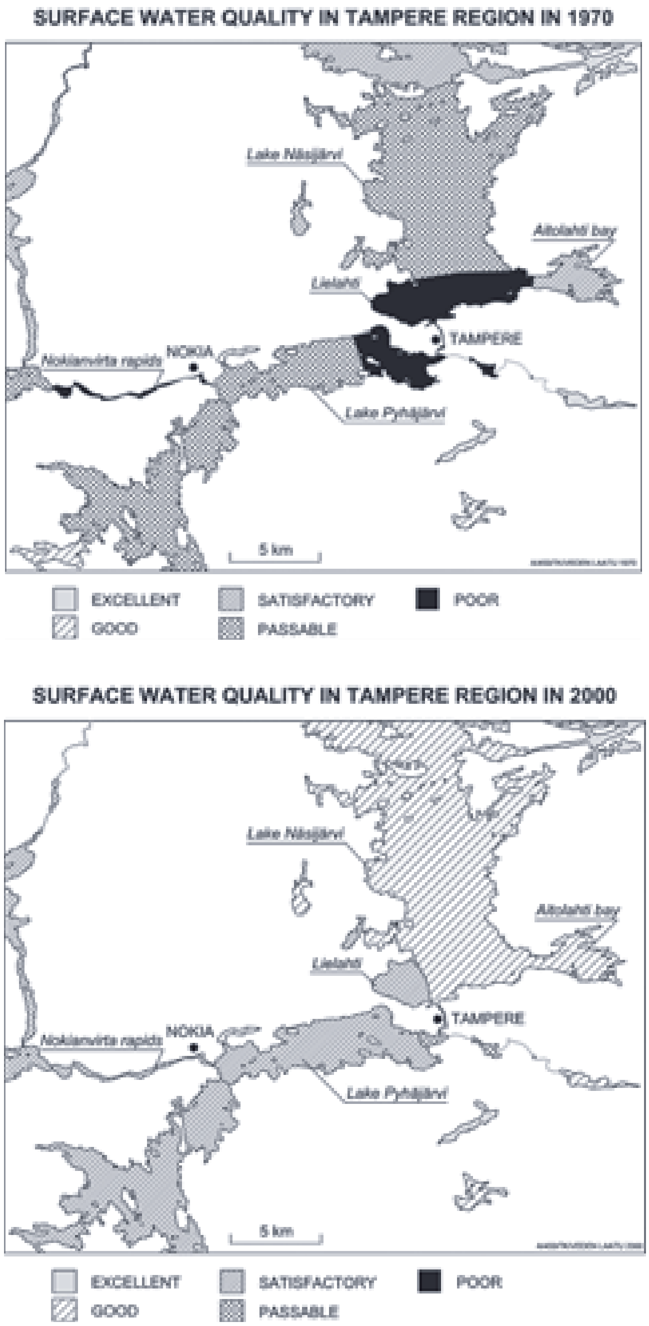


Fig. 10.3 Improvement of surface water quality in Tampere region, from 1970 to 2000, based on the so-called "General classification of water quality" (Water Pollution Control Association of Kokemäenjoki River 2006).

ity, while supporting services are bought from the private sector based on competition. Thirdly, since the 1970s water management has become demand- rather than supply-driven which, on the other hand, is also a challenge for the utility. Fourth, the multi-stakeholder principle - cooperation and networking with various stakeholders has become active at various levels: small and larger systems, industries, other water companies, research and development institutions, regional and national authorities as well as twinning and other international cooperation.

Tampere Water in the national and international context

In the national context Tampere Water, now integrated but earlier operating as two separate entities, represents a typical urban water and sewage utility owned by the city. The same arrangement is also typical in all other Nordic countries which have a long tradition of local government provision of these services. Nationally, knowledge and expertise were initially sought not only from Helsinki, the capital, but also from other cities like Vyborg in Karelia. While Helsinki sent its civil servants abroad to acquire information about facilities and their operation (Hietala 1987), Tampere and other cities also established direct contacts with other countries. This was especially true in the case of the cities with a Swedish-speaking majority located on the western coast across from Sweden.

A special feature in Tampere is its industrial heritage that is reflected in the water services and their evolution. As the final touches are being put on this book, the city is preparing a proposal to have the Tammerkoski Rapids flowing through the city centre and the old factory buildings along its banks to be placed on the UNESCO World Heritage List.

Formally, Tampere Water is obliged to provide water services within its boundaries, but it is also involved in bilateral and inter-municipal co-operation in water supply and sewerage with neighbouring municipalities. Tampere Water, being the third largest public water and sewerage utility in the country, is naturally also involved in various national research and development projects and activities of professional associations and other related institutions. Recently Tampere Water also got involved in twinning activities with the city of Daugavpils, Latvia, thus expanding its area of operations.

Concluding remarks

On the whole, the improvement of water bodies around Tampere has been surprisingly fast. Surface water was initially drawn from nearby sources, and as these became contaminated, from farther away. Utilization of groundwater started later and artificial groundwater will likely be produced in the future. Wastewaters spoiled water systems until efficient treatment started at a relatively quick pace. Industry began to protect waters later in increasing cooperation with the water and sewage works when the time was ripe. When the increase in water consumption levelled off in the 1970s, the emphasis shifted to water quality.

In environmental matters the utility has played, and will continue to play, a key role in Tampere and its surroundings. All in all, Tampere Water (former Tampere City Water and Sewage Works) is an example of a local government-owned public utility that has been, and will continue to be, capable of providing services at reasonable cost. Whatever water sources will be used and wherever properly treated wastewaters will be discharged, they all are to be kept in good condition. The aging infrastructure – particularly the networks –- will bring new challenges in the future.

> *"High quality water is more than the dream of the conservationists, more than a political slogan; high quality water, in the right quantity at the right place at the right time, is essential to health, recreation, and economic growth"*
>
> *EDMUND S. MUSKIE, U.S. Senator, speech, 1 March 1966 (a civil engineer)*

11. Future prospects

Fig. 11.1 Mr. Reijo Kuivamäki, Managing Director of Tampere Water since 2003. Photo: Tampere Water.

The history of Tampere Water, described and analysed in the preceding ten chapters by the two authors, makes one think about the various and changing emphases and strategic changes and decisions of water and sewage services over time – and their subsequent impacts. It also makes one think about the possible, desirable and probable options available for alternative futures. Where would we like to – or where should we – be heading?

The Water Services Act enacted in 2001 in Finland made water supply and sewerage more business-oriented than before. The new legislation reflected overall sectoral development and showed the direction for the futures.

Integrated water acquisition and distribution and wastewater collection and treatment are a service well in line with the Water Services Act – integration is a common practice in the Nordic countries. The act made the duties of the key stakeholders – municipalities, water (in most cases also sewerage) utilities and customers – clearer and more transparent than earlier.

However, today's water utilities are no longer fit to provide stormwater management. Hydrology of the built environment – urban stormwater management – is the duty of the municipality in Finland, since other organisations are not able to assume overall responsibility starting from drainage of building foundations to the regulation of water bodies. If that entire water cycle is considered part of water supply and sewerage, I find that we should move away from business-oriented water services provision towards an integrated municipal water department.

Climate change is becoming increasingly apparent. Rising average temperature will make Finnish winters milder and more rainy – more like winters in Central Europe. Higher summer temperature will lead to extreme weather conditions. Thus, climate change will affect water and wastewater service provision in many ways. For instance, temperature and rainfall impact surface water quality, and heavier rains will make it more difficult to manage stormwaters with the present and developing urban infrastructure.

Over the last few decades, Finnish Government policy has favoured groundwater over surface water in community water supply. In most cases this has guaranteed safe water quality, especially for small utilities, with relatively simple technology. Yet, the longer dry periods accompanying climate change will decrease the groundwater yield. In the future we will have to secure our water supply either by using additional groundwater sources or by creating artificial recharge.

Existing water and sewerage networks are the biggest asset as well as major cost risk of the systems. Their technical lifetime normally exceeds their economic lifetime. This leads to excessive depreciation which, on the other hand, ensures sufficient resources for reinvestment in rehabilitation. Ageing networks require increasing rehabilitation. The challenge for water utilities is to be able to provide adequate funding for rehabilitation, to know their networks well enough and to target rehabilitation measures correctly.

The operational environment of water utilities will change in the future. Centralisation of the systems will increase since competition with other sectors for the personnel required to maintain the high service level will intensify. Thus, the appeal of the jobs offered by water utilities must be guaranteed – from plumbers to directors. This can be done, for instance, by training provided by utilities, improved image maintenance and larger centralised units.

As in the past, the private sector will continue to provide services to water utilities, especially in the area of non-core operations. I believe that the ownership of water utilities will remain in public, that is, the customers´

hands while the private sector will increasingly supply goods, equipment and services. This will offset the need for additional professional staff and the seasonal fluctuation in demand.

Water supply and sanitation are business activities of a unique type. They connect an essential service, huge fixed assets, local water sources and discharge points to water bodies, freely available raw water as well as the views of water users and water conservationists. Yet, a water utility sells products and services that are charged by volume – and in the case of bigger Finnish utilities also yield a profit. Some may consider water services provision problematic since it is neither an outright business nor a tax-funded service. I consider it an interesting combination of the two.

In the present we are living in a moment between the pasts and the futures. With our knowledge of the pasts we look into the futures attempting to forecast the possible and, especially, the desirable options and strategies for them. We make decisions concerning our water utilities whose relevance will be assessed by future generations. We must make decisions on minor and major issues in order to be able to ensure safe and sustainable water services both today and tomorrow.

12. References

Literature and personal communications

- Asola I. 2003. Water tower – landmark of the community. Association of Finnish Civil Engineers. 174 p. (In Finnish, partly in English)
- Brandt A. 1899. Om vattenledning i Tammerfors. Teknikern. Vol. 9, no. 195. pp. 27-29. (In Swedish)
- FIWA (Finnish Water and Waste Water Works Association, International Water Association) & EWA (European Water Association) 2000. The 4th International Conference Flotation in Water and Waste Water Treatment. Helsinki, Finland, 11-14 September 2000. Conference Proceedings. http://www.vvy.fi/julkaisu/daf_proceedings.htm). Selected papers published in: Wat.Sci.Tech. Vol. 43, no. 8., 2001.
- Harjula M. 2003. Tehdaskaupungin takapihat. Ympäristö ja terveys Tampereella 1880-1939. Tampereen historiallisen seuran julkaisuja XVII. (In Finnish). 226 p.
- Heilä S. 2006. Munanmuotoiset viemäriputket itseään puhdistavia. EK-uutisputki. (In Finnish)
- Herranen, T. (2002). 125 Years of Life with Water. The History of Water Services in Helsinki. Helsinki Water, Helsinki. 238 p.
- Hietala M. 1987. Services and urbanisation at the turn of the century. The diffusion of innovations. Studia Historica 23, Helsinki. 481 p.
- Hukka J.J. & Seppälä O.T. 2004. D41: D10b: WaterTime National Context Report – Finland. http://www.watertime.net/docs/WP1/NCR/D10b_Finland.doc
- Hukka J.J. & Seppälä O.T. 2005. D41: WaterTime case study - Tampere, Finland. http://www.watertime.net/docs/WP2/D41_Tampere.doc
- Jansson-Lehtinen M., Koivisto I. & Tuulasvaara-Kaleva T. 1999. Focus on yesterday. Publications of Tampere museums, no. 50.
- Juuti P. 2001. Kaupunki ja vesi. Tampereen vesihuollon ympäristöhistoria 1835–1921. University of Tampere, Doctoral dissertation. (In Finnish, summary: City and Water). Available: http://www.uta.fi/laitokset/kirjasto/vaitokset/2001/2001081.html
- Juuti P. (unpublished) 2004. Yksityisen sektorin osuus Tampereen vesihuoltopalveluista 1700-luvulta 2000-luvulle. (In Finnish) (As assessment

of outsourced goods and services at Tampere Water and Sewage Works, 1700s-2000). 17 p.

- Juuti, P. & Katko T. 1998. Ernomane vesitehras, Tampereen kaupungin vesilaitos 1835-1998 (Marvellous water factory, Tampere city water works 1835-1998). 270 p. (In Finnish, summary in English and Swedish).
- Juuti P.S. & Katko T.S. (Eds.) 2005. Water, Time and European cities. History matters for the futures. Printed in EU. 253 p. Available: htpp://www.WaterTime.net, also http://tampub.uta.fi/index.php?Aihealue_Id=20
- Juuti P. & Katko T. 2006. Vaasan Vedet. Vasa och dess Vatten. Vesihuoltoa ympäristön ja yhteiskunnan ehdoilla 1800-luvulta tulevaisuuteen. Vattenförsörgning på miljöns och samhällets villkor från 1800-talet in in framtiden. 530 p. (In Finnish and Swedish, Summary in English). Available: http://tampub.uta.fi/index.php?tiedot=132
- Juuti P.S. & Pál V. 2007. Sister towns of industry: water supply and sanitation in Miskolc and Tampere from the late 1800s to 2000s. In: Juuti, Katko & Vuorinen (Eds. 2007). Environmental History of Water. IWA Publishers, London.
- Juuti P. & Rajala R. (2007). Veden vuosisata. Espoon vesihuolto 1930-luvulta 2000-luvulle. 448 p. (In Finnish, Summary in Swedish and English) Espoo Water.
- Juuti P., Rajala R. & Katko T. 2000. Terveyden ja ympäristön tähden – Hämeenlinnan vesilaitos 1910-2000 (For the sake of health and environment – Hämeenlinna water works 1910-2000). 216 p. (In Finnish, Summary in Swedish and English).
- Juuti P., Rajala R. & Katko T. 2003. Aqua Borgoensis: Lähteet kertovat - Källorna berättar (Sources telling us). Porvoo water works 1913-2003. (In Finnish and Swedish, Summary in English). 467 p.
- Juuti P. & Wallenius K. 2005. Kaivot ja käymälät. Brief History of Wells and Toilets. KehräMedia Ltd. 160 p. http://granum.uta.fi/granum/kirjanTiedot.php?tuote_id=10868
- Kaleva H., Meriluoto J., Salmelainen J. & Taskinen J. 2006. Tampereen Vesi. Tampereen seudun keskuspuhdistamoprojekti – puhdistamon sijainti- ja purkupaikkojen vertailu. Loppuraportti 17.3.2006. 42 p. (In Finnish) http://www.tampere.fi/tiedostot/5eBhEhWhH/Loppuraportti_170306.pdf

- Katko T.S. 1997. Water! - Evolution of water supply and sanitation in Finland from the mid-1800s to 2000. FIWA, Helsinki, 1997, 102 p.
- Katko T.S., Juuti P.S. & Hukka J.J. 2002. An early attempt to privatise – any lessons learnt? Research and technical note. Water International. IWRA. Vol. 27, no. 2. pp. 294-297.
- Katko T.S, Juuti P.S. & Pietilä P.E. 2006. Key long-term decisions and principles in water services management in Finland, 1860-2003. Boreal Environment Research. Vol 11, no.5. pp. 389–400. http://www.borenv.net/BER/pdfs/ber11/ber11-389.pdf
- Katko T.S., Luonsi A.A.O.& Juuti P.S. 2005. Water Pollution Control and Strategies in Finnish Pulp and Paper Industries in the 20th century. IJEP. Vol. 23, no. 4. pp. 368-387.
- Katko T. & Nygård H. 2000. Views of research on the Evolution of Water, Wastewater and Solid Waste Services. Tekniikan Waiheita. Vol. 18. no. 4. pp. 14-19.
- Koskinen M. 1998. Kun kulkutauti saapui Tampereelle. pp. 88-99. In: Juuti & Katko, 1998.
- Laakkonen S. 2006. Kun vesivessa ei tullut Suomen. Ympäristö & Terveys. Vol. 37, no. 8. pp. 4-6. (In Finnish)
- Lillja J.L.W. 1937. Helsingin kaupungin vesijohtolaitos 1876-1936. (In Finnish)
- Melosi M.V. 1998. Water supply and wastewater systems in the United States in the 19th and 20th centuries. A workshop paper. Tampere University of Technology. Aug 14, 1998. 50 p.
- Melosi M.V. 2000. The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present. The Johns Hopkins University Press. 600 p.
- Nagler B.E. 1966. Elevated Concrete Reservoirs in Finland. J AWWA. Vol. 58, no. 11. pp. 1429-1445.
- Niemi O. 2005. Tampere region, Excellent Business arena. NCC Property Development Oy. 1.4.2005. ppt presentation.
- Perälä H. 2006. Tampereen seudun yhteistarkkailu. Vuosiyhteenveto 2005. Kokemäenjoen vesistön vesiensuojeluyhdistys r.y. Julkaisu no 539. (In Finnish)
- Pietilä P. & Spokas R. 2004. Comparison of water services development in Finland and Lithuania. European Water Management Online.www.ewaonline.de/journal/2004_05.pdf (5 July 2004)

- PREC (Pirkanmaa Regional Environment Centre) 2006. Pirkanmaan vesihuollon kehittämissuunnitelma . Vaihe II. Yleissuunnitelma, Ympäristöselostus. Pirkanmaan ympäristökeskuksen alueellinen ympäristöjulkaisu nro 411. (In Finnish) http://www.ymparisto.fi/download.asp?contentid=45950&lan=fi
- Rajala R.P. & Katko T.S. 2004. Household water consumption and demand management in Finland. Urban Water Journal. Vol. 1, no.1, pp. 17-26.
- Tampere City Water and Wastewater Works 1977-81. Annual reports.
- Tampere Water 2005. Annual report. (in Finnish; http://www.tampere.fi/tiedostot/5fCIU791D/Tampereenvesi_toim.kert05.pdf
- Tikkanen M. 2006. Tammerkoski syntyi 7500 vuotta sitten. Aamulehti. A 2. 3.12.2006. (In Finnish)
- Timonen R. 2003. Landscapes of Finland. Photographs by T.Heikkilä. Otava. 214 p.
- Turunen H. 1985. Lakeuden joet. Etelä-Pohjanmaan vesienkäytön historia. Kytösavut XV. Eteläpohjanmaan maakuntaliiton julkaisu. 280 p. (In Finnish)
- UNDP (United Nations Development Programme) 2006. Human Development Report 2006. Beyond scarcity: Power, poverty and the global water crisis. http://www.undp.fi/julkaisut/hdr06.pdf
- Vehmaskoski, T., Pietilä, P. and Seppälä, O. 2002. Vesihuollon alueellinen operointi. Helsinki University of Technology, Laboratory of Environmental Engineering. Report TKK-VHT-32. 160 p. (In Finnish)
- Viita L. 1947. Concrete mixer (Orig. in Finnish: Betonimylläri). pp. 141-145. In: Carpelan B., Meri V. & Suurpää M. 1992. A way to measure time. Contemporary Finnish literature. Finnish Literature Society.
- Vuoriranta P. S., Mäki M. , Nevatalo L. & Puhakka J. 2006. Seasonal variation of bacterial density and population diversity in water distribution network biofilms. European Workshop: Drinking Water Quality in Distribution Systems. SAFER. 7-8 September, 2006. Nancy, France.

Personal communications

- Anttonen K. 2006. City of Tampere. Personal communication. 21.12.2006.
- Haume E. 2006. Personal communication. 15.12.2006.
- Heinonen T. 2006. Hämeenlinna Regional Water and Sewage Company. 10.12.2006.
- Jokela P. 2006. Tampere Water. Personal communication. 20.12.2006.
- Kuivamäki R. 2006. Tampere Water. Personal communication. 2.11.2006.
- Leinonen M. 2006. Personal communication. 12.12.2006.
- Molarius R. 1997. Personal communication. 26.9.1997.
- Nordman I. 2006. Turku Water. Personal communication. 30.10.2006.
- Pirinen J. 2006. Helsinki Water. Personal communication. 2.11.2006.
- Pulli P. 2006. Tampere Water. Personal communication. 21.12.2006.
- Rasi K. 2006. Tampere Water. Personal communication. 21.11.2006.
- Water Pollution Control Association of Kokemäenjoki River, Tampere. 2.11.2006.
- Westman S. 2006 Stockholm Water. Personal communication. 18.10.2006.

Web-pages

- City of Tampere. 2003. The general information. http://www.tampere.fi/english_v/general.htm. Updated 6.8.2003.
- City of Tampere 2006a. Tilinpäätös. http://www.tampere.fi/talous/tilinpaatos/index.html
- City of Tampere 2006b. Environment. http://www.tampere.fi/english/environment/index.html
- The Council of Tampere Region. 2004. http://www.pirkanmaa.fi/english/
- Kansallismaisemat (National landscapes). 22.10.2006. http://www.ymparisto.fi/default.asp?node=686&lan=fi
- Koivisto I. & Tuulasvaara-Kaleva, T. 2000. The old town centre. http://www.history.tampere.fi/city/index2.htm
- Laitinen I. 2006. Museokeskus Vapriikki, Tampere. :http://www.info.

tampere.fi/~ypyvapri/Viita/ 14.10.2006.
- Tampereen vesi 2006. Jäteveden puhdistamoiden tarkkailutulokset. Vuosiyhteenveto 2005, Jätevesiä koskevan velvoitetarkkailun vuosi-yhdistelmä (44 kilotavua) http://www.tampere.fi/tiedostot/5eCCvibSV/Viinikanlahti-kuormitukset_ja_reduktiot_2005.pdf
- Tampere Water 2006. http://www.tampere.fi/vesi/english/index.html
- Tuulasvaara-Kaleva T. 2006a. Power from the rapids. Bridges. http://www.history.tampere.fi/rapids/index2.htm
- Tuulasvaara-Kaleva T. 2006b. Power from the rapids. Factory areas. http://www.history.tampere.fi/rapids/index3.htm)
- Tuulasvaara-Kaleva T. 2006c. Power from the rapids. Water power. http://www.history.tampere.fi/rapids/index4.htm
- Silander M. 2006. Tampereen Pellava- ja Rauta-Teollisuus Oy. http://www.uta.fi/koskivoimaa/tyo/1940-60/tampella.htm

About the Authors

Dr. Petri S. Juuti is a historian, Senior Research Fellow and Adjunct professor at the Department of History, University of Tampere. His major area of interest is environmental history, especially urban environment, city-service development, water supply and sanitation, urban technology, pollution, and public policy. He is the author of several books. Email: petri.juuti@uta.fi.

Dr. Tapio S. Katko is a sanitary engineer, Senior Research Fellow and Adjunct professor at Tampere University of Technology. His main research interests are long-term development of water and related infrastructure as well as institutional, management and policy issues of water and sanitation services. He is the author of several books and papers. Email: tapio.katko@tut.fi.