

Technical meeting

Hydraulic Facilities

as technical equipment and cultural heritage

19 - 20 September 2019

The Peterhof State Museum-Reserve, St. Petersburg, Russia

Minutes

Participants:

- Klaus PANHOLZER (Schloss Schönbrunn)
- Elfriede IBY (Schloss Schönbrunn)
- Mette Marciniak Mikkelsen (Danish Agency for Culture and Palaces)
- Gilles Bultez (Château de Versailles)
- Frank Torsten Hakenbeck (SPSG)
- Martin Alfred Prill (SPSG)
- Luis Vallejo Velasco (Patrimonio Nacional)
- Victor Cageao Santacruz (Patrimonio Nacional)
- Sergio Gorjao (National Palace of Mafra)
- Maurizio Reggi (Consorzio Residenze Reali Sabaude)
- Alessia Bellone (Consorzio Residenze Reali Sabaude)
- Marcin Mazur (The Royal Castle in Warsaw)
- Piotr Zaborovski (The Royal Castle in Warsaw)
- Daniel Drozd (The Royal Castle in Warsaw)
- Piotr Wieslaw Skowronski (Royal Lazienki Museum in Warsaw)
- Joanna Maria Szumanska (Royal Lazienki Museum in Warsaw)
- Marta Boguta (Royal Lazienki Museum in Warsaw)
- Alexander Belousov (The Peterhof State Museum-Reserve)
- Pavel Petrov (The Peterhof State Museum-Reserve)
- Andrey Biryukov (The Peterhof State Museum-Reserve)
- Igor Gerasimov (The Peterhof State Museum-Reserve)
- Maria Yushmanova (The Peterhof State Museum-Reserve)
- Elena Alliaudi (Network of European Royal Residences)
- Hélène Legrand (Network European Royal Residences)

Meeting began with **welcome speeches** by Elena Kalnitskaya, Director General of the State Peterhof Museum-Reserve and Elena Alliaudi, coordinator of the Network of European Royal Residences.

PRESENTATIONS

History of the Peterhof Fountain System in the 18th–early 20th Centuries

Alexander Belousov (The Peterhof State Museum-Reserve)

The idea to build a fountain park belongs to Peter I. He had seen a lot of beautiful examples during his trips to Europe at the end of 17th and beginning of the 18th centuries. He visited a lot of magnificently decorated royal residences and decided to create something similar in Saint Petersburg, the new capital of Russia.

The water supply system was constructed by the Russian engineer Vasily Tuvolkov in 1720–1721. He was trained to work with hydraulic facilities in France during the Peter's embassy. For example he observed the construction of the Canal de Mardick near Dunkirk and le Canal de midi.

In August 1721 the fountains of Peterhof were launched. It was Peter I himself who unlocked the Valve in Ropsha. The construction and maintenance of the system required a number of people, during some of the months more than 2000 people at a time worked there. At the same time fountains were being constructed. It was a mission of foreign specialists, because no one in Russia knew how to do it.

The first project of Peterhof fountains belongs to Jean-Baptiste Alexandre Le Blond, who drew on Peter the Great's sketch. According to that plan there should have been two basins on both sides of the Upper garden, that were to supply water to the canal around the garden. To provide water there should be a mill run by the horses.

Peter I approved this project with some revisions, but it wasn't applied because of its complexity and the death of Le Blond. N. Miketti developed a new project and with the French craftsman Paul Sualem (who was a relative of the Machine de Marli, Renken Sualem) they construct the first fountains of Peterhof - Grand Cascade, Pyramide, Adam and Eve, Bowls, Sheave and Trick fountains.

Construction of the fountains were stopped only after the death of Peter I's wife, Catherine I, and were relaunched under the rule of Anna Ioannovna. It was during her reign when the famous Samson was built and installed to memorize the victory of 1709 in battle of Poltava.

During the 18th - 19th centuries the unique landscape was created along the water supply system, including the English Palace, Rose Pavilion, Belvedere, Lake Pavilion and a lot of parks.

During the reign of Nicholas I Peterhof reached its fullest flourishing. The town was reconstructed to some extent, new parks were laid out and the upgrading of the water supply system was initiated. Two engineers were in charge of this work - Mecheslav Pilsudski and Sergei Likhardov.

By the beginning of the 20th century both fountains and the water supply system fell into decay because of the lack of proper maintenance.

Restoration of the Petrodvorets Fountain System in 1946-1950s

Pavel Petrov (The Peterhof State Museum-Reserve)

Since the early 20th century no important repairs of the Peterhof hydraulic structures had been done and by the early 1920s some of the fountains no longer functioned. In addition a big flood happened in September 1924, it caused serious damage to the Lower Park, its fountains and ponds, so it was necessary to urgently begin repairs and restoration works. In the period from 1925 to 1933 all the cascades – the Grand Cascade, Chessboard Hill Cascade, and Golden Hill Cascade, as well as all the main fountains of Peterhof were overhauled. As a result of those works, many fountains, previously inactive for 20, 30, and even 50 years, were put in function again.

The Great Patriotic War caused enormous damage to the palaces, parks and fountains of Peterhof. It was necessary to completely restore the entire ensemble, but there were no financial opportunities for simultaneous restoration of all the objects. Therefore, it was decided to do it in several stages.

The year of 1946 was a turning point in the fate of the palaces and parks of Petrodvorets. On February 14 the meeting of the Leningrad City Executive Committee made a historic decision "On the restoration of the fountains and park facilities in the town of Petrodvorets", which ordered to make in 1946 "the first stage of the restoration works of the fountain system and park facilities in the amount of 1,260 thousand rubles".

Large-scale works on restoration of the water supply system and fountains of Petrodvorets were launched. By August 20, 1946, the restoration works were completed, and preliminary formal acceptance was made with a full launch of 38 fountains. The result of these grand restoration works was the official opening on 25 August 1946 in Petrodvorets of the fountains of the first stage of works, to which a mass festival in the Lower Park was dedicated.

Though, the most difficult work to restore the fountain system of Petrodvorets still had to be done. On April 17, 1947 the meeting of the Leningrad City Executive Committee made a decision to "fulfill the 2nd stage of restoration of the fountains in Petrodvorets". According to the approved schedule of works, it was necessary to make a model of the sculpture of Samson by May 20, to cast it by July 1, and to gilt and mount the sculpture of Samson by July 20.

After the recommendations of the Leningrad Union of Soviet Artists, the reconstruction of the fountain sculpture of Samson was entrusted to the famous sculptor, Professor V.L. Simonov. Finally, on 14 September there was a big festival in Peterhof during which the Samson fountain and all the fountains of the Grand Cascade were launched.

In total 43 fountains (216 jets) were restored in 1946-1947 in Peterhof, the cost of works equaled to 9 million rubles. By 1955, 126 fountains of the Lower Park and the Upper Garden with all the sculptures and decorative bronze ornaments and vases, including 3 cascades, were restored in Petrodvorets. During 1956-1957, the fountains of Sun, Orangery (or Triton), Fable, Shell, Fir-tree, and others were restored. In 1956, the restoration of the Lion Cascade, destroyed during the war, the most difficult in terms of its décor, was started. However, after a few years of works, they were stopped due to a number of difficulties. After a long break, in 1963, the original sculptural décor of the fountain of Whale on the Sand Pond in the West part of the Lower Park was restored.

As a result, in the early 1960s, almost all the fountains of the Lower Park and the Upper Garden were restored. Only one Lion Cascade in the West part of the Lower Park remained inactive. In the late 1980s, the restoration works began, but then they were stopped due to the lack of funds. The works were re-started only in the late 1990s, and in August 2000, the Lion Cascade was inaugurated. The restoration of the trick-fountain of Water Road, which had not functioned for 280 years, served as a logical completion of the fountain system of Peterhof. In May 2001, all 300 jets of this fountain started functioning on the Monplaisir Alley in the Lower Park.

At present, all 157 fountains of Peterhof are in function and give pleasure to numerous visitors of our palaces and parks.

The Fountains of Schönbrunn

Klaus Panholzer, Elfriede Iby (Schloss Schönbrunn)

Schönbrunn Palace with its park assumed its prominent status as an imperial residence under Maria Theresa. Remodelled at her behest during the 1770s, the gardens have remained a characteristic feature of the complex to this day. The mid-18th century remodelling of the Baroque gardens included the installation of numerous fountains, most of which accentuate the existing axes of the park as points de vue. Water as an enlivening element of the Baroque gardens remained in the shape of the new fountains with their elaborate sculptural decoration, flowing into generously proportioned basins, as exemplified by the Neptune Fountain. In addition, further smaller fountains with sculptural decoration were built, together with a system to supply water to all these structures.

However, subsequent lack of maintenance resulted in extensive damage to the fountains and their sculptural decoration during the 19th century. By the end of the monarchy many of the fountains were in disuse and were only reinstated gradually during the 1960s after war damage to the complex had been remediated. Comprehensive restoration of the large fountains started in 1993 and their supply systems upgraded to the latest technical standards.

Errors arising from earlier restorations have been corrected and in some cases sculptural decoration re-attached in accordance with verified historical sources, The

water supply systems from the same historical period have been continuously renewed over the past 200 years using the materials and techniques of the times in which this repair work was undertaken. In the meantime the restoration of all the fountains at Schönbrunn has been completed. In the 21st century a number of things have been automated (e.g., the sprinkling of the lawns); in 2008/2009 a water pressure booster facility was installed. The automation of the irrigation system and running it overnight has led to an approximately 20% reduction in water volume.

The Fountains of the Royal Gardens of La Granja de San Ildefonso. History and Main Challenges

Víctor-Manuel Cageao Santacruz, Luis Vallejo Velasco (Patrimonio Nacional/Royal Site of La Granja de San Ildefonso)

In these brief minutes that I will share with you I will try to explain the origin and history of La Granja fountains, and mainly why I think they are universally important, and also what problems they present today and how we try to solve them.

I will begin by introducing you to the Institution we represent and in which the Royal Site of La Granja is framed. National Heritage is integrated by several properties owned by the State, affected to the use and service of the King and the other members of the Royal Family, for the exercise of the high official representation. In my opinion, this is one of the main peculiarities of the Spanish royal palaces, as they are fully in use. Among these large groups we could mention the Royal Palace of Madrid, the Monastery of San Lorenzo de El Escorial and the Royal Sites of Aranjuez, El Pardo and La Granja.

In any case, the Royal Site of La Granja is one of the best Royal Sites of Spain, which you can see here in a general representation made by the chamber painter of King Fernando VII, Fernando Bambrilla, who was entrusted with the representation of the Royal Sites in the third decade of the 19th century.

La Granja is situated in the province of Segovia, only 77 km in a straight line from Madrid, 90 Km by road, and 10 km from Segovia. The creators of the Royal Site were the King Felipe V and his wife, Queen Isabel de Farnesio, who reigned in Spain for more than 45 years.

Apparently, the idea came to the king in 1720, when he decided to abdicate and retire in a lonely place, just as Carlos I did in Yuste. At that time, he must have thought that this idyllic place could be found in a farm, a "Granja" of the Jerónimos monks of El Parral, built in the 18th century. In March of that year it was signed the acquisition of the farm of San Ildefonso with the Jeronimos monks, and the renovation works, directed by the main master of the Royal Palace of Madrid, Teodoro Ardemans, began in April of 1721.

Although the whole of the Royal Site is truly extraordinary, it is probably its gardens, and within them its fountains and water games the main elements by which it is universally known. There are many reasons to explain the exceptional value of these fountains, but among the most prominent we could mention that:

- They are the result of the collaboration, simultaneous or staggered, of architects, landscape designers and plumbers.
- The whole set is complete nowadays: no fountain or sculptural element has disappeared.
- The entire hydraulic system is currently complete, except for some restored elements.
- Thanks to continuous maintenance during the 18th, 19th and 20th centuries, the fountains are currently fully operational.

As we said, the team of professionals who created the fountains of La Granja, entirely French, was made up of architects, gardeners, sculptors, engineers and plumbers. The original general system was built in only four years. The central element of the set is the central axis, with the Parterre, the fountain of the Great Waterfall and the Golden Cabinet, a small pavilion that serves as the end point of the perspective. To the right, also in front of the palace, the garden called "Bosquete de los Vientos". To the left, the heroic axis of the "Horse Race", which commemorates the victory in the War of Succession. After the death of Luis I, the garden was completed.

One of the main aspects that extraordinarily revalue this set is that the hydraulic system was integrally designed at the time of the creation of the garden, has remained intact and is still in operation. The entire system's water supply comes from several streams, and it is directed from the mountain thanks to the realization of canals, to the dam, the main element of the complex, known as The Sea. It has a capacity of more than 161,000 m³ and is located at the highest level of the garden (1,249 meters above sea level).

From the main reservoir, the entire system operates by gravity, combining its reserve with another 8 ponds, located at different levels, thus achieving adequate manometric pressures at the fountains each supplies.

Distributed by the gardens there are 18 fountains, two waterfalls and an artificial river. All pour into the artificial river, minus four.

Each fountain is equipped with a valve chamber or cassette with keys for opening the "water games", and also keys to regulate the reach of the oblique jets. The bottom drains are operated by means of "sopapo" keys.

The total length of the pipes is approximately 13 kilometers. Both the interior of the pipe and the unions have, in general, good condition despite having passed 250 years, due to the high quality of the water and the continuous maintenance. The pipes that form the old hydraulic system are mostly made with molten iron and have various diameters. Bifurcations and junctions with valves were built in lead.

The sections of the tubes have plates with four or eight holes for the passage of special joining bolts. The joints are resolved with leather and lead.

To ensure the proper functioning and maintenance of the hydraulic system, a multitude of tools were created and still exist.

As you can imagine, although the processes of conservation and maintenance have been continuous, the fountains arrived at the end of the twentieth century with some obvious problems, among them:

- Deterioration of the masonry that formed the vessels.
- Lack of general waterproofing.
- Pipes embedded in the bottoms as a result of re-growth after construction.

So, it was necessary to act. The most important large-scale intervention was carried out from the year 2000. The execution of the work was very complicated, due to issues such as:

- The extension of the works,
- The impossibility of dismantling the sculptural groups due to their size,
- The inability to disassemble the iron structure,
- The difficulty of access to the pipes, etc.

The civil work solved the problems of the most important fountains, performing, among other ones:

- Demolition and reassembly of walls.
- Extraction of filling materials in funds.
- Elevation of pipes and creation of new ground bases.
- Deep and superficial waterproofing.
- Replacing sections of degraded pipes.

On that occasion it was also carried out the restoration of the sculptural groups.

The action carried out from the year 2000 was very important, you can see in this picture the fountains restored in blue, and, at that time, significantly cutting edge; however, restoration criteria have evolved and it would now be considered invasive.

Later, and until now, minor interventions have been carried out to maintain and conserve the fountains, executed by the National Heritage staff or hired in occasions to external companies. The main works consisted of:

- Repairs of breaks in original lead pipes inside and around the fountains.
- Repair and maintenance of boxes and maneuvering keys for starting the operating of the fountains.
- Punctual repairs of sculptural sets, such as the deer in Eight streets or the arm of Neptune.
- Disinfection and cleaning of silt inside the fountain vessels and contribution ponds.
- Maintenance and lighting repairs in fountains with night operation.

To guarantee the operation of the complex, the Royal Site of La Granja currently has a team composed of one technical architect, one general manager, 3 plumbers (specialists) and 12 operators (painters, carpenters ...).

Thanks to these maintenance works, the current state of La Granja fountains is good, although it would be necessary to address some works of some relevance, the most important being the restoration of the Grand Waterfall.

The main damages detected in the fountain are:

- Advanced state of deterioration of the stone material, especially on fronts and right side
- Poor state of preservation of the base structure
- Punctual damages in hydraulic pipes
- Inadequacy of the lighting system.
- Damages in the lead and marble sculptures, with localized cracks and fissures, deformations and erosions.
- Dragging of materials and loss of symmetries in the landscaping.

The technical criteria that are being followed for the preparation of the restoration project are the following:

- Accurate documentation, rigor, respect at all times
- Interdisciplinarity
- Minimal intervention
- Specificity of the solutions
- Use of similar materials and construction techniques
- Reversibility..

The documentation and previous studies are completed and the project is practically written; in these planes of previous information the detected damages can be observed. In the Action Plan of the Directorate of Real Estate and Natural Environment, the contracting and execution of the restoration of the Great Waterfall is scheduled, with a multiannual execution from 2021. The biggest drawback is the necessary budget, which exceeds five million euros.

In the present moment, La Granja fountains currently operate on Wednesdays, Saturdays and Sundays On May 30, July 25 and August 25, all fountains work. During the dry season the operation of the fountains can be interrupted, like this year, given the significant drought in Spain.

Water and Water Management at SPSG in the time of Climate Change

Martin Prill (Prussian Palaces and Gardens Foundation Berlin-Brandenburg)

Since construction began in 1747, hydraulic and water systems have been an ongoing challenge at Park Sanssouci in Potsdam/ Germany. Today the Prussian Palaces and Gardens Foundation's water systems include 7 historical pumping stations and over 300 kilometres of pipeline. Via major modernization projects at Charlottenburg Gardens in Berlin and at the "Mosque" Steam Engine House in Potsdam, which supplies Sanssouci Park, staff have reduced water usage, avoided breakage, and are better equipped to react to climate changes. This presentation provides a historical overview of the Foundation's various irrigation and hydraulic systems, shares highlights from modernization projects as case studies as well as address ongoing challenges.

The most typical kind of hydraulic facilities at our residences are pump stations for surface water with a water reservoir on a hill because in our geographical area it isn't possible to use spring water. The water pumping stations take the water from the river Havel through the over 175 year-old cast iron pipes of the water reservoir. Some kilometres of these original cast iron pipes we have preserved by the close fit relining method in the last years. Another project was the preservation, restoration and commissioning of a great part of the water system (about 10 km of water pipe network for fountains, garden watering, watercourses and little lakes) in Babelsberg park.

Hydraulic systems are organized by the department of monument conservation. Our team of 10 specialised craftsmen with one master craftsman and one engineer is responsible among other things, for garden watering in about 2,000 ha garden area with approximately more than 180 km pressure lines (fresh water - 30 km) and garden water (150 km), about 100 fountains, 6 pump stations (500m³/h - 55 m³/h) and water reservoirs (8,000 m³ - 230 m³) and about 60 km fountain, rain, and waste water canal system. A few of these hydraulic facilities are located outside the museum territories. The operation of the water networks is safeguarded by a emergency maintenance for 24h with our personal. Endangering problems are the quality of surface water. For example we have a large load of organic content and zebra mussels. That's why we have to install now and will have to install in the future more and more backflushable filter systems (lower then 25 micrometer) in the pump stations or recirculation systems for sensitive fountains with pieces of architecture and sculptures.

Another problem is the rising requirements of garden irrigation in an era of climate change.

To complete projects on preservation like the close fit relining of main pipelines because the over 175-years-old cast iron pipes have for example particular material

fatigue (road crossing areas with heavy duty traffic, overbuilding of the historical pipelines in areas outside the museum territory with residential buildings) In Babelsberg park we also have to complete infrastructure destroyed by the inner German border. Because of more than 30 to 40-year-old pumps we also need new technical equipment with backflushable filter systems and uv-systems. One of the great jobs will be automatic irrigation because of lack of personnel and the rising requirements of garden irrigation.

Peterhof Fountains: Construction and Contemporary Maintenance

Andrey Biryukov (The Peterhof State Museum-Reserve)

The water supply system is the main and integral part of the Peterhof fountain complex. Its sources are located 20 kilometers South of Peterhof, on the Ropsha heights. A system of natural springs, streams and rivers forms two waterways with the outlets in the Old-Peterhof and New-Peterhof canals. 11 kilometers further both canals unite in one canal, the so-called Peterhof Canal, which ends in the double Shinkarsky water-lock 8 kilometers away from Peterhof. Then, through one of the locks water flows to the fountains, and through the other to the Strelka river and then into the Gulf of Finland. The water conduit was built under the order of Emperor Peter I by the Russian hydraulic engineer, Vasily Tuvolkov, in less than a year. In August, 1721 the Peterhof fountains were launched. The realization of this idea of a system of ponds, canals and pipelines, supplying fountains with water, required a huge amount of human labor and enormous material costs. Two thousand workers were engaged in the construction of canals in the last phase of the works.

It should be said in more detail about the design of the entire fountain system. The water supply system of Peterhof ends in the grandiose fountain constructions. A few kilometers from the Upper Garden and the Lower Park, the water canal branches in three directions, supplying water to the fountains of the Central, East and West parts of the Park. Each branch, passing through its own system of ponds and connecting canals, through special water intake and water distribution facilities, directs water to storage ponds located on the upper terrace at the altitude of about eighteen meters above sea level. The water, collected in this way, rushes through underground pipes to the fountains and cascades of the Lower Park.

The favorable landscape, descending from the Ropsha heights to the Gulf of Finland, contributed much to the water supply of Peterhof fountains. Delivering water to the water jet sprayers does not require any pumping devices. It uses the elementary physical law of communicating vessels: ponds-reservoirs are located much higher than the Park. Therefore, when the locks are open, the natural hydrostatic pressure makes water balance out to the same level.

The structure of the water supply system was mainly formed by the mid-19th century, and until now it has not undergone any significant changes. It includes 16 ponds, 9 canals, 12 large streams and rivers, about 140 engineering constructions (bridges, dams, water locks, etc.). The total length of all watercourses is about 60 km, the water surface area is 100 hectares. The average annual water consumption for the fountains is 7.5 million m³.

The main tasks that have to be solved during the operation of the water supply system are as follows:

- guaranteed water supply to the fountains;
- prevention of pollution of underground and surface water runoff within the entire catchment area;
- re-construction of engineering constructions;
- clearing ponds and canals.

The last point is particularly relevant, as during the summer season there is a constant growth and death of aquatic vegetation, polluting the water with decay products. In the second half of summer, canals and ponds get overgrown so much that it prevents the free flow of water. At this time, a significant part of the useful volume of storage reservoirs is filled with aquatic vegetation, which creates difficulties with the supply of water to the fountains.

To improve the condition of most canals, ponds, structures, and natural watercourses, deepening and cleaning ponds and canals from silting is carried out, their banks are reinforced.

The territory, located in the zone of water-supply system, is currently being actively built up with residential houses, they uncontrollably take water from open canals and underground aquifers, make artesian wells. This created conditions for uncontrolled use of water resources, which contributed to a decrease in the amount and deterioration of the quality of water, supplied to the fountains.

The pressure pipes with the total length of about 14 kilometers in the park are very diverse in materials: they are of cast iron, steel, lead, bronze, copper. However, until the mid-1750s a large number of water pipes were made of wood. Then they were completely replaced with cast-iron pipes. These works were completed by 1769. But in 1995, a wooden pipe with the diameter of 300 mm, which served about 270 years, was found on the water discharge system at the Marly canal.

Until now, the air valves, the simplest devices installed on the pipes of the Samson and Neptune water conduits by the talented fountain master Fyodor Strelnikov in the early 19th century, are working properly. These necessary mechanisms were designed to ensure that the compressed air would not break the pipes at the launch of the water.

An important point in the maintenance of the fountains is the adjustment of fountain jets in respect of their height and direction, which should be made every day, and if necessary, even several times a day. The Pyramid fountain, which has a complex composition of fountain jets requires especially careful adjustment. Its construction is

as follows: the cast-iron plate of the pedestal, covering the water tank, has 505 holes with internal thread, the sprayers are screwed into it, being located in seven squares, decreasing to the center. Vertical jets pass through these sprayers, gradually rising to the center and thus creating a water pyramid. Each row of jets has its own valves, which regulate their height.

The design of the pools and fountain bowls allow to fully drain them. For this purpose, every day before the launch of the fountains, the fountain pools are cleaned of debris and silt, the rotary mechanisms, water supply pipes and control valves are systematically examined.

In high-water and ordinary years, the fountains of Peterhof are fully supplied with water 10 hours a day throughout the whole season. At the same time, the daily water consumption is 36 thousand m³ per day. In dry years in order to fully supply the fountains with water it is necessary to make seasonal flow regulation and additional regulation of water in the storage reservoirs. The wastewater from the fountains is drained into the Gulf of Finland through pipes, open trays and a network of drain-ditches.

To maintain the efficiency of the equipment and preserve the historic appearance of the main elements of the fountain complex of Peterhof, we carry out planned restoration works and restoration overhaul, so that the ensemble is preserved as a complete work of art.

How to Preserve Cultural Heritage and the Safety of the Hydraulic Employees

Gilles Bultez (Château de Versailles)

When I arrived at the castle of Versailles 15 years ago I found a very small team of fountain-keepers. They were demotivated. They were full of skills for maintenance, but there was a lack of management, lack of safety for the health of fountain-keepers. So, first of all I have to preserve fountain cultural heritage and also the health of my employees. So I present to you some activities in this field. We'll see what is our hydraulic heritage today, who are the fountain-keepers in Versailles and what do they do, and we'll see specific sealing works with lead, because lead is very dangerous and we have to prevent this danger. And we'll see different techniques of such prevention.

I won't show you all the fountains of Versailles, I'll show you the park that is 800 hectares. This park was huge in the 17th century, and they had to work on the territory of 150 square kilometers. There were many drain pipes, many underground aqueducts under 50 water ponds for sewage ten thousand millions of litres. All of this still exists, but doesn't go to Versailles. So, for the previous 40 years our water supply came from the canal, and we have to pump the water to the main tanks, and after that all the water comes down to the fountains with the help of gravity. So fifty

fountains under the seventy water jets, 35 kilometers of pipes, and there are 70 water valves to retain water drain. But the water of our fountains is like an iceberg, because the fountain is only partly visible. The invisible part is very huge - there are pipes and valves and all the skills of our employees. The skills are hidden, invisible, but it's major, it's crucial to maintain this.

We have a small team, 12 people in the fountain service with 8 fountain-keepers. We make bronze pieces for water-jet, for the fountain of Latone there were 70 water-jets to make.

Under the ground there are very long cast iron, brass and lead pipes, and fountain-keepers have to repair all these materials. When they arrive they only know how to repair brass pipes, so they learn in Versailles to repair the lead and the cast iron ones. They also have to weld lead pipes when there are leaks. But in France, when you work with lead, if your lead-level in blood increases and is above 500 microgram, you have to stop all your activity with the lead. It is very easy to have this level of lead, if you work with lead pipes all day. It is very toxic and cancer causing and we have to prevent all this. We have to discuss with fountain-keepers how to adopt our activity to this problem. So, we have to install specific bangalore, which separates the clean room from the "dirty" (connected with lead activities) room. In the morning the fountain-keepers come in their own clothes and leave them in the clean room and put on their clothes for the lead-work in the "dirty" room and after that they can work with lead all day. And after the work they do vice versa. Fountain-keepers have specific equipment for this kind of activity, and they have to wear a mask with air suction to depollute the air they breathe. It is very difficult to work with that, but they have no choice, because their health is a priority for me and for the castle.

We see here the yard of the square pond of Trianon, where the seal covered all the pond. It was all lead, and very old lead. It was cut in a few sheets, after that, in order not to turn all lead in dust, fountain-keepers had to vacuum all the dust. They cut lead in very small pieces so it was not a very big load to lift. Then masons had to rebuild a lot of stones, afterwards the fountain-keepers rolled out the lead.

[Showing a short video of the lead work performed by fountain-keepers]

We also have to present our activity to groups, to professionals, to schools, to the employee of the Castle of Versailles, because it is very important for fountain-keepers to show what they are doing. Our team is very little and we want to attract visitors, to attract adults, professionals to come and maybe to become fountain-keepers.

Our heritage is made of the pipes, of the valves, of the fountains, but also of the skills of the fountain-keepers. And protecting their health is our priority now, so that the maintenance could go on and the fountains could play for a long time.

Closed Circuit, Second Life of Water

Marcin Mazur, Piotr Zaborowski, Daniel Drózdź (The Royal Castle in Warsaw)

We are going to talk about a new garden that has existed since last year. It cost 4 000 000 euro. The fountain system is completely new. We use the water from the central system and we keep that water in the fountain. We use chemistry, but we think about the changing of the system and keeping this water biological. We change the water in the fountain every month, when we clean the fountain. And we have a problem with green water, that doesn't look nice and we try to find a solution for that. All the trees and buildings in the garden are new and we plan to construct a water system. We hope to keep the rain water and drain system from the garden. We check the filters once a week, because the water in Warsaw is a little bit cropped, and we have to keep doing it, cause the system doesn't work if it is polluted.

We also install irrigation systems in different areas of the park. And we want to switch to a one-application system. At the moment our garden has an irrigation application, we use 100 cubic meter per day and it is a lot and we are trying to find a solution for this also. We maybe will use the ozone technology, but we haven't decided yet, because the garden is new and we have the five year guarantee, so all new investments are possible after the five years.

So, it is a new story, we don't have so many fountains as do Peterhof or Versaille, that is why our presentation will be short.

Authority-Water-Spectacle. New Exhibition in the Royal Łazienki Museum

Piotr Wiesław Skovroński, Joanna Maria Szumańska (Royal Łazienki Museum)

This presentation deals with the new exhibition that has been prepared in the Water Tower in Łazienki. The Water Tower was built before 1765. It was used as a collection tank to collect water from local sources and then to channel it to the Palace on the Isle through pipes. On the ground floor, consisting of only 68.5 square meters, we have created an exhibition about the history of the building, its function and significance for our residence. The exhibition will include multimedia presentations, mock-ups of the buildings and information boards in furniture drawers. It will be the first exhibition in Łazienki about the hydraulic facilities and their symbolism. We are going to present assumptions of the exhibition describing all the three rooms (+ front foyer) in which we will hold it, one by one.

In the front foyer in the Water Tower, we can see the original pipe from the 18th century. The pipe is placed under a glass floor. The pipe was discovered during archeological excavations.

In the 1st room of our exhibition, we will present the symbolical meaning of the water in the architecture of Łazienki Residence. From the beginning of the history of the Palace on the Isle, it was associated with the mythological reference to the source of Hippocrene (from Greek Horse's Fountain), a source of inspiration for poets and artists. A room imitating a natural grotto with a fountain was located in the centre of the Bath pavilion (later on rebuilt as the Palace on the Isle). Our visitors will also have a possibility to study the history of the hydrological system of Łazienki with plans of this residence from 17th to 21st century.

In the 2nd room, we will tell the story of the Water Tower itself. We believe that our visitors will be surprised that the form of this building is very different from the one from the times of Stanisław August Poniatowski (founder of Łazienki). In 1777, the Water Tower was not plastered; it had a brick elevation, and the residents of the Royal Łazienki associated it with a medieval tower. For that reason, it was also called Baszta (Keep) or Okrągłak (Round Building). The current form, designed by Christian Piotr Aigner in 1823, was modelled after the ancient Tomb of Caecilia Metelli from the 1st century BC, located on the Appian Way in Rome. The façade was decorated with chamfered stonework, topped with a cornice composed of bucrania and festoons and topped with an attic. The entrance received a two-column portal.

In the last room in The Water Tower, we will show four graphics from the 18th century that depict Cleopatra ballet as an example of using the water spectacles in creating monarchs' prestige. On September 7, 1791, the Cleopatra ballet was staged at the Amphitheatre. The performance was organised on the anniversary of Stanisław August's election and the occasion of the Amphitheatre's grand opening. Three thousand Varsovians came to see the show and admired how ships intensely luminous with colours began the battle. The cost of the spectacle paid out of the King's pocket, amounted to over 3,000 ducats, not including gifts for the actors. The ballet, in court custom, ended with a fireworks show and joyous shouts: Long live, September 7, 1764! Long live, May 3, 1791! (September 7, 1764 is the date of S.A.'s election and May 3, 1791 is the constitution day in Poland). In the last room in The Water Tower we will show four graphics by Jean Pierre Norblin survived from the 18th century projected onto a screen in a parallax sequence.:

- The first one depicts Audience awaiting the spectacle, in the background the Amphitheatre and the Palace on the Isle. In the background, there is the Amphitheatre and the Palace on the Isle.
- The second graphics shows ships sailing in front of the stage of the Theatre on the Isle
- The third graphics presents a view from behind the scenes of the Theatre on the Isle
- In the last graphics we can see a group of spectators at the edge of the pond and the Amphitheatre in the background.

It will be the first exhibition in Łazienki narrating the presence of water in our residence, the hydraulic facilities and their symbolism. It will give us a new possibility to tell the history of water in Łazienki (using more and more popular aquatic studies) and prepare new educational opportunities for our visitors.

Discussion

Elena Alliaudi: I would like to thank all the people who gave a speech, all these presentations gave us the idea of the complexity of this subject. We are going through very specific issues from very technical to more social, like, how to deal with fountain-keepers or how to promote this activities that are always the hidden iceberg. Maybe those who are engaged in it want to give us your impressions? How is it organized in your countries? Or maybe you have other questions?

Elfriede Iby: I have one question. During the last 5-10 years we've done a lot in the field of digitalization and automation of our services. So as far as I understood, surprisingly, nobody of you is using computerized, automated services?

- My impression was that people want to keep the tradition?

Elfriede Iby: I understood it in your case, but for us it was a need, because since the Maria Teresia epoch the water supply was always a challenge, because geographically our water is at the bottom and our fountains on the top. So there was always technique needed to provide pressure. And as far as I can see, in Peterhof water is on the top, so it was much easier. But in our case it was a challenge, so it was logical, that it was computerised.

Victor Cageao Santacruz: In the case of La Granja we have the luck today. During previous centuries - 18th, 19th, 20th we have the luck of having all the set complete, the set of the 18th century. So we work like they did in the 18th century. We have no automation except one fountain. The Baths of Diana can be automatic if we want. It was an interesting project, and now it can function with both automatic and 18th century systems. But it is true, our reservoirs are at the top and gravity is a solution for us.

Elfriede Iby: I'm just interested. In our case I figured out that there are a lot of renovations or interventions that have been done in the 20th century. We do not even have historical systems which survived. So, in your case, in La Granja or in Versailles, were there any interventions? Our historical basins were just destroyed, I mean, we have the bottoms of the basins, they were covered with cement and there were just a few fountains. So there was no need to keep the cement surfaces of the bottom and we substituted it with for example polyester basins, because it's easier

for the further maintenance. So we couldn't reconstruct them, because we always have to consider what was done until nowadays.

Victor Cageao Santacruz: You are right, for example, we are working with different criteria for the big works we are projecting. For example, now we are working with our Great Cascade, and it's difficult for us to have equilibrium between the old solutions and old facilities and the new elements. And we are working on a project of the Cascade with both old and new technologies. As I've said in the morning, it is very important, we worry about this project: we have a lot to do, but we don't have enough money for the restoration of the Great Cascade. So the president and the manager of the National Heritage are now trying to work with companies to raise funds, but we do not have a solution yet.

Question: How do you preserve the knowledge? Because it is very important to keep the younger generation knowing how things work. So, do you train people in your palaces?

Luis Vallejo Velasco: Knowledge passes from one generation to another. A very-very good plumber in general can be not so good at working in La Granja, so it is necessary to study with the older generation. But there is nothing written, there is no compendium written about the knowledge of the plumbers. You can read a lot about the history of La Granja and the history of the fountains of La Granja, but not so much about the functioning of the fountain system. Before I became a general manager of the fountains I was a plumber, and my father was also a plumber. It is a normal situation in the National Heritage of Spain. There were a lot of families that have been working for the royal palaces for years. But now the situation is changing, so it's a challenge for us, because in Spain (and I think in your countries also) after the crisis of 2008 the number of employees of the National Heritage is going down. So, in La Granja and other Royal Palaces we have the number of plumbers, carpenters and other workers reduced. So we have to work with external companies, and it is difficult, because people change all the time.

Elfriede Iby: I also thought about it. Specialists are not staying at one site, in one company anymore. And just telling the knowledge is not enough anymore. And we have so many technical and digital services that we can document the steps of maintenance, of changes, whatever. So it would be better to keep this knowledge written, because we don't have any guarantee that knowledge will be transmitted orally and be kept for a long term period.

Victor Cageao Santacruz: Yes, until now we were working that way, but I think for the future it is necessary to record this knowledge.

Elfriede Iby: We always have problems with the lack of sources, lack of records.

Luis Vallejo Velasco: I'm very proud of my work. Being a plumber in La Granja is a special work. But we have to work for the future and we have to enter the 21st century with a different approach to work. We have to record, to write in order to provide the knowledge transfer.

Marta Boguta: I have a question about climate change, because at Lazienki we have fountains, ponds and canals, and we have to pump water to keep the landscape. And each year we pay more for the water, so we are thinking about alternative sources of water. So, maybe you have some experience? We thought about underground wells, but our underground water is too cold, and it wouldn't be good to keep biological life in our ponds. We also thought about rain water, but we haven't found a solution, because we have problems with tanks that should be hidden somewhere in a monumental garden and it is quite difficult. So, maybe you have some experience?

Elfriede Iby: Since we automated our system we reduced the volume of water for 20%, because irrigation now is automatic. And it stops when it's not necessary, and we also irrigate during the evenings, during night time when it is not very hot and the water doesn't evaporate. And it is also a contribution to the climate challenge.

Victor Cageao Santacruz: We do not have such a problem, because the system was already in the 18th century, the reservoir of La Granja is enormous, it has a lot of water for the operating of the fountains. But the sea is not a reservoir only for La Granja, part of the water is used today for the normal consumption of the inhabitants of La Granja and they want to use this water, because it is very pure. And we have to be very careful with our reservoir. This year, for example, we had no problem with functioning during all the summer, but at the end of June we had to stop the operation of the fountains. Not because of the fountains, but because of the village. So, it is a problem. Another problem related to climate change was a serious fire in the mountain forest. There was a possibility that the fire could reach the gardens. Fortunately there was no wind. Now in Spain it rains a lot, and all the ashes of the fire came through the canals and we cannot let this black water inside the sea. Not only for the fountains, but also for the village.

Sergio Gorjao: I would like to know if the hydraulic system in your palaces is just for palaces? Because in Mafra we don't have this kind of fountains, so monumental. In the original projects there were fountains decorating the gardens, but they were not built. But the system was used to supply water to kitchens and toilets in the palace. And it's interesting, because this system was used even 8 years ago, and then there was a law that prohibited using this water. And now our system is in danger, because we don't use it anymore.

Elfriede Iby: In our case we still use the historical pipes system. It is about 40 kilometers and was developed during the time of the monarchy. And what we are

just doing is partly renewing tubes to new ones, because they can break. And the water was mainly used for gardening, for sprinkling, maybe also for the kitchen. This is not recorded. But drinking water we get from the public water supply.

Visits

The presentations' session (on Thursday) has been completed with different technical visits.

- Guided tour to the Museum of Fountain Craft and the Grottoes of the Grand Cascade
- Guided tour to the sites of the Peterhof fountains water supply system
- Guided tour to the Lower Park.
- Tour to the hydraulic engineering constructions of Oranienbaum.
- Visits to the museums of Oranienbaum

The technical visits allowed participants to exchange with the team of Peterhof and to discover the specificities of the hydraulic system of Peterhof. It served as basis to pursue discussion.