

Paris city of water. Preparation for flooding at the National Library of France

English translation of the original paper “Paris, ville d’eau. Préparation à une crue à la Bibliothèque nationale de France (BnF)”

Translated by: Céline Allain, Département de la conservation, Bibliothèque nationale de France, Paris, France.

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Céline Allain

Département de la conservation, Bibliothèque nationale de France, Paris, France.
E-mail : celine.allain@bnf.fr

Cécile Descamps-Filiatre

Département des moyens techniques, Bibliothèque nationale de France, Paris, France.
E-mail : cecile.descamps-filiatre@bnf.fr



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Abstract:

Paris has been hit by two major floods successively in June 2016 and January 2018, which made the Seine water level rise for about six meters and burst some of its banks. With two sites placed right next to the river Seine, François-Mitterrand and Arsenal sites, the national Library of France was caught up at the frontline of the ‘battlefield’ with water. The Library management decided to close the François-Mitterrand and the Arsenal sites to the Public, and to implement the flood risk prevention plan. For the program “Forward thinking to lessen the effects of disasters”, the paper focuses on the description of the specific risks and the flood means of protection, how they are designed and maintained.

Keywords:

Flood, vulnerability, risk, BnF, protection

The challenge of a flood of the river Seine may come as a surprise, but Paris has been hit by two major floods successively, in 2016 and 2018, which made the water rise so high that flood risk prevention plans had to be implemented. In June 2016, the flood wave reached 6.07 meters on the Austerlitz scale. This caliber of flooding occurs roughly every twenty years.

Seine is a river with a moderate and regular flow. But when its tributaries, Marne and Yonne rivers, are flooding simultaneously, the Seine overflows. Although these episodes are uncommon, they punctuate the city's history. The most important flood was in 1658 when it reached 8.81 meters high. First related to magical phenomena, floods were accepted as an ailment with no cure. They were not precisely described until the 17th century when three important floods occurred successively in 1649, 1651 and 1658. The historical rising that serves as a point of reference today is the flood of 1910 that reached 8.62 meters on the Austerlitz scale. The receding started after 9 days of flooding, and lasted 35 days.

Meeting this recurrent threat, authorities have taken measures. Works have been carried out in the city and above. There is a legal instrument, the Plan for Flood Risk Prevention (PRFP) that aims at reducing the sensibility of the stakes involved in Paris. A specific provision of the PRFP imposes on public service organizations situated in the flood plain to have a flood protection plan. This plan should demonstrate to the administrative authorities the achievement of a diagnosis of vulnerability and the development of an action plan. Stipulated by a prefectural decree on 17 June 1998, the PRFP of the city of Paris has been approved in 2003 and revised in 2007. The European directive 200/60/EC of 23 October 2000 defines a strategic framework for water policy and sets out an obligation of results.

The national Library of France initiated its flood protection plan in 2003 with the first diagnosis of vulnerability for three of its sites: François-Mitterrand and Arsenal situated in the PRFP's perimeter and Richelieu outside the PRFP's perimeters but likely to be affected by a flood. For IFLA's program « Forward thinking to lessen the effects of disasters », the BnF proposes a presentation of the means of protection to avoid water discharge in case of a flood. The article focuses on the risk assessment, and the physical means of protection, their design and maintenance.

1 LEGAL AND METHODOLOGICAL FRAMEWORK

The PRFP of Paris covers the prevention of flood damage from overflowing of the river with water surging at 1910 recorded levels. But other issues can occur, including:

- Flooding of the basement due to the rising of the groundwater tables. Water infiltrations are facilitated by the porosity of the walls, cables routes or pipes;
- Flooding with sewage as a consequence of a burst pipe or the saturation of the drainage system;
- Power shortage involving the loss of key functions and, as a result, the evacuation of the public and the staff members.

The PRFP consists of the applicable regulatory requirements: the Regulation itself and a zoning map advising the relevant geographical areas, the nature of the hazardous phenomena and their consequences. For the flood prone arrondissements, three zones are distinguished:

zones prone to the overflowing of the river, zones prone to flooding of the basements, zones prone to power shortage.

The Flood Protection Plan of the BnF describes the technical facilities, specifies the early warning systems at all levels for each site, the organization in case of a flood, and the measures of protection of the buildings. This document is drafted by the Department of the technical resources, responsible for the building management. The Emergency Preparedness and Response Plan for the collections is drafted in a separate document, by a coordinator affected at the Conservation Department. This document consists of different scenarios of securing the collections according to different levels of flooding. It is to be triggered by the crisis management cell. Since 2016, a monitoring committee, headed by the safety officer, meets several times a year with the Department of technical resources and the Coordination of the Emergency preparedness and Response plan to follow up on the developments of the flood protection plans.

2 ADAPTATION AND ACCEPTABILITY OF THE RISK

According to the PRFP, François-Mitterrand and Arsenal sites are located in a zone prone to a flood by overflowing of the river, rising of the groundwater tables, and power shortage. The Richelieu site would be vulnerable to power shortage only.

The Louviers Island in the Marais is protected from the Seine since 1843, when a high embankment was constructed, the quai Henri IV. This is where is located the Arsenal Library, hosted in an historic monument dating from the 17th century, l'hôtel du Grand Maître de l'Artillerie. The Library has a collection of thousands of manuscripts whose history is closely tied to that of the monument: this is where the Marquis de Paulmy kept his own library, composed in 1775 of 60 000 items. Sumptuous interiors kept from the apartments of the 17th and the 18th centuries are partly classified as historic monument. This is why in the 1960ies, the basement was the only place where a repository could be accommodated. Three linear kilometers of precious documents are still kept in this repository. The lowest level of the repository is 33.59 meters NGF. Although the basement has no specific protection, there is no record of a flood in 1982 when the water reached 33.5 meters NGF.

In the 90ies, the accommodation of the very big library in the 13th arrondissement is an opportunity of developing a neighbourhood project on a large space close to the city center.

In this space along the Seine banks, the BnF covers an area of 7.5 hectares. The complex is composed of 6 parts with 4 high-rise buildings, a podium made up of 7 basement levels, a forecourt, an interior garden and a three levels car park. Repositories are distributed in the towers (from the 8th to the 18th floor), and in the podium over 4 stories. The lowest level is 20.50 meters NGF, a few meters below the groundwater table whose level fluctuates between 22.50 meters and 29.50 meters NGF. The podium is thus in permanent contact with water. The building is made watertight by a 1 050 meters long wall made of concrete that rests on a watertight geological disposal, and runs along the whole perimeter of the building. With a height reaching 30 meters, it rises the level reached by the 1910 flood + 60 cm. This 65 cm thick wall provides the core protection against water. Seals, referred to as Water Stop, ensure the leakproofness of the junction of each panel of the wall.



1 Concrete wall covering the perimeter of the building



2 Details of the concrete wall

Dewatering wells and rain water collection systems were created along the construction of the building. These pits are connected by a drain channel that runs around the interior garden. In the case of a flood, this network provides empty areas suitable for collecting the potential influx of water. This network is thus crucial for the protection of the site. The division of space inside the building also contributes to the mitigation of risks for the collections, repositories being separated from the concrete wall by large corridors.

Richelieu, the historical site of the BnF is currently under renovation. It has not been affected by the 1910 flood neither by a surface flooding nor from the groundwater table. But a survey conducted in the 30ies found that in case of a 1910 flood, the groundwater table could reach 32 meters NGF. Aware of this vulnerability, the architect Roux-Spitz (1888-1957) constructed a casing around all the spaces he built in the basement under 33.50 meters NGF. Several recent surveys ordered by the department of the technical resources at the BnF have confirmed the possible rising of the ground water up to 32 meters NGF in the older basement. These surveys have confirmed the stability of the structures and the well preserved state of the casing built by Roux-Spitz. Theoretically only the basements built in the 19th century are prone to flooding if the water reaches the 1910 level. The Richelieu site is not included in the PRFP. Within the framework of the renovation, all repositories of the basement will be reused.

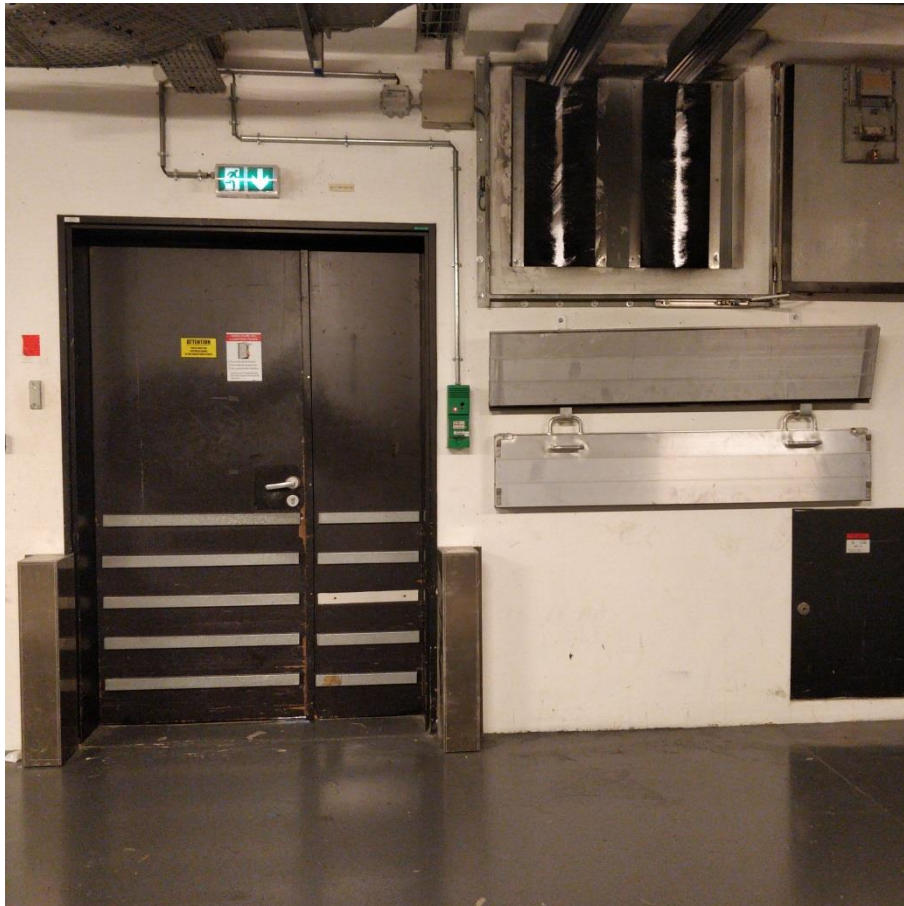
3 MITIGATION MEASURES AND MEANS

In a mitigation strategy, the most essential part is the full understanding of the nature of the threat, because dangers vary from one building to another, and there is no ready-made solution. The risk of damage from overflowing of the Seine is excluded for all the sites of the BnF up to the height reached in 1910. But several different waterways have been identified, including the rising of the groundwater table, sewage, car park entrances, and ventilation shafts. In order to preserve the physical and functional integrity of all sites, the Department of technical resources of the BnF has provided means of self-awareness and protection intended on the one hand to mitigate the devastating effects of a flood on the housing, and, on the other hand to ensure minimum functional conditions in a degraded situation. These means would be implemented successively as the water rise.

Flood forecasting is indispensable to avoid damage on the housing or the collections. The Seine floods are slow and therefore foreseeable thanks to a substantial lag with the rainfalls before them. The temporal dimension is a crucial component of the BnF flood protection plan. Alert thresholds are determined in accordance with the flood level and actions taken by the PRFP; priority measures of monitoring, protection, evacuation to take are defined for each site. To complement the global flood alert system, the BnF has surveillance capabilities to take measures adapted to the on-going situation. Hence piezometers have been installed to monitor the groundwater. The François-Mitterrand site is equipped with manometers to measure at various points the water pressure variations on the concrete wall in the basement. As they are connected to the Centralised Technical Management system, potential reinforcements or repairs can be done in the event of an alert. Different levels of means are defined to protect the collections from flooding: prevent water from entering the building, avoid direct contact of water with the collections, and withdraw the water. Plug drains are prepared to be put in place in the event of an alert to prevent sewer back up. These are inflatable pipe plugs to be inserted inside the pipes. Each pipe plug is kept in a referred box with its compressed air cylinder. Car parks are equipped with watertight doors. To protect

repositories from potential water inflow, cofferdams are prepositioned close to the door access to the repositories. This equipment is composed of several elements:

- Guide ways in tempered steel ;
- 31 aluminum interlocking panels, 50 cm high, with full-length handles to provide fast handling;
- Compartments for the storage of the interlocking panels, 60 cm high, fixed near the doors.



3 Cofferdams prepositioned near the doors leading to the repositories

Where cofferdams could not be installed, floodsax will help derive the water and avoid the water penetration inside the repositories. Pumping stations for waste water and the pumps of the rain water collector systems would ensure the evacuation of excess water from the crawl space to the outside. These high volume pumps have a cumulated capacity of 1 600 m³ per hour. A set of mobile pumps powered by a generator completes the equipment.

Fallback spaces have been identified on all sites to keep prioritized or threatened collections in a safe place. Folding crates with lids are kept exclusively for anticipatory relocation of collections in the event of an alert, including a flood. At the Arsenal library, the collections kept in the basement have been rehoused in permanent boxes to hasten the relocation if needed. These boxes, made of stiff cardboard allow moving collections half shelf by half shelf. Open at the front, they do not restrict the retrieval for communication purposes.



4 Boxes to facilitate the relocation of collections in an emergency

Avoiding the retrieval one by one and the re-boxing during the alert phase, valuable time is thus gained, and handlings are reduced. The 2016 and 2018 floods have given us the opportunity to test and estimate the time required to move the collections, either by the internal staff or carriers. In the event of a flood alert, the decision of relocation can be taken according to the water ground table fluctuations and the time required for relocating the collections to a safe place. But this can only be achieved provided that power is supplied for the safety of the people and for the use of a lift, essential to reach the fallback spaces in the upper floors. A power generator complements the equipment, and an on-call duty is included in the contract with the lift maintenance.

Making the electricity supply in the event of a flood reliable on every site is crucial to ensure the monitoring of the building and to pursue the requisite interventions. Priority of electric supply given to lighting, pumping and air conditioning is provided by generators.

In order for those means and measures to be effective in the event of a flood, a regular maintenance of the buildings and equipment is required. The water tightness of the joints of concrete wall in the basement of François-Mitterrand is regularly renewed. The last campaign dates back 2013. The Department of the technical resources has established a multi-year program of inspection and cleaning of the water networks in the basement. Periodic inspections and tests are also conducted to ensure the availability of all means in the event of a flood.

VULNERABILITY, AN EFFICIENT CONCEPT ?

The idea that all the means of protection are not the only response to a risk of flooding is well established at the BnF. According to the Department of technical resources it would be difficult to face exceptionally heavy flooding higher than in 1910, or a burst pipe during a flood. The interdependency of the inner measures of protection with exterior factors and the security of the people has been emphasized: the site closure to the public and the evacuation of the staff are partly determined by the power failure and the fitting of the pipe plugs. In this context, relocating the collections must be anticipated several hours before, not the penetration of water inside the building, but before power failures and the evacuation of the staff. The decision of relocating the collections may be considered as prejudicial to public interest especially as it must be taken in a moment when nobody can be sure that the water will rise to critical levels. All activities are not affected in the same way none to the same extent. Establishing a typology of disorders would help demonstrate the grades of vulnerability in terms of direct damages.

The mitigation of the effects of a flood is more efficient in the course of a mid-term to long term program that includes measures to reduce risks in projects that directly affect the collections (relocation, renovation works ...). With no structured procedure requesting the explicit consideration of impacts of disasters in new projects, different interests might obstruct actions to reduce the collections vulnerability. But at the scale of a project, it is often difficult to resolve all problems at the same time.

To lessen difficulties for which measures would produce effects only in the long-term, the BnF has reinforced its crisis management capacity. In its scheme, all stakeholders are represented, including people in charge of the collections and the coordination of the Emergency and Response Plan. The decision-making regarding the collections results of a consultation that allows an appropriate consideration.

Acknowledgments

This paper is inspired by the surveys and the documentation produced by the Department of the technical resources of the BnF, in particular by Jean-Luc Durand and Michel Vial who produced the first version of the Flood Protection Plan of the national Library of France.

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