INITIATIVES POUR L'AVENIR DES GRANDS FLEUVES
INITIATIVES FOR THE FUTURE OF GREAT RIVERS

Synoptic sheets

Rivers of the world

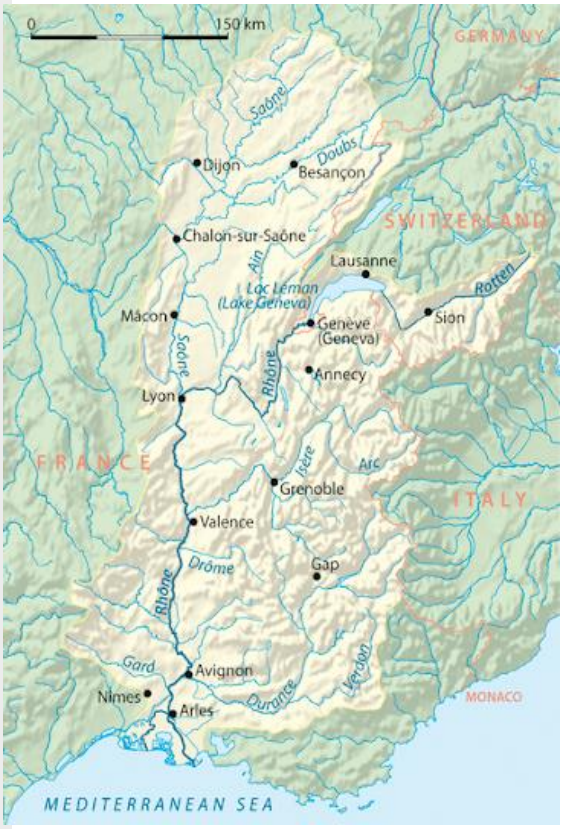
The Swiss Rhone

Initiatives
pour l'Avenir des
Grands Fleuves

The Swiss Rhone

Although the sources of both rivers lie in the massif of Saint-Gothard, the Rhone differs from the Rhine due to its impetuosity. From the Furka glacier to the delta of the Camargue, its course is marked by irregularities: from elbows to rocky gorges, flood plains to steep slopes. To prevent its floods and tame its course, human beings have always attempted to subdue it, though without complete success. Conscious of the danger it represents, the Swiss have for long tried to keep it at arm's length.

New challenges have arisen with climate change: the risks of rain and floods are increasing, the glacier may disappear and the ecosystems around it are weakened. Relations with the river are evolving to maintain the services it renders, reconcile human beings and water, and find the economic, environmental, urban and societal conditions of an alliance capable of succeeding in the future.



The origins

The source of the Rhone - *Rotten* in Swiss – lies in the glacier of the same name, on the Furka mountain in the Saint-Gothard massif at the eastern end of Valais, at an altitude of 2,300 m. This massif is also the source of the Rhine, another large river of Western Europe.

The Rhone then crosses the canton of Valais for a distance of 164 km, before flowing into Lake Geneva, the largest lake in Western Europe. On exiting Lake Geneva, the Rhone flows for another 25 km before crossing the border and entering France, where its ends its course in the Camargue delta and flows into the Mediterranean.

The Valais has a sunny climate and is the driest region of Switzerland, resulting from the configuration of the relief of the local terrain. Thus the Rhone plays a fundamental role in this part of Switzerland, as almost all the towns of the canton (Brig, Sion, Martigny) lie on its banks.

Technical sheet

Length: 812 km including 290 km in Switzerland

Watershed: 97,800 km² (including 7,800 km² in Switzerland)

Hydrological regime: 1/In the Swiss Alps, a *glacial regime* characterised by low water in winter and high discharges when the ice of the glaciers melts in spring and summer. 2/ In the south, a glacial-nival regime with a maximum discharge between May and July, caused by melting ice and snow. 3/ In northwest and southeast Switzerland, a *nival-pluvial regime*: two peak discharges, one in the spring as the snow melts and the other in autumn due to rainfall.

Average discharge: 182 m^3/s at the entrance to Lake Geneva and 251 m^3/s at its outlet. The Arve, a tributary of the Rhone, has a discharge of 80 m^3/s.

Average rainfall: 759 mm/year in Switzerland

Swiss cantons crossed: Geneva, Vaud, Valais

Main tributaries in Switzerland: Vispa, Grande Eau, the Veveyse, the Venoge, Versoix, the Arve, the Allondon

Initiatives
pour l'Avenir des
Grands Fleuves

The Swiss Rhone

Developing the river, From the Middle-Ages to today

History of a ravaging river

At the beginning of the Middle Ages, the Swiss Rhone was slow and not very dangerous with a large number of braids and no main channel. These braids flowed between tree covered dunes, meadows and fields. **A landscape totally different from that of today, whose biodiversity was constant within a bucolic environment**. A peasant population settled in the plain, tending cattle, collecting wood and straw, and living off an agropastoral economy. **The river and its surrounding population maintained good relations.** To protect themselves from the potential angry outbursts of the Rhone, the inhabitants built dikes by heaping gravel and stones, intertwined branches and barriers with stakes.

The last part of the Middle-Ages in the northern hemisphere saw the beginning of the ***Little Ice Age*** *(from 1350 to 1860)*, marked by heavy rainfall and the considerable expansion of glaciers. That of the Rhone reached a length of 10 km in 1850. **The Rhone became increasingly dangerous and unstable.** The rivers and torrents transported sediments into the bed, raising it. This led to often devastating floods, especially since the Rhone often formed a municipal boundary. During a flood, a terrain cultivated by the inhabitants of a municipality could become inaccessible and then be taken over by another municipality, generating numerous conflicts. Floods could also damage and destroy entire harvests.

The population sought means to tame the river. The flood of 1545 led the Federal Assembly to consider adaptive measures to protect the pastures and the main road located downstream of La Morges, a Swiss river in the canton of Valais. **In the middle of the 16th century, the population began to implement its knowledge of river dynamics and the knowhow it had learned**. However, the human and financial resources proved insufficient to carry out major works to build flood protection dikes.

The "corrections" of the Rhone

The flood of October 2000 at Saillon, in the canton of Valais. Source: Wikiwand. Correction of the Rhone upstream of Lake Geneva.

The economy of Valais continues to suffer from the overflows of the Rhone: traffic is interrupted, goods transport is heavily affected and travel becomes difficult. **Two events during the 19th century sealed the fate of the river.** In 1815, the canton of Valais joined the Swiss Confederation which wanted to open out to Italy. A project to build a railway line between them led to the first major dike works. **So, from 1860 onwards, the people of the canton joined together to master the river.**

Several development projects were undertaken on the Rhone. The first two phases of "correction" works were aimed at preventing floods, progressively breaking the links between the river, the population and the natural environment. **It was not until the 2000s that the paradigm changed from "living next" to the river to "living with" it.** The 3rd correction project, which began in 2009 and is still in progress, plans for the global and integrated management of the Rhone, that's to say flood protection, the restoration of natural habitats and the reappropriation of the river by the surrounding population.

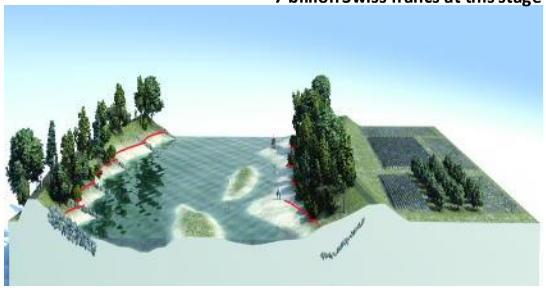
The projects to correct the Rhone

3rd CORRECTION PROJECT: DEEPENING AND WIDENING

+ Global project from the source to Lake Geneva: 160 km of river to be developed.
+ Strengthen fragile, unstable and poor quality dikes.
+ Lower the riverbed and widen it depending on the sections and safety needs - nearly 800 additional hectares planned to carry out the project.
+ Recreate a link between the population and river by developing spaces for leisure and relaxation.

Since 2009

7 billion Swiss francs at this stage

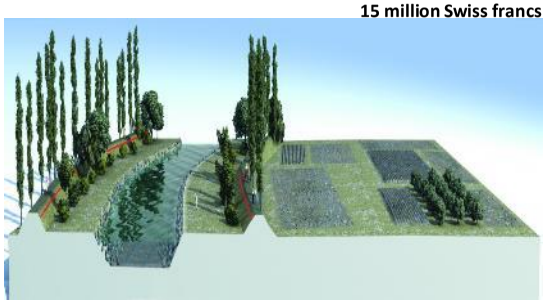


2nd CORRECTION PROJECT: RAISING THE DIKES

+ Keep the dikes of the first correction, raise and strengthen them.
+ Narrow the river bed by linking the heads of groynes and sections of riprap to increase bedload velocity.
+ Develop the exploitation of gravel quarries along the river to reduce deposits of materials and avoid raising of the bed.
+ A river landscape that remains natural but with the development of industrial and residential areas.

1934 - 1961

15 million Swiss francs

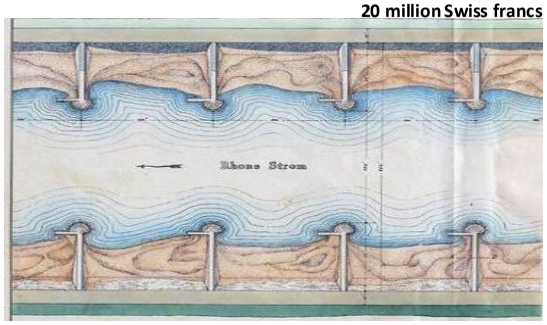


1st CORRECTION PROJECT: DAMMING

+ Build two parallel dikes of rockfill and earth to form a new bed, secure the roads and land on the plain.
+ Dry the marshes and clear large areas to make arable land available to the population: development of intensive agriculture.
  The consequences were:
  - × The formation of marshes during floods;
  - × The absence and lack of drainage increased flood risks.

1863 - 1894

20 million Swiss francs



The Swiss Rhone

Harnessing the power of the river

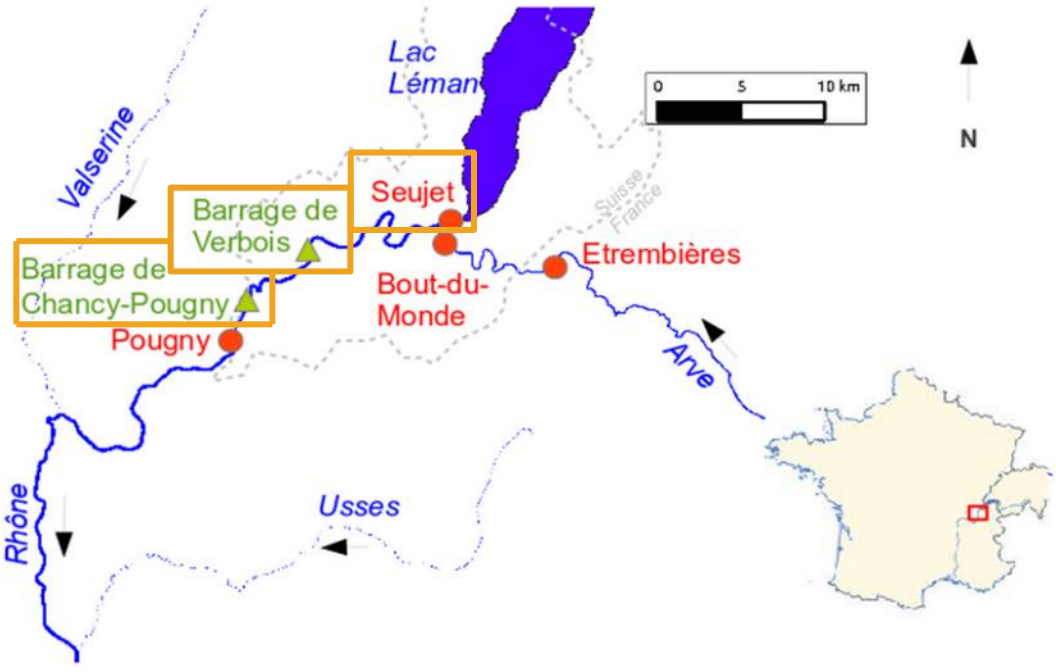
As early as the Middle-Ages, human beings wanted to harness the river's hydraulic force and water mills multiplied in the canton of Geneva in the 15th century. In the middle of the 19th century (1841-1843), Jean-Marie Cordier, a French engineer, invented a new machine that was installed in the bed of the Rhone. **The mechanical force of the water used up to then to drive pumps and mills was also used to produce electricity using a generator.** Switzerland, with its many mountains and rivers was at the vanguard of the development of hydraulic installations.
Hydroelectricity dams were built in the cantons of Valais – which had the most propitious terrain – and Geneva.

The Federal Council's current strategy determines strong development of hydropower as one of its priority directions, by about 10% from now to 2050. The contribution of Valais to this federal goal involves increasing cantonal hydroelectricity production by about 250 GWh/year from now to 2030.

<u>In the canton of Geneva:</u>
In 1882, Theodore Turrettini built the plant of Coulouvrenière in Geneva, composed of 18 turbines driving two hydraulic pumps. It was the first plant to use pressurised water to supply a huge network of industrial sites and the most powerful run-of the-river development in Europe at the end of the 19th century. **Hydroelectricity in Geneva began at the Pont de la Machine in 1887.**

Demand for electricity rose after the Second World War. **The Services Industriels de Genève (SIG)**, originally a private electricity and gas company when founded in 1896, became an independent entity under public law in 1973.

The SIG operates 3 hydropower plants in the canton of Geneva covering 95% of the city's consumption.

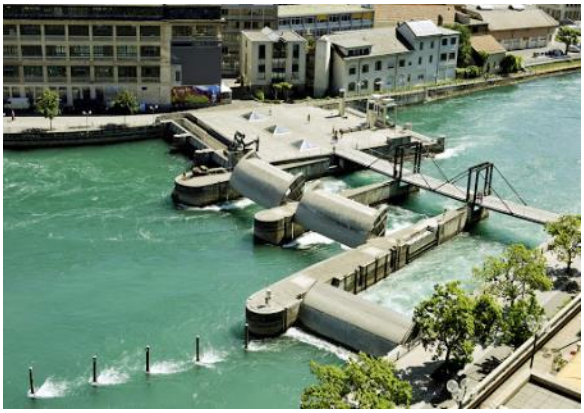


Source: Launay, M., Le Coz, J., Diouf, S., Camenen, B., Thollet, F., & Coquery, M. (2019). Re-evaluation of average inflows of suspended materials from the Arve to the Rhone. White Coal, (2), 89-100.

Initiatives
pour l'Avenir des
Grands Fleuves

The Swiss Rhone

- **Seujet Dam,** built between 1987 and 1995. It is used to produce electricity, modulate the discharge of the Rhone and regulate the level of Lake Geneva. **Its annual production is low at 25 GWh**, i.e. 1% of the consumption of the inhabitants of Geneva.



- **The works on Verbois dam** began in 1938 and ended in 1943. This dam has four gates, one plant with two lateral dikes and four Kaplan turbines, giving it a **high energy output despite the variations of discharges throughout the year**. It is a run-of-the-river plant, that's to say with a reservoir with a small volume of water. However, thanks to the modulation of the discharge of the Rhone at Seujet dam, the site of Verbois can produce more electricity during periods of high demand. **Annual production is 466 GWh,** representing 15% of the consumption of the population of Geneva.

- **The French-Swiss dam of Chancy-Pougny** was built between 1921 and 1925. It is operated by the Société des Forces Motrices de Chancy-Pougny (SFMCP) whose shareholders are the SIG and CNR (Compagnie nationale du Rhône). It is also a run-of-the-river dam**. Its annual production is 250 GWh**, i.e. 8.3% of the consumption of the canton's consumption.

In the canton of Valais:

Valais has an annual hydroelectricity output of 10 billion kWh, representing between 25 and 30% of Swiss production. About 95% of this energy is produced by 46 large hydropower plants (more than 10 MW of installed capacity), characterised by high heads and a large storage capacity. The remainder comes from 121 small plants. **5 installations are run-of-the-river plants on the Rhone (Ernen, Mörel, Massaboden, Chippis and Lavey).**

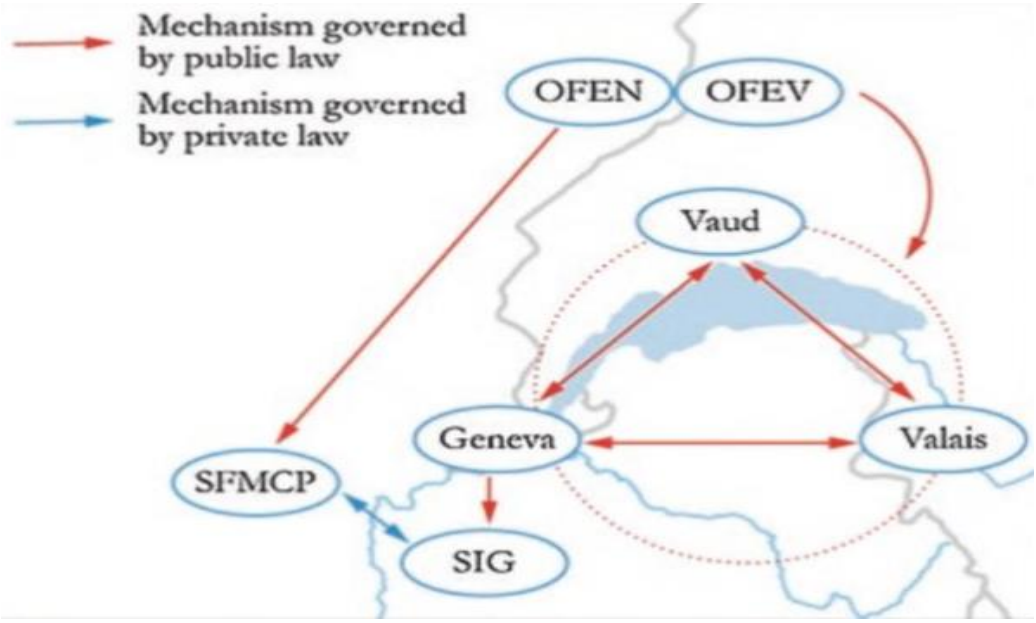
The Swiss Rhone

Governance and international cooperation

Governance

Upstream of Lake Geneva, the Rhone is the property of the Federal Office of the Environment (OFEV). Downstream of Lake Geneva, it is the property of the Canton of Geneva and is managed by the Services Industriels de Genève.

The structure of the river's governance in Switzerland is mainly based on legal bodies subject to public law and is characterised by the intervention of a large number of actors.



Source: Bréthaut, C., & Pflieger, G. (2019). Governance of a Transboundary River: The Rhone. Springer.

- **Federal structures**

1. The OFEV (Federal Office of the Environment) is the body responsible for ensuring that the activities linked to operating natural resources (water, air, soil, forests) comply with the sustainable development goals that have been determined relating to preserving biodiversity, conserving the quality of landscapes and carrying out Switzerland's international environmental policy. In addition, the OFEV examines and attributes financial aid in the form of commitment credits to river development projects.

2. OFEN (Federal Energy Office) is a centre reporting to the Federal Department of the Environment, Transport Energy and Communication (DETEC). It deals with all issues relating to energy supplies, and ensuring compliance with safety standards for the production, transport and efficient use of energy.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Office fédéral de l'environnement OFEV

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Office fédéral de l'énergie OFEN

Initiatives pour l'Avenir des Grands Fleuves

The Swiss Rhone

Governance and international cooperation

Governance

- **Cantonal structures**

The presence of the cantons is strong regarding governance, both in the definition and application of the Inter-cantonal Act relating to the correction and regulation of the waters of Lake Geneva, and in their position as delegators of concession contracts for the management of regulation structures.

1. **The canton of Geneva occupies a key position**. It is situated between, on the on hand, the concerns of the actors located upstream of Geneva (cantons and municipalities bordering Lake Geneva) and, on the other, the actors located downstream. It is the majority shareholder of the founding capital of Services Industriels de Genève (SIG). It represents the authority that determines both the terms of the concession contracts for the dams of Seujet and Verbois and the missions assigned to the SIG.

2. **The canton of Valais lies at the head of the river's watershed. The Environment Service (SEN) of the canton controls the quality of the canton's water**. It works in close collaboration with the Federal Office of the Environment (OFEV) to ensure the drainage of hydroelectric installations and carry out cleaning and flushing operations to reduce their impact on the environment.

3. **The cantons of Vaud, Geneva and Valais collaborate in the framework of the 3rd project to correct the Rhone**: widening and deepening the river bed and consolidating the dikes to increase the discharge of the Rhone. The General Direction of the Environment ensures that the project conforms to Vaud's policies relating to energy and the climate, environmental protection, the preservation of resources and natural heritage.

- **Industrial actors**

1. The Services Industriels de Genève (SIG): a semi-public company founded as an independent body subject to public law responsible for the operational management of the installations. **The SIG produces electricity, distributes heat, gas and water, and manages waste and telecommunications**. Although the company is wholly owned by the public sector - 55% of the shares belong to the State of Geneva, 30% to the City of Geneva and 15% to the municipalities of the canton of Geneva, it nonetheless operates as a traditional industrial entity within a market partially open to competition. The SIG **works to achieve the objectives of both the canton of Geneva for a *"society at 2000 W without nuclear energy"* with a 35% reduction of annual energy consumption from now to 2035, and those of the Confederation (Energy Strategy 2050) to ensure that Geneva becomes the most energy efficient region in the world.**

2. The SFMCP (Société des Forces Motrices de Chancy-Pougny) is a joint stock company subject to Swiss law. The hydropower plant of Chancy-Pougny is located on the **hydroelectricity cascade between the installation of the SIG, upstream, and the plants of CNR downstream**.

Governance and international cooperation

International cooperation

1 – Sediment management

The Arve joins the Rhone between the spillway of Seujet and Verbois dam. This torrent is loaded with suspended matter (SM) of which around 500,00 tonnes a year are deposited in the reservoirs of Verbois and Chancy-Pougny. To avoid silting and the dangerous raising of flood water heights liable to threaten the lower-lying districts of Geneva, **sediment removal operations are carried out every 3 or 4 years, starting from Verbois dam, and are assisted by the French operator CNR on its structures on the Upper Rhone.** New management procedures that are better coordinated and more environmentally friendly have been implemented under the name "joint sediment management".

2 – Protecting the waters of Lake Geneva

The effects of climate change also require collaboration between France and Switzerland to preserve the lake's waters. **The International Commission for the Protection of the Waters of Lake Geneva (CIPEL)** – founded in 1963 and composed of experts, scientists and elected representatives of the French departments of Ain and Haute-Savoie and the Swiss cantons of Geneva, Vaud and Valais – have implemented an **Action Plan 2011-2020. It sets four strategic directions: the protection of wetlands, preserving the quality of water, the exploitation of the water of Lake Geneva and the combat against climate change** *(cf. Synoptic sheet on Lake Geneva)*.

The Swiss Rhone

The river tomorrow

Vanishing glaciers

Climate forecast models show that climate change will lead to the disappearance of Alpine glaciers by the end of the century. The catalysing factors are: the decrease in summer rainfall, the increase of winter precipitations, the reduction of volumes of snow. The Rhone glacier is currently losing from 5 to 7 meters in thickness every year. In normal climatic conditions, two thirds of its surface is covered by snow at the end of summer. However, this situation is far from being the case. Despite the use of white anti-reflection covers, the phenomenon of ablation – the disappearance of snow and ice on the surface of the glacier – is accelerating.

Disappearance of the Pizol glacier in Switzerland in 2019.

The melting of the Rhone glacier will have direct impacts on the discharge of the Rhone. The atmospheric warming of the Alps will modify the rainfall regime, with a reduction from 10 to 40% of summer rains, increase from 10 to 20% of winter rains, and a reduction of the maximum quantity of water due to the early melting of the snow mantle (Gabbi, J., Carenzo, M., Pellicciotti, F., Bauder, A., and Funk, M., 2014). This will **have direct impacts on the discharge of the Rhone,** especially with the occurrence of severe low flow episodes.

Dam lakes and alpine forests will also be affected. The melt water will no longer fill the reservoir lakes, leading to a substantial reduction of hydroelectricity production. As for alpine forests, essential due to their contribution to ensuring the quality of surface water and combating erosion, they will undergo the same effects caused by climate change. If alpine vegetation is reduced and becomes sparse, we will witness the acceleration of surface runoff and increased risks of erosion and sediment loads in rivers.

These changes will have other economic impacts. **Winters with less and less snow will lead to the progressive disappearance of ski resorts at medium and low altitudes**. Thus, it will be necessary to reconsider facilities for tourists. Moreover, in the canton of Valais, on the Rhone plain, strong heatwave episodes will make agriculture in the mountains difficult.

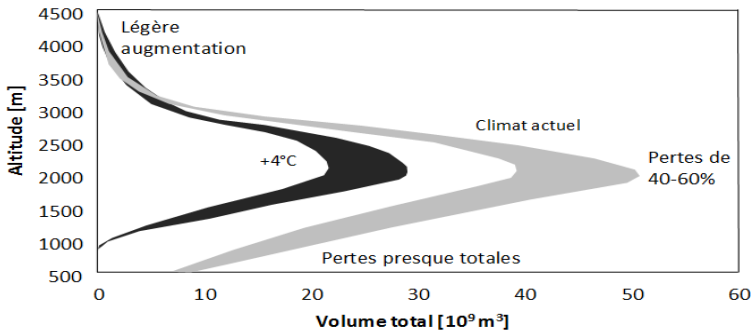
The Swiss Rhone

*The effects of climate change on melting glaciers**

To understand the phenomenon of ablation, it's necessary to understand the crucial role played by snow, an essential element in mountain hydrological systems. The seasonal nature, quantity and duration of the snow mantle have impacts on glaciers and influence peak flows in alpine rivers. The volume of snow is defined by multiplying the thickness of the snow cover and the surface area under it. In winter, the volume of snow is distributed as a function of altitude.

Scenario 1: For normal seasonal temperatures
Below an altitude of 2,000 m, the surface area is large but the quantity and volume of snow are low. Above 2000 m, the surface areas and terrain covered by snow and its volume are small, but the thickness of the snow mantle is considerable.

Scenario 2: For an increase in winter temperatures of 4°C
The duration of snow cover will decrease to 100 days between altitudes between 1,500 and 2,000 m, winter rains will no longer be sufficient to offset the effect of higher temperatures on snow cover. Although the changes will be minimal at high altitudes, there will be almost no snow at lower ones.



Distribution as a function of altitude of the seasonal maximum volume of snow in the Swiss Alps for the current climate (grey) and a climate with winters 4°C warmer (black).

The volume of a glacier is determined by the balance between the area in which snow accumulates and the ablation zone (melting of the glacier). Climate change modifies the thickness of the snow mantle, and the altitude of the isotherm. According to recent studies (Beniston, M., 2018), the surface temperatures of Alpine glaciers are close to freezing point. This means that an increase of the temperature above 0°C risks accelerating glacier melting. **Climatic models show that by 2100, 50 to 90% of mountain glaciers could vanish**.

*BENISTON Martin, B. (2018, June 27). The impact of climate change on Alpine snow cover and glaciers: consequences for water resources. Available on: https://www.encyclopedie-environnement.org/eau/role-glaciers-debits-fleuves-cas-rhone-alpin/

The Swiss Rhone

The river tomorrow

Protecting the river and its biodiversity

- **The different infrastructures on the Rhone have favoured the development of intensive agriculture, roads, and industrial zones.** However, these often pollutant activities that emit CO_2 have a considerable impact on the river. For example, between 1930 and 1976, at Viège in Haut Valais, the chemical and biotech company Lonza spilled from 200 to 250 tonnes of mercury onto the plain of the Rhone. This chemical element progressively accumulated in the sedimentary layers. Agriculture was also affected, since polluted sludges were used as fertilisers.

- **Other substances, such as micropollutants, have been identified in wastewater in Switzerland and France.** They are residues from agricultural, industrial and domestic products, like cosmetics, detergents and drugs. The State of Geneva, the Services industriels de Genève (SIG) and the conurbation of Annemasse have decided to invest €13 million to reduce by 80% the amount of micropollutants in the water treated. The two countries plan to link up two wastewater treatment plants, Ocybèle in France and Villette in Switzerland, where the wastewater will be treated before being discharged into the Arve and then join the Rhone. At the cantonal scale, **the STEP of Aïre operated by the SIG will also be used to treat the wastewater of Geneva and thus preserve the quality of the water of the Rhone**.

- **Preserving the fauna and flora.** The construction of dams can lead to disturbing the balance of aquatic species. The company SIG has therefore decided to equip its dams – at Verbois and Seujet – with **fish passes** allowing thousands of fish to swim upstream easily, and **wooden ramps to help beavers cross the Rhone to reach Lake Geneva.**

Fish pass at Verbois dam.

Wooden ramp for beavers at Seujet dam.

The Swiss Rhone

The river tomorrow

Buddleias, butterfly bushes.

Human and industrial activities have also had an impact on the flora. **Invasive exotic species - neophytes – threaten biodiversity, agricultural activities and human health**. In order to protect alluvial areas, various actors like the cantons, farmers, doctors and the municipalities, work together to prevent these neophytes from invading crops and proliferating. **For example, in the valley of the Allondon in Geneva, Buddleias, also called *butterfly bushes*, are regularly uprooted to allow sites to return to their natural states.** In recent years the valley has become the home of a large number of species including reptiles, butterflies and bats.

The need to strengthen cross-border governance

The Rhone is not immune to cross-border tensions, aggravated by the impacts of climate change. Strong interdependence between France and Switzerland regarding the water of the Rhone should give rise to a legal framework. Failing adapted legal instruments, management is often limited to punctual collaborations to solve specific problems, though without a global vision of the challenges.