1. Problematic

**Who:** KWO (Kraftwerke Oberhasli AG) hydropowerplant in the Berner Oberland

**What:** Releases its turbined water in the river Aare in Innertkirchen, creating hydropoaking

**Problem:** In order to lower the impact of the hydropower plants on the river and to respect the federal prescriptions: plan to construct a retention basin and a tunnel (initially 80’000m³), expectation 94’000m³ to mitigate the effects of hydropoaking

**Constraints:**
- Increasing rate (to limit the macrozoobenthos drifting)
- Decreasing rate (to avoid fish stranding on the gravel banks)

**3 cases studied:**
A) Simulation from 2009 to 2012 for two volumes:

<table>
<thead>
<tr>
<th>Volume</th>
<th>Increasing rate</th>
<th>Decreasing rate</th>
<th>Respect of the constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1: 80’000 m³</td>
<td>0.7 m³/s/min</td>
<td>0.14 m³/s/min</td>
<td>all the constraints respected at 95%</td>
</tr>
<tr>
<td>A2: 94’000 m³</td>
<td>0.5 to 0.7 m³/s/min</td>
<td>0.14 m³/s/min</td>
<td>all the constraints respected at 95%</td>
</tr>
</tbody>
</table>

B) Simulations for November only, with a constraint of a maximal outflow (20 m³/s) for fish spawning.

C) Algorithm with a bearing (German: Vorschwale) for both volumes (80’000 and 94’000 m³) to create a “warning” effect when the flow increases.

2. Methods

**I) Datasets and data treatment**

**Why:** To perform the simulation: need of the data of the water released by the turbines (Qturbi) and the residual Aare from 2009 to 2012.

**How:** Values were missing from March to November: extrapolation from downstream.

**II) Design of the algorithm**

- Starting from the algorithm developed by Martin Bieri during his thesis at EPFL
- Respect the environmental constraints
- Manage to keep a minimal stored water volume (Vtot = 12’000m³)

**III) Choice of the bearing parameters**

- Determine the optimal parameters corresponding to 4 different bearing’s limits: 2 in summer, 2 in winter.
- By iterations, we looked for the parameters allowing the highest number of bearings to happen.

3. Results

**A) First case : 2009 to 2012**

<table>
<thead>
<tr>
<th>Volume max</th>
<th>Increasing rate</th>
<th>Decreasing rate</th>
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</tr>
</thead>
<tbody>
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</tbody>
</table>

**B) Second case : November**

<table>
<thead>
<tr>
<th>Volume = 94’000 m³</th>
<th>Without constraint</th>
<th>With Qmax = 20 m³/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q = 20 m³/s excess ratio</td>
<td>92 %</td>
<td>37%</td>
</tr>
<tr>
<td>Ratio of events with Q&lt;20 m³/s for 12 hr</td>
<td>37.5%</td>
<td>91.4 %</td>
</tr>
</tbody>
</table>

The algorithm is able to increase significantly the number of events where Qout < 20 m³/s during 12 hours, respecting the other constraints at 95%.

**C) Third case : bearing (Vorschwale)**

<table>
<thead>
<tr>
<th>Vmax: 94’000 m³</th>
<th>Vtot: 12’000 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% increasing rate: 0.7 m³/s/min</td>
<td>95% decreasing rate: -0.24 m³/s/min</td>
</tr>
</tbody>
</table>

**Optimized parameters**

- Winter: 5 m³/s -> 8 m³/s, 14 m³/s -> 17 m³/s.
- Summer: 16 m³/s -> 19 m³/s, 29 m³/s -> 34 m³/s.

The problem of the decreasing rate could be avoided by using a Vtot volume of 15’000 m³, and we would have a decreasing rate at 95% of -0.14 m³/s/min.

4. Take Home Message

- **Algorithm**
  - Evaluate the outflow of the retention basin
  - Using 20 different possibilities
  - Based on the next 15-minutes value
  - Depending on several constraints
  - The results are quite good and promising for the future retention basin management with these 3 different scenarios
  - Doesn’t take several technical difficulties that could be encountered into account.

- **Retention basin:** great potential to reduce the impact of the hydropoaking on the environment