

CFD for the Hydropower Industry

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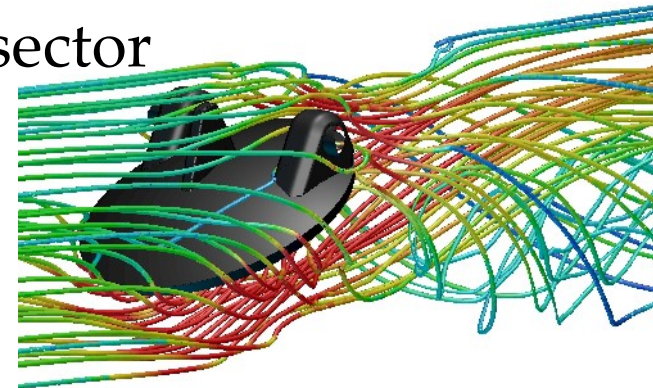
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 - Pumped storage power plant I
 - Pumped storage power plant II



F2E

- > 15 years experience in CFD for the energy sector
- Services:
 - Power Plants
 - CFD-analysis of e.g. steam valves
 - Wind energy
 - Turbulent wind loads in wind farms
 - Wind conditions in complex terrain
 - Hydro Power
- Located in Hamburg since 2008



Introduction

- Motivation
 - Increasing flood water and high tide events
 - Increased and changed use of systems (e.g. pump storage)
 - Increased safety requirements
 - Increased demand for renewable energy
- Standard allows for the modelling of hydrodynamics
 - Circulation, surge and downsurge, water hammer, waves
 - Hydrodynamic forces during movement of locks have to be taken into account
- Small scale model ↔ CFD



Introduction

- Basic conditions and major challenges
 - 2-phase-flow
 - Large span of dimensions:
 - river/reservoir (km) → gate/turbine (m)
 - Transient flow
 - Moving/sliding geometry
 - Compressible flow
 - Wide variety of data sources:
 - Airborne elevation data →

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Geprüft		Johann		
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River power plant I

Tasks:

- Lock gate closure
 - Water hammer
 - 1-D-analysis
 - Full 3-D-CFD
 - Swell on river (~0.2m freeboard)
- Optimization of power canal
 - Mass flow distribution at turbines
 - Velocity distribution across turbine inlet
 - Hydraulic resistance



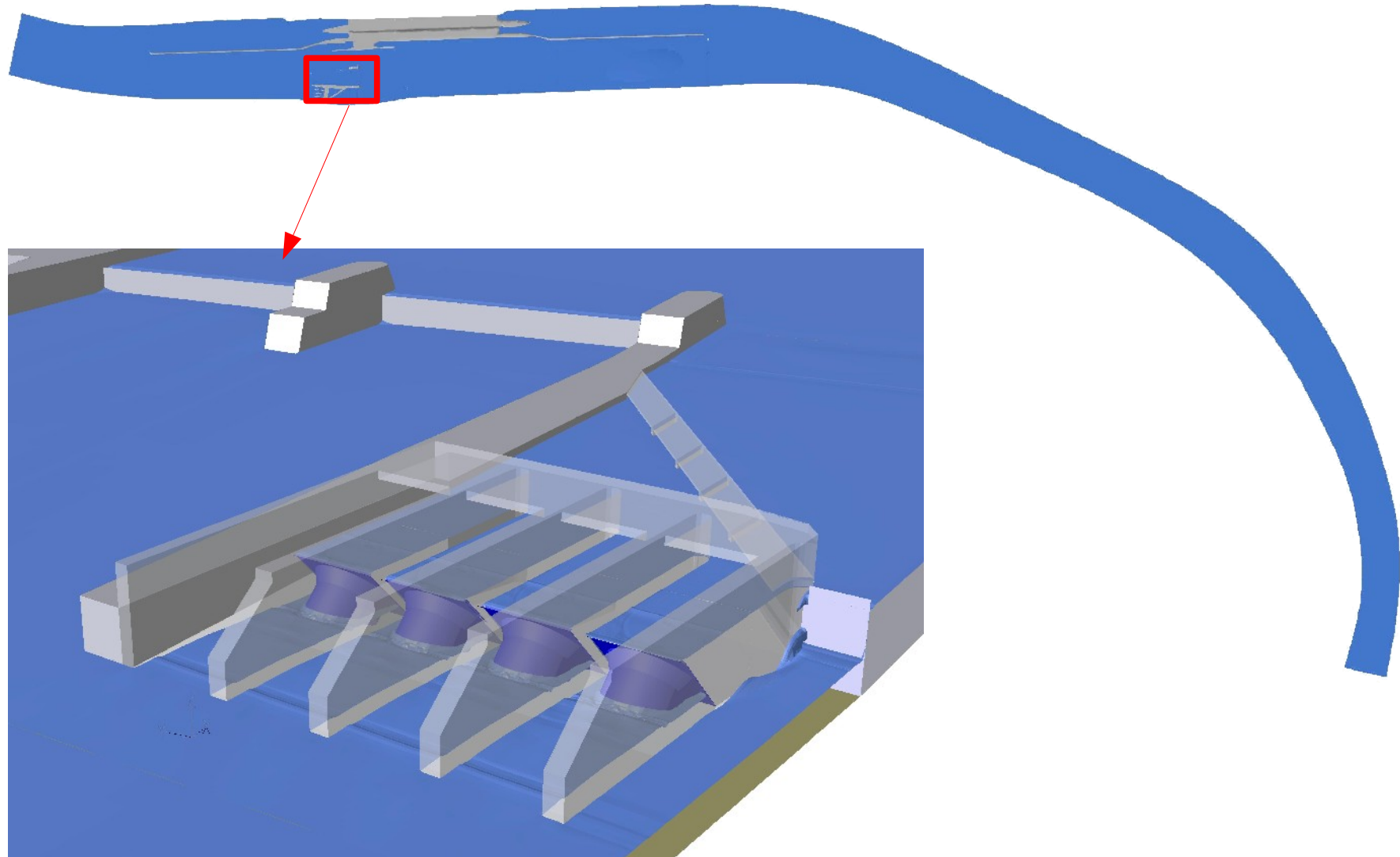
River power plant II

Tasks:

- Mass flow distribution across turbines
- Assessment of flow at
 - Rake
 - fish pass
 - scour outlet
 - stilling basin
- Impact on sea lane

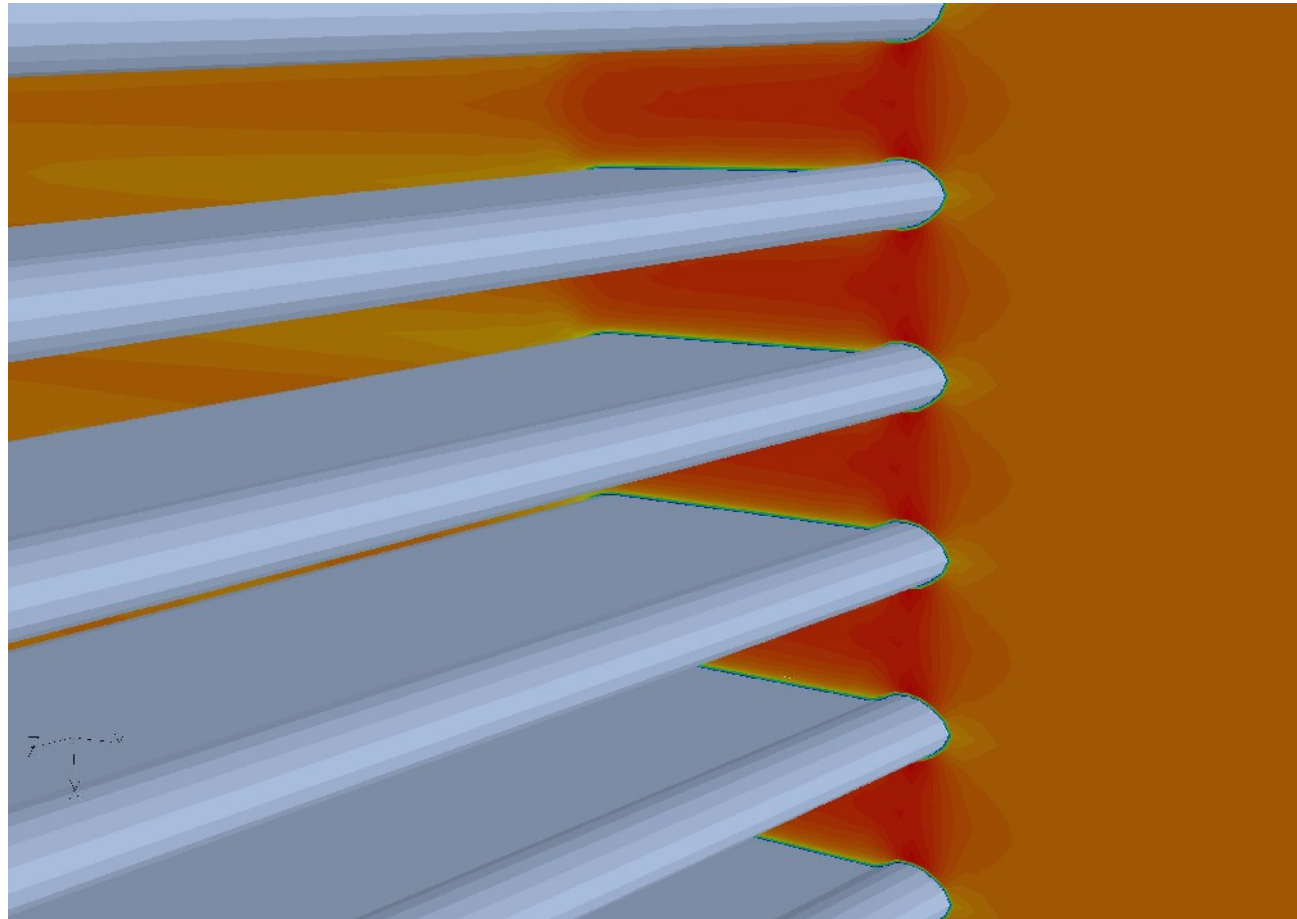
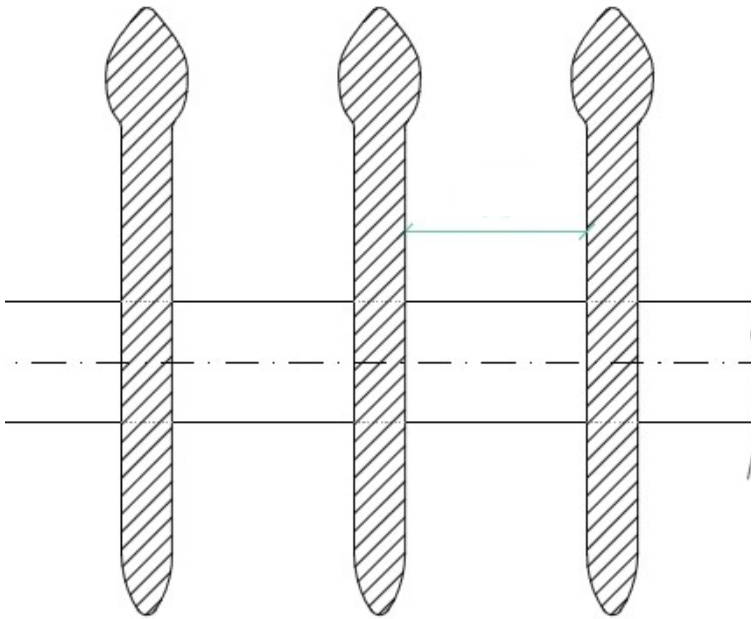


River power plant II

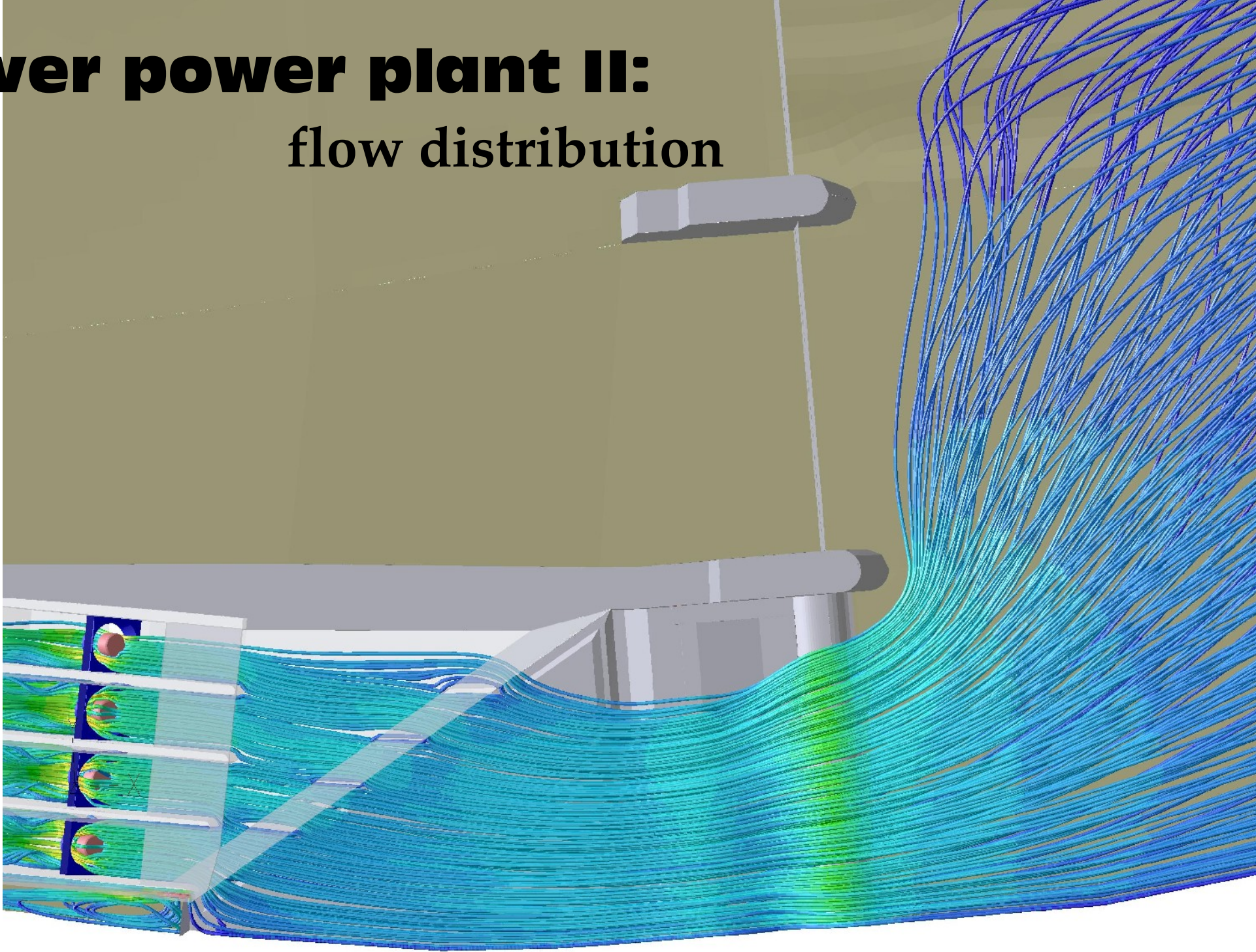


River power plant II:

hydraulic resistance of rake



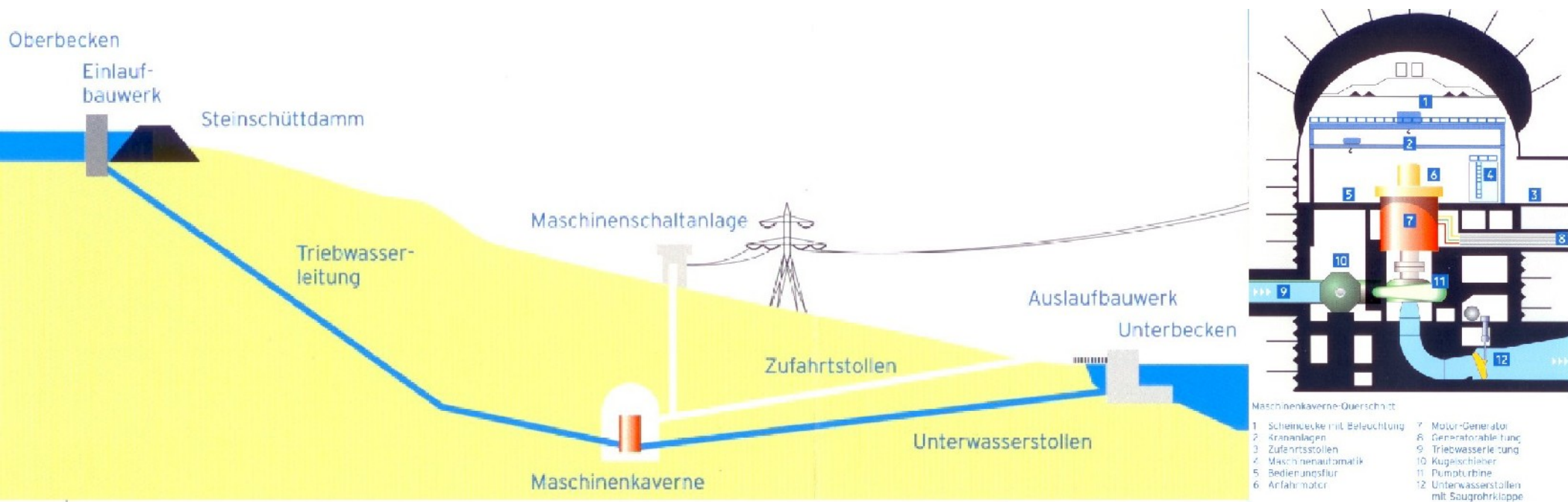
River power plant II: flow distribution



Pumped storage power plant I

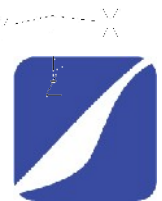
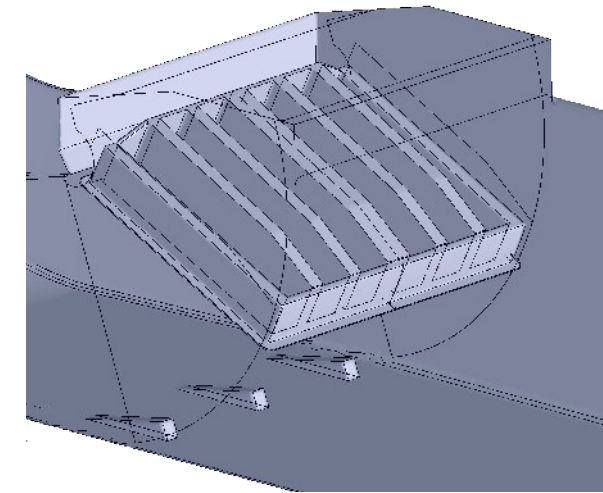
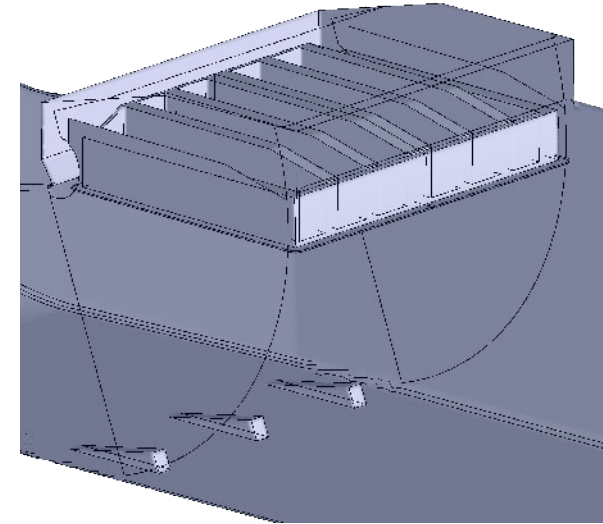
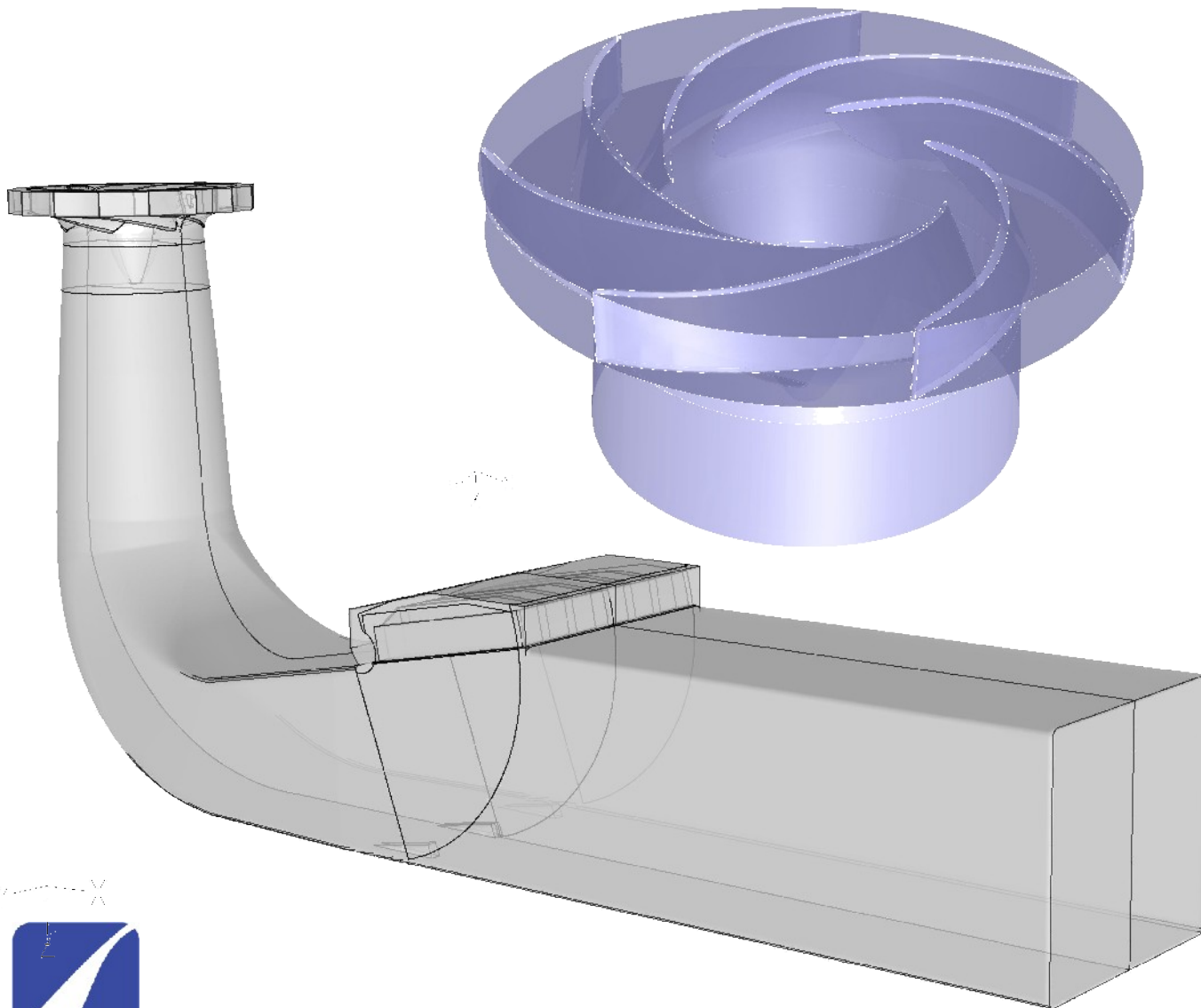
Tasks:

- Lock gate closure under varying flow conditions
 - Forces and moments on gate and hydraulic drive



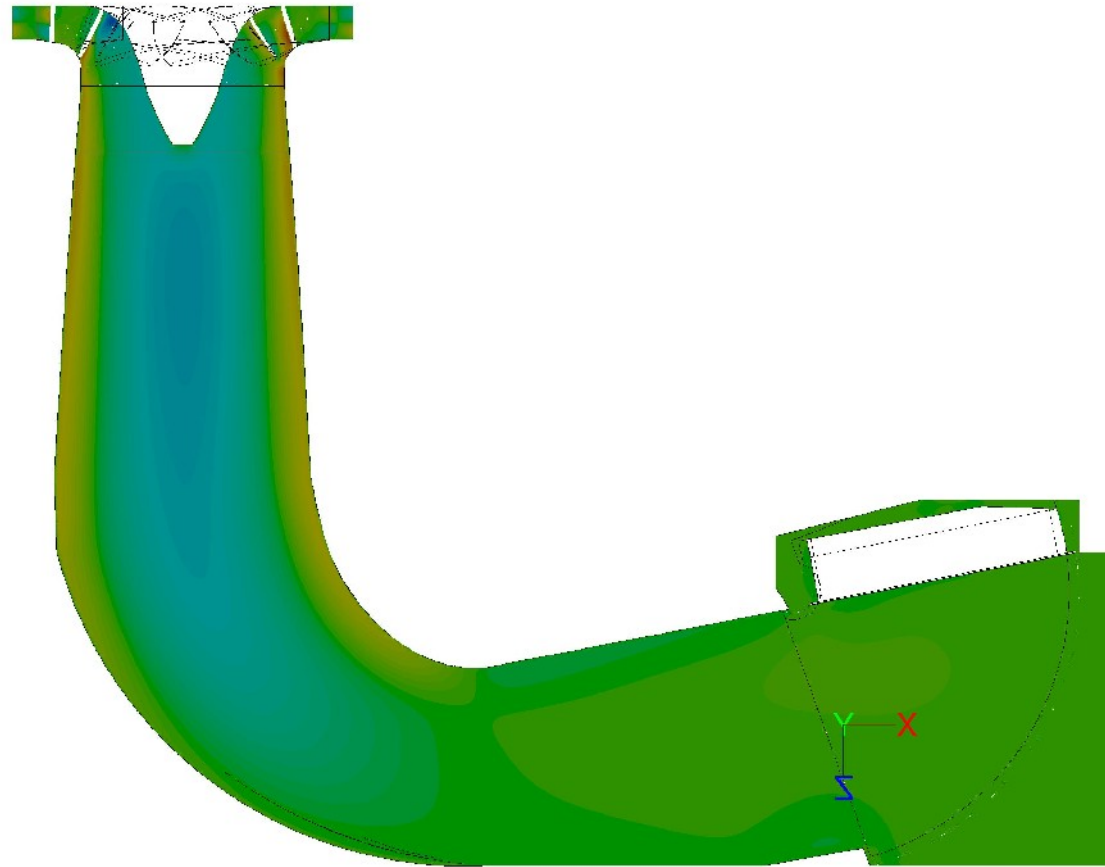
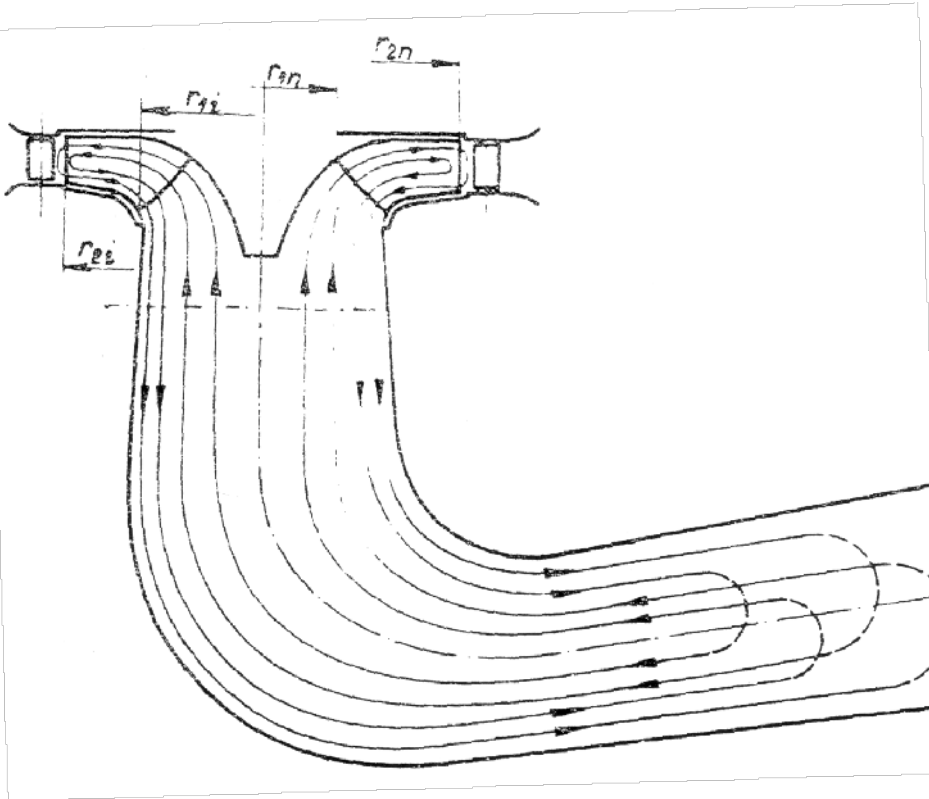
Pumped storage power plant I:

Model of turbine and lock gate



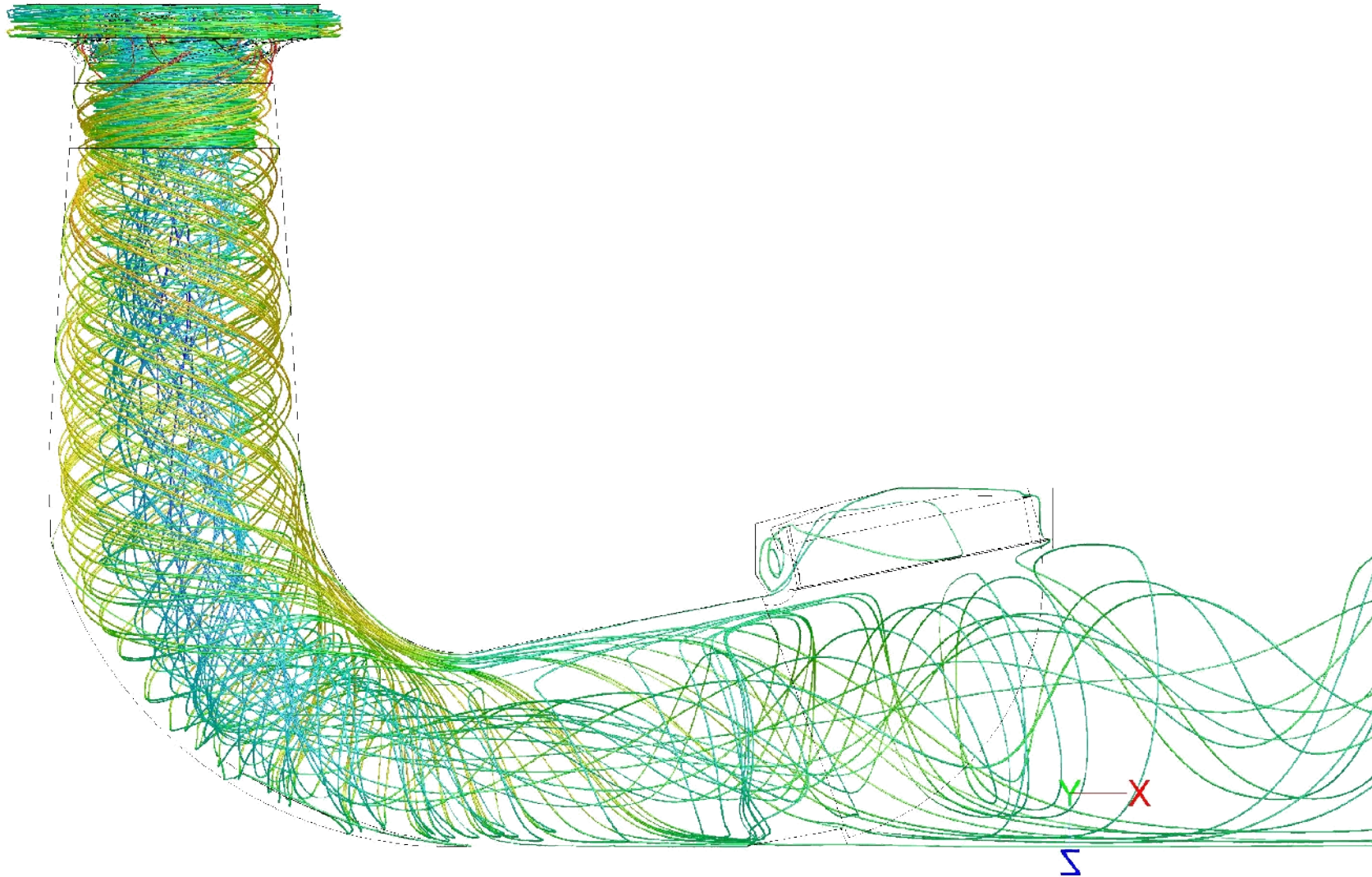
Pumped storage power plant I:

Principal flow



Pumped storage power plant I:

Principal flow pathlines



Pumped storage power plant II

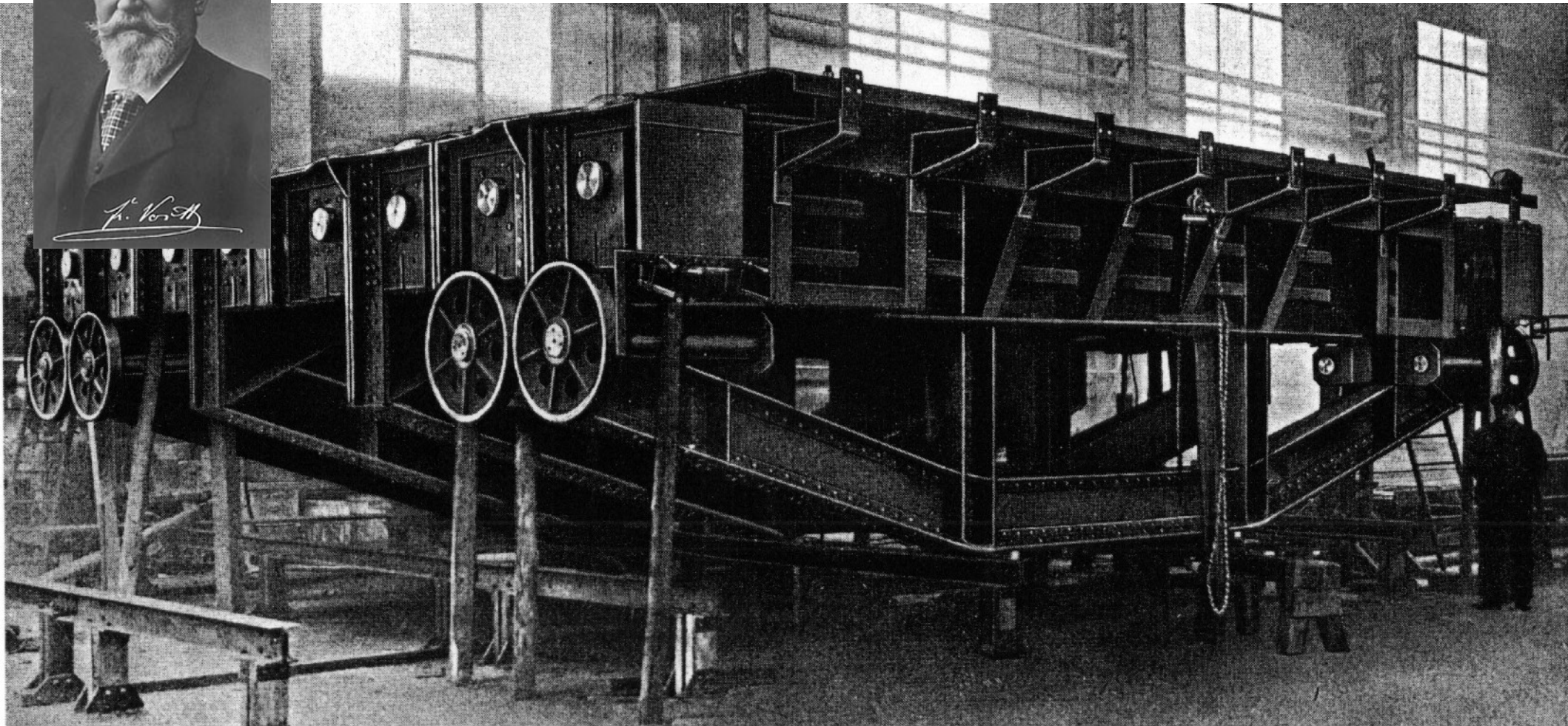
Tasks:

- Sliding lock gate closure
 - Forces and moments on gate
 - Mass flow
- Opening of weir for flood relief
 - Forces and moments on weir
 - Mass flow



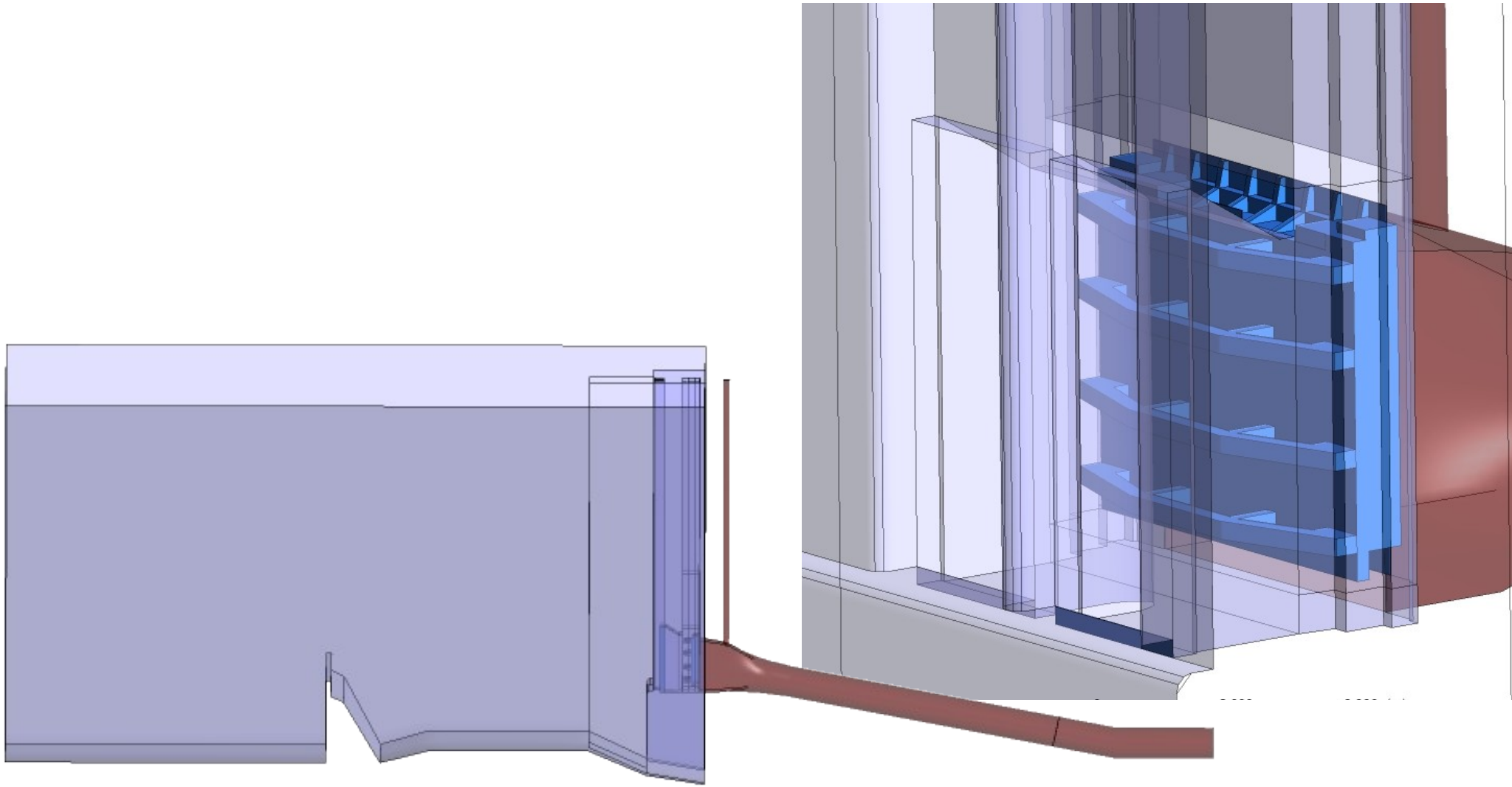
Pumped storage power plant II:

Lock gate



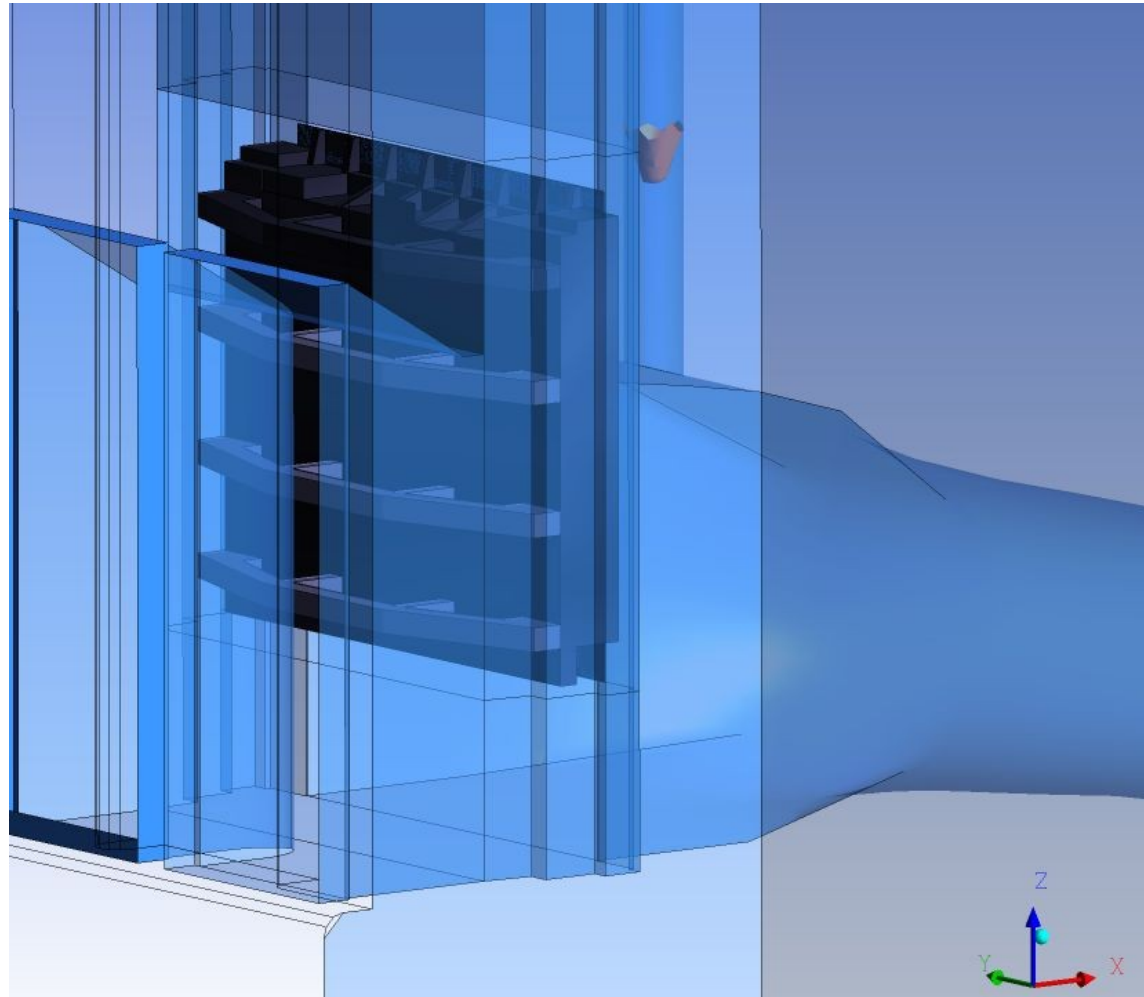
Pumped storage power plant II:

Model of dam and lock gate



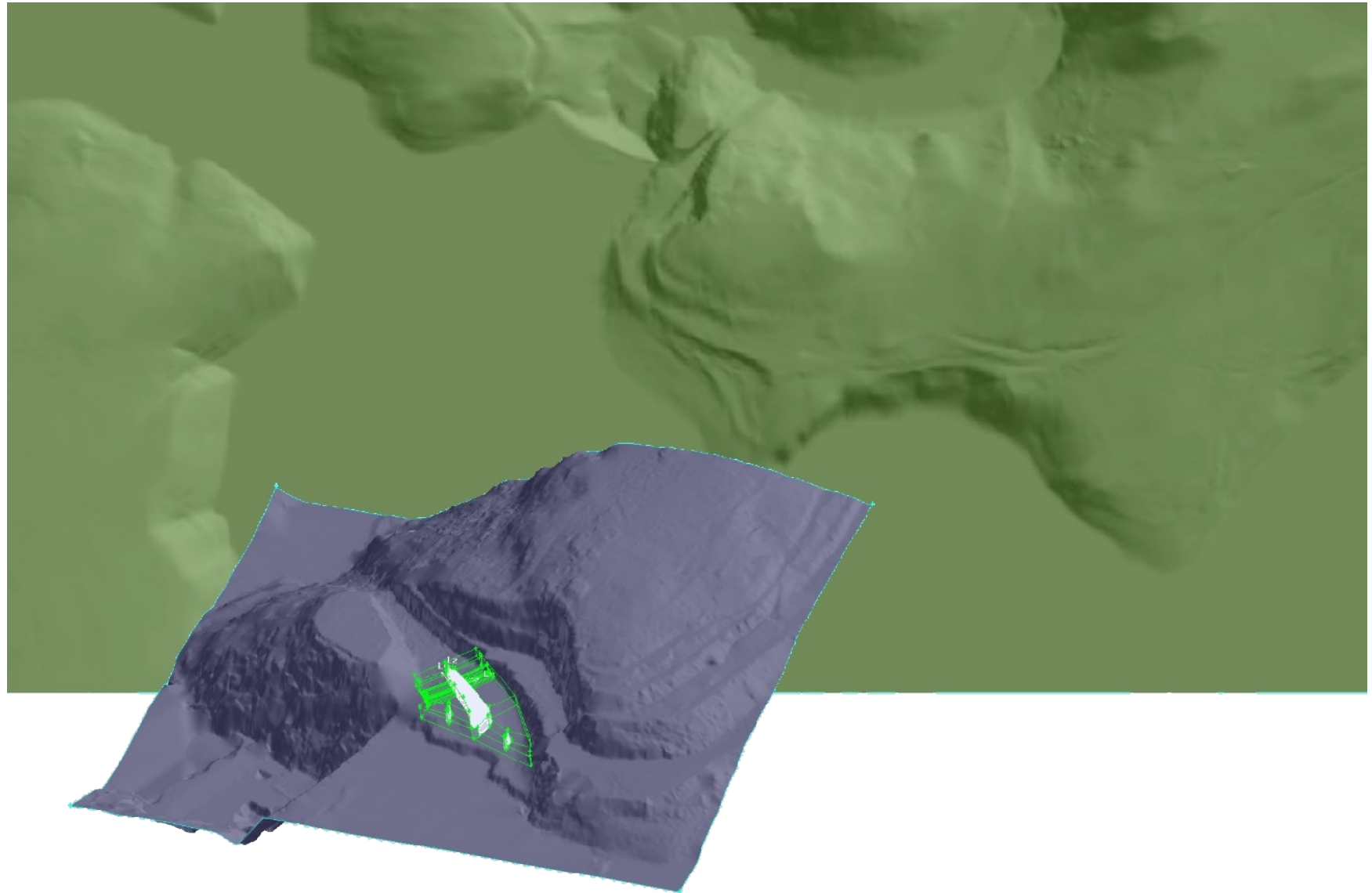
Pumped storage power plant II:

Movement of lock gate



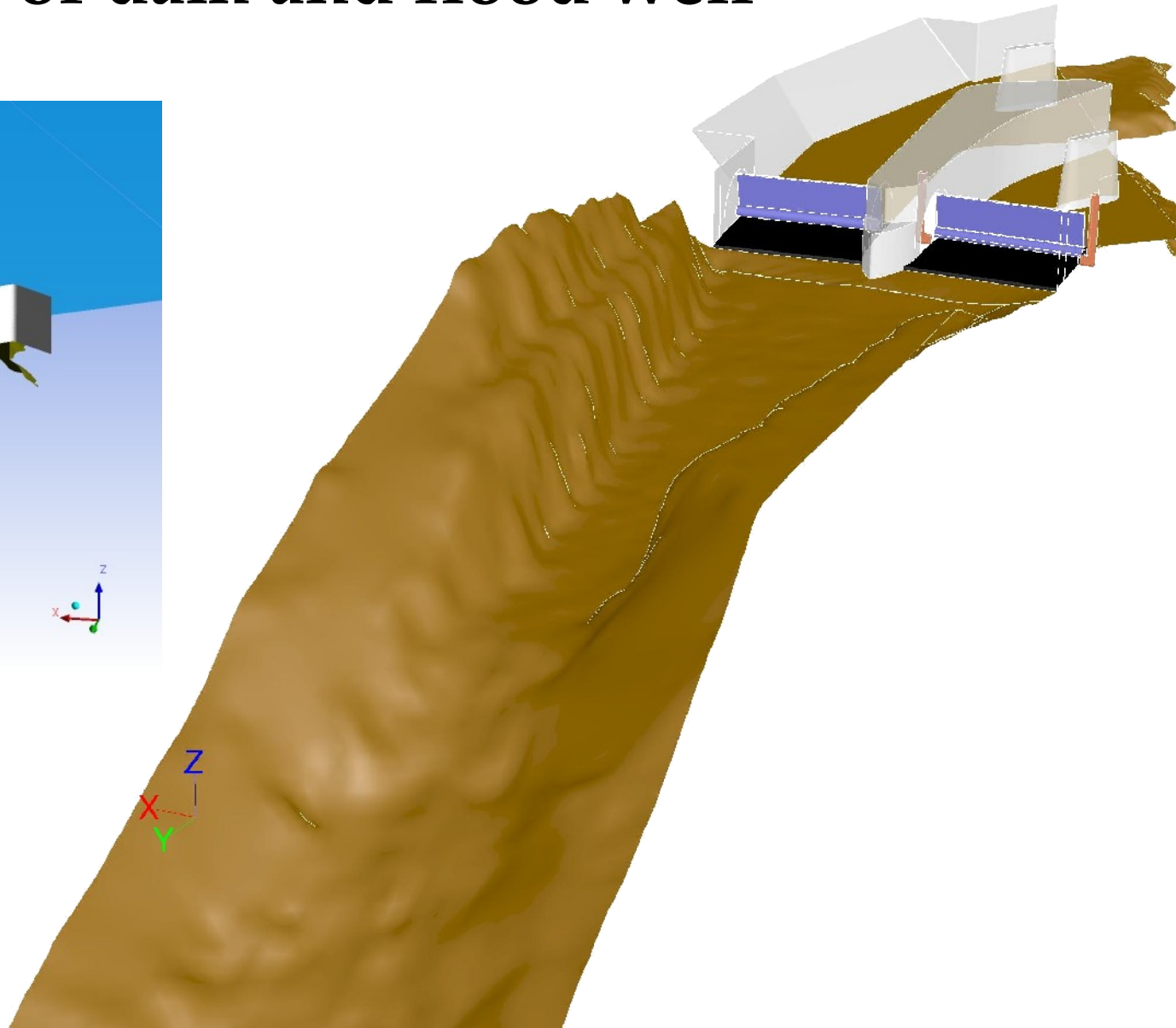
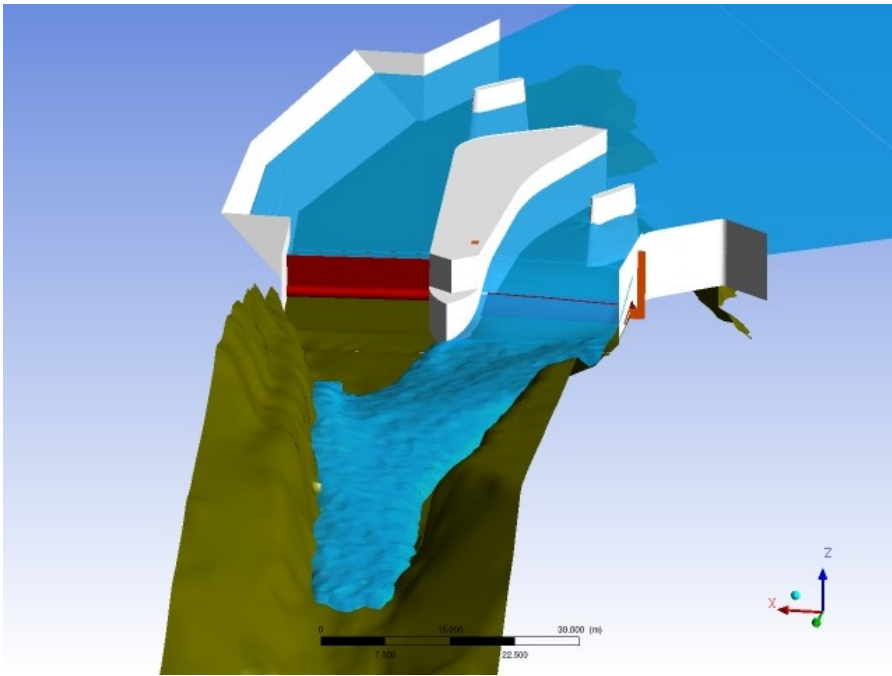
Pumped storage power plant II:

Model of dam and flood weir

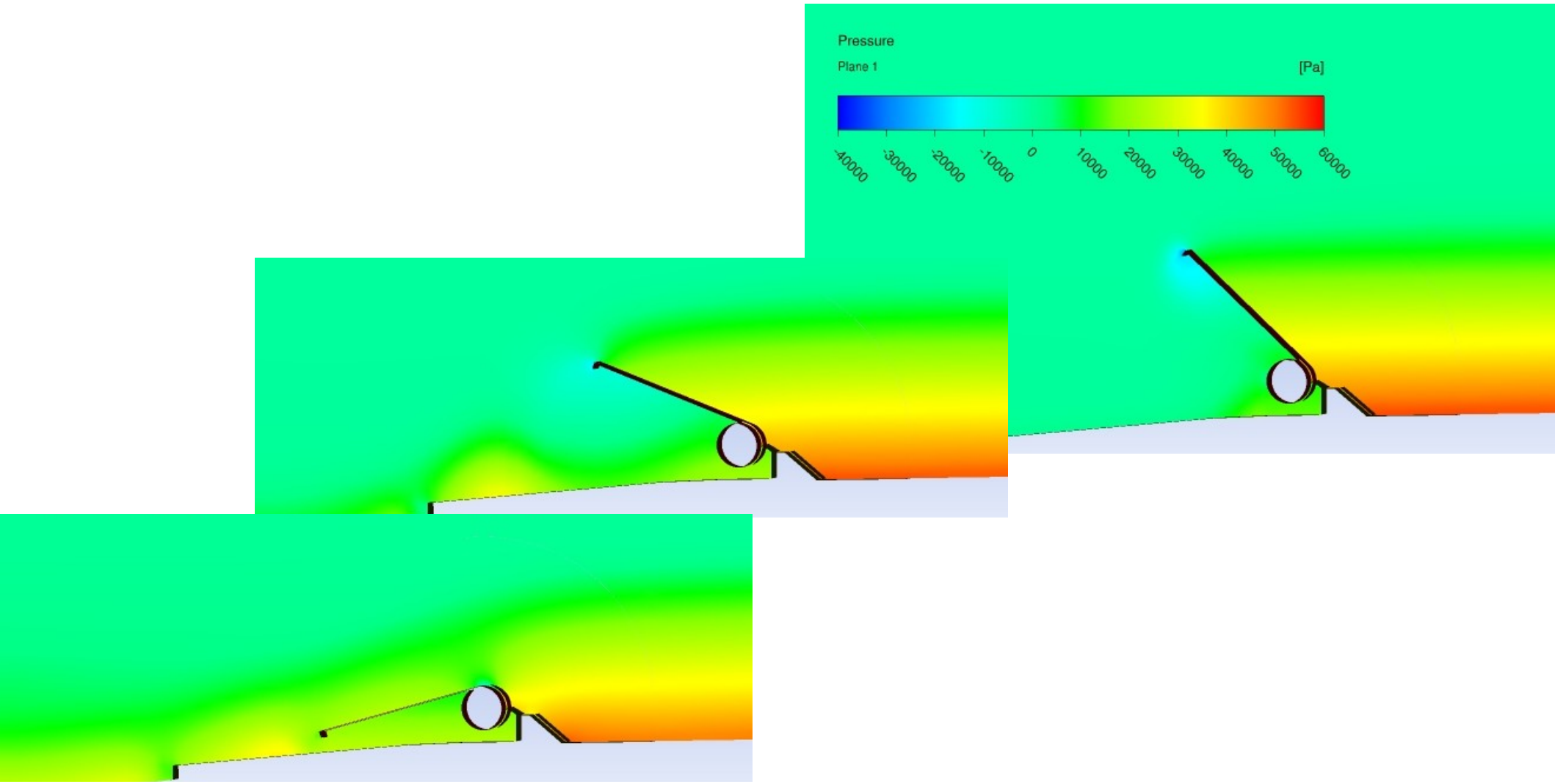


Pumped storage power plant II:

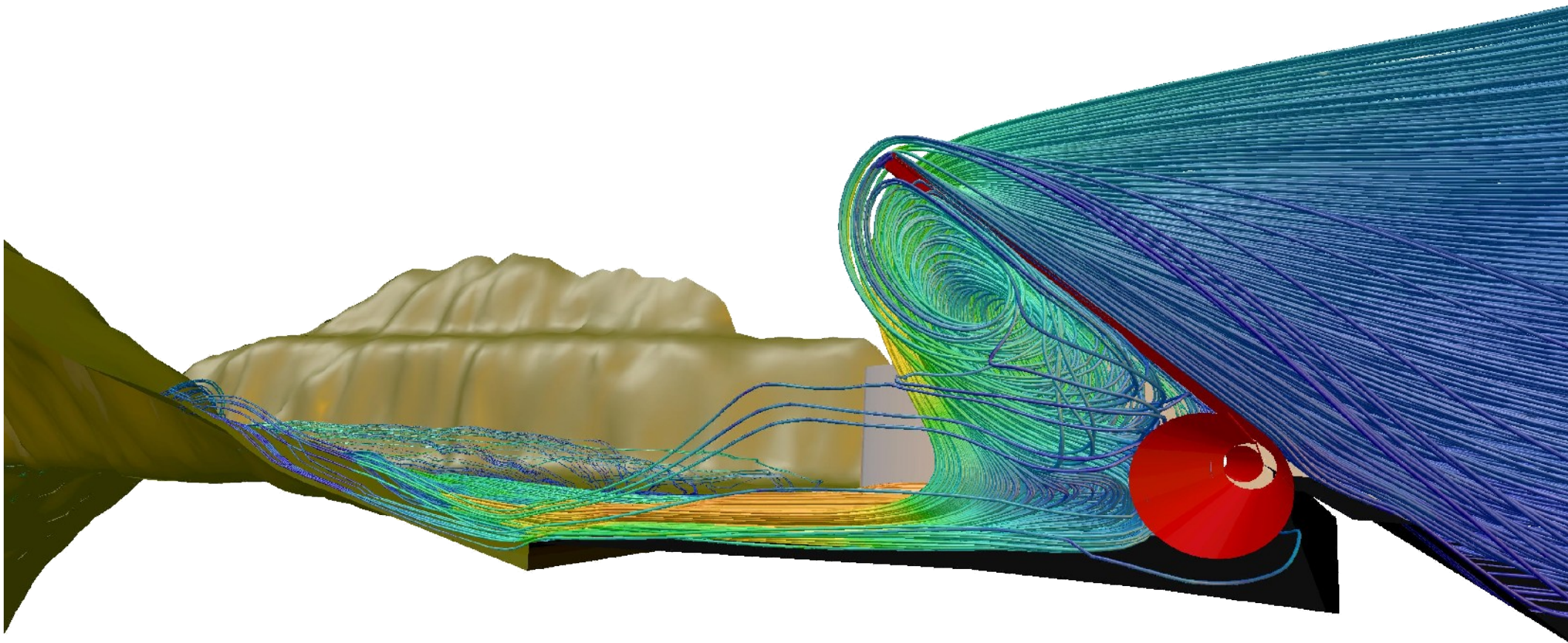
Model of dam and flood weir



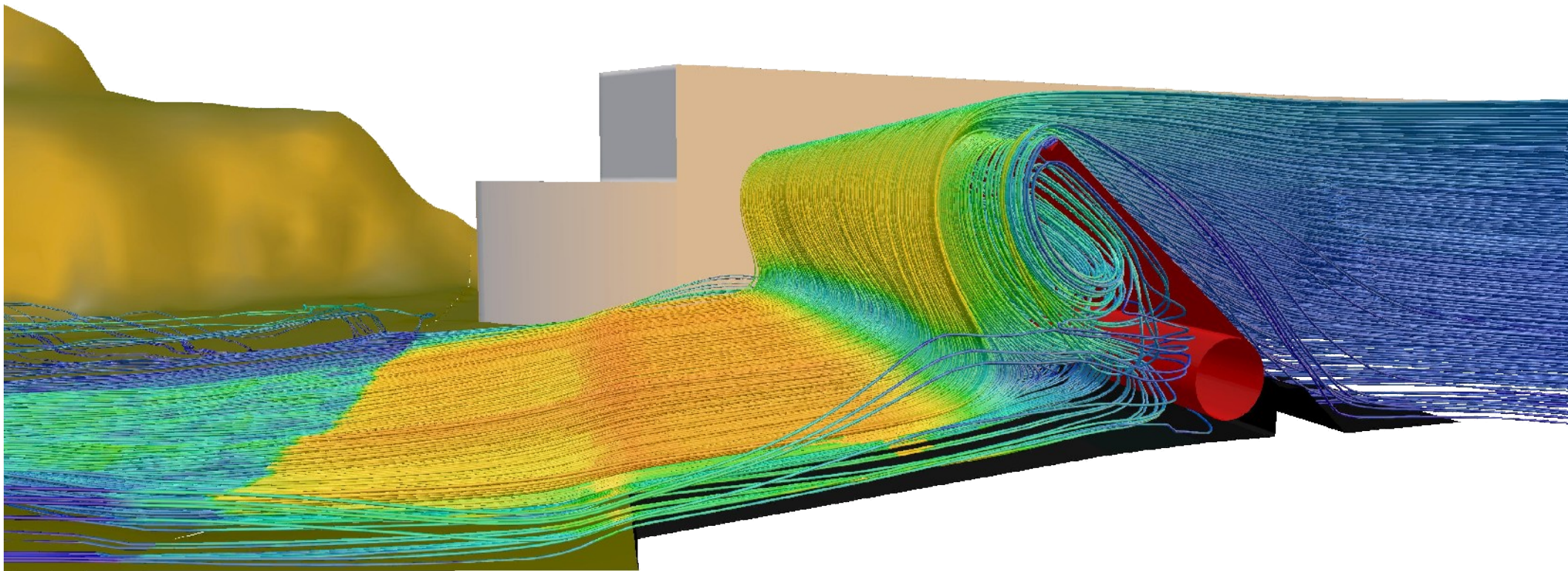
Pumped storage power plant II: pressure distribution at weir



Pumped storage power plant II:



Pumped storage power plant II:



Thank you for your attention

