Politecnico di Torino

Dams & Reservoirs DAY 2025

Water and Energy security for Europe

OPEN DAY ON DAMS



Dams and environment: engineering solutions for the future

TORINO , 28 maggio 2025

Improving the discharge capacity of dams: the example of the Vinchiana dam

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ITCOLD – II Concorso Fotografico

Improving the discharge capacity of dams: the example of the Vinchiana dam



Program presentation

- Introduction to power plant
- Case study: Vinchiana dam
- Dam safety requirements: italian directives
- Design
- Construction
- Lesson learned

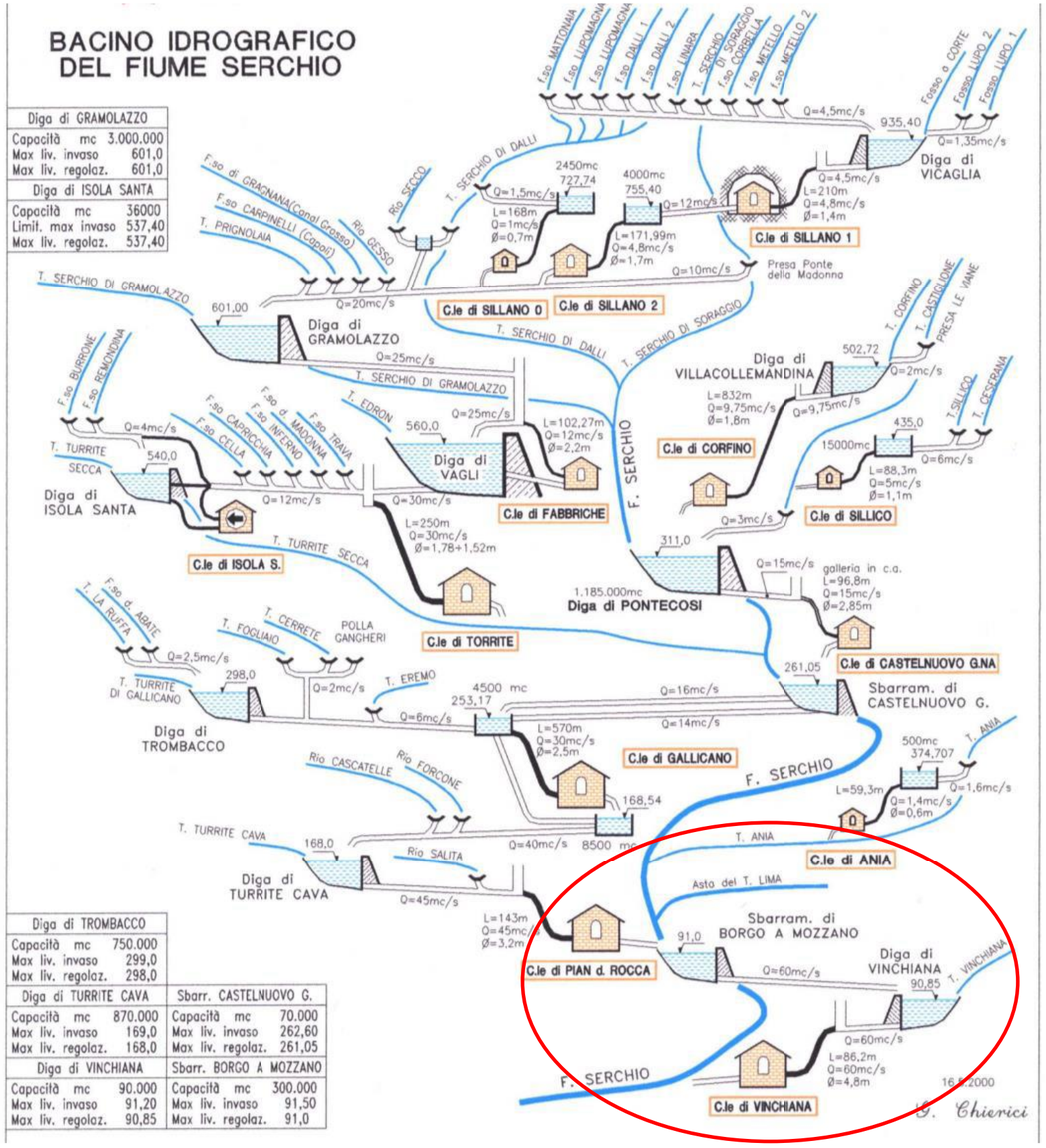






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Vinchiana Enel Greenpower power plant - Chorography

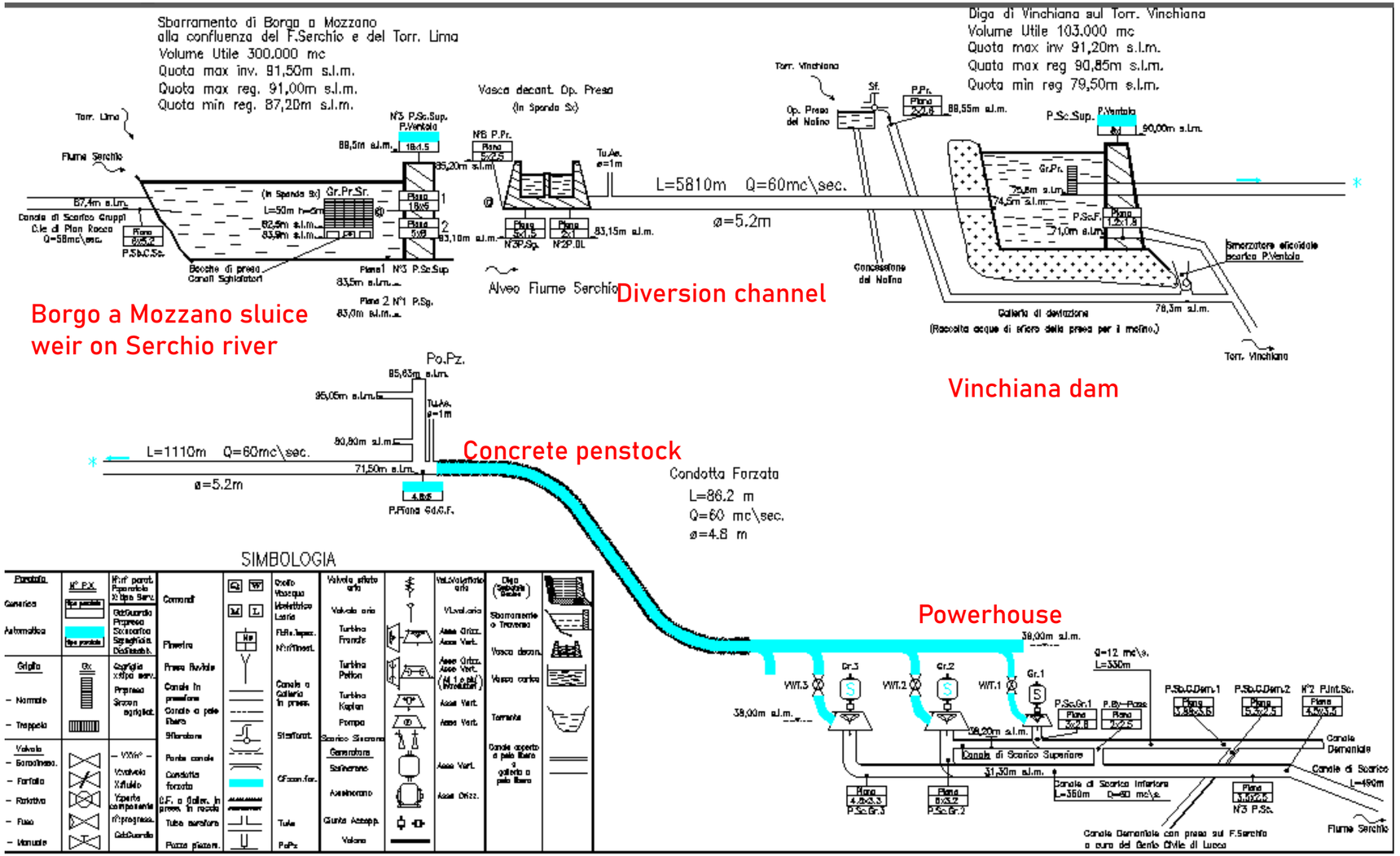




Introduction to power plant | Case study: Vinchiana dam | Dam safety requirements: italian directive | Design | Construction | Lesson learned

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Vinchiana Enel Greenpower power plant – Hydraulic diagram



Hydropower plant main data

Maximum flow rate = 60 m^3/s

Geodetic height = 55 m

Installed power = 34 MVA

Estimated annual production = 100 GWh

Borgo a Mozzano sluice weir

Type = weir with vertical sluices

Reservoir capacity = 300 000 m^3

Maximum regulation level = 91,00 m s.m

Maximum flood level = 91,50 m s.m.

Diversion channel

Lenght = 5810 m

Diameter = 5,20 m

Maximum discharge = 60 m^3/s

Vinchiana dam

Type = concrete buttress dam

Reservoir capacity = 103 000 m^3

Height = 22,50 m

Maximum regulation quota = 90,80 m s.m.

Maximum flood level = 91,20 m s.m.

Penstock

Length = 56,2 m

Diameter = 4,8 m

Material = concrete

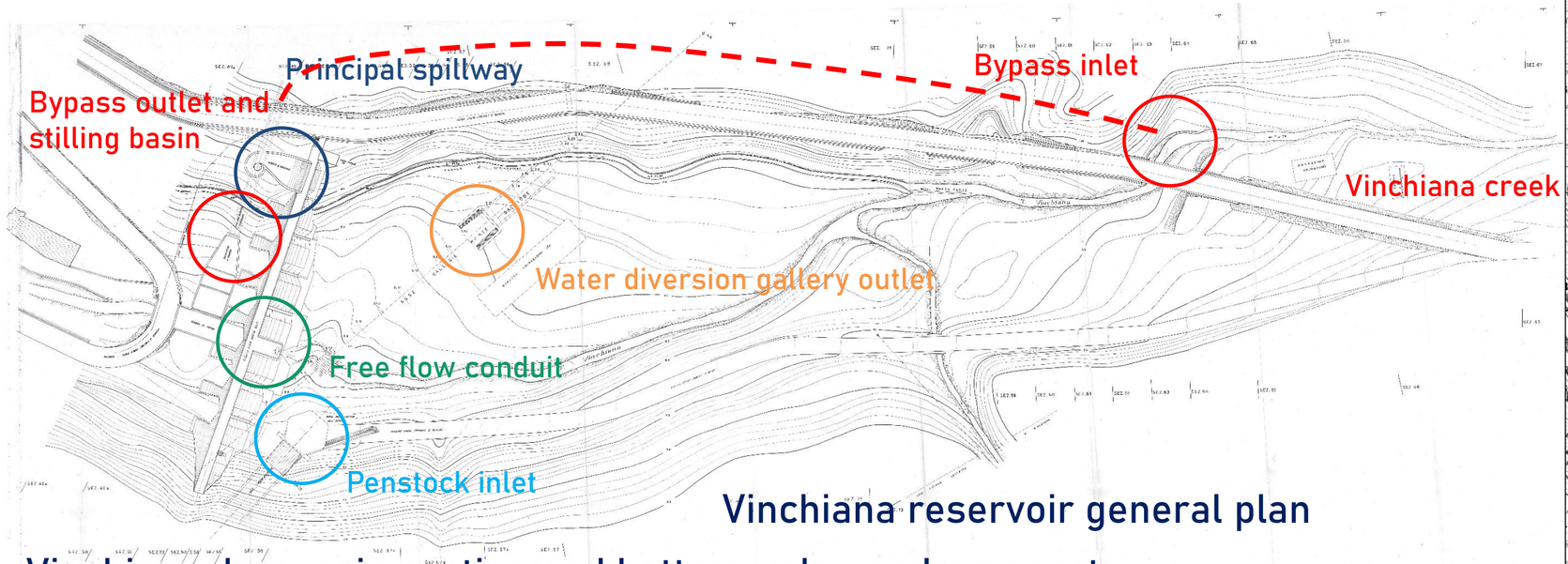
Powerhouse

Turbine number = 3

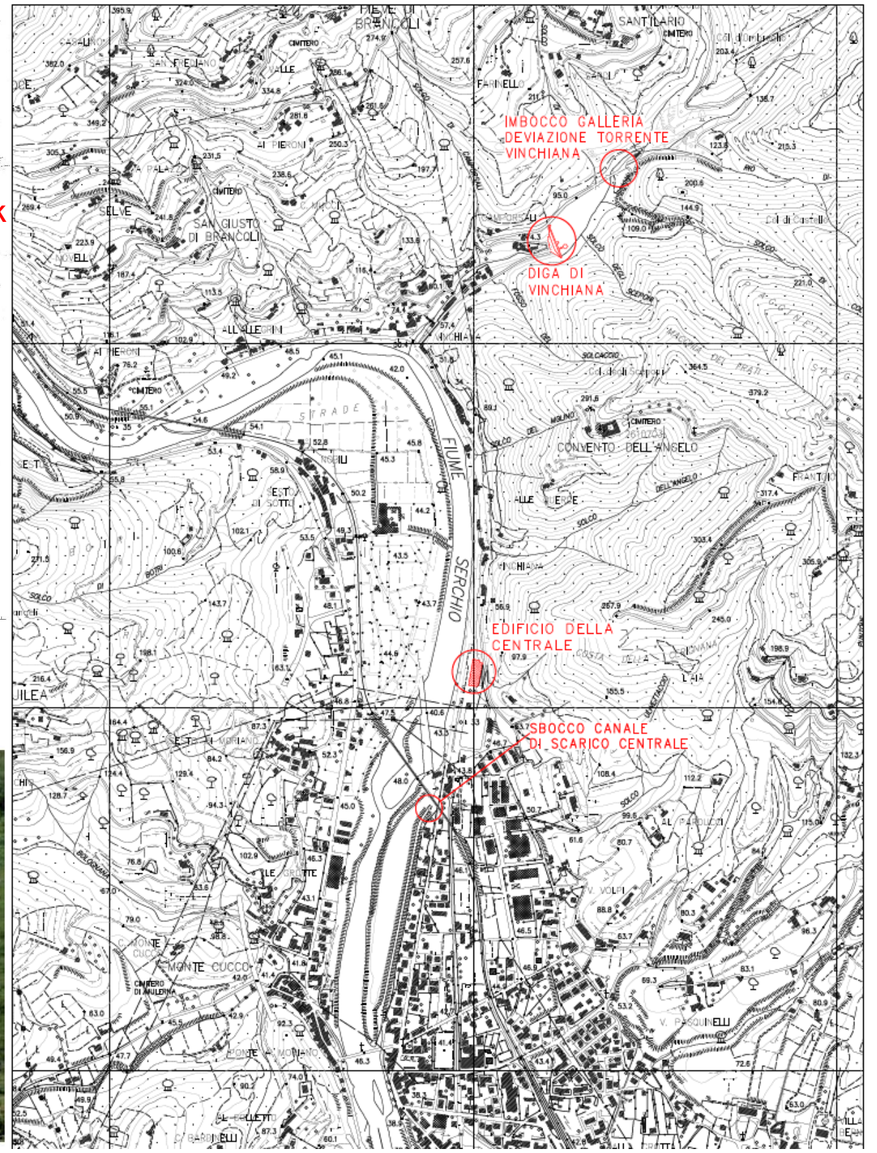
Turbine type = vertical axis Francis

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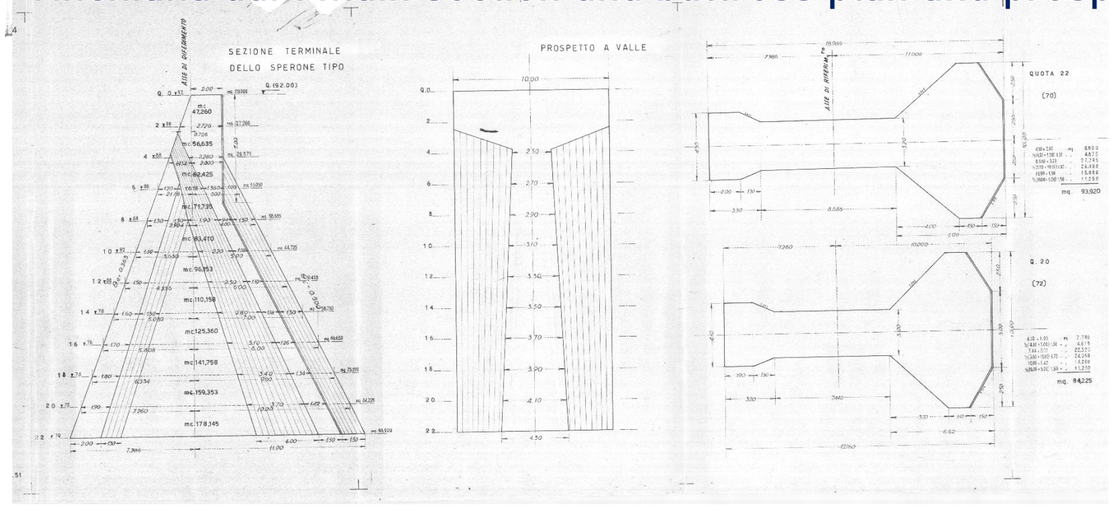
Vinchiana Enel Greenpower power plant – Vinchiana dam



Vinchiana reservoir general plan



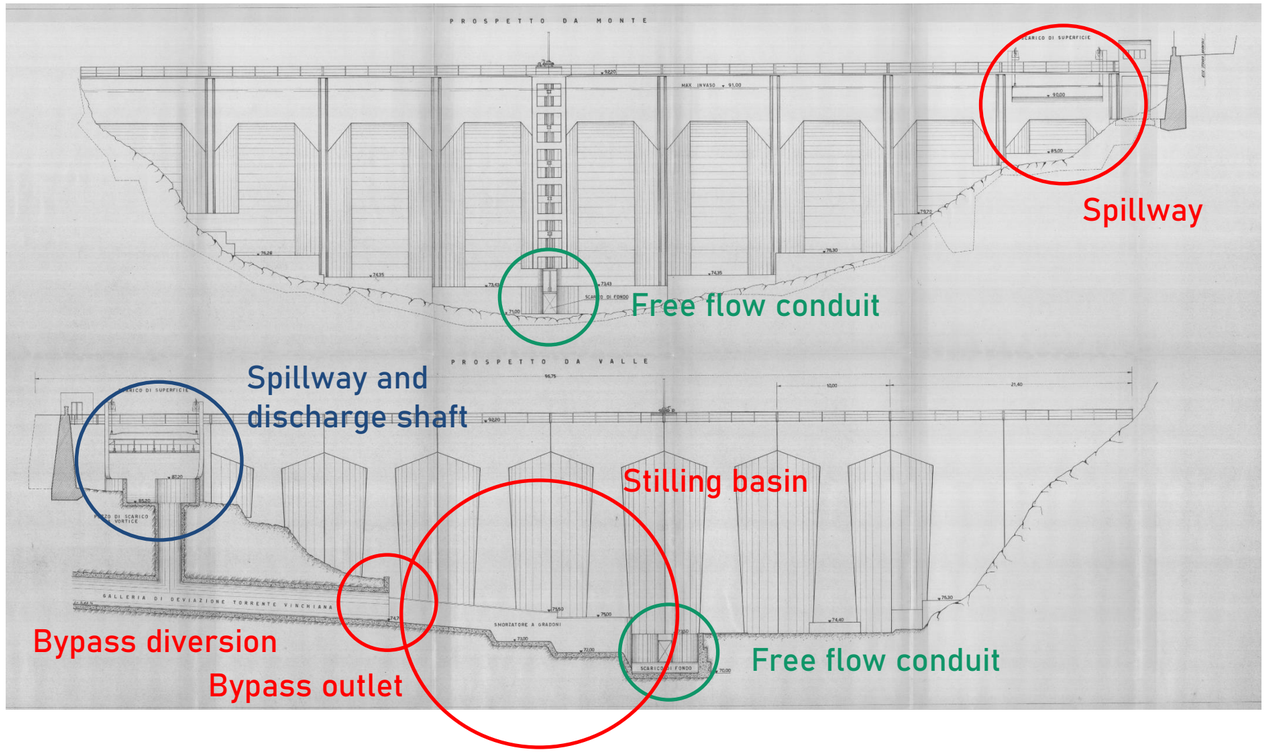
Vinchiana dam main section and buttress plan and prospect





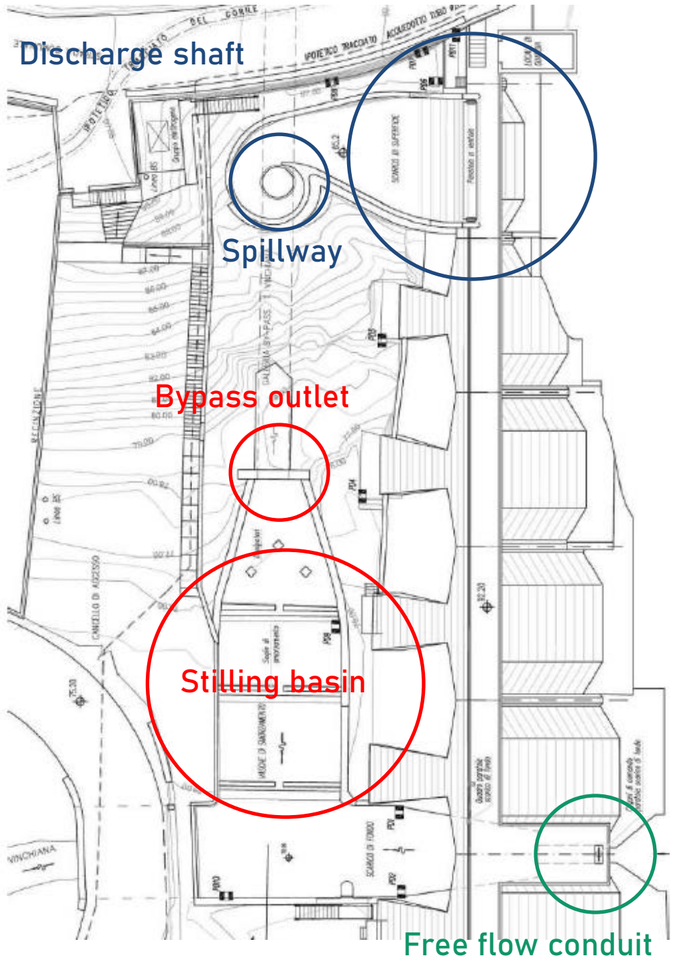
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Vinchiana dam – Outlet works and flow distribution before improvement works







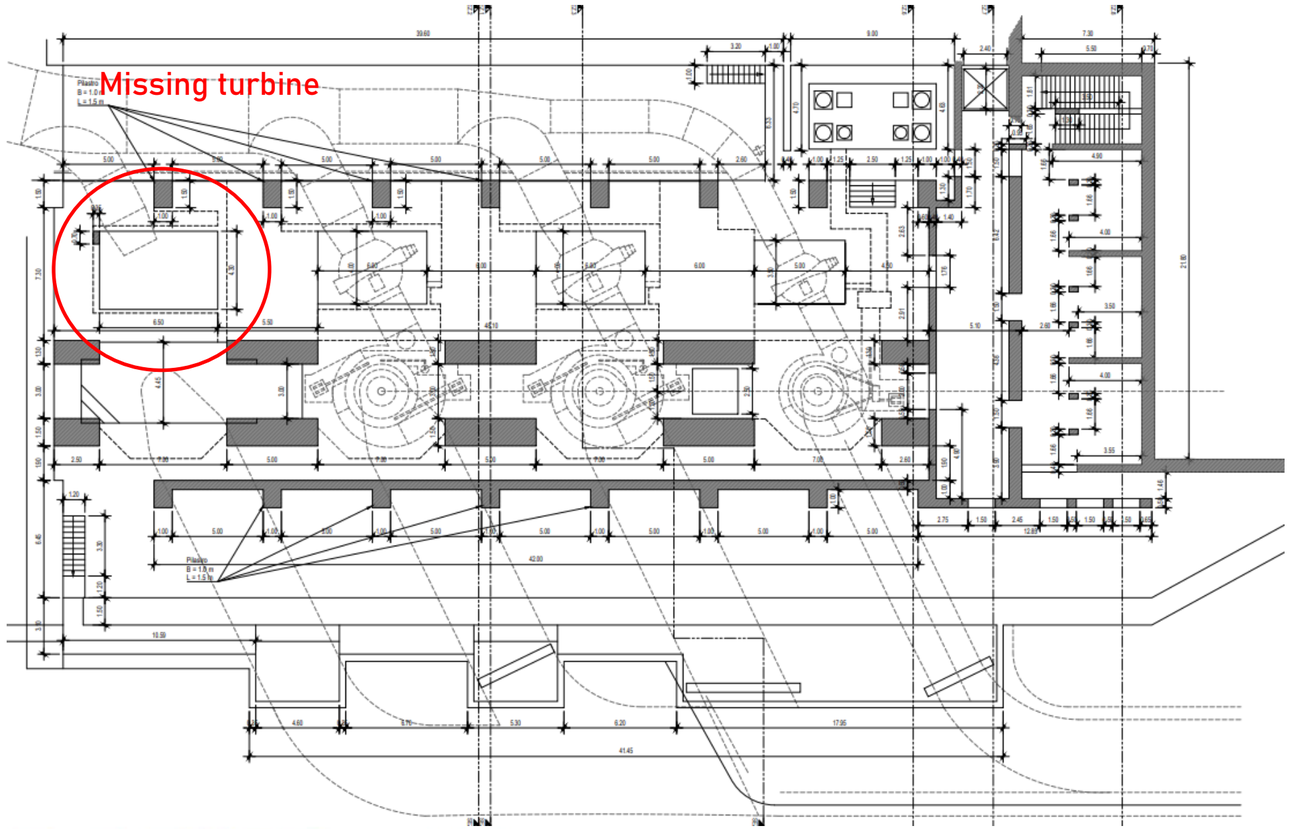


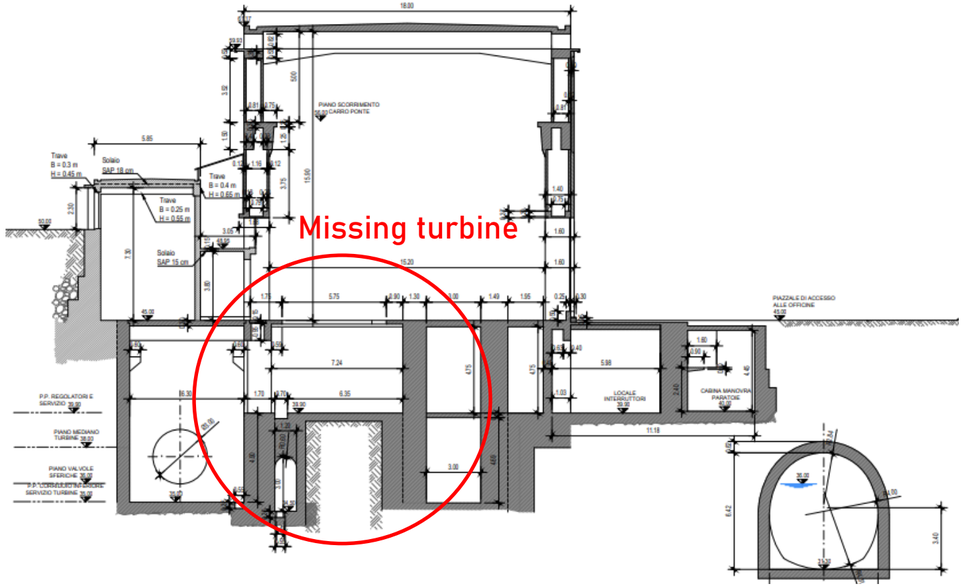
Hydrological flow rates	
Q_{50} =	61,00 m³/s
Q_{100} =	72,00 m³/s
Q_{200} =	82,00 m³/s
Q_{500} =	95,00 m³/s
Q_{1000} =	106,00 m³/s

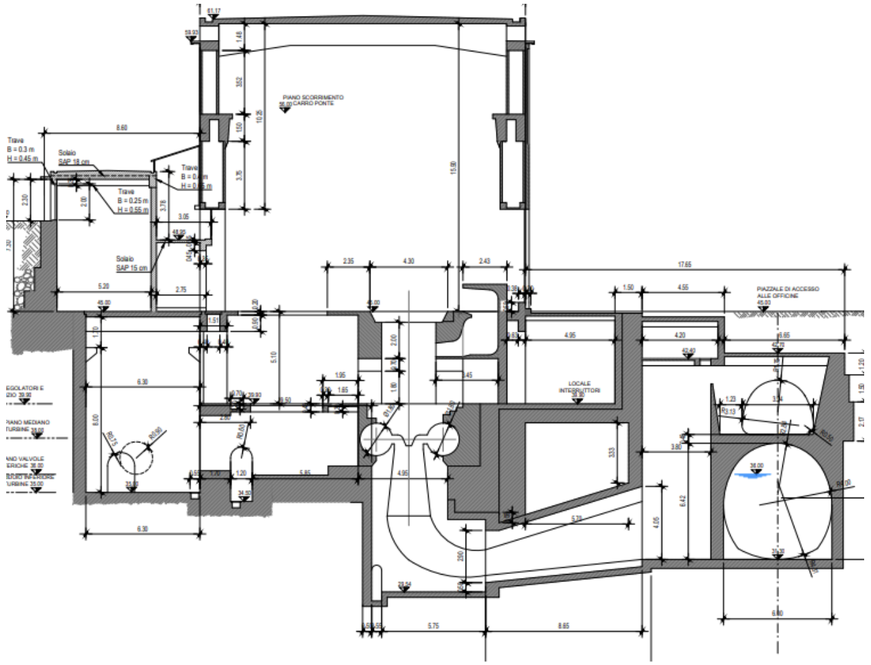
Outlet works flow rate distribution	
Total	67,20 m³/s
Spillway flow rate	22,40 m³/s
Bypass diversion flow rate	19,10 m³/s
Free flow conduit	25,70 m³/s

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Vinchiana dam – Power house before improvement works













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Vinchiana dam – Design flow and Italian regulation

Main authorization steps

– Rivalutazione idrologica delle portate di piena

– Richiesta DG Dighe di adeguamento capacità di scarico

– Predisposizione Progetto Definitivo da parte di Enel con portata di progetto Q tr 500 anni

– Approvazione del Progetto Definitivo con prescrizioni da parte di DG Dighe

– Predisposizione del Progetto Esecutivo di miglioramento idraulico

2021 – Inizio dei lavori

2024 – fine dei lavori

N.B. Si evidenzia la possibilità di impiego definitivo della derivazione come organo di scarico ausiliario e che, a tal fine, venga dotata di dispositivi (by-pass di sicurezza con dissipatore) che ne garantiscano il funzionamento indipendentemente dalle regole di esercizio e dallo stato di manutenzione della Centrale di Vinchiana.

Main regulatory aspects

2004 - all'art. 4, comma 1 del D.L. 29/03/2004 n. 79 "Disposizioni urgenti in materia di sicurezza di grandi dighe e di edifici istituzionali", convertito con legge n. 139 del 28/05/2004 – «Rivalutazioni idrauliche»

2014 - Decreto Min. Infrastrutture e dei Trasporti 26 giugno 2014 – *Articolo H.2.2. Intervento di miglioramento*

H. Dighe esistenti

Omissis

H.2.2. Intervento di miglioramento

È fatto obbligo di procedere almeno ad interventi di miglioramento idraulico, in conseguenza alla valutazione della sicurezza idraulica in base ai criteri di cui al cap. H.3.4., se il tempo di ritorno della portata di piena scaricabile rispettando il franco idraulico indicato al cap. C.1 risulti inferiore a 500 anni per le dighe di calcestruzzo e a 1000 anni per le dighe di materiali sciolti.

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Vinchiana dam – Design main goals and issues

Hydrological flow rates

Q_{50} =	61,00 m^3/s
Q_{100} =	72,00 m^3/s
Q_{200} =	82,00 m^3/s
Q_{500} =	95,00 m^3/s
Q_{1000} =	106,00 m^3/s

Totale design flow rate >> Vinchiana creek flow capacity

SOLUTION:
USING THE PENSTOCK AS AN ADDITIONAL OUTLET WORK, EQUIPPED WITH A SPECIAL DISSIPATION VALVE INSTALLED IN THE POWER HOUSE OF THE PLANT WITH A MAXIMUM DISCHARGE CAPACITY OF 30 m^3/s, IN CASE OF HYDROLOGICAL FLOW RATE
> 67,20 m^3/s

MAIN ISSUES:
POWER TO DISSIPATE (about 20 MW)
AVAILABLE SPACE IN THE POWER HOUSE

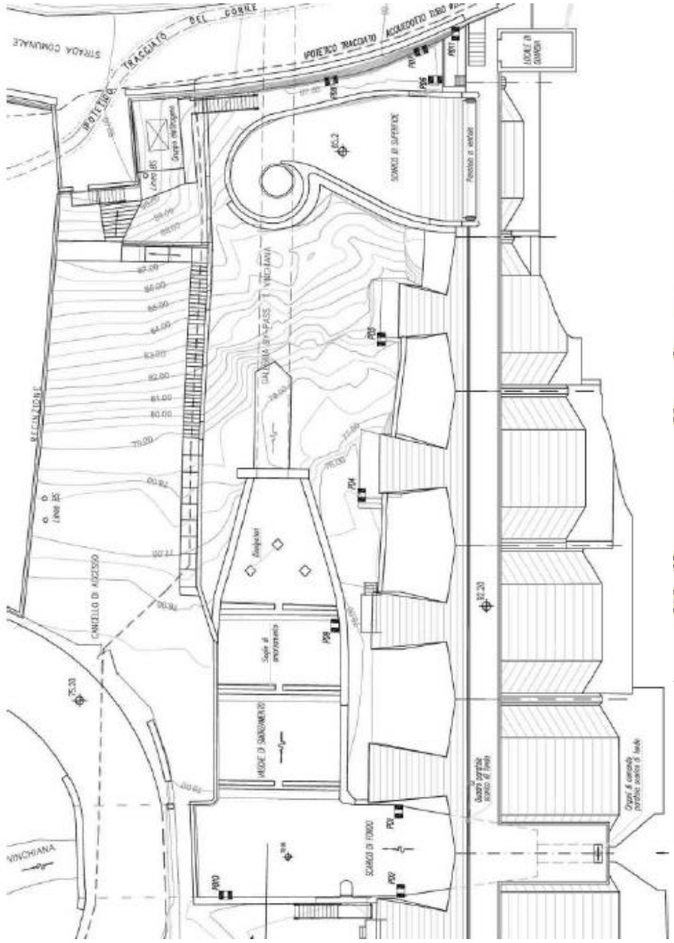
Q max = 30 m^3/s

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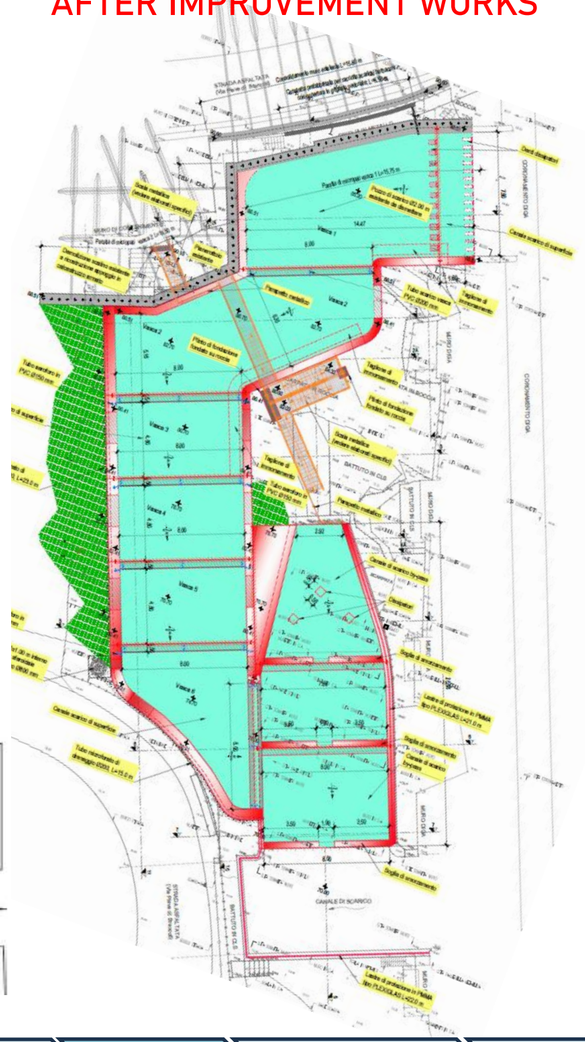
Vinchiana dam – Spillway diversion channel and stilling basin

DESIGN GOAL: IMPROVING THE DISCHARGE CAPACITY OF THE OUTLET WORKS AT THE SERVICE OF THE SPILLWAY

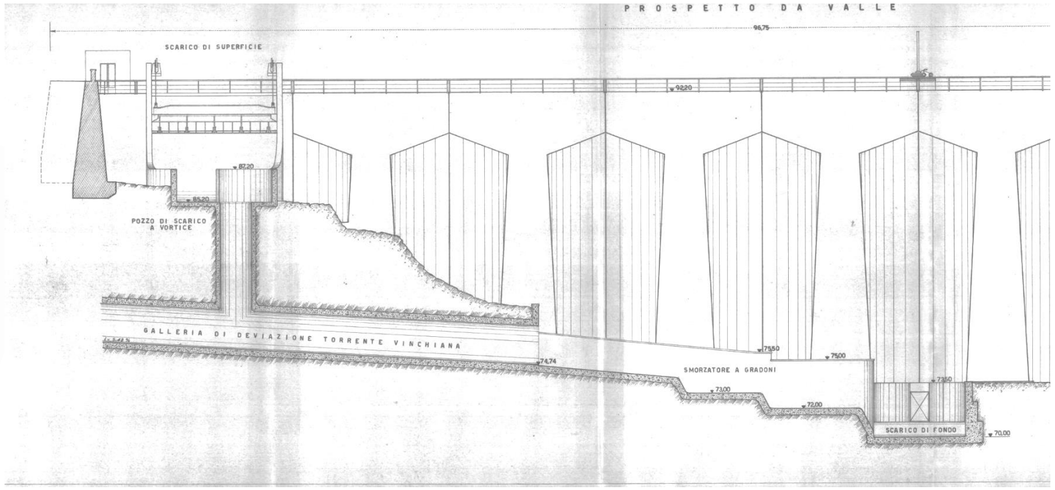
BEFORE IMPROVEMENT WORKS



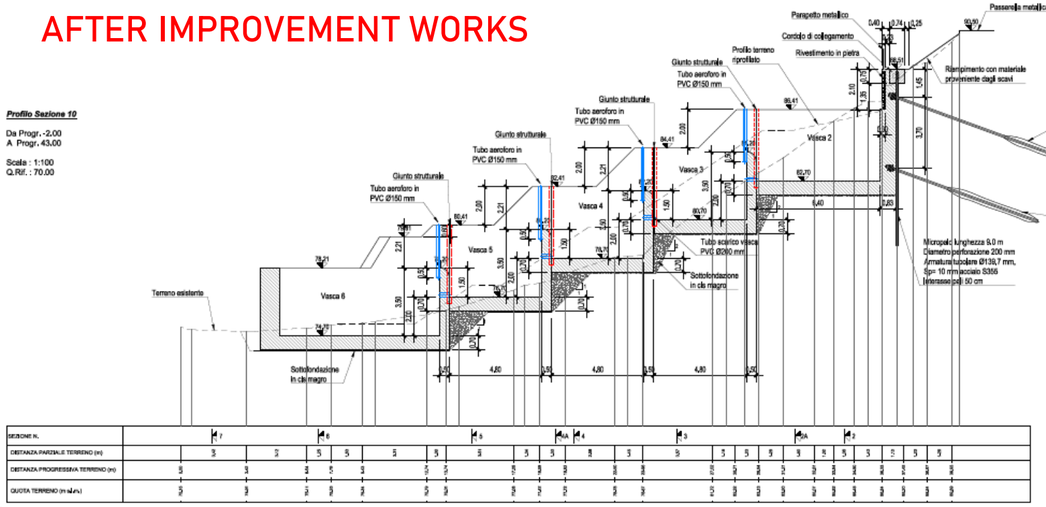
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BEFORE IMPROVEMENT WORKS



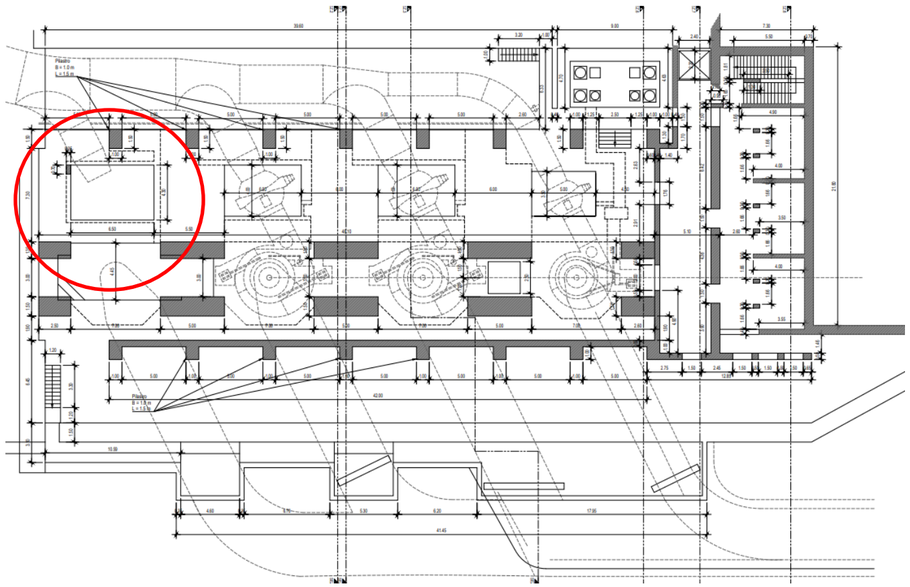
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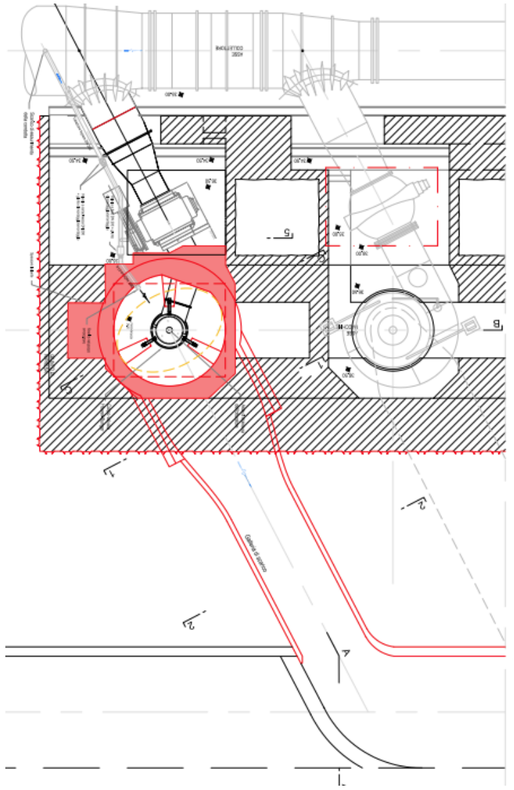


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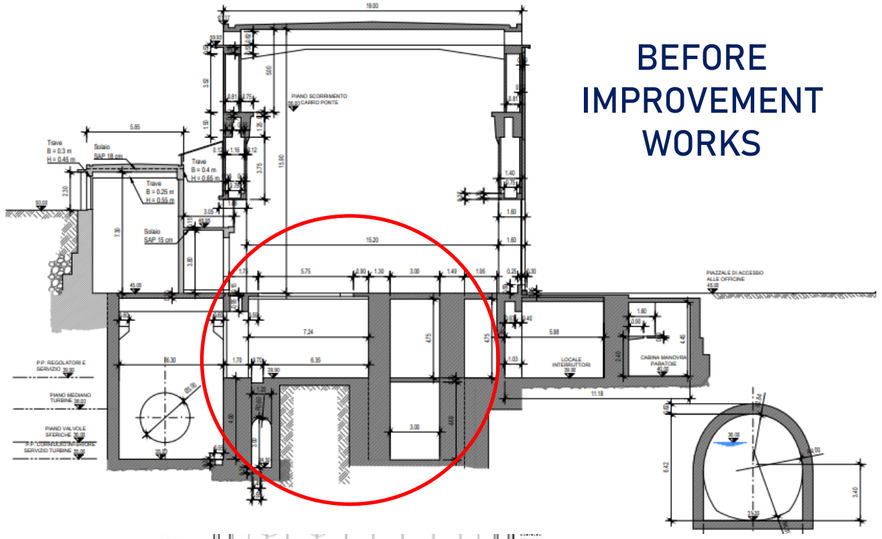
Vinchiana dam – Additional outlet work installed in the power house

DESIGN GOAL: INSTALLING NEW DISSIPATION VALVE IN EXISTING SPACE INSTEAD OF A FUTURE 4° TURBINE

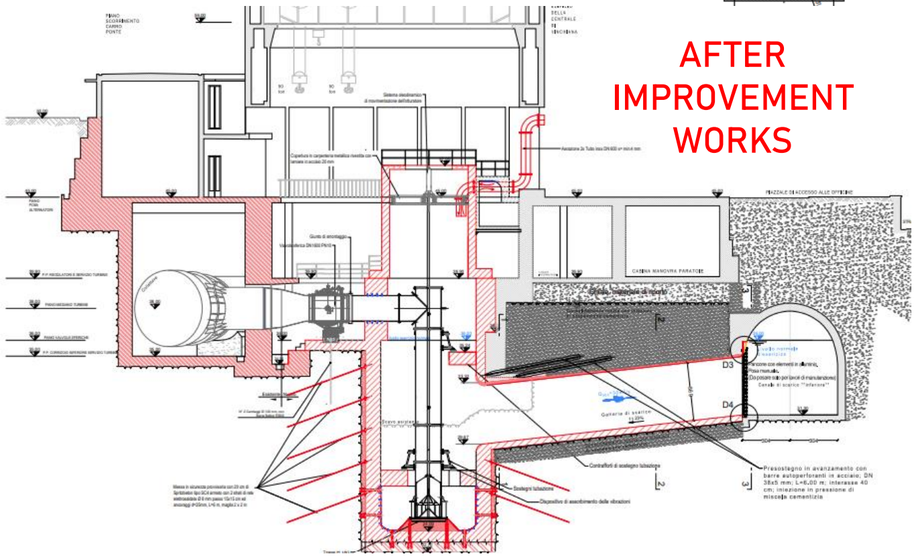




BEFORE IMPROVEMENT WORKS



AFTER IMPROVEMENT WORKS



POTENTIAL ISSUES:

- POWER DISSIPATION AND WATER LEVELS IN THE SHAFT
- VIBRATIONS RELATED TO THE EXIXSTING STRUCTURES
- UNDERGROUND EXCAVATION AND DEMOLITION WORK

SOLUTIONS:

- HYDRAULIC PHYSICAL MODEL
- VIBRATIONS DAMPERS
- CEMENT INJECTION, TEMPORARY SUPPORT WORKS, CONTINUOUS MONITORING OF THE BUILDING

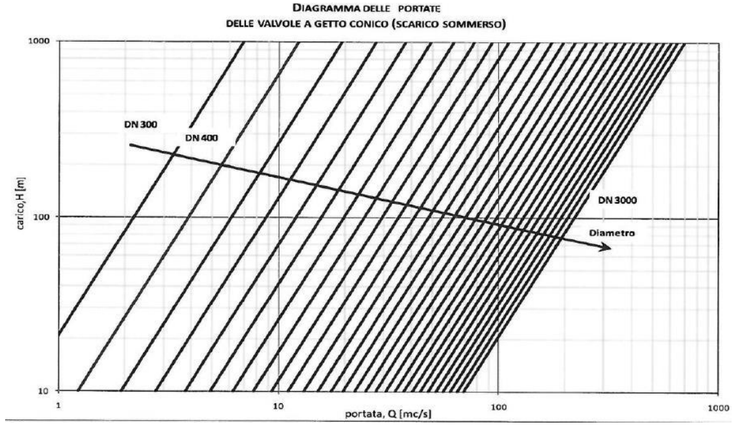
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Vinchiana dam – Additional outlet work installed in the power house

DESIGN GOAL: INSTALLING NEW DISSIPATION VALVE IN EXISTING SPACE INSTEAD OF A FUTURE 4° TURBINE

VALVE DESIGN STEPS:

- PREDIMENSIONING THE VALVE AND THE SHAFT REFERRING ON THEORETICAL PRINCIPLES OF DISSIPATION WITH SHAFT SUBMERGED VALVES



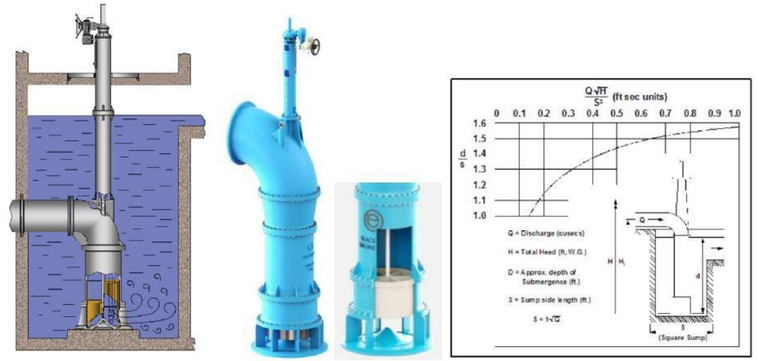


Figura 2: *Schizzo/foto di un sistema tipo "Vertical Sleeve Valve" della società Blackhall (UK) e relative curve standard per il dimensionamento del pozzo.*

According to literature data the section of the shatf is function of the shape and the flow rate:

$S = n \times \sqrt{Q}$, *for squared shape: n = 1.0 ; for circular shape: n = 0.90-0.95*

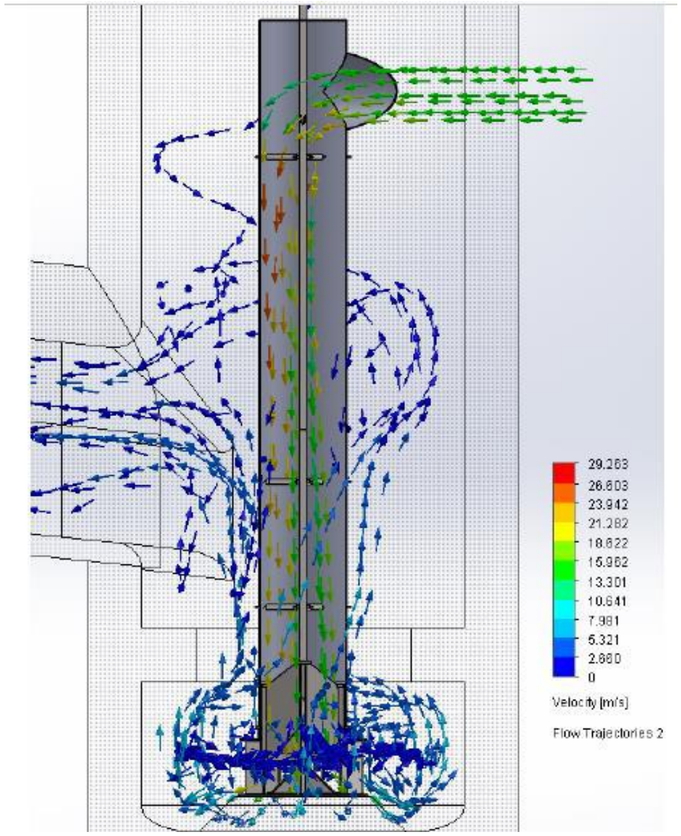
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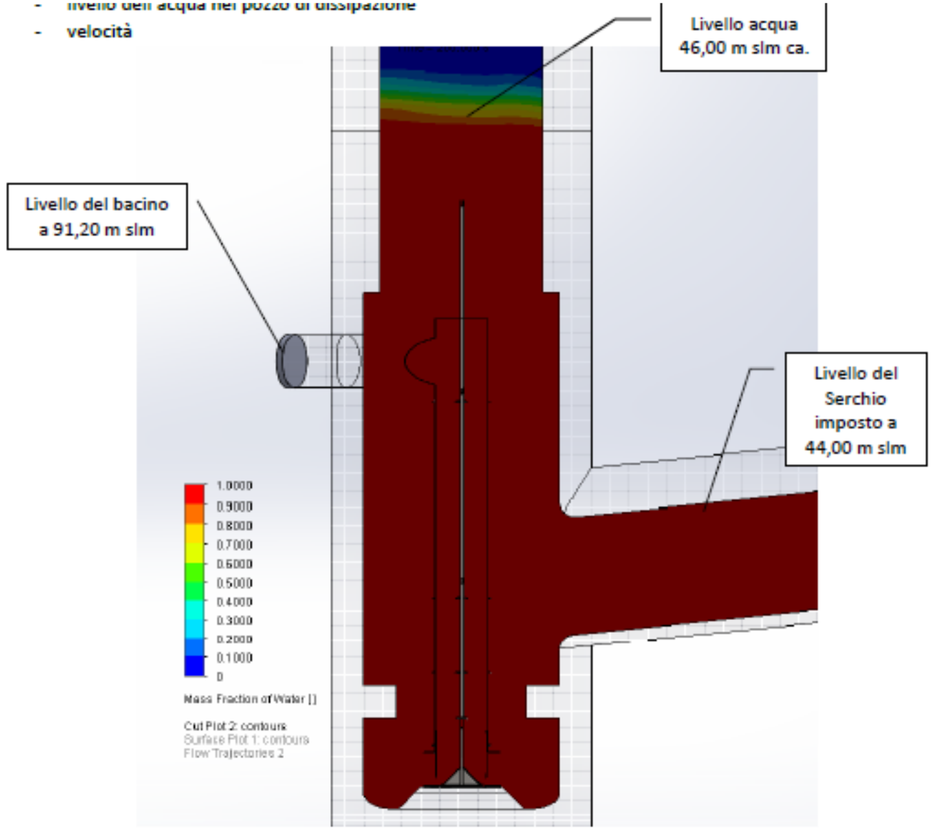
Vinchiana dam – Additional outlet work installed in the power house

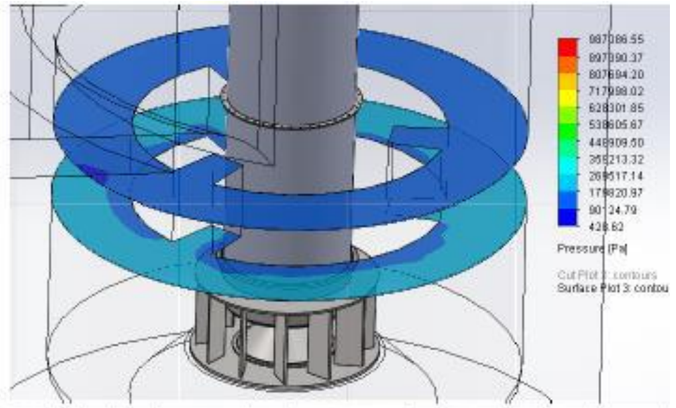
DESIGN GOAL: INSTALLING NEW DISSIPATION VALVE IN EXISTING SPACE INSTEAD OF A FUTURE 4° TURBINE

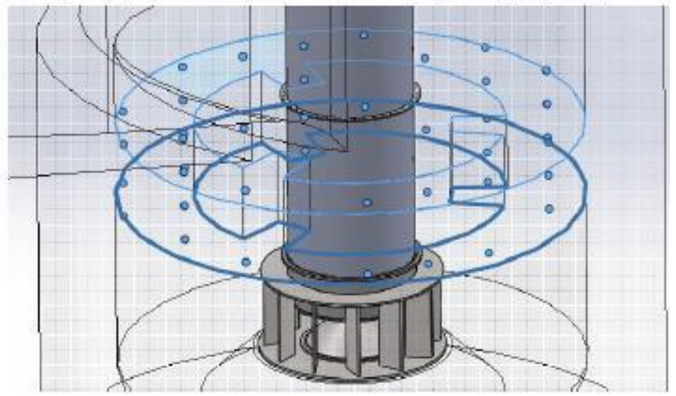
VALVE DESIGN STEPS:

- **Numerical modeling** aimed at defining the water levels in the shaft and at vorticity analysis to determine the frequency of sizing of the dampers









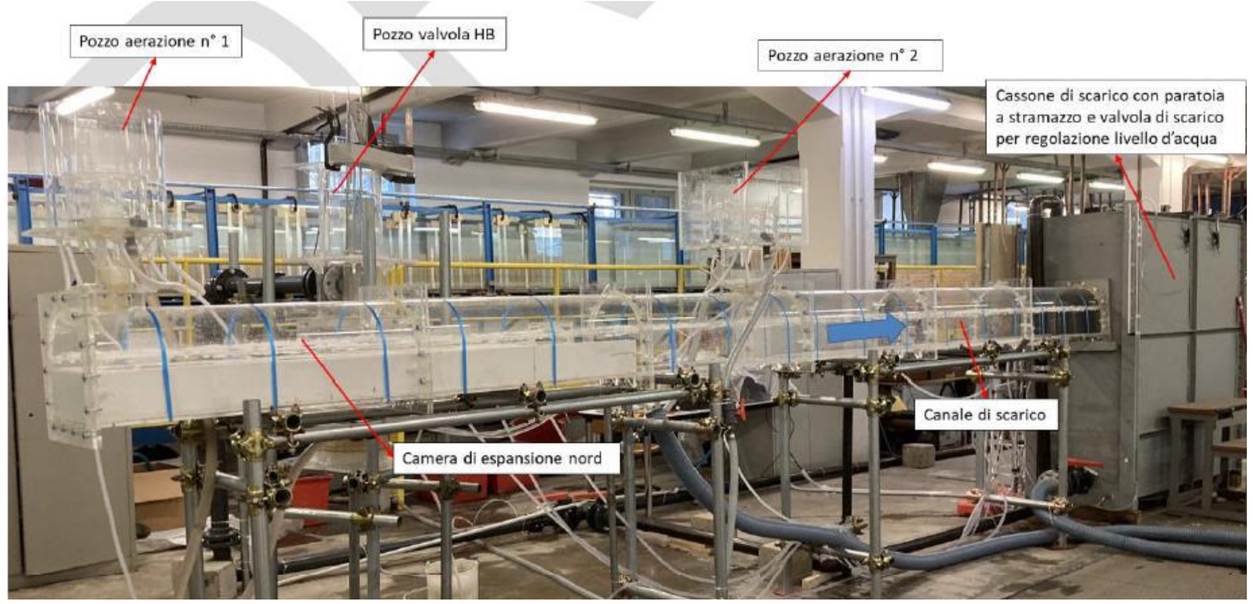
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Vinchiana dam – Additional outlet work installed in the power house

DESIGN GOAL: INSTALLING NEW DISSIPATION VALVE IN EXISTING SPACE INSTEAD OF A FUTURE 4° TURBINE

VALVE DESIGN STEPS:

- **Physical modelling** aimed at:
  - Verify the reference disposal capacity Q (up to 30 m^3/s) in the different tunnel operations from free surface to pressurized;
  - Verify the maximum water heights in the shaft;
  - Verify the heights of the ventilation well, even in the transitory, and interferences with Serchio levels
  - Definition of the outlet capacity diagram of the shaft and valve assembly



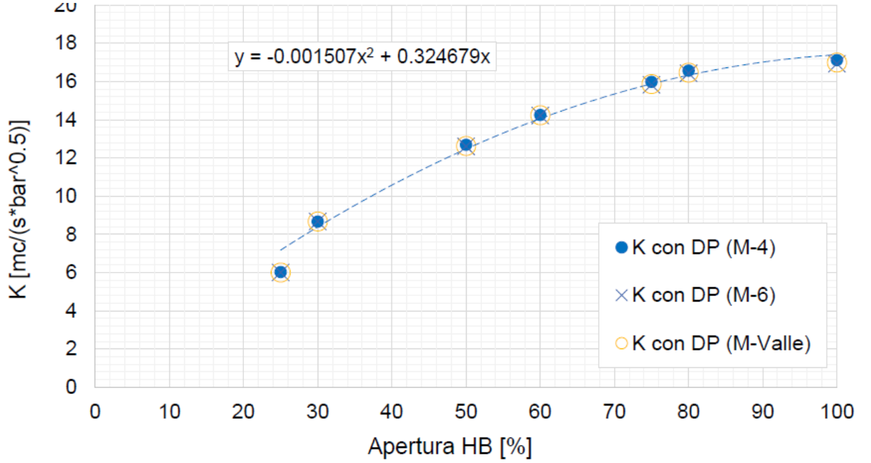


Figura 11: Grafico coefficiente di efflusso impianto

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Vinchiana dam – Spillway diversion channel and stilling basin

DESIGN GOAL: IMPROVING THE DISCHARGE CAPACITY OF THE OUTLET WORKS AT THE SERVICE OF THE SPILLWAY

BEFORE IMPROVEMENT WORKS



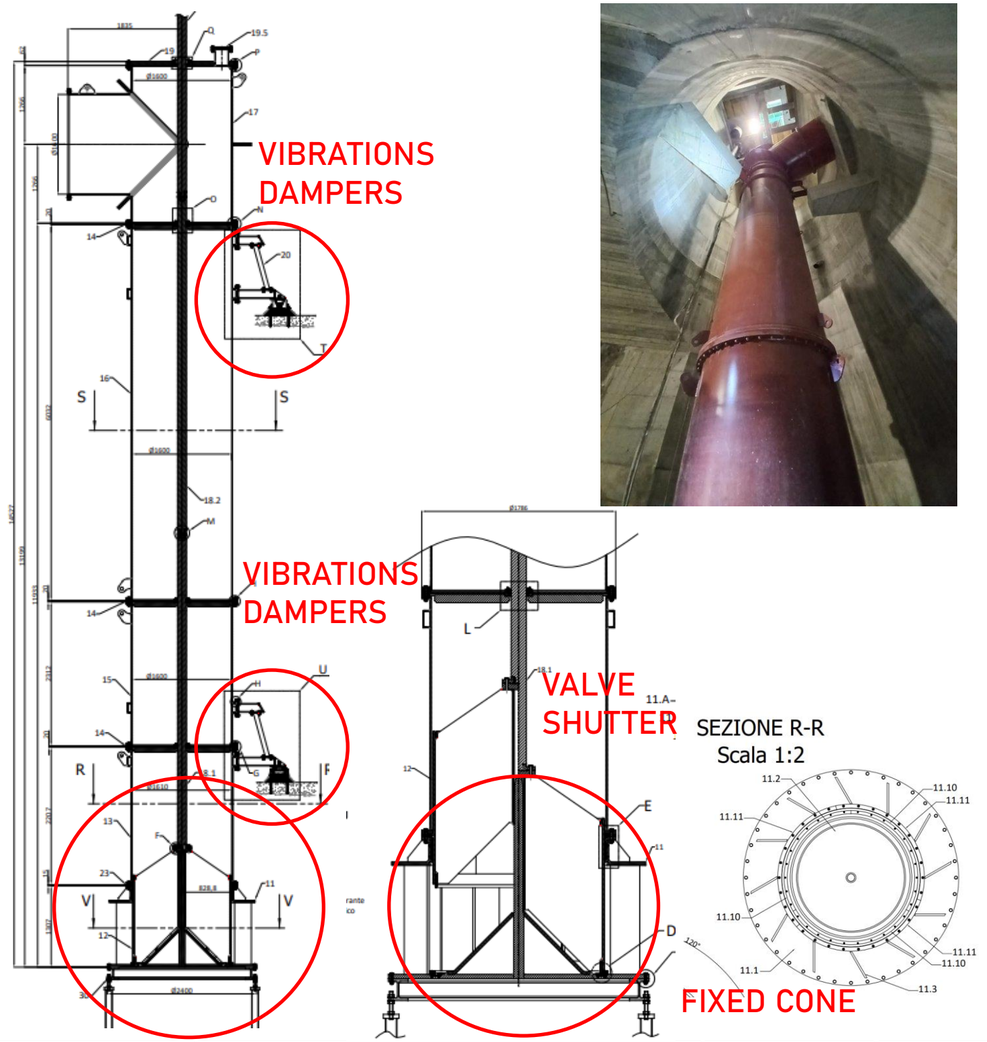
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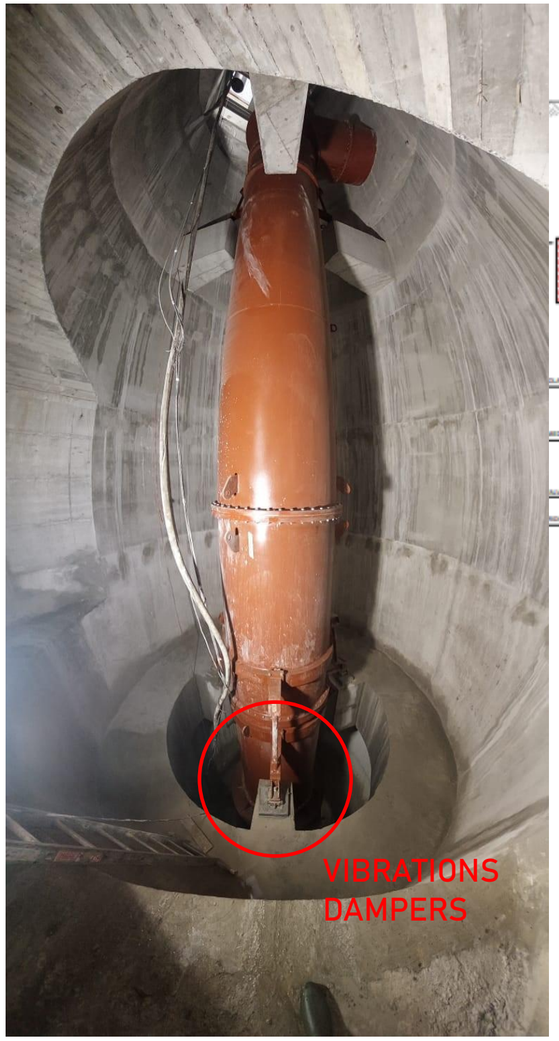


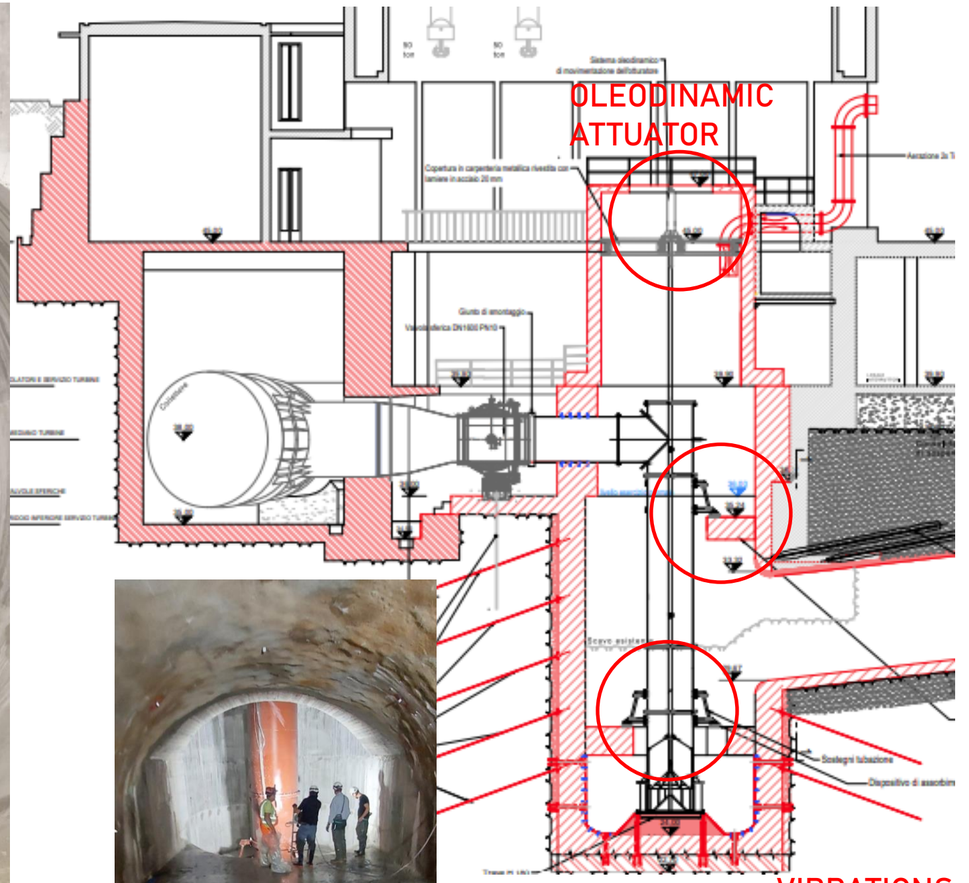
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Vinchiana dam – Additional outlet work installed in the power house

HOWELL BUNGER FIXED CONE DISSIPATION VALVE





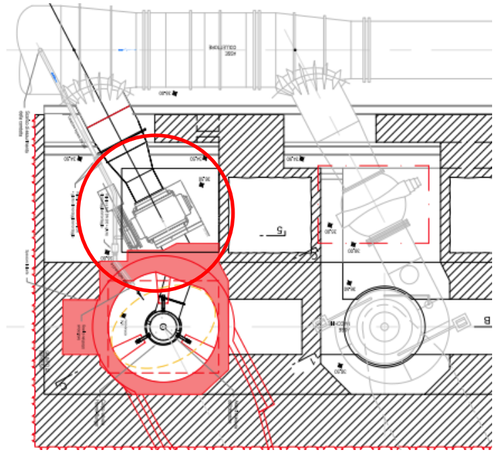


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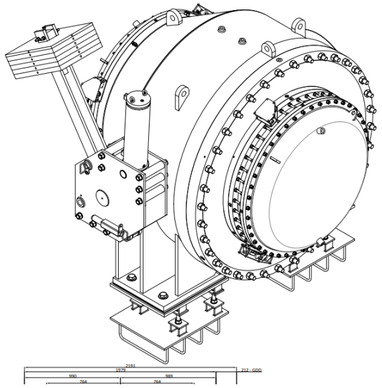
Vinchiana dam – Lesson learned

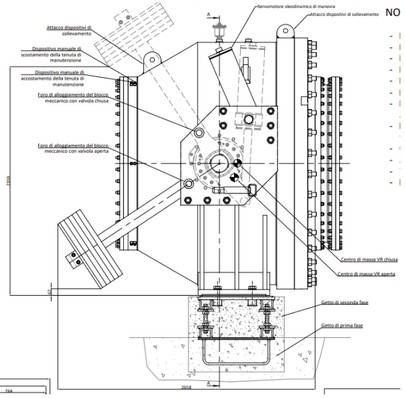
THE DEVIL IS IN THE DETAILS

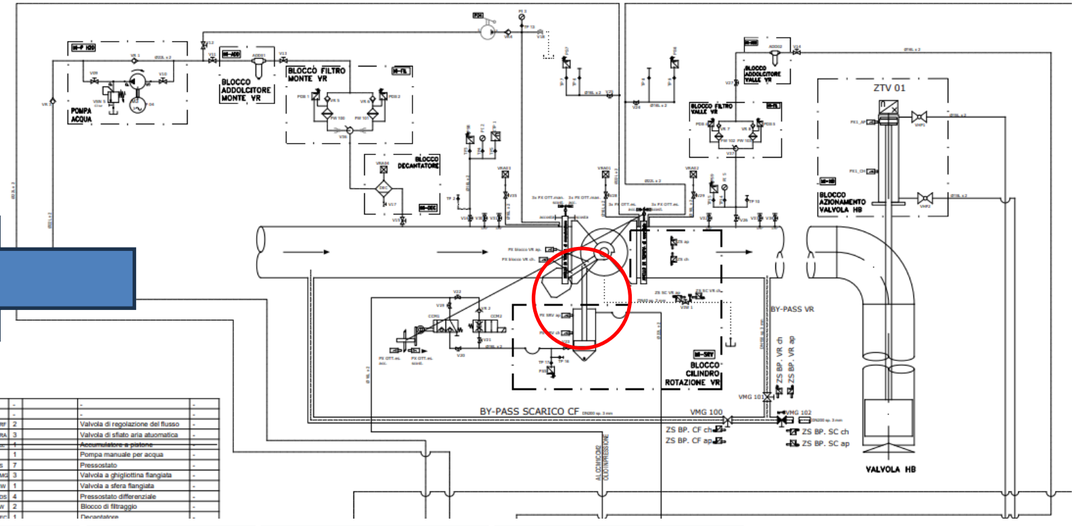
WHEN YOU HAVE TO WORKS THAT REFERRED IN PARTICULAR TO HYDROLOGICAL SAFETY AND SAFETY IN GENERAL, THAN GO SIMPLE! SIMPLE MEANS CHOOSING ROBUST, EASY-TO-USE, EASY-TO-MAINTAIN DESIGN SOLUTIONS

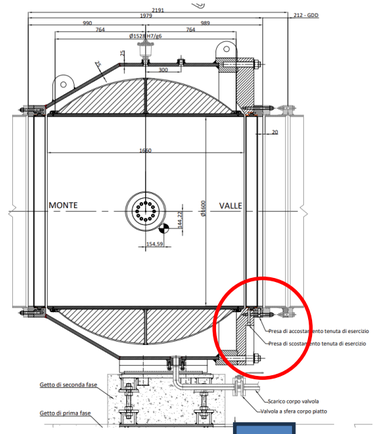


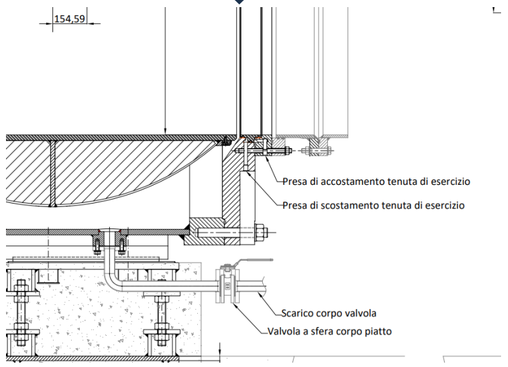












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