

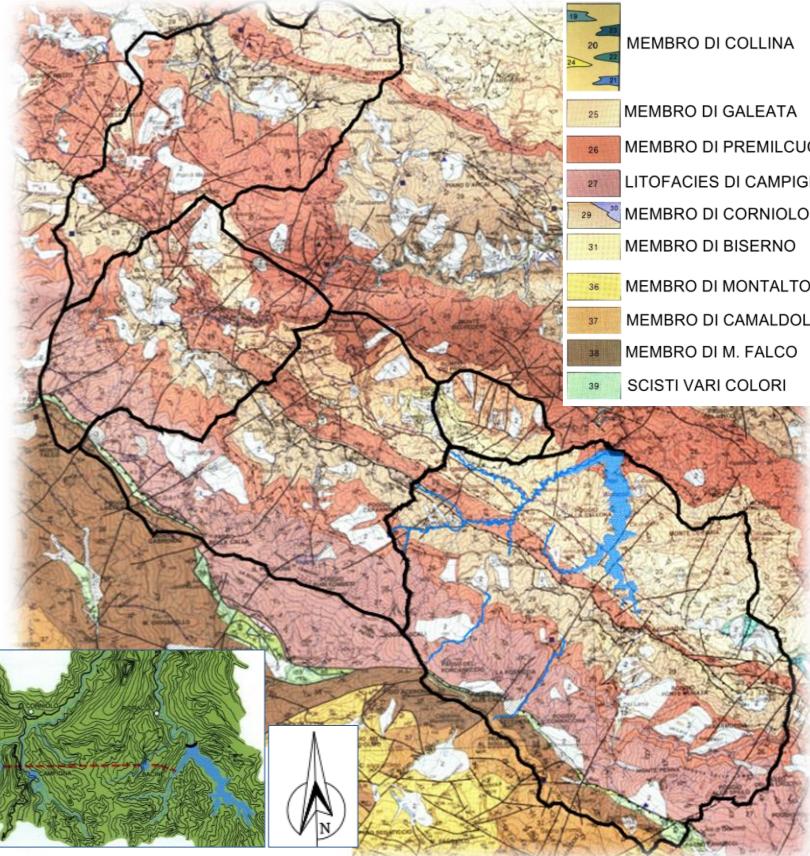
FEATURE OF TECHNICAL SERVICE

Subject	Management project of the reservoir «Diga di Ridracoli» according to the instructions of Ministerial Decree 30 june 2004, under Article 40 Comma 2 of D.L. 11 may 1999 N.152
Carried out by	SGAI Srl di E. Forlani & C.
Client	Romagna Acque-Società delle Fonti S.p.A
Service length	2005

RESERVOIR «DIGA DI RIDRACOLI» – Investigation stage, characterisation of the reservoir and sedimentation process

The reservoir of the Ridracoli dam is located in the province of Forlì-Cesena, within the Foreste Casentinesi National Park, Campigna Park and Monte Falterona, along of the Bidente river at the confluence with the Rio Celluzze, at about 10 km from the town of Santa Sofia. The dam is of the arch-gravity type with a height of 103.5m and with a crowning development of 432m. The basin covers an area of 1,035 km², allowing the storage of **35.5 million m³ of water**. The primary use of the basin is for water supply purposes with annual regulation of the flow rates of the Bidente River, while the secondary one concerns the hydroelectric production in the nearby Isola plant. According to the disposal of the Ministerial Decree 30 june 2004, an accurate study of the basin, dam and hydraulic equipments was carried out, thanks to define the **forecast framework of the management and maintenance activities** to carry out for ensure the **maintenance and gradual restoration of the useful capacity of the reservoir**, ensuring the operation of the discharge and catchment systems in all operation conditions. The design approach has seen the realization of **accurate geological-geotechnical, hydrological, hydraulic and environmental studies**, thanks to which it is possible to carry out the qualitative characterization of sediments and suspended solid material; **calculate the annual solid transport volume** and the **volume of sedimented material**; as well as **investigating the water quality** of the basin. Analyzing the geological and geomorphological framework of the reservoirs of the Ridracoli reservoir, the presence of **medium tenacity and little erodible lithologies** was found, consisting mainly of the marly-arenaceous formation of Romagna in its various components. The vegetal coverings, made up of thick coppice woods, help to limit the surface erosion of the soil, reducing even more the supply of debris. Therefore, the volume of sediment produced annually in each sub-basin was estimated, obtaining an accumulation of debris in the reservoir for about 41,000 m³/year. Conducting **geotechnical, physical-chemical and mineralogical analyzes** on the sediments, the presence mainly of angular-shaped gravel emerged with strong heterogeneity in the various parameters, indicating a very short moving of the material before deposition. The values of heavy metals, hydrocarbons, pesticides, Phosphorus, Nitrogen and BOD₅ are very low and all parameters verify the standard value limits. The suspended solid material is present with an amount less than 1% of the solid transport intercepted by the tidal barrage. In relation to the parameters described and the trends recorded, it is noted that the temperature, dissolved oxygen and pH are characteristic of reservoirs with **good water quality**. The investigation survey showed that the sedimented material for the entire duration of the concession is less than 5% of the reservoir capacity and, if it was filled from the bottom, it would not reach the elevation of the bottom discharge tunnel without affecting the useful basin capacity.

Watersheds tributary to the Ridracoli reservoir



Spillway crest and stilling basin



Bottom discharge tunnel



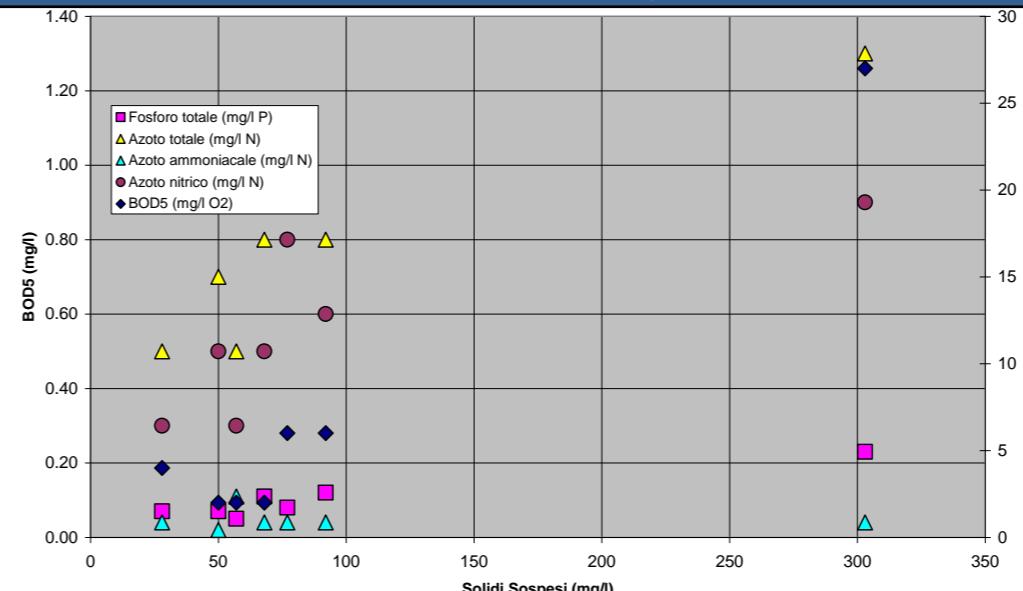
Outlet of the bottom discharge tunnel



View of the reservoir «Diga Ridracoli»



Water quality analysis: suspended solids, BOD₅, Nitrogen and Phosphorus



Outlet of the middle discharge tunnel



HYDRAULIC STRUCTURES, MARITIME
ENGINEERING, DAMS

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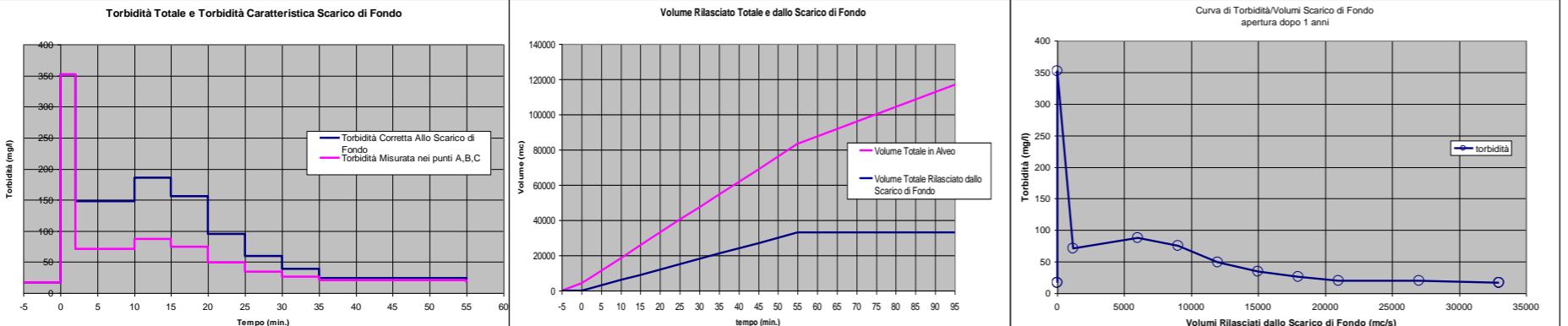
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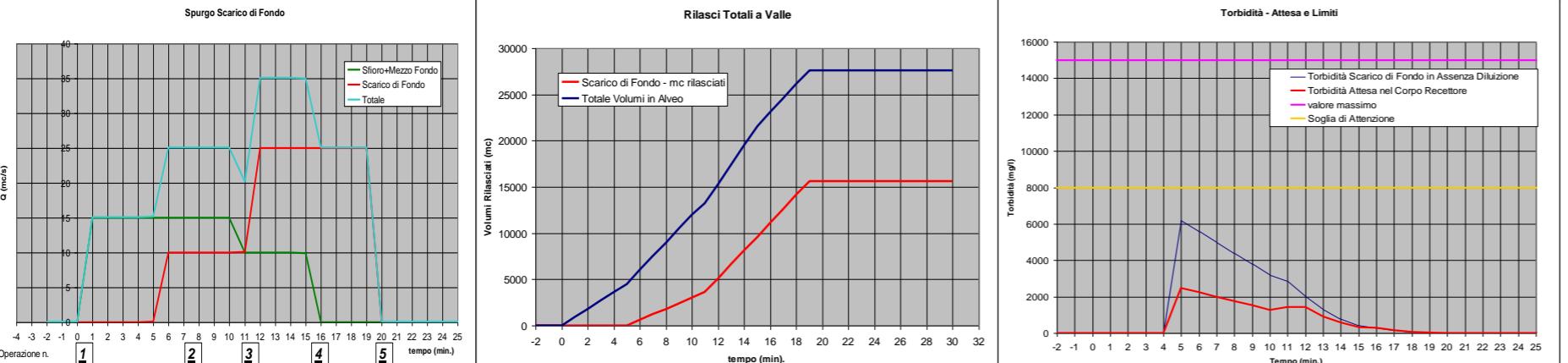
Aerial view of the reservoir «Diga di Ridracoli»



Characteristic turbidity curves of the bottom discharge tunnel



Checks of the turbidity levels during the draw-off and maintenance operation



RESERVOIR «DIGA DI RIDRACOLI» – Management project of the basin, design issues and their resolution

Management project of a reservoir, according to the instructions of the Ministerial Decree 30 june 2004, consists of the preventive definition of the **management and maintenance procedures to carry out for ensure the maintenance and gradual restoration of the useful capacity of the basin**, while limiting the effects, related to the outflow of muddy waters, in the river bed downstream of the dam. In order to define the procedures for opening the discharge system, for each of these, it is necessary to **establish the permissible turbidity curves** by estimating the movement of sedimented material at the site of the floodgates, based on the typical speeds of runoff water. In detail, the Ridracoli dam is equipped with the following hydraulic equipment: spillway crest, middle discharge tunnel, bottom discharge tunnel and emptying drainage. The spillway crest consists of an overflow threshold composed by 8 spans of 14m each. To protect the foundation of the structure there is a stilling basin with a tidal barrage of 14m height. The middle discharge drain, consisting of a 4m diameter tunnel under the left abutment, allows to drain flow rates up to 130 m³/s. The bottom discharge drain consists of a tunnel on the right abutment, of a length of about 400 m, with a disposal capacity of up to 170 m³/s. To best calibrate the opening procedures of the bottom discharge tunnel, an opening test was performed, in order to obtain the "characteristic" curve of turbidity according to the volume released. During the test, not being aware of the sediment intake downstream, it was expected that a good mixing of the water from the bottom discharge drain with high quality reservoir water would be ensured. It is important to define the frequency between one maneuver and another, since the turbidity values could increase a lot. In fact, by opening the bottom discharge tunnel after 3 years, a **turbidity of 2050 NTU was obtained, equal to about 6,000mg/l**. The turbidity curve obtained made it possible to define the correct opening procedures for the discharge system. Since there are no sedimentation problems in the reservoir and on the quality of the water, the study focused on the activity of the bottom discharge, so that the turbidity levels remain acceptable during the flaring and maintenance operations. For this purpose, it was considered to perform turbidity sampling at the height of the valley bridge every 5 minutes from the beginning of the operations with verification of the limit values and reconstruction of the real curve. In detail, an operating sequence was considered with activation of the middle discharge drain, in preferable overflow condition, and following the opening of the bottom discharge drain at a flow rate of 10m³/s for 3 minutes. In this phase the **maximum turbidity will be diluted in a 1.5:1 ratio**. Once the peak of turbidity has passed and entered areas compatible with the thresholds, the background drain will be divided into 10m³/s and the background drain will be raised to 25m³/s. The management plan, in order to avoid local phenomena of abnormal sedimentation nearest the discharge organs, provides for opening operations of the hydraulic organs regularly, ensuring the opening of the bottom and middle discharge drain at least once a year.

	Q Nulle	Q Bassa	Q Elevate
Soglia e Corso d'Acqua		—	—
Scarico di Mezzo Fondo	—	—	—
Scarico di Fondo	—	—	—

MANAGEMENT PROJECT - Opening procedures of the hydraulic discharge system

