

## 13<sup>TH</sup> AUGUST 1935: A CATASTROPHIC DAM FAILURE IN THE ORBA VALLEY (PIEDMONT, ITALY)

VITTORIO BONARIA(\*) & GIOVANNI TOSATTI(\*\*)

(\*) Engineering Geologist - Studio Tecnico Associato BIERREVI - Via San Siro 12/2 - 16124 Genoa (Italy)

(\*\*) Università di Modena e Reggio Emilia - Dipartimento Scienze Chimiche e Geologiche - Largo S. Eufemia 19 - 41121 Modena (Italy)

### ABSTRACT

Between 1919 and 1925 the “Officine Elettriche Genovesi” (O.E.G.), a large industrial company, built a hydroelectric plant in the municipality of Molare (Piedmont, north-western Italy). The reservoir created by the barrage of the Torrent Orba (hydrographic catchment of the River Po) by means of two dams had a capacity of 18 million m<sup>3</sup>. On the morning of 13<sup>th</sup> August 1935, after nearly ten years of operation, the rock sill on which one of the two dams had been constructed - named Secondary Dam of Sella Zerbino - collapsed following a heavy rainstorm. The failure caused the sudden emptying of the reservoir and a large amount of water poured into the underlying valley, wreaking havoc along the whole course of the Torrent Orba as far as its confluence with the River Bormida, some 50 km away, near the town of Alessandria. At least 111 people lost their lives in the disaster. The criminal trial held by the Turin Courts in 1938 returned a verdict of acquittal for the managers of the O.E.G. and the designer of the plant. This article pinpoints the multiple causes which led to the disaster and which can be mainly ascribed to the lack of geological investigations within the hydroelectric plant area. In addition, thorough hydrological and hydraulic studies were not carried out, which could have accurately tested the adequacy of the dam's discharge system. Finally, the original project was changed several times in order to reduce building costs and increase the volume of water stored without

ever considering the proper safety of the plant. The Orba Valley disaster, which occurred nearly 30 years before the Vaiont catastrophe, shows disturbing analogies with the latter, which will be discussed later. The dam which remained standing, named “Main Dam of Bric Zerbino”, still lies within a remote, abandoned meander of the Torrent Orba which, after the 1935 collapse, found a new course in correspondence with the rock sill where the failed dam had stood. The Orba and Vaiont disasters represent two unfortunate examples of the serious consequences which can be brought about by underestimating or neglecting the geological and environmental setting of sites where important engineering works have to be built.

**KEY WORDS:** *Orba Valley disaster, dam, hydroelectric plant, Italy*

### FOREWORD

The Torrent Orba is a north-bound stream running through a small portion of Liguria and southern Piedmont (northern Italy) as far as its confluence with the River Bormida, near the town of Alessandria. In 1926 the construction of a large hydroelectric plant was completed in the municipality of Molare. The impoundment was obtained by barring the Torrent Orba at Ortiglieto (Fig. 1) by means of two dams: the Main Dam of Bric Zerbino and the Secondary Dam of Sella Zerbino.

After nearly ten years of operation, on 13<sup>th</sup> August 1935, after a very heavy rainstorm the Secondary Dam



Fig. 1 - Map of northern Italy: arrows show locations of Orba, Gleno and Vaiont dams



Fig. 2 - The Main Dam of Bric Zerbino showing the twelve dam siphons (O.E.G. photo, 1925)

collapsed together with a portion of the ground on which it was founded. A huge wave of water and debris swept down the valley causing the loss of at least 111 lives and serious damage to the villages located downstream.

In 1938, at the end of the criminal trial held against the planners, owners and managers of this plant, all the defendants were excused from any responsibility for this disaster.

Today, in the Orba Valley the Main Dam of Bric Zerbino is still standing, although the stream does not flow any longer in its original riverbed. What is left of this plant is now located within a protected wetland surrounded by wood-covered slopes. Like the dams of Vaiont and Gleno, the dam is now a monument to the thoughtlessness and lack of accountability of man.

## HISTORY OF THE PROJECT

The history of the hydroelectric plant of the Orba Valley (Piedmont, northern Italy) dates back to the end of the 19<sup>th</sup> century when a project concerning the storage and exploitation of the water of the Torrent Orba was presented by an engineer, Mr Luigi Zunini (ZUNINI, 1899), to the prefectures of Genoa and Alessandria with the purpose of supplying the Genoa-Ovada-Alessandria railway with electric power.

In the following years, notwithstanding the strong opposition of a group of municipalities from the Orba Valley, the project was enlarged from the original 8 million m<sup>3</sup> to over 16 million m<sup>3</sup>. This considerable increase would be obtained with the construction of a 40 m high gravity dam.

In 1912 a concession for the construction of a dam was granted to a society owned by Mr Zunini himself, who presented the first project in 1914.

During the years of the First World War no funds

were available for the implementation of the project and the works were limited to the construction of a service road and the levelling of the ground for the first hydraulic structures.

Finally, in 1916 a new concession was granted to a company named "Officine Elettriche Genovesi" (O.E.G.) which was presided over by Mr Zunini since 1918. The O.E.G. was located in Genoa and was controlled by "Edison", the largest Italian energy company.

Eventually, from 1922 onward construction proceeded rather quickly after changes were made to the original project by another engineer, Mr Vittorio Gianfranceschi, who decided to increase the height of the Main Dam. Therefore, the Torrent Orba was barred at Ortiglieto by a 47 m high slightly curved gravity dam (whereas the maximum height originally planned for the dam was 34 m) equipped with four water dischargers. The plant was completed in 1926 and named Main Dam of Bric Zerbino (Fig. 2). This dam could provide water storage of 18 million m<sup>3</sup> with a 24,000 metric horsepower hydraulic force.

This decision, though, posed a serious problem: at one point of the perimeter of the planned impoundment, some 300 m west of the Main Dam, a saddle formed by two ridges would have been at a lower elevation with respect to the maximum storage level. As a consequence, water could have overflowed the saddle and poured out into the underlying riverbed.

Therefore, it was held necessary to construct a secondary barrage, made up of a 110 m long and 14 m high summit wall. This barrage was planned and built rather hastily, without the support of adequate geological investigations since, according to the planners, this saddle "was made up of sound rock". The second dam, named Secondary Dam of Sella



Fig. 3 - The reservoir and Secondary Dam of Sella Zerbino (photo from the mid-1920s)

Zerbino (Fig. 3), was a massive wall of Portland cement on top of which ran the road leading to the adjacent Main Dam.

The reservoir resulting from the two barrages stretched upstream for some 5 km with an irregular shape and a maximum width of some 400 m. The basin's storage, at the maximum level of 322 m a.s.l., was 18 million m<sup>3</sup>. The hydroelectric plant fed by this reservoir was built 3 km downstream of the two dams (Fig. 4).

In 1924 the Commission for checking large dams (named "Commissione Gleno", since it was established after the 1923 hydraulic disaster in the Scalve Valley<sup>11</sup> gave its approval for filling the reservoir up to an elevation of 317.40 m a.s.l., corresponding to a volume of some 13.5 million m<sup>3</sup> of water. Once the basin was filled, water leaks (up to 30 l/s) were noticed across the rock diaphragm of Sella Zerbino on which the Secondary Dam stood. Several attempts were made to make the rock mass impervious with no satisfactory results. Paradoxically, these leaks were not recorded during the final inspection carried out by the Civil Engineers Board in December 1927.

Between 1925 and 1935, several interventions of ordinary maintenance were carried out on the Secondary Dam and the underlying saddle of Sella Zerbino. In the reports drawn up by the engineers in charge in 1928 and 1929 various problems concerning the dyke of the Secondary Dam were pointed out. In particular, in April 1929 it was written that: "The glass fissuremeter fixed across the crack on the right hand side of the Secondary Dam is broken owing to temperature

<sup>11</sup> On 1<sup>st</sup> December 1923 a concrete dam collapsed in the Scalve Valley near Gleno (upper Lombardy). In half an hour some 6 million m<sup>3</sup> of water, mud and debris poured out of the artificial basin and swept down the valley as far as Lake Iseo. At least 356 persons lost their lives

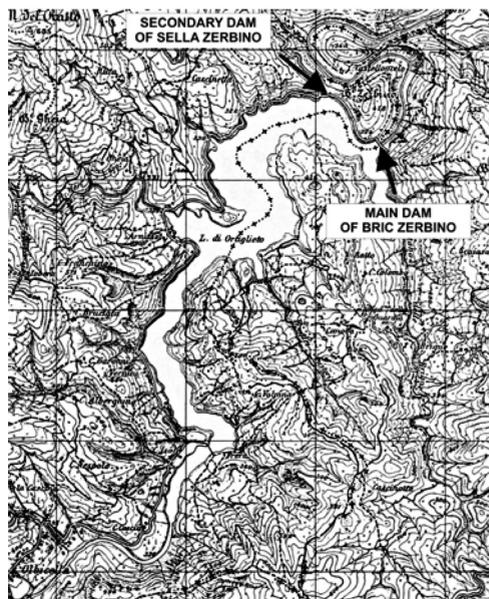


Fig. 4 - Map showing plan view of the reservoir with the position of the two dams (reduced from Topographic Map of Italy, 1:25,000 scale, 1934)

changes. The dam's plaster shows several network-like fissures... Nevertheless, the inspections have confirmed that the two dams are in normal condition".

In November 1926, a considerable high-water event in the Torrent Orba catchment increased the reservoir surface by nearly 70 cm above the maximum filling level, with a real overflow risk. Following this event O.E.G. decided to lower the position of the floodway to an elevation of 319 m a.s.l. with respect to the originally planned 322 m a.s.l. Eight years later, in November 1934, a sudden rainstorm rapidly increased the level of the impoundment which was satisfactorily controlled by the newly placed floodway.

## GEOMORPHOLOGIC AND GEOLOGIC SETTING

The upper part of the Orba Valley is characterised by the typical features of the north-western Apennines and Maritime Alps, such as steep slopes and narrow riverbed, often with an incised-meander pattern. North of the village of Molare, these landforms give way to the more gentle hills of the Monferrato district, where the riverbed is wider and follows a less winding route. Finally, north of Ovada, the stream flows into the open Po Plain.

This morphological differentiation is due to the

diverse geological environments (pre-Tertiary, Tertiary and Quaternary) which characterise the Orba Valley. The stream which gives its name to the valley originates from the ridges forming the Ligurian-Adriatic watershed ascribable to the rock formations of the Voltri Group. This term, which was introduced late in the 19<sup>th</sup> century (ISSEL, 1892), designates one of the largest metaophiolite and metasediment complexes cropping out in the SW Alps. These rocks were originally portions of oceanic crust, with their overlying sediments, belonging to the Jurassic Ligurian-Piedmont Ocean. Following Alpine orogenesis, these rocks were subject to metamorphism, displaced and overthrust onto the margin of the European paleocontinent.

The place named Ortiglieto, where the two dams were built, is characterised by the presence of rock types ascribable to the Voltri Group such as mostly broken and displaced serpentinites, serpentine schists and metabasites affected by numerous joint systems (CHIESA *et alii*, 1975) which influence the slope morphology and, in particular, the hydrographic network pattern. Typically, there are E-W and ENE-WSW oriented sub-vertical faults which sometimes turn to a N-S direction in correspondence with the main watercourse.

In 1925, the technical review "L'Energia Elettrica" emphasized the technological magnificence of the new plant, though it provided a rather biased description of the local geology: "The most important feature of the rocks belonging to the Voltri Group is the absence of deep joints. The layers' surfaces are soundly cemented to the bedrock; therefore there seem to be no cavities at depth" (O.E.G., 1925).

Today, at the point of the dam breach of Sella

Zerbino, the tectonic boundary between the antigorite serpentinites, which make up the backbone of Bric Zerbino (right hydrographic side), and the metabasites cropping out on the opposite side of the valley is well exposed (CAPPONI *et alii*, 1988). Furthermore, the whole area is characterised by intense cataclasis due to the presence of numerous fault systems (VIGO, 1998) (Fig. 5).

### THE DISASTER OF 13<sup>TH</sup> AUGUST 1935

After a long lasting drought, early in the morning of 13<sup>th</sup> August 1935 a very heavy rainstorm hit the upper Orba Valley. The main stream and all its tributaries were swollen and there was flooding in many places (BONARIA *et alii*, 2005).

The reservoir level had been very low for several weeks but at 10:00 hrs it had risen by about 8 m, reaching an elevation of 318 m a.s.l. (VISENTINI, 1936). The plant caretaker started an emergency manoeuvre by opening the bottom discharge valves, which stopped working after a few minutes. At this point, the reservoir could only discharge by means of the surface spillway and the twelve dam siphons (Fig. 2). Nevertheless, by 12:30 hrs the basin was full and water started to flood over the top of the two dams. At 13:15 hrs the rock saddle of Sella Zerbino, where the Secondary Dam had been built, gave way causing the collapse of the overlying dam. Within a few minutes the level of the reservoir went down by some 25 m while a wave of more than 20 million m<sup>3</sup> of water poured down into the valley sweeping away the hydroelectric plant (Fig. 6) which had just been abandoned by technical staff. A huge wave of water, mud and debris wreaked havoc

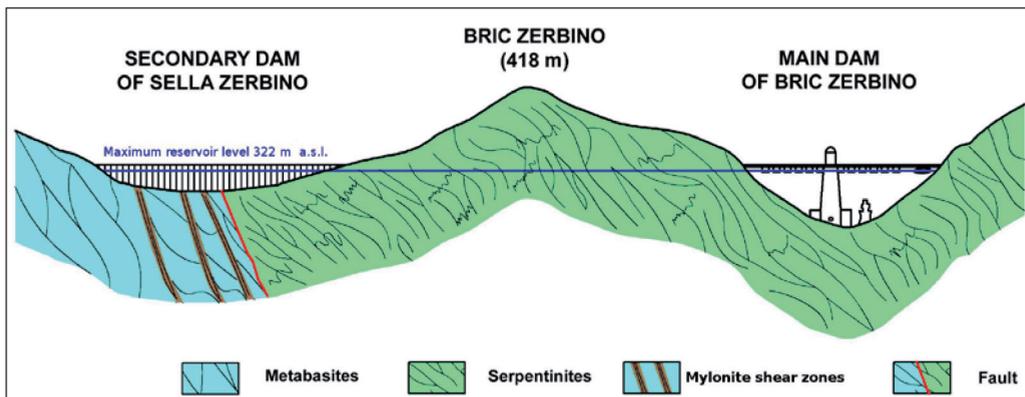


Fig. 5 - Geological section across the Orba Valley reservoir showing the mylonite shear zones in correspondence with the Secondary Dam (modified after CAPPONI *et alii*, 1988)

on the valley downstream, bringing death and destruction to the villages of Molare, Ovada and several other hamlets (Fig. 7). There were 111 ascertained victims, half of whom were from Ovada. 90 houses and 4 bridges were destroyed and the farming activities of the mid-lower Orba Valley severely compromised. The total damage caused by this disaster was estimated at over 45 million lire of the time.

The investigations carried out by the members of a Ministry Commission set up in the aftermath of the disaster established that a spate wave ran across the River Po itself for eight days after the failure, recorded even by the farthestmost hydrometers.

The Sella Zerbino disaster shows striking analogies also with the collapse of the Malpasset dam (Var District, France) of 1959, in which 423 persons lost their lives (LUINO & TREBO, 2010).

On 6<sup>th</sup> December 1923, a few days after the Scalve Valley disaster, Mr. Luigi Mangiagalli, an authoritative hydraulic engineer, declared that *“Obviously, if there had not been construction faults, there would not have been the Scalve Valley catastrophe. Nevertheless, this incident should not arouse apprehension or hostility among the people living in valleys where hydroelectric plants stand, since dams can be built and managed nowadays with a mathematical level of safety”* (MANGIAGALLI, 1937). Fifteen years later, the same engineer coordinated the various technical reports of the legal consultants of O.E.G., which established the absolute unavoidability of the Orba Valley catastrophic failure.

On May 1938, the Appeal Court of Turin pronounced a verdict of acquittal for all the defendants in the criminal trial concerning the failure of the Sella Zerbino dam. Therefore, nobody was responsible for this terrible event since, according to the verdict, the

disaster had been caused by an unforeseeable event such as exceptional precipitation: over 100 lives lost just because of a heavy rainstorm...

## CAUSES OF THE DISASTER

Unfortunately, the Orba Valley catastrophic dam failure was not the only hydraulic disaster that struck Italy in the 20<sup>th</sup> century:

1) In the morning of 1<sup>st</sup> December 1923, a dam barring the Torrent Povo in the Scalve Valley (Lombardy) collapsed after a few days of heavy rainfall. The huge wave thus generated swept the Scalve and Camonica valleys as far as Lake Iseo. Along its route of about 10 km, it destroyed entire villages, scattered houses and electric power stations taking at least 356 lives.

2) Late in the evening of 9<sup>th</sup> October 1963, a large portion of the northern slope of Mt. Toc (Friuli) slid into the hydroelectric reservoir of the Vaiont dam, which withstood the violent impact of the landslide. Nevertheless, a huge wave resulting from the displaced water hit two villages on the opposite side of the valley, overflowed the top of the dam and struck the bottom of the River Piave valley with incredible violence, destroying most of the village of Longarone (Veneto). The ascertained lives lost were 1917.

These events, together with the Orba Valley disaster (111 lives lost), make up the three great hydroelectric plant catastrophes which first marked the development and then the decline of the Italian hydroelectric industry in the 20<sup>th</sup> century.

As in the Orba Valley Disaster, several factors contributed to the failure of the Sella Zerbino rock sill and the collapse of the overlying dam. They can be summarised as follows: i) geological causes; ii) hydraulic causes; iii) planning causes.



Fig. 6 - Destruction of the hydroelectric plant during the emptying of the penstock (August 1935)



Fig. 7 - Aftermath in the Orba Valley by the village of Ovada (August 1935)

## GEOLOGICAL CAUSES

The planning history of the Orba Valley hydroelectric plant lasted some 30 years, from the first project proofs in 1898 up to 1926, when the final executive project was presented to the Civil Engineers Board.

During this long period the only geological document attached to the project was the report by Professor Francesco Salmoiraghi, from the Milan Polytechnic. This geological report consisted of a few pages in which the geological features of the valley were summarised (SALMOIRAGHI, 1898). No detailed geomorphological surveys were carried out, no structural analyses on the rock masses, let alone boreholes. Nevertheless, this geologist stated that the rocks found in the Orba Valley, although belonging to the same formation (i.e., the Voltri Group), showed extremely variable characteristics. According to the same author, this morphological diversity was to be considered a positive factor, since at one point there was a narrow gorge suitable for a barrage whereas upstream the valley was much wider and therefore suitable for hosting a large reservoir. Professor Salmoiraghi concluded his report by asserting that: “...in any part of this area it is possible to build a dam in full safety conditions”.

In 1926, when the final project was presented, the only geological report in attachment was the “Salmoiraghi report”, although this geologist had died in 1910. Indeed, O.E.G. had been long aware of the real conditions of the rocks making up the sill of Sella Zerbino.

If in-depth and thorough structural-geological surveys had been conducted in the Ortiglieto-Bric Zerbino area, where the reservoir was located, they certainly would have identified the extremely unfavourable geological characteristics of the outcropping rocks which eventually led to the dam’s complete failure. For example, in correspondence with Sella Zerbino (Fig. 4) accentuated lateral fluvial erosion on the torrent’s right-hand side had shown the presence of particularly jointed rocks and easily recognizable shear zones affecting greenish-blue mylonites (Fig. 5). Geological investigations should have been corroborated by boreholes and exploration drills, which were already available when this plant was built. Mr Ettore Scimemi, a hydraulic engineer, in his work *Dighe (Dams)*, published in 1928, stated that: “*It would have been advisable to carry out boreholes and drills on both sides of the valley in order to avoid the geologi-*

*cal surprise given by the undetected presence of joints or thinner rock levels. This system of investigation is rather simple, although fairly expensive”.*

After a century, it should be stressed that these are still the most important in situ investigations in order to acquire adequate geological knowledge of an area chosen for the implementation of large engineering works such as dams. These investigations should also be accompanied by geophysical prospecting and remote sensing imagery interpretation.

On the other hand, as regards analytical assessments of slope stability around the reservoir, it would have been necessary to wait until the 1970s for the development of correct approaches by BIENIAWSKY (1973) or BARTON & CHOUHEY (1977) applied to rock slopes in order to evaluate properly rock mass quality and joint shear strength.

Years later, another geologist, Professor Mario Airolidi, wrote a report in which he stated that “...*the identification of jointed and faulted rocks should not have been difficult even before the construction of the Secondary Dam since they were cropping out on the upstream flank of the rock sill, where they were subject to erosion by the Torrent Orba*” (AIROLIDI, 1935). Further evidence on the widespread presence of jointed rocks was offered when a water load tunnel was dug at a short distance from the rock sill of Sella Zerbino before the construction of the Secondary Dam. Unexpectedly, the excavation works intercepted highly fractured and water-rich rock levels, corresponding to mylonite bands, and the tunnel walls and vault had to be strengthened with reinforced concrete (CANNONERO, 1935). These levels played a major role in the collapse of the rock sill since they are weaker horizons within the rocky septum.

Therefore, notwithstanding its modest size, it was the Secondary Dam which collapsed since it had been built on poorly compact and intensely jointed rocks, whereas the still standing Main Dam was founded on sounder serpentinites.

## HYDRAULIC CAUSES

The area occupied by the dam impoundment was not provided with a pluviometric gauge and, for this reason, errors and speculations in assessing the precipitation trend were possible (as indeed occurred during the trial). After ten years of activities, O.E.G. did not consider it necessary to install any pluviometric

gauge around the area occupied by the reservoir. As a consequence, the meteorological data available for the technical advisors during the trial were scanty (VISENTINI, 1936).

Several pluviometric gauges within the Orba Valley and adjacent catchments recorded for 13<sup>th</sup> August 1935 precipitation values exceeding 300 mm within a time of less than 8 hrs, corresponding to nearly 30% of the mean annual precipitation (TROPEANO, 1989).

The technical commission appointed by the Italian Ministry of Public Works, which visited the site of the disaster the following day, calculated for the Torrent Orba a maximum flow rate of 2280 m<sup>3</sup>/s ( $\approx$ 16 m<sup>3</sup>/s each km<sup>2</sup>). Unfortunately, the actual discharge capacity of the dam was about 850 m<sup>3</sup>/s (6 m<sup>3</sup>/s each km<sup>2</sup>). In addition, the two submerged discharge valves stopped working minutes after they were opened following the rapid level increase of the reservoir. At this point, the reservoir's discharge was possible only by means of the surface spillway and the dam's siphons: only 1/3 of the actual flow rate could therefore be discharged by the plant.

Due to this severe hydraulic inadequacy, the reservoir level kept rising up to nearly 2.5 m over the top of the dam until failure occurred, due to the rapid erosion of the jointed rocks which made up the foundation ground of the Secondary Dam.

## PLANNING CAUSES

The changes introduced in the original project by Mr Gianfranceschi, which consisted of raising the top of the Main Dam by 13 m, certainly played a major role in the tragic failure of the Secondary Dam.

With regard to this aspect, it should be pointed out that inappropriate and unsuitable changes to hydraulic and geotechnical structures were aggravation causes in all the great industrial disasters in Italy. The Gleno dam was initially planned as a gravity dam but, owing merely to economic reasons, during construction it was turned into a multiple-arch structure (PEDERSOLI, 1973). In the Vaiont dam project several increases of the dam's height were introduced (from the original 200 m up to 264.5 m) which heavily reduced the stability of the left shore of the reservoir (HENDRON & PATTON, 1985; SEMENZA, 2001). In the Stava Valley the marshy and ill-suited nature of the soil on which the two tailings dams were built was completely ignored (ROSSI, 1973) and the outer dams of the basins were

raised well beyond the height approved by the District Mining Board of Trent; as a consequence, the sudden collapse of the Stava unstable earth dams caused the death of 268 people (TOSATTI, 2003).

Similarly, also the Main Dam of Bric Zerbino in the Orba Valley was augmented in height by over 1/3 with respect to the initial height (from 34 m to 47 m). This decision was not followed by adequate adjustment of the water discharge equipment which was unable to allow rapid emptying of the reservoir during the heavy rainstorm which preceded failure. Even more important, the final increase of the reservoir level revealed the geological-structural critical state of the rock sill at Sella Zerbino which, nevertheless, was not properly assessed. The implementation of the Secondary Dam as a simple containment work, rather than a proper dam equipped with a spillway, which would have guaranteed higher water discharge, was the direct consequence of the ill-planned changes to the project (BONARIA *et alii*, 2005).

## FINAL REMARKS

The incident of 13<sup>th</sup> August 1935 in the Orba Valley preceded the Vaiont catastrophe by nearly 30 years; nevertheless the two events show striking similarities.

In both cases the predisposing factor is to be found in the critical geological and hydrogeological conditions of the slopes surrounding the reservoirs rather than in the actual sites where the dams were built.

As for the Orba Valley, the feasibility of the plant was assessed on the basis of the most suitable site for constructing the Main Dam, as happened at Vaiont. Therefore, it is not a coincidence that the Orba Main Dam and the Vaiont dam survived these disastrous events undamaged, since they had been built in morphologically and geologically suitable sites.

Mr Zunini considered the noticeable widening of the Orba Valley upstream the plant as favourable, since it could host a large reservoir. Nevertheless, this sharp morphological change should have warned the planners of the presence of a complex geological-structural situation, evident also at the rock sill of Sella Zerbino.

Unfortunately, both Messrs Zunini and Gianfranceschi in the Orba Valley and Mr Carlo Semenza in the Vaiont Valley focused their attention nearly exclusively on the engineering works, neglecting the geological context of the two sites and the consequences that a large mass of water could have on the stability

of already precarious rock slopes.

In the case of the Orba Valley this shortcoming was further aggravated by the total lack of geological investigations even during construction or when, later on, problems concerning water infiltration through the rock sept of Sella Zerbino were not properly assessed. Furthermore, it should be pinpointed that, in order to save money, the Secondary Dam was poorly and hastily constructed just on the most critical site: the rock sill of Sella Zerbino.

Also the discharge system of the Main Dam was completely inadequate, since no meteorological or hydraulic models were elaborated before construction.

Since the collapse of the Secondary Dam, the Torrent Orba has found a new route across the rock sill of Sella Zerbino whereas the Main Dam is still standing. In what used to be the reservoir a vast wetland has developed with the presence of numerous vegetal and

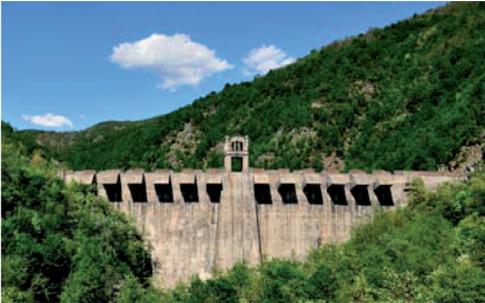


Fig. 8 - The surviving Main Dam of Bric Zerbino as it appears today (June 2012)

animal species.

After years of silence, in the mid-1970s new proposals for a possible re-activation of the plant started to circulate (CALVINO & SICCARDI, 1980). These triggered new discussions between environmentalists and supporters of a new hydroelectric plant (among whom there were local administrators worried about the recurrent summer droughts and lack of water storage), although nothing was decided for years. In 2005, the still standing dam (Fig. 8) was definitely cancelled from the register of Italian dams, thus putting an end to a decades-long debate and favouring ecological upgrading of the area.

Only in 2005, in coincidence with the 70<sup>th</sup> anniversary of the Orba Valley disaster did new popularisation initiatives take place. The “active memory” of this tragic event was revived, thanks to local publications, the website “www.molare.net” and various commemoration events, such as travelling photographic exhibitions. In 2010, legal procedures were activated in order to give the State the ownership of the surviving dam. This fact could be of great importance in order to organise guided tours of the site, historical-nature trails for hikers, equipped with explanatory panels, and the implementation of a remembrance museum (like the one set up in the Stava Valley, cf. GIORDANI *et alii*, 2003). Only through this sort of initiatives would it be possible to revive the memory of one of the three greatest hydroelectric plant disasters of Italy’s troubled industrial history.

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